

RESEARCH

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**VIRTUAL TECHNOLOGIES AND ENVIRONMENTS (VIRTE):
DEPLOYABLE TRAINERS FOR NAVY AND MARINE CORPS
EXPEDITIONARY WARFARE**

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This article concerns Virtual Technologies and Environments (VIRTE), an Office of Naval Research (ONR)-sponsored program under the Capable Manpower Future Naval Capability (FNC). The objective of the program is to demonstrate and transition virtual- and augmented training technologies to the Navy and Marine Corps, to supplement live combat training in a deployed setting. The program comprises three phases: (1) Combat Vehicles and Craft, for which the Naval Postgraduate School (NPS) is developing an MV-22/helicopter simulator; (2) Close Quarters Battle, for which NPS is developing a prototype small-footprint combat simulator for individual marines; and (3) Full-Spectrum Combat, for which NPS is developing a prototype combined-arms simulator for forward observers and forward air controllers.

Introduction

The United States military has long been a leader in the use of simulation for training, but for the most part, U.S. training systems bear an extremely high cost and tend to be large, complex, and inflexible. They are designed to do one thing well—but what they may gain in fidelity, they lose in practicality. Their high cost limits their availability, which in turn limits their value in the training pipeline. Low-fidelity, deployable simulators (“computer-based trainers” or CBTs) are also available (these are often multimedia-based applications that run on available computing hardware), but they represent a different class of training application because their simulations of training environments are not fully interactive. With recent advances in graphics hardware and gaming technologies, the time is right to investigate the possibility of getting the best of both worlds. Can we build high fidelity, low-cost deployable training systems that allow us to “train as we fight?” We believe so, and this is the goal of VIRTE.

We contend that a training asset a warfighter gets to use only a handful of times in his career (due to lack of availability) is not really an asset at all. Our objective is training systems that can be used in asynchronous access, readily available as needed—and therefore cost cannot be an issue in any system we build, because high cost impedes availability.

Deployability is important as well. Currently, there are few, if any, opportunities to train once the trainee is deployed; the full weight of our training resources are spent on the pre-deployment train-up cycle. Unfortunately, once trainees are aboard ship and underway, skill atrophy becomes a critical concern—a concern VIRTE’s training

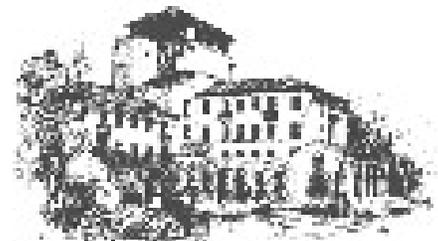
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system is highly interested in addressing.

Besides skill atrophy, one critical aspect of training commonly overlooked is joint- and combined-arms training. In Afghanistan today, we see the Air Force working with Special Forces, and the Marines with the Army. These are warfighters who do not typically train together, making joint operations inherently difficult. Low-cost, reconfigurable, interoperable simulation systems such as VIRTEs are essential to overcoming barriers to successful joint-combat operations.

In contrast with previous research and development, the VIRTE endeavor embraces two critical elements for success. First, all aspects of VIRTE have a transition sponsor before work is begun. While VIRTE demonstrations aren't expected to be products in the literal sense, technologies developed for demonstrations are targeted for specific acquisition programs currently underway. Second, all VIRTE training systems adhere to the CNO's "Human Performance Model," which can be viewed at http://www.excel.navy.mil/human_model.htm and in Figure 1.

VIRTE developers begin with a careful analysis of what we want to train, what the critical aspects are of that skill or set of skills, and what measures are appropriate to follow. Next

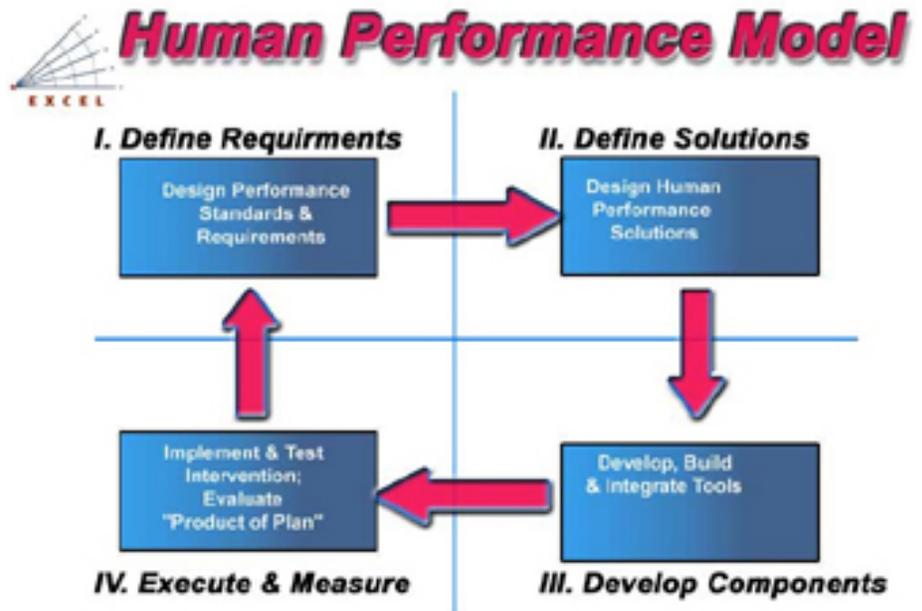


Figure 1. The Chief of Naval Operations' Human Performance Model

a requirements specification is written, which is matched carefully to available technologies to determine a good solution, and the solution is then implemented. Finally, the system is thoroughly tested for its adherence to the original requirements—not just technical, but also human-performance requirements. Training-transfer studies are essential to this process, as are usability studies to examine ease of use in the

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About the INVESTIGATORS

Associate Professor Rudy Darken is the Technical Director of Human Performance Engineering for The MOVES Institute. He is an Associate Professor of Computer Science,



Rudy Darken

joining the department in July of 1996. He is also the Chair of the MOVES Academic Committee and serves as its Academic Council Representative. Professor Darken co-founded the first virtual environment laboratory at the Naval Research Laboratory in Washington, D.C. in 1991. He has served on advisory panels for

the NASA Ames Research Center, the National Science Foundation, and the Engineering and Physical Sciences Research Council (U.K.). He is a Senior Editor of *PRES-ENCE Journal*, the MIT Press journal of teleoperators and virtual environments. He received his B.S. in Computer Science Engineering from the University of Illinois at Chicago in 1990 and his M.S. and D.Sc. degrees in Computer Science from The George Washington University in 1993 and 1995, respectively.

Commander Joseph Sullivan is an instructor in the Department of Computer Science and a member of The MOVES Institute. CDR Sullivan graduated from Catholic

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absence of special training on the system.

Ultimately, there is no greater criterion by which a training system is judged than how well it trains. This seems obvious, but unfortunately, this step is often overlooked. The return on investment (ROI) of a training device is almost always unknown for traditional systems; considering the high cost and increasing dependence invested in these systems, this ignorance is unsettling.

VIRTE is a six-year program (FY02 through FY08), broken into three phases each, culminating in a concept demonstration. Our partners in VIRTE include the Naval Research Laboratory, Naval Air Warfare Center Training Systems Division, Lockheed Martin Information Systems, the Southwest Research Institute, Dynamic Animation Systems, BMH Associates, the University of North Carolina at Chapel Hill, and others.

The first phase, Combat Vehicles and Craft, is concerned with the “amphibious triad,” the AAV amphibious-assault vehicle, the LCAC landing-craft air cushion, and the MV-22 Osprey tilt-rotor. The second phase, Close Quarters Battle (CQB) for Military Operations in Urbanized Terrain (MOUT) involves training building-clearing tactics, techniques, and procedures. The third phase, Full Spectrum Combat, involves pulling everything together into a coherent, full-scale combat-simulation environment for training combined-arms operations.

Demonstration I: Combat Vehicles and Craft

The objectives for the first demonstration are to show how these deployable trainers can be built and to investigate the current status of low-cost training simulation. The first phase, begun in FY02 and scheduled for completion in FY03, demonstrates three interoperable training systems: the AAV, LCAC, and the MV-22. The MV-22 is under development by The Modeling, Virtual Envi-

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University of America in 1986 with a Bachelor of Science in Computer Science, attended Aviation Officer Candidate School, and was commissioned in 1986. After completing his initial tour at Helicopter Antisubmarine Squadron Five (HS-5), CDR Sullivan was assigned instructor duty at Helicopter Antisubmarine Squadron Ten (HS-10). At HS-10, he trained student pilots for carrier-based helicopter missions, including low-level terrain navigation. After a tour on the *USS New Orleans* (LPH-11) as member of the Air Department, he was assigned to the Naval Postgraduate School where he earned a Masters of Science in Computer Science. His most recent operational tour was as Operations Officer at Helicopter Antisubmarine Squadron Eight (HS-8) where he was responsible for the training and readiness of all aircrews. As a member of The MOVES Institute, CDR Sullivan is pursuing a doctorate degree and leads all efforts in rotary wing training systems. CDR Sullivan developed the original Map Interpretation and Terrain Association Virtual Environment System (MITAVES) that was tested at HS-10 in 1997 and is the basis for all helicopter training systems efforts at the Naval Postgraduate School.



CDR Joseph Sullivan

Lieutenant Commander Russell Shilling is Technical Director for Immersive Technologies for The MOVES Institute and lead audio scientist and sound designer for The MOVES Institute videogame, *America's Army: Operations*. He has been working in the immersive audio realm for over 16 years. As an associate professor, he teaches human-performance measurement, human-performance evaluation, and human factors in information warfare. Professor Shilling entered the Navy in 1992 as an Aerospace Experimental Psychologist after receiving his Ph.D. in experimental psychology (neuroscience) from The University of North Carolina at Greensboro. He has been an Associate Professor at the U.S.



LCDR Russell Sterling

Air Force Academy and a program manager at the Naval Air Warfare Center Training Systems Division. He maintains collaborations with Lucasfilm THX, Skywalker Sound, Dolby Interactive, Creative Labs, and various videogame developers.

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ronments and Simulation (MOVES) Institute, in cooperation with the U.S. Naval Academy. Key technologies for the first demonstration include embedded (or appended) trainers, human behavioral modeling, team training, and intelligent tutoring systems.

The great problem in Demonstration I is very practical: lack of space aboard ship for an additional training device, let alone several. Our answer is to use the aircraft itself as the training device. The concept demonstration for the MV-22 (referred to as VEHELO) involves using Chromakey™ technology to achieve an appended trainer (Lennerton, 2002). Like an embedded trainer, an appended trainer uses actual equipment for training but with additional components. In our case, the aircraft alone is insufficient as a training platform, but when our simulation and display apparatus are added, it trains nicely. The system we envision folds into a small case or cart that can be hand-carried to the aircraft and stowed easily.

In our concept, all cockpit glass is covered with blue-screen material. The pilot sits in the aircraft at the controls and wears a tracked head-mounted display, with a camera mounted just above the eyes. Data from the head-tracker is sent to the simulation engine, which generates a virtual environment. The image of the virtual battle space is then mixed with the camera signal, replacing all blue pixels with the virtual scene. The result is that the user sees his immediate environment

inside the cockpit as captured by the camera on his head, but everything outside the cockpit is replaced with the virtual environment. This expedient allows the pilot and co-pilot to see each other and use maps and gauges—which are critical aspects of our training, as described in our analysis and system specification. In the laboratory, we use a wooden platform and helicopter controls to substitute for the aircraft (Figure 2). A flat-panel LCD displays the gauges, and these are linked to the

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Figure 2. The VEHELO apparatus.

RELATED STUDENT THESES

Demonstration I: Combat Vehicles and Craft

LCDR Loren Peitso, USN (September 2002): *Visual Field Requirements for Precision Nap-of-the-Earth Helicopter Flight.*

Major Robert List, USMC (September 2002): *Rendering System Independent High-Level Architecture Implementation for Networked Virtual Environments.*

Major Mark Lennerton, USMC (March 2002): *Exploring a Chromakeyed Augmented Virtual Environment as an Embedded Training System for Military Applications.*

Demonstration II: Close Quarters Battle

Major Warren Aronson, USA, (September 2002): *A Cognitive Task Analysis of Close Quarters Battle.*

Captain Jordan Reece, USMC, (September 2002): *A Virtual Close Quarters Battle (CQB) Graphical Decision Trainer*

CDR Eric Krebs, USN, (September 2002): *An Audio Architecture Integrating Sound and Live Voice for Virtual Environments*

LT Stephen Ulate, USN, (September 2002): *The Impact of Emotional Arousal on Learning in Virtual Environments*

Major Thomas Greenwald, USA, (September 2002): *An Analysis of Auditory Cues for Inclusion in a Virtual Close Quarters Combat Room Clearing Operation*

LT Krist Norlander, USN, (September 2001): *Emergent Leadership on Collaborative Tasks in Distributed Virtual Environments*

Demonstration III: Full Spectrum Combat

LtCol David Brannon, USMC, and Maj Michael Villandre, USMC, (September 2002): *The Forward Observer Personal Computer Simulator (FOPCSIM).*

FEATURED PROJECT

THE PEER-TO-PEER LIMITED OBJECTIVE EXPERIMENT

Associate Professor Bill Kemple, Department of Information Science
 Senior Lecturer Steve Pilnick, Meyer Institute of Systems Engineering
 CAPT Jeff Kline, USN, Department of Operations Research
 CAPT Hezekial Barge, Jr., United States Marine Corps
 Heather Penta, Digital Consulting Service

In March 2002, Naval Postgraduate School (NPS) students and faculty, from a variety of curricula and departments, participated in the Peer-to-Peer (P2P) Limited Objective Experiment (LOE) on the NPS campus. The P2P LOE was the culmination of a year long research project funded by the Joint Futures Laboratory of the United States Joint Forces Command (USJFCOM): Joint Experimentation Directorate (J9). The goal of the P2P LOE was to demonstrate the potential for wireless, portable P2P computing technologies and explore their implications for Command and Control (C2). More than 30 students (representing the U.S. Army, Navy, Air Force, Marine Corps, and International countries) and 15 faculty members contributed to the project.

What is Peer-to Peer?

Peer-to-peer (P2P) computing is the sharing of computer resources and services by direct exchange between systems. In P2P architecture, computers (that have traditionally been used solely as clients) communicate directly amongst themselves and can act as both clients and servers, assuming whatever role is most efficient for the network. P2P computing isn't really new – the idea goes back over thirty years in the world of computers.

There has been a recent surge in the P2P movement enabled by inexpensive computing power, bandwidth, and storage. A well-known P2P success story is the universal file-sharing model popularized by Napster for the exchange of digital music files via the Internet. Within the Department of Defense (DoD), P2P collaboration technology is generating a lot of interest as a paradigm for C2. Advocates assert that P2P offers several advantages over classical client-server collaboration that historically supports traditional hierarchical C2.

In order to discover issues associated with P2P as an integral part of military C2, NPS and USJFCOM initiated the

P2P LOE. LOEs focus on the effectiveness of new concepts or technologies and how they are applied to tactics, techniques, and procedures (TTPs) used by warfighters (i.e., does the concept or technology provide the warfighter with enhanced capabilities?). LOEs employ an aggregation of technologies used to create a product or tool that may be somewhat akin to a “prototype”; thus it can become a stand-alone application that has specific functions and is directly applicable to DoD C2 systems. The LOE at NPS was centered around the use of P2P computing on hand-held and portable devices in a wireless network environment. The primary objective of the LOE was to explore the potential of using mobile communication devices, collaborative technology, and wireless communications at the tactical level.

LOE Scenario

The setting for the LOE was a hostage situation in an urban area. It started with a Reconnaissance and Surveillance Team

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P2P LOE Goals and Accomplishments

Goals	Objectives
Demonstrate ability to conduct enroute mission planning	<ul style="list-style-type: none"> • Player designated as en route Commander (in separate facility and connected to wireless Local Area Network (LAN) via Internet) tasked and received information from local team • Successfully tested Groove connectivity from commercial aircraft via airphone and dial-up modem
Form and synchronize a distributed response team	<ul style="list-style-type: none"> • Six field team members and one stationary team member formed a Reconnaissance & Surveillance Team (RST) to develop situational awareness using distributed and collaborative tools
Reach back to common information repository	<ul style="list-style-type: none"> • Local team members were required to access building and floor information from local database • Local team members were required to contact USJFCOM HQ for information • Intelligence information on bomb booby traps had to be requested and sent from USJFCOM in Norfolk, VA
Push near-real-time information to a common information repository	<ul style="list-style-type: none"> • Digital photos that were requested by en route commander were taken and provided (for all participants) in shared work space
Ability to do collaboration over a variety of wireless media	<ul style="list-style-type: none"> • Voice over internet protocol (IP), Wireless LAN, and collaborative work spaces were utilized by the RSTs

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THE PEER-TO-PEER LIMITED OBJECTIVE EXPERIMENT, *continued from page 6*

(RST) on the ground. The primary mission of the RST was to build sufficient situational awareness (SA) for a Hostage Rescue Team (HRT) to conduct a rescue mission after arrival. The following provides a brief overview of the forces involved, their roles, and missions:

Enemy Forces

- The LOE started when an unknown number of terrorists took hostages and were believed to be hiding, with the hostages, in the NPS academic quadrangle.
- The enemy force established defensive positions and booby traps.
- For the LOE execution, the enemy, hostage or hostages, booby-traps, etc. are represented by signs and placards (Figure 1).

Hostage Rescue Team (HRT)

- The LOE assumed a trained HRT was enroute to the scene to conduct a take-down-hostage rescue mission upon arrival.
- The HRT was represented by a cell within the LOE control group – no actual takedown or hostage rescue was conducted.
- The functions of the HRT cell were to prompt the RST for information needed to develop SA (using LOE checklists pre-planned with the help of experts); RSTs checked-off information received against checklists and determined when sufficient SA has been built-up for the HRT mission (and completion of the LOE event).

Reconnaissance and Surveillance Team (RST)

- Six RSTs were deployed using mobile P2P equipment; each team had a laptop computer and a pocket PC (Compaq iPAQ) outfitted with GPS transmitter/receiver (Figure 2).

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Situational Awareness Snapshots

Key to Symbols

<p>Terrorist(s):</p> <p></p> <p>The number inside a red triangle indicates the <u>number of Terrorists</u> reported at that location.</p> <p>Examples:</p> <p> = <u>1 Terrorist</u> at this location</p> <p> = <u>3 Terrorists</u> at this location</p>	<p>TM n = Reported location of Team "n"</p> <p>LAC = Local Area Coordinator</p> <p>ENR = En Route Cmdr</p> <p> = Hostage(s)</p> <p> = Automatic Weapons Fire</p>	<p>Bomb(s):</p> <p></p> <p>The number inside a black circle indicates the <u>number of Teams</u> that have reported a bomb at that location.</p> <p>Examples:</p> <p> = 1 bomb report by <u>2 Teams</u></p> <p> = 1 bomb report by <u>5 Teams</u></p>
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Figure 1. Key to Situational Awareness (SA) symbols used on the Groove and Pocket PC maps.



Figure 2. LCDR Harold Valentine, USN, and Maj Terry Jordan, USAF, using a Compaq iPAQ and GPS for team member positioning and a laptop for Groove-based situational awareness interface.

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THE PEER-TO-PEER LIMITED OBJECTIVE EXPERIMENT, *continued from page 7*

- The RSTs connected to the network with wireless cards in their laptops and in the pocket PCs.
- Groove was the collaborative tool used to facilitate P2P collaboration amongst the RSTs and others (Note: Pocket Groove was not developed in time for the P2P LOE; thus laptops with Groove installed were used for collaboration).
- Researchers at NPS developed a suite of collaborative application tools and mapping applications specifically for the P2P LOE.
- The RSTs could report their positions to all other partici-

pants on a “clickable” map (developed at NPS) on the pocket PCs.

- The goal for the RST was to gather sufficient SA for the HRT to execute a hostage rescue immediately upon arrival.
- The challenges for the RSTs were self-organization within RSTs; shared-awareness within RSTs; collaborative planning and rapid re-planning within the RSTs; collaborative planning with HRT and others; dealing with P2P network outages; participants dropping out (due to enemy action); and

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P2P Participants

NPS and J9 Personnel

Associate Professor Bill Kemple (NPS-Information Science)
Senior Lecturer Steve Pilnick (NPS-Meyer Institute)
CAPT Jeff Kline, USN (NPS-Operations Research)
Professor Dan Boger (NPS-Information Science)
Lecturer Rex Buddenberg (NPS-Information Science)
Associate Professor Alex Bordetsky (NPS-Information Science)
Research Associate Professor Wolfgang Baer (NPS-Computer Science)
LCDR Jeff Crowson, USN (NPS-Information Science)
CDR Sue Hutchins, USN (NPS-Space Systems Academic Group)
Research Associate Curt Blais (NPS-MOVES Institute)
Research Associate Jeff Weekley (NPS-MOVES Institute)
LCDR Glen Cook, USN (NPS-Information Science)
LCDR Ray Buettner, USN (NPS-Information Science)
Professor Pat Jacobs (NPS-Operations Research)
Distinguished Professor Donald Gaver (NPS-Operations Research)
Heather Penta (Digital Consulting Service)
Keith Curtis (J9)
Ron Adamo (J9)
Gary Wheatley (J9)
F. Lee Sawyer (J9)
Rick Paradiso (J9)
Russ Richards (J9)

Student Participants

Capt Charlie Ahciarliu, Romanian AF
LT Vanessa Ambers, USN

LCDR Vincent Anderson, USN
Maj Hez Berge, USMC
Capt Stever Barriger, USMC
Capt Henry Blackshear, USMC
Capt Adel Boukraa, Tunisian Army
LT Frank Clark, USN
LCDR Scott Corsano, USN
ENS Frank Couture, USN
LT Jeff Davis, USN
LCDR Alan Dunston, USN
LCDR James Ginder, USN
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LT Henry Kim, USN
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LCDR John MacMichael, USN
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LCDR Michael Adams, USN
LCDR Michael Miklaski, USN
Maj Raj Mohan, Indian Army
LCDR Valter Monteiro, Brazilian Navy
Maj Brian O’Keefe, USMC
LCDR Pat Roche, USN
LT Joe Roth, USN
LT Rob Rulof, USN
Capt Jason Schwartz, USMC
Kimberly Seid, USN
LCDR Tim Thate, USN
Capt Jim Trachier, USAF
Capt Bill Uhrig, USAF
LCDR Harold Valentine, USN
Capt Russell Voce, USAF

ACQUISITION, TRACKING, AND POINTING OF BIFOCAL RELAY MIRROR SPACECRAFT

On 5 June 2002, the NPS-AFRL Optical Relay Spacecraft Laboratory was dedicated by **RADM David Ellison, USN**, Superintendent of the Naval Postgraduate School, and Dr. Earl Good, Director, Air Force Research Laboratory (AFRL) Directed Energy Directorate. **Distinguished Professor Brij N. Agawal**, Department of Aeronautics and Astronautics, is Director of the Lab. The associate directors are Dr. Ty Martinez, AFRL, and **Dr. Marcello Romano**, National Research Council Postdoctoral Associate. The objective of this laboratory is to develop and validate technologies for acquisition, tracking, and pointing (ATP) of a bifocal relay mirror spacecraft.

primary mirrors, as shown in Figure 2. The transmit telescope has a majority of the spacecraft bus subsystems including the attitude control sensors and the actuators. The spacecraft mass is 3300 kg at launch and spacecraft orbit altitude is 715 km with an inclination of 40 degrees. The mission requirements are for a three-meter spot beam and mean dwell duration per pass of 250 seconds. The ATP requirements for the BRM spacecraft are significantly more challenging than required for the Hubble Space Telescope as we have two telescopes rotating relative to each other with interconnected optics. Each of them has different targets with an uncooperative target and high-low pointing jitter requirements. The spacecraft has tight pointing and jitter requirements, less than 144 nanorad for both telescopes.

In December 2000, an NPS-AFRL team, led by Professor Agrawal won a prestigious National Reconnaissance Office (NRO) Director's Innovation Initiative (DII) Award of \$340K to develop a precision acquisition, tracking, and pointing (ATP) technology for BRM spacecraft. Dr. Sergio Restaino from the AFRL was the co-investigator of this project. The team has research strengths in spacecraft attitude control and vibration isolation from NPS and optical beam control from AFRL.

With the support of Boeing SVS, the NPS and AFRL team performed both analytical and experimental tasks on ATP tech-

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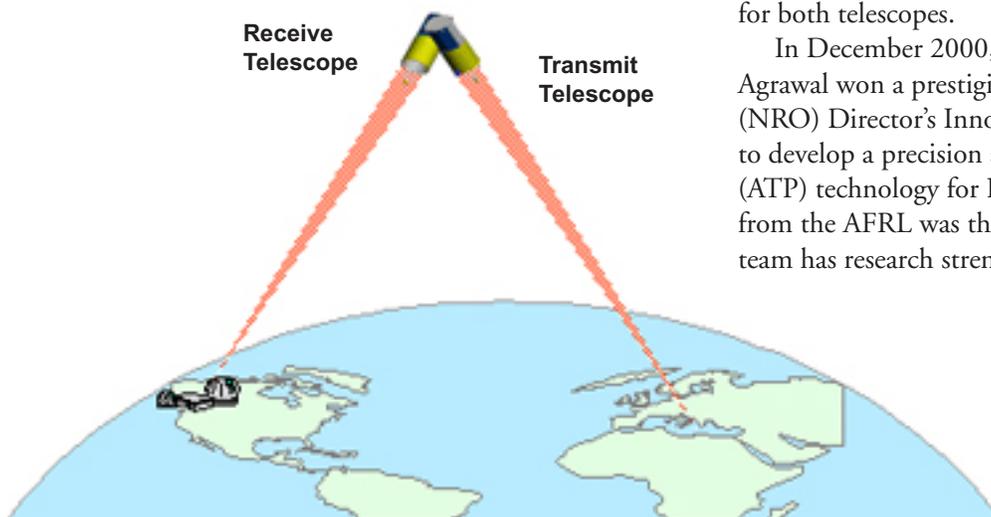


Figure 1. Bifocal Relay Mirror Operations.

The laboratory is a culmination of joint efforts by NPS and AFRL in the development of the design and technology for the Bifocal Relay Mirror (BRM) Spacecraft during the last two years. The Bifocal Relay Mirror Spacecraft is composed of two optically coupled telescopes used to redirect a laser light from a ground-based, aircraft-based, or spacecraft-based laser to distant points on the earth or in space for a variety of DoD missions, as shown in Figure 1. During the summer of 2000, eleven NPS students completed a preliminary design of the spacecraft as part of Professor Agrawal's Spacecraft Design Course. The design introduced several innovative ideas such as, single axis relative motion between the two telescopes, which significantly simplified the design and testing of the spacecraft. The spacecraft consists of a single axis-gimbaled receive and transmit telescopes with 1.64 meter diameter pri-

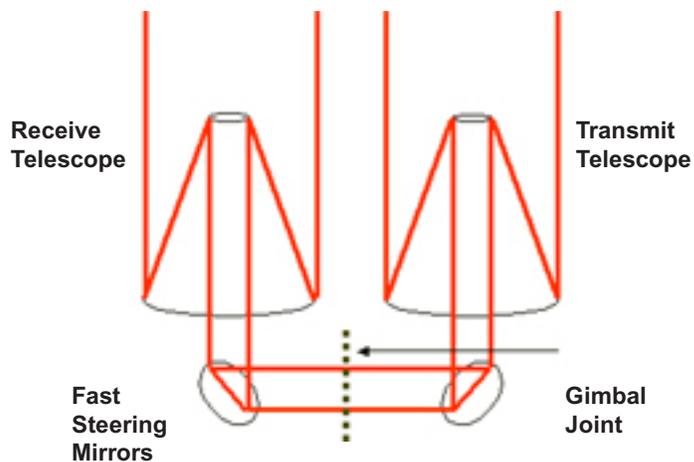


Figure 2. Spacecraft Optical Payload.

BIFOCAL RELAY MIRROR SPACECRAFT, *continued from page 10*

nology under the NRO DII project during 2001. In a short period, there were major achievements made by the team. The attitude control system consists of reaction wheels, star trackers, gyros, and sun sensors. Feed forward control and quaternion formulations are used. A Kalman filter is used to update the rate gyros biases and the attitude angles during star tracker measurements. The telescopes have fast steering mirrors for fine pointing. Integration of spacecraft control is required to meet the performance requirements. Figure 3 shows the integrated spacecraft-fast steering mirror control. The spacecraft follows the commanded attitude for tracking. The tracking sensor deter-

mines the line of sight error and feedback to the fast steering mirror (FSM) for error correction. In order to offload the motion of the fast steering mirror as it has limited angular

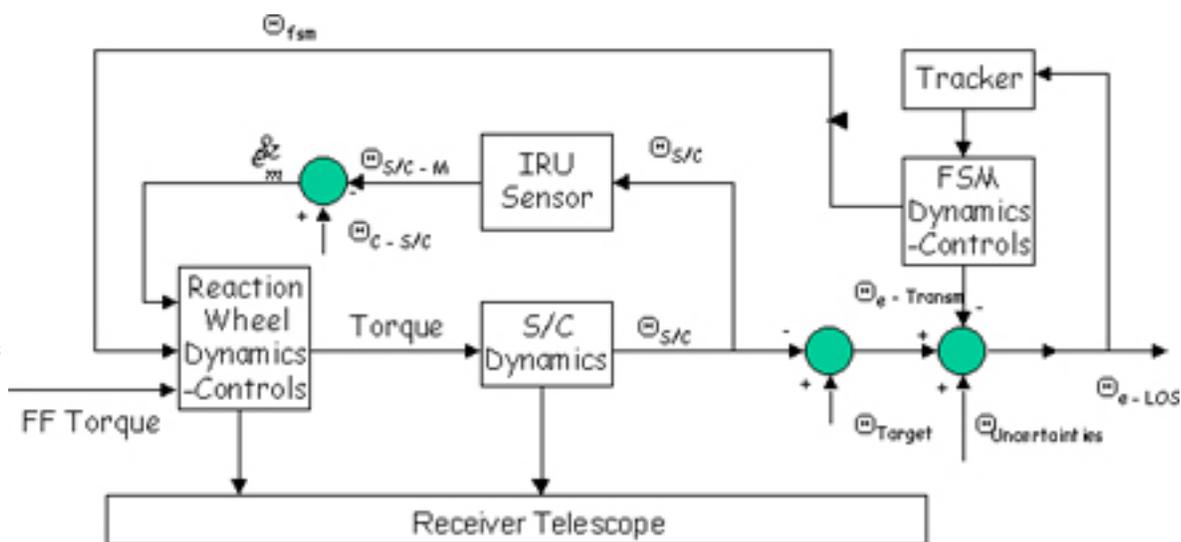


Figure 3. Integrated Spacecraft and Fast Steering Control.

mines the line of sight error and feedback to the fast steering mirror (FSM) for error correction. In order to offload the motion of the fast steering mirror as it has limited angular

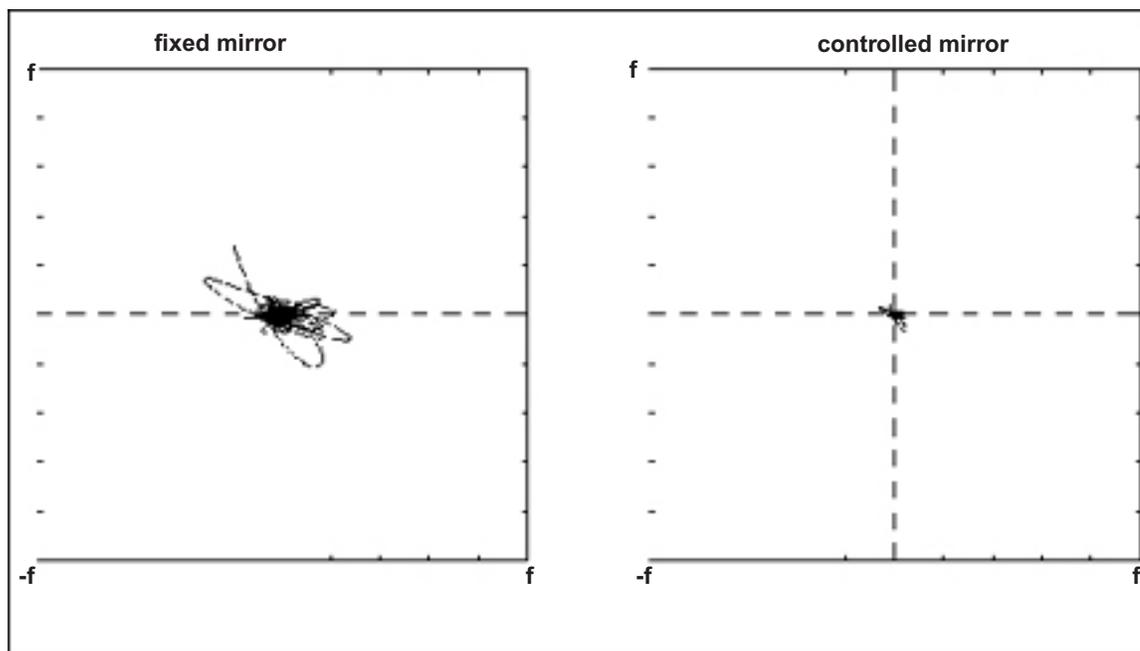


Figure 4. Performance with and without use of the Fast Steering Mirror Control.

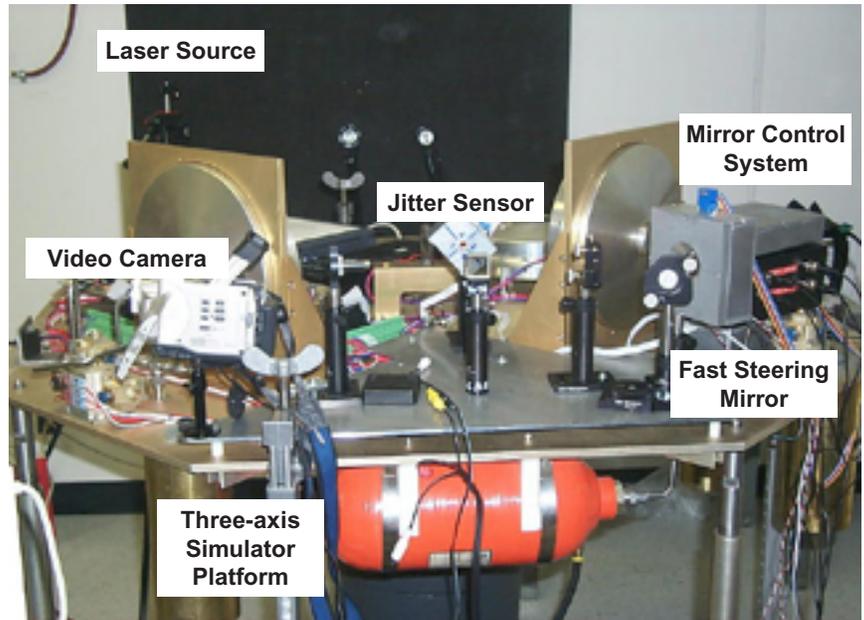
motion capability, the error is also fed to spacecraft for error correction. Figure 4 shows the results of a simulation. The figure on the left shows the performance in the absence of FSM mirror correction. The figure on the right shows integrated spacecraft and FSM control. It is shown that in order to meet performance, FSM control is necessary.

Using the NPS Spacecraft Control Simulator, the NPS/AFRL team successfully tested ATP technology for a single telescope. The tracking of a moving

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BIFOCAL RELAY MIRROR SPACECRAFT, *continued from page 11*

target by a laser beam was demonstrated. Figure 5 shows the schematic diagram for target tracking experiment. The laser source is red and the target is green. The target is moving. The laser source beam is reflected from FSM through a mirror to the target. A digital video camera looks at the target and the laser source and finds line of sight error. The camera output is transmitted to the control computer by wireless connection. The control system provides command to the FSM to follow the target. The FSM has to correct motion of the three-axis simulator and the target motion. Figure 6 shows the hardware for the three axis-simulator and the optical payload. The three-axis simulator has three reaction wheels and thrusters as actuators, rate gyros and sun sensors as sensors. It has an on-board computer. The simulator is supported on a spherical air bearing.



--continued on page 13 **Figure 6. Current ATP Testbed.**

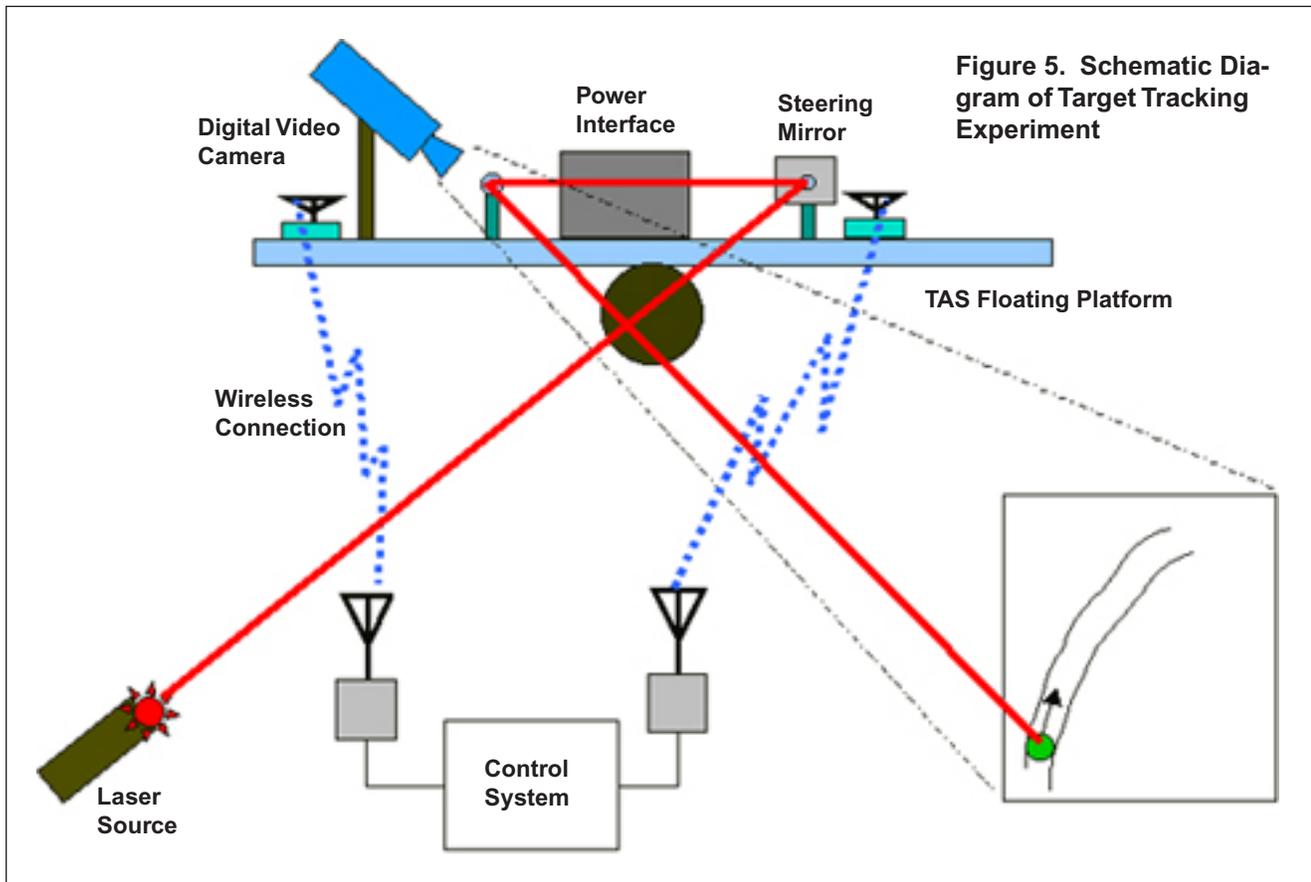


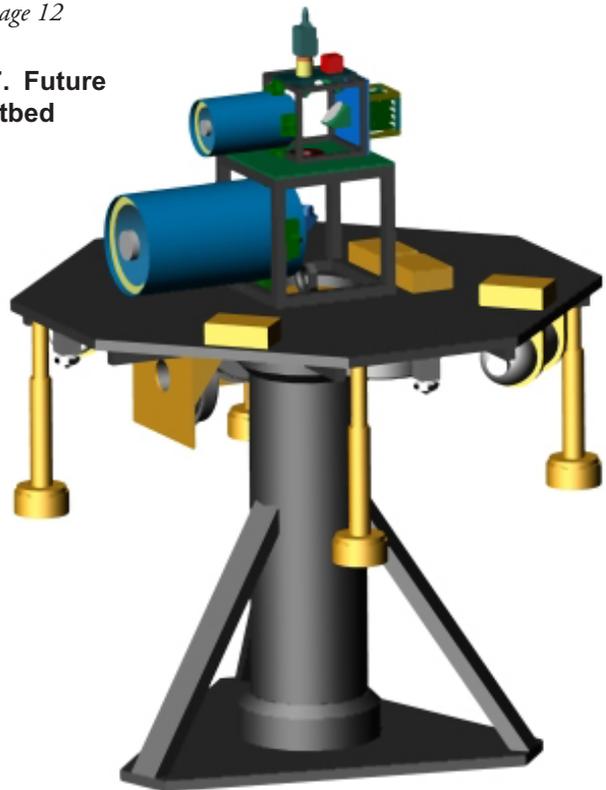
Figure 5. Schematic Diagram of Target Tracking Experiment

BIFOCAL RELAY MIRROR SPACECRAFT, *continued from page 12*

A road map for the development of ATP technology was prepared under the project. A new testbed shown in Figure 7 was designed to demonstrate end-to-end bifocal relay mirror spacecraft beam control, acquisition, tracking, and pointing performance. The team made a final presentation on the project to NRO in February 2002. The NPS and AFRL team has done pioneering work in the design of spacecraft and test bed, analytical simulations, and road map for the development of ATP technology. This is the first serious investigation of the coupled attitude control and beam control systems to maintain dual line of sight.

For FY 02, additional funding received under the Dual Line of Sight Control Project allowed Professor Agrawal to continue the development of the new testbed and this technology. In addition to NPS faculty and research scientists at NPS and AFRL, several Navy, Air Force, and Army students at NPS are doing their thesis work in this laboratory and contribute in the development of this challenging and important technology. The technology is applicable to other DoD missions such as imaging and laser communications spacecraft.

Figure 7. Future ATP Testbed



CENTER FOR CONTEMPORARY CONFLICT'S STRATEGIC INSIGHTS EDUCATE SERVICES, PUBLIC

Since their debut last spring the Center for Contemporary Conflict's (CCC) web-based *Strategic Insights* have quickly gained a large audience, both within the armed forces and within the public at large. As the research arm of the Naval Postgraduate School's Department of National Security Affairs, the CCC maintains a dynamic internet presence highlighted by monthly publishing of concise assessments of regions and issue areas critical to U.S. national security. To date these *Strategic Insights* have drawn more than 13,000 "hits," with a monthly base of several thousand readers and growing.

Authored by Department of National Security Affairs faculty and research staff and posted on the CCC website at the beginning of each month, *Strategic Insights* have provided ongoing insight into such central security themes as the War on Terrorism and the building conflict with Iraq. For the War on Terrorism, *Strategic Insights* have addressed

issues such as intelligence failure, al Qaeda's Weapons of Mass Destruction (WMD) potential, the prospects for foreign aid and trade policy to serve as counter-terrorism tools, and the impact of the counter-terrorism campaign on U.S. relations with Russia and China. Other *Strategic Insights* have assessed the India-Pakistan clash in Kashmir, the Israeli-Palestinian conflict, economic and political struggles in Latin America, and evolving U.S. policy for the use of nuclear weapons. In total more than fifty *Strategic Insights* have been published through the CCC website to date, with another five or six posted monthly.

Approximately 30% of the traffic to *Strategic Insights* comes from the U.S. military, with 15% coming from academia or government agencies, 40% from the U.S. public, and 15% from international publics. Nearly three-quarters of *Strategic Insights* traffic comes directly to individual *Strategic Insights* from internet search engine users. Servicemen, officials, and citizens using search engines to gather information and insight about the key national security issues of the day are likely to find *Strategic Insights* placed high within their search results.

To read *Strategic Insights* on the War on Terrorism, Iraq, and other topics, visit the CCC web site at www.ccc.nps.navy.mil, and enter the *Strategic Insights* section.

STUDENT RESEARCH

TechSat 21 RADIOMETER TESTING AT NPS

LT Richard H. Harrison, United States Navy

Master of Science in Space Systems Operations – September 2002

LT Dale D. McGehee, United States Navy

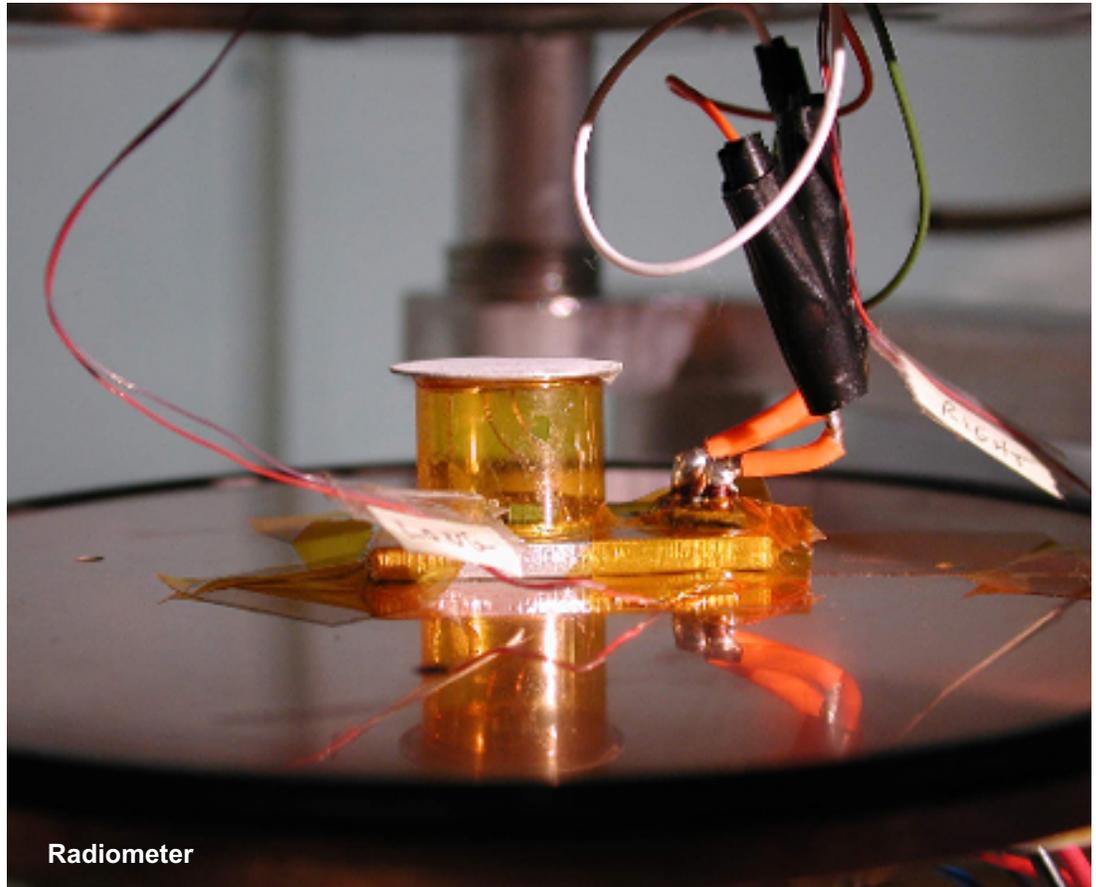
Master of Science in Space Systems Operations – September 2002

Thesis Advisor: Dr. Stephen A. Whitmore, Michael J. Smith NASA Chair Professor, and Assistant Professor Michael Spencer, Department of Aeronautics and Astronautics

One goal of TechSat 21, an experimental constellation of three small satellites linked as a sparse aperture radar being designed by the Air Force Research Lab (AFRL), is to develop a predictive model for how Hall Effect thrusters affect spacecraft contamination. This will be accomplished by validating the TechSat 21 thruster contamination model with experimental data obtained from both ground and on-orbit testing.

The radiometers manifested aboard TechSat 21 are calorimeters designed to be sensitive to changes in sensor coating due to thruster-sensor interaction. Sunlight impinges upon the radiometer top disk and the absorptivity (α) and emissivity (ϵ) are determined. Changes in α and ϵ due to thruster operation will be observed for both ground and on-orbit conditions. The radiometer with its casing can be seen in the picture depicted below.

Because the TechSat 21 radiometers are experimental and specially designed for minimum mass, the thermal model must be validated for these sensors. Validation is accomplished by utilizing the NPS solar simulator, which precisely represents the radiated energy and spectrum of the sun. Dr. Mike Dulligan from AFRL assembled five prototype radiometers with varying model parameters such as wire thickness, Kapton thermal bridge length, optical shielding, etc. The solar simulator illuminates each radiometer and temperature



Radiometer

data is collected as a function of time after exposure begins in order to simulate TechSat 21 moving out of umbra in low earth orbit (LEO).

To simulate the space environment a vacuum capable stainless steel cube, constructed by Ray Fong, a NASA Jet Propulsion Lab Undergraduate Summer Research Fellow, will be used to prevent thermal convection while the enclosed copper shroud that is cooled by liquid nitrogen serves to minimize black body radiation. The thermal model includes radiative and convective terms but energy transfer is dominated by conduction through the Kapton thermal bridge and

--continued on page 15

STUDENT RESEARCH

ANALYZING TACTICAL EFFECTIVENESS FOR ANTI-TERRORIST FORCE PROTECTION (AT/FP) USING X3D GRAPHICS AND AGENT BASED SIMULATION

Lieutenant James William Harney, United States Navy (March 2003)

Advisors: Associate Professor Donald Brutzman, Department of Information Science, Professor Gordon Schacher, Meyer Institute of Systems Engineering, Research Professor John Hiles and Research Associate Curtis Blais, The Modeling, Virtual Environments, and Simulation (MOVES) Institute

Despite the many advances achieved within both Modeling and Simulation and Information Technology over the past several decades, practical application of such technology remains unused at the Tactical-Strategic Level of War by operational units in the United States Navy. Furthermore, when such technology has been deployed in the last decade it has been to exercise operator proficiency or increase C4I battlespace awareness, but not for the 'warfighter' to run 'what-if' scenarios to aid in development of tactical plans for employing published doctrine.

The approach taken in this thesis is to select an exemplar warfare area, in this case Anti-Terrorism and Force Protection

for Navy ships. In conjunction with the Wayne E. Meyer Institute of Systems Engineering and Commander Third Fleet (C3F), we have developed 'Continuum of Force' concepts to identify, develop, and deploy the necessary modeling and simulation technologies to demonstrate a prototypical planning tool that can be used by today's warfighter. All research and software development was conducted in a Web-based, 'user-centric' fashion utilizing a combination of user and /or agent based control of entities for simulation iterations, together with various Open Source technologies, including Extensible 3D Graphics (X3D), Scalable Vector Graphics

--continued on page 16

TechSat 21,

continued from page 14

the instrument wires. Additionally, the cube has a temperature controlled copper plate to simulate the satellite temperature. Each radiometer is exposed to the solar illumination for two simulated spacecraft temperatures, 0 and 30 degrees Celsius, to validate the thermal model in the two extreme cases of umbra and direct illumination by the sun. The vacuum cube along with the solar simulator can be seen in the pictures depicted below.

Numerous test cases and configurations will be used during testing of the prototype radiometers. Each case is chosen to identify the influence of a given model parameter. The time response and absolute temperatures predicted by the model will be used to compare against that experimentally determined from the NPS solar simulator and ultimately the on-orbit data received from the spacecraft.



LT Harrison, LT McGehee and Dr. Dulligan



Stainless Steel Vacuum Cube

Stainless Steel Vacuum Cube under Solar Illumination



STUDENT RESEARCH

ANALYZING EFFECTIVENESS FOR ANTI-TERRORIST FORCE PROTECTION, *continued from page 15*

(SVG), and Extensible Markup Language (XML). The work integrates several academic disciplines including: Computer Science for graphical interface design and software design techniques; Operations Research for defining measures of effectiveness and collection and processing of statistics for assessment of protection plans against surfaceborne terrorist threats; and Modeling, Virtual Environments, and Simulation (MOVES) for agent-based modeling, networked virtual environments, and XML-based technologies for data interchange, 2D graphical display, and 3D visualization. The leveraging of these disciplines was made possible through the conceptual modeling of potential events during C3F and NPS executed Anti-Terrorist/Force Protection Limited Objective Experiments.

The result of this work is a fully integrated prototypical Java-based application that demonstrates how various Open-Source, Web-based tech-

nologies can be applied to provide the tactical operator with tools to aid in Force Protection planning. Scenarios can be auto-generated, viewed, and manipulated by end users with little to no computer experience necessary beyond requirements for operation of a desktop personal computer (PC) in the IT-21 environment at sea. Additionally, various exemplar scenarios are created and executed to provide insights into potential weaknesses in the defensive plans.



Figure 1 (left). 2-Dimensional View of an Anti-Terrorist / Force Protection Scenario Setup with one High-Value-Unit, one defending picket boat, and one threat craft with various tactical parameters entered.



Figure 2 (above). 3D Visualization of an Anti-Terrorist / Force Protection scenario run in progress allowing insight to be gained for the relationships between the different defensive and offensive postures, tactical parameters, background shipping, and other parameters.

STUDENT RESEARCH

SUNSET SUPPLY BASE: LONG TERM COSTS SUPPORTABILITY, IMPLEMENTING AFFORDABLE METHODS AND PROCESSES

Mr. Michael Barkenhagen, Naval Surface Warfare Center-Corona Division, and Mr. Michael Murphy, Naval Air Warfare Center-Lakehurst Division

Master of Science in Product Development – September 2002

Advisors: Associate Professor Douglas Moses and Visiting Associate Professor Laurie Anderson, Graduate School of Business and Public Policy, Associate Professor John Osmundson, Department of Information Science

This research defines, documents, pilots and recommends implementation procedures for a Sunset Supply Base support system for U.S. Navy hardware that incorporates the use of Commercial-Off-The-Shelf (COTS) products. This research provides the U.S. Navy a set of transportable/transferable tools, methods, and processes that can be replicated by the Navy as a reusable product throughout the fleet. The thesis research produced four deliverables for the Sunset Supply Base concept: Systems Architecture Model, Systems Engineering Development and Implementation Model, Business Case and Marketing Plan. The documents, i.e. deliverables, are iteratively and recursively developed in parallel with the piloting of this concept on three specific Navy programs. The end result is a useable Sunset Supply Base concept (product) for the Navy, already tested and refined. Research Analysis shows how implementation of this concept can save the Navy millions of dollars in support costs.

SOCIAL NETWORK ANALYSIS

Mr. Dale L. Moore, Naval Air Systems Command

Master of Science in Product Development – September 2002

Advisors: Associate Professors Gail Fann-Thomas and Mark Nissen, Graduate School of Business and Public Policy

In this thesis, a social network analysis is conducted for the Naval Air Systems Command National Materials Competency. The National Materials Competency is a geographically dispersed organization responsible for the full life cycle and full spectrum of materials and processes research and engineering. Social Network Analysis (SNA) is shown to be a valuable tool to evaluate the flow of knowledge and expertise across the enterprise. The flow of knowledge and expertise, enable for social capital, crates new intellectual capital essential for high organization performance. This is particularly important for the National Materials Competency because of the pressing need to provide enabling advanced materials technologies and critical safety-related engineering solutions to the warfighter. In this research, the National Material Competency leadership provides input regarding work interactions, communications and knowledge flows, and specialized SNA software is employed to visualize and analyze exiting flow patterns. Key finding and new insights from such visualization included the identification of network topologies, structural holes, one and two-way flows, and levels of cohesion within groups and sites. Based on such findings and insights, recommendations for improved organizational performance include enhancements to network connectivity and cohesion, social capital, organization processes and policies, information technology, and knowledge management.

The Navy's Revolution in Business Affairs took a giant step forward at the Naval Postgraduate School in September with the graduation of the first class to earn the Master of Science degree in Product Development through distributed learning tele-education. The joint engineering and management degree is part of the Navy's two-year-old Product Development Leadership in the 21st Century (PD 21) Consortium Program with the Massachusetts Institute of Technology, Rochester Institute of Technology and University of Detroit Mercy. Designed primarily for DoD civilian acquisition and program managers in the Navy system commands -- NAVSEA, NAVAIR and SPAWAR -- PD 21 is also open to active duty military and select DoD contractor civilians.

STUDENT RESEARCH

DESIGN, IMPLEMENTATION AND TESTING OF AN ASIC VLSI HIGH PERFORMANCE ARCTANGENT FUNCTION

Captain Ronald Christopher Altmeyer - Canadian Army

Master of Science in Electrical Engineering

Advisors: Associate Professor Douglas J. Fouts and Professor Phillip E. Pace, Department of Electrical and Computer Engineering

Digital image synthesizers use complex samples, in-phase (I) and quadrature (Q), of an intercepted and downconverted radar signal to generate false target modulations for counter-targeting and counter-surveillance. The false target modulations are easier to perform digitally if the phase of the signal is used instead of the I and Q components. This thesis documents the research, circuit design, and simulation testing of an Application Specific Integrated Circuit (ASIC) that extracts the phase angle information from the complex samples using the arctangent relationship. Design specifications include implementing the design in CMOS technology with a minimum transistor count and the ability to operate at a clock frequency of 700 MHz. Various methods to compute the arctangent function were investigated. The coordinate rotation digital computer (CORDIC) algorithm was chosen due to its ease of implementation. MATLAB simulations were used to calculate and verify the accuracy of the design. Digital design involved running the Quine-McClusky logic algorithm to minimize the number of transistors required. A T-SPICE netlist was generated from the circuit design and simulations were run to determine operation and timing performance. Finally, the logic was tested for all possible input I, Q combinations using a Very high speed integrated circuit Hardware Description Language (VHDL) simulation.

A STUDY OF VULNERABILITY OF COMMERCIAL IMAGING SATELLITES TO COMMERCIAL LASER TECHNOLOGY

Captain Robert J. Myhre, United States Air Force

Master of Science in Space Systems Operations – September 2002

Lieutenant Wesley S. Sanders, United States Navy

Master of Science in Space Systems Operations – September 2002

Advisors: Associate Professor D. Scott Davis, Department of Physics, and LCDR James M. Bachelor, USN, Space Systems Academic Group

The focus of this thesis research project has been to determine whether or not current on-orbit commercial imaging satellites (both foreign and domestic) are vulnerable to blinding or degradation by commercially available lasers. Second, upon completion of the vulnerability analysis, the following assessment was conducted. The assessment determined whether or not the necessary hardware, software and satellite ephemeris data (i.e. lasers, mount, telescope, pointing and slewing software, etc.) were readily available without restrictions via purchase or other means. Finally, the likelihood of fielding this type of offensive space control system was closely coupled to development and operational costs. The final research question was to determine if an offensive space control system could be developed and fielded for under five hundred thousand dollars.

FORWARD OBSERVER PERSONAL COMPUTER SIMULATOR (FOPCSIM)

Lieutenant Colonel David A. Brannon, United States Marine Corps

Master of Science in Computer Science – September 2002

Major Michael R. Villandre, United States Marine Corps

Master of Science in Computer Science – September 2002

Advisors: Associate Professor Rudolph Darken and CDR Joseph Sullivan, USN, Department of Computer Science

This joint thesis addresses the need for a task trainer for the artillery forward observer task. In recent years, declining budgets, limitations on artillery ammunition and encroachment into training areas have reduced the opportunity to conduct live fire artillery training. Simulation systems available to operating forces utilize technology that is several years out of date and none have a deployable configuration. The goal was to develop a proof of concept simulator that uses advanced 3D graphics to replicate the artillery call for fire task. The system utilizes Digital Terrain Elevation Data (DTED) to produce accurate 3D geometry that is further enhanced by the use of color satellite imagery as a texture overlay to produce extremely realistic terrain. The procedures utilized in the FOPCSIM are taken directly from a cognitive task analysis and executed through keyboard, mouse or voice recognition interfaces. The accuracy of these procedures was validated through a series of studies involving military personnel trained as forward observers. A wide variety of mission types, munitions, targets, training areas, and environmental effects are available to the user and may be set at the beginning of the simulation or changed during the simulation through a Graphical User Interface.

STUDENT RESEARCH

SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO STUDENT RESEARCH FELLOWSHIPS AWARDED

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 Student 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. Sixty-eight students have been awarded fellowships to date. The fellowship includes a \$10,000 award to support the student's research. The latest recipients are:

- **Major Thomas E. Arnold, Jr., USMC**
Topic: Application Layer Implementation of Self-Configuring, Ad Hoc Wireless Networks on Self-Routing, Handheld Mobile Clients Using Open Standard Software Tools and Commercial-Off-the-Shelf Hardware
NPS Advisor: **Associate Professor Geoffrey Xie**, Department of Computer Science
SSC-SD Mentor: **Dr. Stephen Lopic**, Communication and Information Systems Department
- **LT Tracy Black-Howell, USNR**
Topic: Network Design for Quantum Key Distribution in a Navy Battle Group
NPS Advisors: **Professor James Luscombe**, Department of Physics, and **Associate Professor John McEachen**, Department of Electrical and Computer Engineering
SSC-SD Mentor: **Mr. Triet Vuong**, Communication and Information Systems Department
- **Major Stephen C. Brzostowski, USMC, and Major Larry E. Smith, II, USMC**
Topic: Transition of Naval Expeditionary Force Mission Planning Systems to a Global Collaborative Capability
NPS Advisor: **Associate Professor Alex Bordetsky**, Department of Information Science
SSC-SD Mentor: **Dr. Lorraine Duffy**, Command and Control Department
- **LTC Rene G. Burgess, USA**
Topic: Autonomous Agent-Based Assessment of Simulation to Provide Realistic Stimulation of CRISR Systems

NPS Advisors: **Associate Professor Rudy Darken**, Department of Computer Science, and **Research Professor John Hiles**, The Modeling, Virtual Environments and Simulation (MOVES) Institute
SSC-SD Mentor: **Dr. Jacob Langford**, Command and Control Department

- **LT Samuel Chance, USN, CPT Marty G. Hagenston, USA, and MAJ Clyde E. Richards, USA**
Topic: Semantically Enabled Habitat for Rapid Knowledge Capture, Storage and Transfer
NPS Advisor: **Associate Professor Magdi Kamel**, Department of Information Science
SSC-SD Advisor: **Ms. Kim Swecker**, Intelligence, Surveillance and Reconnaissance Department
- **Maj William C. James, USMC**
Topic: Wireless Data Communication Network Security Assessment Methodology
NPS Advisor: **Lecturer Richard Harkins**, Department of Physics
SSC-SD Advisor: **Mr. Phil Barlow**, Communication and Information Systems Department
- **Maj Joseph Petto, USMC**
Topic: Developing a Virtual Networking Laboratory to Complement Classroom Instruction of Computer Network Security and Vulnerability Assessment Techniques
NPS Advisor: **LCDR Chris Eagle, USN**, Department of Computer Science
SSC-SD Advisor: **Mr. Glenn Tolentino**, Command and Control Department
- **Capt Eric Walters, USMC**
Topic: Developing Training Material and Procedures to Teach Vulnerability Assessment Techniques in a Web-Based Distance Learning Virtual Lab Environment
NPS Advisor: **Lecturer Richard Harkins**, Department of Physics
SSC-SD Advisor: **Mr. Glenn Tolentino**, Command and Control Department
- **LT Manoleto Z. Williams, USN**
Topic: Autonomous Agent-Based Robot Control and Manipulation of Complex Goal Oriented Task
NPS Advisors: **Lecturer Richard Harkins**, Department of Physics, and **Research Professor John Hiles**, The Modeling, Virtual Environments, and Simulation Institute

PROJECT NOTES

IMAGE GENERATION ALGORITHM LIBRARY MODULES FOR LARGE FALSE TARGET RADAR IMAGES

Associate Professor Douglas Fouts and Professor Phillip Pace, Department of Electrical and Computer Engineering, and Professor Ted Lewis, Department of Computer Science, are teaming with researchers from George Washington University, University of South Carolina, George Mason University and the National Security Agency on a reconfigurable computing research effort. The goal of this government-sponsored research is to establish an alternative form of super-computing based on programmable technologies such as Field Programmable Gate Arrays (FPGA). The expected outcome of this research is to move two prototype reconfigurable computing machines closer to being easily programmable by application developers such as mathematicians.

Image Generation Algorithm Library Modules for Large False Target Radar Images is the NPS research contribution for year one to this cross-country research collaboration. The Center for Joint Services Electronic Warfare at the Naval Postgraduate School recently developed algorithms and equations necessary to digitally generate realistic false target radar images of large targets, such as aircraft carriers. These algorithms and equations were tested on a general-purpose workstation using Matlab. However, the execution time of the Matlab code running on such a platform is significantly longer than what is required by an actual electronic attack system. To be able to deceive an interrogating radar, an electronic attack system must be able to synthesize false target images in near real time. It is proposed that the algorithms and equations necessary to digitally synthesize realistic large false target radar images be programmed on a computing platform with a reconfigurable architecture. The execution performance can then be measured to determine if such a platform is suitable for actual use in an electronic attack system. Performance comparisons can also be made against the simulated performance of a proposed, full-custom, application-specific integrated circuit that has been proposed as an alternative solution but that would be extremely expensive to fabricate.

This cross-country research collaboration with civilian universities is made possible through the Local University Contract for IT Exchange (LUCITE) Program. Now in its fourth year, LUCITE is structured to optimize multi-institutional collaboration while minimizing the admin-

istrative and contractual overhead. The National Security Agency is the program director. LUCITE is open to anyone in the Intelligence Community. The National Reconnaissance Office and Defense Information Services Agency are using the program to accomplish some of their research needs. The strategy for this new model for academic collaboration is local access with nation- and world-wide reach. Doctoral institutions within 50-mile radius of NSA, Ft. Meade are the LUCITE universities (Johns Hopkins University, University of Maryland - Baltimore County, George Washington University, University of Maryland – College Park and George Mason University). In submitting proposals, it is administratively straightforward for the LUCITE universities to include institutions outside the 50-mile radius. Teaming with NPS professors is a first for the LUCITE program. As the Navy's "Corporate University," NPS offers an academic environment with close ties to potential users of reconfigurable super-computers. It is expected to open the way for government task leaders in other technologies to follow suit. LUCITE's structure offers a streamlined administrative and contractual process while allowing government Task Leaders and academic researchers to focus on the technical challenges and solutions.

HOOVER INSTITUTION PROJECT ON CHINA

Lyman Miller, associate professor in the Department of National Security Affairs, is serving as general editor of a new project on analysis of Chinese leadership politics, the *China Leadership Monitor*. The project is sponsored by the Hoover Institution at Stanford University.

The project begins at a time of continuing public debate in the United States over the implications of China's rise as a great power for American interests in Asia and for U.S. foreign policy in general. The *Monitor* seeks to inform the American debate by providing comprehensive and systematic quarterly assessments of PRC leadership politics and policy-making in areas of key interest to U.S. policy-makers and to the broader policy-interested American public.

The quarterly analyses are written by a team of six regular contributors, each of who is a recognized specialist in his assigned area. The contributors include: Professor Thomas Christensen (Massachusetts Institute of Technology) on Chinese foreign and national security policies; Dr. James Mulvenon (RAND Corporation) on the People's Liberation Army and military affairs; Professor Barry Naughton (University of California at San Diego) on Chinese economic

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PROJECT NOTES

A QUIET REVOLUTION: ASSESSING THE NUCLEAR POSTURE REVIEW

In May 2002, the Mountbatten Centre invited visiting **Office of the Secretary of Defense Fellow James Russell** and **Professor James Wirtz**, Department of National Security Affairs, to the University of Southampton in the United Kingdom to participate in a two-day conference to assess the changing strategic environment. Experts in arms control and disarmament from around the world attended the Mountbatten Centre's Missile Control Forum. Papers were presented on deterrence, asymmetric threats, arms control and regional missile proliferation.

Russell and Wirtz presented their paper, "A Quiet Revolution: U.S. Nuclear Strategy in the 21st Century." It addressed the proposed changes in U.S. nuclear strategy that were described by the *Nuclear Posture Review*, which was released by the Bush administration in January 2002. They suggested that a revolutionary transformation is quietly occurring in U.S. nuclear strategy and defense policy. It is quiet because it is being overshadowed by the war on terrorism, fundamental organizational changes in the U.S. government that are flowing from the new requirements of homeland security, and a chaotic international environment exemplified by the ongoing dispute between Israelis and Palestinians. It is revolutionary because it reflects a fundamental change in the threats, capabilities, philosophy and strategy that have preoccupied U.S. nuclear planners since the 1950s. It also highlights significant changes in the way the U.S. military is organizing to fight future wars.

Like all revolutions, such fundamental change is bound to disturb both supporters and critics of the status quo. But at least from the perspective of realism, the transformation reflects a rational response to a changing threat environment, especially the end of the Cold War. The Bush administration has launched the first significant departure in U.S. nuclear policy since the demise of the Soviet Union.

HOOVER INSTITUTION PROJECT ON CHINA, *continued from page 20*

policy; Professor Joseph Fewsmith (Boston University) on political reform issues and state-society relations; Professor Li Cheng (Hamilton College) on center-province relations; and Miller himself on party leadership politics.

Monitor analysis is available via the project website (www.chinaleadershipmonitor.org) and will also be available soon in hard-copy journal format. Free subscriptions to the journal may be obtained via the project website. Two rounds of quarterly assessments are already available on the website, and a third is about to be posted. A fourth round will sum up Chinese politics and policy trends on the eve of the Chinese Communist Party's 16th National Congress, which opened on 8 November.

Project analysis has already attracted interest among policy-makers—including the White House and the National Security Council, in the American intelligence community, and among the American press.

CYBER RISK MANAGEMENT TRAINING PROGRAM

Network implementations that support the sharing and use of critical data, in general, are scalable and cost effective. The inherent risk is the exposure of the network beyond the traditional boundaries and country borders. The security and integrity of critical data has become an evermore difficult problem in light of recent events. It is important to understand this exposure so we can systematically address vulnerabilities.

The Cyber Risk Management Office (CRMO) is a consortium of NPS faculty and students dedicated to the research, analysis, and development of cyber risk management tools, products and resources. The CRMO is developing a DoN training program to address the education and training of civilian and military personnel with regard to network security and integrity. The emphasis will be on portability with a face toward remote site education and training. The CRMO, under the leadership of **Lecturer Richard Harkins**, Department of Physics, and **LCDR Chris Eagle, USN**, Department of Computer Science, is developing a DoN Network Vulnerability Assessment Training Site (VATS) that scales from 10 to 100 connections. CRMO will also provide the prototype pilot training program.

The Mountbatten Centre will publish the Russell-Wirtz paper in the fall of 2002 as part of a book called *The Changing Nature of Post-Cold War Deterrence*. A version of the article also will be published by the journal *Contemporary Security Studies*. Russell and Wirtz also have another article on the topic currently under review. Several of their Strategic Insights dealing with the *Nuclear Posture Review* can be accessed at the Center for Contemporary Conflict website at www.ccc.nps.navy.mil.

RESEARCH CENTERS

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS) VOTED A NATIONAL OCEANOGRAPHIC AIRCRAFT FACILITY

The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) at the Naval Postgraduate School was voted a National Facility as part of the University National Oceanographic Laboratory System (UNOLS) on 27 September 2002 at the UNOLS Annual Meeting. UNOLS is an organization of academic oceanographic institutions working in cooperation with agencies of the U.S. Federal Government to ensure broad access to modern, well-operated, state-of-the-art research vessels, submersibles, aircraft and facilities required to support a healthy and vigorous research and education program in ocean sciences.

A National Oceanographic Aircraft Facility is an academic organization or institution that operates one or more aircraft in support of oceanographic research or education and that is made available to qualified scientists from any institution with funding for the use of the facility. The purpose is to provide access to aircraft facilities to scientists that do not operate or otherwise have available the required aircraft facilities. The

Naval Postgraduate School, the Office of Naval Research, and the California Institute of Technology formed CIRPAS as a joint research facility to support scientific research and technology development. The facility provides Remotely-Piloted Aircraft (RPA) as well as manned aircraft services to the science, research, test and evaluation communities. CIRPAS also provides an array of meteorological, aerosol and cloud particle sensors, data acquisitions systems, calibration and data reduction service. CIRPAS conducts payload integration, reviews flight safety and provides logistical planning and support to research and test projects. CIRPAS missions are almost entirely over the ocean and have supported several oceanographic and atmospheric research projects in recent years.

The primary CIRPAS aircraft for oceanographic support is the UV-18A Twin Otter. The UV-18A functions as a sensor platform and chase aircraft during UAV flight operations

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RESEARCH CENTERS

CIRPAS VOTED A NATIONAL OCEANOGRAPHIC AIRCRAFT FACILITY, *continued from page 22*

outside of restricted areas. Characteristics of the UV-18A include:

- Large Payload Capability (4500 lbs); nose, cabin and wing stores
- >4200 W Power available
- Integrated Data Acquisition System
- Extended Duration Missions with Additional Fuel Tank System
- Wide Speed Range (65-165 KIAS)
- 25,000 foot ceiling (oxygen installed)
- SATCOM communications allowing real-time data and voice transmissions

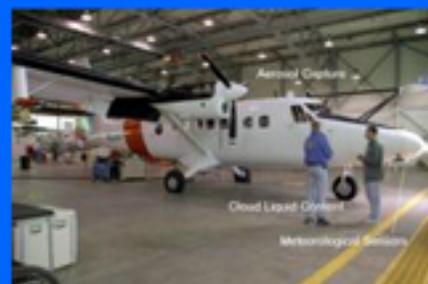
UNOLS also established a standing committee with the responsibility for designating National Oceanographic Aircraft Facilities. This committee, the Scientific Committee for Oceanographic Aircraft Research (SCOAR) will be operated under UNOLS. Initially the Committee will consist of a Chair, four appointed members from the research community and ex-officio members from designated National Oceanographic Aircraft Facilities. Ex-Officio members from CIRPAS

are **Dr. Hafidi Jonsson**, Chief Scientist, **Robert Bluth**, Director, and **Distinguished Professor David Netzer**, Executive Director.

The SCOAR will provide advice and recommendations to facility managers and supporting federal agencies on aspects of operations, sensor development, fleet composition, utilization and data services as appropriate. In addition, SCOAR and the UNOLS Office will provide the ocean science user community with valuable information and advice concerning experiment design, facility usage, scheduling and capabilities. The committee will promote collaborations and cooperation between facility operators, funding agencies and the scientific community to improve the availability, capabilities and quality of aircraft facilities supporting the ocean sciences. By promoting collaboration between the ocean science community, the atmospheric science community and other science communities using aircraft in support of their research, the committee will work to improve utilization and capabilities for all of these capabilities.



NPS-CIRPAS SCIENCE MISSIONS



Expendable Sensors:

- Wave Buoy
- T-Drop
- Visibility Sonde
- Chem Sonde

Facility Measurement Capability:

- Meteorological Properties
- Aerosol Particles: Physical, Radiative, and Chemical Properties
- Cloud Particles: Physical Properties
- Solar Radiation
- Gas Chemistry
- Ocean Surface Properties

CHAIR PROFESSORSHIPS

NATIONAL RECONNAISSANCE CHAIR PROFESSORSHIP RENEWED

The Memorandum of Agreement between the Naval Postgraduate School, the National Reconnaissance Office (NRO), and the Aerospace Corporation was renewed in August. The National Reconnaissance Chair was established for the purpose of exposing NPS students to expertise that is not readily available on campus. The NRO Chair Professor will teach selected courses, serve as a thesis advisor to NPS students, and support conferences, workshops, symposia and seminars when appropriate. In addition, to facilitate technical research of interest to the NRO, he will serve as the Director of the Center for Reconnaissance Research. The current incumbent is **CDR David Kretzmann, USN (Ret.)**. The Chair resides within the Space Systems Academic Group.

OFFICE OF NAVAL RESEARCH ARCTIC MARINE SCIENCE CHAIR PROFESSORSHIP BEGINS 25TH YEAR

The Office of Naval Research established and has continued to support the Arctic Marine Science Chair Professorship at the Naval Postgraduate School for the past 25 years. The Chair Professor is involved in research, teaching and thesis advising, and interaction with the naval establishment.

Dr. Max Coon, a senior scientist at North West Research Associates Inc. in Seattle, is the current incumbent. Dr. Coon has been one of the world's leading experts on sea-ice mechanics and dynamics for the past thirty years. Dr. Coon's distinguished career includes teaching at several universities (University of Michigan, Manchester, and Washington) and conducting sea ice research both in the field and with the use of numerical models. He has been a leader in most of the major Arctic field programs relating to understanding the role, behavior and motion of sea ice under varying conditions and spatial scales.

During his tenure in the Chair, Dr. Coon will collaborate with faculty in the Department of Oceanography in the ONR-sponsored endeavor to improve the Navy's operations sea ice forecasting model, PIPS. In particular, he will continue with the development and implementation of this frazil/pancake ice model to more accurately represent conditions within the marginal sea-ice zone. The ultimate objective is to provide the analysts at the National/Navy Ice Center with an enhanced analysis and forecast tool to track the motion and extent of sea ice near its margins.

NATIONAL SECURITY AGENCY CRYPTOLOGIC INNOVATION CHAIR PROFESSORSHIP ESTABLISHED AT NPS

The Naval Postgraduate School and the National Security Agency (NSA) have entered into a Memorandum of Agreement to allow assignment of a NSA employee to the faculty of NPS as the Cryptologic Innovation Chair Professor. The agreement provides for the assignment of eminent NSA civilian professionals to enrich the faculty of the NPS and to enhance the graduate-level education of the military officers and the NSA civilians enrolled.

The Cryptologic Innovation Chair will provide faculty and students with familiarity and insight into the cryptologic community (e.g. organizations, analytic focus, technology issues, future challenges). The Chair will participate with other NPS faculty in the design, development and teaching of multidisciplinary cryptologic and intelligence courses, as well as act as a conduit for areas of research of interest to the NSA. Areas for a mutually beneficial exchange could include computer science, electrical and computer engineering, information warfare, information technology, mathematics, national security affairs, business policies and acquisition, and space systems. The Cebrowski Institute for Information Innovation and Superiority (CINFINIS) and the Department of Computer Science will host the Chair.

The initial incumbent of the Cryptologic Innovation Chair Professorship is **Joanne Kim**. Ms. Kim received her Master of Science in Systems Technology from the Naval Postgraduate School. Her NSA career spans both the signals intelligence and information assurance directorates. While at NSA, she managed a large-scale software development project, established a network evaluation laboratory, and transformed central site operations to secure distributed computing. Most recently, Ms. Kim created a prototype government/academic program to expedite knowledge acquisition while at the same time yielding valued added results for the intelligence community. As an innovation vehicle, it offers the intelligence community the opportunity to seek solutions with an academic consortium that has worldwide reach. Ms. Kim's has also had intelligence community tours at the State Department, Defense Intelligence Agency, and the National Imagery and Mapping Agency.

CHAIR PROFESSORSHIPS

CHAIR OF UNDERSEA WARFARE ESTABLISHED AT NPS

A Memorandum of Understanding between the Naval Undersea Warfare Center and the Naval Postgraduate School has established the Chair of Undersea Warfare (USW). The Chair will also serve as the Director of the Undersea Warfare Center. The resurgence of interest and concern about USW as a component of littoral and expeditionary warfare resulted in initiatives at NPS to enhance the academic and research content in several curricula with USW related material. The result of those initiatives, along with the establishment of the Undersea Warfare Center and the Undersea Warfare Chair Professorship, places NPS as a major center of excellence for instruction, research, and analysis in the field of undersea warfare.

The USW Chair Professor will be involved in the review of USW curriculum to assure appropriate content relative to undersea and antisubmarine warfare principles and technology applications. The Chair will liaison with Navy laboratories, acquisition programs managers, program sponsors, and operation commands to identify prioritized needs for research topics in the USW area. The Chair will also be involved in wargaming support for the Office of Naval Research and other naval activities, particularly in the antisubmarine warfare area of wargaming. Concurrently assigned as the Director of the Undersea Warfare Center, the Chair will be involved in the research planning and program execution of the Center.

The Naval Undersea Warfare Center in coordination with NPS is currently recruiting for the Chair Professor.

MEMORANDUM OF AGREEMENT ESTABLISHES NAVY WARFARE DEVELOPMENT COMMAND CHAIR FOR WARFARE INNOVATION

The Naval Postgraduate School and the Navy Warfare Development Command (NWDC) entered into a Memorandum of Agreement to establish the Navy Warfare Development Command Chair for Warfare Innovation to invigorate and conduct research and analysis required to develop doctrine, tactics, techniques, procedures, and maritime and joint operational concepts. The Chair will act as a liaison point for collaborative efforts between NPS Institutes and Graduate Schools and NWDC. This cooperative effort will provide valuable opportunities for faculty and student professional development at NPS while enhancing NWDC's mission to foster naval innovation.

The first incumbent of the NWDC Chair for Warfare Innovation is **CAPT Jeff Kline, USN**. CAPT Kline received his Master of Science in Operations Research from NPS in 1992. He also graduated from the Naval War College in 1997. From 1993-1996, he was assigned

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CHAIR OF ACQUISITION MANAGEMENT DUALY SUPPORTED BY THE PEO-EXPEDITIONARY WARFARE AND PEO-THEATER SURFACE COMBATANTS

The Naval Postgraduate School entered into Memoranda of Understanding with the PEO Expeditionary Warfare and PEO Theater Surface Combatants to establish a Chair in Acquisition Management in the Graduate School of Business and Public Policy. The objective of the Chair Professorship is to provide a direct relationship between the PEOs and NPS to 1) conduct and manage relevant research, and 2) provide opportunities for professional development for both faculty and students in acquisition management and related curricula at NPS.

Rear Admiral Jim Greene, USN (Ret.) has assumed the newly created Acquisition Chair in the Graduate School of Business and Public Policy. He brings to the position extensive experience at all levels of the acquisition process. The first half of his active duty career culminated in Command at Sea. He then served in the Office of Legislative Affairs as Executive Assistant to the Assistant Secretary of the Navy (Shipbuilding and Logistics). RADM Green founded the Material Professional Program, a precursor of today's Acquisition Professional Corps, and served as Project Manager of the Aegis shipbuilding project, Senior Military Assistant to the Undersecretary of Defense (Acquisition) and as Assistant Deputy CNO (Logistics). He holds Masters of Science degrees in Electrical Engineering (1972) and Program Management (1973) from the Naval Postgraduate School.

When asked what he hoped to accomplish as the Acquisition Chair, Admiral Greene stated: "I have long been indebted to the Naval Postgraduate School and its faculty for all they did in preparing me for success in my active duty career. It is my hope that I can stimulate renewed interest by research sponsors in relevant and timely acquisition research efforts by the faculty and students at NPS. I would like to see NPS emerge as the 'place of choice' for acquisition research efforts. Additionally, I hope to be able to share with students, through classroom contact and as project adviser, the many lessons learned during my somewhat unique acquisition career. It's great to be back!"

AGREEMENTS

CALIFORNIA TECHNOLOGY, TRADE AND COMMERCE AGENCY AND NPS ESTABLISH INTERGOVERNMENTAL COOPERATIVE AGREEMENT

As a follow-on to the Letter of Intent between the Naval Postgraduate School (NPS), the California State University System, and the California Technology Trade and Commerce Agency (CTTCA), NPS and CTTCA have entered into an intergovernmental agreement whereby NPS will provide student interns and or NPS faculty to CTTCA. The interns will perform various services on a variety of projects related to military base homeland defense, military base encroachment, retention and reuse. All projects will be of joint benefit to the State of California and the Department of the Navy. Projects may be related to specific military bases within California or a combination of military bases in a particular region within California.

SAN DIEGO STATE UNIVERSITY AND NPS PROMOTE JOINT EDUCATIONAL AND PROFESSIONAL PROJECTS

The Naval Postgraduate (NPS) and San Diego State University (SDSU) have established an Education and Research Partnership Agreement to provide joint educational and professional projects for each participant's mutual advantage and to forge a cooperative relationship to further the educational, research and service missions of each partner. The purpose of this partnership is to encourage and enhance education and research opportunities by combining the capabilities and resources of the partners. NPS and SDSU will take steps to encourage formal and informal working relationships of mutual benefit.

INDUSTRIAL COLLEGE OF THE ARMED FORCES AND NPS SIGN MEMORANDUM OF UNDERSTANDING FOR VISITING PROFESSORSHIPS

To enhance the common Joint Professional Military Education mission of both institutions, the Naval Postgraduate School (NPS) and the Industrial College of the Armed Forces (ICAF) within the National Defense University have entered into a Memorandum of Understanding to establish a strategic alliance within the personnel research and policy arena. To this end, there will be an emphasis on leadership and senior leader development. **Dr. Janice Laurence** and **Dr. Armando Estrada** from NPS' Graduate School of Business and Public Policy (GSBPP) are serving as visiting professors at ICAF. Dr. Laurence and Dr. Estrada are encouraged to lend their skills and talents to bring mutual benefit to both GSBPP and ICAF through research, service and teaching.

UNITED STATES SPECIAL OPERATIONS COMMAND RENEWS RELATIONSHIP WITH NPS

A Memorandum of Agreement between the United States Special Operations Command (USSOCOM) and the Naval Postgraduate School (NPS) continues the responsibilities and relationships in support of the Special Operations curriculum. The Special Operations curriculum (originally called Special Operations-Low Intensity Conflict (SO/LIC)) was established in 1992 to meet USSOCOM's need for specialized graduate professional education for a select group of Special Operations Forces officers. Since its founding, the curriculum has evolved and now operates within the Department of Defense Analysis at NPS and provides individual officers with a common education core and the opportunity to specialize in a range of distinct technical and non-technical tracks. Under the agreement, NPS provides specialized interdisciplinary education in areas of political violence, SO/LIC, and operations other than war, and the technological and organizational revolution in military affairs. In addition, NPS promotes student and faculty research in the areas of political violence, irregular warfare, and unconventional military roles, missions, forces, organizational forms, and technologies.

The agreement also establishes the Special Operations Chair. The Chair serves as a faculty member in the Department of Defense Analysis. In this capacity, the Chair instructs in areas of the Special Operations curriculum, ensures relevancy of the Special Operations curriculum, develops and sustains a systemic means of integrating thesis and research with the needs of USSOCOM, and serves as a member of the NPS Center on Terrorism and Irregular Warfare. The current chairholder is **COL Joseph Tyner, USA**.

FOUR NEW COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS INITIATED AS A RESULT OF NPS FACULTY RESEARCH

The Naval Postgraduate School has an active technology transfer program. The most common form of technology transfer is the faculty and student publications. NPS researchers also partner with industry through the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) Programs and through Cooperative Research and Development Agreements (CRADAs). The most recent CRADA partnerships are listed below.

The American Institute of Aeronautics and Astronautics, Inc., (AIAA) and the Naval Postgraduate School, in consideration of the AIAA publication *The Fundamentals of Aircraft Combat Survivability: Analysis and Design* published in 1985 and authored by **Robert E. Ball** have mutually agreed to collaborate in the revision and preparation of a revised manuscript for the second edition of *The Fundamentals of Aircraft Combat Survivability: Analysis and Design*. Dr. Ball is an Emeritus Distinguished Professor of Aeronautics and Astronautics.

The Naval Postgraduate School and Intel Corporation's CRADA partnership has three objectives: (1) to develop an Impression Creep based approach to directly test individual BGA solder balls; (2) develop a unified creep model incorporating the effect of phase coarsening applicable to Lead-Free Solders; and (3) provide fundamental mechanistic insight into the roles of microstructural and compositional artifacts on the evolution of creep behavior during Thermo-Mechanical Cycling. The NPS technical point-of-contact is **Associate Professor Indranath Dutta**, Department of Mechanical

Engineering.

The Naval Postgraduate School and SILVACO INTERNATIONAL are CRADA partners in a Small Business Technology Transfer award as a result of STTR Solicitation No. AF02-T005. NPS, in cooperation with SILVACO, will simulate and design a simple device structure to provide characterization information on the GaN epitaxy. The NPS technical point-of-contact is **Associate Professor Todd Weatherford**, Department of Electrical and Computer Engineering.

The Naval Postgraduate School and the Consiglio Nazionale Delle Ricerche-Instituto Per Lo Studio Della Dinamica Delle Grandi Masse (CNR-ISDGM) have entered into a CRADA to further a collaborative effort. This agreement will involve analysis of surface ocean velocity maps from a network of high frequency (HF) radar systems deployed along the northern coast of the Adriatic Sea near Venice, Italy. The instruments are owned and operated by the CNR-ISDGM oceanography group in Venice. They have been deployed in support of a larger program designed to monitor the exchange of water between the Adriatic Sea and the Venice lagoon. Specialized software developed at NPS for processing of HF radar data will be transitioned to colleagues in Italy. At the same time, NPS personnel will analyze long-term records from the Venice array for coherence with local and remote winds and will compute and map tidal constituents of the surface velocity field using harmonic analysis techniques. The NPS technical point-of-contact is **Associate Professor Jeffrey Paduan**, Department of Oceanography.

NAVY WARFARE DEVELOPMENT COMMAND CHAIR FOR WARFARE INNOVATION,

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to Naval Forces Division Program Analyses and Evaluation (PA&E), Office of the Secretary of Defense. In that position, he authored the Maritime Chapter of the Secretary of Defense Report to the President and Congress. Operational experience includes command of the *USS CUSHING* (DD-985) and *USS AQUILA* (PHM-4), and as Operations Officer for a Tactical Destroyer Squadron. He has extensive experience in undersea warfare, battle group operations, counter-drug operations, and joint land warfare. He is currently serving as the Associate Dean for the Graduate School of Operational and Information Sciences.

Within the next year, CAPT Kline hopes to invite RADM

Ron Route, Commander, NWDC and NWDC department representatives to NPS to conduct a Navy Concepts Symposium. This symposium will provide NWDC the opportunity to present SEA TRIAL initiatives, Tactical Development and Evaluation Problems, and current Limited Objective Experiments to faculty and students, and will expose members of NWDC to current research being conducted at NPS.

CAPT Kline is also mentoring several students in researching such fleet-relevant topics as Navy Information Operations, LCS Mission Area Analysis, Force Structure requirements, Theater Logistics scheduling, and TBMD Operational Aides for asset deployment and allocation. He will continue to act as a conduit to bring operational concerns to NPS classrooms and research Institutes while forwarding their products to fleet users.

CONFERENCES/SHORT COURSES

SYMPOSIUM ON NEW TRENDS IN NONLINEAR DYNAMICS AND CONTROL, AND THEIR APPLICATIONS

The Symposium on New Trends in Nonlinear Dynamics and Control, and their Applications was held 18-19 October 2002 at the Naval Postgraduate School (NPS). The symposium was organized in conjunction with the 60th birthday of Professor Arthur J. Krener, University of California-Davis, a pioneer in nonlinear control theory and its applications for the last three decades. The symposium provided a wonderful opportunity for control theorists to review major developments in nonlinear control theory from the past, to discuss new research trends for the future, to meet with old friends, and to share the success and experience of the community with many young researchers who are just entering the field. The symposium was funded by National Science Foundation, Air Force Office of Scientific Research, NPS, and Southern Illinois University (SIU). NPS hosts for the event were Associate Professors Wei Kang and Carlos Borges, Department of Applied Mathematics.

The symposium got off to an excellent start with an opening lecture by Arthur J. Krener, who gave an excellent survey of the minimum energy estimator, introduced in 1968 and refined in 1980. He closed his talk with a brand new result on the global convergence of the Extended Kalman Filter under broad and verifiable hypotheses.

The remainder of the conference was organized into five sessions each one beginning with a featured speaker, all of whom held to the same high standard set in the opening lecture. Alberto Isidori, Washington University and University of Rome, addressed a new problem on the adaptation of internal models to exogenous inputs. The presentation clearly demonstrated the potentials of a new design methodology, in which a model of all expected exogenous inputs is embedded into the controller, and the parameters of these models are continuously adapted. Witold Respondek, Laboratoire de Mathématiques de l'INSA, France, spoke about the symmetries of nonlinearizable single-input systems. A rather surprising result, proved using the canonical form, was that such systems admit at most two 1-parameter families of symmetries. Roger Brockett, Harvard University, spoke on quantum control with applications to quantum computing.

After a brief review of earlier results on tracking performance posed by unstable zero dynamics, Petar Kokotovic,

University of California-Santa Barbara, presented examples of a method of dynamic compensation that alleviates the effects of stable unmodeled dynamics with unstable zeros in feedback stabilization problems. Chris Byrnes, Washington University, opened his talk with an exposition of some less well-known results in the Poincaré-Bendixson theory and some higher dimensional analogues developed by G. D. Birkhoff. He then presented some existence results for periodic responses to periodic forcing for signals with arbitrary amplitude in arbitrary dimension.

The five sessions contained an additional 25 invited pre-



Professors Mingqing Xiao, Arthur J. Krener, Carlos Borges, and Wei Kang

sentations showcasing the leading edge in nonlinear dynamics and control from around the world. Lively discussions and debates were the norm and these generally continued out into the lobby of the lecture hall during the breaks.

At midday on October 19 a panel discussion on future directions of nonlinear dynamics and control was held. The panel, chaired by Professor Richard Murray, California Institute of Technology, consisted of Professors Chris Byrnes, Petar Kokotovic, David Mayne, Imperial College, London, and A. Stephen Morse, Yale University. Each panel member gave a very brief outline of their thoughts on new trends in the development of nonlinear control. This was followed by a lively open discussion between the panelists and audience. It was the general sense of the panelists that this is an exciting and critical moment in the development of nonlinear control theory. There are increasing demands on development of nonlinear control theory to enable engineers and scientists to deal with the complexity of various problems such as the design

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CONFERENCES/SHORT COURSES

NPS HOSTS THE AIR FORCE INFORMATION WARFARE CENTER PHOENIX CHALLENGE CONFERENCE

The Cryptologic Research Center at the Naval Postgraduate School recently hosted and participated in an Air Force Information Warfare Center (AFIWC) conference, Phoenix Challenge 2002 (PC2002). The conference, held at NPS 10-13 September 2002, included high-level DoD, military and contractor attendees from across all agencies and offices, which have an Information Operations/Assurance (IO/IA) mission. NPS faculty contributions to PC 2002 included presentations on IO-related curriculum and research, as well as tours of NPS IO-related laboratories.

Phoenix Challenge is an AFIWC and Office of the Secretary of Defense for Command, Control, Communications and Intelligence (OSD/C3I) jointly chaired initiative to identify state-of-the-art information operations (IO) technologies, systems, and capabilities of DoD and Government IO organizations, industry and academia that could be leveraged and incorporated into current and future DoD (and Government) IO systems and weapons. It is a shared, collaborative process that affords experts in IO and traditional warfighting disciplines an opportunity to discuss in an open-forum environment their IO requirements, challenges and technology solutions (both non-material and material).

The NPS September Phoenix Challenge 2002 conference objective was to identify and address a myriad of IO/IW challenges and technology areas that transcended both organizational and service boundaries. Ms. Carol Haave, Deputy Assistant Secretary of Defense for Security and Information Operations (OSD/C3I) and a sponsor of the Phoenix Chal-

lenge series of conferences, provided an overview of the Secretary of Defense's perspective on Information Operations in the 21st Century. Additionally, to increase the operational and technical relevancy of the program and conference series, the conference format included a "warfighter panel" to afford participants an opportunity to gain a better appreciation of the IO/IW challenges and problem sets facing Unified and Specified Commanders in the performance of their missions. Members of the warfighter panel included: LTG Donald Kerrick, USA, National Security Advisor to the President, Brig-Gen Douglas Fraser, USAF, Commander of the Space Warfare Center, BrigGen Jack Catton, Jr., USAF, Deputy Director of the IO/Information Operations Directorate Joint Staff.

NPS contributions to the agenda included several presentations during the course of the three-day conference. **CAPT Frank Petho**, USN, the NPS Chief of Staff, provided opening remarks to the group on the first day in King Hall, welcoming them to NPS and highlighting the NPS Corporate University model. **Ms. Rita Painter**, the Cryptologic Program Manager and SPAWAR Systems Center liaison to NPS, provided an overview of the NPS Cryptologic Research Center highlighting IO-related research in the two member laboratories, the Computer Network Research Lab, and the Cryptologic Research Lab. **LCDR Steve Iatrou**, USN, from the Department of Information Science provided an overview of the NPS IO curriculum and professional development programs designed for future information warriors educated at NPS.

Associate Professor David Tucker from the Department of Defense Analysis presented a progress report on educating the 21st century information warrior and how educational requirements are meeting the demands of the IO/IW challenge.

Phoenix Challenge is conducted twice a year at different locations. This was the first time NPS hosted this conference. An estimated 295 participants from 145 DoD, Government, Industry and academic organizations attended, the highest turnout since AFIWC began the series two years ago. The next Phoenix Challenge conference is planned for an east coast venue probably during March 2003. For the actual dates, locations and details of the next Phoenix Challenge please contact Ms. Rita Painter at 831-656-2110 or by email at rpainte@nps.navy.mil.

SYMPOSIUM ON NEW TRENDS IN NONLINEAR DYNAMICS AND CONTROL, *continued from page 28*

of highly interconnected systems, robust control of networks, and management of unmanned vehicles for missions. It was noteworthy that the panelists also discussed the importance of numerous problems from biology and medical sciences that will surely yield fruitful directions for future research in nonlinear dynamics and control.

The symposium's guest of honor was Professor Arthur J. Krener and a conference banquet was held on the evening of October 18 to celebrate his 60th birthday and his fundamental contributions in many critical areas of nonlinear dynamics and control theory. The highlight of the evening was a phenomenal presentation by Chris Byrnes on the life and times of a man he very succinctly described as "a great researcher, teacher, and friend."

CONFERENCES/SHORT COURSES

MOVES INSTITUTE OPEN HOUSE 2002

Over one hundred conferees from government, industry, entertainment, academia, and the military traveled to the Naval Postgraduate School in August to see what's new at the MOVES (Modeling, Virtual Environments and Simulation) Institute's third open house.

The annual open house featured talks and demonstrations by MOVES students and professors. This year's topics ranged from the prospects of using graphics and simulation to hunt terrorists to enhancing memory through sound manipulation.

MOVES director **Professor Michael Zyda** described the event as the best yet. Most of the attendees were notable researchers on the frontiers of modeling and simulation. The open house is a comprehensive, informative, well-put-together conference.

This year's highlights included a one-day workshop on Extensible Modeling and Simulation Framework (XMSF) as well as sessions on:

- Networked Virtual Environments and 3D Visual Simulation

The George L. Phillips Modeling, Virtual Environments and Simulation Award is presented to the graduating MOVES student with the most well-rounded record with respect to the NPS MOVES program, a student whose excellent grades and outstanding thesis helped the most in providing leadership and energy for the MOVES program.

The award is named for CDR George L. Phillips, USN (Ret.). CDR Phillips is responsible for moving the U.S. Navy into modern modeling and simulation, through his leadership in setting up the NPS Modeling, Virtual Environments and Simulation academic program. CDR Phillips defined the subspecialty code (P-code) fulfilled by the MOVES degree, obtained N6 as a sponsor for the academic program, and worked with the Navy, Army and Marine Corps to provide students for the MOVES program. CDR Phillips is a 1967 graduate of the NPS Operations Research program.

Recipients of the George L. Phillips Modeling, Virtual Environments and Simulation Award and their thesis topics are listed below:

- CDR Brian Osborn, USN (September 2002): An Agent-Based Architecture for Generating Interactive Stories
- CDR Eric Krebs, USNR (September 2002): An Audio Architecture Integrating Sound and Live Voice for Virtual Environments
- LT David Back, USN (March 2002): Agent-Based Soldier Behavior in Dynamic 3D Virtual Environments
- 1LT Eray Unguder, Turkish Army (September 2001): The Effects of Natural Locomotion on Maneuvering Task Performance in Virtual and Real Environments
- LTJG Askin Ercetin, Turkish Navy (March 2001): Operational-Level Naval Planning Using Agent-Based Simulation
- LCDR Kim Roddy, USN (September 2000): Modeling Human and Organizational Behavior Using A Relation-Centric Multi-Agent System Design Paradigm

- Evolving Operational Modeling
- Immersive Technologies
- Human-Performance Engineering
- Computer-Generated Autonomy
- Defense/Entertainment Collaboration

DESIGN, PERFORMANCE AND ANALYSIS OF UNMANNED AERIAL VEHICLE SYSTEMS SHORT COURSE

The Naval Postgraduate School will offer a Design, Performance and Analysis of Unmanned Aerial Vehicles Short Course from 17-21 February 2003. This course is intended for military officers and civilians who have a technical interest in the design of Unmanned Aerial Vehicles (UAVs) and Unmanned Combat Aerial Vehicles (UCAVs). This program is of special significance since it concentrates on the current missions and operations as well as MASINT, sustainability and force effectiveness. Also included are sessions on training

of UAV operators and human factor issues of crew station design. Special emphasis is given to safety and reliability concerns, vehicle design tradeoffs, payloads and links. Navigation, guidance and control for weapons delivery and the design of UAV antenna systems are also presented. This Short Course will provide an excellent opportunity for exchanging information and UAV, UCAV technology in a relaxing and stimulating environment. **Professor Phillip E. Pace**, Department of

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CONFERENCES/SHORT COURSES

CONTAINER AND SHIPPING INTELLIGENCE WORKSHOP II: SENSING AND MONITORING

The Container and Shipping Intelligence Workshop II: Sensing and Monitoring was hosted by the Naval Postgraduate School (NPS) on 8 and 9 October 2002. The Workshop was sponsored by the Central Measurement and Signature Intelligence (MASINT) Organization (CMO), the Office of Naval Intelligence (ONI) and the Department of Energy National Nuclear Security Administration.

The Workshop objectives were to further strengthen cooperative interactions between members of the intelligence, science and technology communities focused on research and development; and to develop recommendations for research, development, and implementation for sensing and monitoring containers and container contents for prohibited weapon materials prior to arrival in U.S. ports of entry. To meet these objectives, the group examined all aspects of the latest information related to sensors, target signatures, and other elements necessary to verify that shipping containers are not used to infiltrate chemical, biological, radiological, nuclear, high explosive, or other weapon materials. They reviewed current and future R&D efforts sponsored by government agencies involved in homeland defense and developed information needs and how MASINT capabilities and technology developments may be used to our advantage. The ultimate goal of the workshop is to produce recommendations in the form of a Research and Investment Plan for the agencies and organizations involved in this effort that will guide future activities and funding. The intention of this R&D Investment plan is to ensure that effective MASINT systems are fielded quickly, and best use is made of resources.

The conference was attended by 45 people representing over 35 different organizations.

DESIGN, PERFORMANCE AND ANALYSIS OF UNMANNED AERIAL VEHICLE SYSTEMS SHORT COURSE, *continued from page 30*

Electrical and Computer Engineering, is the course coordinator. An overview of the course is provided below.

Missions, Operations, Lessons Learned

- Non-lethal and lethal mission problems and how UAVs are the solution
- System components that make up a UAV
- Use of UAVs in Kosovo and Afghanistan, Task Force Hunter
- Service requirements
- UAVs in a distributed geometry for NWC operations
- Usefulness in search and rescue missions

Introduction to Measurement and Signatures Intelligence (MASINT)

- Introduction to MASINT as an intelligence discipline and its relationship to Signals Intelligence and Imagery Intelligence
- Roles and responsibilities of the Central MASINT Organization
- Six different technical areas comprising MASINT and how this information is used by national policy makers and warfighters
- Implication of MASINT collection to UAV sensor and data distribution design

UAV Sustainability, Force Effectiveness

- Quantifying number of UAVs, of given types and payload configurations needed to provide specified regional coverage, and identifying potential mobile targets such as SAMs, TELs, tanks, etc., with specified probability, and with acceptably small mis-identification and false alarm probability; effectiveness of swarming (small) UAVs
- UAV regional coverage and target-finding as function of (1) platform, sensor, and communications air frame, propulsion, landing and recovery, and payload reliability, (2) maintenance and diagnostic assets and personnel furnished, (3) human factors and training issues will be considered

UAV System Safety and Reliability

- Issues of safety, reliability and maintainability of UAV systems

The "Man" in Unmanned Systems

- Overview of human factors issues including crew station design, the man-machine interface, and human oversight of autonomous systems
- Service specific issues of UAV operator selection, training and performance
- Required crew complement for 24/7 operations for various

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CONFERENCES/SHORT COURSES

FOURTH SYMPOSIUM ON NON-STOICHIOMETRIC III-V COMPOUNDS

The IEEE Monterey Bay Subsection hosted the 4th Symposium and Non-Stoichiometric III-V Compounds on 2-4 October 2002. The symposium was sponsored by the Air Force Office of Scientific Research, the Office of Naval Research, the Naval Postgraduate School, University of California-Berkeley, and various industry sponsors.

The symposium was a workshop-like interdisciplinary meeting combining material scientists and electrical engineers. There were thirty presentations relating to non-stoichiometry crystal and epitaxial growth, superconductivity, photoconductive devices, and radiation effects.

DESIGN, PERFORMANCE AND ANALYSIS OF UNMANNED AERIAL VEHICLE SYSTEMS SHORT COURSE, *continued from page 31*

UAV systems

- Crew work/rest schedule for a given UAV system
- Projected human operator performance characteristics with various manning schedules and assessment of the performance decrement resulting from reduced manning

Vehicle Design

- Aerodynamic design of UAVs
- Design goals and desired mission of a vehicle configuration: power and thrust, endurance and range, slowest speed and top speed, payload weight
- Extended capabilities for the Global Hawk and the turbo-prop Predator B

Payloads and Links

- Various trade-offs in receivers for COMINT, emitter location and datalinks
- Basic jamming relationships to UAV applications
- Various architectures for today's chemical and biological detectors
- Multiple payload restrictions
- Radar payloads and imagery payloads including link impact, video compression techniques used
- Link performance and performance of spread spectrum modulations
- Link-16 structure, SatCom link structure and the application of laser communications
- Capabilities and I/O of Angel Halo, Hawk Link and other

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

The N912 Threat Missile Simulator Validation Working Group (SVWG) Meeting, chaired by Professor P. E. Pace of the Department of Electrical and Computer Engineering, was held 27-29 August 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 and computer simulations. 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/simulations also support operational testing of shipboard weapon systems such as the NULKA and SEWIP (SLQ-32 upgrade) and are used in acquisition milestone decisions.

similar links

UAV Design and Payload Tradeoffs

- Design and use of UAVs and dependence on operational objectives; tradeoffs using measures of effectiveness

Antenna Systems for UAVs

- Trade-offs in designing antenna systems for UAV DF, radar
- Wireless power required for flight (LOS)
- Effect of indoor and urban propagation issues
- Design of low cross section UAV vehicles in IR, RF, Visual

Case Study in UAV Development: Global Hawk

- Evolution of the Global Hawk from Advanced Concept Technology Development (ACTD) through current acquisition status
- Requirements and tradespace constraints

Navigation, Guidance and Control of UAVs for Weapons

- Navigation in earth-centered inertial coordinates
- Basic guidance and control laws
- Guidance and control using UAV aerodynamic surfaces
- UAV target hand-off requirements for successful engagements (ground, air, ballistic missile targets)

For further information on the Short Course, call (831) 656-3560.

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NAVAL POSTGRADUATE SCHOOL RESEARCH AND SPONSORED PROGRAMS

The Naval Postgraduate School has a vigorous research program in support of its primary mission of graduate education. The majority of NPS research is conducted for external sponsors with the Navy being the primary external sponsor. A small Institutionally Funded Research Program provides support to new faculty to establish their research programs.

In the past few years, NPS sponsored programs have grown to include a sizeable sponsored education program. The sponsored education program includes distance learning programs, short courses, executive education, mobile education teams, and certificate

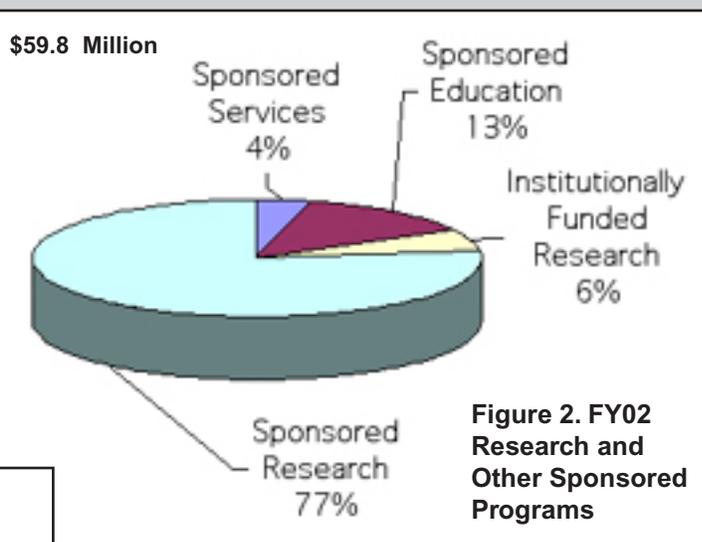


Figure 2. FY02 Research and Other Sponsored Programs

programs.

In FY02, the NPS Research and Sponsored Programs totaled almost \$60M. A profile of these programs is included in Figure 1. Figure 2 indicates the breakout of sponsorship for NPS Sponsored (Research and Education) Programs.

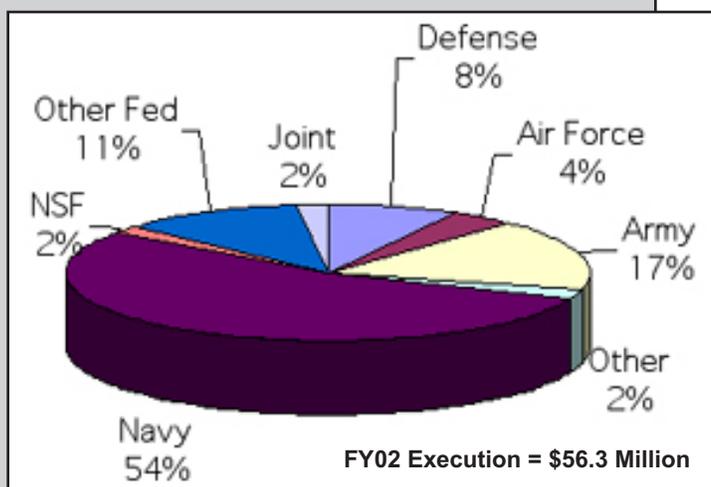


Figure 1. FY02 Sponsored Programs (Research and Education)

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FEATURED PROJECT

VIRTUAL TECHNOLOGIES AND ENVIRONMENTS, *continued from page 5*

training the very physical task of building-clearing in close-quarters combat. The second phase began exploratory research in FY02 and will deliver a concept demonstration in FY07. This phase is much more technologically demanding than the first demonstration, because the trainee must achieve immersion in the stimuli necessary for training. In the cockpit, simulated cues were almost entirely visual and only minimally aural, and all were outside the aircraft, which simplified our task. Such is not the case for CQB. Here, the marine and his team members are encompassed by a simulated building, and they must safely and efficiently

execute an operation that may include unpredictable factors such as hostages, hostile forces, bad lighting, traps, unexpected floor plans, etc. The task is extremely visual, but aural cues are also important, along with haptic and kinesthetic cues.

We began our work with a thorough task analysis of CQB from the perspective of a four-man team clearing a three-room building (Aronson, 2002; Figure 4) under a variety of conditions that we later validated using experts from the Marine Corps, the U.S. Army Special Forces, and a S.W.A.T. team. The analysis touches on all aspects of the task, including the high-level goals of each team member, communications within the team, visual stimuli, decision points, and contingencies. A separate task analysis was completed on the audio portion of the task (Greenwald, 2002) and was used extensively in the development of the subsequent training system (Reece, 2002).

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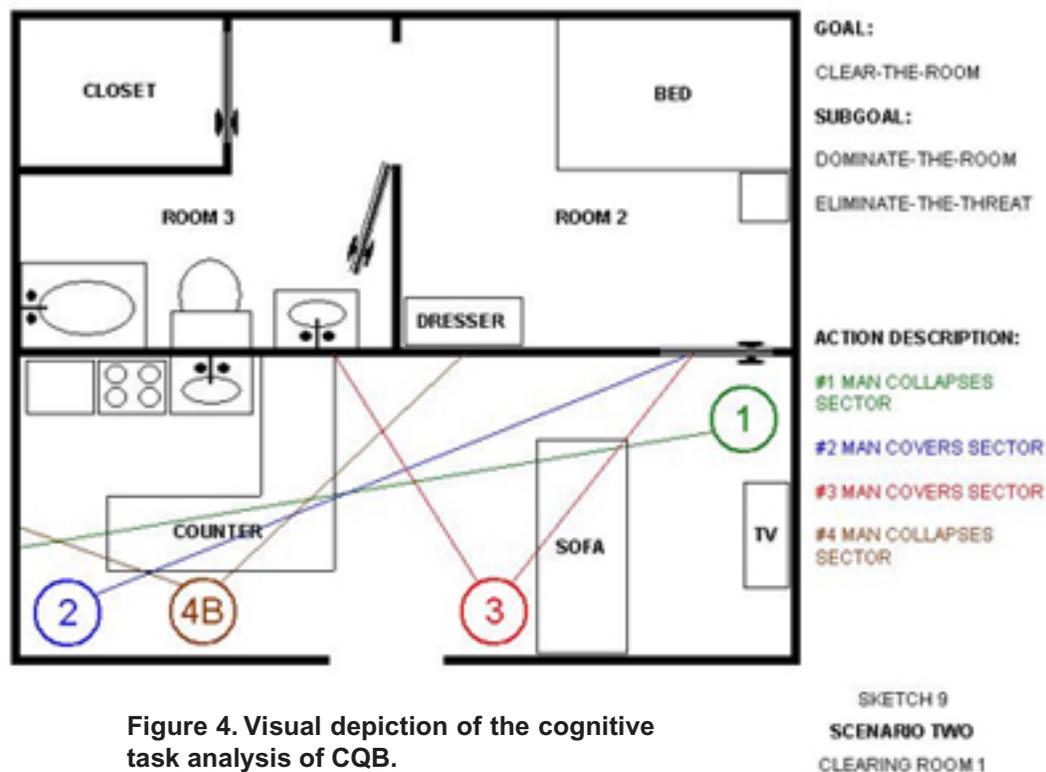


Figure 4. Visual depiction of the cognitive task analysis of CQB.

It was determined by the overall VIRTE team that the "full-body" nature of this task demanded some level of full-body interface. Immersing the trainee in the virtual space to induce high stress in task performance and force him into rapid decisions is a key factor of the system (Ulate, 2002). We determined that an instrumented weapon was needed, but decided that certain deficiencies in tracking technology limited our ability to deal with marksmanship. Because marksmanship is a highly developed, sensitive skill that we did not want to degrade in any way, we circumvented the problem by snapping the sight to the target when a weapon is lifted to the eyes.. This solution was consistent with our aim to develop a *cognitive* trainer for

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mental aspects of a task while remaining reasonably faithful to physical realities.

In our prototype, the user wears a stereoscopic, tracked, head-mounted display with stereo headphones and a boom microphone (Figure 5). Unlike the VEHELO apparatus, there is no camera—the user sees only computer-generated imagery. Technological mastery of movement in virtual space is an ongoing work. We are developing a simple weapon-mounted joystick, but plan eventually to move to a pressure-pad walk-in-place system developed at the Southwest Research Institute. The user enters the virtual building with his team, who are wearing identical apparatus and are connected with each other via a wireless local-area network. Each team member is represented by an avatar (a human model in the environment) so he can see and speak to the others (Krebs, 2002). Other persons within the simulation are also represented as avatars.

We are currently porting the prototype to a commercial game engine. The prototype will be integrated with ISMT-E instrumented weapons and the SwRI pressure-pad locomotion device to demonstrate a team building-clearing exercise next year. Further enhancements will include computer-generated

autonomous OPFOR and hostages, and after-action-review capabilities.

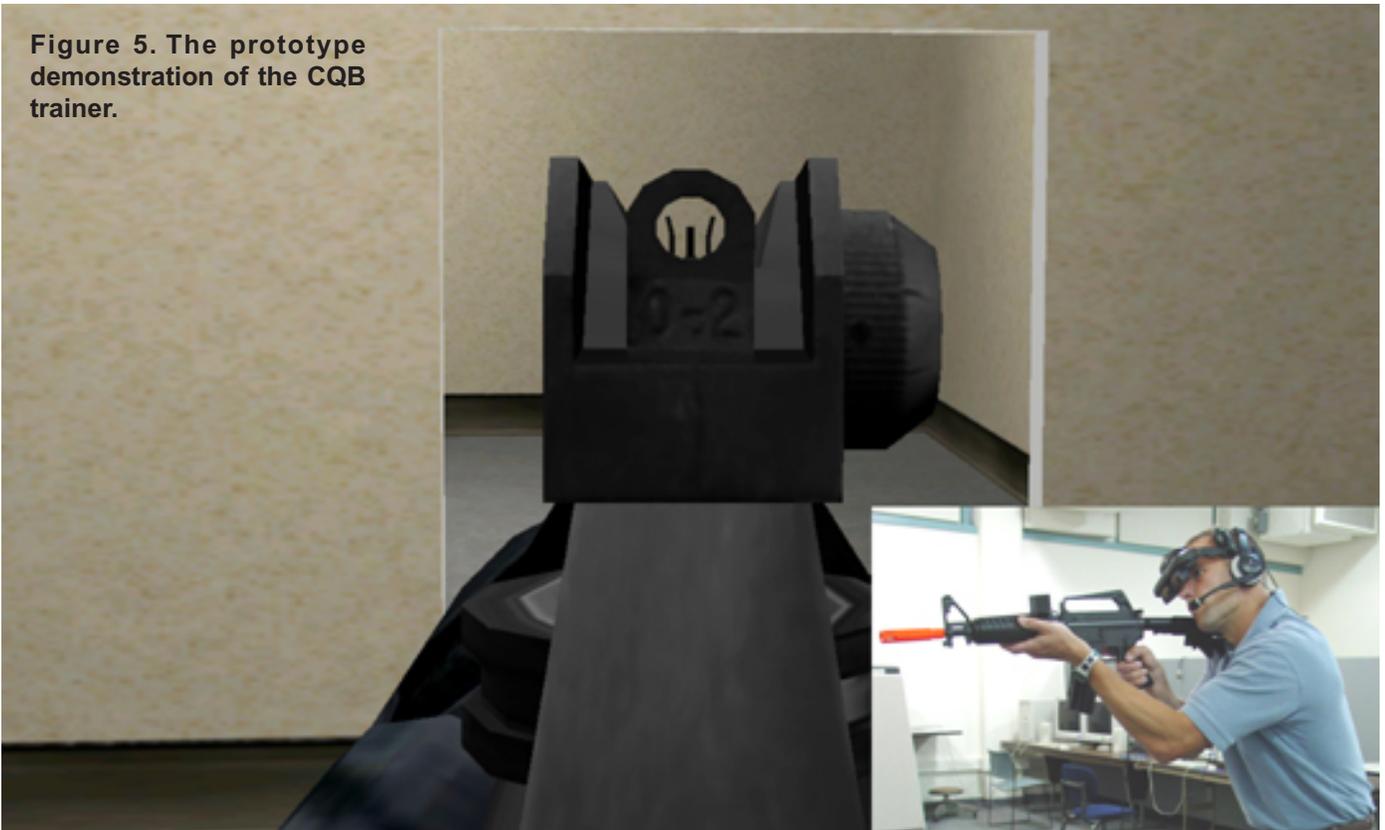
Demonstration III: Full Spectrum Combat

The greatest challenge of all is the third phase of VIRTE, which involves all aspects of expeditionary warfare and the integration necessary to execute a complete simulated operation from start to finish. Technological development of the third phase of VIRTE has not yet begun, but is planned for FY04 to FY08.

There are many practical and human-factors challenges in this phase, because for the members of a combined-arms force to execute their aspect of a mission, their interface must provide a reasonable representation of the real world in terms of *how* they do the task. Since we know that virtual-environment interfaces cannot replicate a real-world interface with today's technology (and it is highly unlikely that this will change markedly in the next few years) we need to determine the critical aspects of each operator's tasks and faithfully represent them using the resources we have. At the

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Figure 5. The prototype demonstration of the CQB trainer.



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same time, we propose to assist in developing those nascent technologies that show promise of allowing close approximation, where necessary, of real-world task execution.

As an exploratory concept demonstration, we developed a Forward Observer (FO) training system (Brannon and Villandre, 2002) (Figure 6). In this system, the FO calls for and observes indirect fire and must adjust accordingly. We simulated a wide variety of munitions as well as the inevitable delays in firing rounds after a call is made. The salient point

is that there is no way for the FO to “cheat” on the task in the simulator. He cannot click on the screen to direct a round or perform any other abstraction of the task. He must observe the target, identify it, locate it, and properly construct a fire order to engage the target. The simulator provides feedback in a form consistent with actual tools used (Figures 6 and 7).

We conducted an initial study on this system to determine if performance in the simulator approximated performance in the field, using benchmarks from the artillery school as a basis for study. All subjects had experience with the Forward Observer mission and objectives. They were given a series of targets to engage while we tracked their performance in terms of time and error. We found that performance in the simulator was slightly better than expected, but believe this was due to aspects of the task we could not simulate. For example, when using a lensatic compass in real life, the FO must hold it steady for a short period of time in order to get an accurate reading. In the simulator, the virtual compass

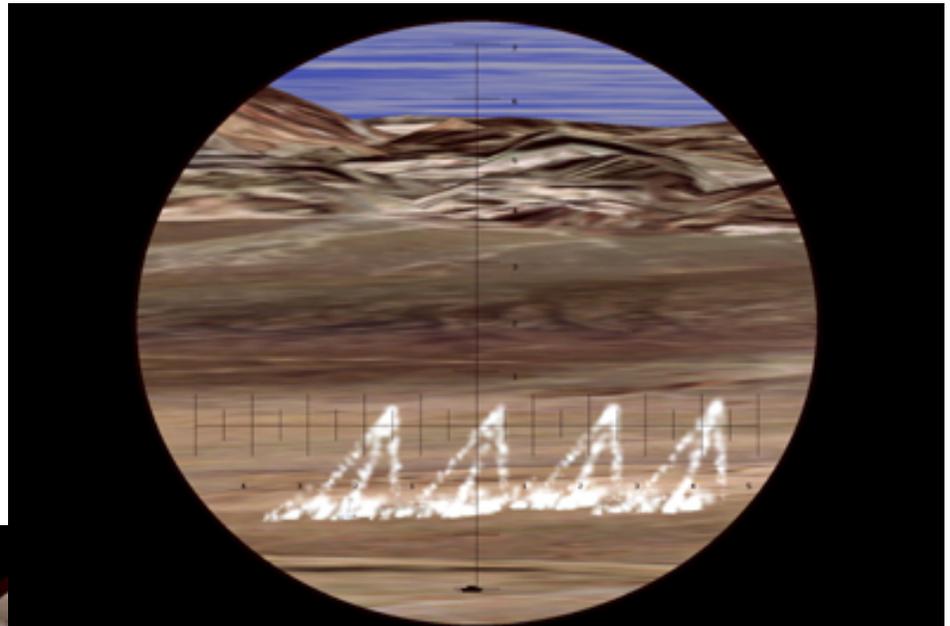


Figure 6 (above). View of the Forward Observer trainer through the binoculars.

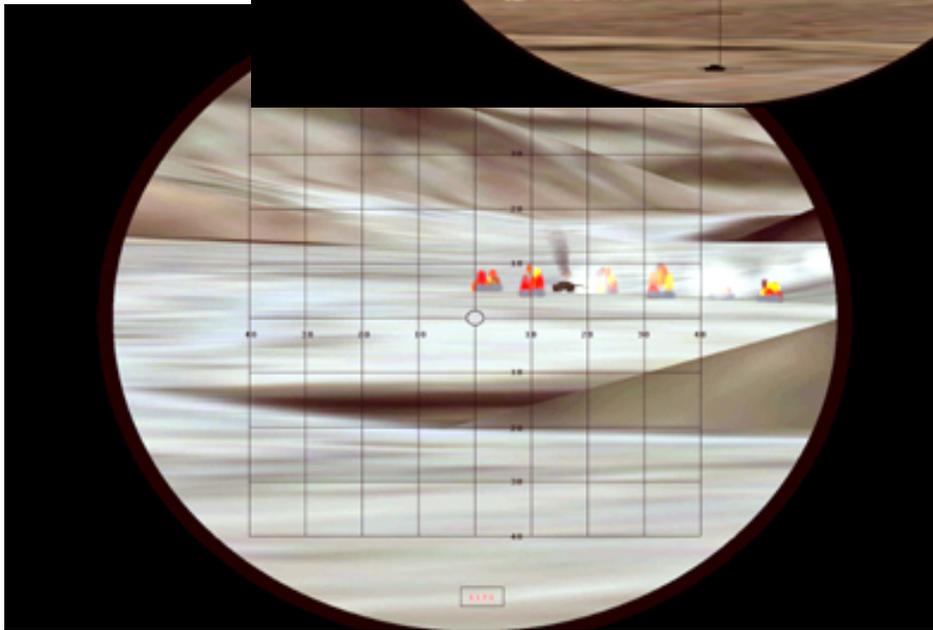


Figure 7 (left). View of the Forward Observer trainer through the MULE (Modular Laser Engagement System).

gives an accurate reading much more rapidly.

The FO trainer has been integrated with our VEHELO trainer so that we can begin to investigate the Forward Air Controller mission and its training objectives. We currently can interoperate, but munition effects must be represented accurately before we can conduct our first effectiveness study. The next step will be moving the trainer to a MOUT environment. At present it is difficult to train combined-arms operations in a MOUT environment in any contemporary training range or facility; the ability to simulate such would be an important contribution to expeditionary warfare training.

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teams (together). We were also interested in the SA of the en route SAC and of the USJFCOM HQ in Norfolk, Virginia. SA “Snapshot” forms were given to all participants and were identical to the map images (Figure 4) used on their laptop and pocket PC. The map consisted of an overview of the NPS central Quad area, bounded to the south by Spanagel Hall, to the west by Bullard Hall, to the east by Root Hall, and by a lawn area to the north. The map extended a distance around each building, and generally gave an easy-to-recognize overview of the LOE area. To aid in identification, buildings were displayed in gray, lawn areas were in green, and most campus pathways and roads were shown.

Terrorist locations were indicated by a triangle, while a black circle indicated the location of an explosive device. Team member locations were labeled with a “TM,” followed by the team number. Other important information, such as the location or number of hostages, reports of gunfire, or movement of terrorists was also reported (Figures 1 and 4).

Discoveries and Technical Findings

The following are brief descriptions of the P2P LOE findings.

- *Self-organizing Behavior:* We observed self-organizing behavior of RST members in switching modes of communication; they used voice over IP with Groove and GPS locations via the clickable maps. A strong (and unanticipated) self-organizing behavior

emerged at the LCP-NOC site; the LCP established direct communication with NOC for getting performance and fault data to synchronize voice and data sharing between RST members.

- *Bandwidth and Connectivity:* Because Groove client lacks a wireless connectivity monitor, the RSTs frequently used Orinoco client (wireless connectivity monitor) to examine wireless coverage and adjust their operations to the failing coverage. Network monitoring in NOC became useful to the RSTs and the LCP for understanding team status. Bandwidth (reported by NOC to the LCP) was a critical form of operational feedback to the team members.

- *Combining P2P with Client-Server Communications:* The LOE demonstrated that P2P and Client-Server integration is feasible, but sensitive to roaming between wireless access point coverage areas. It should be noted that application sharing is especially sensitive to roaming and mobile units drop application processing by crossing the access point boundaries with substantial packet loss.

- *Red Team Vulnerability Assessment:* The Red Team deter-

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Situational Awareness

Snapshot #3 (17:00 PST) FINEX

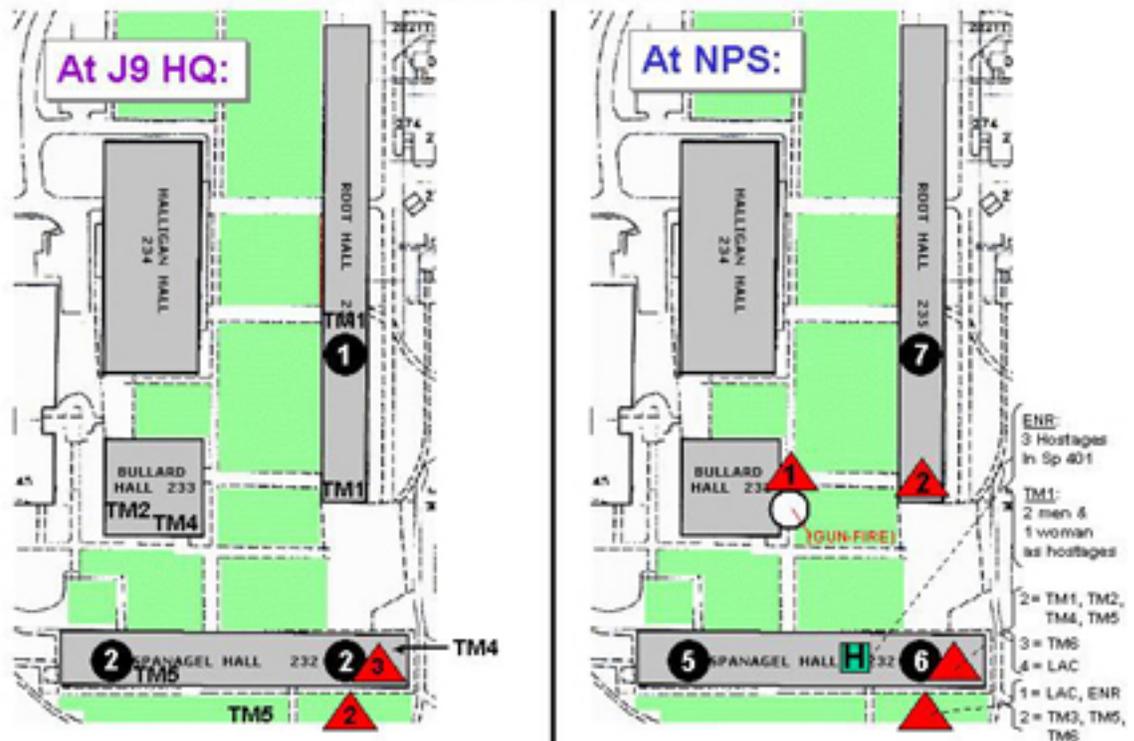


Figure 4. Situational Awareness Snapshot (15:20 PST)

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mined that object level security (e.g. in Groove) is the right product because it focuses on security of data in transit and meets the intent of draft DoD instruction on wireless security. But, security in storage is also needed. For example, the theft of an operating (logged-in) laptop by the enemy instantly breaks all security at all levels. Also, the enemy has access to the same technology and gadgets as friendly forces (i.e., consumer off the shelf products). Breaking confidentiality and authenticity is MUCH more dangerous than breaking into the network.

Conclusion

The RSTs were able to locate the enemy forces, the explosive devices, and the hostages in a manner in which the other RSTs, the LCP, and others had the same SA. Another bonus was the ability of each RST to know the location of the other RSTs – via the clickable map and GPS – without any of the teams having to verbally report their

position. The SA of all participants rapidly converged into an accurate representation of the situation.

The purpose of the LOE was to explore the use of mobile communication devices, collaborative technology, and wireless communications at the tactical level. Everyone who participated in the LOE was encouraged by the capabilities of the technologies used. The ability of the RSTs to maintain situational awareness of each other and the environment without voice communication was impressive. The strength of P2P technology, using the right applications and coupled with client-server applications, has potential. The main limitation exposed during the P2P LOE was the “heads-down” focus on the equipment instead of the environment.

The LOE demonstrated the use of mobile communication devices, collaborative, and wireless technology can be used as a combat multiplier, and further research and development is recommended.

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Future Plans

With Phase 1 of VIRTE rapidly drawing to a close, the time to study training transfer has arrived. Easy access to experienced helicopter pilots at NPS has made usability studies and feasibility studies relatively simple; but studying training transfer is another issue. We are teaming with the U.S. Naval Academy and the Naval Research Laboratory to complete this work. The plan is to construct a VEHELO apparatus at the Naval Academy, not only to involve midshipmen in the project, but also to study the system’s ability to train individuals before they enter flight school, which will provide an accurate measure of training effectiveness on untrained personnel. We will then take the system to NAS North Island, where it will be used in the training cycle of an operational helicopter squadron prior to deployment. We can then use their scheduled air-wing training at NAS Fallon as a measure of effectiveness for trained personnel.

For the CQB trainer, a variety of technical issues must be resolved; locomotion is an important example. We are working towards a reasonable abstraction to actual walking and running, short of treadmill, which we have found to be problematic in the past. The walking-in-place metaphor used by the SwRI pressure-pad device may yield a workable solution. Another critical issue is intelligent behavior in autonomous adversaries; that is, in order to train well, the system

has to support an OPFOR that behaves intelligently. Research in this field at the MOVES Institute will be tapped for the project.

Finally, we have only just begun to investigate issues surrounding combined-arms trainers. If we consider the combat-vehicles phase of VIRTE, extending forward towards interacting and engaging with ground forces, and the second phase of VIRTE, extending back from the breach point of a building into the streets of a MOUT environment, combined-arms training is where we are headed. The need appears as a massive distributed simulation that will demand area-of-interest management, peer-to-peer communications, and multiple levels of scenic detail to support the various types of participants who may be involved in a simulated event. Simulation and training researchers have been working these issues for many years, but rarely have we seen these principles put into practice in an actual training system that is subsequently evaluated for effectiveness.

VIRTE has the potential to transform the way we approach military training. Low-cost, high-fidelity deployable trainers are only as good as their ability to improve the warfighting abilities of our personnel. It is our opinion that only through programs like VIRTE can we hope to achieve radical improvements in training and bring much-needed resources to the fleet.

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