United States Military Academy
West Point, New York 10996

RESEARCH PLAN

OF THE

DEPARTMENT OF SYSTEMS ENGINEERING

AND THE

OPERATIONS RESEARCH CENTER

FOR THE

ACADEMIC YEAR 2007

DTIC No. ADA455049

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EXECUTIVE SUMMARY

The purpose of this document is to formally present the research program of the *U.S. Military Academy Department of Systems Engineering (DSE) and the Operations Research Center for Excellence (ORCEN)* for the Academic Year 2007. The research plan includes a statement of purpose for research which supports DSE and the ORCEN, a description of the two organizations, a list of the key personnel responsible for executing the plan, and an overview of the annual research cycle.

After this introduction, we present research summaries for applied research or problem-solving project, including Cadet Capstone Projects. Each summary includes a problem statement, a proposed methodology for project execution, project requirements and deliverables, estimates of milestones, and the number of man-years required to complete the work. Additional information is provided on the senior investigator, principal analyst or Capstone team, the client organization, and points of contact.

PART I – THE DEPARTMENT OF SYSTEMS ENGINEERING RESEARCH PROGRAM

The purpose of the research program within the Department of Systems Engineering is to support cadet education and faculty development through the organization, execution and presentation of relevant Army and Department of Defense research opportunities for significant clients.

The Department of Systems Engineering research projects provide the faculty and cadets with the opportunity to investigate a wide spectrum of interdisciplinary, systemic issues and to apply many of the systems engineering, engineering management, and operations research concepts studied in the classroom to real-world problems of interest to the Army and the Department of Defense (DoD). These projects demonstrate for both cadets and faculty the relevance and importance of systems engineering in today's high-technology military.

The research program in the Department of Systems Engineering (DSE) directly addresses four specific Academy needs.

1. Research enriches cadet education. Cadets learn best when they are challenged and when they are interested. The introduction of current issues facing the military into their curriculum achieves both. Early in their education, cadets are taught by their instructors the application of techniques to real issues and problems – issues and problems they will face upon graduation. Through this, they gain an appreciation of the robustness of the discipline and a greater understanding of their profession. As they progress in their education, they begin to apply these techniques to heretofore unsolved issues and problems. This codifies their education on the techniques and instills a adaptive, problem-solving mentality in the cadets.

2. Research enhances professional development opportunities for Army faculty. It is important to develop and grow as a professional officer in each assignment. On the DSE faculty, officers conduct research on relevant projects to remain current in their operational branch or functional areas. The research they conduct keeps them abreast of Army and DoD issues, at the forefront of their academic discipline and is returned to the classroom. They become better officers and leaders through the knowledge they gain and impart.

3. Research maintains strong ties between the Academy and Army/DoD agencies. The US Military Academy and DSE is a tremendous source of highly qualified analysts for the

Army and DoD. Each faculty member holds an advanced degree in a technical discipline and has a deep understanding of the military and its issues. Research ensures that the Academy remains a significant part of the Army and DoD and not just another source of commissioning for junior officers.

4. Research provides for the integration of new technologies into the academic program. As the pace of technological advances increases, the Academy's education program must not only keep pace but must lead to ensure our graduates and junior officers are prepared for their continued service to the Army. Research applying the most advanced technology and techniques is critical to achieving this objective.

By being fully engaged in current Army and DoD issues, the Department of Systems Engineering and the Operations Research Center assures that systems engineering education at USMA and our faculty remain current and relevant. The military's return on its investment is meaningful career development experiences for officers, especially those in Functional Areas 49/51/53/57, an enhanced education program for the USMA cadets, and important investigation of vital Army and DoD problems at far less cost than would be required through civilian contracts.

There are four aspects to the research program within the Department of Systems Engineering: The Operations Research Center of Excellence, Faculty research, Cadet Capstone research and Academic Individual Advanced Development opportunities (AIADs). Though each aspect has its own structure and scope, they are all complimentary and together support the overall DSE research program objective. Each is described in detail in the following sections.

PART II – THE OPERATIONS RESEARCH CENTER OF EXCELLENCE

The purpose of the Operations Research Center of Excellence (ORCEN) is to provide a small, full-time analytical capability to both the Academy and the United States Army and the Department of Defense. The ORCEN was established in 1990 through a Memorandum of Agreement between the Department of Systems Engineering, the Department of Mathematics (DMath) and the Office of the Assistant Secretary of the Army (Financial Management and Comptroller). Its establishment was born of the need for developing research opportunities to enrich DSE and DMath education.

Personnel authorizations in the ORCEN are established by a Table of Distribution and Allowances (TDA). Funding support for the Operations Research Center was established by a Memorandum of Agreement with the Office of the Assistant Secretary of the Army (Financial Management). The Operations Research Center is organized under the Office of the Dean as an Academy Center of Excellence. A permanent military academy professor or senior faculty member provides oversight and supervision to the Center. In addition, the TDA authorizes one O5 analyst, three O4 analysts, and a GS5 secretary. By agreement between DSE and DMath, DSE provides three analysts, an Academy Professor as the Director and one permanent staff member to serve as Executive Administrator and assistant to the Director and DMath provides one analyst.

The Operations Research Center was originally sponsored by the Assistant Secretary of the Army (Financial Management & Comptroller). Fully staffed since Academic Year 1990-1991, the Operations Research Center has made significant contributions to cadet education, faculty development, and the Army at large.

The following is a list of key personnel from the Operations Research Center responsible for executing the Research Plan for the Academic Year 2007. A detailed description of each research project is given in Part VIII - PRINCIPAL RESEARCH ACTIVITIES FOR AY 2007.

Table 1: Key ORCEN Personnel

TITLE & ORGANIZATION	NAME	PHONE (DSN)	EMAIL
Professor and Department Head Department of Systems Engineering	COL Timothy E. Trainor, Ph.D.	688-5534	Tim.Trainor@usma.edu
Professor and Department Head Department of Mathematical Sciences	COL Michael Phillips, Ph.D.	688-5285	Michael.Phillips@usma.edu
Director, ORCEN & Assistant Professor	LTC Simon R. Goerger, Ph.D.	688-5529	Simon.Goerger@usma.edu
Administrative Assistant	Ms. Nancy Higgins	688-5897	Nancy.Higgins@usma.edu
Deputy Director, ORCEN & Instructor	LTC Dale Henderson, Ph.D.	688-5539	Dale.Henderson@usma.edu
D/SE Analyst & Instructor	MAJ Paul Evangelista, M.S.	688-5661	Paul.Evangelista@usma.edu
D/SE Analyst & Instructor	MAJ Gregory Griffin, M.S.	688-3573	Gregory.Griffin@usma.edu
D/MS Analyst & Instructor	MAJ Gary Kramlich, M.S.	688-5168	Gary.Kramlich@usma.edu

PART III – FACULTY RESEARCH

The Department of Systems Engineering encourages its faculty to conduct research of value for the Army and the Department of Defense during their tenure at the United States Military Academy. This specifically includes the rotating junior faculty to support their professional development.

The Department of Systems Engineering has 38 faculty members holding 17 Ph.D.s and 39 Masters Level Degrees. Additionally, there are two faculty adjunct faculty members for the Department who support research and are assigned to other organizations. Each holds their advanced degrees in disciplines which support research in systems engineering, engineering management and/or operations research. This is a tremendous research potential for significant clients within the Army and DoD.

All research in the Department of Systems Engineering is overseen by a Senior Investigator (SI) to ensure quality and completeness for the client. These Senior Investigators all hold a Ph.D. in a qualified discipline for the research project presented. Most research projects have an associated junior analyst assigned to them. This contributes to the development of the junior analyst as a researcher, the Senior Investigator as a research lead and provides the client with the best research available by the Department.

The individuals in the Department who can serve as the Senior Investigator on a research project are listed in Table 2 below. The junior analysts in the Department who can serve as the analyst on a given research project are listed in Table 3 below. Included in each table are the education background and contact information for the faculty members.

Table 2: DSE Senior Investigator

NAME	EDUCATION & DEGREE	PHONE (DSN)	EMAIL
COL Timothy E. Trainor	Ph.D – North Carolina State University – 2001 MBA – Duke University – 1992 BS – USMA – 1983	688-5534	Timothy.Trainor@usma.edu
MAJ Terry Barron	Ph.D - The University of Georgia - 2000 MS - Troy State University Dothan - 1996 MA - The University of Akron - 1996 BA - Bowling Green State University 1988	688-5536	Terry.Barron@usma.edu
Dr. Roger C. Burk	Ph.D – University of North Carolina – 1993 MS – Air Force Institute of Technology – 1985 BA – St. John's College – 1974	688-4754	Roger.Burk@usma.edu
MAJ Scott Crino	Ph.D - University of Virginia - 2006 MS - Texas A & M - 2000 BS - University of Buffalo - 1991	688-2788	Scott.Crino@usma.com
Dr Patrick J. Driscoll	Ph.D – Virginia Tech – 1995 MS – Stanford University – 1989 BS – USMA – 1979	688-6587	Patrick.Driscoll@usma.edu
Dr. Tim Elkins	Ph.D - Rutgers University – 2003 MBA – Rutgers University - 1996 BS - Centre College - 1988	688-2707	Timothy.Elkins@usma.edu
Dr. Niki C. Goerger	Ph.D – Texas A&M University – 1992 MS – Mississippi State University – 1988 BS – Mississippi State University – 1986	688-3180	Niki.Goerger@usma.edu
LTC Simon Goerger	Ph.D – Naval Postgraduate School – 2004 MS – Naval Postgraduate School – 1998 BS – USMA – 1988	688-5529	Simon.Goerger@usma.edu
LTC John Halstead	Ph.D – University of Virginia - 2005 MS – Kansas State University - 1997 BS – USMA - 1986	688-4752	John.Halstead@usma.edu
LTC Dale Henderson	Ph.D – University of Arizona - 2005 MS – Naval Postgraduate School - 1999 BS – USMA - 1989	688-5539	Dale.Henderson@usma.edu
LTC Robert Kewley	Ph.D – Rensselaer Polytechnic Institute - 2001 ME – Rensselaer Polytechnic Institute - 1998 BS – USMA – 1988	688-5206	Robert.Kewley@usma.edu
LTC Donna Korycinski	Ph.D – University of Texas (Austin) – 2003 MSE – University of Texas (Austin) – 1996 BS – Morehead State University - 1986	688-8788	Donna.Korycinski@usma.com
LTC Michael J. Kwinn, Jr.	Ph.D – University of Texas (Austin) – 2000 MS – University of Arizona – 1994 BS – USMA – 1984	688-5941	Michael.Kwinn@usma.edu
Dr. Gregory Parnell	Ph.D – Stanford University – 1985 MS – University of Southern California – 1980 ME – University of Florida – 1974 BS – State University of NY (Buffalo) - 1970	688-4374	Gregory.Parnell@usma.edu
COL Robert Powell	Ph.D – Stevens Institute of Technology – 2002 MMAS – US Army CGSC – 1999 MS – George Mason University – 1995 BS – Texas A&M University - 1984		Robert.Powell@usma.edu
LTC Brian Sperling	Ph.D – Georgia Institute of Technology – 2005 MS – Air Force Institute of Technology – 1999 BS – USMA - 1989	688-4399	Brian.Sperling@usma.edu
Dr. Paul West	Ph.D – Stevens Institute of Technology – 2003 MTM – Stevens Institute of Technology – 2000 MBA – Long Island University – 1993 BS – State University of NY (Albany) – 1983	688-5871	Paul.West@usma.edu

Table 3: DSE Analysts

NAME	EDUCATION & DEGREE	PHONE (DSN)	EMAIL
MAJ Gregory Boylan	MS – Georgia Institute of Technology – 2003 BS – USMA – 1994	688-4792	Gregory.Boylan@usma.edu
CPT Melanie Carlson	MS – University of Virginia – 2006 BS – USMA - 1997	688-3114	Melanie.Carlson@usma.edu
LTC Dave Dinger	ME - Old Dominion University – 1999 BS – USMA - 1989	688-8006/5525	David.Dinger@usma.edu
MAJ Paul Evangelista	MS – Rensselaer Polytechnic Institute – 2005 BS – USMA - 1996	688-5661	Paul.Evangelista@usma.edu
MAJ Steve Gauthier	MS – Naval Postgraduate School – 2006 BS – USMA – 1993	688-6493	Stephen.Gauthier@usma.edu
Mrs. Christy Gelineau	MS – Duke University – 2003 BS – North Carolina State University – 2000	688-5181	Christina.Gelineau@usma.edu
MAJ Ken Gilliam	MS - Georgia Tech – 2003 BS – USMA - 1994	688-2703	Kennon.Gilliam@usma.edu
MAJ Gregory Griffin	MS – University of Virginia – 2005 BS – USMA – 1994	688-3573	Gregory.Griffin@usma.edu
CPT Guy Huntsinger	MS – Texas A&M University – 2006 BS – USMA – 1997	688 - 4857	Guy.Huntsinger@usma.edu
MAJ Chad Jagmin	MSE – University of Michigan – 2003 MS – UMR – Rolla – 1998 BS – USMA - 1994	688-2746	Chad.Jagmin@usma.edu
MAJ Gary Kramlich	MS – Naval Postgraduate School – 2005 BS – USMA – 1996	688-5168	Gary.Kramlich@usma.edu
MAJ Travis (TJ) Lindberg	MS – University of Arizona – 2004 BS – USMA – 1995	688-4311	Travis.Lindberg@usma.edu
MAJ Grant Martin	MS – Georgia Institute of Technology – 2003 BS – USMA – 1994	688-5663	Grant.Martin@usma.edu
MAJ Dan McCarthy	ME – University of Virginia – 1999 BS – USMA - 1990	688-4893	Daniel.McCarthy@usma.edu
COL Kent Miller	MS - Georgia Institute of Technology – 1994 BS – USMA - 1984	688-5578	Kent.Miller@usma.edu
CPT Michael Rainey	MS – University of Texas – 2006 BS – USMA – 1997	688-2668	Michael.Rainey @usma.edu
MAJ Thomas Rippert	MS – University of Texas (Austin) – 2003 BS – USMA – 1993	688-2510	Thomas.Rippert@usma.edu
LTC Rod Roederer	MS - Colorado School of Mines – 1996 BS – USMA - 1987	688-4753	Rodney.Roederer@usma.edu
MAJ Ed Teague	MS – University of Texas – 2006 BS – USMA - 1995	688-7705	Edward.Teague@usma.edu
LTC John Willis	MS – University of Virginia – 1999 BS – University of Virginia – 1989	688-4888	John.Willis@usma.edu
MAJ Ernie Wong	MS – Stanford University – 2004 MA – Stanford University – 2004 BS – USMA – 1994	688-4756	Ernest.Wong@usma.edu

PART IV – CAPSTONE RESEARCH

The third and very significant aspect of the research program within the Department of Systems Engineering is Capstone Research. This is a year-long research project conducted by a group of 3-5 Systems Engineering and Engineering Management majors within the Department of Systems of Engineering. These projects are coordinated and lead by a Senior Investigator (holding a Ph.D.). These Capstone research projects fulfill the requirements for two of the final courses for each of these accredited majors (accredited by the Accreditation Board for Engineering and Technology).

These research projects are developed to support course and program objectives and each has a real-world client and is an "open ended" project. That means the solution is not predetermined by either the client or the research lead. This provides the cadets with the opportunity to apply the techniques they have learned in their previous courses to significant research projects. It also allows the cadets to present their work orally and in writing to clients and to other researchers at conferences.

For Academic Year 2007 we have 22 research projects for 14 different clients. These research opportunities are listed in Part VIII of this research plan.

PART V – ACADEMIC INDIVIDUAL ADVANCED DEVELOPMENT (AIAD)

Cadets are provided with opportunities to participate in Academic Individual Advanced Development (AIAD) opportunities during their summer training months in addition to the military training required for graduation. These opportunities can fill two requirements.

1. Provide a means to conduct background research and initial problem definition for potential capstone research projects (these types of AIADs are provided for course credit), and/or

2. Expose cadets to applications of their academic program in a military or industry environment.

Each of these requirements supports the Department of Systems Engineering's educational objectives. Cadets apply the lessons they learned in previous courses to projects coordinated by clients throughout the United States and many foreign countries. This broadens the cadets' educational experience and provides a significant benefit for the clients involved.

These AIADs are normally three-weeks in length and are funded through the client or in support of other research conducted in other aspects of the Department of Systems Engineering. Though this is a relatively short stint in an organization, cadets often complete significant research projects in this time as they usually require little train-up as they are exposed to many military and academic applications prior to their arrival in a client organization and they are a very eager research source.

The list of AIAD opportunities we provided to cadets in the previous summer is listed in Part VIII of this research plan. We are always seeking new opportunities for cadets to apply their learning to client organizations.

PART VI – THE DEPARTMENT RESEARCH FOCUS

All research in the Department of Systems Engineering, including ORCEN research, supports one or more of six main research thrusts, which are described below. By requiring each research project to support one or more research thrusts, we ensure our research in DSE and the ORCEN is relevant to Army clients. We also maintain our focus on properly developing junior faculty and cadets through projects impacting their profession. The six research thrusts, in no particular order, are:

Manning the Force: This research thrust includes analysis related to the accession, development and retention of enlisted soldiers and officers in the Army. Previous clients have included Army G1, US Army Accessions Command, and Human Resources Command.

Equipping the Force: This research thrust includes analysis related to the requirement development, function requirement definition and acquisition of equipment to support Army and DoD operations. Primary clients for this thrust in particular are logically from the acquisition community. Previous clients have included PEO Soldier, PM-Future Combat Systems, Army Material Command, PM-Bradley and Army Research Laboratory.

Organizing the Force: This research thrust includes analysis related to the organizational structure of units and operations. Previous clients have included the Army Staff, Training and Doctrine Command, Army G3, Assistant Secretary of the Army (Installations and Environment), PEO Soldier, PM-Future Combat Systems and the 3rd Armored Cavalry Regiment, Office of the Army Chaplin's, Office of the Department of the Army Staff.

Training the Force: This research thrust includes analysis related to training development and training support systems across the Army and DoD. Previous clients have included Army G3, Training and Doctrine Command, Army G8, numerous Army Divisions, including the 4th Infantry Division, and the Defense Advanced Research Projects Agency (DARPA).

Fighting the Force: This research thrust includes analysis related to doctrine and tactics for the Army and other DoD agencies. Previous clients have included Army G3, PEO –STRI, Defense/Army Modeling and Simulation Office (DMSO/AMSO), PM-Future Combat Systems and Training and Doctrine Command (TRADOC).

Sustaining the Force: This research thrust includes analysis related to the all aspects of support for the Army and DoD units while in combat, training or home-station. Previous clients

have included Army G4, Surface Deployment and Distribution Command (SDDC), US Army Accessions Command, and Human Resources Command.

PART VII – THE DEPARTMENT RESEARCH CYCLE

Regardless of the research thrust, the research source or the client, each research proposal must be approved through the DSE Research Council and the Department Head. The ORCEN Director, in the role of the Department Research Coordinator, collects potential project proposals from Senior Investigators and brings the research opportunity to the Department Research Council which is headed by the DSE Department Head. This development of research opportunities is normally conducted in the summer, when the academic load wanes for our senior investigators.

At the beginning of the academic year in August, the ORCEN the research council convenes to review each research proposal for support and for the identification of required resources. The ultimate authority for approving the allocation of resources (which includes funding, lab time and analyst time) is the Head, Department of Systems Engineering. Once approved, the researchers can execute the research plan.

The Research Cycle for an Academic Year for the Department of Systems Engineering is illustrated in Figure 3. This is a depiction of the objective annual research cycle, which involves several processes in executing the Research Plan. Among them is the development of research opportunities, the approval timelines and the completion times for each project. Research opportunities can be developed during the academic year, or off-cycle. These projects are tentatively approved through the Department Research Coordinator and the Department Head. They will ultimately be required to be approved by the Research Council in their January, mid-year meeting.

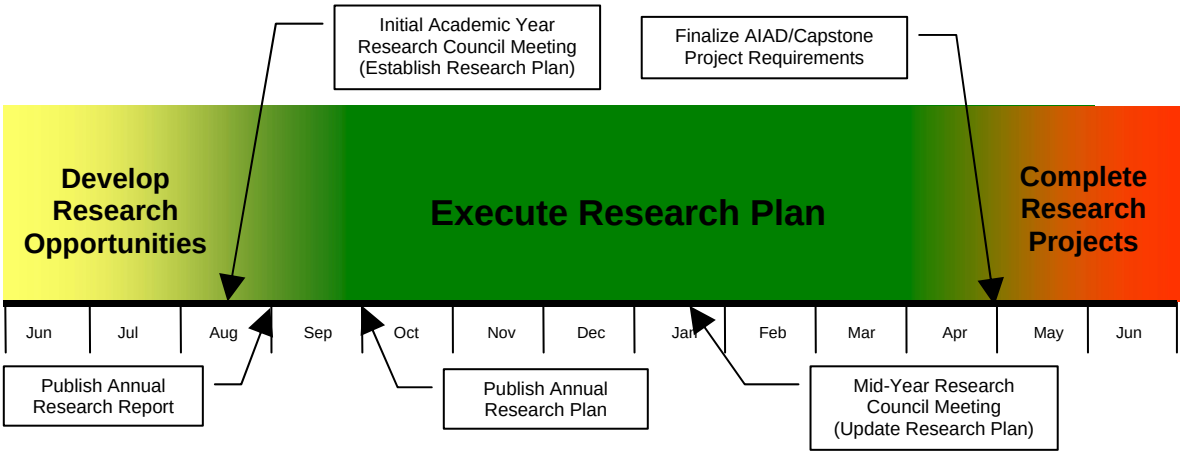

Figure 3: DSE/ORCEN Annual Research Cycle

As can be subsumed based on the cycle above and the research approval process described above, the Systems Engineering Department and the Operations Research Center do not solicit nor conduct many “short turnaround” research projects though there are some they conduct. The reason for this goes back to the initial objectives of the Department’s research program, which is to support the development of the junior analysts. In the ORCEN, the analysts rotate each year. To ensure their time is used and they develop as a researcher, most projects are year-long works.

Because we seek significant, year long projects for our analysts and our Capstone cadets, the Department of Systems Engineering and the ORCEN both seek long-term client relationships. This helps ensure a steady flow of significant, open ended projects which will challenge our officers and cadets and will thereby achieve our research objectives. In the following section, we present our research activities for this current academic year.

PART VIII – FACULTY RESEARCH ACTIVITIES FOR AY 2007

The following pages list each planned ORCEN and DSE faculty research projects to be undertaken within the Department of Systems Engineering for Academic Year 2006-2007.

PROJECT TITLE:	CLIENT ORGANIZATION	PAGE
Small Arms Weapon Effective Life	PEO Soldier	20
Shaping Insurgent Behaviors on the Battlefield: VBIED Detection and Defeat through Insights into Insurgent Decisioning and Response to Traffic Flow Strategies	US Army Engineer Research and Development Center (ERDC)	24
Armed Forces-CARES II: Armed Force Casualty Assistance Readiness Enhancement System II	Army Casualty and Memorial Affairs (HRC)	28
Capabilities-Based Design of Future Battle Command Training Centers - Phase II: Model Enhancements and Transition Plan	Directorate of Training, Training Simulations Division (DAMO-TRS)	34
Simulation Roadmap for Program Executive Office Soldier	PEO Soldier	39
Brigade Combat Team (BCT) Case Study – Driving Factors/Best Practices Influencing Effectiveness in the C-IED Fight	JIEDDO Operations Research Cell	44
Analysis of the PEO Soldier Budget Model	PEO Soldier	48
Assessment of Supply Chain Management for RFI	PEO Soldier	51
Behavior Algorithms for Counter-Insurgent Techniques in S&R Operations	Soldier Focus Area Collaborative Team (FACT)	54
Shaping Insurgent Behaviors on the Battlefield: VBIED Detection and Defeat through Insights into Insurgent Decisioning and Response to Traffic Flow Strategies - Phase II	US Army Engineer Research and Development Center (ERDC)	56
Temporal System Modeling of Counter-Insurgency Policy Dynamics		59
NATO Wastewater Reuse Risk Management	NATO Advanced Research Workshop	61

Any questions regarding these problem statements should be directed to the D/SE Senior Investigator, the Principal Analyst, or the Client POC listed for the respective research project.

PART IX - Academic Year 2007 Faculty Research Program

Small Arms Weapon Effective Life

Research Proposal No.: DSE-R-0625

Client Organization: Program Executive Office (PEO) Soldier Programs

Points of Contact:

NAME	ADDRESS	PHONE	EMAIL
Mr. Mike Friedman		(973) 724-4368 DSN 880-4368	mfriedma@pica.army.mil
Mr. Charlie Tamez	PEO Soldier 5901 Putnam Road, Bldg 328 Fort Belvoir, VA 22060-5422	(703) 704-4073 DSN 654-4073	Charlie.tamez@us.army.mil

Problem Description:

As with other equipment, small arms (5.56mm to 40mm) weapons systems for the US Army undergo extensive wear and tear. Traditionally larger weapons systems and machinery are replaced based on a myriad of means to determine the level of use or wear of the mechanisms. However, small arms weapons systems do not have the same level or type of tracking systems as larger, less numerous systems. With the more extensive use of small arms weapons systems since the turn of the century, the need to determine an "effective life" in years, rather than rounds, for weapon systems has become readily apparent and essential for maintaining operational readiness of all personnel. Units need an "effective factor" based upon their historical weapons use - the same way ammunition is allocated by unit type on the STRAC tables to help them determine when they need to be replacing their systems. The Army needs an effective means of forecasting when replacement systems will be required by units in order to have appropriate levels of replacement systems in the inventory ready for use.

AMC is looking for the holistic approach to condition based mainentnence (CBM) for small arms weapons (pistols to MK-19 grenade launchers). The overall methodologies examined and recommended would be those that best fit the needs to army the force; some of the factors – types of units, number and type of operational deployments, areas/regions of utilization, etc… are some of the factors which should be considered. Currently, the Squad Automatic Weapon (SAW) is one of the weapons of greatest interest.

Objective:

The objectives of this study are to (a) identify the minimal maintenance levels required for the sustained use of an individual SAW, (b) to develop a baseline methodology for assessing the remaining life of individual SAWs, and (c) to provide a framework for future assessment for the effectiveness of the methodology.

Technical Approach (Methodology):

For this research, we propose to employ the Systems Engineering Management Process (SEMP) to identify potential players, measures of effectiveness, and viable alternatives to resolve the methodology issues. The SEMP is a robust, deliberate problem solving methodology taught in the Department of Systems Engineering at the United States Military Academy. It has been used widely in a variety of applications, both on military and commercial problems. The SEMP has recently been employed in development of an operational assessment system for Operation

Enduring Freedom, in support of the Base Realignment and Closure (BRAC) study group, and to analyze the regional structure of the Army Installation Management Agency. The SEMP will be used to review the needs of the client, identify the key components of the current system, develop and assess viable alternatives to the current system, and present recommended small arms CBM methodology options to the client. More elaboration on SEMP-related tasks follows.

The Army is transforming to anticipate future threats. Part of that transformation involves implementing a condition based maintenance system for appropriate equipment which will assist in reducing battlefield maintenance failures, increase lethality and effectiveness, track maintenance status and efficiency, and reduce overall cost in time and dollars to the nation. In order to efficiently achieve this, it is necessary to create a methodology for managing and replacing our small arms (5.56mm to 40mm) weapons systems. This research will provide an enhanced baseline methodology predicated on the SAW.

Proposed Work:

Tasks to be performed and issues to address:

- Define Problem – Small Arms (5.56mm to 40mm) Weapon Effective Life
    - Scope problem with client in terms of options for small arms weapon effective life methodology with regards to users, maintenance personnel, supply chain, and manufacturing for the Squad Automatic Weapon (SAW).
    - Develop focus and brainstorming questions for needs analysis sessions
    - Identify stakeholders and conduct needs analysis to capture ideas and issues for possible SAW Effective Life Methodologies
    - Identify existing and developing SAW users, maintenance personnel, supply chain, and manufacturing organizations
- Conduct Design and Analysis of Alternatives with Stakeholders
    - Host stakeholder analysis and functional decomposition session(s) with focus and brainstorming questions
    - Identify essential elements of use, maintenance, supply, and manufacturing of SAWs which make their life expectance unique
    - Develop several alternatives to SAW Effective Life Methodologies and CBM options
    - Frame alternatives, based on stakeholder priorities, for presentation to those stakeholders
- Recommend and Select Alternatives
    - Prioritize alternatives/elements, based on stakeholder input and a consideration of future requirements
    - Develop recommendations and present to clients and stakeholders
- Implement M&S Installation Facilities Layout
    - Follow-on work for future funding: 1) Conduct case study to assess the effectiveness of SAW Effective Life Methodologies and CBM options and 2) develop effective life methodologies for other small arms (5.56mm to 40mm) weapons systems.

Milestones and Deliverables:

Milestones:

Table 1. Project Milestones

Milestone	Tentative Dates
Scope problem with client (systems on which to focus)	15 Jun 2006
Request available data on weapon system(s) from appropriate sources (PM-Soldier, units, AMSO)	15 Jul 2006
Develop focus and brainstorming questions for needs analysis	15 Jul 2006
Identify stakeholders for potential usability study	01 Aug 2006
Conduct needs analysis with stakeholders to determine desired capabilities	15 Sep 2006
Conduct needs analysis with stakeholders (group sessions)	15 Oct 2006
Identify essential elements of methodologies and weapon system that makes it unique	28 Oct 2006
Develop several alternatives methodologies	13 Jan 2007
Conduct IPR with client to review current issue and status of research to date	13 Jan 2007
Develop prioritized list of methodologies and potential test units	17 Feb 2007
Conduct Final Briefing with client with recommendations for methodology and possible implementation test cases	15 Mar 2007
Establish possible test units and/or follow-on methodologies	15 Mar 2007
Final tech report on work completed	15 May 2007

Project Deliverables and Due Date*:*

- Initial Research Team Briefing with Client: On or About 15 June 2006
- Conduct IPR with client to review current issue and status of research to date: 13 January 2007
- Conduct Final Briefing with client with recommendations for methodology and possible implementation test cases: 15 March 2007
- Establish possible test units and/or follow-on methodologies: 15 March 2007
- Final Technical Report: 15 May 2007

Senior Investigator(s):

LTC Simon R. Goerger , Ph.D., Assistant Instructor and Director Operation Research Center of Excellence, Department of Systems Engineering (MH305), United States Military Academy, West Point, NY 10996, 845.938.5529 (voice), 845.938.5665 (FAX), Simon.Goerger@usma.edu

Primary Investigator(s):

MAJ Gary R. Kramlich, Instructor and Analyst, Operations Research Center of Excellence, USMA, Department of Systems Engineering, 845.938.5168 (DSN: 688), Gary.Kramlich@us.army.mil.

Number of Cadets/Number of Design Teams Involved: TBD

Supporting Laboratory Technician: TBD

DoD Research Thrust:

- **X EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- **X SUPPORTING – the Force**
- □ **TRAINING – the Force**

Shaping Insurgent Behaviors on the Battlefield: VBIED Detection and Defeat through Insights into Insurgent Decisioning and Response to Traffic Flow Strategies

Research Proposal No.: DSE-R-0627

Client Organization: US Army Engineer Research and Development Center (ERDC)

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Dr. Robert E. Davis	Technical Director US Army Engineer Research and Development Center Cold Regions Research and Engineering Laboratory 72 Lyme Road	(603) 646-4219 FAX: (603) 646-4109	robert.e.davis@erdc.usace.army.mil

Project Summary:

Insurgents have effectively employed asymmetric tactics, such as the use of vehicle-borne improvised explosive devices (VBIEDs), as viable threats in urban environments. VBIEDs are often devastating in their physical and emotional effects. They are hard to detect and have proven difficult to thwart or defeat. They would be easier to thwart or defeat if the political, cultural, and physical environments in which they were implemented were more readily constrainable as in full combat operations. However, in stability and support operations, it is important to allow the nearly free flow of people (noncombatants) and goods through an economically developing or thriving community. Moreover, our limited understanding of human behaviors that drive the insurgent's planning, actions, and reactions, and the insurgent's ability to capitalize on the nature of the urban environment in stability and support operations adds to the complexity and challenges of detecting and defeating this threat.

There is a need to increase our understanding of the behavioral aspects, or decision making processes, of threats in the larger context of the physical and cultural environment so that we can provide a means to identify threats by evoking responses or producing recognizable patterns such that we begin to shift the advantage in this contemporary operational environment in our favor.

The objective of this proposed research is to provide insights into insurgent behaviors, or decisioning, given different tactics, techniques, and procedures (TTPs), particularly those associated with traffic flow/ traffic control point (TCP) strategies, employed by counterinsurgents with the goal of shaping insurgent behaviors to make detecting them or defeating them more likely. For example, behaviors can include avoiding a TCP by turning off the main route through a neighborhood with one particular affiliation versus selecting a third route. Can our placement of TCPs affect our ability to thwart and detect VBIED? We will accomplish this via constructive large-scale simulation experiments employing agent based models and extensions of electromagnetic field theory applied to path estimation for infiltration routes. This will create a crucible for providing insights into cause-and-effect relationships associated with counter insurgent tactics, techniques, and procedures and VBIED insurgent response, or decisioning. Thus, this will enable faster generation of viable and effective TTPs/TCP strategies as well as inform their dynamic modification in the evolving environment. The scope includes urban environments, stability and reconstruction operations (SRO), traffic control point strategies and associated TTPs, and VBIEDs employed against stationary targets.

Objective:

The objective of this overall project which this proposed research is supporting is to provide insights into insurgent behaviors, or decisioning, given traffic flow/ traffic control point (TCP) strategies, employed by counterinsurgents. The objectives of this statement of work are to: (a) develop realistic vignettes for assessing traffic flow and TCP strategies in urban environments during stability and reconstruction operations, (b) examine use of artificial electromagnetic (AEM) field theory for route assessment, and (c) assist in data generation and analysis.

Project Description:

This problem, or class of problems, has not been solved to date. If successful, this research will positively impact the current and future fight by assisting in countering the ongoing and effective VBIED asymmetric threat challenging our forces and noncombatants today, keeping our Troops and the local population safer, saving lives and property. Moreover, the methodologies and insights should form a basis for countering to other asymmetric challenges such as IED employed against convoys.

The team has already demonstrated the potential for success through a pilot project looking at the feasibility of utilizing agent based models and simulations as an environment for studying these types of problems. There is key blend of analytical capabilities and operational experience, to include current operational experience, on the team. The methodologies and results should further uncover new dimensions for exploration into the "brain lid" and drive modification of theory applied in other fields, such as site percolation theory, information entropy, and artificial electromagnetic field theory, for utility in this area of research.

Technical Approach: The technical approach will involve the following tasks:

- Task a: Identify potential behavior shaping actions and ranges of responses utilizing historical or realistic behaviors, as validated by subject matter experts. This will involve selecting a geographic area, most likely Baghdad, where we have terrain and ongoing operations and potential information resources. We will research types of targets that were or could be sought by VBIED and associated defining factors such as links to key events or heavily populated areas. Similarly, we will research data and theories on insurgent shaping methods associated with TCPs and other tactics. This information will be used to construct realistic vignettes, establishing targets and conditions, that will be reviewed and approved by SMEs.

- Task b: Utilize modified artificial electromagnetic (AEM) field theory with threat templates to derive potential routes insurgents would use. Task a will inform the creation of threat templates in the area of interest, such as those utilized in the intelligence preparation of the battlefield (IPB) process. This will be used in modified AEM with A* algorithms to pick the k-best routes as possible routes to be used by the enemy when seeking a target. TCPs can be charged to repel the insurgents and certain neighborhoods or areas can be used to attract VBIED for example.

- Task c: Implement route selection factors and trigger points, events triggering state changes/ behaviors in the agents, in simulation. The results of task b will be used in the agent based model, Map Aware Nonuniform Automata (MANA), scenario generation and in setting agent properties and trigger points. More information in MANA is given after the explanation of tasks.

- Task d: Design and run large-scale simulation experiments to provide insights based on key variables affecting success of traffic flow strategies/TTPs on shaping behaviors.

To facilitate the exploration of alternatives, a Nearly Orthogonal Latin Hypercube (NOLH) design of experiments will be used to reduce the number of runs while ensuring good coverage of the design space. Factors identified in the previous tasks will be examined across several levels (design settings) to capture interesting insights. We expect to examine 7 – 20 factors with 17 or so levels each.

- Task e: Analyze results. Logistic regression and/or classification and regression trees will be used to elicit insights regarding behaviors of insurgents. The product will be an assessment of factors/ combinations and levels that contribute to effectiveness.

MANA is more conducive to political, social, and cultural interactions than tradition combat simulations. It consists of entities, or agents, representing military units and noncombatants and allows for agents to change sides or roles. It is not intended to model high-fidelity physics-based interactions but is designed to capture effects, including those on human behaviors, communications, situational awareness, and low-level decision making capabilities. MANA is part of the family of the U.S. Marine Corps Combat Development Command's Project Albert family of agent based models.[1] The Defence Technology Agency of New Zealand developed MANA to conduct research into implications of chaos and complexity theory for combat and other military operational modeling.[2] The entities in MANA utilize their "memory maps" to inform their decisions and provide individual, or group, goals to guide them in the battlescape. MANA entities can also be classified as complex adaptive systems (CAS) which allows agents to adapt, evolve and coevolve with their environment.[3]

Proposed Work:

- Data collection for modeling insurgent behaviors (July 06)
- Extend AEM work previously conducted to plan traffic flow for vignettes (Aug 06)
- Develop 1 – 2 vignettes with excursions (July 06)
- Assist in data generation and analysis (Sep 06)

Requirements and Milestones:

- Review data/ conduct research on behavior shaping actions and response ranges (1 mos)
- Run modified AEM models for path prediction (2 mos)
- Design, implement, and test vignettes (2 mos)
- Conduct initial experimental runs (3 mos)
- Conduct follow-on experiments (4 mos)
- Finalize analysis (5 mos)
- Provide insights/recommendations regarding shaping insurgent behaviors (5 mos)
- Submit report (6 mos)

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[1]Project Albert Fact Sheet. [WWW Document]. Retrieved 01 April 2004 from http://www.mcwl.quantico.usmc.mil/fact_sheets/fs/Pro%20Albert%2007_31_03.pdf, 10 December 2002.
[2]D. P. Galligan, M. A. Anderson, & M. K. Lauren,. *MANA, Map Aware Non-uniform Automata, Version 3.0, Users Manual (Dr.aft)*. Unpublished manuscript, 2003.
[3]S. R. Goerger. *Validating Computational Human Behavior Models: Consistency and Accuracy Issues*. Dissertation. Naval Postgraduate School. Monterey, CA. June 2004.

Project Deliverables and Due Date:

- Technical Report – Nov '06

Senior Investigator(s):

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Paul W. Richmond, Ph.D., Analyst, Army Engineer Research and Development Center (ERDC), Vicksburg, MS, 601.634.3068; Paul.W.Richmond@erdc.usace.army.mil; and

Paul West, Ph.D., Assistant Professor, Department of Systems Engineering, USMA, 845.938.5871; Paul.West@usma.edu

Faculty Analyst(s):

MAJ Paul Evangelista, Instructor and Analyst, Operations Research Center of Excellence, USMA, Department of Systems Engineering, 845.938.5168 (DSN: 688), Paul.Evangelista @us.army.mil; and

MAJ Greg C. Griffin, Instructor and Analyst, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.2668.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 1200 Hours

Principal Analyst: 1200 Hours

Faculty Analyst(s): TBD

Total Cadet Time: 0

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust: (check all that apply)

□ **EQUIPPING – the Force**

X **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

X **TRAINING – the Force**

Armed Forces-CARES II: Armed Force Casualty Assistance Readiness Enhancement System II

Research Proposal No.: DSE-R-0701A

Client Organization: Army Casualty and Memorial Affairs (HRC)

Points of Contact:

NAME	ADDRESS	PHONE	EMAIL
LTC Robert J. Amico	Army Casualty and Memorial Affairs (HRC) Washington, DC 20310-0200	(703) 325-0070 (DSN: 221)	bob.amico@hoffman.army.mil

Problem Description:

To improve the process for those assigned the duties and responsibilities as a Casualty Assistance Officer (CAO). The overall objective is to make it so the primary next-of-kin (PNOK) of deceased service members and retirees receive accurate, timely, and responsive assistance. Starting in August 2005, the ORCEN began development of an automated tool to assist Army CAOs with processing the required forms for military casualty claims and benefits. Issues identified during the development of Armed Forces-CARES Version 1.0 by the Inspector General Study and through Department of Systems Engineering research indicated the need for a more integrated solution that encompassed CAO training, streamlined CAO/CAC procedures, and claims and benefits processing into a complete package for all service components. Additionally, inter-agency coordination issues precluded Armed Forces-CARES Version 1.0 from developing into a completely paperless process. To further advance the program and leverage today's technological capabilities, the next phases of the project will address these issues.

Methodology:

1. Longitudinal study to assess the effectiveness of Armed Forces-CARES. This would be conducted from the introduction of Armed Forces-CARES 1.0 to CAOs. As Armed Forces-CARES progresses to Version 2.0 and potentially Version 3.0, research would continue to track the impact of the program on CAOs, surviving family members, and CAC personnel. While dependent on fielding dates for subsequent versions of the Armed Forces-CARES, the study completion date would be by the end of USMA AY08 (May 2008) with a technical report by 31 September 2008.

   Envisioned End-Product: A technical report which will indicate the usefulness of Armed Forces-CARES; identify how well it and its associated training elements have helped to stream line the CAO process, reduce errors, enhance tracking processes, and provide surviving family members with better casualty assistance support; and provide follow-on recommendations to identified issues not within the scope of the SOW to resolve. An interim report will be generated by 31 May 2007.

   Risk: (Low/Medium) Past and current efforts to of cadet capstone teams and cadets attending Academic Individual Advanced Development (AIADs) with the Army Casualty and Memorial Affairs (HRC) makes this a very high probability for success.

Estimated Time to Complete: 31 September 2008.

2. This is the complete of the work for Armed Force Casualty Assistance Readiness Enhancement System I (funding already received) which is modified to include the integration of revised CAO/CAC procedures and additional Armed Forces-CARES 1.0 forms processing into a single package.

   Envisioned End-Product: An Army process and forms completion software tool called Armed Forces-CARES 1.0.

   Risk: (Low/Medium) Current efforts to work on the development of the product to date makes this a very high probability for success.

   Estimated Time to Complete: 31 December 2006.

3. Integration of updated CAO/CAC training package, revised CAO/CAC procedures, and Armed Forces-CARES 1.0 forms processing into a single package. Transition from Armed Forces-CARES 1.0 which is primarily automated document to be fully operable with future CAO/CAC training package(s) currently under development.

   Envisioned End-Product: An integrated Army casualty assistance process, training, and forms completion software tool called Armed Forces-CARES 2.0.

   Risk: (Low/Medium) Current efforts to work on the development of the training package and the positive collaboration between these project teams makes this a very high probability for success.

   Estimated Time to Complete: 31 May 2007.

4. Support and Upgrade of Armed Forces-CARES to integrate Chaplin availability with in the CAC Location.

   Envisioned End-Product: Provide a link with the Office of the Chief of Chaplains, Army, to providing the Army Casualty and Memorial Affairs (HRC) and CACs a list of available Activity Duty, Reserve, and National Guard Chaplains by demonstration in the region for use in casualty notification.

   Risk: (Low/Medium) The Army Casualty and Memorial Affairs (HRC) is unable to secure agreements with data sources to gain needed data on Active Duty and/or National Guard officers for the COMFORT model. This model already exists and is being used to track Reserve Chaplains.

   Estimated Time to Complete: 31 May 2007.

5. Integration of Armed Forces-CARES Version 3.0 into a paperless version of the product. This requires the cooperation with all associated government agencies to accept paperless products, and the technology requirements associated with this undertaking.

   Envisioned End-Product: A software package that is web-enabled to permit paperless transactions for the processing of all military casualty claims and benefits.

   Risk: (Medium/High) Technologically, this is not an issue; however, participating agencies maybe reluctant to accept such electronic documents or legislation may prevent this from occurring.

   Estimated Time to Complete: 30 June 2008.

6. Support and Upgrade of the different Armed Forces-CARES versions based on changes to entitlements.

   Envisioned End-Product: Integrated changes to entitlements into Armed Forces-CARES within thirty days of becoming law.

   Risk: (Low) The possibility of issues arising from integrating new entitlements is limited due to the open architecture of the prototype product. Only entitlements placed into law prior to 30 September 2008 will be integrated.

   Estimated Time to Complete: 31 December 2008.

Milestones and Deliverables:

Milestones:

Table 1. Project Milestones

Milestone	Tentative Dates
Conduct Initial Program Telecon with CAO staff	15 Jun 2006
* Provide Software Package for AF-CARES Beta to HRC and test participants	26 Jun 2006
Develop modifications to initial AF-CARES survey for base line study.	01 Jul 2006
* Conduct In-Progress Review Briefing (AF-CARES Beta) with HRC	01 Aug 2006
* Provide Software Package for AF-CARES 1.0 to HRC	21 Aug 2006
Develop initial AF-CARES Version 1.0 survey for longitude study.	01 Sep 2006
* Conduct AF-CARES 1.0 Usability Study	15 Sep 2006
* Conduct Final Briefing with HRC on AF_CARES 1.0	15 Nov 2006
Develop initial AF-CARES Version 2.0 survey for longitude study.	01 Dec 2006
* Provide Software Development Package for AF-CARES 1.0 to HRC	31 Dec 2006
* Provide Technical Report for AF-CARES 1.0 to HRC	31 Dec 2006
Provide Software Package for AF-CARES 2.0 Beta to HRC and test participants	01 Jan 2007
Launch AF-CARES Version 2.0 survey for longitude study.	01 Jan 2007
Conduct In-Progress Review Briefing (AF-CARES 2.0 Beta) with HRC	01 Mar 2007
Longitudinal Study Interim In-Progress Review Briefing	31 Apr 2008
Longitudinal Study Interim Report	31 May 2007
Provide Software Package for AF-CARES 2.0 to HRC	31 May 2007
Provide link to Office of the Chief of Chaplains, Army COMFORT Model	31 May 2007

Milestone	Tentative Dates
Provide Technical Report for AF-CARES 2.0 to HRC	31 July 2007
Develop initial AF-CARES Version 3.0 survey for longitude study.	01 Dec 2007
Provide Software Package for AF-CARES 3.0 Beta to HRC and test participants	01 Jan 2008
Launch AF-CARES Version 2.0 survey for longitude study.	01 Jan 2008
Conduct In-Progress Review Briefing (AF-CARES 3.0 Beta) with HRC	01 Mar 2008
Longitudinal Study Final In-Progress Review Briefing	31 May 2008
Provide Software Package for AF-CARES 3.0 to HRC	21 Aug 2008
Longitudinal Study Final Technical Report	31 Sep 2008
Transition Support of AF-CARES to Casualty Assistance Office or designated "host" Organization	31 Dec 2008
Provide Technical Report for AF-CARES 3.0 to HRC	31 Dec 2008

* Requirements from Armed Forces-CARES: Armed Force Casualty Assistance Readiness Enhancement System I

Project Deliverables and Due Date*:*

- Software Package AF-CARES 2.0 (Beta): 1 January 2007
- In-Progress Review Briefing (Product Implementation Recommendations): 31 April 2008
- Software Package AF-CARES 2.0: 31 May 2007
- Longitudinal Study Interim Report: 31 May 2007
- Link to Office of the Chief of Chaplains, Army COMFORT Model: 31 May 2007
- Technical Report for AF-CARES 2.0: 31 July 2007.
- Software Package AF-CARES 3.0 (Beta): 01 January 2008
- Longitudinal Study Final Report: 31 May 2008
- In-Progress Review Briefing (Product Implementation Recommendations): 31 May 2008
- Software Package AF-CARES 3.0: 21 August 2008
- Final Briefing: 15 December 2008.
- AF-CARES Transition to Host Organization Complete: 31 December 2008.
- Technical Report for AF-CARES 3.0: 31 December 2008.

Senior Investigators:

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LTC Brian Sperling, Ph.D., Assistant Professor, USMA – Department of Systems Engineering, 845.938.4399, (DSN: 688), Brian.Sperling@us.army.mil;

LTC Simon R. Goerger, Ph.D., Assistant Professor and Director, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.5529, (DSN: 688), Simon.Goerger@us.army.mil; and

TBD – Two additional Senior Investigators in academic year 2008 and other senior faculty members (Ph.D.s) as required.

Faculty Analyst(s):

MAJ Ernest Wong, M.S., Instructor, Operations Research Center of Excellence, USMA - Department of Systems Engineering, 845.938.5661; LTC Brian Sperling, Ph.D., Assistant Professor, USMA – Department of Systems Engineering, 845.938.4399;

MAJ Paul Evangelista, M.S., Instructor, Operations Research Center of Excellence, USMA - Department of Systems Engineering, 845.938.5661, (DSN: 688), Paul.Evangelista@us.army.mil;

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MAJ Gary R. Kramlich, Instructor and Analyst, Operations Research Center of Excellence, USMA, Department of Systems Engineering, 845.938.5168 (DSN: 688), Gary.Kramlich@us.army.mil; and

TBD – Three additional Faculty Analysts in academic year 2008 and other junior faculty members (Masters) as required.

Number of Cadets/Number of Design Teams Involved:

One or two cadet Capstone Teams (four cadets for each team); and

Two to four Cadets for Academic Individual Advanced Development (AIADs) – three weeks each.

Supporting Laboratory Technician: TBD

Laboratory technician will be hired or contracted by the Department of Systems Engineering to create AF-CARES based on software operational requirements and needs analysis for AF-CARES Alpha, Beta, and the final release versions of the software package.

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- x **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Capabilities-Based Design of Future Battle Command Training Centers - Phase II: Model Enhancements and Transition Plan

Research Proposal No.: DSR-R-0702

Client Organization: Directorate of Training, Training Simulations Division (DAMO-TRS)

Points of Contact:

NAME	ADDRESS	PHONE	EMAIL
LTC Darran Anderson	HQDA DCS G-3/5/7	703.692.6418	Darran.Anderson@hqda.army.mil

Problem Statement:

The Army's Transformation to Future Force and the enabling of the Future Combat System (FCS) require the ability to support battle command and embedded training with models and simulations (M&S). Current installation simulation training facilities have been developed over the decades in a manner which maximized their capabilities based on resources, technology, installation requirements, and expertise available at the time the center was built. This has created unique facilities which are non-standard across the Army making and make it more difficult to interoperate. With Network-Centric Warfare being the road to future inter- and intra-service operations, the ability to quickly modify training facilities and interoperate with other facilities in a timely manner is imperative.

From August 2005 until May 2006, The Operations Research Center (ORCEN) at the United States Military Academy performed a study for the Battle Command, Simulation & Experimentation Directorate (BCSE) which attempted to address a series of issues. The driving issues was the fact that current battle command training center facilities (BCTC) facilities were developed and implemented over the last decade to accommodate the unique training needs of specific "digitized" brigade-sized elements at certain installations (namely AWE and Stryker units) and that these facilities were sized and tailored based on the numbers of these types of units at various installations (typically one brigade). Since there construction, the Army has altered its direction, deciding to digitize the entire force. As a result, concerns have arisen about whether existing facilities can accommodate the evolving and growing training needs of the transforming force. Furthermore, how does the Army determine what BCTC facilities need to look like in order to meet these needs for the foreseeable future? In an attempt to address these issues, a BCTC Working Group of subject matter experts was formed. The developed a series of criteria for new BCTCs to be constructed over the next five to fifteen years. However, prior to the work conducted by the ORCEN on *Capabilities-based Design of Future Battle Command Training Centers project*, little quantitative analytical rigor had been applied to verify the answers to such issues and validate design templates for future facilities.

The initial work performed by the ORCEN resulted in numerous contributions to the Army digital training community to include an analytical tool to assist in the design and development of training facilities to ensure they possess the capabilities required of them. The tool has the capability to simulate training event throughput capabilities of a typical facility in order to identify potential impacts on annual training events conducted based on changes made to:

- Space, staff, and resource levels

- Untimely changes to annual scheduling
- Training requirements (particularly increases)
- Installation unit composition (particularly increases)

Additional research is needed to identify other factors which provide a statistically significant impact on the training event throughput capabilities of a typical future facility and possibly specific existing BCTC facilities. Some of these factors could include:

- Future force composition
- Training event structures
- Additional specified and implied staff requirements
- Cost factors (structural, maintenance, personnel, etc…)
- Pulse factors for surge training times on the installation
- Demands of installation units for specific training schedules to meet mission, deployment, and retraining requirements

Other research is needed to identify issues related to spatial positioning of rooms with in the facility, event locations, and personnel flow to maximize the efficiency of the facility's layout based on the recommended minimal room and support staff requirements generated from the training event throughput model.

Objective:

The initial objectives of this research project are to (a) identify the additional viable variables that have statistically significant impact on the outcomes of the model and integrate them (if feasible) into the model; (b) provide a analyst with working knowledge of the training event throughput model to be a member of the BCTC Working Group; (c) assess alternatives and provide a list of recommended user and maintenance host(s) for the training event throughput model to the client; and (d) assist in the transition of the training event throughput model from the ORCEN to the client designated user and maintenance host(s). The scope of the work will include simulation centers utilized to provide virtual simulations capabilities for training or analysis.

Methodology:

For this research, we propose to employ the Systems Engineering Management Process (SEMP) to identify desired staffing and facilities which would enhance inter-installation simulation center interoperability. Doing so will provide the basis for identifying essential infrastructure and personnel required for installation simulation centers. The Systems Engineering Management Process (SEMP) is a robust, deliberate problem solving methodology taught in the Department of Systems Engineering at the United States Military Academy. It has been used widely in a variety of applications, both on military and commercial problems.

The first step in this process is assessing current needs of the digital training community when developing a BCTC facility for a specified installation. A concurrent step will be to collect information and valid referent on BCTC facilities and annual training event throughput from key stakeholders/installations in the modeling and simulation and training fields to help identify additional statistically significant factors in the modeling and design of BCTC. These efforts will result in a refined definition and more accurate scope of the problem, and information to be used to enhance and validate the current training event throughput model and simulation. Capturing

insights generated through the process will also be critical in linking this project to the efforts of the BCTC Working Group. Based on this information, the ORCEN will make recommendations to the client for possible modifications to this work package to ensure the client's needs are being addressed.

The ORCEN team will also collect information to help generate alternatives and measure to assess alternatives for potential user and maintenance host(s) for the enhanced training event throughput model. Based on this assessment, the team will make recommendations as to the most viable host(s) for the training event throughput model.

The implementation phase will consist of the ORCEN providing a analyst with working knowledge of the training event throughput model to be a member of the BCTC Working Group; and the ORCEN assisting in the transition of the training event throughput model from the ORCEN to the client designated user and maintenance host(s).

Proposed Work:

Tasks to be performed and issues to address:

- Define Problem – M&S Installation Facilities Layout
    - Scope problem with client in terms of options for M&S facilities layouts with regards to infrastructure, staffing and installation digital training requirements
    - With assistance from BCSE and FA57s, query existing and developing installation training and analytical simulation facilities for annual training event through put data
- Conduct Design and Analysis of Alternatives
    - Develop metrics, collect appropriate data and assess statistical significance and viability of appropriate variable(s) and attributes for enhancements to the training event throughput model
    - Develop metrics, collect appropriate data and assess viability of appropriate host organizations to use and maintain the training event throughput model for the client
- Recommend and Select Alternatives
    - Prioritize appropriate variable(s) and attributes for enhancements to the training event throughput model
    - Develop recommendations and present to clients and stakeholders on appropriate host organizations to use and maintain the training event throughput model
- Implement M&S Installation Facilities Layout
    - Integrate appropriate variable(s) and attributes into the training event throughput model for enhancements
    - Develop users manual for the training event throughput model
    - Transfer training event throughput model to appropriate host organizations for use and maintenance

Milestones and Deliverables:

Requirements and Milestones:

Milestone	Tentative Dates
BCTC Working Group Member	Jun 2006 – May 2007
Scope problem with client (systems on which to focus)	02 Aug 2006
With assistance from BCSE and FA57s, query existing and developing installation training and analytical simulation facilities for annual training event through put data	23 Aug 2006
Develop metrics, collect appropriate data and assess statistical significance and viability of appropriate variable(s) and attributes for enhancements to the training event throughput model	13 Sep 2006
Develop metrics, collect appropriate data and assess viability of appropriate host organizations to use and maintain the training event throughput model for the client	30 Sep 2006
Prioritize appropriate variable(s) and attributes for enhancements to the training event throughput model	16 Oct 2006
Integrate appropriate variable(s) and attributes into the training event throughput model for enhancements	30 Nov 2006
Develop users manual for the training event throughput model	30 Nov 2006
Develop recommendations and present to clients and stakeholders on appropriate host organizations to use and maintain the training event throughput model	30 Nov 2006
Transfer training event throughput model to appropriate host organizations for use and maintenance	15 Dec 2006
Final Briefing with BCSE and Model Host Organization(s)	15 Jan 2007
Final Technical Report	28 Feb 2007

Project Deliverables and Due Date*:*

- Initial Client Meeting: on or about 02 August 2006.
- Interim IPRs: 30 September 2006.
- Users Manual and Final Model: 30 November 2006.
- Interim IPR – Host Decision Brief: 1st week of December 2006.
- Transition of Model to Host Organization(s): 15 December 2006.
- Final Briefing: 15 January 2007.
- Technical Report: 28 February 2007.

Senior Investigator(s):

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Primary Investigator(s):

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Number of Cadets/Number of Design Teams Involved: N/A

Supporting Laboratory Technician: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- x **SUPPORTING – the Force**
- x **TRAINING – the Force**

Simulation Roadmap for Program Executive Office Soldier

Research Proposal No.: DSE-R-0704

Client Organization: Program Executive Office (PEO) Soldier

Points of Contact:

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Mr. Steve Kishok	PEO Soldier 5901 Putnam Road, Bldg 328 Fort Belvoir, VA 22060-5422	703-704-4073	Steve.Kishok@belvoir.army.mil

Problem Description:

1. **Background:**

PEO Soldier requires a tactical combat simulation capability for Light Infantry missions at the level of platoon and below with resolution down to the individual Soldier. The simulation capability must accept, as input, scenarios and Soldier tactical mission system (STMS) characteristics. It must model the functions of the Soldier in a tactical environment, and provide, as output, the measures of effectiveness (MOEs) used to evaluate STMS. The simulation(s) will provide the analytical capability to support PEO Soldier decision making.

Given this effective need, during Fiscal Year 2004, the Operations Research Center of Excellence (ORCEN) developed the set of specific characteristics required of such a simulation. After a thorough study of alternatives, we recommended that PEO Soldier pursue the modification of and linkage between Combat[XXI], Infantry Warrior Simulation (IWARS), and OneSAF Objective System (OOS) as the alternative that would best meet PEO Soldier needs. PEO Soldier supports our recommendation and has asked ORCEN to begin with the implementation.

Over the course of Fiscal Year 2006, we proceeded forward with the implementation of our recommended course of action. This essentially consisted of a four-phased approach in which we strove to accomplish the following:

a. **Summer 2004: Stakeholder Analysis and Approval:** Gain Senior Joint and Army stakeholder "buy-in" whereby we worked with PEO Soldier to prepare and conduct executive-level briefings for senior Army and Joint leadership.

b. **June 2004 - May 2005: Planning for Action:** initiation of the implementation phase by establishing a dialogue with PEO Soldier organizations and simulation proponents, refining simulation requirements, estimating implementation lifecycle costs, and building a tentative execution timeline.

c. **June 2005 - May 2006: Execution:** worked to coordinate, mediate, and draft Memoranda of Agreement (MoA) and/or Memoranda of Understanding (MoU) between PEO Soldier and simulation proponent agencies. Additionally, we continued to work the finalization of initial funding requirements, estimates of implementation lifecycle costs, refinement of simulation requirements, and finally to assist with development of product simulation support plans (SSPs).

d. **June 2005 - May 2006: Supervision:** This fourth phase consisted of monitoring all reports, re-solving administrative issues, updating memoranda, and coordinating for and executing the independent assessment of simulation development and capability.

The ORCEN executed each of these four phases over the past two years, in some cases simultaneously. Currently, PEO Soldier has drafted a MOA and circulated it among the simulation proponents. While not yet signed, the simulation proponents have indicated concurrence with the contents and appear ready to proceed.

2. Discussion:

a. One priority task for FY07 is the actual signing of the MOA between PEO Soldier and the simulation proponents. This step serves to tie these organizations together and facilitate discussions on how to best proceed in achieving PEO Soldier's M&S objectives. Upon the signing the MOA, all parties will meet and discuss the next steps forward. Moreover, it is through these meetings and discussions that PEO Soldier, in conjunction with the simulation proponents, will be able to assign specific tasks and requirements for each task. Subsequent to and based upon these assignments, participating simulation development teams can further refin cost estimates and allocations.

b. In determining the specific modeling requirements, PEO Soldier identified an initial set of the highest-priority products that it wished to have modeled. It circulated these among the proponents for estimates on difficulty, a projected timelines for modeling, and cost estimates. Each of the three proponents provided fairly detailed levels of information in addressing each of these areas.

c. What remains is a thorough refinement of those modeling requirements to fully capture the effects/impacts on Soldier functions. This will require in-depth analysis of the characteristics/attributes of the STMS components being modeled, their basic effects on the Soldier's battlefield functions, and the behavioral representations/adjustments that each model must incorporate. These refinements will enable the simulation proponents to move forward with their respective models.

d. Subsequent to these activities being set in motion, PEO Soldier can then look next at the set of prioritized products for the modelers to work. This begins the refinement process for a new set of modeling requirements.

3. **Conclusions:**

The US Soldier deserves the best equipment available in the shortest amount of time. It is PEO Soldier's goal to improve timely and cost-effective fielding of individual Soldier equipment with effective modeling and simulation (M&S). Improving the linkage between Combat[XXI], IWARS, and OOS provides the Army with a powerful set of tools to support PEO Soldier decision making.

Proposed Work:

Tasks to be performed and issues to address:

1. Implement the plan – Execution

a. Finalize the Memoranda of Agreement (MoA) and/or Memoranda of Understanding (MoU) between PEO Soldier and simulation proponent agencies which include:

1. Intermediate and long-term objectives;
2. Execution timeline, to include initial set of meeting dates;
3. Critical path.

b. Finalize initial funding requirements.

c. Estimate implementation lifecycle costs.

d. Refine simulation requirements.

e. Assist with development of product simulation support plans (SSPs).

f. Provide monthly interim progress reports (IPRs) to the Deputy, PEO Soldier (DPEO Soldier).

2. Refinement of the specific modeling requirements based on the initial set of products identified by PEO Soldier.

a. Translate specific PEO Soldier product requirements into modeling requirements in order to fully capture all of the effects/impacts on Soldier functions, to include the tangential impacts ranging from the individual Soldier to the platoon level.

b. Determine modeler-to-task assignments for all requirements, to include finalized cost requirements for development and implementation

c. This will be an extension of last year's work whereby the ORCEN provides a detailed refinement of the modeling requirements spreadsheet, which will include the following:

- Comprehensive lists of characteristics/attributes for each of the selected products
- The basic effects of each product (i.e., the advertised value; the effects on Soldier functions; and the aggregated effects on the team, squad, and platoon level units)
- Identification of behavioral representations/adjustments required as a result of the product.

3. Identification of the next set of specific modeling requirements

a. This will begin once the current set of modeling requirements is partitioned among the simulation proponents.

b. Conduct a refinement of specific modeling requirements for the next set products, as described in (2) above.

c. Work with PEO Soldier and the simulation proponents in partitioning/assigning these tasks to a respective proponent and generating new cost estimates/allocations for this next level of work.

4. Controlled linked simulation exercise to verify accomplishment of stated goals

a. Propose a limited exercise, tentatively named Chainmail '07, to be conducted at agreeable location to test linked simulations ability to perform previously accomplished work.

b. As outlined in table below, completion of exercise will commence refinement of future goals and expectations.

c. Results of Chainmail '07 establish quantifiable metrics to base follow-on goals.

Chainmail '07 Requirements and Milestones

Milestone	Date
MoA Finalized	08 Sep 06
Initial meeting w/ MoA signatories (method TBD)	NLT 15 Oct 06
Modeling tasks assigned to simulation proponents	30 Oct 06
Program Review	15 Nov 06
Refinement of modeling requirements (AY07 set) complete;	1 Jan 07
Installation and networking of simulations on-site of proposed exercise location to establish platform for Chainmail '07	o/a 15 February 07
Chainmail '07 & Program Review	o/a mid April 07
Identify next set of products with PEO Soldier	o/a mid April 07
Program Review	15 May 07
Refinement of modeling requirements (AY07 set) complete; Modeling tasks assigned to simulation proponents	TBD
Program Review	15 Aug 07
Technical Report Complete	30 Sep 07

Project Deliverables and Due Date:

1. Modeling requirements refinements for the PEO Soldier products by 01 Jan 07
2. Chainmail '07 simulation exercise o/a mid-April '07
3. In-Progress Reviews (Monthly)
4. Technical Report. (30 Sep 07)

Senior Investigators:

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LTC Dale Henderson, Ph.D., Assistant Professor and Deputy Director, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.5539.

Faculty Analyst(s):

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MAJ Gregory Boylan, MS, Assistant Professor, USMA – Department of Systems Engineering, 845.938.4792, Greg.Boylan@usma.edu; and

MAJ Grant Martin, M.S., Assistant Professor, Department of Systems Engineering, United States Military Academy, West Point, NY 10996, 845.938.5663, Grant.Martin@usma.edu.

Number of Cadets/Number of Design Teams Involved: N/A

Supporting Laboratory Technician: TBD

Resources Required for Project

Research Hours Required (by position):

Senior Investigator: 60 Hours

Principal Analyst: 750 Hours

Lab Technician: TBD

Total Cadet Time: N/A

Lab Use Hours: Combat Simulation Lab, 80 hours

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- X **FIGHTING – the Force**
- □ **MANNING – the Force**
- X **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Brigade Combat Team (BCT) Case Study – Driving Factors/Best Practices Influencing Effectiveness in the C-IED Fight

Capstone Research Proposal No.: DSE-R-0710

Client Organization: JIEDDO Operations Research Cell
Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Stephen J. Kirin JIEDDO/Contractor	Joint IED Defeat Organization (JIEDDO)	703-601-4384	Stephen.Kirin@jieddo.dod.mil kirin@mitre.org

Problem Description:

The Contemporary Operational Environment (COE) in Iraq poses many significant challenges for the Counter-Improvised Explosive Devices (C-IED) fight. It is imperative that we assess what we have been doing and what seems to make a difference with respect to countering IEDs. Volumes of data pertaining to IEDs are being collected though different initiatives. This data consists of numerous, differing data elements collected over time and in varying formats. This data may offer insights about best practices, but extracting information from this data will require significant data reduction, cleaning, and analysis.

Objectives: (1) Conduct an inventory of provided BCT data with the aim of cataloging and generating a metadata framework under which to conduct analysis. (2) Using this data and framework, perform a case study to identify key factors/best practices influencing our ability to counter IEDs.

Proposed Work:

The research will be based on data provided by the sponsor and collected by four BCTs that operated in or are currently operating in Iraq. The data should include significant activities, intelligence summaries, patrols, various reports, etc. It is anticipated that there will be a need to try to collect data and information to "fill in the gaps" where necessary by contacting unit POCs. These additional data calls will be performed judiciously and executed through the sponsor (JIEDDO). The research team will apply systems engineering, operations research, and statistical analysis for large data sets/"messy" data in the conduct of this project. Milestones and progress will be reported on a frequent basis and deliverables will be provided throughout the duration of the project.

Project tasks are outlined below:

- Review content of the data (provided on several CD-ROMs by the sponsor) and catalog the content. Note the file structure, formats, intersections, similarities between BCTs and various products.
- Conduct an analysis of the textual data contained in those relevant products to determine if and what consistent themes exist across the data set and within various subsets of the data space (e.g., within units, within time periods, within regions). Produce an initial assessment of the results of text analysis (utility, important themes detected, path forward). Full-scale assessment of the effectiveness of text analysis and exploitation of the results to continue through the project lifecycle.
- Characterize the operational environment in terms of key factors in the context of the COE for C-IED. Examine this characterization in terms of the data set catalog and text

analysis and make appropriate adjustments. Initial characterization and review of existing (e.g. Effects Based Assessment System, stakeholder's analysis, literature) related descriptions of the environment. Refinement/revision/extension toward a baseline (version 0.1) database specification to continue through the December 2006 time frame.

- Create an analytically useful database structure using the operational environment characterization and meta-data framework from the text analysis and review of CDs. Develop techniques for populating this database with the data embedded in the CDs (version 0.1 populated database released end December 2006).
- Apply messy data, large data set, and exploratory data analysis techniques as needed to search for cause-effect relationships, correlations, filtering strategies, and key feature identification. This will be conducted throughout the project lifecycle and will begin with subsets of data. An analysis plan will be developed after the data is received and thoroughly reviewed.
- Develop results on best practices and driving factors.

Provide continuous feedback to the sponsor (at any point that such insights are discovered).

Requirements and Milestones:

Milestone	Tentative Dates
Working meeting with sponsor and TRAC WSMR on problem definition and scope	Mid-Aug 2006
Catalog with content of CDs	End-Aug 2006
Analysis plan for application messy data, large data set, and exploratory data analysis techniques after receipt and review of data	End-Sep 2006
Baseline characterization of the operational environment based on stakeholder's analysis, literature, and existing related efforts	End-Sep 2006
Initial assessment of the results of text analysis to help frame exploration of best practices along with insights on key factors	End-Oct 2006
Insights from data analysis based on subset of data	End-Nov 2006
Analytically useful database/structure using the operational environment characterization and meta-data framework from the text analysis and review of CDs	End-Dec 2006
Updated analysis plan for application messy data, large data set, and exploratory data analysis techniques after receipt and review of data	End-Jan 2007
Data gap analysis and inquiries	As Needed
Insights from data analysis based on data sets	End-Mar 2007
Final Briefing with sponsor on actionable recommendations regarding driving factors/best practices and data collection	End-June 2007
Final Written Report delivered to sponsor	End-June 2007
IPRs with Sponsor	As Requested

Project Deliverables and Due Date:

- Catalog with content of CDs 31 Aug '06
- Analysis plan for application messy data, large data set, and exploratory data analysis techniques after receipt and review of data 30 Sep '06
- Baseline characterization of the operational environment based on stakeholder's analysis, literature, and existing related efforts 30 Sep '06
- Initial assessment of the results of text analysis to help frame exploration of best practices along with insights on key factors 31 Oct '06
- Insights from data analysis based on subset of data 30 Nov '06
- Analytically useful database/structure using the operational environment characterization and meta-data framework from the text analysis and review of CDs 31 Dec '06
- Data gap analysis and inquiries As Needed
- Updated analysis plan for application messy data, large data set, and exploratory data analysis techniques after receipt and review of data 31 Jan '07
- Insights from data analysis based on data sets 31 Mar '07
- Final Briefing with sponsor on actionable recommendations regarding driving factors/best practices and data collection 31 Jun '07
- Final Written Report delivered to sponsor 31 Jun '07

Senior Investigator:

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LTC Dale Henderson, Ph.D., Assistant Professor and Deputy Director, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.5539; and

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MAJ Gary Kramlich, Instructor and Analyst, Operations Research Center of Excellence, USMA – Department of Mathematics, 845.938.5168; and

MAJ Gregory Boylan, MS, Assistant Professor, USMA – Department of Systems Engineering, 845.938.4792, Greg.Boylan@usma.edu.

Number of Cadets/Number of Design Teams Involved: N/A

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator: .5 PSY

Principal Analyst: .8 PSY

Faculty Analyst(s): TBD

Total Cadet Time: N/A

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- X **FIGHTING – the Force**
- □ **MANNING – the Force**
- X **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- X **TRAINING – the Force**

Analysis of the PEO Soldier Budget Model

Research Proposal No.: DSE-R-0715

Client Organization: Program Executive Office (PEO) Soldier, ATTN: SFAE-SDR, 5901 Putnam Road, Bldg 328, Fort Belvoir, VA 22060-5422

Points of Contact:

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Mr. Randy Long	PEO Soldier	1-703-704-1305	Randy.long@us.army.mil

Problem Description:

The Program Executive Office (PEO) Soldier defines its purpose as follows: "to develop the best equipment and field it as quickly as possible so that our Soldiers remain second to none in missions that span the full spectrum of military operations".[4]

The PEO Soldier budget is approximately $4 billion, 20% of which is program funding and 80% supplemental funding.[5] Supplemental funds provided to PEO Soldier in support of the war on terrorism have enabled extraordinary progress with several PEO Soldier initiatives. The rapid fielding initiative, new Army Combat Uniform (ACU), ground combat helmet, and various weapons advances have all been made possible by supplemental funding. This supplemental funding is a temporary situation. Given the forecasted federal budget challenges, we may expect substantial decreases from current DoD funding levels particularly in the emergency wartime supplemental funding that has fueled recent PEO Soldier successes. This expectation is consistent with recent experience and historical practice.[6]

Soldier readiness is a national priority and deserves appropriate, sustained, and predictable funding. The immediate question upon consideration of the scale of supplemental funding for meeting unit and soldier equipment needs over the last five years is "Why weren't these equipment advances and fielding initiatives programmed and anticipated, especially since this is an issue of soldier and unit readiness?".

A partial answer is that theater specific requirements and innovation in the face of the current conflict drove our recent rapid development and fielding efforts, but in a larger sense the heroic efforts in innovating, developing and fielding critical items to our warfighters undertaken since the outset of the current conflict were necessary because of inadequate or mis-allocated efforts prior to the onset of the conflict.

Soldier and unit equipment readiness requirements related to the PEO Soldier mission required significant heroic effort and supplemental funding to meet immediate mission requirements. This ad hoc process has continued throughout the conflict. An obvious conclusion is that PEO Soldier

[4] https://peoSoldier.army.mil/
[5] Phone conversation with PEO Soldier office, 12 July 2006. Program funds refer to funds appropriated under the regular annual authorization-appropriation process, whereas supplemental funds refer to funds appropriated under supplemental or emergency appropriations.
[6] Steven M. Kosiak, "FY 2007 Request: DoD Budget Continues to Grow, Modest Program Cuts", Center for Strategic and Budgetary Analysis, February 6, 2006

programs were not adequately or properly resourced prior to the war on terrorism. As the current ad hoc supplemental funding system comes to an end, PEO Soldier should be able to clearly and quantitatively develop, assess, and put into practice the best system for managing soldier and unit equipment programs. Knowing what options are available.

Increasing the level program funding would enable a more methodical and deliberate approach towards equipment development and fielding, thus reducing the requirement to rely on supplemental funding at the onset of future conflicts. This study would seek to answer:

- What is an appropriate range of programmed funding which PEO Soldier requires to meet readiness requirements of future battlefields?
- What is the appropriate balance between stable program funding and theater or conflict specific emergency supplemental funding?
- What are some of the lessons learned from recent equipment fielding practice which can be used to analyze historical trends?

Proposed Work:

This research project includes

- An extensive historical review of soldier and unit equipment fielding initiatives that have or would have (prior to the existence of PEO Soldier) fallen under the umbrella of PEO Soldier as well as the funding sources of these initiatives.
- An analysis of federal budget authority and supplemental appropriations trends, focusing on how military needs affected these trends. Historical trends will also provide an indication of how often the military required significant supplemental appropriations to support Soldier and unit equipment requirements related to PEO Soldier responsibilities.
- Historical trend analysis, coupled with expected future missions and activities of our armed forces, will provide the foundation necessary to describe future requirements and illuminate solutions for meeting those requirements.
- The project will include some preliminary analysis, or the development of a framework for analysis of the alternative approaches to meeting these requirements. The range of solutions is likely to be quite broad, and the alternative will accomplish the mission in very different ways. This work will require careful analysis and documentation of representative alternatives, bounding cases, and expected or most likely future scenarios.

The current budget model for PEO Soldier consists of modest funding during times of peace with supplemental appropriations meeting needs during wartime. An initial goal of this study is to provide the PEO Soldier with an analytical framework for explaining whether, how and why the current budget model needs to change.

Proposed Timeline

Milestone	Date (On or About)
SOW Finalized	18 Aug '06
Current Budget Process Model Examination	22 Sep '06
Alternate Budget Process Model(s) Cost Estimation	20 Oct '06
Analysis of Alternatives	10 Nov '06
Draft Report Submitted	04 Dec '06
Final Report Published	22 Dec '06

Senior Analyst(s):

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LTC Simon R. Goerger, Assistant Professor and Director, Operations Research Center of Excellence, United States Military Academy, West Point, NY 10996, 845.938.5529 (DSN: 688), simon.goerger@us.army.mil.

Primary Analyst(s):

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DoD Research Thrust:

- **X EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
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- □ **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Assessment of Supply Chain Management for RFI

Research Proposal No.: DSE-R-0717

Client Organization: Program Executive Office (PEO) Soldier, ATTN: SFAE-SDR, 5901 Putnam Road, Bldg 328, Fort Belvoir, VA 22060-5422

Points of Contact:

NAME	ADDRESS	PHONE	EMAIL
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Mr. Randy Long	PEO Soldier	1-703-704-1305	Randy.long@us.army.mil

Problem Description:

The Rapid Fielding Initiative (RFI) receives equipment from a multitude of suppliers. All of these suppliers ship the equipment to a central warehouse on the east coast where it is packaged into sets and then shipped on to the end user. This portion of the supply chain costs the Army resources and the using unit time. Is there a better way that decreases the commitment of resources and improves delivery time to the unit?

Objective:

The objectives of this study are to (a) assess the current operation of the supply chain, (b) assess the methods used by other organizations with similar supply chain management issues, and (c) modeling the alternative solutions to the problem.

Technical Approach (Methodology):

The Operations Research Center (ORCEN) and the Department of Systems Engineering at the United States Military Academy uses a formal systematic method when approaching a problem. This method, the System Decision Process (SDP), ensures we address the entire problem and the client's needs. The SDP helps us properly define the problem, develop solutions, recommend a decision and plan the implementation. This holistic approach will comprehensively assess the current system, determine the end state and identifies the capabilities gap between the two. Through this process we will identify key metrics of performance to compare the current system to the feasible alternatives, compare the alternatives and develop a recommendation. Throughout the process, we will periodically update the client on our progress giving preliminary results, get feedback and refine our direction. In the end, the ORCEN delivers a recommended solution and implementation plan through a briefing and a published technical report.

Typically, as we address the problem, we will develop tools, models and simulations. In this particular problem, we will build a simulation that compares the different feasible solutions. In order to do this, we have to examine the best practices of other organizations to see how they solved this problem. In the end, you can expect to see a comprehensive look at modern industry best practices and how that helped create the solution we recommended.

Proposed Work:

Tasks to be performed and issues to address:

- Define Problem – Selecting the Optimal Supply Chain System
    - Scope problem with client in terms of options for the system.
    - Develop focus and brainstorming questions for needs analysis session.
    - Identify stakeholders and conduct needs analysis to capture ideas and issues for possible supply chain systems.
    - Identify the unique and/or special functions this system performs and conditions it operates under.
- Conduct Design and Analysis of Alternatives with Stakeholders
    - Host stakeholder analysis and functional decomposition session with focus and brainstorming questions
    - Research current best practices in industry.
    - Identify essential elements of receiving, transferring, warehousing, assembly and shipping of the chain.
    - Develop several alternative systems for optimal selection.
    - Frame alternatives, based on stakeholder priorities, for presentation to those stakeholders
- Recommend and Select Alternatives
    - Prioritize alternatives, based on stakeholder input and a consideration of future requirements.
    - Implement Modeling and Simulation (M&S) of the feasible alternatives to clearly analyze and compare them.
    - Develop recommendations and present to clients and stakeholders.

Milestones and Deliverables:

Milestones:

Table 1. Project Milestones

Milestone	Tentative Dates
Scope problem with client (systems on which to focus)	07 Aug ‘06
Request available data on current system from appropriate sources	11 Aug ‘06
Develop focus and brainstorming questions for needs analysis	05 Sep ‘06
Identify stakeholders for potential usability study	11 Sep ‘06
Conduct needs analysis with stakeholders (group sessions)	15 Sep ‘06
Develop several alternative systems from existing system and other organizations	17 Oct ‘06
Conduct IPR with client to review current issues, status of research to date, and present alternatives	23 Oct ‘06

Milestone	Tentative Dates
Develop prioritized list of alternatives and implement M&S	04 Dec '06
Conduct Final Briefing with client with the results of the M&S and recommendations for the system.	15 Dec '06
Final tech report on work completed	12 Jan '07

Project Deliverables and Due Date*:*

- Initial Research Team Briefing with Client: On or About 07 August 2006
- Conduct IPR with client to review current issue and status of research to date: 23 October 2006
- Conduct Final Briefing with client with recommendations for methodology and possible implementation test cases: 15 December 2006
- Final Technical Report: 12 January 2007

Senior Investigator(s):

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Faculty Analyst(s):

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DoD Research Thrust:

X EQUIPPING – the Force

□ **FIGHTING – the Force**

□ **MANNING – the Force**

X ORGANIZING – the Force

X SUPPORTING – the Force

□ **TRAINING – the Force**

Behavior Algorithms for Counter-Insurgent Techniques in S&R Operations

Research Proposal No.: DSE-R-0718

Client Organization: Soldier Focus Area Collaborative Team (FACT)

Points of Contact:

NAME	ADDRESS	PHONE	EMAIL
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Problem Statement:

The Soldier Focus Area Collaborative Team (UO FACT) FY 07 Call-for-Proposals (CFP) called for assistance is resolving three major issues for the Soldier: Soldier Reaction to Contact/Fire, Soldier and Small Unit Engagement of Cued Target Locations, and Modeling of Soldiers and Small Units in Stability and Reconstruction Operations. The third area addresses the development knowledge, algorithms and data for potential S&RO missions including (but not limited to): secure a route, secure a site (FOB), conduct cordon and search, execute a traffic control point (TCP), and escort a convoy.

Objective:

Develop a capability to simulate the behaviors of insurgents using asymmetric tactics, such as suicide bombers, and vehicle borne IEDs as threats in Stability, Security, Transition, and Reconstruction (SSTR) Operations, along with current counter-insurgent TTP. In addition, these behaviors will include interaction with the nearly free flow of people (noncombatants) and goods (vehicles) through the area of interest and non-combatant reactions. This work will develop behaviors of counter insurgent forces for use in high fidelity simulations (Combat XXI, OOS), based on recent agent based model studies and subject matter expert surveys by Goerger et al.(2006 Spring SIW and to be presented at the Fall 06 SIW).

Methodology:

The general approach will be to develop intelligent behavior libraries that are independent of the model in which they will be implemented. For each behavior, the team will correlate incident data, terrain data, friendly data, and enemy data to determine the suitability of different terrain locations for different types of operations. Intelligent planning algorithms will use these results develop key positions and routes for each type of operation. The development team has prior experience with the development of mobility models, terrain data, route planning, intelligent agents, and automated tactical planning. In addition, the team has done recent work in developing automated threat templates using data mining techniques to correlate previous incidents with terrain features in the area of operations. This allows automatic generation of IED or ambush “hot spots” even if there is no incident data for the given scenario. The team has a working relationship with the Joint IED Defeat Organization, the Combat XXI development office, and the Topographic Engineering Center. The proposed work will provide collateral benefit to these organizations as we work together on common problems. A candidate simulation (Combat XXI, Objective OneSAF, or IWARS), selected in conjunction with simulation developers’ will be selected for demonstration of the planned behaviors.

Proposed Work:

The key deliverables are behavior libraries or an API and documentation. For insurgents, the code will enable automatic selection of locations for IED, mortar, ambush, and VBIED attacks and route planning. For counter-insurgents, the library will enable automatic selection of TCPs, sniper overwatch, NAIs for surveillance, and the planning of routes. The library will be demonstrated in a small scenario for one simulation (simulation platform TBD).

The key evaluation measures for this effort deal with verification and validation of the behavior libraries. For a small scenario such as a company-sized area of operations, the timings, frequency, and locations of insurgent and counter-insurgent events should correlate statistically with historical data for the same area of operations. These can be checked by comparing geospatial and temporal statistics for the simulated operation and a real operation. In addition, the behaviors should have "face validity" with subject matter experts. They should be plausible actions which could be taken by real insurgents. At the completion of this project, the Army will have a capability to evaluate the value-added of different TTP's, force levels, sensors, and command and control schemes in an insurgent environment. The soldier will realize the benefit as added effectiveness due to better informed decisions on the fielding of forces and equipment or publication of new doctrine.

Milestones and Deliverables:

Requirements and Milestones: TBD

Project Deliverables and Due Date*:* TBD

Senior Investigator(s):

Niki C. Goerger, Ph.D., Assistant Professor and ERDC Liaison, Department of Systems Engineering, USMA, 845.938.3180, 845.938.5665 (FAX), Niki.Goerger@usma.edu;

LTC Robert H. Kewley, Jr., Ph.D., Academy Professor, USMA – Department of Systems Engineering, 845.938.5206;

Paul W. Richmond, Ph.D., Analyst, Army Engineer Research and Development Center (ERDC), Vicksburg, MS, 601.634.3068; Paul.W.Richmond@erdc.usace.army.mil; and

Burhman Q, Gates, Analyst, Army Engineer Research and Development Center (ERDC), Vicksburg, MS, 601.634.3200; burhman.gates@erdc.usace.army.mil.

Primary Investigator(s): TBD

Number of Cadets/Number of Design Teams Involved: N/A

Supporting Laboratory Technician: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- X **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Shaping Insurgent Behaviors on the Battlefield: VBIED Detection and Defeat through Insights into Insurgent Decisioning and Response to Traffic Flow Strategies - Phase II

Research Proposal No.: DSE-R-0719

Client Organization: US Army Engineer Research and Development Center (ERDC)

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Dr. Robert E. Davis	Technical Director US Army Engineer Research and Development Center Cold Regions Research and Engineering Laboratory 72 Lyme Road	(603) 646-4219 FAX: (603) 646-4109	robert.e.davis@erdc.usace.army.mil

Project Summary:

Insurgents have effectively employed asymmetric tactics, such as the use of vehicle-borne improvised explosive devices (VBIEDs), as viable threats in urban environments. VBIEDs are often devastating in their physical and emotional effects. They are hard to detect and have proven difficult to thwart or defeat. They would be easier to thwart or defeat if the political, cultural, and physical environments in which they were implemented were more readily constrainable as in full combat operations. However, in stability and support operations, it is important to allow the nearly free flow of people (noncombatants) and goods through an economically developing or thriving community. Moreover, our limited understanding of human behaviors that drive the insurgent's planning, actions, and reactions, and the insurgent's ability to capitalize on the nature of the urban environment in stability and support operations adds to the complexity and challenges of detecting and defeating this threat.

There is a need to increase our understanding of the behavioral aspects, or decision making processes, of threats in the larger context of the physical and cultural environment so that we can provide a means to identify threats by evoking responses or producing recognizable patterns such that we begin to shift the advantage in this contemporary operational environment in our favor.

The objective of this proposed research is to provide insights into insurgent behaviors, or decisioning, given different tactics, techniques, and procedures (TTPs), particularly those associated with traffic flow/ traffic control point (TCP) strategies, employed by counterinsurgents with the goal of shaping insurgent behaviors to make detecting them or defeating them more likely. For example, behaviors can include avoiding a TCP by turning off the main route through a neighborhood with one particular affiliation versus selecting a third route. Can our placement of TCPs affect our ability to thwart and detect VBIED? We will accomplish this via constructive large-scale simulation experiments employing agent based models and extensions of electromagnetic field theory applied to path estimation for infiltration routes. This will create a crucible for providing insights into cause-and-effect relationships associated with counter insurgent tactics, techniques, and procedures and VBIED insurgent response, or decisioning. Thus, this will enable faster generation of viable and effective TTPs/TCP strategies as well as inform their dynamic modification in the evolving environment. The scope includes urban environments, stability and reconstruction operations (SRO), traffic control point strategies and associated TTPs, and VBIEDs employed against stationary targets.

Project Description:

This problem, or class of problems, has not been solved to date. If successful, this research will positively impact the current and future fight by assisting in countering the ongoing and effective VBIED asymmetric threat challenging our forces and noncombatants today, keeping our Troops and the local population safer, saving lives and property. Moreover, the methodologies and insights should form a basis for countering to other asymmetric challenges such as IED employed against convoys.

The team has already demonstrated the potential for success through a pilot project looking at the feasibility of utilizing agent based models and simulations as an environment for studying these types of problems. There is key blend of analytical capabilities and operational experience, to include current operational experience, on the team. The methodologies and results should further uncover new dimensions for exploration into the "brain lid" and drive modification of theory applied in other fields, such as site percolation theory, information entropy, and artificial electromagnetic field theory, for utility in this area of research.

- Task a: Use results and scenarios from Phase I as a foundation for further exploration
- Task b: Add slowdown factor for civilian traffic at TCPs
- Task c: Make TCP traffic slow down directional
- Task d: Provide Civilian Traffic an aversion to the TCP
- Task e: Focus on factors used to vary the experiments in the types of things we can change with the strategies (i.e. the number of TCPs, the ratio of Flash to Long Term TCPs, distance of TCPs from the target, turns the VBIED is forced to make en route to the target.
- Task f: Leverage investigation of unclassified findings from JIEDDO research

MANA is more conducive to political, social, and cultural interactions than tradition combat simulations. It consists of entities, or agents, representing military units and noncombatants and allows for agents to change sides or roles. It is not intended to model high-fidelity physics-based interactions but is designed to capture effects, including those on human behaviors, communications, situational awareness, and low-level decision making capabilities. MANA is part of the family of the U.S. Marine Corps Combat Development Command's Project Albert family of agent based models.[7] The Defence Technology Agency of New Zealand developed MANA to conduct research into implications of chaos and complexity theory for combat and other military operational modeling.[8] The entities in MANA utilize their "memory maps" to inform their decisions and provide individual, or group, goals to guide them in the battlescape. MANA entities can also be classified as complex adaptive systems (CAS) which allows agents to adapt, evolve and coevolve with their environment.[9]

Proposed Work:

- Follow-on research to DSE-R-0627; summer 2006; TBD – Nov '06

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[7]Project Albert Fact Sheet. [WWW Document]. Retrieved 01 April 2004 from http://www.mcwl.quantico.usmc.mil/fact_sheets/fs/Pro%20Albert%2007_31_03.pdf, 10 December 2002.
[8]D. P. Galligan, M. A. Anderson, & M. K. Lauren,. *MANA, Map Aware Non-uniform Automata, Version 3.0, Users Manual (Dr.aft)*. Unpublished manuscript, 2003.
[9]S. R. Goerger. *Validating Computational Human Behavior Models: Consistency and Accuracy Issues*. Dissertation. Naval Postgraduate School. Monterey, CA. June 2004.

Requirements and Milestones:

- TBD – Nov '06

Project Deliverables and Due Date:

- TBD – Nov '06

Senior Investigator(s):

Niki C. Goerger, Ph.D., Assistant Professor and ERDC Liaison, Department of Systems Engineering, USMA, 845.938.3180, Niki.Goerger@usma.edu;

LTC Simon R. Goerger , Ph.D., Assistant Instructor and Director Operation Research Center of Excellence, Department of Systems Engineering (MH305), USMA, West Point, NY 10996, 845.938.5529 (voice), 845.938.5665 (FAX), Simon.Goerger@usma.edu; and

Paul W. Richmond, Ph.D., Analyst, Army Engineer Research and Development Center (ERDC), Vicksburg, MS, 601.634.3068; Paul.W.Richmond@erdc.usace.army.mil.

Faculty Analyst(s):

MAJ Paul Evangelista, Instructor and Analyst, Operations Research Center of Excellence, USMA, Department of Systems Engineering, 845.938.5168 (DSN: 688), Paul.Evangelista@usma.edu; and

MAJ Greg C. Griffin, Instructor and Analyst, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.2668, Gregory.Griffin@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 1200 Hours

Principal Analyst: 1200 Hours

Faculty Analyst(s): TBD

Total Cadet Time: 0

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

X **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

X **TRAINING – the Force**

Temporal System Modeling of Counter-Insurgency Policy Dynamics

Research Proposal No.: DSE-R-0720

Client Organization: TBD

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Dr. Andrew Caldwell Group Leader – Policy & Planning Analysis	The Defence Science & Technology Laboratory PCS Dept, DSTL A2 Bld, Ively Road Farnborough, GU14 0LX	Tel: 01252 45(5376) Fax: 01252 45(5031)	**ADCALDWELL@DSTL.GOV.UK**

Problem Description:

The challenge of identifying insurgent force intent and thus structuring effective counter-insurgency strategy is complicated by a host of elements, not the least of which are the lags of time-dependent effects propagated throughout the coupled systems comprising a metropolitan area. When lagged effects are evident, they can be mistakenly attributed to causes observed in the near past or present, thereby confounding effective response planning efforts. To complicate matters further, there is a lurking suspicion remaining that despite the efforts of U.S. forces to strengthen the infrastructure of Iraqi cities, these cities will collapse to an unsatisfactory state once U.S. forces are withdrawn.

Statistical and pattern analysis techniques applied to insurgent incidents are limited in that they neither capture the dynamic and stochastic nature of insurgent behavior itself, nor are capable of leveraging these elements to estimate insurgent intent that contains elements of long term intended effects. Moreover, they completely fail to provide analysts with guidelines against which any data mining efforts should be structured and performed.

Proposed Work:

- In this study, we propose a new stochastic modeling approach for informing counter-insurgency strategy at the theater level of operations based on linear dynamic control system theory. This approach is intended to specifically overcome the shortcomings in available methods noted above. Using this approach, we show that any effective counter-insurgency strategy must necessarily capture the linkage between physical layer components and the critical services they provide. Against this structure, incident data takes on a new perspective, one that provides significant insights into the intent of insurgent strategy, yielding significant criteria against which to structure a data-based exploration of insurgent incidents that supports strong inference.
- This work is collaborative work with the Defence Science & Technology Laboratory of the United Kingdom.

Requirements and Milestones:

- TBD

Project Deliverables and Due Date:

- TBD

Senior Investigator(s):

Patrick Driscoll, Ph.D., Professor, Department of Systems Engineering, USMA, 845.938.6587; Patrick.Driscoll@usma.edu; and

Niki C. Goerger, Ph.D., Assistant Professor and ERDC Liaison, Department of Systems Engineering, USMA, 845.938.3180, Niki.Goerger@usma.edu.

Faculty Analyst(s): TBD

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- X **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- □ **TRAINING – the Force**

NATO Wastewater Reuse Risk Management

Research Proposal No.: DSE-R-0721

Client Organization: NATO Advanced Research Workshop

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mohammed Zaidi	Idaho State University College of Engineering Campus Box 8040 Pocatello, ID 83209		zaidmoha@isu.edu
Prof Nava Haruvy	Netanya Academic College 1 University Rd. Natanya 42100, Israel	972-8-9463189 972-52-3611260 Fax: 972-8-9365345	navaharu@netvision.net.il

Problem Description:

Enhancing public welfare through the deliberate management of water resources is vital for every society. Pollution, overuse, and consumption challenge a society's ability to develop and sustain water supplies for municipal, agricultural, industrial, and recreational use while protecting fisheries and wetlands. Scarce water resources also threaten international and regional security due to water conflicts. Water resource management decisions are complex and involve risk. The client organization is seeking methodologies for water resource risk management for NATO and Mediterranean countries.

Proposed Work:

The Department of Systems Engineering will develop a risk- and values-based decision support system (DSS) for evaluating water resource management alternatives. Specifically, DSE will:

- Identify critical risk factors.
- Provide a structure for valuing risk factors and determining individual and combined factor utility.
- Develop a DSS for quantifiably assessing alternatives based on comprehensive risk factor utility.

Requirements and Milestones:

- TBD

Project Deliverables and Due Date:

- Article for publication in *Wastewater Reuse – Risk Assessment, Decision-Making and Environmental Security*, TBP in the NATO Science Through Security Series: C – Environmental Security: October 2006
- Final Briefing: October 2006
- Technical Report: December 2006

Senior Investigator(s):

Paul West, Ph.D., Assistant Professor, Department of Systems Engineering, USMA, 845.938.5871; Paul.West@usma.edu.

Faculty Analyst(s): TBD

Number of Cadets/Number of Design Teams Involved: N/A

Supporting Laboratory Technician: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- **X SUPPORTING – the Force**
- □ **TRAINING – the Force**

PART X - Academic Year 2007 Capstone Research Program

Identification of critical factors for close range and quick reaction engagements in urban operations

Capstone Research Proposal No.: DSE-CR-0701

Client Organization: TRAC-Monterey

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
MAJ Jon Alt	TRAC-Monterey, ATTN: ATRC-RDM, PO Box 8695, Monterey, CA, 93943-0695	831-656-3732 (voice), 845-401-7986 (cell)	jonathan.alt@us.army.mil
MAJ Eric Tollefson	TRAC-Monterey, ATTN: ATRC-RDM, PO Box 8695, Monterey, CA, 93943-0695	831-656-7574 (voice), 831-656-3084 (fax)	eric.tollefson@us.army.mil

Problem Description:

Because of the current operational environment experienced by U.S. Army soldiers and the advancement of future Army systems in support of these soldiers, there is an increased demand for models that represent individual soldier actions. The objective of this project is the determination of factors that impact a soldier when faced with a short range engagement.

This effort will enhance future Army modeling efforts with respect to the individual infantry soldier who faces a short range engagement. The largest barrier to modeling these types of engagements is understanding individual soldiers actions M&S development of these actions.

The resulting models will be validated by SMEs within the DSE at West Point. Output from this process will provide the critical factors that effect soldier actions in close range engagements.

CLIENT PROBLEM DESCRIPTION

Small arms direct fire engagements at close-in UO ranges is expected to be the most common, and important, aspect of direct fire modeling in UO. While many algorithms exist dealing with combatant weapons use (e.g. weapon aiming, delivery accuracy, engagement timelines), existing data is focused on longer-range engagements in "open terrain." Minimal data and algorithms exist to represent infantry performance in UO environments. An additional shortfall includes the lack of standard "urban" personnel target dimensions unique to UO environments.

Identifying critical factors to focus data development and model design has not been accomplished. While the need to accurately model close range, quick reaction engagements, and some key factors have been identified, more work must be done to identify and prioritize additional relevant factors. The development and identification of critical factors, still in its infancy, is essential for data development and model design for these engagements.

Proposed Work:

The basis for this work began in the form of a three week Advanced Individual Academic Development (AIAD) opportunity between the Department of Systems Engineering at the United States Military Academy (USMA). The work proposed herein will serve as an extension of the AIAD work performed.

Specifically, for this research, we propose to use the Systems Decision Process, SDP, to identify critical factors that impact soldier combat effectiveness in close range engagements. Doing so will allow scientists to better model the infantryman and therefore allow the Army to manage its limited resources and equip its soldiers more effectively. The SDP is a four-phased iterative process that allows for refinements to any product or systems based upon new information or discoveries, regardless of where in the process those discoveries occur.

First, we will begin with a reinvigorated problem definition phase. This will include a comprehensive literature review, a more in-depth stakeholder and needs analysis, a re-evaluation and, if necessary, modification of existing functional decompositions of the soldier system, and a refined application of value modeling to more accurately and completely reflect stakeholder needs. Next, we will transition to the solution design phase in which we will develop alternatives in the form of critical factor sets. We will model these critical factor sets in an urban environment using various agent based and/or analytical modeling and simulation (M&S) tools, such as MANA, Pythagoras, and IWARS. The purpose of the modeling will be to develop a quantitative and qualitative assessment of the impacts of critical factors on soldier combat effectiveness in the contexts of vetted value measures. Possible higher level measures include lethality, survivability, and mobility. Pursuant to modeling and analysis of alternative sets, we will incorporate value-focused thinking to compare and contrast alternative performance relative to stakeholder values and to determine which set(s) of factors most effectively achieve(s) the stated objectives. The expected endstate is a recommended course of action that describes either a specific set of critical factors or a prioritized grouping of sets on which the modeling community can then focus their modeling efforts.

Proposed Work:

Tasks to be performed and issues to address:

- Define Problem – Factors that effect Close Range Engagements
    - Scope problem with client in terms of what specifically needs to be addressed – i.e. scope of project.
    - Develop focus and brainstorming questions for needs analysis sessions with TRAC-Monterey
    - Identify stakeholders and conduct needs analysis
    - Extensive review of literature (OEF, OIF, related Operations)
    - Host stakeholder analysis and functional decomposition session(s) with focus and brainstorming questions
    - Review existing studies of functional decomposition and reassess their outcomes
    - Value Modeling
        - Prioritize critical factors/elements, based on stakeholder input and a consideration of future requirements
        - Develop Value Scores for each Factor and make recommendations accordingly
- Solution Design
    - Alternative Generation

        - Develop set of critical factors
        - Determine Alternate Factors for Study
    - Use agent based and/or analytical simulation tools (i.e., MANA, IWARS, PYTHAGORAS) to model and assess critical factors
- Decision Making
    - Score each set of critical factors
    - Conduct sensitivity analysis on critical factors
    - Validate critical factor list with client and SME's

Milestones and Deliverables:

Requirements and Milestones:

- Problem Definition Complete – 20 October 2006
- Design and Analysis Complete – March 2007
- Decision Making Complete – April 2007
- Implementation Complete – May 2007

Project Deliverables and Due Date*:*

Deliverable	Due Date	Associated Product
IPR #1	25 Sep 06	Stakeholder Analysis Report
IPR #2	11 Oct 06	Functional Analysis Report
IPR #3	20 Oct 06	Value Modeling Report
IPR #4	6 Dec 06	Initial Solution Design Report
Interim Tech Report	8 Dec 06	Completed report
IPR #5	18 Jan 06	Initial modeling and analysis report
IPR #6	7 Mar 06	Modeling and Analysis results report
Final Decision Brief	April 07	Briefing
Final Tech Report	9 May 07	Completed report

Senior Investigator(s):

MAJ Gregory Boylan, MS, Assistant Professor, USMA – Department of Systems Engineering, 845.938.4792.

Faculty Analyst(s): TBD

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: John Melendez for the installation and management of MANA, Pythagoras, and IWARS licenses on SE lab systems

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 100 hours

Laboratory Technician Hours: 5 hours

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- X **TRAINING – the Force**

Joint Analysis System Usability Study

Capstone Research Proposal No.: DSE-CR-0702

Client Organization: Office of the Secretary of Defense (OSD) Program Analysis and Evaluation, Simulation Analysis Center (OSD PA&E)

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
LTC John Crino	PA&E/SAC, Suite 620 1555 Wilson Blvd, Rosslyn, VA	703-696-9601	John.Crino@osd.mil

Problem Description:

The Joint Analysis System (JAS) is a 10 year $100M DoD effort to develop a Jointly balanced campaign analysis tool that incorporates C4ISR. JAS is now mature enough to begin DoD studies, but there are some issues with usability. Output data is sometimes difficult to generate and input GUIs can be complex.

Proposed Work:

There are three proposed deliverables:

1. As a campaign modeling and analysis exercise, prepare a briefing to senior leaders that analyzes the campaign outcome.
2. Provide feedback to the JAS Program office on GUI usability.
3. Provide feedback to the JAS Program Office on output usability.

Requirements and Milestones:

- TBD

Project Deliverables and Due Date:

IPR #1: 4 OCT 06

IPR #2: 5 DEC 06

IPR #3: 12 FEB 07

Final Briefing: 27 APR 07

Technical Report: 10 MAY 07

Senior Investigator(s):

MAJ Scott Crino, Ph.D., Instructor, USMA – Department of Systems Engineering, 845.938.2788, Scott.Crino@usma.edu.

Faculty Analyst(s): TBD

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- X **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- X **TRAINING – the Force**

Value Design for Officer Accession via ROTC

Research Proposal No.: DSE-CR-0703

Client Organization: US Army Accessions Command

Points of Contact:

NAME	ADDRESS	PHONE	OTHER
Sponsor: COL Rocky Gay Ph.D. Director, Center for Accessions Research	US Army Accessions Command Fort Knox, KY 40121	(502) 626-0321	Ralph.Gay@usaac.army.mil
Client/POC: LTC William S. Bland, Ph.D. Chief, Accessions Systems Division	CAR, USAAC Fort Knox, KY 40121	502-626-0341 (DSN: 536)	William.Bland@usaac.army.mil

Background: **(being developed currently)**

ROTC is one of a limited number commissioning sources for meeting manning requirements for officers in all branches of service to the U.S. military. The Army ROTC program, instituted on June 3 with President Woodrow Wilson's signature of the National Defense Act of 1916, was initially conceived and implemented as a system with the mission to supplement the two US Service Academies through civilian universities. Since then, many changes have been made to the program, principally to adapt the structure or processes imbedded in the system so as to deliver a higher degree of value to its major stakeholder, principally scholastic, athletic and leadership excellence.

A major change to the program was initiated by the ROTC Revitalization Act of 1964 when the program began offering a full four-year program, a two-year program for those who were unable to participate earlier, and a new scholarship program. The largest changes in the program were commensurate with the passage of The Defense Officer Personnel Management Act (DOPMA) legislation in 1981). DOPMA removed the assignment of active duty (AD) versus active duty reserve status based on commissioning sources. As a result, as an officer acquisition program, the playing field was leveled, thus allowing for a good degree of choice on the part of potential future officers as to how they were to obtain their commission and what their (typically) 4-year college experience was going to be. Following the DOPMA, the US Army ROTC Cadet Command was established in 1986, in order to over see the program.

The current stated mission of Army ROTC is to commission the future officer leadership of the US Army and motivate young people to be better citizens In its current form, Army ROTC is a distributed network program that takes place at 4 year undergraduate universities and colleges across the nation.

Problem Description: (initial)

As the Army's budget continues to tighten as a result of its commitment to the Global War on Terrorism (GWOT), there is an ever increasing demand to make operational programs as effective as possible. Among these programs are those affecting the accession of junior officers for the Army, principally the ROTC program. There are expressed concerns of low production rates quite possibly tied to specific locations, as well as questions as to whether the Army is receiving a good return on investment in the various dimensions of the program.

For this analysis, it appears appropriate to examine the structure of the current ROTC programs with an emphasis on exploring answers to the concerns noted along with determining how to best

deliver value to the major stakeholders of the program. Alternative designs could quite possibly contain feasible and significant changes to what schools participate, how scholarships are distributed, the structure of incentive components of the program, faculty and course composition, among others.

A systems thinking approach to this problem that takes into account the interaction of other systems will most likely add value to the project results.

Problem Statement: (initial)

ROTC, a system whose purpose is to commission 2nd Lieutenants for the Army, is currently inefficient. This current state creates inefficiencies, which are not desirable for the United States Army.

Project Plan of Work:

Design team executes the following:

1. Investigate the historical background of the Army ROTC program in order to understand:
    a. The current ROTC program, its system composition and interactions, the major stakeholders in the system, and ultimately to begin to determine the value that the program is expected to deliver to each of the major stakeholders.
    b. The evolution and changes it has experienced since 1973 to become what it is today and the motivating objectives for changes.
    c. Estimate an initial problem statement for the client and explore how a systems approach might be able to suggest revisions and alterations to the program to enhance the value it delivers.
2. Conduct a face-to-face initial meeting with USAAC and CDT CMD representatives to:
    a. Increase project team understanding of the current challenges and potential dissatisfactions with the Army ROTC program.
    b. Refine the initial problem statement estimate
    c. Refine major and minor stakeholder list
    d. Begin to structure the scope of the problem that will be addressed during this capstone effort.
3. In the ensuing months, the team intends to apply the Systems Decision Process (SDP) in order to generate a set of feasible, attractive alternative design parameters for USAAC to consider.
4. A critical component for insuring that the overall effort results in a substantially valued result from the project team, client-team sharing of information must be an on-going process throughout the project.

Requirements:

Design team provides the following deliverables to the client in the form of a Report:

1. All items relevant within the Systems Decision Process and in accordance with the administrative requirements of SE402/3.
2. All proposed work items (to be discussed with client).

Project Deliverables and Tentative Due Date:

See attached calendar of events [you need to set a handful of milestones, as a minimum starting with the IPR's listed in the VTC schedule so that the client knows when these are set] .

Client and/or POC is expected to attend the final project outbrief in April 2007(location TBD). Additionally, both Client and POC will receive invitations to attend the USMA Capstone Conference in early May 2007.

A final project report is due to the Client no later than end of term, May 2007.

Project Advisors:

Prof. Patrick J. Driscoll, Ph.D., Department of Systems Engineering, United States Military Academy, West Point, NY 10996, patrick.driscoll@usma.edu, Ph: 845.938.6587 (DSN: 688), F: 845.938.5919 (DSN: 688);

LtCol Andrew P. Armacost, Associate Professor and Director of Operations Research, USAFA, CO 80840, Andy.Armacost@usafa.af.mil, Ph: 719.333.8476; and

Prof. Jim Lowe, Dept of Management, 2354 Fairchild Dr Suite 6H-242, USAFA, CO 80840, Jim.Lowe@usafa.af.mil, Ph: 719.333.3122.

Number of Cadets: Interdisciplinary Team:

Patrick DuBois, Systems Engineering major, USMA

Christopher Stoinoff, Operations Research major, USMA

Joshua Heacock, Systems Management major, USAFA

Timothy Balthazar, Systems Management major, USAFA

Supporting Laboratory Technician: None

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Evaluation of the Office of Force Transformation's Education for Transformation Initiative Program's Information Technology Capability Using a Systems Engineering Approach

Capstone Research Proposal No.: DSE-CR-0704

Client Organization: Office of Force Transformation

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
TBD	Office of Force Transformation		

Problem Description:

The perceived problem is that the current information technology (IT) system originally deployed by OFT to facilitate the networking of transformation chairpersons (TFXs), the community of interest (COI) they develop, and to diffuse / disseminate the knowledge (e.g. short courses, case studies, research papers, etc.) related to force transformation created by this practicing body, is inadequate to the task. Some of these inadequacies include:

- Archiving / data basing – There needs to be a means of archiving (data basing / cataloguing) the publications already generated and perhaps the current research underway, too. This information should be accessible to the community and in a format that is searchable. Currently, only a few of the case studies are available to the entire community and these are published on the OFT website. None of the research papers are available either on the website or through Groove.
- Groove – This commercial, off-the-shelf package has a great deal of capability built in. However, there are some issues such as:
    - Some of the transformation chairs institutions have not allowed the installation of Groove on their systems.
    - Similarly, others in the COI (or potential community) may not have access to Groove.
    - Files can be stored and accessed in a hierarchy of folders, but there (apparently) is no mechanism for performing searches (keyword, author, etc.).
- Participants – Similarly, it might be advantageous to be able to have a searchable data base of community practitioners that list information such as contact information and areas of interest, especially since one of the goals is collaboration.
- Distance Learning – Is the capability to deliver seminars and courses remotely desirable?

Proposed Work:

We propose to apply formal decision analysis as the problem is not only important but there are multiple stakeholders, some risks and capital investment.[10]

The researcher will lead a USMA Department of Systems Engineering (D/SE) year-long senior capstone team consisting of three to five cadets. The cadets will be composed of majors from within the departments of Systems Engineering and/or Mathematics, which may include Information Engineering, Systems Engineering, Systems Management, Engineering Management, and/or Operations Research. This senior capstone course in D/SE allows cadets an opportunity to work on a real research project for an external client / sponsor, within the DoD community.

The capstone team will utilize the Systems Decision Process (SDP).[11] The process will begin with the current system in place and culminate in a recommendation for an "optimal" system which includes a cost/benefit analysis. The recommendation(s) developed will be based on input from stakeholders (OFT leadership, transformation chairs, OFT strategists, and any additional stakeholders and decision makers identified). The SDP, which is an iterative process, entails four steps:

1. Problem definition,
2. Solution design,
3. Decision making, and
4. Solution implementation.

Requirements and Milestones: TBD

Project Deliverables and Due Date:

- Client IPRs: Dec. 2006, Feb. 2007
- Presentations and publications (minimum):
  - Presentation at USMA – D/SE Capstone Day May 2007
  - A final report to be presented to OFT and published in the Annual Report of the D/SE and the ORCEN.[12] May 2007

May also include a presentation at one of the following forums:

- Presentation at a section of the Decision Sciences Institute, e.g. Northeast Regional Conference, March 2007,
- Presentation at the IEEE Systems Information Engineering Design Symposium, University of Virginia, April 2007
- Presentation at the MORS Symposium, June 2007
- Presentation at the INFORMS Annual Meeting, November 2007

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[10] ***Systems Decision Making in Systems Engineering and Management***, Gregory S. Parnell, Patrick J. Driscoll, and Dale L. Henderson, Editors, Fall 2006 Edition, Printed by Wiley & Sons Inc., 2006.
[11] Ibid.
[12] Operations Research Center of Excellence.

Timelines:

- Sep – Dec 2006: Conduct a thorough stakeholder analysis, identify key issues, system functionalities, and develop a revised problem statement. Begin identifying alternative solutions.
- Jan – Mar 2007: Perform appropriate analysis of alternative solutions.
- Apr – May 2007: Complete analysis and final report. Prepare presentation.

Senior Investigator(s):

Timothy T. Elkins, Ph.D., Department of Systems Engineering, United States Military Academy, Bldg. 752 – Mahan Hall (Rm 422), West Point, NY 10996, Tel: 845.938.2707 (DSN: 688), Fax: 845.938.5919, timothy.elkins@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

□ **TRAINING – the Force**

Analysis of the Marketing System used to attract potential recruits

Research Proposal No.: DSE-R-0705

Client Organization: United States Army Accessions Command (USAAC), ATTN: ATZG-PA-HC21, Fort Monroe, VA 23651-6130

Points of Contact:

NAME	ADDRESS	PHONE	OTHER
COL Rocky Gay	Army Accessions Command	(502) 626-0556	RALPH.GAY@USAAC.ARMY.MIL
LTC Donna Dorminey	Center for Accessions Research	(502) 626-0556	DONNA.DORMINEY@US.ARMY.MIL
COL Donna Brazil	USMA BS&L	845.938.5031	DONNA.BRAZIL@USMA.ARMY.MIL
DR Don Snider	USMA Sociology	845.938.5797	DON.SNIDER@USMA.ARMY.MIL

Problem Description:

The United States Army Accessions Command (USAAC) is creating a new marketing system to communicate the values of Army service to the target recruiting population.

Recruiting is a vital aspect of maintaining the strength of the Army. Research indicates that in the year 2005, Army recruiting missed their mission for the first time in five years. The goal was to reach 80,000 Active Army soldiers and 22,175 Reserves; however, they both fell short by approximately 7,000 Active and 2,000 Reserves respectively. For year 2006, the United States Army Recruiting Command (USAREC) has met their goal thus far. Furthermore, by educating the youth market about the values of Army service it is our goal to inspire more youth to join the forces.

With the Army's current state, recruiting is a huge priority due to the existing conflict. It is likely the nation will continue to combat terrorism in the future and without the necessary manpower the Army will be unable to fight our nation's wars. Moreover, the youth market understands this and it might be barrier keeping them from joining the military. By communicating Army values, the nation's youth may gain a sense of pride and commitment to country.

Proposed Work:

This research project includes:

- A comprehensive Stakeholder Analysis which identifies the users, consumers, and customers to the system. The stakeholder analysis will also identify the functions, objectives, and constraints of the system.
- A review of the Center for Accessions Research's (CAR) attempts to expand the recruiting market. Such attempts include increasing the enlistment age, Army Values, and the Soldier's Creed. Review reasons why the Army is considered the last resort as a military career choice, and develop potential solutions for these problems.[13]

[13] 2004 Image Equity Study.

- Analysis of previous successful and unsuccessful marketing campaigns used by the Army. Analysis will include quantitative analysis of recruiting statistics for the Army along with the other Armed Services. Additionally, we will review the environmental, economic, social, and political factors with each respective study.
- A budget analysis of previous Army marketing campaigns. The analysis will look at the most successful method of advertisement, and a proposed budget for our marketing design.
- The creation of a new marketing system, which incorporates our research and analysis, and communicates the values of Army service to the target population.

Proposed Timeline:

Milestone	Date (On or About)
Complete Stakeholder Analysis	10 October 2006
Review and analysis of CAR data	15 November 2006
Analysis of previous marketing campaigns	8 December 2006
Budget analysis of previous marketing campaigns	1 February 2007
Creation of a new marketing system	15 March 2007
New marketing design complete	1 May 2007

Senior Analyst:

LTC John B. Halstead, Ph.D., Assistant Professor and Core Engineering Sequence Program Director, Department of Systems Engineering, United States Military Academy, West Point, NY 10996, 845.938.4752, John.Halstead@usma.army.mil.

Primary Analyst(s):

CDT Michael J. Martin, Analyst, USMA, Department of Systems Engineering, Michael.Martin@usma.army.mil

CDT Sean Grevious, Analyst, USMA, Department of Engineering Management, Sean.Grevious@usma.army.mil

CDT Casey Holland, Analyst, USMA, Department of Engineering Management, Casey.Holland@usma.army.mil

CDT Cory Sinning, Analyst, USMA, Department of Systems Engineering, Cory.Sinning@usma.army.mil

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- X **MANNING – the Force**
- □ **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Mini-Baja- Society of Automotive Engineers Mini-Baja Competition 2007

Capstone Research Proposal No.: DSE-CR-0706

Client Organization: Department of Civil and Mechanical Engineering, United States Military Academy

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
MAJ Wes Williamson	Department of Civil and Mechanical Engineering, United Stated Military Academy, West Point, NY 10996	845.938.4076	Wesley.Williamson@usma.edu

Problem Description:

Problem Description:

The USMA Mini-Baja Team 2007 must design and construct a single-seat vehicle for an off-road enthusiast to compete against mechanical engineering teams from across North and Central America in the areas of design, safety, top speed and acceleration, torque, handling and maneuver, steering and suspension, water maneuverability, and endurance.

Proposed Work:

The Engineering Management work provided by a cadet (with the help of a faculty mentor) in the Department of Systems Engineering is in the role of Project Manager for the team Specifically, the cadet with Assist with the planning, scheduling, resourcing, monitoring, controlling, terminating, and auditing of the project. This includes the development of a project action plan and all the required engineering management tools necessary to manage this project.

Project Deliverables and Due Date:

Registration for the competition is traditionally January (20007). Pre-competition at Camp Buckner is scheduled for the beginning of March 2007. Technical reports and cost reports are due several weeks prior to the competition and the competition traditionally occurs o/a the end of April. Project's Day (to include a poster presentation by the cadet) at United States Military Academy is 3 May 2007.

Interim IPRs: Several scheduled throughout the academic year.

Final Briefing: 3 May 2007.

Technical Report: 3 May 2007.

Research Thrust this Project Supports: This project supports equipping the force.

Senior Investigator(s):

MAJ Chad Jagmin, Instructor, Department of Systems Engineering, United States Military Academy, West Point, NY 10996, 845-688-2746, Chad.Jagmin@usma.edu.

Number of Cadets/Number of Design Teams Involved: 10 cadets.

- Cadet 1: CDT Thang Tran (DSE)
- Cadet 2-10: 9 cadets from DCME

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

X **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

□ **SUPPORTING – the Force**

□ **TRAINING – the Force**

Terrain Data Analysis and Visualization

Capstone Research Proposal No.: DSE-CR-0707

Client Organization: US Army Topographic Engineering Center

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Dave Lashlee	Engineering Research and Development Center (ERDC) Topographic Engineering Center (TEC) Fort Belvoir, VA	(703) 428-7133	J.David.Lashlee@erdc.usace.army.mil

Problem Description:

The US Army is developing Future Combat Systems as an integrated development effort with 18 different materiel systems, an integrated command and control environment, focused on the soldier. The integrated command and control system will have terrain data about the area of operations. However, raw terrain data is difficulty to manipulate, visualize, and use for command and control.

Proposed Work:

In order to address this problem, a cadet team from the United States Military Academy Department of Systems Engineering will investigate all aspects of this problem in order to provide insights about ways to enrich, summarize, and visualize this data in order to improve command and control. These methods may include calculated enrichments such as mobility and line of sight, or different visualizations that allow commanders to see aspects of the terrain not on military maps or conventional views. In addition, this team must provide this data with a realistic understanding of what could be collected in a potentially hostile foreign land.

Requirements and Milestones: TBD

- Problem Definition Complete – 09 October 2006
- Design and Analysis Complete – 25 March 2007
- Decision Making Complete – 19 April 2007
- Implementation Complete – June 2007

Project Deliverables and Due Date:

- Interim IPRs: IPR #1 11 September 2006
  IPR #2 09 October 2006
  IPR #3 16 November 2006
  IPR #4 06 February 2007
  IPR #5 25 March 2007
- Final Briefing: 19 April 2007
- Technical Report: 26 April 2007

Senior Investigator(s):

LTC Robert Kewley, Assistant Professor, Department of Systems Engineering, 845.938.5206, Robert.Kewley@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: John Melendez for the installation and management of necessary modeling software (TBD)

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 100 hours

Laboratory Technician Hours: 5 hours

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- X **TRAINING – the Force**

Integrated Base Defense

Capstone Research Proposal No.: DSE-CR-0708

Client Organization: Army Materiel Command

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Mike Jennings	Director Night Vision Labs/AMC Rapid Prototypes and Prototyping Division Fort Belvoir, VA	(703) 704-1032	Mike.Jennings@nvl.army.mil

Problem Description:

Currently, the US Army must provide base defense capabilities in a variety of locations in the United States and overseas. In many cases, particularly for combat support and combat service support bases in hostile environments, the troop requirements for base defense greatly reduce mission capabilities. One potential solution to the problem is to use a combination of existing military and commercial sensors as force multipliers. However, most base and installation commanders do not have the necessary technical training and expertise to employ and integrate the varied and ever-changing array of sensors.

Proposed Work:

In order to address this problem, a cadet team from the United States Military Academy Department of Systems Engineering will investigate all aspects of this problem in order to provide base commanders with useful guidance on the deployment and integration of these sensors in different tactical situations. This research will potentially allow commanders to provide higher levels of force protection with fewer troops.

Requirements and Milestones: TBD

- Problem Definition Complete – 10 October 2006
- Design and Analysis Complete – 26 March 2007
- Decision Making Complete – 20 April 2007
- Implementation Complete – June 2007

Project Deliverables and Due Date:

- Interim IPRs: IPR #1 12 September 2006
  IPR #2 10 October 2006
  IPR #3 17 November 2006
  IPR #4 7 February 2007
  IPR #5 26 March 2007
- Final Briefing: 20 April 2007
- Technical Report: 27 April 2007

Senior Investigator(s):

LTC Robert Kewley, Assistant Professor, Department of Systems Engineering, 845.938.5206, Robert.Kewley@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: John Melendez for the installation and management of necessary modeling software (TBD)

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 100 hours

Laboratory Technician Hours: 5 hours

DoD Research Thrust:

X EQUIPPING – the Force

X FIGHTING – the Force

X MANNING – the Force

X ORGANIZING – the Force

X SUPPORTING – the Force

X TRAINING – the Force

USMA Lean Six Sigma Dining Facility Research Project

Research Proposal No.: DSE-CR-0709

Client Organization: USMA Cadet Dining Facility

Points of Contacts and/or initial stakeholders:

NAME	ADDRESS	PHONE	OTHER
LTC John Zsido	USMA Lean Six Sigma Deployment Director Office of Policy, Planning, & Analysis West Point, New York 10996	845.938.5963 DSN 688-5963	john.zsido@usma.edu
Marion Voltaire	Food Planner, Logistics Support Services Organization 745 Washington Hall, Room 004 West Point, New York 10996	845.938.7365 Fax 845.938.3213	marion.voltaire@usma.edu
Jose E. Roman	Chief, Plans, Analysis, and Integration Office U.S. Army Garrison West Point, New York 10996	845.938.6948 DSN 688-6948	jose.roman3@us.army.mil
Kelli Kidd	USMA Dietician Washington Hall, 4th Floor, Room 4102 West Point, NY 10996	845.938.7519	kelli.kidd@usma.edu
Salvatore Mineo	Cook Supervisor, DOL West Point, NY 10996	845.938.4295	sal.mineo@usma.edu

Problem Description:

The cadet dining facility is required to feed a large quantity of cadets every day. The problem arises out of forecasting how many cadets will be present at each meal, in particular, optional meals. The difficulty in forecasting leads to inefficient use of resources. USMA is beginning its implementation of Lean Six Sigma in order to improve efficiency and effectiveness.

Proposed Work:

Provide an effective way to forecast cadets at meals; **Define** the Customer/s, their Critical to Quality (CTQ) issues, and the underlying processes within the scope of our problem definition; **Measure** the performance of the individual processes within the cadet dining facility; **Analyze** the historical and current data to determine the root causes of inefficiency in forecasting; **Improve** the process by increasing productivity and decreasing waste; creating means to better accurately forecast the amount of cadets; **Control** the process by supervising and implementing the improvements within the process.

Project Deliverables and Due Date:

- Interim Written Report due to Stat-A-Matrix: December, 2006.
- Interim Report to Process Owner: December, 2006.
- Final Briefing to Process Owner: TBD, 2007.
- Technical Report: TBD, 2007.

Research Thrust: this Project Supports the USCC

Faculty:

LTC Donna Korycinski, Ph.D., Assistant Professor, Department of Systems Engineering, USMA; 845.938.8788, Donna.Korycinski@usma.edu.

Cadets Involved:

- **Cadet 1:** DEVINE,PATRICK C
- **Cadet 2:** DOMINGUEZ,MAURICE P
- **Cadet 3:** FARRAR,WADE A
- **Cadet 4:** LEE,LEON
- **Cadet 5:** PRICE,DEREK E

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X SUPPORTING – the Force

□ **TRAINING – the Force**

Army Modularity Technology Integration

Capstone Research Proposal No.: DSE-CR-0710

Client Organization: Systems Engineering Program

Points of Contact:

NAME	ADDRESS	PHONE	OTHER
LTC Michael Kwinn	Department of Systems Engineering United States Military Academy West Point, New York 10996	845.938.5941 DSN 688-	michael.kwinn@usma.edu

Problem Description:

The Systems Engineering Program was founded in 1989. This program has changed little since its creation. The Systems Program has been ABET accredited and become a successful engineering program, however has only undergone minor evolutionary changes. Since the program is receiving a new Department head and is facing ABET re-accreditation, we feel that this is a great opportunity to complete a comprehensive review of the Systems Engineering Program. The Systems Program at West Point is only 1 of 11 System Engineering Centric Programs in the Nation. The Systems program is a relatively new engineering discipline and there are few benchmarks to measure the qualities of a successful project.

Proposed Work:

First we will analyze the program that is currently in place through the last ABET re-accreditation report that was conducted and a self study questionnaire. Next we will do a literature review of Systems Engineering education in other undergraduate institutions. Then we will create a stakeholder analysis using Systems Department faculty and the Board of Advisors which includes generals, respected engineers and former faculty. They will provide feedback on the strengths and weaknesses of the program as well as characteristics that make a successful program. The feedback and input we will receive from faculty and the Board of Advisors will be used to create a value hierarchy. This value hierarchy will help us screen for alternatives that are feasible and provide the most benefit to the program. Once we have determined our feasible solutions we will weight and score our alternatives to determine which of these should be implemented into the Systems Program. Once we have determined our proposed solution we will submit a comprehensive report of the changes we want to make.

Project Deliverables and Due Date:

Advisory Committee Presentation IPR: Oct 6, 2006.

Problem Definition IPR: Nov 6, 2006

Mid Project Report: Dec 5, 2006.

Comprehensive List of Possible Alternatives: Jan 31, 2007

Implementation and Decision Making: Mar 26, 2007

Final Report: April 19, 2007

Senior Investigator(s):

LTC Michael Kwinn, Ph.D., Associate Professor, Department of Systems Engineering, USMA, 845.938.5941; Michael.Kwinn@usma.edu

Number of Cadets/Number of Design Teams Involved: Scott Brown, Jeffrey Cho, Nathan Collier, and Nick Hill

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- X **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Falcon Wings

Research Proposal No.: DSE-CR-0711

Client Organization: Army Unmanned Aircraft Systems

Points of Contact:

NAME	ADDRESS	PHONE	OTHER
LTC Michael Kwinn	Academy Professor and Systems Engineering Program Director	DSN 688-5941 (845)938-5941	Michael.kwinn@usma.edu
Mr. James Charlton	Army Unmanned Aircraft Systems	Cell: (256) 426-2495	James.Charlton@us.army.mil

Problem Description:

Requests for better technology in the field of unmanned devices has greatly increased in modern day warfare. Soldiers have found that the ability to see around corners, knock down doors, and fire on the enemy without exposing themselves to be invaluable. Additionally, a unit that is disposable and can be operated by the average soldier without putting them in harms way is much desired. Currently, the Army has the technology of unmanned aerial vehicles that provide surveillance and eyes-on capabilities. However, these units are very expensive and require extensive training to operate. It is our job to develop a low-cost unit, whether aerial or ground operating, device that can allow the small unit (platoon or company) the capabilities listed above without putting soldiers in harm's way.

Proposed Work:

In order to solve this problem our team will conduct extensive background research investigating a broad range of backpackable, non-line of sight unmanned remote devices—both developed and undeveloped. We will also research and evaluate weapons that could be utilized in conjunction with such a device in order to achieve lethality. Using the principles of systems engineering we will develop an evaluation matrix that will allow us to determine alternatives which will best assist the ground commander. Some of the key variables we will be evaluating are: weight, size, usability, durability and lethality of the device.

Project Deliverables and Due Date:

Interim IPRs:

- Problem Definition IPR: MONDAY 30 OCT 2006
- Solution Implementation: IPR: MONDAY 4 DEC 2006

Final Briefing: Projects Day, 15 MAY 2006

Technical Report: Projects Day, 15 MAY 2006

Senior Investigator(s): LTC Michael Kwinn

Faculty Analyst(s): LTC Michael Kwinn

Number of Cadets/Number of Design Teams Involved:

Cadet Julia Carier

Cadet Earnest Smith

Cadet Andrew Wade

Cadet Paul Walker

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analysts: TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 20 hours

Laboratory Technician Hours: 6 hours

DoD Research Thrust: (check all that apply)

X **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

X **ORGANIZING – the Force**

□ **SUPPORTING – the Force**

□ **TRAINING – the Force**

Stability, Security, Transition, and Reconstruction Operations (SSTRO) Study

Capstone Research Proposal No.: DSE-CR-0712

Client Organization: G-3/5/7 DAMO-SS0

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Brenda Wyler	DAMO-SSO, Asst Dir for Warfighter Support, R&D Readiness XXI Team Lead	(202) 761-1850	Brenda.D.Wyler@hq02.usace.army.mil, Brenda.d.wyler@us.army.mil

Problem Description:

The Army needs the ability to assess and successfully reconstitute critical infrastructure/ essential services in a cost-effective manner in order to stabilize and reconstruct failed states and war-torn societies. In order to support this Army need, the DAMO-SSO is seeking a reliable tool to provide decision makers the ability to assess policy, investment options, and COAs that address critical infrastructure/ essential service needs – near and long term. Furthermore, this tool should be able to quantifiably assess a region's infrastructure status, while simultaneously accounting for environmental factors, in order to prioritize the allocation of infrastructure renewal assets.

Proposed Work:

1. Proper assessment of critical infrastructure/ essential services needs;
2. Optimization tools for allocating scare resources to priority efforts; and
3. Reliable methods to measure progress.

Requirements and Milestones: TBD

Project Deliverables and Due Date:

Interim IPRs: IPR 1: Oct/ Nov, IPR 2: Jan/ Feb, IPR 3: Mar 2007.

Final Briefing: Apr/May 2007.

Technical Report: May 2007.

Senior Investigator(s):

MAJ Travis J. (TJ) Lindberg, Instructor, Department of Systems Engineering, USMA, 845.938.4311; travis.lindberg@us.army.mil

Faculty Analyst(s):

Patrick Driscoll, Ph.D., Professor, Department of Systems Engineering, USMA, 845.938.6587; Patrick.Driscoll@usma.edu;

Niki C. Goerger, Ph.D., Assistant Professor and ERDC Liaison, USMA – Department of Systems Engineering, 845.938.3180, Niki.Goerger@usma.edu;

LTC Dale Henderson, Ph.D., Assistant Professor and Deputy Director, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.5529, (DSN: 688), Dale.Henderson@us.army.mil; and

MAJ Paul Evangelista, M.S., Instructor, Operations Research Center of Excellence, USMA - Department of Systems Engineering, 845.938.5661, (DSN: 688), Paul.Evangelista@us.army.mil.

Number of Cadets/Number of Design Teams Involved:

Cadet Design Team:

- Cadet 1: Brandon Corbin (EM)
- Cadet 2: Chris Haag (EM)
- Cadet 3: Chris Miorin (EM)
- Cadet 4: Erick Taylor (EM)

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

□ **TRAINING – the Force**

Automated Study Information System

Capstone Research Proposal No.: DSE-CR-0713

Client Organization: Studies & Analysis Division, Requirements Integration Directorate, Army Capabilities Integration Center (ARCIC), TRADOC

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
LTC Barry Ezell, Ph.D	Deputy, Studies & Analysis Division, Fort Monroe, VA	757.788.5802	barry.ezell@us.army.mil

Problem Description:

Provide a capability to analysts where they can go to a single site and enter a query and get a report that has went into an integrated repository (DoD, Industry, and Academia) to get a report of documents to answer their questions.

Proposed Work:

Develop a better system to manage current research and analysis projects, store complete reports, and develop a capability to search and retrieve useful data from DoD repositories, FFRDCs, and Academia.

Requirements and Milestones:

- TBD

Project Deliverables and Due Date:

- Interim IPRs: OCT/NOV, NOV/JAN 2006/7.
- Final Briefing: MAR, 2007.
- Technical Report: APR, 2007.

Senior Investigator(s):

LTC Kent M Miller, M. S., Assistant Professor, USMA – Department of Systems Engineering, 845.938.5578, Kent.Miller@usma.edu.

Faculty Analyst(s): N/A

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- □ **SUPPORTING – the Force**
- **X TRAINING – the Force**

Army Physical Fitness School Study

Capstone Research Proposal No.: DSE-CR-0714

Client Organization: Army Physical Fitness School

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Frank Palkoska	Director, USAPFS, Fort Benning, GA	706-545-4975	palkoskaf@benning.army.mil
Steve Van Camp	Chief of Doctrine and Training, USAPFS, Fort Benning, GA	706-545-4975	vancamps@benning.army.mil

Problem Description:

The Army Physical Fitness School is planning to begin staffing a successor to FM21-20 this November. This proposed doctrine advocates performance based physical fitness standards (e.g., the ability to evacuate a wounded soldier from the battlefield.) Performance based physical fitness standards will result in an increased emphasis on strength and movement techniques.

Proposed Work:

Given new physical fitness doctrine, the cadet capstone group will conduct a study to determine an appropriate, realistic, and replicable physical fitness assessment.

Requirements and Milestones:

- TBD

Project Deliverables and Due Date:

- Interim IPRs: OCT/NOV, NOV/JAN 2006/7.
- Final Briefing: MAR, 2007.
- Technical Report: APR, 2007.

Senior Investigator(s):

LTC Kent M Miller, M. S., Assistant Professor, USMA – Department of Systems Engineering, 845.938.5578, Kent.Miller@usma.edu.

Faculty Analyst(s): N/A

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- □ **TRAINING – the Force**

Capability Assessment of Hypersonic Weapons to defeat Rockets, Artillery, and Mortars

Capstone Research Proposal No.: DSE-CR-0715

Client Organization: Advanced Science & Technology Directorate, ARMDEC

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Robbie Roberson	Advanced Science & Technology Directorate AMRDEC Aviation and Missile RD&E Center ATTN: AMSRD-AMR-DB, Building 5400 Redstone Arsenal, AL 35898-5000	(256) 876-3660	Herman.Roberson@us.army.mil
Mr. Jim Jordan	U. S. Army PEO Missiles and Space Attention: SFAE-MSLS-O Building 5250 Martin Road Redstone Arsenal, AL 35898	(256) 313-3479	Jim.Jordan@msl.army.mil
Dr. Billy Walker	System Simulation Directorate US Army Aviation & Missile Command AMSRD-AMR-SS-ST Bldg 5400, Room E380 Redstone Arsenal, AL 35898	(256) 876-4329	bwalker@cfd.rdec.redstone.army.mil
Mr. Bob Walker	BAE Systems Analytical Solutions 310 Voyager Way Huntsville, AL 35806	(256) 864-2134	bob.walker4@baesystems.com

Problem Description:

The U.S. Army requires the capability to defeat rockets, artillery and mortars (RAM). The USMA Department of Systems Engineering will evaluate the potential capabilities of hypersonic weapons against RAM, assess the status of technologies critical to the use of hypersonic weapons, and examine the full range of issues relevant to the use of hypersonic weapons against RAM.

ARMDEC has proposed to develop a Counter Rockets, Artillery, Mortars System (CRAM) using hypersonic technologies. The proposed program is currently in the concept development phase. ARMDEC has completed some functional decomposition and some conceptual design work. In addition, they have developed some models and simulations to support concept analysis and design. The proposed work will leverage the work done by ARMDEC and their contractors.

Proposed Work:

The cadet capstone research project team will use the Department of Systems Engineering's Systems Decision Process to perform a technology assessment.

1. **Problem Definition.** Develop a definition of the CRAM capability assessment problem. Perform stakeholder analysis, operational functional analysis, and identify operational capability performance measures for capability assessment.
2. **Design Solutions.** Develop alternative CRAM system concepts and develop modeling and simulation capability to evaluate the concepts.
3. **Decision Making.** Provide a CRAM capability assessment concept evaluation decision brief to client.

4. **Solution Implementation.** Develop CRAM capability assessment implementation plan for ARMDEC.

The cadet capstone will provide a Technical Report documenting their research findings and recommendations. The report will be provided to the research sponsors in June 2007.

Senior Investigator and Primary Analyst:

Gregory S. Parnell, Ph.D., Professor of Systems Engineering, USMA – Department of Systems Engineering, 845.938.4374.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

X **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

□ **SUPPORTING – the Force**

□ **TRAINING – the Force**

Technology Assessment of Hypersonic Weapons to defeat Rockets, Artillery, and Mortars

Capstone Research Proposal No.: DSE-CR-0716

Client Organization: Advanced Science & Technology Directorate, ARMDEC

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Robbie Roberson	Advanced Science & Technology Directorate AMRDEC Aviation and Missile RD&E Center ATTN: AMSRD-AMR-DB, Building 5400 Redstone Arsenal, AL 35898-5000	(256) 876-3660	Herman.Roberson@us.army.mil
Mr. Jim Jordan	U. S. Army PEO Missiles and Space Attention: SFAE-MSLS-O Building 5250 Martin Road Redstone Arsenal, AL 35898	(256) 313-3479	Jim.Jordan@msl.army.mil
Dr. Billy Walker	System Simulation Directorate US Army Aviation & Missile Command AMSRD-AMR-SS-ST Bldg 5400, Room E380 Redstone Arsenal, AL 35898	(256) 876-4329	bwalker@cfd.rdec.redstone.army.mil
Mr. Bob Walker	BAE Systems Analytical Solutions 310 Voyager Way Huntsville, AL 35806	(256) 864-2134	bob.walker4@baesystems.com

Problem Description:

The U.S. Army requires the capability to defeat rockets, artillery and mortars (RAM). The USMA Department of Systems Engineering will evaluate the potential capabilities of hypersonic weapons against RAM, assess the status of technologies critical to the use of hypersonic weapons, and examine the full range of issues relevant to the use of hypersonic weapons against RAM.

ARMDEC has proposed to develop a Counter Rockets, Artillery, Mortars System (CRAM) using hypersonic technologies. The proposed program is currently in the concept development phase. ARMDEC has completed some functional decomposition and some conceptual design work. In addition, they have developed some models and simulations to support concept analysis and design. The proposed work will leverage the work done by ARMDEC and their contractors.

Proposed Work:

The cadet capstone research project team will use the Department of Systems Engineering's Systems Decision Process to perform a technology assessment.

1. **Problem Definition.** Develop a definition of the CRAM technology assessment of hypersonic weapons problem. Perform stakeholder analysis, functional analysis, and value modeling.
2. **Design Solutions.** Identify the key technologies for the CRAM system concepts. Develop a CRAM life cycle cost model. Develop a technology assessment methodology and apply the methodology to alternative CRAM system concepts.
3. **Decision Making.** Provide CRAM technology assessment decision brief to client.

4. **Solution Implementation.** Develop CRAM technology assessment implementation plan for ARMDEC.

The cadet capstone will provide a Technical Report documenting their research findings and recommendations. The report will be provided to the research sponsors in June 2007.

Senior Investigator and Primary Analyst:

Gregory S. Parnell, Ph.D., Professor of Systems Engineering, USMA – Department of Systems Engineering, 845.938.4374.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

X **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

□ **SUPPORTING – the Force**

□ **TRAINING – the Force**

Designing a System to Create a Lab Research and Development Space Object Catalog

Capstone Research Proposal No.: DSE-CR-0717

Client Organization: Maui High Performance Computing Center (MHPCC)

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
MAJ Thomas Rippert	Department of Systems Engineering Mahan Hall West Point, NY 10996	845-598-3194	Thomas.Rippert@usma.edu
Dr. Paul Schumacher	Deputy Director AFRL/DESM 535 E. Lipoa Pkwy, Suite 200 Kihei, HI 96753	(808) 879-5077 ext. 250	Paul.Schumacher@maui.afmc.af.mil
Dr. Francis Chun	AFRL/DESM 535 E. Lipoa Pkwy, Suite 200 Kihei, HI 96753		Francis.Chun@maui.afmc.af.mil
Betty Duncan	AFRL/DESM 535 E. Lipoa Pkwy, Suite 200 Kihei, HI 96753		Betty.Duncan@maui.afmc.af.mil

Problem Description:

The current situation is that a space catalog with approximately 13,000 satellites has been constructed and maintained by the Space Sensor Network (SSN). The Space Control Center (SCC) has maintained the space object catalog since 1957 when the first Sputnik satellite was launched. In the near future, new S-band radar systems will be added to the SSN. These S-band radars are more powerful than any of the optical telescope or radar systems currently in the SSN. This technological advancement will increase the number of observable objects orbiting the Earth from approximately 13,000 satellites to approximately 100,000 satellites

The problem we are faced with is updating the current space object catalog from its current state of 13,000 objects to the 100,000 objects that the new S-band radars will detect. This increase is comparable to building a catalog from scratch. A problem also exists in dealing with this large number of UCTs. Tracking the 90,000 new objects by hand and identifying them as a UCT will be too daunting of a task for a few individuals to handle. The lag in the process of correlating tracks for UCTs is problematic in the current system.

Proposed Work:

From its current state the, the values hierarchy needs to be developed and flushed out. The current hierarchy needs to be changed after more interviews and input from subject matter experts. In the process of refining the hierarchy, the team needs to develop weights and an objective function for solution scoring. Next, after potentially more contact with experts and previous work, the team will develop utility curves to best fit the evaluation criteria. During this time, alternatives will be generated upon discussion with experts and various evaluation measures of the values hierarchy. These alternatives will be simulated on the SSNAM at the MHPCC and then evaluated using the solution scoring potential of the values hierarchy. If there is time the most promising alternatives will be tested on the lab research and development telescopes at the center. There is likely to be little or no implementation of this project on the active system due to the limitations on testing and experimenting with the active system. For the

duration of this project, the team will produce a tech report at the end of each semester and a final project at the conclusion of the spring semester. Additionally reports and presentations will be completed as necessary for any meetings or feedback to the stakeholders.

Requirements and Milestones: TBD

Project Deliverables and Due Date:
The deliverables to the client at the end of this project will be the best scoring alternative system or at least a framework on how to continue the alternative generation process for another organization to finish after the end of this academic year.

Space Object Catalog Requirements Analysis

- Technical Report 1 Due: 6 December 2006
- Technical Report 2 Due: 9 May 2007
- Final Project Briefing: 11 May 2007

Senior Investigator(s):

MAJ Thomas Rippert, Department of Systems Engineering, Mahan Hall, West Point, NY 10996, 845.938.2510, Thomas.Rippert@usma.edu.

Faculty Analyst(s): N/A

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

X **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

X **ORGANIZING – the Force**

X **SUPPORTING – the Force**

□ **TRAINING – the Force**

Casualty Assistance Officer Improvement Project

Research Proposal No.: DSE-CR-0718

Client Organization: Army Casualty and Memorial Affairs

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
LTC Robert J. Amico	Army Casualty and Memorial Affairs (HRC) Washington, DC 20310-0200	(703) 325-0070 (DSN: 221)	bob.amico@hoffman.army.mil

Problem Description:

Research for potential improvements in the Army's casualty assistance system, given the three fundamental stakeholders: Casualty Assistance Officer (CAO), Casualty and Memorial Affairs Operations Center (CMAOC), and regional Casualty Assistance Centers (CACs). The problem to address is how to provide better service for the family. Given the current Global War on Terrorism, many constraints are put on the three stakeholders within these constraints they are tasked with providing the best service possible to family members. Lack of training for the CAOs and regional CACs and lack of a chain of command relationship with CMAOC, a main stakeholder, are two primary concerns. Additionally this research will address the flexibility of this system. For instance, when a conflict ends, the task load placed upon CMAOC and the CACs may require the system to reduce in numbers but maintain the capability to expand when necessary. Historically, knowledge and expertise gained during periods of conflict is lost. Development of a standardized set of training and principles for regional CACs could minimize this loss of information. This research will be focused on improving the service that a CAO can provide to a grieving family; ultimately, the family is the main benefactor in the casualty assistance process.

Proposed Work:

Initially, the research team will focus on gathering information, conducting background searches on various documents in relation to the Casualty Notification and Assistance Process. The team will not solely focus on just the Army's Casualty Assistance Process, but will also become knowledgeable on the other service branches assistance process'; this could lead the group to possible directions or methods to solve the problem of better service for the family, while improving efficiency amongst the stakeholders. The team will use the Systems Design Process to define the problem.

While conducting stakeholder analysis in Alexandria, Virginia at CMAOC the team identified three primary stakeholders. Previous research focused on the CAO; this team will focus on the regional CACs and CMAOC. A goal of this research is to determine the productivity of the relationship between regional CACs and the

CMAOC to include the CAC responsible for operations in Iraq and Afghanistan (located in Kuait). Upon visiting the CAC in Kuwait The team would conduct stakeholder analysis, similar to what was done at CMAOC, in the form of surveys, focus groups, and interviews. Since there is a direct link between CMAOC and the CAC in Kuwait, this would complete the team's understanding of the difficulties the two organizations might have in working with each other.

In the second half of the first semester, the group will submit a literature review detailing the casualty assistance process. The purpose of this is not only to get all group members up to speed on all issues relating to casualties, but also to possible introduce new avenues from which to propose solutions to. The overall goal is to provide the best service possible for the family. The ultimately the team will develop a recommendation regarding organizational change that will best provide service for the families, while decreasing redundancies in CMAOC and CACs.

Requirements and Milestones: TBD

Project Deliverables and Due Date:

- Interim IPRs: One per semester, expected dates: October, 2006 & March 2007.
- Final Briefing: Due date, May, 2007.
- Final Report: Due date, May, 2007.

Senior Investigator(s):

LTC Brian Sperling, Ph. D., Assistant Professor, USMA – Department of Systems Engineering, 845.938.4399, Brian.Sperling@usma.edu.

Faculty Analyst(s):

LTC Dale Henderson, Ph.D., Assistant Professor and Deputy Director, Operations Research Center of Excellence, USMA – Department of Systems Engineering, 845.938.5529, (DSN: 688), Dale.Henderson@us.army.mil; and

MAJ Ernest Wong, M.S., M.A., Assistant Professor, USMA, Department of Systems Engineering, 845.938.4756, ernest.wong@usma.edu.

Number of Cadets/Number of Design Teams Involved: 4 cadet design team

Supporting Laboratory Technician: TBD

Resources Required for Project: TBD

Research Hours Required (by position):

Senior Investigator(s): 180

Principal Analyst: TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

x **ORGANIZING – the Force**

x **SUPPORTING – the Force**

□ **TRAINING – the Force**

Tactical C2 Data Requirements

Capstone Research Proposal No.: DSE-CR-0719

Client Organization: US Army Topographic Engineering Center

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Dave Lashlee	Engineering Research and Development Center (ERDC) Topographic Engineering Center (TEC) Fort Belvoir, VA	(703) 428-7133	J.David.Lashlee@erdc.usace.army.mil

Problem Description:

The US Army is developing Future Combat Systems as an integrated development effort with 18 different materiel systems, an integrated command and control environment, focused on the soldier. In order to test the effectiveness of this system, the command and control architecture must be tested in an exercise. This command and control system requires a variety of data sets with information on terrain, incidents and events, capabilities, and enemy forces. The requirements for this data must be specified in detailed form with an understanding of the capabilities to provide the data to the users.

Proposed Work:

In order to address this problem, a cadet team from the United States Military Academy Department of Systems Engineering will investigate all aspects of this problem in order to provide insights about the critical data requirements to ensure success of battle command systems for tactical forces, to include those employing Future Combat Systems.

Requirements and Milestones: TBD

- Problem Definition Complete – 09 October 2006
- Design and Analysis Complete – 25 March 2007
- Decision Making Complete – 19 April 2007
- Implementation Complete – June 2007

Project Deliverables and Due Date:

- Interim IPRs: IPR #1 11 September 2006
  IPR #2 09 October 2006
  IPR #3 16 November 2006
  IPR #4 06 February 2007
  IPR #5 25 March 2007
- Final Briefing: 19 April 2007
- Technical Report: 26 April 2007

Senior Investigator(s):

LTC Robert Kewley, USMA – Department of Systems Engineering, 845.938.5206, Robert.Kewley@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician: John Melendez for the installation and management of necessary modeling software (TBD)

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 100 hours

Laboratory Technician Hours: 5 hours

DoD Research Thrust:

- □ **EQUIPPING – the Force**
- □ **FIGHTING – the Force**
- □ **MANNING – the Force**
- □ **ORGANIZING – the Force**
- X **SUPPORTING – the Force**
- X **TRAINING – the Force**

Solid State Heat Capacity Laser Operational Concept

Capstone Research Proposal No.: DSE-CR-0720

Client Organization: Lawrence Livermore National Laboratory

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Mr. Dave Lashlee	Engineering Research and Development Center (ERDC) Topographic Engineering Center (TEC) Fort Belvoir, VA	(703) 428-7133	J.David.Lashlee@erdc.usace.army.mil

Problem Description:

The diode-pumped Solid-State Heat-Capacity Laser (SSHCL) became operational at Lawrence Livermore National Laboratory (LLNL) in 2002, with each subsequent year seeing added enhancements and refinements of the laser system based upon an increased technical understanding and advances in manufacturing techniques. The SSHCL has shown that solid-state laser technology can produce significant amounts of laser output power in a very small volumetric footprint, via an extremely simple and straightforward architecture. High-powered diode arrays used as the laser pump source, an intra-cavity adaptive optics system utilizing deformable mirror technology to correct wave front errors, and lithium-ion batteries as the primary source of power are all examples of advanced technologies that have been integrated into a complete SSHCL system with demonstrated performance and steady-state operation. In addition, the recent installation of a new type of laser gain media, ceramic Neodymium Yttrium Aluminum Garnet (Nd:YAG), into the system has provided both improved performance and a clear pathway of scalability to higher power levels. These advances require some initial development of an operational concept for employment of this laser in a counter-IED and countermine role. This concept should also address the ethical implications of the use of lasers on the battlefield.

Proposed Work:

In order to address this problem, a multidisciplinary cadet team from the United States Military Academy Departments of Systems Engineering, Physics, Civil and Mechanical Engineering, and History will investigate all aspects of this problem in order to provide insights about ways to employ this laser in a counter-IED and countermine role. These insights will guide development of the capability to speed development or required capabilities for operational employment.

Requirements and Milestones: TBD

- Problem Definition Complete – 9 October 2006
- Design and Analysis Complete – 25 March 2007
- Decision Making Complete – 19 April 2007
- Implementation Complete – June 2007

Project Deliverables and Due Date:

- Interim IPRs: IPR #1 11 September 2006

IPR #2 09 October 2006

IPR #3 16 November 2006

IPR #4 06 February 2007

IPR #5 25 March 2007

- Final Briefing: 19 April 2007
- Technical Report: 26 April 2007

Senior Investigator(s):

LTC John Hartke, USMA – Department of Physics, 845.938.5810, John.Hartke@usma.edu.

Supporting Researchers:

LTC Robert Kewley, USMA – Department of Systems Engineering, 845.938.5206, Robert.Kewley@usma.edu; and

LTC Mike Rounds – USMA Department of Civil and Mechanical Engineering, 845.938.2665, Mike.Rounds@usma.edu.

Number of Cadets/Number of Design Teams Involved: Cadet Design Team

Supporting Laboratory Technician:

John Melendez for the installation and management of necessary modeling software (TBD). Maxim Serebrennik for training and support in software and visualization.

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 160 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: 100 hours

Laboratory Technician Hours: 20 hours

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

X **TRAINING – the Force**

Dynamic Natural Attributes (DNA) for Synthetic Military Forces

Capstone Research Proposal No.: DSE-CR-0721

Client Organization: Department of Systems Engineering, USMA

Points of Contact (Client):

NAME	ADDRESS	PHONE	OTHER
Dr. Paul West	MH 309, Department of Systems Engineering, West Point	938-5871	

Problem Description:

Computer Generated Force (CGF) entities in Army combat simulations are created with identical personal attributes. However, in real life no two people are exactly the same or behave in exactly the same manner. Today's constructive Army combat simulations are critical tools for soldier training and system development, yet they have limited focus on human behavioral factors and their impact on the system. The integration of "soft" human factors such as leadership and morale will bridge the "human" gap between actual and synthetic environments and increase the overall fidelity of the host simulation.

Proposed Work:

The EM402 G18 Group will research, develop, model, and test soft human behaviors in a simulation environment and assess their effects on soldier operations. Specifically, G18 will:

- Identify key factors of human behavior relevant to soldier operations.
- Construct a model of the identified factors and their interrelationships.
- Develop measures for assessing the effects of the model.
- Implement the model in simulation.
- Develop test and use case scenarios.
- Develop and execute an experimental design for the model.
- Analyze the main and interaction effects of relevant factors.
- Publish findings.

Requirements and Milestones:

- Problem definition complete, 27 October 2006
- Interim report complete, 8 December 2006
- Design and analysis complete, 26 January 2007
- Implementation plan complete, 26 April 2007
- Projects Day presentation, 3 May 2007
- Technical report complete, 11 May 2007

Project Deliverables and Due Date:

- Interim Report, 8 December 2006
- Final Report, 11 May 2007

Senior Investigator(s):

Dr. Paul West, Assistant Professor, DSE, 845.938.5871, Paul.West@usma.edu

Number of Cadets/Number of Design Teams Involved:

CDT DJ Edwards

CDT Nick Grodevant

CDT Phil Lee

CDT James Peralta

2LT Romain Osmont, St. Cyr visiting cadet (through December 2006)

Supporting Laboratory Technician: TBD

Resources Required for Project*:*

Research Hours Required (by position)

Senior Investigator(s): 180 hours

Principal Analyst: TBD

Faculty Analyst(s): TBD

Total Cadet Time: Approximately 1400 hours

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

DoD Research Thrust:

□ **EQUIPPING – the Force**

□ **FIGHTING – the Force**

□ **MANNING – the Force**

□ **ORGANIZING – the Force**

X **SUPPORTING – the Force**

X **TRAINING – the Force**

Client Organization: National Aeronautical Space Administration (NASA)

Research Proposal No.: DSE-CR-0722

Points of Contacts and/or initial stakeholders:

NAME	ADDRESS	PHONE	OTHER
Jon Paterson	NASA Marshall Space Flight Center EV43 Huntsville, AL 35812	(256) 961-4870	Jon.paterson@nasa.gov
Tom Bryan	NASA Marshall Space Flight Center EV43 Huntsville, AL 35812		
Don Krupp	NASA Marshall Space Flight Center EV03 Huntsville, AL 35812		

Problem Description:

NASA's Lunar Landers have experienced difficulty detecting ground hazards as a result of dust and debris being displaced by lunar thrusters just prior to landing. An automated hazard avoidance system would help future missions in space by allowing the astronauts to see objects that could jeopardize the mission and endanger the crew.

President George W. Bush's guidance for U.S. space exploration helped to motivate NASA to develop the following six major goals:

1. Fly the Shuttle as safely as possible until its retirement, not later than 2010
2. Complete the International Space Station in a manner consistent with NASA's International Partner commitments and needs of human exploration
3. Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration
4. Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement
5. Encourage the pursuit of appropriate partnerships with the emerging commercial space sector
6. Establish a lunar return program having the maximum possible utility for later missions to Mars and other destinations

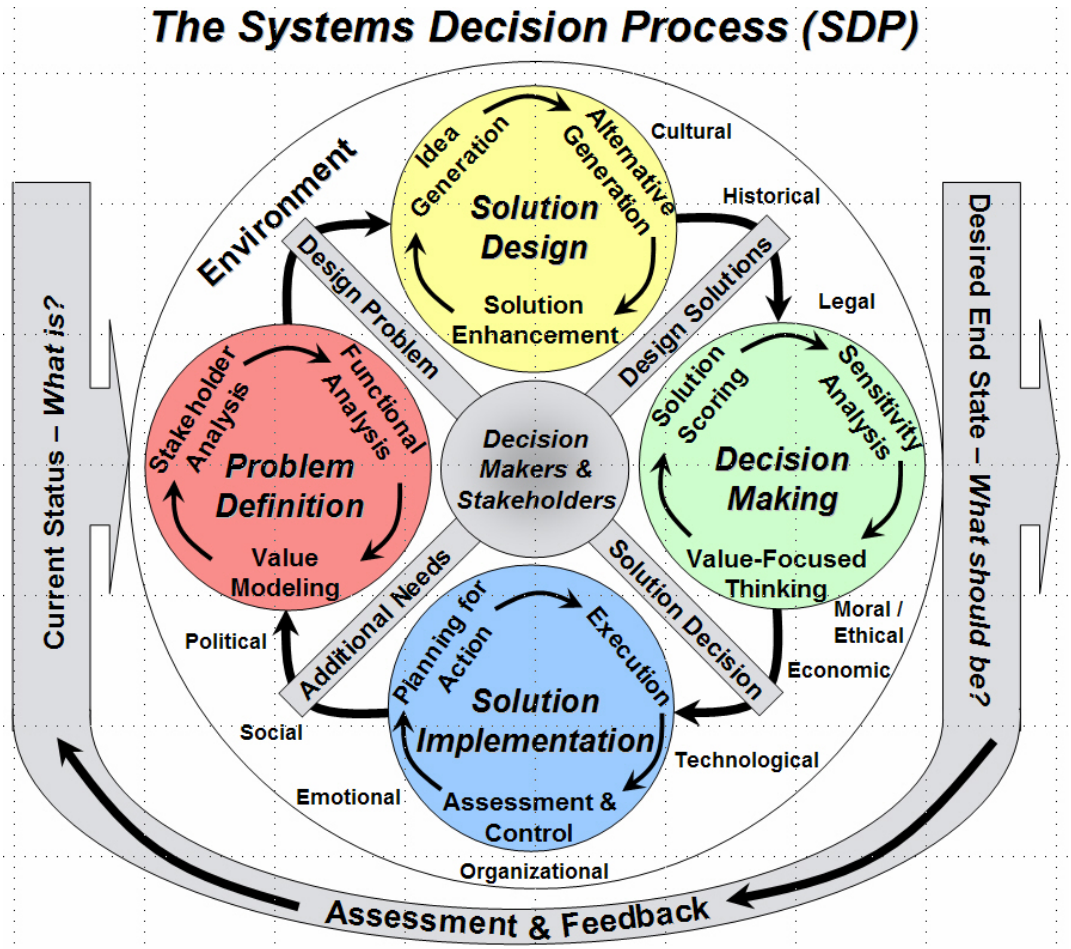
Our initial research into the problem we are looking at for our Capstone project align best with goals #3 and #6 highlighted above.

http://www.nasa.gov/mission_pages/exploration/main/index.html

Proposed Work:

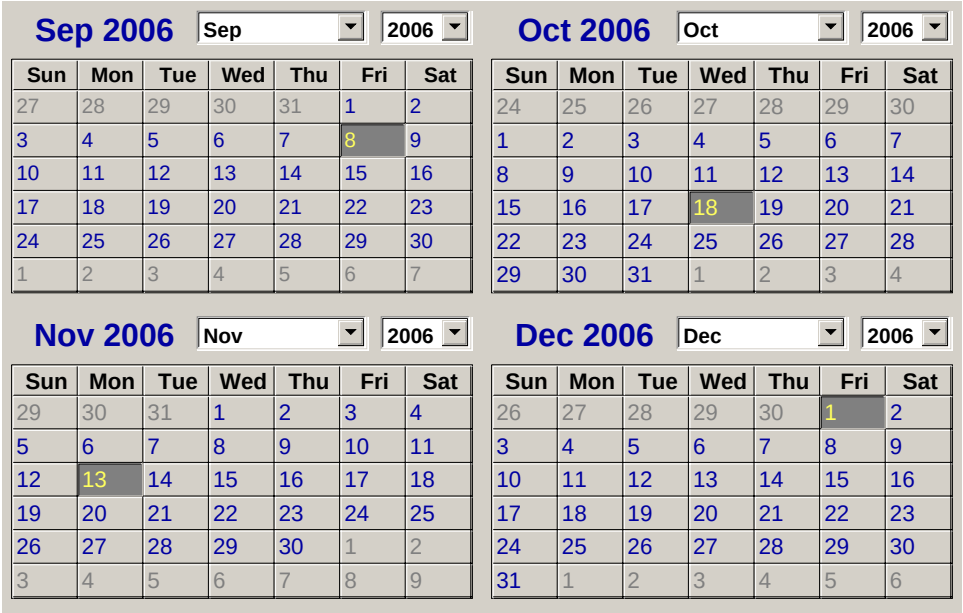
We propose that we work to analyze a system that uses sensors to create an avoidance detection system. This system would help future NASA missions by making landings on foreign planets and satellites safer for those aboard, whether they are humans or machines. Our skills include the ability to break down a system into a functional hierarchy, evaluate a system with a time value of money approach, conduct modeling using various computer programs, and other skills learned over two years of studying systems and engineering management.

Because of our team's diverse background and varying areas of expertise, we plan to employ the Systems Decision Process (SDP) to help ensure we all have a common understanding of the problem we were attempting to solve. The SDP is a process that provides for a structured problem solving process useful in the design of multidisciplinary, large-scale, and complex engineering problems. The SDP will not only help us to better scope the problem we were working on, it also helps us in making sure that our progress on the project is aligned properly with NASA's intent. In short, the SDP will help us bridge the gap between where we are and where we want to be.



Phase I of the project will focus on the first two phases of the SDP—the Problem Definition and Solution Design. Once our team has completed an in-depth stakeholder analysis with key NASA engineers, correctly refined the initial problem statement, and properly identified the scope of our work, we plan to proceed with Phase II of the project—developing analytical models that help NASA design, develop, build, and integrate sensors on board Lunar Landers so that NASA's efforts directed at return of manned missions to the moon and beyond are consistent with its strategic plan.

Phase I Project Deliverables:



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10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Meet w/Sponsor (Video-conference/teleconference): Early SEP 06

Adjust Problem Statement: Late SEP 06

Meet w/Sponsor (Trip): 18 OCT 06

Interim IPR—Project Scope: 13 NOV 06

Finalized Statement of Work: Early DEC 06

Phase II Project Deliverables:

Meet w/Sponsor (Video-conference/teleconference): Late JAN 07

Analytical Models in Support of Project Scope: Late FEB 07

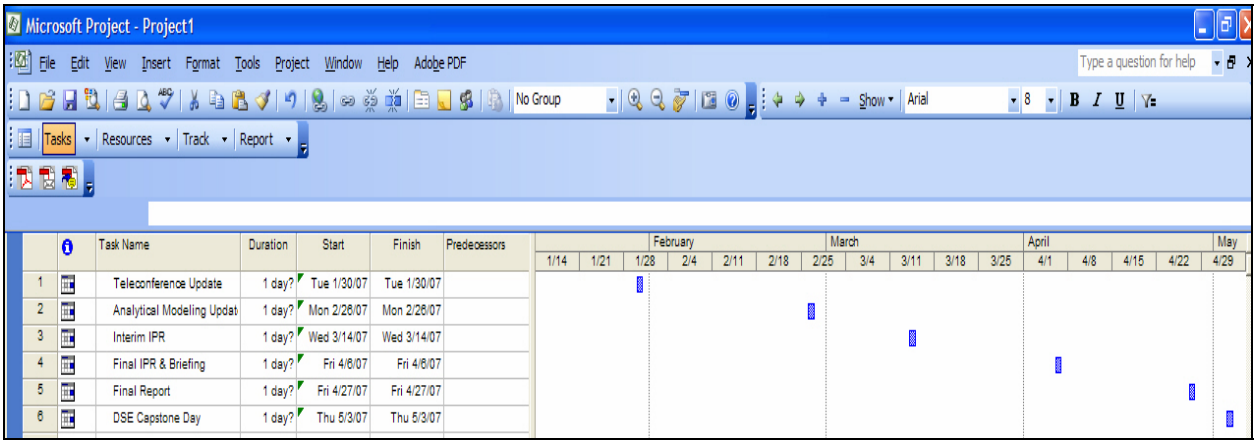
Interim IPR: Early MAR 07

Meet w/Sponsor, Final IPR, and Briefing: Early APR 07

Final Report: Mid APR 07

Potential Conference Briefing (MORS Education Symposium, UVA): Late APR 07

DSE Capstone Project Day: 3 MAY 07



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Research Thrust this Project Supports:

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5a. CONTRACT NUMBER

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6. AUTHOR(S)
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14. ABSTRACT
The purpose of this document is to formally present the research program of the *U.S. Military Academy Department of Systems Engineering (DSE) and the Operations Research Center for Excellence (ORCEN)* for the Academic Year 06-07. The research plan includes a statement of purpose for research which supports DSE and the ORCEN, a description of the two organizations, a list of the key personnel responsible for executing the plan, and an overview of the annual research cycle.

15. SUBJECT TERMS

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