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Summary of Research 2000, Interdisciplinary
Academic Groups (Command, Control &
Communications Academic Group, Electronic
Warfare Academic Group, Space Systems
Academic Group and Undersea Warfare
Academic Group)

Faculty of the Academic Groups

Office of the Associate Provost and Dean of Research, Naval Postgraduate School.

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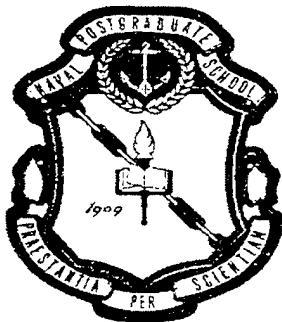
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SUMMARY OF RESEARCH 2000

Interdisciplinary Academic Groups

Command, Control, Communications, Computers, and Intelligence

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Information Systems

Dan Boger, Chair

Information Warfare

James Powell, Chair

Modeling, Virtual Environments and Simulation

Michael J. Zyda, Chair

Space Systems

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Special Operations

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Undersea Warfare

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Monterey, CA 93943-5000

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Monterey, California

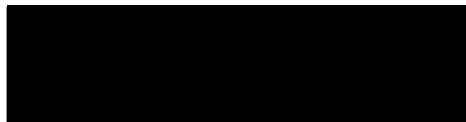
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Provost

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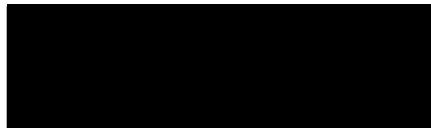
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Associate Provost and
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13. ABSTRACT (Maximum 200 words.)

This report contains project summaries of the research projects in the Interdisciplinary Academic Groups: Command, Control, Communications, Computers and Intelligence; Information Systems; Information Warfare; Modeling, Virtual Environments and Simulation; Space Systems; Special Operations; and Undersea Warfare. A list of recent publications is also included, which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports. Thesis abstracts of students advised of an interdisciplinary nature are also included.

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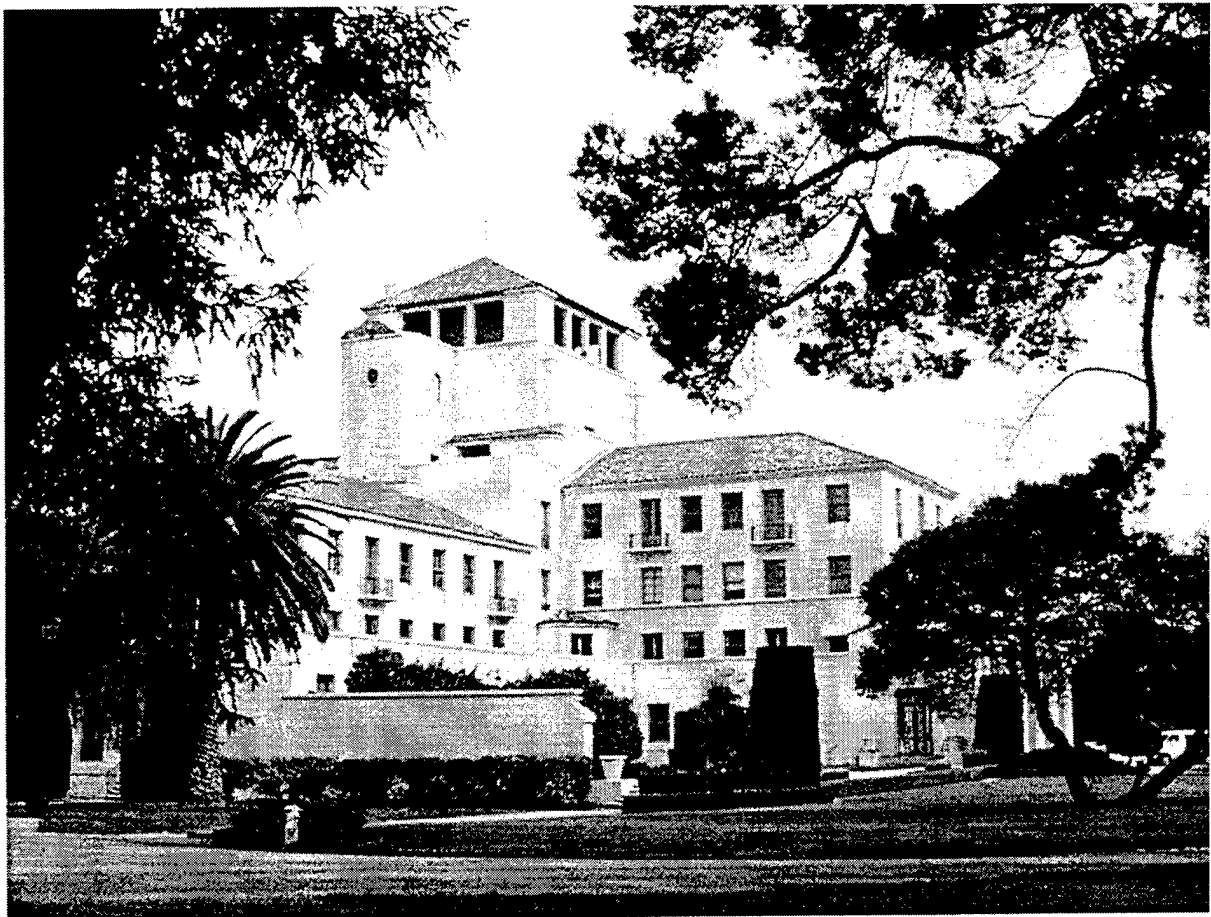


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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four graduate schools (School of International Graduate Studies, Graduate School of Operations and Information Sciences, Graduate School of Engineering and Applied Sciences, and Graduate School of Business and Public Policy) and three Research Institutes (The Modeling, Virtual Environments, and Simulation (MOVES) Institute, Institute for Information Superiority and Innovation (I2SI), and Institute for Defense System Engineering and Analysis (IDSEA). This volume contains research summaries for the projects undertaken by faculty in the Interdisciplinary Academic Groups during 2000. The summary also contains thesis abstracts by students interdisciplinary in nature during 2000.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts:* A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.
- *Naval Postgraduate School Research:* A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.
- *Summary of Research:* An annual publication containing research summaries for projects undertaken by the faculty of the Naval Postgraduate School.

This publication and those mentioned above can be found on-line at:
<http://web.nps.navy.mil/~code09/publications.html>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.
- **Naval Postgraduate School Institutionally Funded Research (NIFR) Program:** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2000, the level of research effort overall at the Naval Postgraduate School was 137 faculty work years and exceeded \$43 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2000, over 93% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2000 is provided in Figure 1.

INTRODUCTION

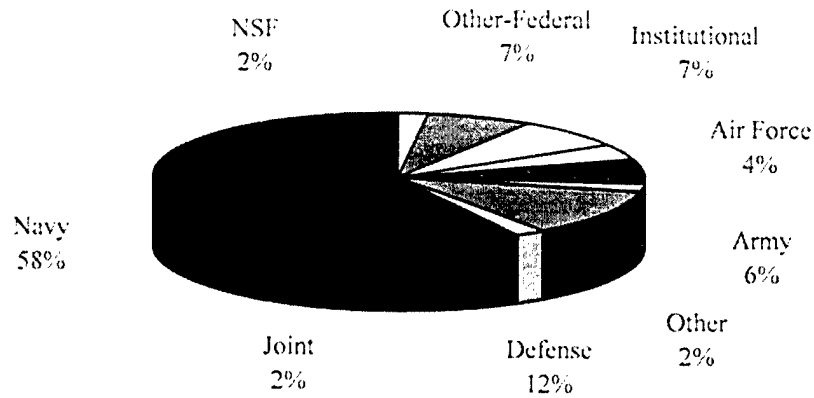


Figure 1. Profile of NPS Research and Sponsored Programs (\$43M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2000 is provided in Figure 2.

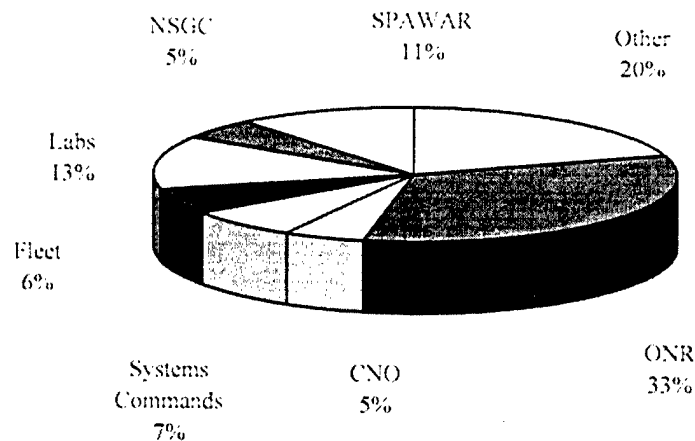


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs (\$25M)

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

December 2001

**COMMAND, CONTROL,
COMMUNICATIONS, COMPUTERS,
AND INTELLIGENCE (C4I)
ACADEMIC GROUP**

**DAN BOGER
CHAIR**

Command, Control, Communications, Computers, and Intelligence (C4I)

OVERVIEW:

The Command, Control, Communications, Computers, and Intelligence (C4I) Academic Group is an interdisciplinary association of faculty. The C4I Academic Group has responsibility for the academic content of the Joint Command, Control, Communication, Computers, and Intelligence curriculum, the Scientific and Technical Intelligence curriculum, and a C4I research program.

CURRICULUM SERVED:

- Joint Command, Control, Communications, Computers, and Intelligence Systems

DEGREES GRANTED:

- Master of Science in Systems Technology

RESEARCH THRUSTS:

- Command and Control
- Modeling and Analysis of Military Systems
- Combat Identification
- Human Systems Interface
- Threat Analysis

RESEARCH FACILITIES:

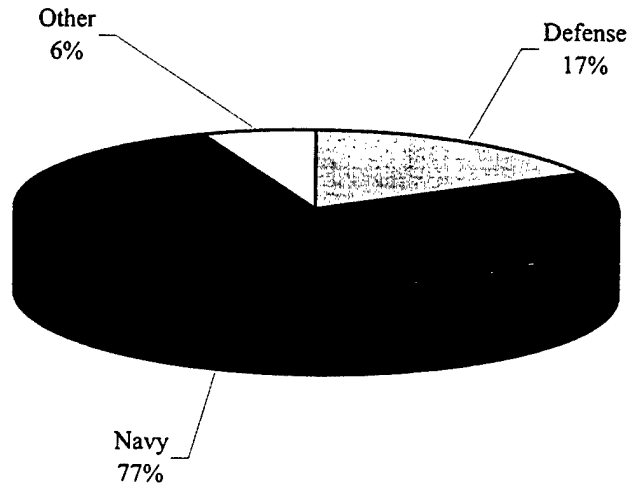
- Systems Technology Laboratories (STL): The Naval Postgraduate School Systems Technology Laboratories provide centrally managed, supported, and funded facilities where students and faculty can conduct research and instruction using tomorrow's C4I systems technologies today. The facilities provide for classified and unclassified capabilities for students and faculty to use for immediate classroom reinforcement, student projects, and theses and for faculty and students to conduct leading edge research in their fields. The labs, through advanced telecommunications and networking, allow local platforms of various types to communicate at very high data rates with each other over the Naval Postgraduate School backbone and with other national laboratories and research facilities worldwide using Internet, SIPRNET, and ATM networks, such as DARPA's Leading Edge Services ATM network, the California Research and Education Net (CALREN), Defense Research and Evaluation Net (DREN), and other wideband wide area networks that define the nation's information infrastructure. Using these capabilities, researchers can collaborate with leading researchers and can participate in systems technology research efforts of national prominence.

The Naval Postgraduate School Systems Technology Laboratories contain (or have distributed access to) actual command and control systems for exercises and experiments. The prime example of this is a fully functional CINC version of the Global Command and Control Systems (GCCS) with SECRET interconnectivity to all CINCs and supporting sites. GCCS permits CINCs to complete crisis action plans including assessment, evaluation, and development of options, as well as selection, dissemination and monitoring of execution. The STL routinely conducts experiments with humans in the loop. Operational teams of officer-students can be trained/tested-using wargames as stimuli and using data collection techniques to evaluate performance under varied, but controlled, conditions. Insights into requirements for new doctrine, training and other aspects of the joint environment may be identified that will speed the acceptance of new approaches to decision-making and training.

Command, Control, Communications, Computers, and Intelligence (C4I)

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Command, Control, Communications, Computers, and Intelligence (C4I) Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$501K

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Command, Control, Communications, Computers, and Intelligence (C4I)

CYBERTERROR

John Arquilla, Associate Professor

**Information Warfare and Command, Control, Communications, Computers, and Intelligence
Academic Group**

Sponsors: Defense Intelligence Agency and Joint Special Operations Command

OBJECTIVE: To develop strategy and doctrine for defending against or countering cyberterror.

SUMMARY: This research examines strategic and doctrinal issues across the spectrum, from cyberspace-based electronic attack to more exotic microwave and radio frequency weapons. It also examines the use of cyberspace for what might be called "combat support" functions. One classified thesis examined defensive anti-cyberterror strategies, the other focused on proactive measures that can be taken against cyberterror.

DoD KEY TECHNOLOGY AREAS: Other (Cyberterror)

KEYWORDS: Cyberterror, Cyberspace-Based, Electronic Attack

ANALYTICAL SUPPORT FOR CONVENTIONAL AMMUNITION PROGRAM

Alexander Callahan, Research Assistant Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: Naval Surface Warfare Center-Crane Division

OBJECTIVE: To provide analyst support to the Conventional Ammunition Program Office by implementing NSFS, AAW, and ASW architectures in the Naval Simulation Systems (NSS) and GCAMS. Support will include developing data sources, devising documentation methods, creating input databases, and performing analyses in support of program review.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Modeling and Simulation, Assessment

GUN WEAPONS SYSTEM COMMAND AND CONTROL PROJECT

Alexander Callahan, Research Assistant Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: Naval Surface Warfare Center-Crane Division and Dahlgren Division

OBJECTIVE: Provide gun weapon system analysis of performance and command and control to include consulting, modeling and simulation.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communication

KEYWORDS: Analysis, Modeling and Simulation

NAVAL SIMULATION SYSTEM (NSS) DEVELOPMENT AND TESTING

Alexander Callahan, Research Assistant Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: Commander-in-Chief, Pacific Fleet

OBJECTIVE: Project to provide development of scenario and operational testing of the Naval Simulation System. Scope includes planning, modeling, simulation, and analysis.

Command, Control, Communications, Computers, and Intelligence (C4I)

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Analysis, Modeling, Simulation

DEVELOPMENT OF THE HUMAN-CENTERED DESIGN ASSOCIATE FOR THE MANNING AFFORDABILITY PROJECT

Susan G. Hutchins, Research Assistant Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: Naval Air Warfare Center-Training Systems Division

OBJECTIVE: The overall purpose of this effort is to support the development of the "Human-Centered Design Associate" (HCDA), an intelligent software agent designed to provide human factors knowledge and expertise to a system designer. In particular, there are three tasks. The first task is to provide human factors guidelines to populate the database of the intelligent search agent component of the HCDA. The second task is to provide guidance in the search for additional high payoff areas within the system design process that can be supported with HCDA components. The third task is to support the testing and evaluation of each component of the HCDA. This work is part of a continuing project.

The focus for this year's effort was on an analysis of design problems found in complex military command and control systems and the ways in which these types of problems can be avoided in future system design. The source of data for this analysis was a group of case studies of forty-two U.S. military systems written by officer-students at the Naval Postgraduate School, Monterey, CA. Systems analyzed span the four military services and include aircraft systems, communications systems, the M-16 rifle, a missile defense system, and a message processing system, weapon systems, and decision support systems. Case studies of military command and control systems contain examples of the ways in which inadequate emphasis on human considerations can negatively impact overall system performance. These case studies were analyzed to provide concrete examples of the types of design problems found and where in the systems engineering process these problems could have been avoided had proper emphasis been given to human factors issues. Documented problems with system use were categorized according to the following measures of effectiveness: Performance, Safety, Usability, Reliability, Maintain-ability, Time and Cost to Train, and Workload.

SUMMARY: Support provided to accomplish project goals included the following: (1) obtaining a set of guidelines on situation awareness to be added to the database, (2) reviewing existing guidelines in the HCDA database to determine where linkages should be established to other parts of the database, i.e., where material found under one topic in the database would also be appropriate under another topic area of the database, and (3) conducting an analysis of case studies of complex military systems to determine what types of system use problems were encountered and how these problems could have been avoided had the appropriate testing been accomplished during system design.

PUBLICATIONS:

Hutchins, S.G., "Application of Naturalistic Decision Making Models to Support Command and Control Decision Making," *Proceedings of Workshop on Modeling for Command*, Royal Military College of Canada, Kingston, Ontario, Canada, 21-22 March 2000.

Hutchins, S.G. and Marvel, O.E., "Analysis of Human Factors Case Studies of Complex Military Systems: Implications for System Design," *Proceedings of the 5th International Conference on Human Interaction With Complex Systems*, 30 April-2 May 2000, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, IL, pp. 153-157.

Hutchins, S.G., "Analysis of Human Factors Case Studies of Complex Military Systems: Surely We Can Do Better," *Proceedings of the International Society of Optical Engineering*, San Diego, CA, 30 July-4 August 2000.

Command, Control, Communications, Computers, and Intelligence (C4I)

Hutchins, S.G., *Case Studies of Complex Military Systems to Illustrate Examples of Poor System Design*, Naval Postgraduate School Technical Report.

PRESENTATIONS:

Hutchins, S.G., "Application of Naturalistic Decision Making Models to Support Command and Control Decision Making," presented to the Royal Military College of Canada, Workshop on Modeling for Command, Kingston, Ontario, Canada, 21-22 March 2000.

Hutchins, S.G., Hocevar, S.P., and Kemple, W.G., "Comparison of High and Low Task Performance Via Assessment of Team Communications in a Joint Command and Control Environment," presented to the Society of Industrial and Organizational Psychologists, 14-16 April 2000, New Orleans, LA.

Hutchins, S.G. and Marvel, O.E., "Analysis of Human Factors Case Studies of Complex Military Systems: Implications for System Design," presented to the 5th International Conference on Human Interaction with Complex Systems 2000, Beckman Institute for Advanced Science and Technology, University of Illinois, IL, 30 April-2 May 2000.

Hutchins, S.G., "Human Factors Analysis of Complex Military Systems: Surely We Can Do Better," Paper presented to the International Society of Optical Engineering, San Diego, CA, 30 July-4 August 2000.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface

KEYWORDS: Human Factors, Automation, Decision Theory, Command and Control, Decision Support System, Human Systems Interface

RED CELL ANALYSIS OF DISRUPTIVE TECHNOLOGIES IDENTIFICATION OF POTENTIAL ADVERSARY SYSTEMS AND TECHNOLOGIES TO DISRUPT U.S. NAVAL OPERATIONS

John S. Osmundson, Associate Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

D. C. Schleher, Professor

Information Warfare Academic Group

Robert C. Harney, Senior Lecturer

Department of Physics

Sponsor: Naval Warfare Development Command

OBJECTIVE: Assess disruptive technologies that might be employed in the 2015 time frame to deny access to the U.S. Navy. Compare the list of disruptive technologies to and reconcile with U.S. intelligence agencies' assessments.

SUMMARY: This study was directed at identifying and analyzing commercial-off-the-shelf and readily available technologies that might be available to a U.S. adversary in the 2007 to 2015 time frame to use in a disruptive manner in an anti-access role against U.S. Naval forces. Five dimensions of battle space were considered: Surface (land and sea), subsurface (land and sea), air, space and cyberspace. Estimates were made of the probability of employment of each of the systems and technologies based on maturity of the systems and technologies, probable costs and development schedules and any other relevant factors. Previous Naval Postgraduate School student area denial study results, published lists of critical technologies, and brainstorming by Naval Postgraduate faculty and systems engineering integration (SEI) students were used as inputs to this study. The approach taken was to encourage "thinking out of the box" rather than relying on observed evidences of potential threats. Systems and technologies were evaluated in terms of their impact on U.S. forces in an anti-access mode and their probability of occurring. Systems ranked high in both impact and probability of occurrence were analyzed further, where appropriate, to determine estimates of system parameters. Twenty-four systems, technologies and attack mechanisms

Command, Control, Communications, Computers, and Intelligence (C4I)

were determined to be high risk to U.S. naval forces. Sixteen systems, technologies and attack mechanisms were found to be medium risk.

PUBLICATION:

Osmundson, J.S., "ANTI-ACCESS SYSTEMS STUDY, Identification of Potential Adversary Systems and Technologies to Disrupt US Naval Operations," Naval Postgraduate School Technical Report, NPS-IJWA-01-015, 31 January 2001.

COMBAT IDENTIFICATION TRADE STUDIES

John S. Osmundson, Associate Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: U.S. Marine Corps Systems Command

OBJECTIVE: Conduct trade studies to 1) determine whether a battlefield wireless communication system designed for command and control can also carry CID information, 2) determine fundamental CID requirements for a variety of USMC scenarios, and 3) determine requirements for joint CID interoperability.

SUMMARY: Three studies were performed at the Naval Postgraduate School under sponsorship of the U.S. Marine Corp Systems Command that address USMC combat identification (CID) issues from a systems and systems engineering perspective. In the first study USMC CID requirements for a range of combat conditions were determined and compared by analyzing computer simulations of several combat scenarios including military operations in urban terrain (MOUT.) In the second study wireless local area networks (WaveLANs) used for recent Extended Land Battlefield (ELB) advanced concept technology demonstrations were scaled, then modeled and simulated to determine their suitability to transmit CID information. Results showed that WaveLANs have the capacity to handle all expected CID information of a large-scale joint battle force, as well as meet USMC CID and other command and control needs. In the third study the interoperability of USMC CID systems with other service and coalition force CID systems was addressed. Conclusions of this study showed that there are major CID interoperability problems and that the Department of Defense is not properly organized to solve these problems.

PUBLICATIONS:

Osmundson, J.S., Arp, L.T., Parker, M.A., Stewart, K.J., and Kemple, W.G., "Scaling Analysis of Wireless Local Area Network Technology to large Scale Battlefields," accepted for publication in *Military Operations Research*, 2001.

Osmundson, J.S., Allegretti, B., Schlafer, C., and Stewart, K., "Systems Studies of U.S. Marine Corps Combat Identification Issues," *CISC 2000 Proceedings*, 12-14 September 2000, Norfolk, VA.

THESES DIRECTED:

Allegretti, B., "Situational Awareness Data Requirements for a Combat Identification Network," Masters Thesis, Naval Postgraduate School, September 2000.

Schlafer, C., "Joint Interoperability Considerations for Combat Identification (CID) Systems in Air-to-Ground Mission Area," Masters Thesis, Naval Postgraduate School, September 2000.

Stewart, K., "Impact of Including Realistic Combat Identification (CID) Requirements on a Large Scale Information System Architecture Versus the Use of a Separate CID Information System Network," Masters Thesis, Naval Postgraduate School, September 2000.

Command, Control, Communications, Computers, and Intelligence (C4I)

INVESTIGATION OF THE UTILITY OF SPACE RECONNAISSANCE AS AN AID TO COMBAT IDENTIFICATION

John S. Osmundson, Associate Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this study was to analyze the utility of space-based reconnaissance to the problem of combat identification (CID) in a joint warfighting environment. In particular the utility of space reconnaissance as a cueing system for organic battlefield combat identification (CID) systems and/or as a system to provide CID information to battlefield users was to be determined.

SUMMARY: CID scenarios were developed and analyzed for joint force operations. Analysis of scenarios indicated that a sensor system that provides positive hostile IDs over a wide battlefield would have high combat utility and that overhead sensor data is compatible with an organic information system.

The problem from a space system point of view is the requirement for real time or very near real time target recognition, implying a high level of on-board processing and the capability to directly link to a battlefield communications node at high data rates. Also, the need to use low earth orbit platforms in order to meet a 0.3 m imaging requirement combined with the lack of predictable and continuous availability of target signatures makes the use of space-based imaging systems for direct support of battlefield CID problematic.

Future CID systems may utilize unmanned air vehicles (UAVs) as an adjunct to organic GPS based organic sensor systems. A space-based system could be valuable in obtaining cueing indicators in areas behind immediate combat areas and providing cueing information to UAVs that in turn would provide positive hostile IDs to an organic CID information system. Processing and dissemination timeline requirements for a space-based cueing system would be relaxed to about 30 minutes when operating in this mode as compared to ~ 15 seconds when operating as a direct adjunct system. Also, the requirement to image to 0.3 m resolution would be relaxed as well as introducing the possibility of collecting other signature data in place of imagery.

OTHER:

Osmundson, J.J., "Investigation of the Utility of Space Reconnaissance as an Aid to Combat Identification," Report to the NRO, 10 December 1999.

ANTI-ACCESS SYSTEMS STUDY

John S. Osmundson, Associate Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

D. C. Schleher, Professor

Department of Electrical and Computer Engineering and Information Warfare Academic Group

Robert C. Harney, Senior Lecturer

Department of Physics

Sponsor: Naval Warfare Development Command

OBJECTIVE: To determine systems and technologies that may pose disruptive threats to U. S. Naval forces when the systems and technologies are used in a mode whose function is to deny U. S. forces access to land and ocean areas.

SUMMARY: A large number of technologies and systems were examined for their potential to provide a disruptive influence on the capability of U. S. Navy forces to exert sea and area control and power projection in the Littoral region. Systems were ranked relative to their impact and likelihood of occurrence while risk was determined as the product of these factors. Twenty-four systems ranked high in both impact and likelihood, sixteen systems exhibited medium risk while seventeen systems were ranked as low risk. Technology and disruptive systems were generally categorized into delivery systems, logistics, attack mechanisms, counter measures, sensors, weapon types and cyber warfare. In addition, sixteen disruptive

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systems are described in detail. These include High Energy Laser Weapons, Naval Glide Bombs, GPS Jamming, Microwave Weapons, Mini and Micro Air Vehicles, and Unmanned Combat Air Vehicles.

DoD KEY TECHNOLOGY AREAS: Other (Disruptive Technologies)

KEYWORDS: Area Access Denial, Disruptive Technology, Threats

**COMMAND, CONTROL,
COMMUNICATIONS, COMPUTERS,
AND INTELLIGENCE (C4I)
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

Command, Control, Communications, Computers and Intelligence (C4I)

CONFERENCE PAPERS

Hutchins, S.G., "Application of Naturalistic Decision Making Models to Support Command and Control Decision Making," *Proceedings of Workshop on Modeling for Command*, Royal Military College of Canada, Kingston, Ontario, Canada, 21-22 March 2000.

Hutchins, S.G. and Marvel, O.E., "Analysis of Human Factors Case Studies of Complex Military Systems: Implications for System Design," *Proceedings of the 5th International Conference on Human Interaction With Complex Systems*, 30 April-2 May 2000, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana, Champaign, IL, pp. 153-157.

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Osmundson, J.S., Allegretti, B., Schlafer, C., and Stewart, K., "Systems Studies of U.S. Marine Corps combat Identification Issues," *CISC 2000 Proceedings*, 12-14 September 2000, Norfolk, VA.

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Hutchins, S.G., "Application of Naturalistic Decision Making Models to Support Command and Control Decision Making," Royal Military College of Canada, Workshop on Modeling for Command, Kingston, Ontario, Canada, 21-22 March 2000.

Hutchins, S.G., Hocevar, S.P., and Kemple, W.G., "Comparison of High and Low Task Performance Via Assessment of Team Communications in a Joint Command and Control Environment," Society of Industrial and Organizational Psychologist, 14-16 April 2000, New Orleans, LA.

Hutchins, S.G. and Marvel, O.E., "Analysis of Human Factors Case Studies of Complex Military Systems: Implications for System Design," 5th International Conference on Human Interaction with Complex Systems 2000, Beckman Institute for Advanced Science and Technology, University of Illinois, IL, 30 April-2 May 2000.

Hutchins, S.G., "Human Factors Analysis of Complex Military Systems: Surely We Can Do Better," International Society of Optical Engineering, San Diego, CA, 30 July-4 August 2000.

Osmundson, J.S., Allegretti, B., Schlafer, C., and Stewart, K., "Systems Studies of U.S. Marine Corps Combat Identification Issues," *CISC 2000*, 12 September 2000, Norfolk, VA.

TECHNICAL REPORTS

Hutchins, S.G., "Case Studies of Complex Military Systems to Illustrate Examples of Poor System Design," Naval Postgraduate School Technical Report, Monterey, CA.

Osmundson, J.S., "Investigation of the Utility of Space Reconnaissance as an Aid to Combat Identification," Report to the NRO, 10 December 1999.

**INFORMATION SYSTEMS
ACADEMIC GROUP**

**DAN BOGER
CHAIR**

INFORMATION SYSTEMS

OVERVIEW:

The Information Systems (IS) Academic Group is an interdisciplinary association of faculty interested in problems associated with defense information systems. The IS Academic Group has responsibility for the academic content of the Information Systems Technology curriculum and a research program in information systems.

CURRICULA SERVED:

- Information Systems Technology
- Information Systems and Operations

DEGREES GRANTED:

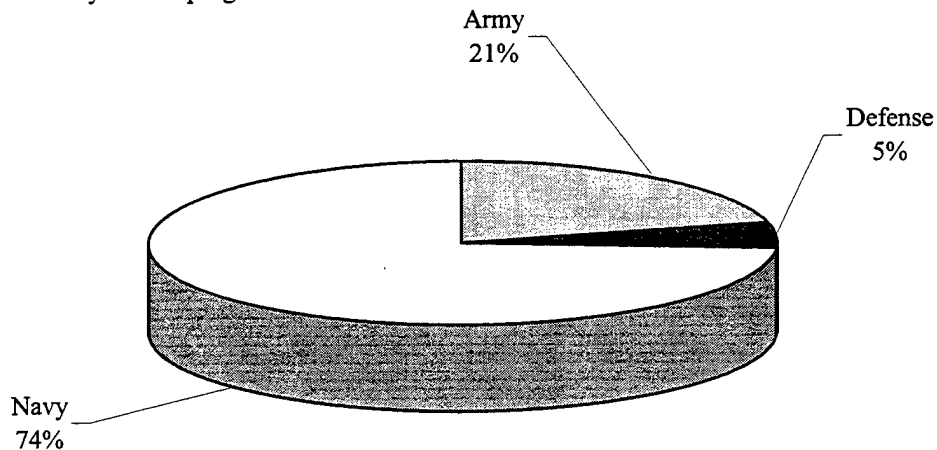
- Master of Science in Information Systems and Operations
- Master of Science in Information Technology Management

RESEARCH THRUSTS:

- Software Metrics and Maintenance
- IT Architectures
- Computer Networks
- Decision Support Systems
- Knowledge Management

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Information Systems Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$448K

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IT ARCHITECTURE SUPPORT FOR DON CIO

Rex Buddenberg, Senior Lecturer

Information Systems Academic Group

Sponsor: Department of the Navy Chief Information Officer

OBJECTIVE: Provide support for DON CIO efforts including architecture development, hosting IPTs and various networking initiatives.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communication

KEYWORDS: IT Architecture

INTEROPERABILITY, ARCHITECTURE, AND PLANNING SUPPORT TO SSC CHARLESTON

Rex Buddenberg, Senior Lecturer

Information Systems Academic Group

Sponsor: Space and Naval Warfare Systems Center-Charleston

OBJECTIVE: To provide support for the fleet NOC and related projects

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: IT Architecture

SIMARMY/MANPOWER LEADERSHIP (SAMPLE): A PERSONNEL BATTLEFIELD DECISION SUPPORT SYSTEM FOR MANPOWER POLICY ANALYSIS

Daniel R. Dolk, Professor

Information Systems Academic Group

Sponsor: U. S. Army Center for Land Warfare

OBJECTIVE: Develop and conduct a business war game for the U.S. Army manpower community to study the effects of various decision policies on intra - and inter-agency connectivity.

SUMMARY: This project was conducted in team ship with Purdue University, using their Synthetic Environment for Analysis and Simulation (SEAS) platform to build a business war game for U.S. Army manpower agencies. A proof-of-concept exercise called Firm Handshake was built for the following Army teams: Force and Policy Structure, Recruiting, Retention, and Training. The one-day exercise was conducted in the WAIC in Arlington, VA on 27 January 2000. Despite numerous hardware and software incompatibilities between Purdue's and WAIC's configurations, the to play enough of the game to see what benefits were available. Primary amongst those were the ability to see how other teams thought and strategized, and the ability to see what conflict and coordination points arose amongst teams in the process of implementing various decision policies. The U.S. Army Recruiting Command (USAREC) subsequently has funded a complete business war game for studying their recruiting policies.

THESIS DIRECTED:

Zimmerman, J., "Business Wargaming: Applications for Marine Corps Manpower Policy Decisions," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Agent-based Simulation, Business Wargame

INFORMATION SYSTEMS

SIMMANPOWER/POLICY (SMP): A BUSINESS WARGAME SYSTEM FOR USMC MANPOWER POLICY ANALYSIS

Daniel R. Dolk, Professor
Information Systems Academic Group
Sponsor: U. S. Marine Corps

OBJECTIVE: Develop and conduct a business war game for the U.S. Marine Corps manpower community to study the effects of various decision policies on intra- and inter-agency connectivity.

SUMMARY: This project was conducted in team ship with Purdue University, using their Synthetic Environment for Analysis and Simulation (SEAS) platform to build a business war game for U.S. Marine Corps manpower agencies. A proof-of-concept exercise called SimMarineCorps was built for the following Marine Corps teams: Force and Policy Structure, Recruiting, Retention and Staffing, and Training. The one-day exercise was conducted USMC Headquarters in Quantico, VA on 27-28 October 2000. Despite numerous hardware and software incompatibilities between Purdue's and USMC's configurations, the participants were able to play enough of the game to see what benefits were available. Primary amongst those were the ability to see how other teams thought and strategized, and the ability to see what conflict and coordination points arose amongst teams in the process of implementing various decision policies. USMC will observe progress on the USAREC war game exercise before deciding to what extent they want to pursue further development of this technology.

THESIS DIRECTED:

Zimmerman, J., "Business Wargaming: Applications for Marine Corps Manpower Policy Decisions," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Agent-based Simulation, Business Wargame

A PERSONNEL MEASUREMENT SYSTEM FOR PERSONNEL ACCOUNTING INVENTORY AND NEC REUTILIZATION TRACKING (PAINT)

Daniel R. Dolk, Professor
Information Systems Academic Group
Sponsor: Naval Personnel Command

OBJECTIVE: Develop a data warehouse-driven system for analyzing multidimensional data pertaining to reutilization of Navy enlisted personnel.

SUMMARY: We developed a single user OLAP application for the Aviation Enlisted Community Manager (PERS-404) to investigate NEC reutilization statistics for enlisted personnel with aviation-related NEC designators. The first step was to build a Microsoft Access database extract of the Enlisted Master File. We then used Cognos Transformer and Powerplay products to construct three different data cubes related to NEC reutilization. Each cube contained a different definition of NEC reutilization. With the cubes built, the ECM was able to "browse" through data in a multidimensional way that previously required a month or more of manual work to accomplish.

THESIS DIRECTED:

Conde, D.J. and Crownover, C. A., "Towards Reengineering the United States Navy Manpower and Personnel Systems - A Data Warehouse Approach," Masters Thesis, Naval Postgraduate School, March 2000.

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DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: OLAP, NEC, Reutilization, Datacube

USAREC RECRUITING STRATEGIC VISION PROGRAM (RSVP) WARGAME SIMULATION FOR STRATEGIC PLANNING AND DECISION SUPPORT

Daniel R. Dolk, Professor

Information Systems Academic Group

Sponsor: U. S. Army Recruiting Command

OBJECTIVE: This is a two-part project: (1) Create and conduct a reusable, multi-player business war game simulation for the U.S. Army recruiting leadership. The purpose of this simulation is to explore strategic planning dimensions of the recruiting organization in the Army. (2) Develop a recruit market simulation allowing USAREC to "test drive" new recruitment products without having to conduct expensive national tests.

SUMMARY: Part 1 of this project is in progress. Scenarios, players, agents, and agent attributes have been identified, and Web-based software interfaces are under development. Databases are being mined for computing the necessary behavior utility functions for each agent type. The simulation exercise is scheduled for delivery during August 2001. Part 2 of the project will be initiated during the summer of 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Agent-based Simulation, Business War Game

KNOWLEDGE DISCOVERY AND DATA MINING FOR SPACE-BASED RECONNAISSANCE

Magdi N. Kamel, Associate Professor

Information Systems Academic Group

Sponsor: Center for Reconnaissance Research

OBJECTIVE: The overall objective of this research is to conduct a detailed survey of knowledge discovery and data mining techniques, identify those techniques that are relevant for space-based reconnaissance, and propose formal techniques for selecting optimal knowledge discovery and data mining techniques from available alternatives.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Knowledge Discovery, Data Mining, Data Visualization

DEVELOPMENT OF AN ADVANCED PROOF-OF-CONCEPT WORLD WIDE WEB PROTOTYPE APPLICATION FOR ONLINE RECRUITING

Magdi N. Kamel, Associate Professor

Information Systems Academic Group

Sponsor: Office of the Secretary of Defense and U.S. Military Entrance Processing Command

OBJECTIVE: The objective of this research is to develop and advanced proof-of-concept World Wide Web prototype application to support prospecting, attracting, screening, closing the sale, and processing of new Navy recruits.

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SUMMARY: The effort for the current reporting period included completing the following tasks:

- Analysis and design of the main components and features
- Development of a planning, requirements specifications, and design document
- Setting up staffing, operating an in-house web research and application development lab

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Application Development, World Wide Web, Internet, Prototyping, e-business, Military Recruiting

REQUIREMENTS SPECIFICATIONS AND ARCHITECTURE FOR A WORLD WIDE WEB PROTOTYPE APPLICATION FOR ONLINE RECRUITING

Magdi N. Kamel, Associate Professor
Information Systems Academic Group
Sponsor: Defense Logistics Agency

OBJECTIVE: The objective of this research is to develop the requirements specifications and architecture for a World Wide Web prototype application for online recruiting to attract and encourage young people to learn about, explore, and apply for Navy jobs compatible with their interests, work values, and qualifications in an appealing, exciting, comfortable, and reliable environment.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Application Development, World Wide Web, Internet, E-Commerce, Military Recruiting

SOFTWARE QUALITY CONTROL AND PREDICTION MODEL

Norman Schneidewind, Professor
Information Systems Academic Group
Sponsor: Jet Propulsion Laboratory

OBJECTIVE: Develop a Quality Control and Prediction Model.

SUMMARY: We develop a quality control and prediction model for improving the quality of software delivered by development to maintenance. This model identifies modules that require priority attention during development and maintenance by using Boolean discriminant functions. The model also predicts during development the quality that will be delivered to maintenance by using both point and confidence interval estimates of quality. We show that it is important to perform a marginal analysis when making a decision about how many metrics to include in a discriminant function. If many metrics are added at once, the contribution of individual metrics is obscured. In addition, the marginal analysis provides an effective rule for deciding when to stop adding metrics. We also show that certain metrics are dominant in their effects on classifying quality and that additional metrics are not needed to increase the accuracy of classification. Related to this property of dominance is the property of concordance, which is the degree to which a set of metrics produces the same result in classifying software quality. A high value of concordance implies that additional metrics will not make a significant contribution to accurately classifying quality; hence, these metrics are redundant. Data from the Space Shuttle flight software are used to illustrate the model process.

PUBLICATIONS:

Schneidewind, N.F., "Investigation of Logistic Regression as a Discriminant of Software Quality," *Proceedings of the 7th International Software Metrics Symposium*, London, England, 4-6 April 2001, 10 pp.

INFORMATION SYSTEMS

Schneidewind, N.F., "Data Analysis of Software Requirements Risk," *Proceedings of the European Software Control and Metrics*, 2-4 April 2001, London, England, 10 pp.

Schneidewind, N.F., "Software Maintenance," in *Encyclopedia of Computer Science*, 4th ed. Anthony Ralston, Edwin D. Reilly, David Hemmendinger, eds., Pub: Nature Publishing Group, London (ISBN 0-333-77879-0); Grove's Dictionaries, USA, 2000, pp. 1624-1627.

Schneidewind, N.F. and Sahinoglu, M., Tutorial Notes, "New Advances in Software Reliability Modeling," *Proceedings of The Fifth Biennial World Conference on Integrated Design and Process Technology*, Dallas, TX, 6 June 2000.

Schneidewind, N.F., "Software Quality Control and Prediction Model for Maintenance," *Annals of Software Engineering*, Baltzer Science Publishers, May 2000, pp. 79-101.

PRESENTATIONS:

Schneidewind, N.F., "Investigation of Logistic Regression as a Discriminant of Software Quality," 7th International Software Metrics Symposium, London, England, 4-6 April 2001.

Schneidewind, N.F., "Data Analysis of Software Requirements Risk," European Software Control and Metrics, London, England, 2-4 April 2001.

Schneidewind, N.F., "The Interaction of Software Reliability Engineering (SRE) and Maintenance: Opportunities for Collaboration and Integration," International Symposium on Software Reliability Engineering and International Conference on Software Maintenance, San Jose, CA, 11 October 2000.

Schneidewind, N.F. and Sahinoglu, M., "New Advances in Software Reliability Modeling," The Fifth Biennial World Conference on Integrated Design and Process Technology, Dallas TX, 6 June 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Software Metrics; Software Maintenance; Modeling

ON THE REPEATABILITY OF METRIC MODELS AND METRICS ACROSS SOFTWARE BUILDS

Norman Schneidewind, Professor

Information Systems Academic Group

Sponsor: National Aeronautics and Space Administration-Jet Propulsion Laboratory

OBJECTIVE: Investigate whether models and metrics are being repeatable across the builds of a software system.

SUMMARY: Over the past several years we have developed the following metrics models: Boolean discriminate functions (BDFs) for classifying quality; Kolmogorov-Smirnov distance for estimating metric critical values; various derivative calculations for assessing the quality that could be achieved with various levels of quality control and inspection; a stopping rule for deciding how many metrics to use in a discriminate function; point and confidence interval estimates of quality; Relative Critical Value Deviation metrics for indexing quality; and non-linear regression functions for predicting quality. We would like these models and metrics to be repeatable across the n builds of a software system. The great advantage of repeatability is that models and metrics only need to be developed and validated once on build 1 and then applied $n-1$ times without modification to subsequent builds, with considerable savings in analysis and computational effort. In practical terms, this approach involves using the same model parameters (e.g., metrics critical values) that were validated and applying them unchanged on subsequent builds. The disadvantage is that the quality and metrics data of builds 2,..., n , which varies across builds, is not utilized. We make a comparison of this approach with one that involves validating models and metrics on each build

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i and applying them only on build i+1, and then repeating the process. The advantage of this approach is that all available data are used in the models and analysis but at considerable cost in effort. We report on experiments involving large sets of discrepancy report and metrics data on the Space Shuttle flight software, where we compare the predictive accuracy and effort of the two approaches for BDFs, critical values, derivative quality and inspection calculations, and stopping rule.

PUBLICATIONS:

Schneidewind, N. F., "The Interaction of Software Reliability Engineering (SRE) and Maintenance: Opportunities for Collaboration and Integration," *Proceedings of Industry Day, International Symposium on Software Reliability Engineering and International Conference on Software Maintenance*, digital, San Jose, CA, 11 October 2000, pp. 121-122.

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Schneidewind, N. F., Tutorial Notes, "Measuring and Evaluating the Development and Maintenance Process Using Reliability, Risk, Test, and Complexity Metrics," Eleventh International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Los Alamitos, CA, 8-10 October 2000, 30 pp.

PRESENTATIONS:

Schneidewind, N. F., Tutorial Notes, "Introduction to Software Reliability with Space Shuttle Example," 2001 Reliability and Maintainability Symposium, IEEE Reliability Society, Philadelphia, PA, 23 January 2001, 29 pp.

Schneidewind, N. F., Tutorial, "Introduction to Software Reliability with Space Shuttle Example," 2001 Reliability and Maintainability Symposium, IEEE Reliability Society, Philadelphia, PA, 23 January 2001.

Norman F. Schneidewind, N. F., Tutorial, "Measuring and Evaluating the Development and Maintenance Process Using Reliability, Risk, Test, and Complexity Metrics," Eleventh International Symposium on Software Reliability Engineering, 8 October 2000, San Jose, CA.

Schneidewind, N. F., "Can Metrics be Applied Across a Set of Releases or Sites?," The International Workshop on Empirical Studies of Software Maintenance '2000, San Jose, CA, 14 October 2000.

Schneidewind, N. F., "The Interaction of Software Reliability Engineering (SRE) and Maintenance: Opportunities for Collaboration and Integration," Industry Day, International Symposium on Software Reliability Engineering and International Conference on Software Maintenance, digital, San Jose, CA, 11 October 2000.

Schneidewind, N. F., "On the Repeatability of Metric Models and Metrics Across Software Builds," Eleventh International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Los Alamitos, CA, 8-10 October 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Software Metrics, Software Maintenance, Modeling

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DEVELOPING THE NEXT GENERATION IEEE DEPENDABILITY STANDARD: IEEE 982 STANDARD DICTIONARY OF MEASURES OF THE SOFTWARE ASPECTS OF DEPENDABILITY

Norman Schneidewind, Professor
Information Systems Academic Group
Sponsor: IEEE Standards Board

SUMMARY: This first phase of the project involves the development of measures to address reliability, maintainability, and availability. The second phase will address security, integrity, and confidentiality. This standard builds upon the IEEE 982.1 Standard Dictionary of Measures to Produce Reliable Software and the companion 982.2 Guide, but will delete outdated measures, modernize the standard with object-oriented measures, and modify measures where appropriate. Because 982 was originally issued in 1988 and has not been revised since then, much of it is obsolete. Thus, there is the need to both update existing measures and to include new measures that reflect developments in software technology since 1988. In revising 982, we are following the recommendations of the IEEE Software Reliability Standards Planning Group as follows:

- Provide specific criteria on how a measure is chosen for inclusion in the dictionary (e.g., some minimum number of recognized uses, validation of a measure with respect to quality factors, or demonstrated or potential utility of the measure in producing reliable software).
- Perform a measure-by-measure review of the items in the dictionary using the stated criteria.
- Identify and incorporate, where appropriate, new measures that have appeared since the original document (e.g., object-oriented, architectural design, process).
- Formulate, where possible, generic measure classes and categorize the existing 982 measure as well as newly defined measures into these classes. The goal of this exercise is to reduce the number of document sections. Example measure classes may be complexity, process, reliability, risk, etc.
- Address major negative comments from the reaffirmation ballot held in 1995.
- Integrate 982 with ISO/IEC 9126 Views of Software Quality and Evaluation Process Model.

PRESENTATION:

Schneidewind, N. F., Tutorial Notes, "A Roadmap To Distributed Client-Server Software Reliability Engineering," Quality Week 2000, San Francisco, CA, 30 May 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Standards, Software Reliability

THE RUTHLESS PURSUIT OF THE TRUTH ABOUT COTS

Norman Schneidewind, Professor
Information Systems Academic Group
Sponsor: National Aeronautics and Space Administration-Jet Propulsion Laboratory

OBJECTIVE: Develop a realistic model COTS acquisition and deployment.

SUMMARY: We expose some of the truths about COTS, discounting some exaggerated claims about the applicability of COTS, particularly with regard to using COTS in safety critical systems. Although we agree that COTS has great potential for reduced development and maintenance time and cost, we feel that the advocates of COTS have not adequately addressed some critical issues concerning reliability, maintainability, availability, requirements risk analysis, and cost. Thus, we illuminate these issues, suggesting solutions in cases where solutions are feasible and leaving some questions unanswered because it appears that the questions cannot be answered due to the inherent limitations of COTS. These limitations are present because there is inadequate visibility and documentation of COTS components.

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PUBLICATION:

Schneidewind, N. F., "The Ruthless Pursuit of the Truth about COTS," *Proceedings of the North Atlantic Treaty Organization, Commercial-Off-The-Shelf Products in Defense Applications*, Information Systems Technology Panel (IST), Brussels, Belgium, 3-5 April 2000, pp. 17-1-17-9.

PRESENTATION:

Schneidewind, N. F., "The Ruthless Pursuit of the Truth about COTS," North Atlantic Treaty Organization, Commercial Off-The-Shelf Products In Defense Applications, Information Systems Technology Panel (IST), Brussels, Belgium, 3-5 April 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: COTS, Software Cost, Reliability, Maintainability, Availability

**INFORMATION SYSTEMS
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

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JOURNAL PAPERS

Kitchenham, B. and Schneidewind, N., "Towards an Ontology of Software Maintenance," *Journal of Software Maintenance: Research and Practice*, Vol. 11, 1999, pp. 365-389.

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Nissen, M., Kamel, M., and Sengupta, K., "A Framework for Integrating Knowledge Process and System Design," *Information Strategy*, Vol. 16, No. 4, pp. 17-27, Summer 2000.

Schneidewind, N.F., "Model Integration in the Data Warehouse Era," *European Journal of Operations Research*, 122, 2 April 2000, pp. 199-218.

Schneidewind, N., "Measuring and Evaluating Maintenance Process Using Reliability, Risk, and Test Metric," *IEEE Transactions on Software Engineering*, Vol. 25, No. 6, November/December 1999, pp. 769-781.

Schneidewind, N.F., "Software Quality Control and Prediction Model for Maintenance," *Annals of Software Engineering*, Baltzer Science Publishers, Vol. 9, May 2000, pp. 79-101

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Ceruti, M., Kamel, M., and Thuraisingham, B., "Restricting Search Domains to Refine Data Analysis in Semantic-Conflict Identification," *Proceedings of the 17th Annual Federal Database Colloquium*, Database '00, San Diego, CA, pp. 211-218, September 2000.

Nissen, M., Kamel, M., and Sengupta, K., "Toward Integrating Knowledge Management, Processes and Systems: A Position Paper," *Proceedings of the 2000 AAAI Spring Symposium on Bringing Knowledge to Business Processes*, pp. 22-29, Palo Alto, CA, 20-22 March 2000.

Schneidewind, N.F., "The Interaction of Software Reliability Engineering (SRE) and Maintenance: Opportunities for Collaboration and Integration," *Proceedings of Industry Day, International Symposium on Software Reliability Engineering and International Conference on Software Maintenance*, digital, San Jose, CA, 11 October 2000, pp. 121-122.

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Schneidewind, N. and Nikora, A., "Predicting Deviations In Software Quality By Using Relative Critical Value Deviation Metrics," *Proceedings of the 10th International Symposium on Software Reliability Engineering*, Boca Raton, FL, 1-4 November 1999, pp. 136-146.

Schneidewind, N., "Investigation of the Risk to Software Reliability of Requirements Changes," *Proceedings of the 1999 NASA Workshop on Risk Management*, Morgantown, WV, 28-29 October 1999.

Schneidewind, N., "Reliability Modeling for Safety Critical Software," *Proceedings of the 12th Annual Software Technology Conference*, Salt Lake City, UT, 30 April-5 May 2000.

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Schneidewind, N.F., (with Dave Castillo, Don Kridel, and Erica Savka), "Decision Technologies for Telecommunications," *Proceedings of the 13th Biennial Meetings of the International Telecommunications Society*, Buenos Aires, Argentina, 1-5 July 2000.

CONFERENCE PRESENTATIONS

Kamel, M., "Data Management for Fleet Battle Experiments," Evolving the Practice of Military Operations Analysis in DoD Workshop, Military Operations Research Society (MORS), Monterey, CA, 28 February-3 March 2000.

Schneidewind, N.F., "The Interaction of Software Reliability Engineering (SRE) and Maintenance: Opportunities for Collaboration and Integration," International Symposium on Software Reliability Engineering and International Conference on Software Maintenance, San Jose, CA, 11 October 2000.

Schneidewind, N.F. and Sahinoglu, M., "New Advances in Software Reliability Modeling," The Fifth Biennial World Conference on Integrated Design and Process Technology, Dallas TX, 6 June 2000.

Schneidewind, N.F., "Can Metrics be Applied Across a Set of Releases or Sites?" The International Workshop on Empirical Studies of Software Maintenance '2000, San Jose, CA, 14 October 2000.

Schneidewind, N., "Cost Framework for COTS Evaluation," COMPSAC 99, Phoenix, AZ, 27 October 1999.

Schneidewind, N., "Predicting Deviations in Software Quality By Using Relative Critical Value Deviation Metrics," 10th International Symposium on Software Reliability Engineering, Boca Raton, FL, 1-4 November 1999.

Schneidewind, N., "Investigation of the Risk to Software Reliability of Requirements Changes," 1999 NASA Workshop on Risk Management, Morgantown, WV, 28-29 October 1999.

Schneidewind, N.F., "On the Repeatability of Metric Models and Metrics Across Software Builds," Eleventh International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Los Alamitos, CA, 8-10 October 2000.

Schneidewind, N.F., "The Ruthless Pursuit of the Truth about COTS," North Atlantic Treaty Organization, Commercial-Off-The-Shelf Products in Defense Applications, Information Systems Technology Panel (IST), Brussels, Belgium, 3-5 April 2000.

CONTRIBUTIONS TO BOOKS

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TECHNICAL REPORTS

Colon, K., Kamel, M., and Sengupta K., "Development of a Prototype Relational Database System for Managing Fleet Battle Experiment Data," Naval Postgraduate School Technical Report, NPS-IJWA-01-006, October 2000.

INFORMATION SYSTEMS

Kamel, M., "Knowledge Discovery and Data Mining for Space-based Reconnaissance," Naval Postgraduate School Technical Report, NPS-IS-00-001, June 2000.

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Schneidewind, N.F. and Sahinoglu, M., Tutorial Notes, "New Advances in Software Reliability Modeling," *Proceedings of The Fifth Biennial World Conference on Integrated Design and Process Technology*, Dallas TX, 6 June 2000.

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Schneidewind, N.F., Tutorial, "A Roadmap to Distributed Client-Server Software Reliability Engineering," Quality Week 2000, San Francisco, CA, 30 May 2000.

Schneidewind, N.F. and Sahinoglu, M., Tutorial, "New Advances in Software Reliability Modeling," The Fifth Biennial World Conference on Integrated Design and Process Technology, Dallas, TX, 6 June 2000.

Schneidewind, N. F., Tutorial Notes, "Measuring and Evaluating the Development and Maintenance Process Using Reliability, Risk, Test, and Complexity Metrics," Eleventh International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Los Alamitos, CA, 8-10 October 2000.

**INFORMATION WARFARE
ACADEMIC GROUP**

**JAMES POWELL, CAPT, USN
CHAIR**

INFORMATION WARFARE

OVERVIEW:

The Information Warfare Academic Group is an interdisciplinary group of faculty representing various academic disciplines. The Group has administrative responsibility for the academic content of the Information and Electronic Warfare curricula. Teaching in this multidisciplinary program is carried out by faculty members attached to the following academic departments or interdisciplinary group: Computer Science, Command, Control, Communications, Computers, and Intelligence, Electrical and Computer Engineering, Mathematics, Operations Research, and Physics.

CURRICULA SERVED:

- Information Systems Technology
- Information Warfare
- Electronic Warfare Systems International

DEGREES GRANTED:

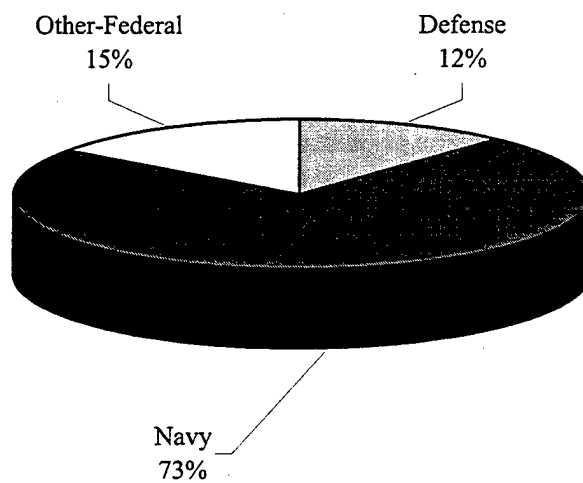
- Master of Science in Systems Engineering
- Master of Science in Systems Technology

RESEARCH THRUSTS:

- Information Warfare
- Information Superiority
- Information Operations

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Information Warfare Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$344K

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INFORMATION WARFARE

CHINESE VIEWS OF INFORMATION WARFARE

John Arquilla, Associate Professor

Information Warfare Academic Group

Sponsors: Office of the Secretary of Defense and Defense Information Agency

OBJECTIVE: Explore the manner in which China is conceptualizing conflict in the information age.

SUMMARY: Both the information developed in the course of this study and the inferences drawn from it are classified, now in a code-word program. Two classified monographs have been delivered to the sponsors as of this writing.

THESIS DIRECTED:

Lee, D., "Command, Control, and the Defense of Taiwan," Master Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Other (Information Warfare)

KEYWORDS: Information Age, China

CYBERTERROR

John Arquilla, Associate Professor

Information Warfare Academic Group

Sponsors: Defense Information Agency and Joint Security Operations Command

OBJECTIVE: To develop strategy and doctrine for defending against or countering cyberterror.

SUMMARY: This research examines strategic and doctrinal issues across the spectrum, from cyberspace-based electronic attack to more exotic microwave and radio frequency weapons. It also examines the use of cyberspace for what might be called "combat support" functions. One classified thesis examined defensive anti-cyberterror strategies, the other focused on proactive measures that can be taken against cyberterror.

DoD KEY TECHNOLOGY AREAS: Other (Cyberterror)

KEYWORDS: Cyberterror, Cyberspace-Based

DETECTING REGIONAL AGGRESSORS

John Arquilla, Associate Professor

Information Warfare Academic Group

Sponsor: Deputy Chief of Staff for Operations

OBJECTIVE: Provide support for the national military strategy of being able to wage two major theater wars nearly simultaneously.

SUMMARY: The project consisted of developing a framework for deterring multiple adversaries, then working with regional CINCs to implement the information operations that would support the strategies developed. The work was briefed both to regional CINCs and to the NCA, whose approval was required for the work to be undertaken. A Top Secret code-word level report was prepared for the sponsor.

DoD KEY TECHNOLOGY AREAS: Other (Military Strategy)

KEYWORDS: Theater WARS, Deterrence, Military Strategy

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THE ILLICIT SMALL/LIGHT WEAPONS TRADE

**John Arquilla, Associate Professor
Information Warfare Academic Group
Sponsor: Defense Information Agency**

SUMMARY: This was a case study of a particular country's involvement in the abovementioned trade. This work was briefed to the sponsor, as well as to the State Department ambassador in charge of this problem. This has resulted in a course of action being developed to deal with the country in question. A Top Secret code-word level report was prepared for DIA.

DoD KEY TECHNOLOGY AREAS: Other (National Security)

KEYWORDS: Weapons Trade

RESEARCH AND ANALYSIS OF TERRORIST INFORMATION OPERATIONS (RATIO)

**John Arquilla, Associate Professor
Information Warfare Academic Group
Sponsors: Defense Information Agency and Joint Security Operation Command**

SUMMARY: This program undertakes a variety of research tasks on behalf of the sponsors, extending to: study of the information technology acquisition patterns of a number of terrorist groups; maintenance of a database of cyber-terror incidents, as well as tools and devices; and field study of former terror group members. In FY 00, seven technical reports prepared under the auspices of the Center for the Study of Terrorism and Irregular Warfare were submitted to the sponsors, along with a comprehensive database of incidents of cyberterror and related tools and devices.

DoD KEY TECHNOLOGY AREAS: Other (Terrorism)

KEYWORDS: Irregular Warfare, Information Technology Acquisition

NPS STUDENT AND FACULTY HIGH POWER MICROWAVE RESEARCH

**CAPT James Powell, USN, Military Faculty
Information Warfare Academic Group
Sponsor: Naval Research Laboratory**

OBJECTIVE: The purpose of this research is to continue development of high power microwave (HPM) and Ultra-Wideband (UWB) technology and capabilities research at the Naval Postgraduate School including source and systems engineering and design, modeling and simulation, and effects testing. This work will have application to ship defense, Information Warfare/Information Operations (IW/IO), and suppression of enemy air defenses (SEAD). Deliverables will include these and NPS technical reports.

DoD KEY TECHNOLOGY AREAS: Directed Energy Weapons

KEYWORDS: HPM, Ultra-Wideband, Directed Energy Warfare, Radio Frequency Weapons, Non-Nuclear Electromagnetic PU

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EA-6B FOLLOW-ON PLATFORM CAPABILITIES STUDY

CAPT James Powell, USN, Military Faculty

Information Warfare Academic Group

Russell W. Duren, Associate Professor

Department of Aeronautics and Astronautics

Sponsor: Chief of Naval Operations (N88)

OBJECTIVE: This study is tasked to support N88 requirements definition in the Airborne Electronic Attack (AEA) Analysis of Alternatives (AoA) process by outlining and prioritizing technical alternatives for future TACAIR Electronic Attack, and by developing a roadmap to use in the conduct of the EA-6B Follow-on Platform AOA.

SUMMARY: Research was completed providing surveys of available information and systems that could be used to support the AEA AoA. A report was completed that surveyed previous AEA studies. The report summarized classified and unclassified studies from the time period of 1992 through 1999. It concluded with recommendations for future research. A set of surveys was performed as part of a master's thesis. These surveys examined a wide range of existing and proposed systems for potential use in an AEA system of systems. Systems that were surveyed included UAV and UCAV platforms; avionics payloads for reconnaissance, SIGINT, and various forms of electronic attack; and smart weapon platforms for SEAD and DEAD missions.

OTHER:

Duren, R. W., "Report on Previous Studies Related to the EA-6B Follow-on Platform," paper provided to the AEA AoA Technical IPT, 5 June 2000.

THESIS DIRECTED:

Nance, L., "EA-6B Follow-On Study: UAVS and UCAVS," Master's Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Air Vehicles

KEYWORDS: EA-6B, Electronic Warfare, Prowler, SEAD, Shielding, Slot Antenna, Smart Weapons, Unmanned Combat Air Vehicles, UCAV, Unmanned Air Vehicles, UAV, Electronic Attack

DETECTION OF LPI RADAR SIGNALS

D. C. Schleher, Professor

Department of Electrical and Computer Engineering and Information Warfare Academic Group

Sponsor: National Reconnaissance Office

OBJECTIVE: To design and synthesize an ELINT receiver capable of detecting LPI radar signals with the same sensitivity as available on equivalent conventional pulsed signals. To accomplish this detection in the presence of a large number of interfering conventional pulsed radars and to measure the radar's mode, allowing the operating range of the LPI radar to be determined.

SUMMARY: An adaptive LPI Radar Detector was previously synthesized and successfully simulated. As determined by simulation, it provided an operationally significant range of 60 km on a known LPI radar signal. In addition, it determined the LPI radar's mode. A temporal mask approach was used to allow detection of the LPI radar signal in the presence of over 500 Furuno radars with random modes. An experimental demonstration was successfully conducted that confirmed the theoretical design. The experiment used a threat simulator that radiated synthesized LPI radar signals. The LPI signals were intercepted by a Low Noise Receiver and A/D converted using a 250 MHz Gage Digital Sampling Oscilloscope. The signal was then processed in a digital signal processor using MATLAB code. LPI signals at a level of -102 dBm were detected and the radar's mode determined.

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THESIS DIRECTED:

Teng, H. and Ong, P., "Digital LPI Radar Detector," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Other (Surveillance)

KEYWORDS: SIGINT, LPI Radar, Digital Pulse Compression

MISSILE IMU MODEL

D. C. Schleher, Professor

Department of Electrical and Computer Engineering and Information Warfare Academic Group

Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: To develop IMU models that allows a missile's attitude to be determined from telemetry data provided by rate sensors aboard the missile. One model is to be developed for non-rolling missiles that use IMU quartz rate sensors. A second model is to be developed for a rolling missile that uses magnetohydrodynamic rate sensors and a magnetoresistive spin sensor. The model is to provide outputs that are within 2 degrees of the actual missile attitude. A three-dimensional animation of the missile's attitude is to be provided.

SUMMARY: SIMULINK models were successfully developed for both the rolling and non-rolling missiles. The models were calibrated using Carco Table test data that matched expected values to within 2 degrees RMS on each axis. An animation capability was developed that allowed the resulting accurate attitude profile to be visually observed.

The models accept digitized strapdown telemetry data that represent distorted rate sensor data. The non-rolling missile model compensates for the distortions and then applies these data through an Euler transformation to convert the strapdown rates to earth-referenced attitude measurements. An alternate Quaternion model is also provided that allows the model to function at all missile attitudes.

The rolling missile model includes a quadrature spin demodulator that extracts the strap down rates from the telemetry data. The spin demodulator is driven by an arc tangent demodulator that is synchronized to a magnetoresistive spin sensor. It was determined that the ATA ARS-04E rate sensors were ineffective in this application. These were replaced by Tokin CG-16D sensors that exhibited good performance.

THESES DIRECTED:

Johnson, T., "Computer Modeling of Jamming Effects on Infrared Missiles," Master's Thesis, Naval Postgraduate School, June 1999.

Hill, C., "Computer Modeling of Jamming Effects on Roll Stabilized Missiles," Master's Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Missile Attitude, SIMULINK, IMU

POSITIONAL ACCURACY OF TDOA MISSILE SYSTEM

D. C. Schleher, Professor

Department of Electrical and Computer Engineering and Information Warfare Academic Group

Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: To analyze and synthesize an FDOA/TDOA system capable of providing one-meter RMS position accuracy from telemetry signals radiated from a test missile during flight test. Also, to investigate

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the accuracy of a Time, Space and Position Information (TSPII) system developed by NAWC-Weapons Division.

SUMMARY: A lower bound on the accuracy achievable using a nine base station configuration, employed at White Sands Missile Range, as a function of signal-to-noise ratio was determined. The simulation used a missile trajectory determined from measured laser tracker data. The methodology used in the simulation was to determine FDOA from each base station with respect to the reference station and then to use this to determine the TDOA of the missile. This was used in the Smith-Able algorithm to determine the position of the missile. A signal-to-noise ratio of 40 dB was required to achieve a one-meter rms positional accuracy of the missile's location. The TSPI system was found to be limited by the susceptibility of the zero crossing counter to noise and fading and the use of a wideband telemetry signal source in the missile. A system using a stable source in the missile modulated by a pseudo noise code was synthesized. This is currently under investigation using modeling and simulation techniques. An experimental test of this system is planned.

THESES DIRECTED:

Klaszky, R., "Analysis of the Positional Accuracy of a Range Difference Missile Position Measuring System," Master's Thesis, Naval Postgraduate School, September 2000.

Heng, C., "Kalman Filtering of FDOA/TDOA Missile Tracking System," Master's Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: TDOA, FDOA, Missile Location, TSPI

ANTI-ACCESS SYSTEMS STUDY

D. C. Schleher, Professor

Department of Electrical and Computer Engineering and Information Warfare Academic Group

John Osmundson, Associate Professor

Command, Control, Communications, Computers, and Intelligence Academic Group

Robert Harney, Senior Lecturer

Department of Physics

Sponsor: Naval Warfare Development Command

OBJECTIVE: To determine systems and technologies that may pose disruptive threats to U. S. Naval forces when the systems and technologies are used in a mode whose function is to deny U. S. forces access to land and ocean areas.

SUMMARY: A large number of technologies and systems were examined for their potential to provide a disruptive influence on the capability of U. S. Navy forces to exert sea and area control and power projection in the Littoral region. Systems were ranked relative to their impact and likelihood of occurrence while risk was determined as the product of these factors. Twenty-four systems ranked high in both impact and likelihood, sixteen systems exhibited medium risk while seventeen systems were ranked as low risk. Technology and disruptive systems were generally categorized into delivery systems, logistics, attack mechanisms, counter measures, sensors, weapon types and cyber warfare. In addition, sixteen disruptive systems are described in detail. These include High Energy Laser Weapons, Naval Glide Bombs, GPs Jamming, Microwave Weapons, Mini and Micro Air Vehicles and Unmanned Combat Air Vehicles.

DoD KEY TECHNOLOGY AREAS: Other (Disruptive Technologies)

KEYWORDS: Area Access Denial, Disruptive Technology, Threats

**INFORMATION WARFARE
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

INFORMATION WARFARE

JOURNAL PAPERS

Arquilla, J., "From Cyberspace to the Noosphere," *New Perspectives Quarterly*, Winter 2000.

Arquilla, J., "Information-Age Terrorism," *Current History*, April 2000.

Arquilla, J., "The Rise of Soft Power," *Gaiko Forum*, June 2000.

CONTRIBUTIONS TO BOOKS

Arquilla, J., "Screen Saver: Preparing for Cyberterrorism," *The New Republic*, 1 May 2000.

Arquilla, J., "Missile Defense," *The Christian Science Monitor*, 22 August 2000.

OTHER

Arquilla, J., *In Athena's Camp: Preparing for Conflict in the Information Age* (Chinese-language edition).

Arquilla, J., *The Zapatista Social Netwar in Mexico* (Spanish-language edition).

Arquilla, J., *Swarming and the Future of Conflict*, National Defense Research Institute, 2000.

**MODELING,
VIRTUAL ENVIRONMENTS,
AND SIMULATION
ACADEMIC GROUP**

**MICHAEL ZYDA
CHAIR**

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

OVERVIEW:

The Naval Postgraduate School Modeling, Virtual Environments and Simulation (MOVES) Academic Group is an interdisciplinary group dedicated to education and research in all areas of modeling, virtual environments and simulation. The focus of the group is on strong academic fundamentals with emphasis on application to Department of Defense and Department of Navy problems.

CURRICULUM SERVED:

- Modeling, Virtual Environments, and Simulation

DEGREE GRANTED:

- Master of Science in Modeling, Virtual Environments and Simulation

FACULTY EXPERTISE:

- Virtual Environments:
Professor Michael Zyda, Military Instructor CDR Russell Shilling, Lecturer Perry McDowell, Senior Lecturer John Falby, Associate Professor Rudolph Darken, Professor Peter Chu, ResearchAssistant Professor Michael Capps, and Associate Professor Donald Brutzman
- Modeling Simulation:
Research Associate Professor Wolfgang Baer, Research Associate Curtis Blais, Professor Gordon Bradley, Distinguished Professor Donald Gaver, Research Professor John Hiles, Professor Patricia Jacobs, Associate Professor Thomas Lucas, Associate Professor Neil Rowe, Professor James Taylor, and Associate Professor Xiaoping Yun
- Human Factors:
Research Assistant Barry Peterson, Professor Robert McGhee, Lecturer Eric Bachmann, Associate Professor Rudolph Darken
- Security:
Associate Professor Cynthia Irvine
- Communications/Networks:
Assistant Professor Geoffrey Xie and Professor Nancy Roberts

RESEARCH THRUSTS:

3D VISUAL SIMULATION

- **3D Visual Simulation** - Virtual naval gunfire support. Immersive ship walkthroughs - damage control virtual environments. Littoral zone warfare. Building and Urban Walkthroughs - urban warfare, hostage extraction, operations other than war. Ocean environment tactical visualization. C4I/IW information visualization. Game-engine utilization and handheld visual simulation delivery systems. Synthetic ocean environment simulations.
- **XML/X3D** - Use of Extensible Markup Language (XML) for deploying 3D M&S products over DoD messaging systems, creating interoperable behavior streams, gaining database schema interoperability, and defining ontologies for software agent interactions compatible with deployed C4I and combat control systems.

NETWORKED VIRTUAL ENVIRONMENTS

- **Multicast and Area of Interest Managers** - Software architectures for facilitating the development of large-scale, media-rich, interactive, networked VEs.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

- **High Bandwidth Networks** - Experimentation and utilization of next-generation Internet technologies for large-scale, networked virtual environments, and collaborative M&S development and application.
- **Wireless** - Handheld delivery systems.
- **Latency-reduction** - Techniques for predictive modeling in distributed simulations.
- **VE Architectures for Interoperability** - Network software architectures for scalability, composability and dynamic extensibility.
- **Standards for Interoperability** - High Level Architecture; Next Generation RTI; Web-based interoperability. Standards for streamed interactive 3D as an automatically created component for joint message systems. Guiding M&S standards interoperability efforts with the Web3D Consortium, World Wide Web Consortium and MPEG4 Streaming Group.

COMPUTER-GENERATED AUTONOMY

- **Agent-based Simulation** - Computer-generated characters that accurately portray the actions and responses of individual participants in a simulation. Adaptability - computer generated characters that can modify their behavior automatically. Learning - computer generated characters that can modify their behavior over time. Organizational modeling.
- **Story Line Engines** - Content production and simulation prototyping. Technologies for autonomous, real-time story direction and interaction.
- **Human Representations and Models** - Authentic avatars that look, move, and speak like humans.
- **Modeling Human and Organizational Behavior** - Integrative architectures for modeling of individuals, including neural networks; rule-based systems, attention and multitasking phenomena, memory and learning, human decision-making, situation awareness, planning, behavior moderators, modeling of behavior of organizational units, modeling of military operations, and modeling of information warfare.

HUMAN-COMPUTER INTERACTION

- **Training in the Virtual Environment** - Fidelity requirements for wayfinding in the virtual environment. Developing virtual environments for training. Evaluating virtual environments for their utility in training.
- **Intelligent Tutoring Systems** - Developing experts via the use of computer-based virtual environments.
- **Human Factors in Virtual Environments** - Multimodal interfaces, task analysis, spatial orientation and navigation, performance evaluation, interaction techniques, interaction devices, virtual ergonomics, cybersickness, usability engineering, training transfer, human perception.

TECHNOLOGIES FOR IMMERSION

- **Image Generation** - Real-time, computer graphic generation of complex imagery, HDTV, DVD, next generation delivery systems, novel display technologies, handheld and body-worn devices.
- **Tracking** - Technologies for keeping track of human participants in virtual environments.
- **Locomotion** - Technologies that allow participants to walk through virtual environments while experiencing hills, bumps, obstructions, etc.
- **Full Sensory Interfaces** - Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, and haptic.
- **Novel Sound Systems** - The generation and delivery for both interactive and recorded media. Spatial sound. Immersive sound and psychoacoustics.

DEFENSE AND ENTERTAINMENT COLLABORATION

- **Technology Transition** - Adapt technologies and capabilities from the entertainment industry.
- **Game-Based Learning** - Distance learning via the use of game technology and development.
- **Internet and Game Delivery Systems** - SimNavy, Army Game Project, SimClinic, SimSecurity.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

NEXT GENERATION MODELING

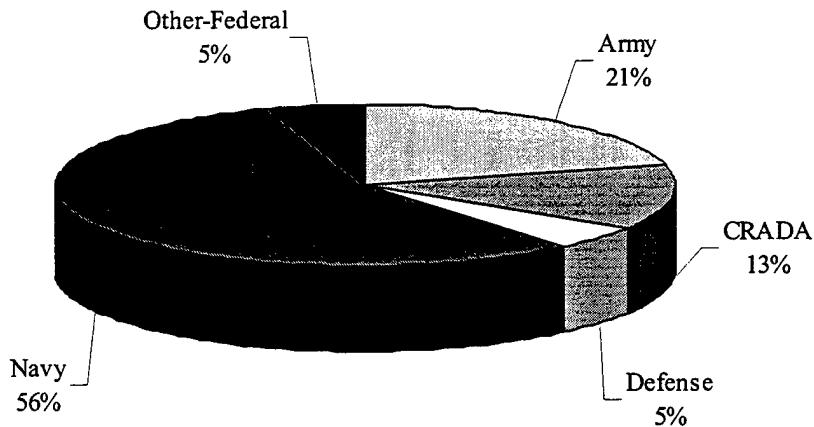
- **Modeling and Simulation** - Dynamic and state space modeling for information warfare and information operations. High-resolution combat models. High-level aggregate models. Network centric warfare. Agent-based simulation. Physically-based modeling to insure physical realism underlies the VR. Theater, tactical and campaign level modeling. Sensor modeling. Architectures for future combat modeling systems.
- **Navy Cyberspace** - Full end-to-end simulation of the ocean environment including subsurface surface, air and space. Oceanographic data sets and models. Tactical databases. Interoperability with live ship tracking message systems. Reusable, in the small or in the large, by fleet assets. Underwater robots. Interoperability with global command and control systems.
- **Current Programs in Combat Modeling** – JSIMS Maritime Battlespace, Naval Simulation System, JSIMS, JWARS, JMASS, OneSAF, HLA, Computer-Generated Forces.

TECHNOLOGY TRANSITION

- Technology transition is part of the MOVES Institute. CRADAs with industry are encouraged as well as the licensing of institute generated intellectual property.

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Modeling, Virtual Environments, and Simulation Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$999k

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MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

MODELING EXPERTISE IN NAVIGATION FOR VIRTUAL ENVIRONMENT MISSION REHEARSAL AND TRAINING SYSTEMS

Rudy Darken, Assistant Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this program is to determine if it is possible to model expertise navigation behavior within the constraints of a cognitive architecture. We have expanded the focus of our research to other areas of cognition at the request of the sponsor to include ship handling. The goal is to be able to model expertise such that we can accurately construct an intelligent tutoring system capable of assisting a novice navigator through a complex navigation task in a manner similar to the way this is done in typical military training exercises.

SUMMARY: We have tried a variety of approaches thus far but a fundamental barrier exists where rule-based approaches fail when modeling expertise in any domain. Experts do not seem to function on the basis of decision making with complete information. Rather, they tend to work with incomplete information very well by applying simple pattern matching techniques based on a wealth of experience and generalizations. Barry Peterson has been working on the majority of the modeling techniques (see "Cognitive Modeling for Training") with this project supporting the empirical data. We have completed experimentation on comparing navigation behavior in real and virtual environments as well as determining the key components that experts use as navigation cues. We have also completed our second cognitive task analysis on pier side ship handling and another on the role of personality in mentoring ship-handling skills.

THESES DIRECTED:

Karahan, B., "Comparison of Performance Measures in the Virtual Environment and Real World Land Navigation Tasks," Masters Thesis, Naval Postgraduate School, September 2000.

Grassi, C., "A Task Analysis of Pier Side Ship-Handling for Virtual Environment Ship-Handling Simulator Scenario Development," Masters Thesis, Naval Postgraduate School, September 2000.

Buziak, C., "The Role of Personality in Determining Variability in Evaluating Expertise," Masters Thesis, Naval Postgraduate School, September 2000.

Wright, G.T., "Helicopter Urban Navigation Training Using Virtual Environments," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Manpower, Personnel and Training

KEYWORDS: Cognitive Modeling, Virtual Environments, Training

THE EFFECTS OF PERCEIVED AND REAL MOTION ON TRAINING TRANSFER AND HUMAN PERFORMANCE IN VIRTUAL ENVIRONMENTS

Rudy Darken, Assistant Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: Office of Naval Research

OBJECTIVE: As a precursor to a new program starting in FY01, we are beginning an investigation of the role of real and apparent motion on training effectiveness. It has long been assumed that motion is a key component to training systems such as flight simulators. Recently, we have begun to see that this assumption is being challenged. If we are to construct training systems capable of being effectively utilized shipboard, we will need to determine whether or not motion is important and if it is, for what set of tasks this is true. If it can be shown that motion is not critical for a large set of tasks, we can save precious space and development funds in building training systems more appropriate to their objectives.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

SUMMARY: To date, we have begun to investigate motion platforms to use as our testbed system in FY01. We believe we have found a reasonable platform for use and have begun working with the contractor towards developing a platform specific to our needs. We have completed several theses related to this project. We have begun to investigate interaction techniques some of which may apply to these shipboard training systems. We also completed the last of several theses on distance perception that will be key as we determine the display configuration to be used with the simulator. Lastly, we completed a study to determine if people can maintain the orientation from streaming video of a person in motion. It turns out, somewhat to our surprise, that they cannot.

THESES DIRECTED:

Durost, R., "Effective Spatially Sensitive Interaction in Virtual Environments," Masters Thesis, Naval Postgraduate School, September 2000.

Bigham, D., "Distance Perception and Visualization Using Virtual Environments," Masters Thesis, Naval Postgraduate School, September 2000.

Kempster, K., "Frame Rate Effects on Human Spatial Perception in Video Intelligence," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Manpower, Personnel and Training

KEYWORDS: Cognitive Modeling, Virtual Environments, Training

SUPPORT AND REVIEW OF THE MODELING OF GROUND COMBAT IN ITEM

James G. Taylor, Professor

**Department of Operations Research and Modeling, Virtual Environments, and Simulation
Academic Group**

Sponsor: Joint Training, Analysis, and Simulation Center

OBJECTIVE: To provide necessary background and inputs for specific topics and methodologies, concerning the representation of ground combat, of interest to the Joint Training, Simulation and Analysis Center (JTASC) to support its use/development of the Integrated Theater Engagement Model (ITEM).

SUMMARY: This work was originally funded to investigate the theoretical basis of the attrition calibration (ATCAL) approach, with an eye on improving how ground-combat attrition and opposed-force movement are played in the Integrated Theater Engagement Model (ITEM). With the advent of JWARS, however, the sponsor directed that efforts be redirected towards helping improve ground-combat attrition in JWARS. Consequently, research focused on the development of new results for single-weapon-system-type kill rates in Lanchester-type combat models, which OSD PA&E will consider for the direct-fire ground-combat attrition algorithm in JWARS. Only a small amount of time remained for this project during the reporting period.

PUBLICATION:

Taylor, J.G., Yildirim, U.Z., and Murphy, W.S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," *Proceedings of the 2000 Winter Simulation Conference*, J.A. Joines, R.R. Barton, K. Kang, and P.A. Fishwick (eds.), Winter Simulation Conference, Orlando, FL, December 2000, pp. 925-932.

PRESENTATION:

Taylor, J.G., Yildirim, U.Z., and Murphy, W.S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," 2000 Winter Simulation Conference, Orlando, FL, December 2000.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Ground-Force-on-Force Attrition, Attrition-Calibration (ATCAL) Method, Joint-Warfare Campaign Models

AN OPERATING PLAN FOR THE INSTITUTE FOR COLLABORATIVE ENVIRONMENT STUDIES

Michael Zyda, Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: U.S. Army Research Office

OBJECTIVE: In the National Research Council report entitled "Modeling and Simulation-Linking Entertainment and Defense," a recommendation is made that the Department of Defense create a research institute to explore how the entertainment industry and the Department of Defense and its associated industries can develop a stronger technology base for modeling and simulation and profit from a closer working relationship. The goal of this proposal is to develop an operating plan for such an institute.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Synthetic Environments

INERTIAL MOTION TRACKING TECHNOLOGY FOR INSERTING HUMANS INTO A NETWORKED SYNTHETIC ENVIRONMENT

Michael Zyda, Professor

Eric Bachmann, Lecturer

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: U. S. Army Simulation, Training, and Instrumentation Command

OBJECTIVE: There is a growing need for realistic Virtual Environments (VE) in which military training and testing can be conducted efficiently and cost effectively. Current technologies are unable to provide a natural and intuitive interface for inserting a human into a large scale networked environment. Present methods of motion tracking all suffer from a range, interference, shadowing, or latency problems. Advances in the design of Micromachined Accelerometers and Angular Rate Sensors and 3D Spatial Positioning using RF present the possibility of tracking human body motion inertially in a manner similar to that of an Inertial Navigation System (INS). The NPSNET research group of the Naval Postgraduate School has been working on developing software for placing articulated humans into the DIS Synthetic Environment. This is a proposal to develop real-time body motion tracing using inertial sensors and RF positioning.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Synthetic Environments, Virtual Environments, Motion Tracking, Inertial Tracking, RF Positioning

ARMY GAME PROJECT

Michael Zyda, Professor

John Hiles, Research Professor

Michael Capps, Research Assistant Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: Office of the Assistant Secretary of the Army (M&RA)

OBJECTIVE: The U.S. Army has a shortfall in recruiting. There is the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames or computer games (both of

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

which are hereafter referred to as videogames). The web-based videogames will: attract people to the Army, provide high fidelity feedback about potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruit. The Naval Postgraduate School Modeling, Virtual Environments and Simulation (MOVES) Academic Group proposes to develop instrumented, networked videogames to improve Army recruiting.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Synthetic Environments, Virtual Environments, Modeling and Simulation, Agent-Based Simulation, Defense and Entertainment

THE MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES)

RESEARCH CENTER-FY00

Michael Zyda, Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: Chief of Naval Operation (N6M)

OBJECTIVE: The Naval Postgraduate School in conjunction with N6M, has established a new degree program, the Modeling, Virtual Environments and Simulation (MOVES) curriculum. That new degree program generates officers that are capable of filling 6202-P coded billets upon graduation. The degree program is roughly half Computer Science and half Operations Analysis, with the goal of producing officers with an understanding of the mathematics and technology behind modern Modeling, Virtual Environment and Simulation Systems. The goal of this proposal is to provide faculty support on mid-term and long-term issues of interest to the N6M sponsor and to couple student theses to N6 programs.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Synthetic Environments, High-Level Architecture, Virtual Environments, Modeling and Simulation

INERTIAL MOTION TRACKING TECHNOLOGY FOR INSERTING HUMANS INTO A NETWORKED SYNTHETIC ENVIRONMENT

Michael Zyda, Professor

Xiaoping Yun, Associate Professor

Modeling, Virtual Environments, and Simulation Academic Group

Sponsor: U.S. Army Research Office

OBJECTIVE: This proposal requests continued support to develop an inertial track body suit that is able to track the entire human body and to integrate the tracking data into a networked virtual environment. This body suit would require the construction of 15 of the MARG Sensors Prototyped in the current effort.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface

KEYWORDS: Networked Virtual Environment, Inertial Track Body Suit

**MODELING,
VIRTUAL ENVIRONMENTS,
AND SIMULATION
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

JOURNAL PAPERS

- Brutzman, D., "Virtual Kelp Forest Exhibit," *Computer Graphics*, Vol. 34, No. 2, May 2000, pp. 48-49.
- Capps, M., McGregor, D., Brutzman, D., and Zyda, M., "NPSNET-V: A New Beginning for Virtual Environments," *IEEE Computer Graphics and Applications*, September-October 2000, pp. 12-15.
- Childs, T. and Brutzman, D., "Web 3D Roundup: Looking Backwards and Forwards," *Computer Graphics*, Vol. 34, No. 2, May 2000, pp. 35-36.
- Storms, R. and Zyda, M., "Interactions in Perceived Quality of Auditory-Visual Displays," *Presence*, Vol. 9, No. 6, December 2000.
- Zelevnik, B., Holden, L., Capps, M., Abrams, H., and Miller, T., "Scene-Graph-As-Bus: Collaboration between Heterogeneous Stand-Alone 3-D Graphical Applications," *Computer Graphics Forum*, Vol. 19, No. 3, p. C91, 2000.

CONFERENCE PAPERS

- Capps, M., Greenhalgh, C., Singhal, S., McGregor, D., Sandvig, C., Schell, S., and Zyda, M., "Developing Shared Virtual Environments," ACM SIGGRAPH 2000, Course #42 Course Notes, July 2000.
- Capps, M., McGregor, D., Brutzman, D., and Zyda, M., "NPSNET-V: A New Beginning for Dynamically Extensible Virtual Environments," *IEEE Computer Graphics & Applications*, September/October 2000, pp. 12-15.
- Capps, M., "The QUICK Framework for Task-Specific Asset Prioritization in Distributed Virtual Environments," *Proceedings of IEEE Virtual Reality 2000*, East Rutherford, NJ, March 2000.
- Doucy, O., Brutzman, D., and Healey, A., "Near-Surface Maneuvering and Station Keeping for an Autonomous Underwater Vehicle," NATO Advanced Technologies Symposium, Ankara, Turkey, 23-29 October 2000.
- Peterson, B. and Darken, R., "Knowledge Representation as the Core Factor for Developing Computer Generated Skilled Performers," *Proceedings of IITSEC*, Orlando, FL, 2000.
- Peterson, B., Stine, J., and Darken, R., "Eliciting Knowledge from Military Ground Navigators," *Proceedings of the 5th Naturalistic Decision-Making Conference*, Tammsvik, Sweden, 26-28 May 2000.
- Peterson, B., Stine, J., and Darken, R., "A Process and Representation for Modeling Expert Navigators," *Proceedings of the 9th Conference on Computer Generated Forces and Behavioral Representation*, pp. 459-470.
- Taylor, J.G., Yildirim, U.Z., and Murphy, W.S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," *Proceedings of the 2000 Winter Simulation Conference*, J.A. Joines, R.R. Barton, K. Kang, and P.A. Fishwick (eds.), Winter Simulation Conference, Orlando, FL, December 2000, pp. 925-932.

CONFERENCE PRESENTATIONS

- Doucy, O., Brutzman, D., and Healey, A., "Near-Surface Maneuvering and Station Keeping for an Autonomous Underwater Vehicle," NATO Advanced Technologies Symposium, Ankara, Turkey, 23-29 October 2000.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION (MOVES)

Peterson, B. and Darken, R., "Knowledge Representation as the Core Factor for Developing Computer Generated Skilled Performers," IITSEC, Orlando, FL, 2000.

Peterson, B., Stine, J., and Darken, R., "Eliciting Knowledge from Military Ground Navigators," 5th Naturalistic Decision-Making Conference, Tammsvik, Sweden, 26-28 May 2000.

Peterson, B., Stine, J., and Darken, R., "A Process and Representation for Modeling Expert Navigators," 9th Conference on Computer Generated Forces and Behavioral Representation, pp. 459-470.

Taylor, J.G., Yildirim, U.Z., and Murphy, W.S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," 2000 Winter Simulation Conference, Orlando, FL, December 2000.

Zeleznik, M., Holden, M., Capps, M., Abrams, H., and Miller, G., "Collaboration between Heterogeneous Stand-alone 3-D Graphical Applications," Eurographics 2000, Interlaken, Switzerland, August 2000.

Zyda, M., "NPS MOVES - Entertainment Research Directions," Medicine Meets Virtual Reality Conference, Newport Beach, CA, 28 January 2000.

Zyda, M., "The NPS MOVES Program - Entertainment Research Directions," Eurographics Workshop on Virtual Environments, Amsterdam, 1 June 2000.

Zyda, M., "Networked Virtual Environments - An Overview," 2000 Summer Computer Simulation Conference, Vancouver, BC, 17 July 2000.

Zyda, M., "The NPS MOVES Academic Program," 2000 Summer Computer Simulation Conference, Vancouver, BC, 17 July 2000.

Zyda, M., "Barriers to AEEs: Interoperability of Systems and Tools," Space 2000 Conference, Long Beach, CA, 21 September 2000.

Zyda, M., "NPS MOVES - Entertainment Research Directions," Military Librarians Conference, Monterey, CA, 19 October 2000.

Zyda, M., "Today in MOVES," Navy TIMS Conference, Washington, D.C., 5 December 2000.

BOOK

Zyda, M., National Research Council, *Advanced Engineering Environments Phase 2 - Design in the New Millennium*, National Academy Press, September 2000, ISBN 0-309-07125-9, 67 pp.

**SPACE SYSTEMS
ACADEMIC GROUP**

**RUDOLF PANHOLZER
CHAIR**

SPACE SYSTEMS

OVERVIEW:

The Space Systems Academic Group (SSAG) was established at the Naval Postgraduate School in 1985 in response to an increasing defense dependence on space systems for navigation, communications, and intelligence gathering. The SSAG is an interdisciplinary association providing direction and guidance for the Space Systems Engineering and Space Systems Operations Curricula. The SSAG relies on faculty and facilities support from the Departments of Aeronautics and Astronautics, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Operations Research, Physics, and the Information Systems Academic Group.

Ongoing projects within the SSAG provide a space-hardware-oriented environment ideal for students to gain experience in design, development, installation, systems integration, and maintenance of spacecraft and payloads. Officer students are exposed to space-related research projects as well as formal classroom instruction, and are required to complete a space-oriented thesis for the Master of Science degree.

CURRICULA SERVED:

- Space Systems Operations
- Space Systems Engineering

DEGREES GRANTED:

- Master of Science in Space Systems Operations
- Master of Science in Astronautical Engineering
- Master of Science in Electrical Engineering
- Master of Science in Mathematics
- Master of Science in Mechanical Engineering
- Master of Science in Physics

RESEARCH THRUSTS:

- Spacecraft Technology-Small Satellite Design Studies
- Satellite Communications
- Remote Sensing
- Space Warfare
- Computer Memory Technology for Space
- Space Radiation Effects on Microelectronics

RESEARCH CHAIRS:

- Navy Space Technology Program Chair
- Navy Tactical Exploration of National Capabilities (TENCAP) Space Chair
- Space Systems Academic Chair
- NASA Michael J. Smith Space Systems Chair

RESEARCH CENTERS:

- Research Center for Military Applications for Space
- Spacecraft Research and Design Center
- Center for Reconnaissance Research
- Center for Radiation Hardened Electronics
- Center for Cryptologic Research

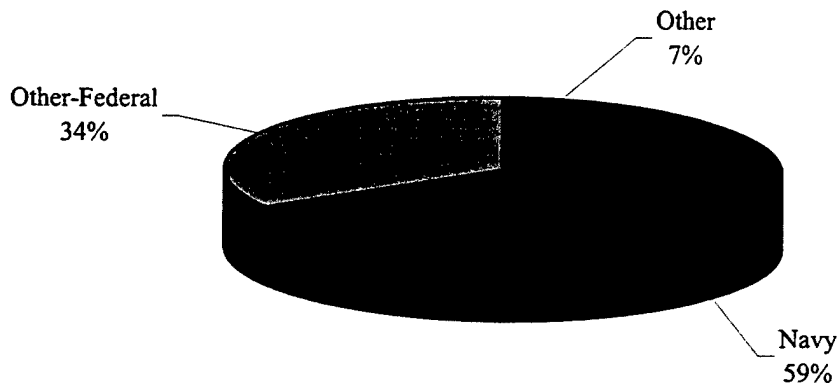
SPACE SYSTEMS

RESEARCH FACILITIES:

- Spacecraft Integration and Test Laboratory
- Open Site EMI/EMC Facility
- Satellite Ground Station Facility
- AIS Computing Facility
- Precision Fabrication Facility
- FLTSATCOM Satellite Operations
- Simulation and Test Laboratory
- Spacecraft Attitude Dynamics and Control Laboratory
- Spacecraft Environmental Simulation and Test Laboratory
- Radiation Effects Laboratory

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Space Systems Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$1447K

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SPACE SYSTEMS

NSA/C4 COMPUTER NETWORK RESEARCH LABORATORY AND THESIS RESEARCH

Herschel H. Loomis, Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: National Security Agency

OBJECTIVE: This effort will continue to expand and enhance the capabilities of the computer network research laboratory. Research areas of interest to the sponsor will be supported as well as an enhanced course to support the laboratory.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Network, Security, Computer, Software, Information Operations

PROJECT RADIANT COPPER SURVEY

Herschel H. Loomis, Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: In support of Project Radiant Copper, perform a survey of the limitations and capabilities of National System Processors and provide recommendations for suitability in Navy cross-platform applications.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations/Information Warfare)

KEYWORDS: Geolocation, Digital Signal Processing, Computers, Software

INFORMATION CONTENT OF ONIR SIGNATURES

Herschel H. Loomis, Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Center for Reconnaissance Research

OBJECTIVE: NPS to research the theoretical limits in the information content of ONIR signatures.

DoD KEY TECHNOLOGY AREA: Other (Information Operations)

KEYWORDS: ONIR Signatures

PMW 163 THESIS RESEARCH AND SIGINT II COURSE SUPPORT

Herschel H. Loomis, Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: Provide technical analysis via the use of SIGINT II course and individual thesis research into shipboard cryptologic systems.

DoD KEY TECHNOLOGY AREAS: Space Vehicles

KEYWORDS: Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation

SPACE SYSTEMS

NSA/K51 CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT
Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering and Space Systems Academic Group
Sponsor: National Security Agency

OBJECTIVE: Support for the Cryptologic Research Laboratory at the Naval Postgraduate School wherein graduate students perform research in support of K51.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations)

KEYWORDS: Modulation, VSAT, COMINT, BLEEPER, Cyclostationary, Detection, Recognition, Exploitation, Protect, Network, Security, Computer, Software, Sensors

PROMOTE CRYPTOLOGIC PROGRAMS AT THE NAVAL POSTGRADUATE SCHOOL
Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering and Space Systems Academic Group
Sponsor: Naval Security Group Command

OBJECTIVE: Support Cryptologic programs at the Naval Postgraduate School to enhance technical research support to the Commander, Naval Security Group.

DoD KEY TECHNOLOGY AREAS: Other (Information Warfare)

KEYWORDS: Geolocation, Digital Signal Processing, Computers, Software

PERSONNEL SECURITY TRAINING IN ACE LABORATORY
Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering and Space Systems Academic Group
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To provide for security training on the Navy Marine Corps Internet to be conducted within the ACE lab at SPAWARSYSCEN.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Network, Security, Computer, Information Operations

**SPACE SYSTEMS STUDENTS THESIS RESEARCH PROJECTS, DIRECTED STUDIES AND
SPACE SYSTEMS ENGINEERING EXPERIENCE TOUR**
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Research Laboratory

SUMMARY: Funds supported six-week experience tours by officer students in the Space Systems Engineering curriculum. This project also supported Space Systems officer students engaged in the Small Satellite Design Program whose purpose is the hands-on design, development, integration, and on-orbit operation of a small satellite by officer students. Work included on-going operations of the PANSAT small satellite, which was launched into orbit in October 1998, as well as the initial design work for the follow-on project.

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) students' thesis research projects, directed studies, and space systems engineering experience tours.

SPACE SYSTEMS

THESIS DIRECTED:

Robinson, M. J., "Prototype Design for NPSAT Visible Imager," Masters Thesis, Naval Postgraduate School, June 2000.

PRESENTATIONS:

Phelps, R., "A Power System Design for the Petite Amateur Navy Satellite-PANSAT," 5th International Symposium, Small Satellite Systems and Services, La Baule, France, 19-23 June 2000.

Sakoda, D., "Naval Postgraduate School Graduate Education in Space Systems Through Space Flight Experience," 5th International Symposium, Small Satellite Systems and Services, La Baule, France, 19-23 June 2000.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Space Systems Engineering

FREQUENCY COLLISION PLANNING

Donald v. Z. Wadsworth, Senior Lecturer

Space Systems Academic Group

Sponsor: Naval Space Command

OBJECTIVE: Develop a set of recommendations for mitigating the military's vulnerability to RFI in UHF satellite communications. This includes how to eliminate deficiencies in RFI resolution capability in order to decrease the impact of RFI on military readiness.

SUMMARY: The initial step in this effort was to compile information on the current status of RFI with satellite systems. The results were included in the June 1999 NPS Master's Thesis by MAJ J. P. Cook. The effort to assess the future impact of RFI on satellite systems was continued in CY2000 under an extension of this research funding. That work is documented in the September 2000 Master's Thesis by LT M. A. Leslie, under the direction of Prof. Wadsworth and CDR Sue Higgins. Information and guidance was obtained from a variety of sources, including the Naval Space Command (J. Trammel and LCDR M. Leonard), SPAWAR (N. Baumgarten), U. S. Atlantic Fleet Headquarters (T. Myers), Office of Spectrum Analysis and Management (R. Cowen-Hirsch), Joint Spectrum Center, Naval Research Laboratory, and others. The recommendations cover the following topics (limited distribution specifics are omitted):

- Develop better tools and requirements for timely RFI geolocation
- Institutionalize the RFI resolution process (equipment, operational procedures, training and exercises)
- Implement RFI resolution metrics at all levels
- Establish formal agreements between organizations for geolocation support (NCTAMS, RSSCs, NSG, CINC DF assets, etc.)
- Increase awareness of criticality of spectrum and space support to the war fighter

THESIS DIRECTED:

Leslie, M. A., "Vulnerability and Impact Analysis of Radio Frequency Interference on Military Ultra High Frequency Satellite Communications," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Satellite, Communications, Spectrum, RFI

**SPACE SYSTEMS
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

SPACE SYSTEMS

CONFERENCE PRESENTATIONS

Phelps, R., "A Power System Design for the Petite Amateur Navy Satellite-PANSAT," 5th International Symposium, Small Satellite Systems and Services, La Baule, France, 19-23 June 2000.

Sakoda, D., "Naval Postgraduate School Graduate Education in Space Systems Through Space Flight Experience," 5th International Symposium, Small Satellite Systems and Services, La Baule, France, 19-23 June 2000.

**SPECIAL OPERATIONS
ACADEMIC GROUP**

**GORDON MCCORMICK
CHAIR**

SPECIAL OPERATIONS

OVERVIEW:

The Special Operations Academic Group is an interdisciplinary association of faculty, representing a wide range of academic and operational specialties. The program provides a focused course of instruction on the dynamics of asymmetric warfare, sub-state conflict, terrorism, information operations, and other "high leverage" operations in U.S. defense and foreign policy. The core program also provides every student with a strong background in strategic analysis, international relations and comparative politics, organization theory, and formal analytical methods.

CURRICULUM SERVED:

- Special Operations

DEGREE GRANTED:

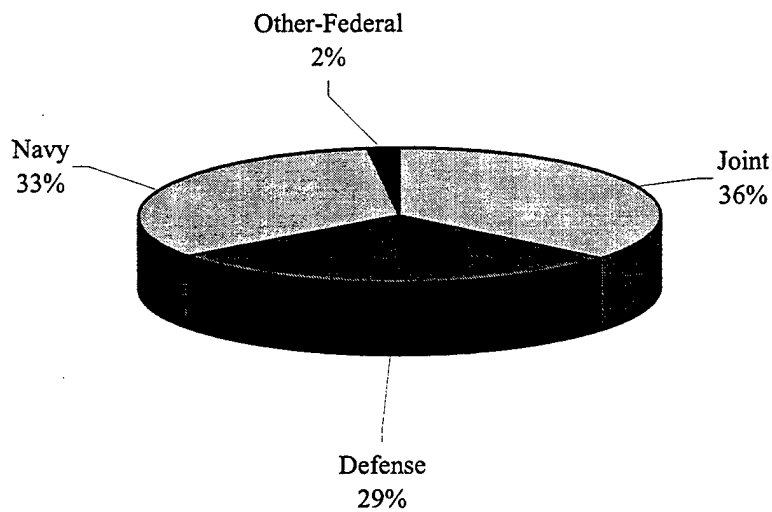
- Master of Science in Defense Analysis

RESEARCH THRUSTS:

- Asymmetric Warfare
- Sub-State Conflict
- Terrorism
- Information Operations
- Defense and Foreign Policy

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Special Operations Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$756K

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SPECIAL OPERATIONS

RESEARCH AND ANALYSIS OF TERRORIST INFORMATION OPERATIONS (RATIO)

**John Arquilla, Associate Professor
Special Operations Academic Group**

Sponsors: Defense Information Agency and Joint Special Operations Command

SUMMARY: This program undertakes a variety of research tasks on behalf of the sponsors, extending to: study of the information technology acquisition patterns of a number of terrorist groups; maintenance of a database of cyber-terror incidents, as well as tools and devices; and field study of former terror group members.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations)

KEYWORDS: Information Technology Acquisition

CHINESE VIEWS OF INFORMATION WARFARE

**John Arquilla, Associate Professor
Special Operations Academic Group**

Sponsors: Office of the Secretary of Defense and Defense Information Agency

OBJECTIVE: Explore the manner in which China is conceptualizing conflict in the information age.

SUMMARY: Both the information developed in the course of this study and the inferences drawn from it are classified, now in a code-word program.

DoD KEY TECHNOLOGY AREAS: Other (Information Warfare)

KEYWORDS: China, Information Age

DETECTING REGIONAL AGGRESSORS

**John Arquilla, Associate Professor
Special Operations Academic Group
Sponsor: Deputy Chief of Staff for Operations**

OBJECTIVE: Provide support for the national military strategy of being able to wage to major theater wars nearly simultaneously.

SUMMARY: The project consisted of developing a framework for deterring multiple adversaries, then working with regional CINCs to implement the information operations that would support the strategies developed.

DoD KEY TECHNOLOGY AREAS: Other (Military Strategy)

KEYWORDS: Deterrence, Theater Wars, Information Operations

MILITARY INNOVATION: THE CASE OF SPECIAL OPERATIONS FORCES (SOF)

**David Tucker, Visiting Associate Professor
Special Operations Academic Group
Sponsor: Smith Richardson Foundation**

OBJECTIVE: This research aims to extract from our past experience lessons about how we can best adapt to the unconventional threats that we are likely to face in the years to come.

SPECIAL OPERATIONS

SUMMARY: During the year, research was done on several of the project's case studies, including the development of counterproliferation as a mission for DoD and SOF, the development of Major Force Program 11, and the development of psychological warfare in the United States, France and Great Britain after World War II.

PUBLICATION:

Tucker, D., "The RMA and the Interagency: Knowledge and Speed vs. Sloth and Ignorance?" *Parameters*, Autumn 2000.

PRESENTATIONS:

Tucker, D., "What's New About the New Terrorism?" American Political Science Association Annual Meeting, September 2000.

Tucker, D., "Trends in Terrorism," FBI National Academy, California Chapter, 13 September 2000.

THESIS DIRECTED:

Rainville, T.A., "Stimulating Innovation in Naval Special Warfare by Utilizing Small Working Groups," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Other (Special Operations)

KEYWORDS: Special Operations Forces, Innovation, Future Conflict

**SPECIAL OPERATIONS
ACADEMIC GROUP**

**2000
Faculty Publications
and Presentations**

SPECIAL OPERATIONS

JOURNAL PAPER

Tucker, D., "The RMA and the Interagency: Knowledge and Speed vs. Sloth and Ignorance?" *Parameters*, Autumn 2000.

CONFERENCE PRESENTATIONS

Tucker, D., "What's New About the New Terrorism?" American Political Science Association Annual Meeting, September 2000.

Tucker, D., "Trends in Terrorism," FBI National Academy, California Chapter, 13 September 2000.

**UNDERSEA WARFARE
ACADEMIC GROUP**

**CLYDE SCANDRETT
CHAIR**

UNDERSEA WARFARE

OVERVIEW:

The Undersea Warfare Academic Group is an association of faculty members representing several, distinct academic disciplines. The Undersea Warfare Academic Group has administrative responsibility for the academic content of the Undersea Warfare program of study. Teaching in this interdisciplinary program is carried out by faculty members attached to the following academic departments: Electrical and Computer Engineering, Mathematics, Oceanography, Operations Research, and Physics.

CURRICULA SERVED:

- Undersea Warfare
- Undersea Warfare International

DEGREES GRANTED:

- Master of Science in Applied Physics
- Master of Science in Physical Oceanography
- Master of Science in Electrical Engineering
- Master of Science in Operations Research
- Master of Science in Applied Science

RESEARCH THRUSTS:

- Ocean Acoustics:
Associate Professor Kevin Smith, Research Professor Thomas Muir, Associate Professor James Sanders, Associate Professor Clyde Scandrett, Professor Ching-Sang Chiu
- Mine Warfare:
Professor Alan Washburn, Professor James Eagle, Chair of Mine Warfare John Pearson, Professor Peter Chu, Visiting Professor Albert Bottoms
- Physical Oceanography:
Associate Professor Mary Batteen, Professor Curtis Collins, Associate Professor Kevin Smith, Professor Ching-Sang Chiu, Military Instructor CDR Arthur Parsons
- Modeling and Simulation:
Associate Professor Donald Brutzman

RESEARCH CHAIR:

- Chair of Mine Warfare

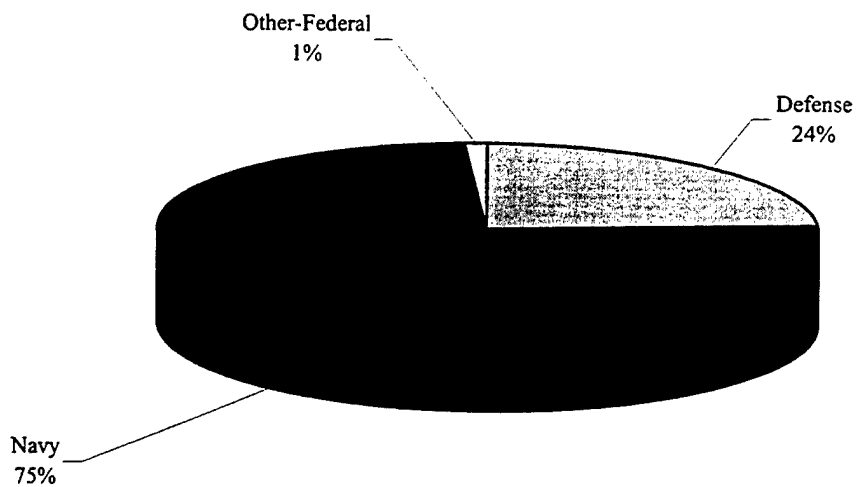
RESEARCH FACILITY:

- Coastal Acoustics Laboratory

UNDERSEA WARFARE

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Undersea Warfare Academic Group is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$1068K

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UNDERSEA WARFARE

OPERATIONS INTEGRATION WORKING GROUP (OIWG) PARTICIPATION

Donald Brutzman, Associate Professor
Undersea Warfare Academic Group
Sponsor: Naval Sea Systems Command

OBJECTIVE: The Navy has initiated the advanced tactical build (ATB) project to infuse advanced tactical control technology into submarine combat control subsystems. An ATB consists of tactical decision aids that assist the commanding officer in achieving control of the tactical situation and making timely tactical decisions. The Operations Integration Working Group (OIWG) is part of the tactical control development-working group, and evaluated current work and provides peer reviews of ATB projects. This proposal supports Dr. Brutzman's attendance at monthly meeting of the OIWG at submarine development squadron twelve, Groton, CT. As part of the various OIWG evaluations, he will provide expert advice on information display technology and designs, particularly with respect to interactive 3D graphics and scientific visualization of sonar sensors.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Tactical Control Technology, Submarine Combat Control Subsystems

STREAMING 3D GRAPHICS USING VRTP FOR DISTRIBUTED SIMULATION

Donald Brutzman, Associate Professor
Undersea Warfare Academic Group
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: NPS and George Mason University C3I Center Networking and Simulation Laboratory have been leaders in exploring new technologies for DoD distributed simulation. Both groups have worked in the areas of virtual environments, network protocol support, and multiplatform software tools based on web browsers and JAVA. The key problem in presenting dynamic physics-based simulations using 3D graphics is effectively streaming behaviors among participants. It is particularly challenging to provide consistent, interactive and responsive animations among collaborative partners. The DIS-JAVA-VRML project demonstrated such functionality, and is a preliminary implementation of the Virtual Reality Transfer Protocol (VRTP) streaming stack. Funded work under this proposal will complete the full VRTP streaming implementation. Remote-participant testing and functional compliance with the HIGJ-Level Architecture will be provided by GMU under separate funding from DTRA. Military student involvement and DTRA relevance will be driven by a progressive series of 3D demonstrations that collaboratively visualize high-profile threat-reduction scenarios.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Distributed Simulation, Virtual Environments, 3D

**INTERDISCIPLINARY
ACADEMIC GROUPS**

Thesis Abstracts

THESIS ABSTRACTS

NETWORK CONFIGURATION USING XML

Mohammad Ababneh-First Lieutenant, Royal Jordanian Air Force

B.S., Mu'tah University, 1994

Master of Science in Information Technology Management-September 2000

Master of Science in Computer Science-September 2000

Advisors: Geoffrey G. Xie, Department of Computer Science

Daniel R. Dolk, Information Systems Academic Group

The primary goal of this thesis is to investigate the use of the Extensible Markup Language (XML) as a network configuration language. Network configuration is a difficult and time-consuming task. Current network configuration solutions are based on proprietary configuration languages and parsers. XML is a platform-neutral data representation language and worldwide standard. It potentially advantageous to use XML to configure networks. However, XML was not developed for network configuration. A new XML based configuration solution for the Server and Agent Active Network Management System (SAAM) is provided to marshal evidence that XML can be used effectively as a network configuration language.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: XML, Quality of Service, Network Configuration, Next Generation Internet, Networks

EXTENSIBLE INTEREST MANAGEMENT FOR SCALABLE PERSISTENT DISTRIBUTED VIRTUAL ENVIRONMENTS

Howard A. Abrams, DoD Civilian

B.S., Embry-Riddle Aeronautical University, 1996

Doctor of Philosophy in Computer Science-December 1999

Dissertation Supervisors: Michael J. Zyda, Department of Computer Science

Donald Brutzman, Undersea Warfare Academic Group

Rudolph P. Darken, Department of Computer Science

Theodore G. Lewis, Department of Computer Science

Sandeep Singhal, IBM Corporation

Eventually there will exist virtual environments inhabited by millions, but as virtual environments grow in size and number of entities, many problems emerge. Because of these problems, increasing attention is being brought to the issue of filtering data that is not of interest to a given client. Such filtering is known as *interest management*.

This dissertation outlines a three-tiered approach to interest management. The first tier breaks the world into manageable pieces. The second tier uses the data from the first to create a protocol independent perfect match between a client's interests and the environment. The third tier, building on the second, adds protocol dependence allowing the client to receive only the data from the protocol it needs. At the same time, separating out the protocol from the core interest management can allow multiple protocols to simultaneously exist within the same environment, while using the same underlying filtering mechanism.

Results from this work have shown that it is possible to create an interest management software architecture that allows bandwidth, packets per second, and CPU time to scale dependent only on the number of entities a given client is interested in at any one time.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Simulation, Multicast, Interest Management, Distributed Virtual Environments, Bamboo

THESIS ABSTRACTS

AN OPTIMIZATION OF A NETWORK STRUCTURE FOR A BRIGADE LEVEL MILITARY ORGANIZATION

**Aydin Akkose-First Lieutenant, Turkish Army
B.S., Turkish Army Academy, 1995**

Master of Science in Information Technology Management-September 2000

Advisors: William J. Haga, Department of Systems Management

**John S. Osmundson, Command, Control, Communications, Computers, and Intelligence
Academic Group**

Networking is vital for all computer-using organizations. No computer can be thought of as a stand-alone computer. Organizations need to analyze and develop the optimal network structures with consideration of their hierarchical structures. Their needs are to be analyzed as well. The topology and the technology of the network to be developed needs to be considered and then planned

This thesis presents the different types of network topologies and network technologies. The structure of a brigade is analyzed and different topology combinations for different levels hierarchical structure are analyzed. The flow of the network traffic and network load is optimized using Extend v4, a general purpose simulation tool.

The results show that the optimal network topology for the subject Brigade is Star topology at all levels. The type of technology to be used is Fiber Distributed Data Interface technology.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Brigade, Network Topologies (Star, Ring, Bus), Network Technologies (Ethernet, FDDI, ATM), Network Simulation, Extend® Version 4.0

SITUATIONAL AWARENESS DATA REQUIREMENTS FOR A COMBAT IDENTIFICATION NETWORK

**Benjamin P. Allegritti-Major, United States Marine Corps
B.S., Arizona State University, 1985**

Master of Science in Information Technology Management-September 2000

**Advisors: John S. Osmundson, Command, Control, Communications, Computers, and Intelligence
Academic Group**

Douglas E. Brinkley, Information Systems Academic Group

The modern battlefield is extremely lethal. Many weapons systems provide the capability to engage a target far in excess of the range at which positive target identification can be made. This capability increases the likelihood of inadvertent engagement of friendly forces or, fratricide. Numerous initiatives have been undertaken to provide solutions to reduce fratricide. These solutions generally focus in one of two areas: target identification or situational awareness. Several situational awareness systems are under development. The Marine Corps has explored the concept of improving situational awareness through a mobile network application; however, the requirements for this system are not well understood.

One method of identifying the situational awareness requirements, which was used in this research, was through simulation. Three simulated combat environments were modeled (urban, mixed, and mountainous desert terrain) and the interaction of forces in the environments was observed. Based on the observations and the author's experience, conclusions were drawn about the requirements for a network situational awareness system. Principle findings of this research include system update rates, visual display resolution, and when situational awareness or target identification systems are preferred.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Combat Identification (CID), Data Requirements, Situational Awareness

THESIS ABSTRACTS

CLASSICAL GREEK AND CLASSICAL CHINESE WARFARE: A COMPARATIVE ANALYSIS

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Master of Science in Defense Analysis-June 2000

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**Second Reader: George Lober, Command, Control, Communications, Computers, and
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This study is a comparative analysis of the warfare traditions of classical China and classical Greece. The first part of this study is designed to provide a framework for understanding how certain characteristics of a society's military tradition arise, and in particular, why certain aspects of the military traditions of classical China and classical Greece are dissimilar while other aspects are similar.

Specifically, chapter two demonstrates that the particular socio-political situation of a given state sets constraints upon the way that state can mobilize, organize, and employ a military force, and shows that intensive militant competition places a market incentive on a state to innovate and to select the most efficient defensive action options from the feasible set of possibilities. The third chapter suggests that the major differences in warfare character between classical Greece and China stem from the robust differences in the socio-political situations of the two societies.

The methodological approach for the second part, chapters four and five, is simple comparative analysis. Chapter four examines organizational differences of classical Greek and Chinese warfare — specifically differences related to armaments, force structures, and command and control elements. The subsequent chapter five examines the main differences relating to classical Greek and Chinese operational concepts.

DoD KEY TECHNOLOGY AREA: Other (Comparative Classical Warfare)

KEYWORDS: Classical Warfare, Military Organization, Concepts of Operations

DISSEMINATION AND STORAGE OF TACTICAL UNMANNED AERIAL VEHICLE DIGITAL VIDEO IMAGERY AT THE ARMY BRIGADE LEVEL

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and**

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The Department of Defense Joint Technical Architecture has mandated a migration from analog to digital technology in the Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) community. The Tactical Unmanned Aerial Vehicle (TUAV) and Tactical Control System (TCS) are two brigade imagery intelligence systems that the Army will field within the next three years to achieve information superiority on the modern digital battlefield. These two systems provide the brigade commander with an imagery collection and processing capability never before deployed under brigade control. The deployment of the Warfighter Information Network (WIN), within three to five years, will ensure that a digital dissemination network is in place to handle the transmission bandwidth requirements of large digital video files.

This thesis examines the storage and dissemination capabilities of this future brigade imagery system. It calculates a minimum digital storage capacity requirement for the TCS Imagery Product Library,

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analyzes available storage media based on performance, and recommends a high-capacity storage architecture based on modern high technology fault tolerance and performance. A video streaming technique is also recommended that utilizes the digital interconnectivity of the WIN for dissemination of video imagery throughout the brigade.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Sensors, Other (Information Technology)

KEYWORDS: Tactical Unmanned Aerial Vehicle, Tactical Control System, Redundant Array of Independent Disks, Warfighter Information Network, Tactical Internet, Global Broadcast System

USING IT-21 TOOLS TO PROVIDE ASYNCHRONOUS DISTRIBUTED LEARNING (ADL) TO THE FLEET

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Information superiority is the foundation of Joint Vision 2010 battlefield dominance. Network Centric Warfare, robust infrastructure and information dissemination to dispersed forces are key elements in achieving information superiority. IT-21 is a fleet driven reprioritization of C4I programs to accelerate the transition to a PC-based tactical support warfighting network. Historically, cost and bandwidth have impeded distributed wargaming. Furthermore, when distributed wargames are conducted, they rarely present the scenario tactical picture to an individual using the same C4I systems used in actual warfighting. A solution is to use IT-21 tools to conduct distributed war games that are able to generate Gold formatted messages. The messages will simulate real-time track information into the Global Command and Control System (GCCS). These tracks can then be displayed on the same IT-21 systems used to fight. Such architecture will enable distributed training with units at sea. This capability would also enable collaborative planning at low costs. A proof-of-concept was conducted as an initial step in developing such a capability. The initial proof-of-concept showed the feasibility of the architecture. It demonstrated its use outside the Asynchronous Distance Learning (ADL) context to provide new collaborative capabilities to the Fleet, virtually anywhere in the world.

DoD KEY TECHNOLOGY AREA: Other (Distributed Learning)

KEYWORDS: Network Centric Warfare, IT-21

RADIANT GOLD: AN ALTERNATIVE CUEING ARCHITECTURE FOR NAVAL THEATER BALLISTIC MISSILE DEFENSE PROGRAMS

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The Theater Ballistic Missile Defense (TBMD) problem is complex and dynamic, requiring the use of space-based sensor system information to enhance mission success. The central purpose of this thesis is to examine the potential of the cueing architecture that results from using Navy Tactical Exploitation of National Capabilities (TENCAP) sponsored research and development program's concept, termed RADIANT GOLD. The program delivers JTAGS processed data derived from national sensor systems to an AEGIS ship. To this end, this project had three goals. First, model and simulate the cueing architecture under varying degrees of complexity and exploring a diverse set of data dissemination methodologies.

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Secondly, to examine data derived from a demonstration of the RADIANT GOLD architecture in a recent Fleet Battle Experiment and compare the performance of the architecture to simulation. Lastly, to provide a subjective analysis of RADIANT GOLD and other architectures.

The results from the research indicate that an Extremely High Frequency (EHF) satellite communications network is a suitable method to deliver time critical TBM data. Additionally, the Global Broadcast Service network is an appropriate alternative to EHF. Research also suggests that the RADIANT GOLD architecture is suitable to support the entire spectrum of TBMD operations.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Command, Control, and Communications, Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Theater Ballistic Missile Defense, Cueing, Defense Support Program, Theater Event System, Joint Tactical Ground Station, Aegis Weapon System, Navy Area Defense, Navy Theater Wide Defense Modeling and Simulation, Fleet Battle Experiment, Global Broadcast Service, Extremely High Frequency Satellite Communications

WEB SERVER CONFIGURATION FOR AN ACADEMIC INTRANET

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LCDR Chris Eagle, USN, Department of Computer Science

The Internet has undergone a tremendous growth in the past decade. After the evolution of personal computers and the radical decrease of their prices, people have the ability to access all the massive information that only the Internet and the World Wide Web can provide. One of the factors that boosted this ability was the evolution of the Web Servers. Using the web server technology man can be connected and exchange information with the most remote places all over the world. So, the web can be thought as a mass medium. This study will provide the necessary information required to configure a Web Server within the boundaries of an academic Intranet. It will also serve as an example for both Greek and US DoDs or other organizations seeking to implement a Web Server as an improvement to their existing Servers.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web Server, Web Browsers, Intranet

MILITARY RESPONSES TO STATE-SPONSORED TERRORISM: RE-THINKING DETERRENCE AND COERCION THEORY

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Second Reader: David C. Tucker, Command, Control, Communications, Computer, and Intelligence Academic Group

The face of conflict is changing. The breakup of the former Soviet Union has changed the balance of power from a bi-polar world to a uni-polar one. This change in the world's power structure has presented the United States with new challenges. The purpose of this thesis is to explore one of these challenges, state-sponsored terrorism, and the range of military responses that might be used to deter states from sponsoring terrorism or coercing states into ceasing their sponsorship. This thesis uses conventional deterrence and coercion theory as well as comparative case studies to analyze the utility of deterrence and coercion against state-sponsored terrorism. In doing so a framework that can be applied to state sponsors of terrorism was developed to determine if a strategy of deterrence or coercion could alter a state's behavior. The findings of this thesis suggest that a determined coercive strategy is more likely to work against state-sponsored

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terrorism than a strategy of deterrence. Finally, the thesis provides a model, a taxonomy of coercion that recommends using lethal and non-lethal options in overt and covert operations as the means to modify the behavior of states that sponsor terrorism.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Other (Special Operations)

KEYWORDS: State-Sponsored Terrorism, Deterrence, Coercion, Rational Choice Theory, Prospect Theory, Operation El Dorado Canyon, Israeli Counterterrorism, Operation Infinite Reach, Counterterrorism (CT)

REQUIRED OPERATIONAL CAPABILITIES FOR URBAN COMBAT

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Currently there exists no Joint doctrine to help commanders plan and coordinate the complex tasks of urban operations. Proposed Joint doctrine, JP3-06 DRAFT, attempts to alleviate this shortfall by providing commanders a framework and list of required operational capabilities to work with in the complex urban environment and states, "The complexity of urban terrain and the presence of noncombatants may combine to erode the effectiveness of current operational capabilities." The purpose of this thesis is to analyze the relevance of the proposed Joint doctrine's required operational capabilities (ROC): Command, Control and Communications (C3); Intelligence, Surveillance and Reconnaissance (ISR); Fires; Maneuver; and Force Protection. The thesis attempts to determine if these are the key requirements for planning and executing successful urban operations. Successful combat operations are defined by doctrine as the fighting force maintaining a combat effective strength of seventy percent and the capability of conducting follow on missions. This thesis will analyze four case studies to determine the most critical elements for successfully planning and executing urban operations. It will then compare those elements against the proposed Joint doctrine's required operational capabilities in order to determine the relevance of the ROCs.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Battlespace Environments

KEYWORDS: Urban Combat, MOUT, Grozny, Chechnya, IDF, Beirut, Suez City, JP3-06, Urban operations, Required Operational Capabilities

THESIS ABSTRACTS

NAVAL SPECIAL WARFARE PREPAREDNESS FOR OPERATIONS IN A CHEMICAL AND BIOLOGICAL ENVIRONMENT

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This thesis will examine both the current chemical and biological warfare threat to Special Operations Forces. It will address, in particular, issues regarding Naval Special Warfare (NSW) CBR doctrines and training to meet this threat. To successfully address chemical and biological threats, NSW requires a comprehensive analysis of the chemical and biological environment, a unified doctrine that establishes a relevant training regime, and the manpower and equipment necessary to successfully prosecute missions within this environment. These threats have grown as the barriers to entry for the chemical and biological race have diminished and the incentives to develop chemical and biological weapons have increased. We define the gap between the threat and NSW readiness as a *Policy Lag*. Policy lag manifests itself in inadequate doctrine, manning, and training. Naval Special Warfare can close this existing gap with a determined effort to develop a training, organization, and equipment plan to conduct special operations in a chemical and biological environment.

DoD KEY TECHNOLOGY AREA: Chemical and Biological Defense

KEYWORDS: Naval Special Warfare, Biological and Chemical Defense, Preparedness

DISTANCE PERCEPTION AND VISUALIZATION USING VIRTUAL ENVIRONMENTS

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Second Reader: Barry Peterson, Department of Computer Science

The studies in this thesis include experiments in training transfer, metric and visual feedback, field of view within the visual display, and cognitive relationships with distance perception. Participants were tested to show positive training transfer, retention of training, and organizational skills. Participants were trained to judge the distance perception in the in-depth plane, given a distance in a frontoparallel plane and also trained to judge perceived distances from themselves to an object. Experiment one shows that a positive training transfer exists from the virtual to the real world and visa versa. Experiments two and three show that perceptual feedback gives more information than metric feedback. Experiment four shows that between 30 – 60 degree geometric field of view setting should be used for optimal performance on distance estimation tasks using an HMD with 60-degree optical FOV. Experiment five shows that there is no correlation between how well participants organize symbols and how well they can be trained to judge distances. Experiments also confirm that as distances increased so did the amount of error.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Distance Perception, Feedback, Human Factors, Human Error, Modeling, Manpower, Personnel and Training, Simulation, Training Transfer, Virtual Reality

THESIS ABSTRACTS

THE AFRICAN CRISIS RESPONSE INITIATIVE: COMMAND AND CONTROL OF A MULTI-NATIONAL FORCE

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As the lone remaining superpower, the United States is often viewed as the world's police force and expected to help restore order wherever problems arise. But as the size of the United States' military continues to shrink and the number of regional conflicts continues to grow, the United States finds itself in a precarious position. How can it help attain regional stability throughout the world with an ever-shrinking military? The African Crisis Response Initiative (ACRI) is one tool being used in an effort to attain this goal in Africa. The overall aim of the ACRI is to train a division's worth of battalions in the necessary tasks to conduct limited Peacekeeping Operations (PKOs) and Humanitarian Assistance Operations (HUMROs). The hope is that with this capability, African nations will be capable of solving their own problems with only minimal assistance being required of the United States. The purpose of this thesis is to identify critical factors and considerations for command and control of a multi-national force in Africa, participating in either PKOs or HUMROs. This thesis will examine recent conflicts in Africa, what lessons have been learned by peacekeeping forces used there, U.S. command and control doctrine, and what is currently being done with ACRI. The thesis will conclude with recommendations for what must be done on both the international and brigade level in the area of command and control, in order to provide the necessary framework to make ACRI successful.

DoD KEY TECHNOLOGY AREA: Other (Special Operations)

KEYWORDS: African Crisis Response Initiative, Command and Control, Peacekeeping Operations, Humanitarian Operations

A NEW PARADIGM FOR MIGRATING TO CONVERGED INTEROPERABLE NETWORKS

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Master of Science in Information Technology Management-September 2000

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In both the military and the commercial sector, requirements for interoperability between systems have grown. The fact that requirements change rapidly in the information age and that customer needs are unknown and often impossible to correctly predict has created the need for an architecture for communication systems that affords flexibility and interoperability. As an alternative to solving the interoperability problem for individual systems, the thesis introduces an object-based network interoperability model in which every system should be designed as a network object. In this thesis a case study of replacing technologies for the existing IPv4 protocol is presented.

At the same time that the demand for interoperability increases, the customer demands that modern communication solutions like telephony- and video-conferencing is implemented to incur savings. Evolving constraint-based routing technology for implementation of a multi-service network that can support full communication interoperability is also investigated as part of this thesis. As a practical example, the Norwegian Defense InterLAN (a nationwide military WAN in Norway) is used to discuss architectural issues and the techniques for migration strategies towards multiservice networks.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Networking, Interoperability, Communication, Converging Networks, Real-Time Services, Quality of Service, Multi-Service Networks, IPv6

IMPROVING MARITIME SITUATIONAL AWARENESS THROUGH THE CORRELATION OF ELINT-DERIVED SHIP TRACKS AND SONAR TIME-BEARING PLOTS (U)

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Master of Science in Meteorology and Physical Oceanography-March 2000

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Second Reader: Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

The purpose of this study was to facilitate the development of a dynamic acoustic noise model based upon correlation of shipping locations and tracks obtained from electronic intelligence (ELINT) and sonar time-bearing tracks from acoustic arrays. This marriage of tracking sources was achieved through the development of the Multiple-Intercept Data Fusion (MIDF) process during the analysis of ELINT and acoustic data collected during FBE-E (Fleet Battle Experiment-Echo). All 28 of the ELINT multiple-intercept tracks of U.S. assets available for comparison with ground truth were correctly identified as military platforms. Twenty-one vessels were correctly typed by category (e.g., DDG, CG) and 19 were accurately identified by hull name.

Correlation between ELINT tracks and acoustic tracks also yielded great success. Of the 28 multiple-intercept ELINT tracks, 23 (82%) were matched to acoustic tracks. Numerous examples were developed to show that when ELINT intercepts are absent, detectable acoustic signatures permit the continued tracking of a vessel. Likewise, the possibility exists to continue tracking a vessel with ELINT data should the acoustic plot become congested as in a near-shore environment. The marriage of ELINT and acoustic tracking methods provides great promise for improving the ship tracking capabilities of the warfighter.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: ELINT, Acoustic, Ship Tracking

CASE STUDY OF THE UNITED STATES MARINE CORPS ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PROGRAM TEST AND EVALUATION STRATEGY

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Orin E. Marvel, Command, Control, Communications, Computers, and Intelligence Academic Group

This thesis examined the evolution of the direct reporting program manager-advanced amphibious assault's test and evaluation strategy from milestone 0 to the present. The research effort involved reviewing the evolution of amphibious doctrine and amphibious vehicles, reviewing the DoD acquisition process and the role of T&E in that acquisition process, and analyzing three DRPM-AAA test and evaluation master plans. Interviews were conducted with personnel from the DRPM-AAA office and general dynamics amphibious systems. Additionally, program documents and acquisition literature were reviewed. An analysis of test and evaluation issues facing the program management office, a determination of the effects those issues had on the program's test strategy, and applicable lessons learned are documented for use by other major defense acquisition programs. Key research findings conclude: that the DRPM-AAA's T&E strategy remained stable and consistent from milestone 0 to the present as a result of the continuity of the AAV's key performance parameters; that the DRPM's decision to develop a working relationship that "actively engages" both oversight and external agencies early in the test planning process serves in achieving test

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resource efficiencies; and that the IPT decision-making process differs significantly from the more formal "staff planning process" used by most military organizations.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Other (Amphibious Warfare, Test and Evaluation)

KEYWORDS: United States Marine Corps, AAV, Advanced Amphibious Assault Vehicle, DRPM-AAA, Major Defense Acquisition Program, Test And Evaluation, Developmental Testing, Operational Testing

A DECISION-MAKING MODEL UTILIZING INFORMATION TECHNOLOGY: COMBINING THE FEATURES OF THE INTERNET, PUBLIC PARTICIPATION, AND PROVEN DECISION-MAKING METHODS

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**Master of Science in Information Technology Management-December 1999
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**Mehmet Ergun-First Lieutenant, Turkish Army
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This thesis research combines several proven methods by which public participation can be used more effectively in a government decision-making process. The research involved fulfills three primary purposes. First, the research provides a flexible user-friendly internet-based platform, whereby the knowledge level of a disparate group of stakeholders can be improved with respect to a complex technical subject. Second, the research demonstrates a method by which stakeholder consensus is derived. Third, the research exhibits a method by which public values are aggregated, whatever the level of consensus; the data is then provided to the government for use in a decision-making model.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Environmental Quality, Human Systems Interface, Other (Decision Analysis, Decision-Making)

KEYWORDS: Web Technology, Internet, Information Technology, Public Participation, Decision-Making, Value Tree Analysis, Multi-Attribute Utility Theory, Analytical Hierarchy Process, Delphi Method, Median Ranking Method, Hungarian Method, Rank Correlation and Aggregation

THE ROLE OF PERSONALITY IN DETERMINING VARIABILITY IN EVALUATING EXPERTISE

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Master of Science in Modeling, Virtual Environments and Simulation-September 2000

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Second Reader: Barry Peterson, Department of Computer Science**

This research investigated how different experts in a single domain chose their individual subjective evaluation criteria of a highly aggregate task based upon their individual differences. The Conning Officer Virtual Environment (COVE) was utilized to provide a domain of experts and a subjectively evaluated task. One hundred sixteen expert shiphandlers were investigated to understand how their personality affects their evaluation of a novice performing an underway replenishment (UNREP). The experts were issued a survey that inventoried their personality, UNREP evaluation criteria, and shiphandling style. In general, the participant experts were lower in neuroticism and higher in extraversion and conscientiousness than the average adult. Extraversion appeared to be correlated with the expert's desire to use sensory input as a

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critical evaluation criterion ($r = .18$) while openness was correlated with analytical input ($r = .16$) and UNREP style ($r = .16$) as critical evaluation factors. Also correlated with UNREP style was agreeableness ($r = .16$). Finally, the expert's level of conscientiousness correlated with the critical evaluation criteria of analytical input ($r = .17$) and sensory input ($r = .39$). Results from this research provide insight to the link between observed behavior and its subjective evaluation and will allow COVE's programmers to develop an Intelligent Tutoring System (ITS) that will customize the automated training process.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Shiphandling, Virtual Reality, Intelligent Tutoring Systems, Interactive Learning Environment, Virtual Environment, Surface Warfare, Computer Simulation, Underway Replenishment, Computer Graphics, Personality, Individual Differences, NEO-FFI, Five Factor Model

INTELLIGENT AGENTS FOR INFORMATION SYSTEM OPERATIONS (U)

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**Master of Science in Information Technology Management-June 2000
and**

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LtCol Terrance C. Brady, USMC, Information Systems Academic Group

This paper discusses new information operations concepts related to the use of intelligent agents. The basic agent concept involves dispatching a group of processes across a network to service a user's request at remote locations and to return selected results. With the growth of high bandwidth backbones, networks, and the expanded use of mobile computing, agents fill an essential niche as extensions of the user. Agents assist users in coping with the ever-increasing extent of information available from a host of heterogeneous sources including the Internet.

Agents operate autonomously, have rules that constrain their operations, and are reactive to changes they detect in their environment. Advanced agents interact and collaborate with other agents and learn from their experiences. Other advances include increasingly sophisticated abilities to adapt their behavior. In networked environments, agents can be mobile to seek the information they need or to follow their user. For mobile users who only connect to a network periodically, the intelligent agent can act as a surrogate representative.

Agent technology depends on the use of standards and technologies to support requested services. In this thesis, 21st century aspects of this technology are discussed, including concepts for information acquisition, protection, processing, transport, and management.

DoD KEY TECHNOLOGY AREA: Other (Intelligence)

KEYWORDS: Artificial Intelligence, Intelligent Agents, Information Operations

THESIS ABSTRACTS

RESOLVING FREQUENCY AMBIGUITIES IN STEP FREQUENCY WIDEBAND COMPRESSIVE RECEIVERS

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Present compressive receiver implementations are limited due to their analog implementation and the necessity for digital processing of the serial output data. Previous research has shown that a stepped-frequency digital design using sub-Nyquist sampling mitigates many of the limitations. An algorithm that implements the Chinese Remainder Theorem to solve the frequency ambiguities that occur in the design due to sub-Nyquist sampling with high resolutions is investigated. Different resolutions, a different number of sampling frequencies, and sampling frequency pairs and triples with various differences are simulated for one to five signals that overlap in the time domain. Predictions for the best achievable resolution, the minimum number of sampling frequencies needed, and the difference required between the sampling frequencies are made according to the comparison of simulation results.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Wideband Digital Compressive Receivers, Resolving Frequency Ambiguities, Chinese Remainder Theorem

HIGH LEVEL ARCHITECTURE PERFORMANCE MEASUREMENT

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Eric Bachmann, Department of Computer Science

High Level Architecture (HLA) uses an implicit Runtime Infrastructure (RTI) that completely encapsulates all simulation systems. This implementation on a networked virtual environment might be limited and could affect the overall system performance. The performance of HLA on PC workstations in a networked virtual environment might not be determined, and therefore the effects and limitations of its implementation could severely hamper the realism of real-time virtual environments. The goal of this thesis is to determine the limitations of the HLA in a networked virtual environment on the Windows NT platform. In identifying the limitations of HLA, we will be able to ascertain the areas in which HLA can be improved. This thesis implements and measures the system performance of three different setups, namely a standalone virtual environment, a networked virtual environment using HLA, and a networked virtual environment using User Datagram Protocol (UDP). The system performance measured includes average CPU, network, graphics and memory processing requirements, frame rate per second, and the reliability of data received. The results indicate the use of heavily threaded processes by HLA significantly reduces overall system performance.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: High Level Architecture, User Datagram Protocol

THESIS ABSTRACTS

COMPARISON OF VEGA™ AND JAVA3D™ IN A VIRTUAL ENVIRONMENT ENCLOSURE

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Michael J. Zyda, Department of Computer Science

Large enclosures offer a myriad of possibilities for virtual environments and can dramatically improve presence for a number of applications. Scene graphs are accepted as the logical and optimized way to generate and render applications, however most scene graphs are proprietary or platform specific. Open source scene graphs are emerging that are easily used and cross-platform.

This thesis describes the physical construction of a large sized Multiple Angle Automatic Virtual Environment (MAAVE) and the programming of visual simulations using Vega, a powerful commercially available software package, and Java3D, an open source scene graph. The two simulations are networked walkthrough virtual environments using the same geometry.

After the MAAVE was built, the two applications were tested on multiple platforms with frame rate being the main measure of performance. Initial expectations were that Vega would be faster, but the ease and speed of development of each application was unknown. Results showed that the Vega application was 10 to 30 times faster on sgi hardware and 4 to 20 times faster on a standard PC. The Java3D application required one third of the development time and was easier to program. Overall, we conclude that Vega is the better development platform for multi-channel walkthrough applications.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Virtual Environment, Visual Simulation, Scene Graph, Networking, CAVE, MAAVE

LOW PROBABILITY OF INTERCEPT RADAR DETECTION TECHNIQUES FOR ADVANCED ELECTRONIC SUPPORT SYSTEMS

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LPI radar detection poses one of the last remaining unsolved problems for ES and ELINT systems at operationally significant ranges. This thesis research investigates two LPI radar detection and processing techniques. First, the adaptive analog correlation LPI radar detector is assembled and tested. It effectively detects and processes low-power LPI radar signals for ideal laboratory conditions, but several major technical limitations are quantified including its poor performance in the presence of pulsed interference signals. Secondly, the digital matched filter LPI radar detector is developed and evaluated. Digital matched filters are formed from captured signals and software-generated signals. Quantitative assessments revealed no major performance limitations. This technique achieves LPI signal detection and SNR improvements to near-theoretical limits, while operating in the presence of high-power, high-density pulsed interference signals. The digital matched filter technique is identified as the clear choice for solution of the LPI radar detection problem, and can be employed to detect and process all complex modulation signals. It is also fully compatible with the next generation of digital ES receivers.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: LPI Radar, Low Probability of Intercept Radar Detector, Digital Matched Filter, Pulse Compression, Advanced Digital ES System

THESIS ABSTRACTS

DECISION SUPPORT FOR SOFTWARE PROCESS MANAGEMENT TEAMS: AN INTELLIGENT SOFTWARE AGENT APPROACH

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Currently, SPAWAR Systems Center is lacking a unified software development environment that would assist software developers to effectively manage software development projects, across a heterogeneous development environment. This unified environment is needed to provide up-to-date accurate information to the right people at the right time, increase the process knowledge base, increase productivity, decrease time-to-market, eliminate redundancy, and ease job stress.

This thesis proposes a conceptual model for software process management decision support in the form of an intelligent software agent network. The intelligent software agent network, called MENTOR, provides the knowledge base that is integral to the software development team, providing for a repeatable, defined, managed, and optimized development environment. This concept provides SSC software development managers and team members with the ability to work in a unified and collaborative environment, regardless of organizational diversity or location.

MENTOR will be utilized as an integral software development team member, providing tutorials and mentoring capabilities for management and process assistance, as well as providing process planning, risk analysis, and strategic planning recommendations for the successful completion of a software development effort at all team levels. In addition, MENTOR will provide an effective communication environment that will enable the development team to minimize the time consuming workload involved in tracking individual tasking.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Intelligent Agents, Software Management, Software Process Guide

DEVELOPMENT OF A PROTOTYPE RELATIONAL DATABASE FOR MANAGING FLEET BATTLE EXPERIMENT DATA

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This research develops a prototype relational database system for storing and managing Fleet Battle Experiment (FBE) data. It is the first step in constructing a knowledge-base system for such data. The objective is to create a relational database capable of generating information from past experiments for analysis and lessons learned to benefit future experiments. Research methodology included literature research of application development methodologies and database systems, as well as observing a FBE and gathering system requirements information from personnel that plan, configure, and participate in FBEs and war games.

Development of the system involved designing a schema (data model) that consists of entities, attributes, and relationships of the FBE environment. The data model is transaction- (event-) based and concentrates on information flow in order to categorize and store the data. These events provide the logical links between the identified entities and the capability to query the system for desired information. Finally, a prototype application against the data model was developed to facilitate data entry, modification, and querying.

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DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Database)

KEYWORDS: Database, Database Management System, Knowledge Management

THE RANGER REGIMENTAL RECONNAISSANCE DETACHMENT: THE ROLE OF TECHNOLOGY IN A HUMINT-BASED ORGANIZATION

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This thesis examines the impact of technology on the capabilities of the Regimental Reconnaissance Detachment (RRD) and looks at how the unit's capabilities can be enhanced, at reasonable cost. The thesis focuses on three current or emerging technologies, consisting of: remote battlefield sensing systems; a Signals Intelligence acquisition platform; and the use of tactical Unmanned Aerial Vehicles (UAVs). This thesis also examines the current capabilities and shortfalls of the RRD, and examines what the above mentioned systems can provide as "stand-alone" technologies. The thesis then considers the likely impact on the unit once these technologies are used in conjunction with the unit's HUMINT capabilities, and whether the RRD's intelligence acquisition capabilities are enhanced. A cost benefit analysis will also be done, in addition to looking at how the unit may need to be reorganized in order to maximize these new capabilities and facilitate the analysis and integration of this new information into the intelligence and targeting cycle. The implication of this research is that the Ranger Regiment needs to have a much more robust, organic, intelligence acquisition organization in order to meet the challenges of the changing, high-risk global environment that the Regiment will find itself operating in. The findings of the analysis show how integrating current and emerging technologies could increase the intelligence acquisition capabilities of RRD and allow RRD, and the Ranger Regiment, to continue to maintain its lead as the US military's premier strike force.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronics Warfare, Sensors, Other (Special Operations Forces)

KEYWORDS: Regimental Reconnaissance Detachment, Ranger Ready Force, Human Intelligence (HUMINT), Special Operations Forces, Remotely Monitored Battlefield Systems, Signals Intelligence, Unmanned Aerial Vehicles

TOWARDS RE-ENGINEERING THE UNITED STATES NAVY ENLISTED MANPOWER AND PERSONNEL SYSTEMS - A DATA WAREHOUSE APPROACH

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Historically, stovepiped information systems have been developed to meet the needs of individual departments or users. Over time, attempts to increase the usefulness of these systems often involved adding layers of additional programming and data structures, resulting in complex and difficult to maintain legacy-based systems. The United States Navy enlisted personnel and manpower database system epitomizes this problem. The current system consists of several mainframe systems and a multitude of front-end systems that often require personnel managers to perform manual data extraction to execute routine activities. To

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illustrate the problem, focus is on the Navy Enlisted Classification (NEC) reutilization, a critical aspect of the personnel assignment process. First, a series of contemporary database topics that form the basis for solving the problems associated with file-based legacy databases is presented. Second, details are provided of the make-up and problems associated with the current system. Third, a prototype relational data mart is developed to prove the value of a data warehouse/data mart driven relational system. Fourth, using the prototype relational data mart as a source system, a contemporary OLAP application is used to prove the effectiveness of using a multi-dimensional data tool to analyze NEC reutilization. Finally, issues involving data quality and their impact on a data warehouse solution to integrating legacy systems are discussed.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: OLAP, Data Warehouse, Enterprise Data Warehouse, Data Mart, Legacy System, Navy Enlisted Classification, Enlisted Personnel System, Enlisted Manpower System

RE-PURPOSING COMMERCIAL ENTERTAINMENT SOFTWARE FOR MILITARY USE

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Virtual environments have achieved widespread use in the military in applications such as theater planning, training, and architectural walkthroughs. These applications are generally expensive and inflexible in design and implementation. Re-purposing these applications to meet the dynamic modeling and simulation needs of the military can be awkward or impossible.

Video games are designed to be both technologically advanced and flexible in design. We evaluated current games and modified Quake 3 Arena™ (Q3A) to serve as both an architectural walkthrough and a primitive team trainer. To accomplish this, a real Naval Postgraduate School building was incorporated into Q3A. The game's source code, characters and their behaviors, weapons models and characteristics, and overall gameplay was modified.

By re-purposing commercial entertainment software, a viable military virtual environment application was produced that is less expensive yet arguably as engaging as current computer-based options. This application was created in approximately 300 man-hours with a cost of \$6780 (including hardware) -far less than the development time and cost of similar military virtual environment applications. Game evaluations included in this thesis facilitate and inform similar modification efforts by highlighting entertainment technology available in the year 2000 game market.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Modeling and Simulation, Software Re-Purposing, Video Games, Entertainment Technology, Architectural Walkthrough, Game Modification

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INFRARED MISSILE AIM-POINT MODELING AND FLARE COUNTERMEASURE EFFECTIVENESS (U)

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In today's battlefield environment, infrared surface-to-air missiles (IR SAMs) pose a significant threat to modern tactical aircraft. Every effort must be made to more successfully combat such threats through the use of flare countermeasures. The Modeling System for Advanced Investigation of Countermeasures (MOSAIC) is a simulation tool that models countermeasure effectiveness vs. different missile-threat situations. This research first compares the three different aircraft source models used by MOSAIC (area, ellipse, and SPIRITS source models). These source models are compared to each other as well as to actual field test results in order to draw conclusions on model accuracy. Second, the effectiveness of flare countermeasures is investigated based on release timing relative to missile aim-point. The aircraft, missile, and countermeasures used in this analysis are the F-15E, the Stinger Basic missile, and the MJU 27 and MJU 8 A/B flares.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Modeling and Simulation

KEYWORDS: MOSAIC, SPIRITS, Infrared Countermeasures (IRCM), Modeling, Simulation, Stinger, F-15E, Aim-point

ASSIGNING UNMANNED UNDERSEA VEHICLES TO MINE DETECTION OPERATIONS

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In an era when mines are inexpensive and easily accessible, present and near-term mine detection and area reconnaissance capabilities are insufficient to enable unencumbered maneuver in the littoral regions. Unmanned undersea vehicles (UUVs) possess potential to provide tactical commanders with full understanding of the mine threat without risk to ships or personnel and without exposing intentions. By integrating an assortment of emerging capabilities, a system comprised of a variety of UUVs could address this growing mine threat. This thesis develops and implements the Mine Reconnaissance System Assessment (MiRSA) model, a mixed integer-linear program to assign a mix of UUVs to search areas within a suspected minefield area. This thesis compares combinations of two Long-term Mine Reconnaissance System (LMRS) vehicles, six Remote Environmental Monitoring Units (REMUS) vehicles, and a notional Manta vehicle searching a 262 square nautical mile area in the Straits of Hormuz. MiRSA finds the two LMRS vehicles can complete a 95% confidence level search in 91 hours, the Manta vehicle can complete the search in 130 hours, and the two LMRS vehicles with Manta employed optimally together require only 52 hours. At a 99.99% confidence level search, Manta operating alone requires 298 hours (approximately 12 days) while optimal employment of the two LMRS, six REMUS, and Manta vehicles together can finish the search in only 104 hours.

DoD KEY TECHNOLOGY AREA: Other (Unmanned Undersea Vehicles)

KEYWORDS: Unmanned Undersea Vehicle, Long-term Mine Reconnaissance System, Remote Environmental Monitoring Units, Manta, Mine Detection

THESIS ABSTRACTS

FEASIBILITY STUDY ON THE UTILIZATION OF SATELLITE INFRARED IMAGERY IN THE DETECTION OF SUBMARINE GENERATED SIGNALS

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Anti-submarine warfare is an area that has grown in complexity over the past decade. There has been growing interest in submarine capabilities as well as increased investments in submarine technologies exhibited by potentially adversarial nations. It is evident that the U.S. must continue to develop its ASW surveillance capabilities if it is to keep pace with the emerging submarine threat. Acoustic sensors have historically been the primary means of detecting, localizing and tracking submarines. With ASW operations shifting to acoustically challenging littoral regions and submarines becoming much quieter, it is evident that non-acoustic sensors need to be developed to complement acoustic sensors. Submarine motions both below and above the ocean surface create disturbances that can be detected in the infrared spectrum. This thesis examines the feasibility in exploiting these IR signatures by looking at factors surrounding the satellite, the submarine and the ocean environment. It makes assessments in the detectability of these IR signatures and further assesses the tactical significance of this type of data. The primary objective of this thesis is to determine if the utilization of satellite IR sensors as ASW detectability assets will contribute to the development of the overall tactical ASW picture.

DoD KEY TECHNOLOGY AREA: Space Vehicles, Sensors

KEYWORDS: Non-Acoustic, Anti-Submarine Warfare, Satellite, Submarine

IPSec-BASED VIRTUAL PRIVATE NETWORK VULNERABILITY ASSESSMENT

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Virtual Private Networks (VPNs) are an emerging security solution for computer networks in both the government and corporate arena. IPSec, the current standard for VPNs, offers a robust, standards based, and cryptographically effective solution for VPN implementation. Because of the immense complexity of IPSec, effective analysis is difficult. In an environment where Information Warfare in general, and computer network attack in particular, are becoming more pervasive, it is necessary develop a critical, independent evaluation of IPSec from a security perspective.

In order to develop an effective evaluation of IPSec VPNs, it is necessary to first develop a framework with which to analyze the various elements of VPN implementation. This framework can be extended for use as a tool to develop methodologies for VPN attack and exploitation, as well as protection. A Cisco Systems VPN router network is an example of how this framework can be applied to a real-world example.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Virtual Private Networks, Computer Network Attack, Computer Security, Network Security

THESIS ABSTRACTS

THE WARFIGHTERS' COUNTERSPACE THREAT ANALYSIS (WCTA): A FRAMEWORK FOR EVALUATING COUNTERSPACE THREATS

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The authors present an evolutionary approach to evaluating the counterspace threat in support of Department of Defense (DoD) decisionmakers. The goal is to present a process that decisionmakers can readily utilize to accurately assess the level of the counterspace threat originating within their Area of Responsibility (AOR). It is particularly useful as the state of affairs change within the AOR. The authors examine the necessity to utilize space to achieve information dominance, strengths and weaknesses of present Counterspace Threat Models, DoD's increasing dependence on space assets, DoD's reliance on commercial space systems to meet future requirements, and potential adversaries' awareness of the dependence of U.S. forces on space systems.

Conclusions stress that the threat is comprised of two essential elements an opponent's willingness to employ a counterspace tactic (their intent) and the opponent's ability to develop the necessary tools to employ a counterspace tactic (their capability). The authors believe that the "intent" component of the threat changes more rapidly than the present models can easily accommodate. Therefore, a process, such as the one presented in this thesis, will enable DoD decisionmakers that experience many of the changes of "intent" first hand to rapidly and accurately assess the threat as the condition changes within the AOR.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Battlespace Environments, Command, Control and Communications, Electronic Warfare, Directed Energy Weapons, Modeling and Simulation

KEYWORDS: Counterspace Threats, Counterspace Threat Assessment, Counterspace Threat Assessment Framework

PLANNING, DESIGNING AND IMPLEMENTING A NETWORK FOR THE NAVAL RESERVE

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This thesis focuses on an analysis of the technology and steps involved in planning, designing and implementing a network for the Naval Reserve Force. The Naval Reserve is undergoing a multi-year program that will dramatically upgrade the Naval Reserve Network. The upgrades are needed to establish an effective Wide Area Network that is compliant with Department of the Navy Chief Information Officer's information technology standards guidance. Through the study, the challenges to implementing an effective network were identified as well as recommended strategies for successfully implementing the network.

The thesis includes a requirements analysis of a typical Naval Reserve Center and a recommendation for a standardized Reserve Center Local Area Network architecture. An overall standard network architecture is needed to improve system performance and interoperability. In addition, the thesis studies how to best stimulate the changes to business practices that will be required to ensure that the network will not be underutilized. The recommendations and information presented will benefit the Naval Reserve Force in their ongoing efforts to implement an effective Wide Area Network and to standardize their Information Technology infrastructure.

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DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Wide Area Network, Local Area Network, WAN, LAN, Network Design, Media, Topology, Hub, Router, Managing Planned Change

MODELING INFLUENCES AFFECTING INDIA'S USE OF NUCLEAR WEAPONS

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Since India and Pakistan became nuclear weapon states, the threat of a nuclear confrontation in South Asia has increased. Continuous fighting between the two countries for over fifty years involving the Kashmir region has raised the question of whether or not nuclear weapons will be used to settle their differences. Both countries have demonstrated the ability to produce or acquire nuclear weapons and the means to deliver them. Crossing of the Line of Control in Kashmir by either India or Pakistan and the possibility of escalation associated with conventional war has increased the chance of a nuclear war.

Utilizing a computer program known as Situational Influence Assessment Module (SIAM), an influence net model is constructed to ascertain the likelihood of India using nuclear weapons. The model is then validated by theater intelligence agencies. SIAM is used to identify critical influences known as pressure points, which may be vulnerable to manipulation as part of an Information Operations (IO) plan. This manipulation could affect India's decision to use nuclear weapons.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: India, Nuclear Weapons, Modeling and Simulation, SIAM, Information Warfare, Perception Management

U.S. AND AUSTRALIAN MINE WARFARE SONAR PERFORMANCE ASSESSMENT USING SWAT AND HODGSON MODELS

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The purpose of this thesis was to investigate a shallow coastal region to compile a detailed environmental picture of its sediment composition and water characteristics and from this model MCM sonar performance at the FBE-H exercise location as a means to determine what parameters exerted the greatest effect on performance. Seven parameters were intercompared to assess their sensitivity in detecting mines: bottom type, SSP, water depth/sonar depth, mine depth, frequency, sonars and models. Performance was assessed using several measures of effectiveness including the signal to noise ratio and initial detection range. Variations in these measures were analysed by investigating how TL and RL responded to changing parameters.

No one single parameter was identified that affected sonar performance significantly above all others. Of the environmental parameters considered, variations in bottom type exerted the most influence on TL and RL and ultimately on sonar performance. TL was clearly a significant factor when the bottom type is comprised of absorptive, fine-grained material. Of the sonar parameters, frequency exerted a significant impact on performance with TL the most sensitive term in this comparison. A higher TL associated with higher frequency reduced the signal level and consequently the bottom RL. The higher frequency displayed a stronger SNR than the lower frequency over short ranges, however the higher frequency was limited by TL at greater ranges with the lower frequency achieving greater initial detection ranges.

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DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Reverberation, Bottom Backscatter, Mine Warfare, PC SWAT Model

HIGH FREQUENCY SONAR COMPONENTS OF NORMAL AND HEARING IMPAIRED DOLPHINS

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A data acquisition device was constructed and tested to obtain toothed whale (Bottlenose Dolphin and Beluga Whale) sonar signals and digitally store them to a PC hard drive. The device had the capability of capturing sonar signals by means of a two-hydrophone array, and a digital video camera in a submersible housing. Cooperation with marine biologists at SPAWAR Systems Center-San Diego enabled the sampling of three animals performing echolocation tasks. Their sonar signals, transmissions of rapid high frequency pulses called clicks, were recorded for further processing. Once the data was captured on video and hard disk drive, it was processed using MATLAB.

Data from three different toothed whales, a normal Bottlenose Dolphin, a Bottlenose Dolphin with a hearing impairment and a Beluga Whale, was analyzed. It was observed that the animals reduced the interval between clicks when they located a target. Correlating the signal data to the video data made this observation possible. It appeared the animals searched with widely spaced clicks, then narrowed the click period upon target detection. Also, it was noted that the frequency of isolated clicks decreased as click period decreased. However, the hearing impaired Dolphin maintained his click frequency regardless of click periodicity.

DoD KEY TECHNOLOGY AREAS: Electronics, Sensors, Computing and Software

KEYWORDS: Marine Mammal Systems, Bio-SONAR, Mine Detection, Dolphin SONAR, Echolocation Signals

KNOWLEDGE MANAGEMENT INNOVATION OF THE COAST GUARD COUNTERNARCOTICS DEPLOYMENT PROCESS

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The major contribution this thesis provides is the application of a "break through" knowledge management system design methodology to a knowledge intensive military work process. Specifically, the methodology was used to develop a knowledge management system (KMS) for the United States Coast Guard (USCG) Pacific Area Tactical Law Enforcement Team (PACAREA TACLET). The focus was on applying knowledge management innovation using the above mentioned methodology to the Law Enforcement Detachment (LEDET) Counternarcotic (CN) Deployment Process, which depends on the combined experience and expertise of all members of the detachment in order for the process to be completed successfully. This thesis provides evidence that this methodology, which was developed by Nissen, Sengupta, and Kamel, is robust enough to be used in civilian knowledge work processes, as well as military environments.

The knowledge management system design process used acknowledges that the knowledge transfer required for the primary process to succeed is dependent upon other processes that do not directly relate to it. These processes are referred to as vertical-flow processes. Knowledge management innovation of the CN Deployment process is focused on the vertical-flow processes because the knowledge required for a

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LEDET to meet the horizontal process goal is dependent on the efficiency of the identified vertical-flow processes.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Manpower, Personnel, and Training

KEYWORDS: Coast Guard, Tactical Law Enforcement Team, Law Enforcement Detachment, Maritime Law Enforcement, Knowledge Management, Information Technology, Counternarcotics

A BUSINESS PROCESS REDESIGN OF THE U. S. COAST GUARD PORT STATE CONTROL BOARDING PROCESS

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The United States Coast Guard Port State Control (PSC) is a port entry tracking process, which is currently performed primarily using paper and pencil. This thesis examines the feasibility and effectiveness of redesigning the PSC process in light of modern Business Process Redesign methodologies that incorporate contemporary information technology. The current process is modeled using the automated redesign tool, KOPeR, to identify pertinent redesign recommendations. A redesign of the process is completed using the recommendations provided by KOPeR and leveraging existing Coast Guard infrastructure and technology solutions. The effectiveness of the redesigned process is evaluated against the current process by using discrete event simulation models to compute the relative cycle times. Three different scenarios are run which show a potential annual reduction in manpower ranging from two to four person years. A Web-based prototype system, Re-engineered Port System (RePortS), is developed using basic tools such as Microsoft Access and Active Server Pages to demonstrate the feasibility of implementing the required functionality. The benefits of replacing the current manual system with a Web-based system are, reduced cycle time, increased accuracy and consistency in the process.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Information Infrastructure, Business Process Re-Engineering, Simulation

INSURGENCY IN URBAN AREAS: IMPLICATIONS FOR SOF

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**Second Reader: Anna Simons, Command, Control, Communications, Computers, and
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Many of the "small wars" that have occurred in the aftermath of the Cold War fit the profile of insurgent conflicts. They pit a constituted state vs. a counter-state. The counter-state relies on a support structure within the population, and the center-of-mass of these conflicts is political and psychological rather than military in nature. The urbanization boom in many underdeveloped countries has stretched the social services and infrastructure of the cities beyond the breaking point, and this dynamic may contribute to the occurrence of insurgency. Increasingly, political entrepreneurs have operated within urban areas to enlist disaffected individuals in campaigns of political conflict. This study argues that the most effective way to counter an insurgency is through a strategy of indirect approach that seeks to dismantle the insurgent support structures. The United States can support friendly governments that are combating insurgent violence through a "vertically integrated" advisory effort spearheaded by Special Operations Forces (SOF).

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These forces can assist a supported nation to develop a "counter-mobilization" framework that targets the *opportunity, means and motives* that allow an insurgency to exist. To attain success, the U.S. should exploit the insurgents' vulnerabilities, defeat their strategy and allow SOF to advise on intelligence collection activities.

DoD KEY TECHNOLOGY AREA: Other (Special Operations)

KEYWORDS: Urban Insurgency, Counterinsurgency Operations, Colombia, Egypt, Chechnya

TRUST AND ITS RAMIFICATIONS FOR THE DOD PUBLIC KEY INFRASTRUCTURE (PKI)

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In order to incorporate trust into e-commerce, public key cryptography, and basic communication, one must understand and effectively manage trust. Various internet security protocols have attempted to address this lack of trust. However, these protocols do not incorporate the user's trust into these protocols. Computational models of trust have been developed in an attempt to automate the logic, variables, and thought processes that a human performs when making a trust-decision. Due to the fact that trust is based on a subjective belief, the models require the assignment of metrics to belief variables or attributes that will have value when evaluating trust. These models address the notion of trust in many different ways and both their definitions and metrics vary significantly. This thesis evaluates the various trust models. It is necessary to understand how trust is defined in each model in order to evaluate how well the operation of a system based on the model satisfies the requirements of the users. Trust models are evaluated based on their characteristics, environmental references, metrics, variables used, and outputs. This thesis concludes with the assessment of a practical application of a trust model to the DoD's PKI system.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Trust Models, Trust Management, Public Key Infrastructure (PKI), Computer Security

GRAPHICAL USER INTERFACE FOR A PHYSICAL OPTICS

RADAR CROSS SECTION PREDICTION CODE

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This implementation of the physical optics approximation method for predicting the radar cross section (RCS) of complex objects utilizes the scientific computational features of MATLAB and its Graphical User Interface (GUI) functions to provide an error-free encoding of input parameters and efficient calculation. The POFACETS GUI provides a convenient tool for both students and electromagnetic professionals to design complex models by representing its component parts as triangular facets and offers options for defining the surface roughness of the scattering object. The GUI calculates the monostatic or bistatic radar cross section of the modeled object based on certain radar frequencies and parameters of interest, creates a variety of plots for the model geometry and its RCS measurement, and provides additional functionalities to enhance visualization of the object and check for accuracy of data. Various help windows and messages are available to the user to serve as guide in the efficient use of the GUI. The simplicity of the GUI design does not require the user to have a detailed understanding of the various steps involved in the RCS calculation.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Electronic Warfare

KEYWORDS: Physical Optics, Radar Cross Section, Monostatic, Bistatic, Electromagnetic Scattering, Graphical User Interface

MILITARY INNOVATION: SOURCES OF CHANGE FOR UNITED STATES SPECIAL OPERATIONS FORCES (SOF)

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Today, in the post-Cold War era, each of the U.S. military services and U.S. Special Operations Command (USSOCOM) realizes that in order to remain relevant it must be able to innovate and change. This thesis defines military innovation as a change in the stated roles or missions of the organization to solve current or projected military challenges or threats as defined by the national strategy. The thesis surveys three contending theories of military innovation. It identifies elements from each and develops a hypothesis to explain innovation in U.S. Special Operations Forces (SOF). This hypothesis is then tested against three instances where U.S. SOF accepted and developed the new missions of counterinsurgency, counterterrorism, and counterproliferation. The study concludes that the variables of SOF culture, changes in the security environment, civilian intervention, and military leaders have combined to cause military innovation in U. S. SOF. Of these variables, military leaders, who control of resources and can provide promotion pathways to junior officers, is necessary for innovation. Recommendations for USSOCOM are then drawn from these conclusions.

DoD KEY TECHNOLOGY AREAS: Chemical and Biological Defense, Command, Control, and Communications, Manpower, Personnel, and Training

KEYWORDS: Special Operations, Military Innovation, Counterinsurgency, Counterterrorism, Counterproliferation

DEFINING DOD'S ROLE IN THE MARITIME INTERDICTION OF NBC/M (U)

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Maritime interdiction is one element of DOD's strategy to counter the proliferation of nuclear, biological, and chemical weapons, and the means to deliver them (NBC/M). However, there exists neither an explicit policy nor a common framework for defining the conditions under which DOD would execute its maritime interdiction strategy. The result is that DOD has refined *how* it will interdict NBC/M at sea without defining *when* it would do so. Given the high stakes involved in a maritime military interdiction, without a clear policy, decisionmakers risk incurring high political costs, while DOD's strategy inefficiently allocates resources to the maritime proliferation problem. This thesis uses an analytical framework based on a simple decision model to identify and examine the key variables in a maritime interdiction decision. The relationship between these variables defines the set of conditions under which DOD is likely to interdict NBC/M at sea. This thesis also analyzes the policy implications, both within and above DOD, that result from defining those conditions.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Counterproliferation, Maritime Interdiction, Weapons of Mass Destruction, NBC/M

THE IMPACT OF THE INTEGRATED BROADCAST SERVICE (IBS) ON THE FORCE OVER-THE-HORIZON TRACK COORDINATOR (FOTC) PROCEDURES

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The Integrated Broadcast Service (IBS) will provide parallel dissemination of over-the-horizon tracking data to DDG, CG, and CV, possibly resulting in conflicting Common Tactical Pictures. What will be the impact of IBS on U.S. Navy Force Over-The-Horizon Track Coordinator (FOTC) procedures? Specifically, how will IBS change how Battle Group (BG) Commanders conduct FOTC operations and what recommended changes should we consider in doctrine, tactics, techniques, and procedures; i.e., Naval Warfare Publication (NWP), and Operational Tasking Message (OPTASKS)? Should the FOTC direct all platforms in the BG, other than the FOTC, to filter all but Theater Ballistic Missile (TBM) data and force everyone to continue to rely on FOTC broadcast for the tactical picture? Should the FOTC allow and encourage each ship to develop their own picture using their direct near real-time access to over the horizon data? These questions must be answered to ensure successful integration, training, and maintainability of warfighting capabilities with the intelligence and information provided by the IBS to the U.S. Navy's combat platforms. The purpose of this thesis is to provide an overview of the IBS and FOTC, address these concerns, and provide a possible course of action.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Integrated Broadcast Service (IBS), Force Over-The-Horizon Track Coordinator (FOTC), Command and Control Warfare (C2W), Command, Control, Communications, Computers and Intelligence (C4I), Over-The-Horizon-Targeting (OTH-T)

FITTING FIREPOWER SCORE MODELS TO THE BATTLE OF KURSK DATA

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This thesis applies several Firepower Score attrition algorithms to real data. These algorithms are used in highly aggregated combat models to predict attrition and movement rates. The quality of the available historical data for validation of attrition models is poor. Most accessible battle data contain only starting sizes and casualties, sometimes only for one side. A detailed database of the Battle of Kursk of World War II, the largest tank battle in history, has recently been developed by Dupuy Institute (TDI). The data is two-sided, time phased (daily), highly detailed, and covers 15 days of the campaign. According to combat engagement intensity, three different data sets are extracted from the Battle of Kursk data. RAND's Situational Force Scoring, Dupuy's QJM and the ATLAS ground attrition algorithms are applied to these data sets. Fitted versus actual personnel and weapon losses are analyzed for the different approaches and data sets. None of the models fits better in all cases. In all of the models and for both sides, the Fighting Combat Unit Data set gives the best fit. All the models tend to overestimate battle casualties, particularly for the Germans.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Combat Modeling, Simulation, Attrition, Validation, Firepower Scores, Battle of Kursk

VALIDATION OF A QUALITY MANAGEMENT METRIC

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The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program are requirements management, estimation/planning management, people management, and risk management. In this thesis a quality management metric (QMM) was used to measure the performance of ten software managers on Department of Defense (DoD) software development programs. Informal verification and validation of the metric compared the QMM score to an overall program success score for the entire program and yielded positive correlation. The results of applying the QMM can be used to characterize the quality of software management and can serve as a template to improve software management performance. Future work includes further refining the QMM, applying the QMM scores to provide feedback and appropriate training to program managers, and using the QMM scores as an input to program cost and schedule estimation methodologies to provide better program estimates.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Management, Requirements Management, Estimation/Planning Management, Risk Management, People Management, Quality Management Metric (QMM)

TESTING AND DEVELOPMENT OF A LOW COST, DIGITAL SIGNAL PROCESSOR BASED TORPEDO COUNTERMEASURE

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Since the early days of submarines, torpedoes have evolved from simple, straight running weapons into advanced vehicles capable of finding and evaluating potential targets. In contrast, torpedo countermeasures have changed relatively little and do not take advantage of inexpensive signal processing technology available today.

Digital Signal Processor (DSP) technology is used extensively in commercial applications making high performance DSP hardware available at relatively low cost. It is now possible to produce low-cost, DSP-based torpedo countermeasures capable of providing better performance than current fleet countermeasures at a fraction of current prices. By analyzing and responding to a threat torpedo's sonar signal only when the threat is actually present, DSP-based countermeasures provide customized decoy signals without having to flood the water with continuous transmissions.

Work on designing, building and testing such a device began at the Naval Postgraduate School (NPS) in 1997. This thesis describes the development, troubleshooting and testing of the NPS second-generation torpedo countermeasure prototypes. Methodologies are presented for hardware and software design efforts and an OpenGL 3D graphics computer simulation is provided. The hardware and software are described in detail along with the testing results and suggestions for future work in this important area.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Conventional Weapons

KEYWORDS: Torpedo Countermeasures, Digital Signal Processing, Acoustic Modem, Acoustic Telemetry, Acoustic Decoy, Signal Analysis

DEVELOPMENT OF A SOFTWARE EVOLUTION PROCESS FOR MILITARY SYSTEMS COMPOSED OF INTEGRATED COMMERCIAL-OFF-THE-SHELF (COTS) COMPONENTS

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Department of Defense (DoD) acquisition policy requires that military system acquisitions incorporate commercial-off-the-shelf (COTS) components into system architectures. Traditional DoD source code development and evolution methodologies do not effectively support COTS-intensive systems. To fully realize the benefits of COTS technologies and products, the DoD must adopt new ways to sustain system evolution in the face of a dynamic market environment subject to constant change.

The thesis proposes a new software evolution methodology to effectively maintain COTS-intensive military systems. The integrated COTS component evolution (ICCE) model provides evolution processes designed to support the maintainer as a consumer of software instead of a source-code developer. The ICCE model affords proactive risk awareness, market awareness, and user awareness activities. The ICCE model also supports a three-tier test and evaluation process. A case study for the U.S. Navy/Marine Corps Meteorological Mobile Facility Replacement (METMF (R)) program demonstrates the effectiveness of the ICCE risk management process.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: COTS, GOTS, Software Evolution, Software Management, Risk Management, Software Evolution Model

APPLICATIONS OF THERMAL HYPERSPECTRAL IMAGERY FOR SPECIFIC MATERIAL IDENTIFICATION

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Thermal infrared spectral imagery provides the opportunity to perform material identification on targets. The Aerospace Corporation's SEBASS High Altitude Research Project (SHARP) collects thermal imagery data in both midwave infrared (MWIR) and longwave infrared (LWIR) regions of the electromagnetic spectrum. This thesis explored the ability to perform specific material identification of targets from SHARP acquired LWIR data from the DESERT RADIANCE III exercise conducted in Yuma, Arizona in February 1999. Data were atmospherically compensated using both an in-scene method (ISAC) and an empirical line method (ELM). The ELM was needed due to the lack of in-scene blackbodies, which limited the performance of ISAC. After calibration, an inverse minimum noise fraction rotation was used to correct a noticeable calibration error in the data. Alpha residual and emissivity normalization methods were used to separate emissivity from temperature. Both alpha residual and emissive data sets were analyzed using the spectral angle mapper algorithm. Spectral angle results were poor for alpha residuals, therefore only the emissive data was further examined using the spectral matched filter algorithm and the K-Means classification method. Only results from the spectral matched filter demonstrated an ability to positively

THESIS ABSTRACTS

identify materials based on specific thermal emissivity.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Remote Sensing, Hyperspectral, Thermal Imagery, Specific Material Identification, SHARP, DESERT RADIANCE III, Spectral Imagery

COMPUTER MODELING OF JAMMING EFFECTS ON ROLL STABILIZED MISSILES

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Development of countermeasures against infrared missiles is enhanced by an ability to quantify the effects of the countermeasure. Analysts must be capable of accurately determining the attitude of the missile throughout its flight. This thesis describes the use of micro-miniature technologies to measure the rates experienced by a missile and the model required to effectively determine the missile's attitude.

The Applied Technology Associates ARS-04E and the Tokin America CG-16D sensors were evaluated for use as rate sensors and the Honeywell, SSEC, HMC1002 was evaluated for use as a roll sensor. Of these sensors, the CG-16D proved its ability to perform in this application. The ARS-04E was ineffective in this application.

A Simulink model is presented that performs the tasks of demodulating the sensors, performing coordinate transformation, and providing animation of the missile attitude for analysis. The model was evaluated for its ability to accurately determine the attitude of the missile based on input from the IMU packages. Sensor data was obtained from testing performed on a CARCO table flight motion simulator, and compared to the ground truth data provided by the CARCO table. Through testing, the model was capable of providing solutions within the 2 degrees RMS requirement.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Simulink, Inertial Measuring Unit, Euler Rotation, Animation

GLOBALSTAR: A NATIONAL SECURITY PERSPECTIVE

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It is expected that LEO-based satellite mobile telephony will thrive in the global marketplace of the 21st century. There are large portions of the world that could reap significant benefit from a satellite communication system such as the GLOBALSTAR. The worldwide communication services of the GLOBALSTAR provide a means to enhance the command and control capabilities of government and military leadership throughout the world. The application of the GLOBALSTAR to U.S. National Security issues deals with the impact of satellite mobile telephony upon the communication structure of U.S. National and foreign entities. Analysis of the GLOBALSTAR and its impact to U.S. National Security provide insight into what modifications need to be implemented to the existing Command, Control, Computers, Communications, Surveillance and Reconnaissance (C4ISR) Systems of the United States to accommodate emerging technologies that have the potential to revolutionize the way the world communicates.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors, Space Vehicles

KEYWORDS: Satellite Mobile Telephony, Satellite Communications

COMPARISON OF PERFORMANCE MEASURES IN THE VIRTUAL ENVIRONMENT AND REAL WORLD LAND NAVIGATION TASKS

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Spatial knowledge acquisition is an integral part of navigation related studies. With the improvement of technology, the researchers gained the capability of testing the spatial ability in a virtual world as well. However, little research has been conducted to understand whether VE performance can predict Real World performance or not and amongst the measures used what measures are most predictive.

This thesis research addresses the validity of performance measures used in virtual and real environments. Ten subjects have participated in two experiments. The first experiment was a navigation task in a building type virtual environment. With some modifications, Hermann Hall model was used for this experiment. The second experiment was a navigation task in a real building. For this experiment Middle East school in DLI was used. Measures of landmark, survey and route knowledge were taken for each participant.

The results did not suggest a correlation in overall performance measures. However a correlation is observed in the performance for the landmark knowledge. The acquisition of survey knowledge by time is also seen in the results of the study.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Virtual Environments, Land Navigation, Spatial Knowledge

ANALYSIS OF THE WATERHAMMER CONCEPT AS A MINE COUNTERMEASURE SYSTEM

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The purpose of this thesis is to provide an analysis of the Waterhammer concept design. Waterhammer is a device intended to generate repetitive shock waves to clear a path through the very shallow water region for amphibious operations. These repetitive shock waves are intended to destroy obstructions and mines alike.

This thesis analyzes the energy budget of the deflagration processes and the basic principles of shock waves and acoustic saturation. When the source amplitude is increased to very high levels, acoustic saturation sets in, a state in which the amplitude of the received signal approaches a limiting value, independent of the source amplitude. Acoustic saturation thus will set physical constraints in the design of Waterhammer. Furthermore, as the pulse propagates in the shallow water environment, reflections from the water's surface and bottom floor will spread the energy in the water column thus reducing the energy density. These combined effects can affect the intended performance of Waterhammer. The results of the analysis in this thesis lead to the conclusion that Waterhammer may not be viable in its present concept design.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Conventional Weapons, Surface/Under Surface Vehicles-Ships and Watercraft, Manufacturing Science and Technology (MS&T)

KEYWORDS: Waterhammer Performance, Acoustic Saturation Limits, Nonlinear Effect in Water Due to Very High Source Levels

FRAME RATE EFFECTS ON HUMAN SPATIAL PERCEPTION IN VIDEO INTELLIGENCE

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This thesis examines the effect that the frame rate of a streaming video feed has on one's ability to maintain spatial perception. It defines the current technologies available to capture and encode digital video. It describes the current and near future wireless information systems that could be utilized to support streaming video.

This thesis investigates through experimental trials of subjects viewing video streams at different frame rates, the effect those frame rates have on the subject's spatial perception. This thesis analyzes and summarizes the data collected from this experiment and provides recommendations. It is determined that the inherent chaotic nature of tactical movement and the method used to encode digital video are not compatible for video streams with high motion in the three dimensional planes. Results of this analysis suggest that a large amount of bandwidth would be consumed to provide the minimum quality of service indicated by the data and suggests that video to the commanders at the frontline is not a useful allocation of bandwidth.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Human Systems Interface, Modeling and Simulation

KEYWORDS: Reconnaissance, Digital Video Imagery, Real-time Video, Wireless Communications, Bandwidth, Spatial Perception

ANALYSIS OF THE POSITIONAL ACCURACY OF A RANGE DIFFERENCE MISSILE POSITION MEASURING SYSTEM

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The Telemetry (TM) Tracker system is designed to determine time, space, and position information (TSPI) of an airborne missile by detecting its telemetry signal at a number of receiver sites. Doppler frequency measurements are converted to range differences between the missile and receiver sites, whose locations are known in three dimensions. An algorithm then utilizes these range differences to obtain missile TSPI with 1-meter accuracy. The TM Tracker was fielded during live missile firings and measurements indicated that the desired TSPI accuracy was not attained.

This thesis examines system requirements and limitations of the TM Tracker to obtain TSPI with 1-meter accuracy. The theory of operation and components of the TM Tracker are introduced. Algorithms used in computing position of a radiating source from range differences are analyzed. MATLAB simulations are conducted with missile trajectory data to determine the required measurement precision and signal-to-noise ratio (SNR) at the receiver sites to obtain 1-meter TSPI. The receivers' 45-degree, 3-dB beam widths are then implemented to observe their effects on TSPI accuracy. Simulations reveal that the TM Tracker system is capable of producing TSPI with 1-meter accuracy provided that precise frequency measurements and adequate SNR values are available at the receiver sites.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Telemetry (TM) Tracker, TSPI, Range Difference, Time Difference of Arrival (TDOA), Frequency Difference of Arrival (FDOA)

MODELING INFORMATION OPERATIONS (IO): ENGAGEMENT OF THE DECISION-MAKING INFRASTRUCTURE OF CHINA (U)

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The United States engages China in order to promote regional stability and economic prosperity while attempting to secure China's adherence to international standards. Engagement options such as military exchange programs, port visits, and professional seminars contribute to a dialogue that is aimed at building a lasting relationship that fosters cooperation and confidence between the United States and China. United States Pacific Command (PACOM), a regional unified command, is responsible for conducting military peacetime engagement with China. This thesis investigates the applicability of using the Situational Influence Assessment Module model as a tool for PACOM to plan and assess the value of possible engagement strategies.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Information Operations)

KEYWORDS: Modeling and Simulation, Information Operations, SIAM, China, Culture, Engagement Planning

NON-LETHAL WEAPONS IN NONCOMBATANT EVACUATION OPERATIONS

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This thesis examines the utility of non-lethal weapons for mitigating risks in demanding tactical scenarios, specifically crowd control. Noncombatant evacuation operations (NEOs) are conducted when a host government becomes unstable. A NEO force's failure to manage the potential for local violence against the mission can lead to negative consequences for U.S. foreign policy and international relations. Therefore, escalation in the threat level must be avoided because mission success could be jeopardized. Along with restrictive rules of engagement, these considerations discourage the use of deadly force. Thus, non-lethal weapons have a role in NEOs.

One of the challenges in NEOs is crowd control. Crowds have the potential for violence. Left unchecked, they can endanger the NEO mission. This thesis finds that a non-lethal capability is essential for responding to these threats. The thesis' methodology produces a short list of suitable non-lethal crowd control weapons for deployment in NEOs. In addition, the arguments for non-lethality in NEOs can be extended to other operations other than war, and thus increase the utility of non-lethal weapons in the US military inventory.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Other (Non-Lethal Weapons)

KEYWORDS: Noncombatant Evacuation Operations, Crowd Control, Crowd Behavior, Non-Lethal Weapons

3D VISUALIZATION OF THEATER-LEVEL RADIO COMMUNICATIONS USING A NETWORKED VIRTUAL ENVIRONMENT

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The military is heavily reliant on the transfer of information among various networks in day-to-day operations. Radio-based communications networks that support this volume of information are complex, difficult to manage, and change frequently. Communications network planners need a way to clearly visualize and communicate mobile operational network capabilities, particularly to network users.

By using the DIS-Java-VRML simulation and modeling toolkit, visualizations of radio-frequency energy and radio path-profiling data can be quickly generated as 3D models. These animated 3D visualizations can be loaded into a networked virtual environment, so that communications planners can detect a variety of problems such as radio frequency interference and gaps in coverage. Planners can also brief senior staff, plan within their own staff, and collaborate with communications staff planners in distant locations using such virtual environments.

DIS-Java-VRML visualization tools can provide a clear picture of the battlespace with respect to the deployed communications architecture. The prototypes presented in this thesis demonstrate the ability to generate a shared visualization that can show a radio communications network in 3D. Such dynamic visualizations increase communications planning information bandwidth and yield more intuitive ways of presenting information to users. Higher information density in a more intuitive format enables better understanding with quicker reaction times. This thesis and the visualization tool discussed provide the foundation for fundamental improvements in visualizing radio communications environments.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Computing and Software, Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: Virtual Environments, Visual Simulation, Signal Planning, VRML, Java, DIS-Java-VRML, X3D

THE UTILITY OF MAKING FUNCTIONAL AREA 39 A BRANCH

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The purpose of this thesis is to suggest that it is time for Functional Area 39 (Psychological Operations/Civil Affairs) to become a branch. The hope is to stimulate critical thinking on this issue and illustrate the demands that are presently being placed on the FA 39 community by utilizing the Spectrum of Conflict as a frame of reference.

As experienced officers with a vested interest in the future of FA 39, we believe it is important to the

THESIS ABSTRACTS

future of the Functional Area to take a critical look at where it is and where it appears to be going. The present degree of reliance on the reserves, argued, is a sub-optimal long-term solution.

Utilizing the Spectrum of Conflict as a model, it is illustrated that conflict trends over the past twenty years show a significantly higher incidence of sub-state conflict, with no change in the foreseeable future. This suggests an increased need for soldiers with Special Operations Forces (SOF) related skills. By examining possible alternatives, we provide arguments and illustrate the merits of change.

The findings of the analysis lead to the recommendation that FA 39 become a branch within the Army. While it may appear that the organization is healthy, the threat environment and increased OPTEMPO necessitate a need for change.

DoD KEY TECHNOLOGY AREA: Other (Special Operations Forces)

KEYWORDS: Functional Area 39, Psychological Operations (PSYOP), Civil Affairs (CA), Spectrum of Conflict, Special Operations Forces, Branch Designation, OPMS XXI, Low Intensity Conflict, PSYOP and CA Reserve Components

VULNERABILITY AND IMPACT ANALYSIS OF RADIO FREQUENCY INTERFERENCE ON MILITARY ULTRA HIGH FREQUENCY SATELLITE COMMUNICATIONS

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Second Reader: CDR Susan L. Higgins, USN, Space Systems Academic Group

As the U.S. military focuses more attention on information warfare and obtaining knowledge superiority on the battlefield, communications capabilities are becoming a critical element to military readiness. Ultra High Frequency Satellite Communications (UHF SATCOM) provides the military with unique capabilities that communication systems operating in other spectrum bands cannot. UHF SATCOM is the primary means of interoperability with Allies. Not only are these systems inexpensive and light enough to be man-portable but they can also operate through weather and foliage. Unfortunately, UHF SATCOM systems are extremely susceptible to radio frequency interference (RFI). The military's vulnerability to UHF SATCOM RFI is caused by technical, regulatory and operational factors.

This vulnerability manifests itself in terms of impact of RFI on UHF SATCOM and corresponding degradation of military operations. RFI is responsible for an approximately 25% decrease in UHF channel availability. Consequently, users often experience intermittent or complete circuit outages. Unfortunately, there is a severe deficiency in the services' ability to identify, geolocate and resolve RFI sources. When the factors and operational costs are analyzed together and reviewed as a whole, the vulnerability of our military's UHF SATCOM to RFI cannot be underestimated. This thesis provides recommendations for mitigating the military's vulnerability, eliminating deficiencies in resolution capability, thereby decreasing the impact of RFI on military readiness.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Electronic Warfare, Space Vehicles

KEYWORDS: Military Satellite Communications, Radio Frequency Interference, Ultra High Frequency Communications

THESIS ABSTRACTS

EVALUATION OF LOW COST NETWORK INTRUSION DETECTION SOFTWARE FOR THE NETWORK CENTRIC NAVY

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Network intrusion continues to be a viable threat to the Department of the Navy's (DON's) information infrastructure. As the U.S. Navy advances toward a knowledge-based infrastructure we are now vulnerable in new ways previously unknown, mainly due to the independent operation of all the emergent IT systems. As follow-on systems develop into a network-centric infrastructure, DOD has made intrusion into a classified system possible by linking from unclassified sites, a very real and serious problem. As a result of budget limitations and the accelerated pace required to catch up, emphasis is being placed on acquiring commercial off-the-shelf (COTS) products, many of which were never intended to completely meet the security demands of the military. To best protect our systems the development of a defense-in-depth layered security concept consisting of awareness, enforced policies, and firewalls, directly supports Presidential Decision Directive 63. This approach must be adopted since no single product provides total security. One element of the layered solution is a COTS network intrusion detection software system which will alert a network administrator to unauthorized intrusion. "NetProwler", a network intrusion detection system produced by Axent Technologies, is evaluated for naval use as a solution to multi-level network security.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Electronic Warfare

KEYWORDS: Information Warfare, Information Systems Technology, Command Systems Technology, CNA/D/E, Intrusion Detection

TERRAIN CATEGORIZATION USING MULTISPECTRAL AND MULTITEMPORAL IMAGERY (U)

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Abstract is classified.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Sensor Fusion, Multitemporal, Terrain Categorization, Imagery Intelligence

DEVELOPMENT OF A QUALITY MANAGEMENT METRIC (QMM) MEASURING SOFTWARE PROGRAM MANAGEMENT QUALITY

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The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program

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are requirements management, estimation/planning management, people management, and risk management. By using current researched practices, interviews with senior program managers, and focus group data, the thesis examines the four areas for practices and structure that a software program manager may implement to positively affect the program. The thesis develops a Quality Management Metric (QMM) to measure the performance of the software manager. The QMM score is determined via a survey consisting of a two-part questionnaire for each of the four main areas examined. The thesis evaluated three software programs for a QMM score. Informal verification and validation of the metric compared the QMM percentile score to an overall program success score for the entire program and yielded positive correlation. The establishment of this methodology to quantify the quality of software management is an important step in evaluation of how past and current programs are managed and can serve as a template to improve software management performance in the future.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Management, Requirements Management, Estimation/Planning Management, Risk Management, Quality Management Metric (QMM)

SPACE-BASED COMPUTER NETWORK OPERATIONS (CNO)

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This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software

KEYWORDS: Internet, Satellite Operations, Computer Network Operations, Space-based Computer Network Operations

AN EVALUATION OF THE HYDRA-7 COUNTERMINE WEAPON SYSTEM

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The basic principle of Maneuver Warfare in the 21st century is the seamless integration of sea and land as maneuver space. Unfortunately, our inability to conduct counter-mine and counter-obstacle operations in the littorals severely curtails our ability to conduct Amphibious Warfare, a key ingredient to maneuver. Hydra-7, a possible solution to this problem, is one of the most promising counter-mine weapons under development, but its final performance level will depend on the effectiveness of sub-component technologies. These sub-component technologies have yet to reach maturity and may not perform as well as desired. This thesis provides analysis procedures and models to predict Hydra-7 effectiveness for a broad range of possible performance values of sub-component systems. The methodology will determine which of the sub-component technologies is most critical to the final performance of Hydra-7.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Simulation, Parameterization, Sensitivity Analysis

THESIS ABSTRACTS

A SOCKETS APPLICATION PROGRAMMING INTERFACE FOR THE PETITE AMATEUR NAVAL SATELLITE

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The Petite Amateur Naval Satellite (PANSAT) is an operational communications microsatellite designed at the Naval Postgraduate School (NPS). PANSAT's communications software was intended to be developed after orbital insertion and transmitted to the satellite.

The Sockets Application Programming Interface (API) developed at the University of California, Berkeley is the de facto standard API for network applications. It provides a strong and flexible platform on which to develop a wide variety of programs. It accelerates the development of new applications by providing a standard set of features and isolating the program from the underlying networking mechanisms.

This thesis studied the viability of implementing of a Sockets API for PANSAT based on the Berkeley Sockets. PANSAT's Sockets API was built on BekTek's Spacecraft Operating System (SCOS). Because SCOS source code was not available, network protocols had to be implemented in user mode. SCOS is optimized for multiple small tasks, not the complex processes required for Internet programming. Because of SCOS' limitations in memory management, the development of this protocol stack and API was not successful. SCOS does not have the features required for an implementation like this.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Space Vehicles

KEYWORDS: PANSAT, Internet, TCP/IP, Sockets

DEVELOPMENT OF THE BEARTRAP POST MISSION PROCESSING SYSTEM 2000 (S2K) HTML HELP PROJECT

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This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into an application operating in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis develops the HTML Help features to support users of the BEARTRAP Post Mission Processing System 2000 (S2K) software application. This application allows an analyst to gather context sensitive HTML Help to support procedural use of the BEARTRAP Post Mission Processing System as well as background information on related fields of study. This document describes the background and development of the HTML Help project with particular emphasis on critical areas fundamental to the HTML Help project development and aspects requiring further research and development.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: HTML Help, BEARTRAP, S2K

THESIS ABSTRACTS

DEFINING CRITICAL TECHNOLOGIES FOR SPECIAL OPERATIONS

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As the military forces of the United States continue to draw down, Special Operations Forces (SOF) are playing a greater role across the entire spectrum of conflict. In order to maintain its relative advantage, SOF is using technology as a means to leverage limited resources – sometimes to the point that mission accomplishment depends critically on a technology's availability. Adversaries will attempt to challenge our advantages. Whether Special Operations Forces are prepared to operate in a degraded environment could determine success or failure.

This thesis examines the issue of *critical* technologies in special operations. *Critical* technologies are defined according to three variables – level of dependence, degree of vulnerability, and substitutability. By examining technologies against these three variables, SOF can gain a better understanding of the impact to SOF operations if a technical capability is lost. Three technologies are examined to illustrate the model – the use of Radar in the Battle of Britain, the Global Positioning System, and UHF Satellite Communications.

By applying the model to actual cases, this thesis hopes to encourage SOF decision-makers to closely examine our growing reliance on vulnerable technologies as a force multiplier and provide recommendations to prevent undue reliance on those technologies.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Electronics

KEYWORDS: Technology, Special Operations, GPS, Satellite Communications

INVESTIGATION INTO THE EFFECTS OF VOICE AND DATA CONVERGENCE ON A MARINE EXPEDITIONARY BRIGADE TRI-TAC DIGITAL TRANSMISSION NETWORK

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In the tactical environment, bandwidth demanded for data, video and voice services have increased faster than the capacity of new transmission devices are able to provide. Using Desert Knight 2000, a Marine Expeditionary Brigade exercise held in California in December 1999, as a case study, an investigation was made into the effects of network convergence on transmission system bandwidth. The focus of this thesis was on the potential gains available by making use of unused bandwidth normally reserved for the voice telephone network for other services, such as video and data.

Using data collected from the exercise, and building a network model using Imagine That, Inc.'s Extend software, several experiments were conducted under varying network conditions to determine if network convergence could be a partial solution to the increased bandwidth demands of today's command and control network. After conducting 27 model runs, results indicate that convergence can provide significantly more bandwidth to the tactical user for other than voice services, as well as better service levels for the voice network.

DOD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: TRI-TAC Circuit Switch, Simulation, Bandwidth Management, Desert Knight 2000, Network Convergence

THESIS ABSTRACTS

INTEGRATING REALISTIC HUMAN GROUP BEHAVIORS INTO A NETWORKED 3D VIRTUAL ENVIRONMENT

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Virtual humans operating inside large-scale virtual environments (VE) are typically controlled as single entities. Coordination of group activity and movement is usually the responsibility of their "real world" human controllers. Georeferencing coordinate systems, single-precision versus double-precision number representation and network delay requirements make group operations difficult. Mounting multiple humans inside shared or single vehicles, (i.e., air-assault operations, mechanized infantry operations, or small boat/riverine operations) with high fidelity is often impossible.

The approach taken in this thesis is to re-engineer the DIS-Java-VRML Capture the Flag game geolocated at Fort Irwin, California to allow the inclusion of human entities. Human operators are given the capability of aggregating or mounting nonhuman entities for coordinated actions. Additionally, rapid content creation of human entities is addressed through the development of a native tag set for the Humanoid Animation (H-Anim) 1.1 Specification in Extensible 3D (X3D). Conventions are demonstrated for integrating the DIS-Java-VRML and H-Anim draft standards using either VRML97 or X3D encodings.

The result of this work is an interface to aggregate and control articulated humans using an existing model with a standardized motion library in a networked virtual environment. Virtual human avatars can be mounted and unmounted from aggregation entities. Simple demonstration examples show coordinated tactical maneuver among multiple humans with and without vehicles. Live 3D visualization of animated humanoids on realistic terrain is then portrayed inside freely available web browsers.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Computing and Software, Battlespace Environments, Command, Control and Communications, Human Systems Interface

KEYWORDS: Virtual Environments, Humanoid Animation 1.1 Specification, Distributed Interactive Simulation, 3D, Aggregation, Mounting Human Entities, Virtual Humans, Avatars, X3D, X3d-Edit, VRML, Java, DIS-Java-VRML, Web3D Consortium

AUTOMATICALLY GENERATING A DISTRIBUTED 3D BATTLESPACE USING USMTF AND XML-MTF AIR TASKING ORDER, EXTENSIBLE MARKUP LANGUAGE (XML) AND VIRTUAL REALITY MODELING LANGUAGE (VRML)

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For the past three decades, the Department of Defense (DoD) has used the U.S. Message Text Format (USMTF) as the primary means to exchange information and to achieve interoperability between joint and coalition forces. To more effectively exchange and share data, the Defense Information Systems Agency (DISA), the lead agency for the USMTF, is actively engaged in extending the USMTF standard with a new data sharing technology called Extensible Markup Language (XML). This work translates and synthesizes Air Tasking Order (ATO) data messages written in XML into a three-dimensional (3D) air attack plan within a virtual environment through the use of the Virtual Reality Modeling Language (VRML).

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Extensible Markup Language (XML), Virtual Reality Modeling Language (VRML), Air Tasking Order (ATO), Extensible 3D (X3D), U.S. Message Text Format (USMTF), XML-MTF, and Defense Messaging System

CYBERTERROR PROFILING (U)

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and

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The reports of various commissions, as well as Y2K concerns, have all brought about the perception the United States has become increasingly vulnerable to an information technology mishap or a deliberate attack of such cascading effect as to paralyze critical economic or military information infrastructures. Many have theorized that terrorist groups will acquire an information warfare capability to seize this opportunity to exploit an "information chink" in America's defensive armor. This research applies a model created in the study, "Cyberterror: Prospects and Implications" to five active terrorist groups and determines each group's relative incentives and disincentives for pursuing cyberterror.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Electronic Warfare

KEYWORDS: Cyberterror, CNA, Computer Network Attack, Computer Security, Information Warfare, Information Operations, Special Operations, Hacker, Terrorist, Terrorism

WHAT DO CHIEF INFORMATION INTEGRATION OFFICERS (CI²O) NEED TO KNOW AND WHAT IS THEIR ROLE?

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As DoD and the Navy move into the 21st Century, information technologies are abounding not only in volume but also in complexity. In order to manage and leverage these technologies, there needs to be a clear vision and it must start at the very top of the DoD Enterprise. With this vision, it will then become the responsibility of the Chief Information Integration Officer (CI²O), previously known as the Chief Information Officer (CIO), at each command to implement that vision. The real challenge is determining what exactly the CI²O needs to know and the role the CI²O should play in the command. Once the requirements are identified, how do we ensure the officer's success? This thesis examines these questions. The results of a meta-analysis from a variety of studies are portrayed in a matrix which identify the critical success factors, reporting levels, roles, core competencies, education and experience to clearly define the requirements for an effective CI²O to be implemented into Navy organizations.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Navy Officers, Information Technology, Information Management, Core Competencies, Chief Information Officer

A FORMAL MODEL FOR RISK ASSESSMENT IN SOFTWARE PROJECTS

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The current state of the art techniques of risk assessment rely on checklists and human expertise. This constitutes a weak approach because different people could arrive at different conclusions from the same scenario. The difficulty on estimating the duration of projects applying evolutionary software processes contributes to add intricacy to the risk assessment problem. This thesis introduces a formal method to assess the risk and the duration of software projects automatically. The method has been designed according the characteristics of evolutionary software processes such as productivity, requirement volatility and complexity. The formal model based on these three indicators estimates the duration and risk of evolutionary software processes. The approach introduces benefits in two fields: a) automation of risk assessment and, b) early estimation method for evolutionary software processes.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Risk Assessment, Software Engineering

AN AD HOC WIRELESS MOBILE COMMUNICATIONS MODEL FOR SPECIAL OPERATIONS FORCES

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The digitization of the battlefield enables special operators to use improved communications supported by computer networks across a range of missions. The communications paradigm is evolving toward mobile wireless ad hoc networks. This development enables an autonomous system of mobile nodes supporting peer-to-peer communications in forward-deployed military networks. Ad hoc networks have to establish a reliable, secure, instant, and usually temporary, communication infrastructure and to be able to access in a global communications infrastructure.

Our model describes a global communication network supporting the special operator in mobile wireless communications. The main purpose is to provide a handheld wireless communications node which is capable of transferring voice, data, and imagery to and from parallel and vertical command structures within an environment replete with electronic countermeasures. The model will support the representation of requirements such as throughput, quality of service with low power consumption, and low probability of detection/interception. Special Forces are moving toward using commercial-off-the-shelf products and services based on availability and cost effectiveness.

Using GloMoSim tool, simulations for a direct action scenario are ran and the efficiency of on-demand and table-driven routing protocols under different bandwidths and communications loads is compared.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Special Operation Forces, Ad Hoc, Wireless, Mobile Communications, Information Operations, Electromagnetic Pulse Weapons, EMP

IDENTIFICATION AND EVALUATION OF ORGANIZATIONAL STRUCTURES AND MEASURES FOR ANALYSIS OF JOINT TASK FORCES

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Joint Task Force (JTF) operate in a variety of missions and uncertain environments. The architectures these organizations must be capable of adapting to changes in the mission, the environment, or the organization itself. Mathematical models that are useful in predicting operational performance are needed for research into the optimum design of a JTF architecture for a given mission. To develop these models, properties of a joint task force organization must be understood and measures must be identified that are both sensitive to changes (differences) in architectures and related to operational performance.

A literature review of civilian research in organizational structures and measures identified several candidates. To analyze the usefulness of these measures to identify differences in operational architectures, to known contrasting JTF organizations are developed using structures found in the literature. Each of the measures is applied to all structures in both architectures and analyzed to determine which measures show promise. Those that identify differences between operationally relevant architectures are deemed useful measures. Limited data from a related Naval Postgraduate School command and control experiment, in which architecture type is a factor, is used to fit a regression-type model that predicts JTF performance based on measures classified as useful.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Organizational Architectures, Organizational Measures, Organizational Structures, Joint Task Force Organization, Measures of Performance, JTF for 2010

DESIGN AND IMPLEMENTATION OF A THREE-TIERED WEB-BASED INVENTORY ORDERING AND TRACKING SYSTEM PROTOTYPE USING CORBA AND JAVA

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Many enterprises are still running and maintaining several operating system and platform dependent legacy applications. The variety of platforms and operating systems poses a challenge to system-wide interoperability and performance, increases the cost of maintenance, locks enterprises into certain vendors, and leads to a lack of an adequate information infrastructure which results in a waste of computer resources, manpower, and time. In this thesis, a component-based three-tiered Web-based Inventory Ordering and Tracking System (IOTS) prototype has been designed and implemented that demonstrates the technical feasibility of making an enterprise's applications both interoperable and scalable on a system composed of multiple platforms and different operating systems. The prototype uses CORBA, an industry-backed, non-proprietary, standard-based distributed architecture and Java, a high-level object-oriented language that enables enterprises to leverage the use of the Internet and benefit from the enhancements in

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the client/server and the decrease in the prices of desktop computers. The prototype demonstrates how to overcome the problem of the stateless nature of HTTP and build the Object Web where Java applets run on the IIOP. The prototype's source code can be tailored to some specific business requirements and enterprises having problems similar to those addressed may benefit from this research and adopt its development methodology.

DoD KEY TECHNOLOGY AREA: Other (Interoperability, Re-Engineering, Inventory Ordering and Tracking)

KEYWORDS: Interoperability, Re-Engineering, Inventory Ordering and Tracking, CORBA, Java, Database, Electronic Commerce, Internet, Web-Database Connectivity

MANAGING KNOWLEDGE IN THE BATTLE GROUP THEATER TRANSITION PROCESS (BGTP)

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At a time when theater environments are frequently hostile, changing rapidly, and uncertain, the need to improve the Battle Group Theater Transition Process (BGTP) between carrier battle groups is intense. Recent developments in information technology help facilitate the transition process, but only data and information are transferred at present, not knowledge. This study provides in-depth analysis of the current BGTP being employed by the Department of the Navy (DoN) in the Arabian Gulf. The purpose of this study is to design a knowledge management system that significantly reduces carrier battle group theater familiarization periods. This study builds upon recent work that focuses on knowledge management and system design from three integrated perspectives: 1) re-engineering, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. This paper uses an integrated framework for knowledge process and system design. This integrated framework covers the gamut of design considerations from the enterprise process in large, through alternative classes of knowledge in the middle, and on to specific systems in detail. This study applies the integrated framework to the BGTP to improve process performance.

DoD KEY TECHNOLOGY AREA: Other (Information Technology)

KEYWORDS: Analysis and Design, Expert Systems, Information Systems, Knowledge Management, Re-Engineering, U.S. Navy, Information Technology

THESIS ABSTRACTS

SCALABILITY STUDY OF WIRELESS TACTICAL COMMUNICATIONS IN SUPPORT OF A MARINE CORPS EXPEDITIONARY BRIGADE

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This thesis reports the findings of a simulation modeling the communications architecture used during Major System Demonstrations 1 (MSD-1) of the Extended Littoral Battlespace (ELB) Advanced Concept Technology Demonstration (ACTD) and a suitable architecture for a large-scale battlespace. The simulation was accomplished with the use of a leading edge simulation tool, EXTEND™, and the specifications inherent to wireless communications. Specifically, EXTEND was used to replicate the protocols that are inherent within the WaveLAN and VRC-99A systems. A feasible sized architecture was modeled utilizing scaling techniques, which simulated the operation of a Marine Expeditionary Brigade (MEB), covering a 200X200 mile wireless tactical battlespace. This thesis further investigates the validity of a completely wireless tactical network versus the additional use of ground relays. This thesis demonstrates that the wireless tactical battlespace is scalable to satisfy the requirements of a Marine Expeditionary Brigade. Lastly, this thesis demonstrates the effects of an all WaveLAN architecture.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Networks, Tactical Network, Communications, Systems

THE CONDUCT AND ASSESSMENT OF A2C2 EXPERIMENT 7

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Adaptive Architectures for Command and Control (A2C2) Experiment 7 is the latest in the series of experiments designed to investigate the effects of modifying current military organizational structures. It is a continuation of A2C2 Experiment 4, which compared the performance of a mission-optimized architecture to a non-optimized traditional architecture. The focus of A2C2 Experiment 7 involves the introduction of complex, unexpected tasks requiring multi-node coordination into the simulation scenario, and the examination of two disparate command and control architectures in dealing with these unexpected tasks. The two architectures, by design, differed in the amount of coordination required to accomplish the known scenario mission tasks. The "Autonomous" optimized architecture's design emphasized inter-nodal autonomy in performing mission tasks, while a "Interdependent" non-optimized architecture, resembling a traditional Joint Task Force (JTF) organization, operated with greater "inter-nodal" coordination. The research team expected the non-optimized architecture to have an advantage over the optimized architecture when dealing with the complex unexpected tasks, due to the higher coordination practiced in the "Interdependent" architecture. The experiment used the accuracy and latency scores of accomplishing each unexpected task as the two primary measures examined. A detailed statistical analysis is performed on the measures and the results discussed.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Adaptive Architectures for Command and Control (A2C2)

TARGET DETECTION AND SCENE CLASSIFICATION WITH VNIR/SWIR SPECTRAL IMAGERY

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Second Reader: Alan Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

Spectral imagery provides a new resource in remote sensing, which can be used for defeating camouflage, concealment and detection, as well as terrain categorization. A new sensor, the Night Vision Imaging Spectrometer (NVIS), provides VNIR/SWIR (0.4-2.5 μ m) spectra, which are used to study such applications. NVIS has a nominal GSD of 0.5-1.5 meters in operational modes utilized for this work, which make the data well suited for studying mapping and classification algorithms. Data taken at Ft. A.P. Hill on April 29, 2000 are studied here.

A Principal Components Transformation was performed on the NVIS data. From this new data set, target spectra were collected for use in classification algorithms. The NVIS data was converted from radiance to reflectance in two different ways: Empirical Line Method and Internal Average Relative Reflectance. Using this data, various standard algorithms were performed. It was found that while none of the algorithms correctly classified all of the selected targets, the Mahalanobis Distance and Mixture Tuned Matched FilterTM algorithms were the most successful.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors

KEYWORDS: Hyperspectral, NVIS, Remote Sensing, Imagery, Electro-Optical Sensing

MINE BURIAL IN THE SURF ZONE

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The volumetric rate of scour and burial of a MK-83 mine by waves in the swash and surf zone were measured in two experiments. The beach was near planar with a 1:40 slope and mean grain size of 0.2 mm. The deep water significant wave height was about 2 m with peak periods of 13 sec. An Acoustic Doppler Velocimeter recorded orbital velocities of the waves. Three dimensional scour was measured manually and with video. Volumetric rate of scour over time relative to the volume of the mine was as high as one during the first hours of mine deployment. Maximum scour volume occurred at 6 hours after deployment and the scour changed from removal to fill after this time. The Shields parameter as a measure of total shear stress experienced by the sand bed was an order of magnitude greater than that required to initiate sediment transport. The mine was completely buried after 24 hours in the surf zone to a depth of 10 cm below the surface of the sand bed.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Mine Burial, Scour, Surf Zone, Mine Warfare

THESIS ABSTRACTS

AUTOMATED TOOL FOR ACQUISITION PROGRAM MANAGEMENT STUDENTS (ATAPMS)

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This thesis explores the top-level requirements for an Automated Tool for Acquisition Program Management Students (ATAPMS) that is designed to enhance training and education in the acquisition management field. The Department of Defense (DoD) has identified the education and training of the acquisition workforce as a strategy to help make the acquisition system more effective and efficient. As a result, the DoD established the Defense Acquisition University (DAU) to provide the required education and training. More recently, EO 13111 and the Defense Reform Initiative have presented a mandate for the DoD to find ways to use technology to further this strategy.

Currently, the consortium schools of the DAU are using emerging technologies to increase access to their courses. However, the DAU curricula lack automated acquisition management training programs that allow instructors to qualitatively assess students' work.

This thesis recommends a set of top-level requirements for an automated program that are in compliance with the Advanced Distance Learning Initiative. It then illustrates through a prototype module, using a commercial authoring tool, how an ATAPMS can assist the DAU instructors teach the critical aspects of Acquisition Program Management.

DOD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel, and Training, Other (Acquisition)

KEYWORDS: Acquisition Program Management, Acquisition Reform, Defense Reform Initiative, DRI, Advanced Distance Learning Initiative, ADL, Authoring Tool, Computer Based Training

MANUAL DIFFERENTIAL CORRECTION (MANDC)

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This thesis is a partial analysis of the Naval Space Command Manual Differential Correction (MANDC) software program. Through a process called Differential Correction, data collected from space surveillance radar observation stations is synthesized with previously composed element sets to maintain accurate orbital object position information. The Automatic Differential Correction (AUTODC) software program is central to this process. Unfortunately, AUTODC fails to converge 1.5% of the time. These failed observations are forwarded to MANDC for lengthy manual manipulation by the watchfloor operators. This thesis will provide an analysis of the MANDC program.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Nonlinear Least Squares, Differential Correction

THESIS ABSTRACTS

TRANSITIONING TO THE UNIFIED CRYPTOLOGIC ARCHITECTURE

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The National Security Agency/Central Security Service (NSA/CSS) is the nation's center for excellence for signals intelligence (SIGINT) and information assurance products and services. To sustain the nation's SIGINT capabilities, the NSA/CSS has begun a period of rapid change that will transform the way it performs the SIGINT mission to cope with the exploding information technology of today and tomorrow. One of the documents that chart the course for the NSA/CSS is the Unified Cryptologic Architecture. This thesis investigates both the systems engineering approach used in the Unified Cryptologic Architecture and the documents that detail the NSA/CSS transformation in order to postulate recommendations to support the transformation process.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Cryptologic Architecture, Business Plan, Signals Intelligence, Access Providers, Technology Forecast

THE NPS SPACECRAFT COST MODEL: TAILORING CURRENT COMMERCIAL SPACECRAFT COST MODELS FOR NAVAL POSTGRADUATE SCHOOL SATELLITE PROGRAMS

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The successful launch of the Naval Postgraduate School (NPS) Petite Amateur Navy Satellite (PANSAT) led to the development of a follow-on satellite program at NPS. Until now, there did not exist a NPS specific cost modeling procedure to ensure accurate pricing information for program management. From the Preliminary Design Review of NPSat an initial attempt at modeling this program was conducted by the author. This thesis will provide an evaluation of this initial model and address procedures for refining the initial estimate with the purpose of providing a generic NPS Cost Model. This model will tailor current commercial cost model outputs to provide accurate price estimates for NPS specific programs. The commercial cost models used were Science Applications International Corporation's (SAIC) NAFCOM model and Aerospace's Small Satellite Cost Model (SSCM). These models do not take into account a university atmosphere where staffs and facilities are reduced. A method of tailoring the outputs of these programs was conducted and integrated into an Excel based spreadsheet. The resultant product is the Naval Postgraduate School's first Cost Modeling program which allows NPS satellite program management to input results from the SSCM and NAFCOM models and output expected cost data.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Spacecraft Cost Modeling, Parametric Estimation, Satellite Design

THESIS ABSTRACTS

RE-ENGINEERING THE MARINE CORPS RIFLE RANGE

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With no significant changes in the design of rifle ranges in more than 100 years, the current range systems are not keeping pace with technological advancements. The Marine Corps rifle ranges are manpower and material intensive, requiring unit commanders to lose personnel to the training evolution for extended periods of non-productive time. Manual target operation, excessive transition time, and extra duties all contribute to eight to ten hours per day to accomplish one hour of live-fire training per individual Marine. Marines must remain at the range to act as scorekeepers, target makers, and/or target operators when not assigned to shoot. The design and implementation of an automated range system with capabilities specifically designed to operate, score, mark, and maintain targets would reduce the non-productive time a Marine spends on the rifle range. Results from this comparative analysis indicate that the automated range would reduce man-hours by seventy-five percent. Furthermore, the implementation of computerized technology will enable instructors and shooters to better analyze each training evolution.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Information Technology, Process Re-Engineering, Marksmanship, and Training

AUTOMATING AVIATION TRAINING RECORDS

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Over the years with advances in computer technology, the Navy has gradually transitioned into a paperless operation. Personnel training records have provided a standardized, documentable individual qualification record for Navy aviation maintenance personnel, however, these records continue to be kept in folders, stored in file cabinets. In addition, paper records create a maintenance burden, in that continued handling and possibility of errors made during data entry and normal wear and tear of documents contained in these records, require pages to be periodically repaired, replaced or completely recreated. A torn and missing page also causes valuable training information to become lost, decreasing the information integrity of the record.

This thesis will examine the benefits and problems in automating aviation training records, and further discuss database design issues and considerations to maximize the flexibility and functionality provided by automation. Incorporating a distributed database is discussed as a solution, with further discussion on further considerations for the proper implementation of a training record database. Interface and alternate local networking options will also be discussed. Recommendations for further research is also presented.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Distributed Database, Training, Automation, Paperless, Records, Network Database System

THESIS ABSTRACTS

MODELING HUMAN AND ORGANIZATIONAL BEHAVIOR USING A RELATION-CENTRIC MULTI-AGENT SYSTEM DESIGN PARADIGM

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Today's modeling and simulation communities are being challenged to create rich, detailed models incorporating human decision making and organizational behavior. Recent advances in distributed artificial intelligence and complex systems theory have demonstrated that such ill-defined problems can be effectively modeled with agent-based simulation techniques using multiple, autonomous, adaptive entities. RELATE, a relation-centric design paradigm for multi-agent systems (MAS), is presented to assist developers incorporate MAS solutions into their simulations. RELATE focuses the designer on six key concepts of MAS simulations: relationships, environment, laws, agents, things, and effectors. A library of Java classes is presented which enables the user to rapidly prototype an agent-based simulation. This library utilizes the Java programming language to support cross-platform and web based designs. It includes a concise users manual and clear documentation in HTML format. Two reference cases are provided that allow for easy code reuse and modification. Finally, an existing networked DIS-JAVA-VRML simulation was modified to demonstrate the ability to utilize the RELATE library to add agents to existing applications. LCDR Kim Roddy focused on the development and refinement of the RELATE design paradigm, while LT Mike Dickson focused on the actual Java implementation. Joint work was conducted on all research and reference cases.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Multi-Agent System, MAS, Human and Organizational Behavior, Agent-Based Simulation, Adaptive Agents, Autonomous Agents, Relationship, RELATE, Architecture

EXAMINATION OF AUTOMATED INTEROPERABILITY TOOLS FOR DOD C4I SYSTEMS

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This thesis examines the ability of C4I systems within DoD to exchange information in the operational battlespace. With the advent of the Information Age and resultant development of the strategy of network-centric warfare, interoperability has become increasingly significant as a criterion for mission success, while also becoming increasingly difficult to achieve as well. The PPBS cycle bears some responsibility for this by creating competition amongst the Services for finite resources, perpetuating the environment that contributes to "stovepipe" C4I systems development. This thesis examines DoD's attempts to solve the interoperability dilemma by using policies and procedures. This thesis demonstrates that a cooperative effort among components, services, and agencies to integrate methodologies within PPBS should enhance the efforts of planners and developers in designing interoperability through the integration of C4ISR architecture development processes. As a part of this examination, several automated software tools are

THESIS ABSTRACTS

also evaluated that have been designed to facilitate interoperability, and recommendations are presented as to how these tools could be integrated to complement their effectiveness within the requirements generation and capabilities development processes.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Interoperability, JCAPS, MSTAR, LISI

COMBAT IDENTIFICATION WITHIN THE JOINT AIR-TO-GROUND ENVIRONMENT

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Combat Identification (CID) has tremendous impact on joint warfighting and is critical to success on the battlefield. Numerous CID systems are being fielded by each Service to improve Situational Awareness (SA) and Target Identification (TI) capabilities in an effort to reduce fratricide while simultaneously improving combat effectiveness. Many of these systems are not interoperable and thus cannot exchange critical information with one another. Recently published joint vision statements emphasize that joint missions will continue to predominate in the future strategic environment. If this is truly the case, achieving an acceptable degree of interoperability among Theater Commander-In-Chiefs, Services, and Agencies (C/S/As) is paramount – particularly in the area of CID. This thesis examines the nature of CID in the joint environment focusing on Close Air Support (CAS) within the Air-to-Ground (A-G) mission area. This thesis then explores interoperability problems associated with CID systems, seeks to elucidate the sources of these problems, examines recent Department of Defense (DoD) efforts to address these problems, and makes recommendations to improve interoperability within the CID warfighting area.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Combat Identification, Fratricide, Interoperability, Close Air Support

BEGINNER'S USER GUIDE FOR THE MAGTF TACTICAL WARFARE SIMULATION

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The MAGTF Tactical Warfare Simulator (MTWS) is a multi-sided computer based gaming system, currently in use by the Marine Corps. Marine operations typically involve movement over land, sea, and air, and sustained operations often involve interaction with other services. MTWS's complexity supports the joint warfare nature of Marine operations. This capability and complexity makes it ideally suited for an academic environment, and at the Naval Postgraduate School MTWS introduces students to a current service simulation, reinforces student coursework, and facilitates student research and experimentation. The drawback of a system so complex though not difficult to learn how to use, is that MTWS is not intuitive. While extensive documentation exists to support the system, it is for experienced users of the system. This thesis is tailored toward beginning users, no matter their level of operational experience, and will bridge the gap to the advanced documentation. It provides an overview of the system, explains graphical user interfaces (GUIs), provides instructions on how to develop and utilize units in the simulation, and furnishes reference charts for current U.S. weapon systems.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Human Systems Interface

KEYWORDS: MAGTF Tactical Warfare Simulator, MTWS, Simulation, Computer Gaming, C4I, Command and Control

REVISED TOMAHAWK PLANNING IN AN ANTI-GPS ELECTRONIC WARFARE ENVIRONMENT

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This study reviews the manner in which the Tomahawk Land Attack Missile (TLAM) Block III utilizes the Global Positioning System (GPS) to navigate and includes threats that may be employed to thwart GPS and consequently TLAM. The study incorporates current TLAM tactics to counter jamming and interference in an electronic warfare environment and utilizes the GPS Interference and Navigation Tool (GIANT) to create and analyze two scenarios with varied terrain features. The results of the scenarios culminate with a planner thought process for revised planning in an anti-GPS Electronic Warfare (EW) environment.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Modeling and Simulation

KEYWORDS: Tomahawk, Mission Planning, Global Positioning System, Electronic Warfare

ANALYSIS OF THE F/A-18G AS THE MANNED TACTICAL AIRBORNE ELECTRONIC ATTACK (AEA) PLATFORM

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The F/A-18G has minor shortcomings relative to the EA-6B ICAP-III baseline of the Advanced Electronic Attack (AEA) Analysis of Alternatives study being conducted by Naval Air Systems Command. By incorporating alterations, such as inclusion of a digital receiver system, complete communications electronic attack system, and routable network information system, this valid core can become a viable force for the future.

The mission radius and time on station figures with typical air defense suppression loads are nearly identical. AEA system components designed for the EA-6B ICAP-III are easily adaptable for use in the F/A-18G. An initial study of the electro-magnetic interference susceptibility for the F/A-18G was concluded with favorable results. Although the LR-700 can be adapted for use in this airframe, a digital implementation revolutionizes electronic surveillance with low probability of intercept radar and complex modulation waveform detection, coherent jamming capability, active cancellation look through, and specific emitter identification. An internet protocol routable network approach is introduced as a possible means to seamless connectivity and fully integrated data picture. The multi-role capability of the F/A-18G will provide synergistic strike and survivability advantages as well as training and readiness challenges. A quantification of overall effectiveness demonstrates the F/A-18G is a viable EA-6B follow-on and AEA platform.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare/Electronic Attack, Command, Control and Communications

KEYWORDS: EA-6B Prowler, F/A-18E/F/G Hornet, Airborne Electronic Attack (AEA), Wireless LAN, Digital Receivers

SENSOR FUSION FOR TERRAIN CATEGORIZATION

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Spaceborne multispectral imaging for terrain classification has been used successfully to identify types of crops and ground cover for agricultural and land management purposes. The information derived from combining multiple sensors operating in different spectral bands into a single image has proven more valuable than that derived from a single band. Although multispectral imaging has not traditionally been associated with military reconnaissance satellites, the ability to automatically identify terrain type has military applications in battlefield characterization and target location. This thesis constructs a multispectral image by combining data from different sensors, and then uses this image for terrain categorization, or TERCAT. One military location in Southern California, San Clemente Island, was imaged using both civilian and National Technical Means (NTM) spacecraft. The civilian images were merged and analyzed using commercial imagery analysis software, producing classification maps of high quality and compared with the results of the same process performed on the NTM data. The military utility of TERCAT products was explored, with emphasis on the intelligence value of the products.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Sensor Fusion, Terrain Categorization, Imagery Intelligence

REQUIREMENTS ANALYSIS AND INFRASTRUCTURE ASSESSMENT METHODOLOGIES FOR INTRANET DEVELOPMENT

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This is a study of intranet planning methodologies with specific focus on two aspects of project planning, requirements analysis and infrastructure assessment. This thesis examines both qualitative and quantitative aspects of assessing and planning for intranets. Thoroughly completing these two areas is important in order to bring success to an intranet project. This thesis examines variables necessary in each area that require consideration during planning. Chapter II is a study of requirements analysis. A three-step methodology will guide planners through a logical process that assists in creating a well-organized plan. Chapter III is a study of infrastructure assessment. Items of infrastructure are defined and listed to assist planners to assess existing infrastructures. A five-step methodology will guide planners through a logical process of assessing enterprise infrastructure. Chapter IV is a case study of the U.S. Marine Corps Collaborative Planning Network, an enterprise-wide intranet project designed to augment the existing Marine Corps Enterprise Network. Methods and processes in this case study closely parallel methods of planning recommended in this thesis. Chapter V contains a summary and recommendations. This chapter also provides recommendations for areas of further study in intranet planning.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications

KEYWORDS: Computer Networks, Intranets

A SURVEY AND ANALYSIS OF GEOLOCATION PROCESSORS

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Geolocation of electromagnetic emitters is a processing intensive endeavor. Numerous signal data processing systems have been developed to accomplish this difficult task. These systems utilize different hardware configurations, software tools, and processing algorithms, with each system possessing varying capabilities and limitations. Many current programs and projects require the employment of these processing suites, necessitating the selection and possible modification of the most suitable system. This thesis document provides a survey and analysis of the currently available signal processing systems and discusses in depth the associated deployment, hardware, software, algorithm and development issues. The analysis provides a unique resource, heretofore lacking, for interested parties to utilize when tasked with the selection of a processing system that will meet their mission specific requirements.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Geolocation, Signal Processing

OBJECT SIGNING IN BAMBOO

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The rapid growth in the Internet has been fueled by an exorbitant number of users, organizations and individuals alike, many relying on e-commerce to conduct business including the transport of files. Public Key Infrastructure (PKI) technology has emerged to the forefront as the basis for ensuring secure transactions throughout the Internet. However, this technology is prohibitively expensive for the majority of users. Object signing technology, a subset of PKI technology, provides a veritable means for file transfer ensuring non-repudiation, authentication, and content integrity at an amenable cost.

This thesis provides an introduction to computer security with a specific focus on PKI and object signing technology. It details the selection and implementation of an object signing system layered on Bamboo, namely Pretty Good Privacy (PGP) v2.6.2. Procedures for establishing a Key Server for certificate distribution are also illustrated. It also introduces security pitfalls associated with PKI systems and identifies the security weaknesses of this object signing implementation. For further research, recommendations are provided to improve the overall functionality of this security system and the potential impact any such migration may have on current users.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Object Signing, Public Key Infrastructure, PKI, PGP

THESIS ABSTRACTS

THE APPLICATION OF A VIEWPOINTS FRAMEWORK IN THE DEVELOPMENT OF C4I SYSTEMS

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In the development of large distributed systems, both the detection and resolution of inconsistency in policy, requirements, and specifications pose major challenges. The purpose of this thesis is to examine the inconsistencies in policy, requirements, and specifications in the development of information/Joint Command, Control, Communications, Computers, and Intelligence (C4I) systems. This thesis explores the application of a "viewpoints" framework to aid in the development of distributed information systems.

A viewpoints framework methodology that was developed to aid in the development of distributed systems is the Reference Model of Open Distributed Processing (RM-ODP). This thesis is concerned with the application of the five viewpoints of RM-ODP and the translation of policy into requirements and specifications. In this thesis, the Ballistic Missile Defense (BMD) system is used as a case study to explain how RM-ODP can be used to develop distributed information systems. It was found that identifying inconsistencies regarding interoperability amongst the subsystems of BMD necessitated the use of multiple viewpoints and that firm conclusions could not be made until the system was viewed at the lower levels.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Ballistic Missile Defense, C4I, Interoperability, Policy, Reference Model of Open Distributed Processing, Requirements Engineering, Viewpoints

KNOWLEDGE MANAGEMENT OF THE SPECIAL WARFARE AUTOMATED PLANNING SYSTEM (SWAMPS): HOW TO PROVIDE TIMELY, RELEVANT AND ACCURATE KNOWLEDGE TO THE OPERATOR DURING THE MISSION PLANNING PROCESS

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This research evaluates the feasibility of implementing a knowledge management scheme into the Special Warfare Automated Mission Planning System (SWAMPS). The objective is to determine not only what type of knowledge is required by the operator but also how to get that knowledge to him within constraints imposed by factors such as time, location and prior experience. This research focuses on utilizing information technology, along with other enablers, to access and retrieve knowledge pertinent to the mission. This knowledge will be accessed as close to real time as possible in order to allow the operator to review the information when and where it is most relevant. Research includes conducting a detailed analysis of the applicable mission planning processes and consolidating technological, operational and human enablers to develop requirements for implementing a knowledge management architecture. Various operators are interviewed in order to clarify what knowledge needs to be presented

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Manpower, Personnel, and Training, Other (Knowledge Management)

KEYWORDS: Knowledge Management, SWAMPS, Mission Support Center, MSC, Push, Naval Special Warfare, NSW, Mission Planning

REAL-TIME RADAR VIDEO RELAY VIA A COMMERCIAL-OFF-THE-SHELF (COTS) WIRELESS LAN

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Network centric operations in the littorals require an extended horizon radar picture for expanding range of operations and adequate early warning for ship defenses. Ship-based SH-60B Light Airborne Multi-Purpose System (LAMPS) Mark III Helicopters can provide the radar signal data to a surface ship through the multi-purpose AN/SRQ-4 HawkLink. The signal data is then processed at the shipboard HawkLink terminal and converted into display data for the ship's radar. To transmit the actual radar video from the aircraft, a higher bandwidth than the HawkLink system is required. In addition, carriers and amphibious assault ships are not equipped with this system, and it can only be downlinked to one ship at a time.

A Commercial-Off-The-Shelf (COTS) Wireless Local Area Network (WLAN) system can support near real-time radar video transmitted from an airborne platform to multiple surface platforms simultaneously. WLANs can support the high bandwidth necessary to transmit a complete radar picture, and are much more compact and less expensive than the current system. In addition, WLANs can be seamlessly integrated into any ship's network that is interoperable with internet protocols.

DoD KEY TECHNOLOGY AREA: Other (Wireless Communications, WLANS, Extension of the Littoral Battlespace (ELB))

KEYWORDS: Real-time Radar Relay, Wireless LAN, COTS

IMPACT OF INCLUDING REALISTIC COMBAT IDENTIFICATION REQUIREMENTS ON A LARGE SCALE INFORMATION SYSTEM ARCHITECTURE VERSUS THE USE OF A SEPARATE COMBAT IDENTIFICATION INFORMATION SYSTEM NETWORK

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This thesis reports the findings of a simulation to determine the most effective solution between a dedicated Combat Identification (CID) situational awareness network versus including CID information on a full functioning network. The architecture used to make this determination was based on the Navy and Marine Corps Extended Littoral Battlespace (ELB) Advanced Concept Technology Demonstration (ACTD). This demonstration implemented a wide-area wireless battlenet using WaveLan and VRC 99A technologies. The simulation was accomplished with the use of a leading edge simulation tool, EXTEND™, and the specifications inherent to wireless communications. EXTEND was used to replicate the protocols that are inherent within the WaveLAN and VRC-99A systems. A feasible sized architecture was modeled utilizing scaling techniques, which simulated the operation of a Marine Expeditionary Brigade (MEB), covering a 200X200 mile wireless tactical battlespace. A full functioning network was developed and then modified to include CID information requirements. A comparison of the data latency between the models was the determining factor. This thesis demonstrates that a full functioning network is capable of handling CID

THESIS ABSTRACTS

information requirements.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Combat Identification, Networks, Tactical Networks, Communications, Systems

REPRESENTING TACTICAL LAND NAVIGATION EXPERTISE

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Tactical land navigation is a very important, but extremely difficult task performed daily by small unit leaders. In an effort to find ways to develop expertise more efficiently, a detailed description of expert performance is presented and contrasted with novice and intermediate performance. This definition fits the Recognition Primed Decision model of human cognitive behavior. Then, through use of the Critical Decision Method of knowledge elicitation, interviews with experts at the U. S. Army Special Forces Qualification Course formed the basis of a detailed cognitive model of expert tactical land navigation. Four important characteristics of experts emerge: (1) they rely on high-fidelity mental maps; (2) they blend multiple cues; (3) they adjust and recalibrate tools dynamically; and (4) they visualize spatial information. Finally, a multi-agent system computationally represents the route planning portion of the performance model.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Human Systems Interface, Ground Vehicles, Modeling and Simulation

KEYWORDS: Agent Based Modeling, Land Navigation, Multi-Agent System, Human Performance Modeling

NON-IMAGING DETECTION AND TRACKING OF MOBILE TARGETS

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In August, 1999, observations with a non-imaging satellite revealed an aircraft (not in afterburner) flying over the ocean. Although this initial detection was made quite by chance, a specialized sensor configuration was devised, and several additional aircraft observations were performed. The precise parameters required for such remote detection are still unclear due to the processing and analysis limitations of current system algorithms. Nevertheless, the successful collections made thus far do provide valuable insight into the phenomenon behind these observations. Furthermore, they point to specific hardware and software shortcomings which may be improved in the near future. This thesis includes a full explanation of the sensor and processing systems, a compilation of accomplished collections, and a thorough analysis of data. It explains the current status of this emerging capability and identifies the steps that are necessary to make remote aircraft detection and tracking into a tactical tool in the future.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Aircraft Detection and Tracking, Space Sensors

THESIS ABSTRACTS

IMPLEMENTATION OF A FAULT TOLERANT COMPUTING TESTBED: A TOOL FOR THE ANALYSIS OF HARDWARE AND SOFTWARE FAULT HANDLING TECHNIQUES

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With spacecraft designs placing more emphasis on reduced cost, faster design time, and higher performance, it is easy to understand why more commercial-off-the-shelf (COTS) devices are being used in space based applications. The COTS devices offer spacecraft designers shorter design-to-orbit times, lower system costs, orders of magnitude better performance, and a much better software availability than their radiation hardened (radhard) counterparts. The major drawback to using COTS devices in space is their increased susceptibility to the effects of radiation, single event upsets (SEUs) in particular.

This thesis will focus on the implementation of a fault tolerant computer system. The hardware design presented here has two different benefits. First, the system can act as a software testbed, which allows testing of software fault tolerant techniques in the presence of radiation induced SEUs. This allows the testing of the software algorithms in the environment they were designed to operate in without the expense of being placed in orbit. Additionally, the design can be used as a hybrid fault tolerant computer system. By combining the masking ability of the hardware with supporting software, the system can mask out and reset processor errors in real time. The design layout will be presented using OrCAD® schematics.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

MARITIME IRREGULAR WARFARE: A LONG-RANGE VIEW

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Maritime irregular warfare (MIW) has been around since the dawn of sea power. While conventional naval warfare holds the premier position in naval affairs, MIW constitutes a less understood but equally important "other" tradition that merits closer attention. History demonstrates a link between the evolution of regular naval warfare and its irregular counterpart. When fully understood and correctly utilized, MIW actions have proven extremely effective at providing unconventional solutions to complex military problems. Consistently, MIW forces have powerfully affected the outcomes of conflict both at sea and on land. Through the skillful employment of MIW, this long historical pattern can continue to affect conflicts of the 21st century.

In an era of rapid change, the ability to clearly identify and understand emerging trends in conflict and military affairs is an essential element in assessing MIW's future. As conventional warfare begins to realign for future threats, practitioners of MIW need to begin thinking proactively about how MIW can stay relevant, and the concerted actions that need to be taken in order to fit into the future of warfare. This thesis is an attempt to take a first glimpse of MIW's future.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Other (Maritime Irregular Warfare)

KEYWORDS: Maritime Irregular Warfare, Information Age Conflict

THESIS ABSTRACTS

AUTHENTICATION IN SAAM ROUTERS

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Server and Agent based Active network Management (SAAM) is a network protocol developed at the Naval Postgraduate School to address the router software requirements for the Next Generation Internet (NGI). A working prototype has existed for over nine months to materialize abstract research ideas in the field of active networking.

Authentication is particularly important because SAAM uses mobile code, called resident agents. These resident agents are loaded onto SAAM routers dynamically, and execute on the destination SAAM router. Mobile code in the SAAM system requires an authentication scheme to prevent an outsider from sending a malicious resident agent. Two issues explored are time synchronization and authentication. This thesis focuses on authentication.

With authentication, SAAM can be used as the technical network infrastructure to support Network Centric Warfare (NCW) as described in JV2010. The NCW network must allow mobile code to securely execute on the fly. The prototype developed in the thesis authenticates new nodes that join a SAAM network using Kerberos. Signaling data, also called control traffic, is certified with a dynamic signature key that changes every two minutes. Once a SAAM node is authenticated, its identity is protected throughout the battle. In the same way that Allied forces use Identification Friend or Foe (IFF) traffic today, SAAM authentication could support NCW.

The NCW network must also be self-healing. Autoconfiguration is already integrated into the SAAM prototype. Network failures are detected within 500ms. Probing agents are also deployed to investigate suspicious activity within the network. Future probes could fingerprint a specific group of hackers while on-line, using genetic algorithms.

The effects of SAAM on the organizational behavior of a tactical Information Warfare (IW) organization are explored in this thesis.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Authentication, Encryption, Routing, Java, Key Distribution, Kerberos, Secure Time Synchronization

COTS SOFTWARE DECISION SUPPORT MODELS FOR USPACOM'S THEATER ENGAGEMENT PLAN (TEP)

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As part of the process of achieving national security objectives, the mission of United States Pacific Command (USPACOM) is to enhance security and promote peaceful development in the Asia region by deterring aggression, responding to crises and fighting to win. USPACOM's Theater Engagement Plan (TEP) contributes to the accomplishment of this mission by planning, coordinating, and implementing peacetime military activities to shape the region's security environment. USPACOM, J56 (Future Plans and Operations, Engagement) has a requirement to assess the effectiveness of engagement activities proposed, planned and conducted within its Area of Responsibility. USPACOM's goals and objectives for the engagement process have been formally defined, but no process exists to link engagement activities to

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goals and objectives. Consequently, there is no way to comparatively assess the value of one engagement activity versus another. This research focuses on the basics of Multi-Attribute Utility Theory (MAUT) and Analytical Hierarchy Process (AHP) techniques for alternative selection following a literature review, which addresses some of the issues in decision support, traditional modeling techniques, and some of the traditional methodologies for quantifying subjective judgments. Additionally, this research illustrates the usefulness of currently available COTS decision support software in assisting the decision-maker in this endeavor.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Decision Support, Decision Analysis, Multi-Attribute Utility Theory, Analytical Hierarchy Process

IMPLEMENTATION OF A SUBMARINE SHIP-WIDE, COMMON NETWORK ARCHITECTURE

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This thesis will examine the proliferation of multiple Local Area Network (LAN) and information technologies aboard United States Navy submarines. The author will examine the evolution of Congressional Defense Acquisition Reforms which mandates the use of Commercial Off-The-Shelf (COTS) and commercial items. The resulting impacts of this policy on the submarine force as it relates to burdens imposed with regard to training of personnel, technology refresh and insertion, obsolescence, and logistics will be addressed.

The study will examine the implementation of a submarine shipwide, mission critical, tactical network, based upon open systems architecture, which provides the ability to process classified and unclassified data; as well as providing a migration path to a common hardware and software baseline across all submarine classes. The implementation of this technology would be the initial instantiation of such an information system on any class of United States Navy warship and may potentially provide a template for use Navy wide. Finally, a sound, programmatic recommendation to implement a Submarine Ship-Wide, Common Network Architecture will be made.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Submarine, Local Area Network, LAN, Submarine Network, Submarine Architecture, Shipboard Network

A SIMULATION OF THE JOINT TACTICAL RADIO SYSTEM BANDWIDTH REQUIREMENTS TO SUPPORT MARINE CORPS SHIP-TO-OBJECTIVE MANEUVER IN 2015

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The United States Marine Corps is exploring the concepts of Operational Maneuver From the Sea (OMFTS) and Ship-To-Objective Maneuver (STOM) as methods for employment of maritime forces in the future. At the same time, the Department of Defense (DoD) is pursuing the acquisition of the Joint Tactical

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Radio System (JTRS), a multi-band, multi-channel, multi-mode family of radios, designed to form self-organizing, self-healing communications networks. The JTRS will have to support Marine forces in combat at long distances from the forces' support and higher headquarters units. This extended range will require the use of relay radios in order to maintain connectivity between the attacking force and its support.

This thesis explores the relay station bandwidth requirements to support Marine forces. The question is analyzed through the use of a discrete-event simulation written in Java, which models the behavior of a JTRS network in a STOM scenario. Quality of service of the communication network is measured by timely delivery of messages.

The results of the simulation indicate that the JTRS network performance is insensitive to relay station bandwidth. Rather, the subordinate headquarters involved in the scenario were the most overloaded nodes in the network.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Command, Control and Communications

KEYWORDS: C4I, Simulation, Java, Object-Oriented, JTRS, STOM, OMFTS

DYNAMIC EXPLORATION OF HELICOPTER RECONNAISSANCE THROUGH AGENT-BASED MODELING

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This thesis uses Multi-Agent System modeling to develop a simulation of tactical helicopter performance while conducting armed reconnaissance. It focuses on creating a model to support planning for the Test and Evaluation phase of the Comanche helicopter acquisition cycle. The model serves as an initial simulation laboratory for scenario planning, requirements forecasting, and platform comparison analyses.

The model implements adaptive tactical movement with agent sensory and weaponry system characteristics. Agents are able to determine their movement direction and paths based on their perceived environment, attributes, and movement personalities. The model incorporates a three-dimensional aspect to properly simulate aerial reconnaissance. An integrated Graphical User Interface enables the user to create environments, instantiate agent propensities and attributes, set simulation parameters, and analyze statistical output.

The resulting model demonstrates the ability to represent helicopter reconnaissance behavior. It captures simulation summary statistics that illustrate enemy performance, helicopter performance, and logistical requirements. The model establishes an initial simulation tool to further explore Comanche operational requirements and planning for its Test and Evaluation phase.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Battlespace Environments, Computing and Software, Conventional Weapons, Human Systems Interface, Sensors, Ground Vehicles, Manufacturing Science and Technology (MS&T), Modeling and Simulation

KEYWORDS: Multi-Agent System, Agent-Based Modeling, Helicopter Reconnaissance, Comanche, Adaptive Behavior, Modeling and Simulation

THESIS ABSTRACTS

INTEGRATION OF MARITIME SHIPPING TECHNICAL DATA INTO A COMMON DATABASE FOR USE IN A GRAPHICAL DISPLAY

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Maritime Situational Awareness has been an important part of the overall shipping picture since the beginning of high seas exploration. Both military and civilian professionals have desired the knowledge of what ships are in their vicinity and what ships will be in their vicinity in the near and distant future. A common database will enhance the integration of multiple data sources into an accurate display of past, present, and future shipping tracks. In the past, shipping professionals relied on one or two sources to provide them with a picture of the maritime situation. Advancing technologies of the present and future allow and will allow for an increased number of data options to assist in providing a display of the shipping picture. This thesis will describe the generation, integration, and correlation of multiple sources of maritime shipping data into a common database. Examples presented show the application of the database and the display to the ship-tracking problem.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Maritime Situational Awareness, Database, Graphical Display

AN ANALYSIS OF DECISION MAKING STRATEGIES USED BY P-3 PILOTS IN HAZARDOUS SITUATIONS

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Effective decision making in aeronautical environments, which often involves high elements of risk, is critical to mission success. Unfortunately, no proven methodology exists to train pilots to make successful decisions. Cockpit decision making has relied on traditional analytical models and methodologies that underestimate the role of pilot experience, expertise and judgment. Naturalistic Decision Making (NDM) models contend that decision makers facing real-world decisions use experience and judgment to make timely decisions without analyzing a multitude of alternatives.

This thesis analyzes 438 P-3 aviation hazard reports (HAZREP) to ascertain which cognitive strategies from either the analytical or naturalistic methodology are more appropriate for handling malfunction situations. The author presents a hybrid model of decision making by P-3 pilots based on the results of the analysis and strategies from both methodologies.

This thesis recommends that decision making training be treated as a core activity of pilots not only in flight school, but after qualification is complete. Training pilots to become experts will improve situational awareness and reduce the number of unfavorable outcomes in hazardous situations.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel, and Training, Air Vehicles

KEYWORDS: P-3 Aviation Hazard Report (HAZREP), Aeronautical Decision Making, Naturalistic Decision Making (NDM), Analytical Decision Making (ADM), Situational Awareness, Expert Behavior

THESIS ABSTRACTS

EXPLOITATION OF WEB TECHNOLOGIES FOR THE JOINT BATTLESPACE INFOSPHERE

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Today's military command and control (C2) systems provide much information to today's combatants, but because these legacy systems are disjointed, there exists an overload of poorly organized and incomplete data during operations. These systems tend to be "stovepiped," inflexible, difficult to integrate, and hard to use in building a common operational picture. The information exchange model for DoD C2 systems is migrating away from dedicated point-to-point and broadcast systems (information push) toward a model based partly on Internet and World Wide Web technologies (publish and subscribe). The USAF Scientific Advisory Board has created a visionary combat information management concept called the Joint Battlespace Infosphere in response to this movement.

The purpose of this thesis is to identify and evaluate emerging Internet/Web-based technologies that could be employed by the DoD to improve upon existing information exchange services. This survey will examine the strengths and weaknesses of technologies such as client-server architectures, search engines, middleware, intelligent software agents, and multicast delivery tools that could enhance the development of the Joint Battlespace Infosphere.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications

KEYWORDS: Joint Battlespace Infosphere, Command and Control Systems, Global Information Grid, World Wide Web, Internet, Search Engines, Software Agents, Middleware, Multicast Delivery

APPLICATION OF FAULT-TOLERANT COMPUTING FOR SPACECRAFT USING COMMERCIAL-OFF-THE-SHELF MICROPROCESSORS

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Low availability, high cost, and poor performance of radiation hardened (rad-hard) equipment has driven the market to rely on commercial-off-the-shelf (COTS) equipment for the computing needs of today's spacecraft. This thesis describes the tailoring of a COTS embedded real-time operating system and design of a human-computer interface (HCI) for a triple modular redundant (TMR) fault-tolerant microprocessor for use in space-based applications. One disadvantage of using COTS hardware components is its susceptibility to the radiation effects present in the space environment, and specifically, radiation-induced single-event upsets (SEUs). In the event of an SEU, a fault-tolerant system can mitigate the effects of the upset and continue to process from the last known correct system state. The TMR basic hardware design used for this research is an acceptable fault-tolerant design candidate for the main processor for space-based applications. We found that a COTS embedded real-time operating system could be tailored to support the TMR hardware. The HCI accepts serial data from the TMR, correctly identifies the source of the error, allows for processor mode selection and provides system- and board-level reset capabilities. The tailored operating system combined with the HCI is a viable software implementation to support hardware-

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based fault-tolerant computing in a space environment.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Space Vehicles, Human System Interface

KEYWORDS: Fault Tolerance, Embedded Operating System, Human Computer Interface, Triple Modular Redundant Hardware, Spacecraft Design

A STUDY OF THE FEASIBILITY AND APPLICABILITY OF SHAPE CONTROLLED SPACE BASED INFLATABLE MEMBRANE STRUCTURES

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Inflatable structures used for space applications offer mass, volume, and cost savings to spacecraft programs, allowing larger space structures to be built. For certain space applications, there are advantages to using large structures. For example, antennas achieve higher gains when they are increased in size. Higher gains equate to higher data throughputs. Therefore, inflatable structures offer improvements in performance to certain types of spacecraft components.

Environmental factors induce surface errors on large inflatable structures. This degrades performance, especially for inflatable antennas. To reduce this degradation, active and passive control systems can be used to sense errors and control the shape of the antenna. One method of applying an active and passive control system is by using piezoelectric films that are either attached to or are part of the inflatable structure.

The research performed for this thesis explored the theoretical performance of a large inflatable space-based antenna via spreadsheet analysis and the physical performance of a piezoelectric film via laboratory experimentation. For the laboratory experiment, the film was attached to a drum and varying internal pressures and voltages were applied. Also, in order to validate the experimental results, an analytical model was created using MSC/PATRAN and MSC/NASTRAN software.

DoD KEY TECHNOLOGY AREA: Other (Communications)

KEYWORDS: Piezoelectric Film, Inflatable Structure, Antennas, Communications, Satellite Development

INFORMATION MANAGEMENT SYSTEM DEVELOPMENT FOR THE CHARACTERIZATION AND ANALYSIS OF HUMAN ERROR IN NAVAL AVIATION MAINTENANCE RELATED MISHAPS

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The purpose of this thesis was to develop a prototype safety information management tool to capture human error in Naval Aviation maintenance mishaps. The Human Factors Analysis and Classification System-Maintenance Extension taxonomy, an effective framework for classifying and analyzing the presence of maintenance errors that lead to mishaps, incidents, and personal injuries, is the foundation of this management tool. The target audience for this information management system tool included safety personnel, mishap investigators, Aircraft Mishap Board (AMB) members, and analysts. A review of three

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areas was needed to produce the prototype: (1) the collection, use, and management of accident information, (2) human error theories as related to aviation mishaps, and (3) the design of an effective mishap database tool. A usability study was conducted using potential end-users (Naval Aviation Safety Officers). The participants were given both written procedures to navigate through the prototype and an exit survey. The results of the survey, including objective and subjective responses about the prototype were gathered. The resulting data indicated an improved version of the prototype could directly lead to a decreased mishap rate and overall increased mission readiness due to the training and analysis opportunity it provides.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Human Factors, Human Systems Interface

KEYWORDS: Aviation Accidents, Aviation Mishaps, Accident Classification, Maintenance Mishaps, Maintenance Error, Human Factors, Human Error, Naval Aviation, Trend Analysis, Information Management System

AN ANALYSIS OF RE-ACQUISITION AND IDENTIFICATION SENSORS FOR VERY SHALLOW WATER MINE COUNTERMEASURES (VSW MCM) WARFARE

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The Naval concepts Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM) will not succeed unless mines and obstacles can be located, identified and cleared from the amphibious approaches. The US Navy's Mine Warfare Plan and the Navy Investment Strategy for Development of Unmanned Underwater Vehicle Systems in Support of naval Very Shallow Water and Explosive Ordnance Disposal Mine Countermeasures Missions have defined specific strategies for achieving a very shallow water mine clearance capability. This thesis examines the potential for various technologies (sensors) to support very shallow water minefield clearance in the re-acquisition and identification of mines and obstacles. First, the mission is defined and current capabilities are reviewed. Second the requirements for the Very Shallow Water Mine Countermeasures mission are examined from the point of view of a notional concept of operations, the operating environment, and required performance characteristics, and, criteria are developed to evaluate potential detection and identification systems. Finally, detection and identification technologies are examined and evaluated against derived criteria. The results are two tables that can be used together as a tool to determine optimum combinations of sensors based upon mission priorities (precise identification, object location, neutralization, area survey) and vehicle capability (incremental energy available for sensors, payload capacity, mission portability, mission duration).

DOD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Conventional Weapons, Other (Mine Countermeasures)

KEYWORDS: Electro Optics, VSW MCM, EOD, AUV, STOM, OMFTS, Mine Hunting, UUV

THESIS ABSTRACTS

THE ROLES AND REQUIRED CAPABILITIES OF FUTURE NATIONAL SIGINT SYSTEMS

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Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

National systems provide critical signals intelligence (SIGINT) support to both military commanders and national-level decisionmakers during peacetime, wartime, and contingency operations. This thesis explores how changes in the global technological environment are necessitating changes in the roles and required collection capabilities of future national SIGINT systems. It is imperative that future national SIGINT systems be tailored to the future signals environment, and be developed in the context of the overall SIGINT effort of multiple access providers detailed in the *Unified Cryptologic Architecture*. This thesis provides an estimate of the future SIGINT environment from a technological point of view, analyzes the roles that should be assigned to national systems, and develops collection-related requirements for the future national SIGINT architecture. Furthermore, this thesis briefly describes currently projected national SIGINT systems, focusing on collection-related shortcomings relative to future requirements. Finally, a brief outline is provided of possible evolutionary changes that have the potential to meet the future SIGINT collection requirements.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Other (Intelligence)

KEYWORDS: Signals Intelligence, Electronic Intelligence, Collection Requirements, Access Providers, Technology Forecast, National Systems

BUSINESS WARGAMING: APPLICATIONS FOR MARINE CORPS MANPOWER POLICY DECISIONS

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Complexity is abundant in nature, in society, and in the workplace. The business sector has recently experimented with business wargaming, which is based upon complex adaptive systems theory, as a tool for policy analysis and management training. Business wargames, based upon agent-based simulation technology, provide a flexible platform using software agents that are programmed with simple rules, interact with each other and their environment. This interaction leads to emergent behavior, which evolves from the collective interaction and adaptation of these agents. This thesis discusses the experiences and lessons learned from the U.S. Army's Firm Handshake Proof of Principle business wargame, and applies them to a Marine Corps' counterpart game called SimMarineCorps. SimMarineCorps will model the Marine Corps' Human Resource Development Process (HRDP). This architecture consists of players, screens, agents, rules of engagement, and relationships among and between the players and agents. Critical success factors for SimMarineCorps is General Officer support to ensure that the necessary data/metrics are collected and validated.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Manpower, Manpower Policy, Business Wargaming, Simulation, Agent Based Simulation, Complexity, Complexity Theory

THESIS ABSTRACTS

THE FEASIBILITY OF USING DESIGN RATIONALE TO AUGMENT THE IMPLEMENTATION STRATEGY OF MANAGED CARE

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The feasibility of using argumentation based design rationale capture techniques for improving the implementation strategy of managed care is investigated. The hypothesis is made that managed care is failing because it deals in "wicked" problems, which are fundamentally different than the "tame" problems encountered in traditional medicine, and that the organizational structure of managed care is not equipped to handle wicked problems. It is shown that argumentation based design rationale tools are an excellent candidate for bridging the ideals of traditional medicine to the realities of managed care for three reasons: the tools are specifically designed to explore the resolution of wicked problems, the problems encountered in managed care possess many similarities to problems that have been shown to have successful utilization of design rationale capture techniques, and the power relationships within managed care are most fitting with a collaborative implementation strategy. Recommendations for a collaborative implementation strategy of managed care, using design rationale capture tools as a mechanism of collaboration, are given.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Knowledge Management, Design Rationale, Medicine, Managed Care, Human Computer Interaction, Process Knowledge

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