## Session Schedules and Abstracts

<table>
<thead>
<tr>
<th>CEU Courses</th>
<th>27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorials</td>
<td>28</td>
</tr>
<tr>
<td>Special Sessions</td>
<td>33</td>
</tr>
<tr>
<td>Demonstrations</td>
<td>38</td>
</tr>
<tr>
<td>Posters</td>
<td>41</td>
</tr>
<tr>
<td>CG A Homeland and International Operations</td>
<td>43</td>
</tr>
<tr>
<td>CG B C4ISR and Net-Centric Operations</td>
<td>44</td>
</tr>
<tr>
<td>CG D Resource/Readiness/Training</td>
<td>47</td>
</tr>
<tr>
<td>CG E Acquisition</td>
<td>48</td>
</tr>
<tr>
<td>CG F Interdisciplinary Advances in OR</td>
<td>50</td>
</tr>
<tr>
<td>CG G Hybrid Warfare</td>
<td>52</td>
</tr>
<tr>
<td>DWG 1 – Human Behavior and Performance</td>
<td>53</td>
</tr>
<tr>
<td>DWG 2 – Unmanned Systems</td>
<td>55</td>
</tr>
<tr>
<td>WG 1 Strategic Operations National Security Analysis</td>
<td>57</td>
</tr>
<tr>
<td>WG 2 Chemical, Biological, Radiological, Nuclear, and Advanced Explosives (CBRNE) Defense</td>
<td>62</td>
</tr>
<tr>
<td>WG 3 Infrastructure Analyses, Protection and Recovery</td>
<td>64</td>
</tr>
<tr>
<td>WG 4 Homeland Security, Homeland Defense and Civil Support</td>
<td>68</td>
</tr>
<tr>
<td>WG 5 Information and Cyber Operations</td>
<td>73</td>
</tr>
<tr>
<td>WG 6 Battle Management Command and Control (BMC2)</td>
<td>78</td>
</tr>
<tr>
<td>WG 7 ISR and Intelligence</td>
<td>81</td>
</tr>
<tr>
<td>WG 8 Space Acquisition, Testing and Operations</td>
<td>88</td>
</tr>
<tr>
<td>WG 9 Air and Missile Defense</td>
<td>93</td>
</tr>
<tr>
<td>WG 10 Joint Campaign Analysis</td>
<td>98</td>
</tr>
<tr>
<td>WG 11 Land and Expeditionary Warfare</td>
<td>104</td>
</tr>
<tr>
<td>WG 12 Maritime Operations</td>
<td>109</td>
</tr>
<tr>
<td>WG 13 Power Projection and Strike</td>
<td>111</td>
</tr>
<tr>
<td>WG 14 Air Warfare</td>
<td>114</td>
</tr>
<tr>
<td>WG 15 Casualty Estimation and Force Health Protection</td>
<td>118</td>
</tr>
<tr>
<td>WG 16 Strategic Deployment and Distribution</td>
<td>124</td>
</tr>
<tr>
<td>WG 17 Logistics, Reliability and Maintainability</td>
<td>127</td>
</tr>
<tr>
<td>WG 18 Manpower and Personnel</td>
<td>139</td>
</tr>
<tr>
<td>WG 19 Readiness</td>
<td>146</td>
</tr>
<tr>
<td>WG 20 Analytic Support to Training and Education</td>
<td>151</td>
</tr>
<tr>
<td>WG 21 Operational Energy</td>
<td>156</td>
</tr>
<tr>
<td>WG 22 Experimentation</td>
<td>162</td>
</tr>
<tr>
<td>WG 23 Measures of Merit</td>
<td>165</td>
</tr>
<tr>
<td>WG 24 Test and Evaluation (T&amp;E)</td>
<td>170</td>
</tr>
<tr>
<td>WG 25 Analysis of Alternatives (AoA)</td>
<td>176</td>
</tr>
<tr>
<td>WG 26 Cost Analysis</td>
<td>182</td>
</tr>
<tr>
<td>WG 27 Decision Analysis</td>
<td>188</td>
</tr>
<tr>
<td>WG 28 Modeling and Simulation</td>
<td>194</td>
</tr>
<tr>
<td>WG 29 Computational Advances in OR</td>
<td>217</td>
</tr>
<tr>
<td>WG 30 Wargaming</td>
<td>222</td>
</tr>
<tr>
<td>WG 31 Operational Environments</td>
<td>228</td>
</tr>
<tr>
<td>WG 32 Special Operations and Irregular Warfare</td>
<td>234</td>
</tr>
<tr>
<td>WG 33 Social Science Methods and Applications</td>
<td>240</td>
</tr>
</tbody>
</table>
## CEU Courses

<table>
<thead>
<tr>
<th>Group</th>
<th>Day &amp; Time</th>
<th>Location</th>
<th>Author/Presenter</th>
<th>Co-Author(s)</th>
<th>Classification</th>
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<tbody>
<tr>
<td>CEU Course</td>
<td>22 Jun 08:30 - 17:00</td>
<td>DoD - 10</td>
<td>Mr. Mark L Axtell</td>
<td>Mr. Dan C. Caudill Mr. Jeffrey Alton Dubois</td>
<td>UNCLASSIFIED</td>
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<td></td>
<td>23 Jun 10:00 – 12:00</td>
<td>Hilton - Birch</td>
<td></td>
<td>Mr. Michael W. Garrambone Bret Givens Mr. Michael S. Goodman Mr. Thomas C. Hughes Mr. Evan P Rolek</td>
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<tr>
<td>13321 - Introduction to Analysis for Practitioners</td>
<td>An introductory course for young analysts from civilian or military schools that have just joined an analytical defense firm or have recently joined federal service. Designed for junior analysts with one to five years of experience who have not been exposed to the fundamentals of analytical studies or have limited project experience. A 10-hour 1.0 CEU practical applications course taught by MORS senior analysts to prepare new analysts with the knowledge, skills, and study savvy to perform as solid members of analytical teams.</td>
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<td>Group</td>
<td>Day &amp; Time</td>
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<td>Co-Author(s)</td>
<td>Classification</td>
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<td>CEU Course</td>
<td>22 Jun 08:30 - 17:00</td>
<td>DoD - 2</td>
<td>Dr. Darryl Ahner</td>
<td>Mr. Frank Campanile Mr. Dan C. Caudill Ms. Kristi Greenwell Mr. Thomas C. Hughes Mr. Chris R. Linhardt Mr. Evan P Rolek Julie A. Seton, Ph.D.</td>
<td>UNCLASSIFIED</td>
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<td>23 Jun 10:00 – 12:00</td>
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<td>13320 - Introduction to Analysis for Study Leaders</td>
<td>An introductory course for new study leaders and program managers who are building analytical teams. Designed for analysts with three to ten years of experience who have been selected to lead analytical studies. A 1.0 CEU (10-hours) practical applications course taught by MORS senior analysts, project leaders, and program managers that will prepare new leaders to negotiate the hurdles of time-sensitive, limited-resourced effectiveness and cost conscious studies.</td>
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<td>CEU Course</td>
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<td>DoD - 18</td>
<td>Mr. Michael W. Garrambone</td>
<td>Mr. Mark L Axtell Mr. Dan C. Caudill Bret Givens Dr. Deborah Grismer Mr. Michael A. Ottenberg Mr. Robert Pollick Mrs. Lee Ann Rutledge Julie A. Seton, Ph.D. Mr. Scott D. Simpkins</td>
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<td>23 Jun 10:00 – 12:00</td>
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<td>13319 - Wargaming and Technology</td>
<td>An introductory course for individuals who want to learn about wargaming as an operations research tool for analysis with an additional slant on technology. Designed for students with backgrounds in science, technology, engineering, or mathematics who have not had a formal course in wargaming, but have been tapped for leadership positions or are designated to attend games, or make use of wargame information. A 1.0 CEU (10-hours) practical applications course taught by MORS senior analysts, wargame experts, research scientists, engineers, and technical program managers that will prepare individuals to use wargames to examines processes, elicit novel ideas, experience adaptive conflict, underst</td>
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## Tutorials

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<tr>
<td>Tutorial</td>
<td>22 Jun 08:30 - 12:00</td>
<td>DoD - Auditorium</td>
<td>Mr. Dennis R. Baer, FS</td>
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<td>UNCLASSIFIED</td>
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### 11560 - Introduction to Cost Estimating Course (Part I)

This four hour course will cover the first two phases (initiation and research, and assessment), which consists of seven of the 12 steps. This includes the initial setup of the cost estimate through developing the point estimate. Attendees will also develop an understanding of how this cost estimation process fits into the overall Operations Research process. Although emphasis will be on Life Cycle Cost Estimation, instruction will also include other study efforts in the acquisition process such as Analysis of Alternatives (AoAs), Business Case Analysis (BCAs), etc. The MORS Introduction to Cost Estimation Course was developed for all individuals involved in any cost estimating role. The student will understand how to define the estimate purpose, develop an estimate plan, define a program and determine the estimate structure, identify ground rules and assumptions, obtain data, normalize it, and analyze it, and develop the point estimate.

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<th>Co-Author(s)</th>
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<td>Tutorial</td>
<td>22 Jun 12:00 - 13:00</td>
<td>DoD - 13</td>
<td>Mr. Michael W. Garrambone</td>
<td>Mr. Michael W. Garrambone Ms. Tara A. Garrambone</td>
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### 12552 - Introduction to the Drive on Metz Wargame - Monday

This tutorial is designed for novices who are interested in wargaming or players getting ready to participate in the succeeding Symposium’s Drive on Metz (DoM) wargame. It provides basic understanding about military wargaming from the context of DoM, a special wargame designed for teaching by the master, Mr. James F. Dunnigan. While Jim’s classic board game provides a special opportunity to quickly become an active wargame participant or knowledgeable observer, it is important to first understand the basics of the game in order to follow the game play or contribute to analyzing the action. In this tutorial, students will learn to be US Corps-level co-commanders facing opposing German co-commanders applying their strategies and tactics similar to those opponents who historically clashed in the Lorraine Region of France during September 1944.

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<tr>
<td>Tutorial</td>
<td>22 Jun 13:00 - 14:00</td>
<td>DoD - 4</td>
<td>Dr. Thomas A. Donnelly</td>
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### 11604 - Building Better Models Using Robust Data Mining Methods

Through case studies, you'll learn to build better and more robust models with advanced predictive modeling techniques. Featured methods will include many types of regression, neural networks, and decision trees. Most importantly you will learn to partition your data into training, validation (tuning) and test subsets to prevent over fitting. And, you'll see how to use comparison techniques to find the best predictive model. This tutorial is for analysts, scientists, engineers and researchers interested in learning how predictive modeling can help them use the data they have today to better predict tomorrow.

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</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>22 Jun 13:00 - 15:00</td>
<td>DoD - 17</td>
<td>Dr. David S Alberts</td>
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### 11070 - C2 Agility: Related Hypotheses and Experimental Findings

This presentation summaries the body of work related to C2 Agility Theory and related experimentation and analysis. Internationally developed definitions of Agility, C2 Approach, and C2 Agility are provided along with associated quantitative measures that have been employed in experiments. Hypotheses suggested by the previous work related to Network Enabled Capability are presented and the extent to which these are supported by experimental results and case studies are discussed. Finally, C2 Agility is viewed in the context of multi-genre network experimentation.
**12544 - Certified Analytics Professional (CAP®) Refresher—Preparing for the Exam**

There is a clear and present need to identify and retain the analytic services of professionals who have the knowledge, experience, and discipline to lead data analytics projects. The Institute for Operations Research and the Management Sciences (INFORMS) has designed a Certified Analytics Professional (CAP®) that aligns with MORS' disciplined approach to excellence in Operations Research. The CAP® reflects important elements of MORS' analytic method and other best practices. During the 83rd Symposium, MORS will partner with INFORMS to provide the DoD and its partners with an opportunity to be among early adopters by taking the INFORMS CAP® in rooms adjacent to the symposium and at a discounted rate. Begin with independent review of the Candidate Handbook & Study Guide (https://www.informs.org/Certification-Continuing-Ed/Analytics-Certification/Candidate-Handbook).

Enhance the chance for success by attending this half-day "CAP® Refresher—Preparing for the Exam" Session during the MORS Symposium. A panel of MORS members who are successful CAP® credential holders will provide coaching and their perspectives on best practices for preparing for the CAP®. A review of 24 sample questions and their answers will provide you with great insight on what the exam entails.

Earning the CAP helps you to: advance your career potential by setting you apart from the competition; drives personal satisfaction of accomplishing a key career milestone; improves your overall job performance by stressing continuing professional development; boost your salary potential by being viewed as experienced analytics professional; demonstrate your commitment to the field; and prove to stakeholders that your organization follows industry-standard analytics practice.

**11557 - Developments in Establishing a "Big A" Affordability Analysis Capability – A Familiarization and an Overview**

In 2009 Congress passed the Weapon System Acquisition Reform Act (WSARA) which demanded more fidelity and rigor in affordability analysis. The MORS Affordability Analysis Community of Practice (AA CoP) was formed to continue the research from the October 2012 workshop and develop a “how to” manual for affordability analysis. This MORS Course was developed for all individuals involved in any affordability analysis. The student will learn about the history of MORS and Affordability Analysis, differences between cost analysis & affordability analysis, the value of conducting a full affordability analysis, other community best practices and lessons learned, and an overarching process for conducting “Big A” affordability analysis with 6 modules on:

- Introduction to Affordability Analysis
- Requirements & Needs Activity
- Baseline & Gap Assessments Activity
- Alternative Analyses & Valuation Assessments Activity
- Trade-Off Analysis & Evaluation Activity
- Summary of conducting “Big A” affordability analysis

**12182 - Foundations of Data Visualization**

The design of visual displays is a key step in presenting numerical information for analysis or decision support in military planning activities. Ideally, data displays take advantage of the characteristics of human visual/cognitive systems. They also respect their limitations. In this tutorial, we provide an overview of the characteristics of human visual cognition, and illustrate how to apply these principles to the design of data displays. We draw material from several fields of study, including Cognitive Psychology, Visual Analytics, Scientific Visualization, Exploratory Data Analysis, and Statistics.

We begin with a survey of the field, and then illustrate some of the common data analysis traps that an analyst can avoid through good data visualization. Next, we review the physiology, operative characteristics and limitations of human visual/cognitive systems, paying particular attention to their effect on good data visualization design. Building on this foundation, we illustrate the pros and cons of various methods for visualizing patterns in and compiling high-level information about data sets of different types. These include single-variable, time-series, bi-variable and multi-variable structures.
### 11606 - Using Definitive Screening Designs to Get More Information from Fewer Trials

This tutorial is for testers interested in learning to use the new Definitive Screening Design (DSD) method of Design of Experiments. DSDs not only efficiently identify important factors but can often support second-order predictive models. For the same number of factors three-level DSDs are often smaller than popularly used 2-level fractional-factorial (FF) designs yet yield more information especially about curvature for each factor. DSDs when first published in 2011 worked only with continuous factors. Subsequent publications in 2013 and 2015 added support for categorical factors with two levels and blocking factors. When the number of significant factors is small, a DSD can collapse into a 'one-shot' design capable of supporting a response-surface model with which to make accurate predictions. A case study will be shown in which a 10-factor process was optimized in just 24 trials. Checkpoint trials at the predicted optimum show the process yield increased substantially. In cases where too many factors are significant and the design can't collapse into a one-shot design, existing trials can economically be augmented to support a response-surface model in the important factors. Comparisons between DSDs and FF designs will show DSDs yield more information in fewer trials.

### 12283 - Strategies for Analyzing Modern Screening Design of Experiments

The new Definitive Screening Designs (DSD) provide clean estimates of all main effects and squared effects for the design factors. This leads to saturated or nearly saturated models and the potential to falsely identify lower power squared terms as important. Effective strategies for analyzing these designs are reviewed to build a consensus model from the data. In this tutorial we examine several strategies for analyzing DOE data sets. We start with graphical exploration of the data using interactive distributions and scatterplots. With an idea of what factors are visually dominant we move on to conservative modeling approaches such as looking at first order effects before moving on to second order effects - including interactions - guided by "effect heredity" and "effect sparsity" principles. Finally aggressive strategies are used which include stepwise regression using several different stopping criteria to prevent over fitting and even fitting "All Possible Models." Actual vs. Prediction plots with checkpoints can be used to help choose models. The use of transformations to help make the data better match the assumption that they are normally distributed will also be demonstrated.

### 12280 - Efficient Modeling & Simulation Using Design of Experiments Methods

This tutorial will show how Design of Experiments (DOE) methods can be used to extract the most useful information from the smallest number of computer simulation runs. By sequentially running blocks of simulations, computer experimenters can conduct the overall fewest trials necessary to do sensitivity analysis of the factors being studied without over-utilizing high performance computing resources. The greatest benefit occurs when fast-running (seconds) surrogate model can be developed for long-running (hours, days or weeks) simulations.

The fast surrogate model enables testers and analysts to interactively query the modeled process to find optimal operating conditions or the frontiers of the acceptable operating window. These conditions of high interest can then be run using the full simulation to both validate the surrogate model as well as increase the accuracy of prediction. Design solutions demonstrated will include the application of traditional DOE methods to discrete event and agent-based simulations, and modern space-filling designs to more complex physics-based simulations such as Computational Fluid Dynamics (CFD). When to use, and how to choose among traditional linear regression approximation methods and spatial regression interpolation methods will be discussed. The effective practice of using checkpoint simulations for determining the accuracy of surrogate model predictions will be demonstrated.
12185 - A Tutorial on Design of Experiments for Simulation Modeling

Simulation models often have many input factors, and determining which ones have a significant impact on performance measures (responses) of interest can be a difficult task. The common approach of changing one factor at a time is statistically inefficient and, more importantly, is very often just incorrect, because for many models factors interact to impact on the responses. In this tutorial we present an introduction to design of experiments specifically for simulation modeling, whose major goal is to determine the important factors with the least amount of simulating. We discuss classical experimental designs such as full factorial, fractional factorial, and central composite followed by a presentation on Latin hypercube designs, which are designed for the complex, nonlinear responses typically associated with simulation models.

This is a two-hour tutorial for Monday, June 22, 2015.

11490 - Practical Statistics Review

Abstract

This short review is designed as half hour refresher course for operations research analysts who regularly use statistical analysis in the workplace.

Whether you are a seasoned analyst or new to the defense industry fresh from college, you may find yourself wondering about the correct interpretation of a particular numerical analysis, or how to convey the meaning of your analysis to a senior leader who is not familiar with statistics.

The review will discuss:
1. How to “smell” the data and identify the outliers
2. The quick way to get desired sample size, confidence interval, and probability based on the means, standard deviation, and Z score
3. Steps for a successful hypothesis test in three scenarios
4. The correlation strength rule of thumb
5. Experimental measures: reliability versus validity
6. Different levels of measurement based on three types of data: nominal, ordinal, and interval (e.g. when to use the χ2 test)
7. Quick tips for using SPSS

12399 - The Nine Questions of ORSA Research

The Nine Questions of ORSA Research

During this 83rd MORS symposium, you will sit through many presentations made by very capable individuals. They will educate, enlighten and entertain you, regarding the substantive areas of research they have chosen, the metrics they have selected and quantitative tools they have used to answer questions that will help senior level decision makers make better decisions. But what is the framework of these research studies? What are the logical elements that contribute to the research process that allows an individual or a group of individuals to work on a research project and try to find a reasonable solution?

Dr. Kenneth Lewis will frame the entire ORSA process by posing his nine basic questions that, if followed and answered, will add practical and significant meaning to the ORSA process.
**11748 - A Tutorial: “A Methodology for Determining the Impact of Cyber Attacks on Tactical Mission Threads”**

The Services have become increasingly dependent on their tactical networks for mission command functions, situational awareness and in some cases for kinetic target engagements (i.e. terminal weapon guidance). While the network brings an unprecedented ability to project force by all echelons in a mission context, it also brings the increased risk of cyber-attack on the mission operation. With both this network use and vulnerability in mind, it is necessary to test and analyze the effectiveness of new systems (and networked Systems of Systems (SoS)) in a cyber-vulnerable tactical network context.

A new technology, StealthNet, has been created by the DOD Test Resources Management Center (TRMC) to support the analysis of the impact of cyber-attacks against mission threads. StealthNet is a simulation based virtual environment that can provide a representation of a full scale tactical network deployment (both Radio Frequency (RF) segments as well as the wired networks at command posts). In addition to representing the tactical network architecture, and key mission message traffic, the system also models the cyber vulnerabilities of patched/unpatched operating systems on computer hosts supporting the command and control of the tactical mission.

This tutorial will present a methodology using StealthNet for determining cyber-attack effectiveness as they are launched to disrupt and destroy tactical missions. Measures of Effectiveness representing mission delay and the disruption of key mission information will be investigated. Using StealthNet, methods for collecting these measures will highlighted. Finally two Use Cases demonstrating the cyber impact on both an Army and a Navy mission thread will be presented.

**11789 - Analytic Wargaming: Introduction, Roles, and Best and Worst Practices**

As the demand for wargaming grows, it is clear that the skills needed to design, develop, conduct, and analyze wargames are not well known, or if known, not well implemented. There are still many “wargames” being conducted that are little more than BOGGSATs (bunch of guys and gals sitting around a table), as evidenced by the lack of useful wargaming results from many of DoD’s higher level wargaming events. This presentation provides an overview of analytic wargaming, including best and worst practices, and outlines how wargaming is used in combination with computer-based combat modeling to conduct studies such as Analyses of Alternatives and Campaign Analysis.

**12210 - Discrete-Event, Agent-Based, and System Dynamics Simulation and When to Use Each**

In this tutorial we discuss and contrast discrete-event simulation, agent-based simulation, and system dynamics. Typical applications and the best commercial software for each type of simulation will also be given. The talk concludes with live demonstrations of several interesting simulation models.

**12194 - OptDef: A Simulation Optimization and Analysis Tool**

OptDef is a wrapper for simulation models that provides a suite of optimization, analysis, and graphing tools. OptDef is a government rights tool that is the culmination of multiple SBIR projects. OptDef has been integrated with the DoD simulation models EADSIM, I-Sim, KIDD, G6, and C2BMC Planner as well as the commercial simulation tool ExtendSim. Its architecture allows integration with additional tools with limited effort. OptDef allows an analyst to define multiple simulation parameters as decision variables and then apply one or more constraints and objectives. OptDef supports single or multi-objective optimization and is driven by the COTS library OptQuest which uses metaheuristic search methods to drive iterative simulation runs with different parameter combinations. After the completion of the search, the tool automatically applies different statistical and data mining techniques to provide insight into the influence of the variables on the objectives and to identify good and bad regions of the tradespace. Design of experiments and batch simulation runs are also supported.

This tutorial will provide an overview of the OptDef tool and some of the optimization and analysis techniques embedded in the tool. The tutorial will cover the basics of setting up and running OptDef with EADSIM, and will describe how to interpret various analysis products provided by the tool including the results of regression analysis and classification trees. Practical examples will be presented to demonstrate how the tool can be used to answer questions and provide insights for a number of common DoD simulation analysis tasks.
### Special Sessions

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<th>Group</th>
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<th>Location</th>
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<th>Classification</th>
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<tr>
<td>Special Session</td>
<td>22 Jun 13:00 - 17:00</td>
<td>IDA - 6701</td>
<td>Joseph F Adams</td>
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<td>SECRET</td>
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<tr>
<td>12228 - Rist Prize Competition</td>
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<td>Rist Prize competition presentations.</td>
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<td>12596 - A Comprehensive and Theoretically Sound Method for Assessing and Managing Risk</td>
<td>23 Jun 15:30 - 17:00</td>
<td>DoD - Auditorium</td>
<td>Dr. Ernest Forman</td>
<td></td>
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<td>A framework and methodology for risk management, including risk identification, risk assessment, and risk treatment/mitigation/response will be presented. The process includes the derivation of ratio scale measures of the likelihood and impact of risk events, effectiveness of controls to reduce risks, and the allocation of resources to reduce risk.</td>
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<tr>
<td>14217 - Academy Papers</td>
<td>23 Jun 15:30 - 17:00</td>
<td>DoD - 4</td>
<td>Joseph F Adams</td>
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<td>This session offers this year’s prize-winning projects from the DoD Service Academies. The winners of USMA’s Hollis Award, USAFA’s Capstone Award, and USNA’s Best Paper Award will present their work.</td>
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<tr>
<td>12575 - Deployed Analyst Special Session</td>
<td>23 Jun 15:30 - 17:00</td>
<td>DoD - 18</td>
<td>Dr. Adam Shilling</td>
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<td>MORs hosts a question and answer session with analysts recently returned from deployment abroad. They will answer your questions, in an unclassified setting, about their deployments concerning analysis, assessment, living conditions, and professional development opportunities. Analysts who are considering deployment, leaders of deployed analysts, reminiscing about their own deployments or curious about life downrange are invited to pose a question or just listen.</td>
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<td>12589 - Heritage Special Session - 50 Years Ago - Analysts in Vietnam</td>
<td>23 Jun 15:30 - 17:00</td>
<td>Hilton - Plaza I</td>
<td>Mr. E. B. Vandiver, III, FS</td>
<td>Mr. Eugene P. Visco, FS</td>
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<td></td>
<td>A Deployed Analyst in Vietnam E. B. Vandiver III, FS The deployment of American forces to Vietnam began in early 1965, and by the summer of that year, the flow was becoming a flood. Major combat operations were fully underway by the fall. Then Secretary of Defense Robert S. McNamara directed the Army to conduct an evaluation of combat operations to refine organization, doctrine, and equipment for this kind of war in this new environment. The tasking cascaded down the chain eventually landing in the U. S. Army Combat Development Command, its supporting analysis contractor the Combat Operations Research Group (CORG), and some of the Army’s most junior of junior analysts, including the author. This talk describes the Army Combat Operations in Vietnam (ARCOV) Study, conducted in Vietnam in 1966. MACOV: A Vietnam Adventure Following in the Footsteps of E. B. Vandiver Gene Visco, FS A year later, the CDC chartered a follow-on in-country study of armored combat operations; the designation was MACOV for Mechanized and Armored Combat Operations, Vietnam. ARCOV made a number of recommendations to modify the tactical units’ formations; essentially all recommendations were accepted by the Army Chief of Staff. A year later, none of the MACOV recommendations were accepted! The story is not simply the fact that E. B. Vandiver’s participation on ARCOV was more effective than Gene Visco’s participation (as leader of the civilian analysts assigned to MACOV). The story is more complex.</td>
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### Group: Special Session

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<tr>
<td>23 Jun 15:30 - 17:00</td>
<td>Hilton – Plaza C</td>
<td>Dr. Igor Linkov</td>
<td>Prof. David L. Alderson Ms. Nicole Sikula</td>
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#### 12642 - Resilience and Risk: Problems and Solutions for Mission Assurance

As the military relies more upon integrated cyber-physical systems, the importance of the security of these systems increases. Yet as new safeguards are developed and implemented, adversaries continue to develop novel ways to breach and disrupt critical infrastructure and threaten mission assurance. Significant advances in the field of risk assessment have addressed issues such as these; however, risk-based solutions tend to focus on assessing and hardening individual components of complex systems under specific threat scenarios. In today’s world, unknown, novel or unpredictable threats are common. With the realization of our inability to predict threats, significant interest has developed in resilience-based management, which focuses on the ability of a system to prepare, plan for, absorb, recover from, and more successfully adapt to adverse events. Resilience thus uses strategies of adaptation and mitigation to augment traditional risk management. The panel will focus on the needs for resilience-based management and ways in which military commanders could enhance operational resilience. Methods and tools that are able to reconcile conflicting information, as well as the complex context of the decision making environment, will be discussed.

### Group: Special Session

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<tr>
<td>23 Jun 15:30 - 17:00</td>
<td>DoD - 2</td>
<td>Michael Harman</td>
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#### 11780 - T&E Special Session

Fiscal challenges will continue to threaten both the tangible and intellectual resources available for test and evaluation. As education is a flexible and adaptable force multiplier, the panel of DoD T&E leaders will describe and discuss plans for workforce development to support systems of the future to include increased rigor in testing, reliability assessments, cybersecurity, increased integration of modeling and simulation, and system-of-systems testing.

### Group: Special Session

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<td>23 Jun 19:00 - 21:00</td>
<td>Hilton - Beech B</td>
<td>Mr. Michael W. Garrambone</td>
<td>Mr. Michael W. Garrambone Ms. Tara A. Garrambone</td>
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#### 12554 - Wargame Drive on Metz

Military Wargaming is a tool of Operations Research that has risen in rank for its ability to look at the more complicated non-quantifiable thorny OR problems. It has become highly useful because it provides insights into operations and processes that cannot be touched by other OR techniques. It is through wargaming that we discover technological innovations, underlying blind spots, and novel strategies and tactics. Most importantly, it is during the dynamics of games that outstanding questions springing forth which require much traditional follow-on analytical work. Students of the game and Monday and Tuesday tutorial attendees will be participating in this two hour evening special event which will be observed by analyst collecting data during the actual wargame. The Drive on Metz (DoM) wargame will consist of US Corps-level co-commanders facing opposing German co-commanders applying their strategies and tactics similar to those opponents who historically clashed in the Lorraine Region of France during September 1944. The game itself will be personnel and time-limited, because it tends to be “too” interesting. So, if you are new to wargaming, looking to patch holes in your background or experience, you will greatly enjoy and learn from this short tutorial on DoM.

### Group: Special Session

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<td>Hilton - Beech A</td>
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#### 14566 - INFROMS CAP Exam

INFORMS Cap Exam requires preregistration with INFORMS.
## Growth through Professional Development and Continuing Education

### 14215 - Navy Special Session

Within the staff of the Chief of Naval Operations, the Assessment Division (N81) acts as the single headquarters' analytic organization for implementation of Navy's Corporate Analytic Agenda, as well as DoD and Joint Staff's Analytic Agenda. N81 conducts studies and analysis across a wide spectrum to assist in development of investment plans and programs that deliver combat-ready naval forces in support of Navy and Joint mission requirements. Analyses range from force structure, campaign, and warfare mission-level analysis to maritime security, irregular warfare, afloat and ashore readiness, manpower and training. In addition, N81 evaluates and prioritizes warfighting and warfighting support capability gaps and programs. Finally, N81 manages the Chief of Naval Operations' World Class Models Initiative, a modeling and simulation improvement program designed to enhance the current toolset, identify gaps and develop new methodologies across the analytical spectrum.

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<td>Special Session</td>
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<td>Mr. Charles P. Werchado</td>
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### 12593 - Army Sponsor Special Session

Wargaming has recently emerged as an area of concern for the Deputy Secretary of Defense. According to his guidance, published 9 February 2015, his goal is to reinvigorate, institutionalize, and systematize wargaming across the Department of Defense. The new wargaming program will focus on near-, mid-, and long-term horizons. The purposes of wargames include enhancing current concepts of operation and helping expose problems and solutions applicable in both the near- and mid-term, including the development of innovative operational and logistical approaches. The results will inform portfolio-rebalancing exercises, competitive strategy path games, and senior leader decision-making.

The Center for Army Analysis is an Army leader in operational wargaming. They have the expertise and experience to provide analysis through tabletop wargaming, Table Top Exercises, and modeling to support Combatant Commands, Operational Joint Commands, the Army Staff, and others. Current and previous wargame support includes operational plan development and synchronization tabletop wargames for USPACOM, USPACFLT, USSOCAPAC, as well as a number of tabletop wargames for generating Army positions on Strategic Studies and Analysis Outyear scenario development. This presentation looks at the requirement for wargaming course of action feasibility prior to conducting modeling using theater campaign simulations.

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<td>Dr. David Knudson</td>
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### 14770 - A Pair of Daunting Risk Analysis Challenges

Two very thorny risk analysis issues persist within the national security community: 1) How do we model a threat that is constantly changing, and doing so rapidly? and, 2) How do we validate risk models for rare-event scenarios, and especially scenarios in which events have never happened? Spanning both questions, the fundamental challenge is decision analysis in situations which involve adversaries or threats about which very little is known.

Some of the threats we face are "familiar;" e.g., battlefield combatants, pandemic disease, drug trafficking. Some threats are considered "emerging;" e.g., global terrorism, network attack, regional nuclear powers. Other threats might be considered "unknown" or "yet to emerge," in the sense that we can imagine them, but they have not yet transpired; e.g., nuclear strike or EMP attack, homegrown terrorism, cyber terrorism. As we progress from familiar to emerging to unknown, the pool of available risk methods and models rapidly diminishes.

In two distinct but connected talks, Dr. Lathrop and Dr. Ezell describe the nature of the problem and describe the state of the art with respect to risk analysis involving adaptive adversaries. This includes identifying all of the critical uncertainties and incorporating them into our analysis; e.g., Who are the adversaries? What capabilities and resources are available to those adversaries? What do these adversaries know? What do these adversaries think they know? The analytic challenges are just as intimidating as identifying the threats: How do we model activities that are generally not known? How do we aggregate predictions from multiple models? How do we validate methods and models in situations completely lacking data? What computational methods or applications are available to assist the analyst?

Bottom Line: The aim is to help analysts identify appropriate and credible representations of the likelihood and consequence for these ill-defined evolving threats in order that they might provide the best decision support possible.

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<td>24 Jun 15:30 - 17:00</td>
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<td>Dr. Stephen R. Riese</td>
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**12603 - Education Special Session**

This session consists of presenters from educational institutions sharing recent initiatives and challenges through short presentations followed by a panel discussion on current educational and training needs throughout DoD.

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<td>24 Jun 15:30 - 17:00</td>
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<td>Dr. Darryl Ahner</td>
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**12376 - ODNI Special Session**

Operations Research in Support of the Intelligence Community (ODNI Special Session)

For the fifth year, the Office of the Director of National Intelligence will hold a special session on Operations Research in Support of the Intelligence Community (IC). The Associate Director of National Intelligence for Systems & Resources Analysis (ADNI/SRA) was established with the principal responsibility to inform IC resource allocation decisions through combined technical, system, cost, and program analyses that consider balanced alternatives through a multi-year lens.

ADNI/SRA organizes MORS sessions to showcase operations research activities used for major IC decisions. The objective of this special session is to expose current work by the operations research arm of the ODNI and research with or by other IC partners. The session will address three recent studies:

Alerting and Warning Major Issue Study
An assessment of strategic and anticipatory intelligence efforts across the IC with proposed alternatives to provide timely notification to policy makers of upcoming threats and opportunities.

Measuring Effectiveness of C-IED Airborne ISR platforms With the Score
An examination of Counter-Improvised Explosive Device airborne platform performance using a novel "FI metric" to score effectiveness.

Improving ISR persistence (on the IC side of the Budget)
Support to intelligence missions increasingly challenge the IC to monitor activity for longer periods of time. Recently, the IC has looked at a number of alternatives to improve in this area. The presentation will address how we quantified persistence, what comparisons we have made, and discuss the value trades that are driving future investments.

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<tr>
<td>Special Session</td>
<td>24 Jun 15:30 - 17:00</td>
<td>IDA Bldg 4900 Room 720</td>
<td>Mr John C. Cole</td>
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**12227 - Prize Paper Rist**

This session is for the Rist Prize winners to present their paper at the symposium.

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<tr>
<td>Special Session</td>
<td>24 Jun 16:00 - 16:30</td>
<td>IDA - 6701</td>
<td>Joseph F Adams</td>
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**12083 - Session Concept: Are Wargames Quasi Experiments?**

Wargames are both criticized and celebrated for a lack of analytical rigor. Critics argue that compared with other operations research methods, wargames are inefficient and do not produce valid results for warfighting decisions. Proponents argue that when applied to warfare, other modeling and simulation methods not only do not produce valid results, they provide policy makers with a dangerously false sense of certainty about an inherently uncertain decision making environment. Yet few wargamers are fully satisfied that we are consistently achieving our design objectives. This 90-minute session will explore the potential for extending approaches in quasi-experimental design to wargame design. The session will include the following components:

1. A brief introduction to the session and an overview of quasi-experimental design concepts, focusing on validity issues (15 minutes). A short technical paper will be provided for background for panel participants and attendees
2. A moderated panel discussion with 2 experienced wargame designers and an experienced operations modeling and simulation specialist that addresses the following questions (45 minutes):
   a. Is it useful to think about wargames as quasi-experiments?
   b. What are the challenges to internal validity in wargame design? External validity?
   c. What can we do to address validity issues in wargame design?
3. Group discussion: Attendees and panelists (25 minutes)
4. Wrap up (5 minutes)
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<tr>
<td>Special Session</td>
<td>24 Jun 15:30 - 17:00</td>
<td>DoD - 14</td>
<td>Mr. Gregory Giles</td>
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**14214 - The Iranian Nuclear Negotiations: State of Play and the Road Ahead**

On April 2, 2015, the “P5+1” powers (i.e., the United States, the United Kingdom, France, Germany, Russia, and China) and Iran announced that they had reached an agreement on a framework for a comprehensive resolution of the controversy surrounding the Iranian nuclear program. The announcement marked a culmination of diplomatic efforts dating back to 2003. A number of diplomatic, informational, military, and economic factors aligned to enable such a breakthrough. But the deal is not sealed. It faces vocal critics here and in Tehran, and it is not clear if the remaining issues can be agreed by the July 1, 2015 deadline. This presentation will review the origins of the Iranian nuclear dispute, what the negotiators have agreed to, what they hope to do next, and the prospects for acceptance in Washington and Tehran. The presentation will give special emphasis to the views of various Iranian centers of power.

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<td>12226 - Prize Paper Session - Barchi</td>
<td>24 Jun 15:30 - 16:00</td>
<td>IDA - 6701</td>
<td>Joseph F Adams</td>
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This is the placeholder for the Barchi Prize session, where the authors present their paper.

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<td>Special Session</td>
<td>25 Jun 10:30 - 12:00</td>
<td>DoD - Auditorium</td>
<td>Patricia Anne Hickman</td>
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**14216 - USAF Sponsor Special Session**

During the USAF Sponsor Special Session, Mr. Kevin Williams, SES, the new Headquarters Air Force Studies, Analyses and Assessments Director and USAF MORS Sponsor, will present 2014 Air Force Annual Awards and announce the renaming of the Lifetime Achievement Award.

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<td>DoD - 15</td>
<td>Major Aaron D</td>
<td>Mr. Walter DeGrange</td>
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**12588 - Junior-Senior Analyst Special Session**

The Junior / Senior Analyst Session presents a moderated panel to drive insights from the experience of our seasoned professionals and the passion of a younger workforce. The panel’s spectrum of leaders from the DoD and National Security analytics community will field questions on issues including: professional development, driving c-level decisions, and the capabilities or gaps among innovative or emerging concepts and technologies. The moderated panel will transition to an open forum whereby all attendees will be invited to contribute towards the discussion.

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<td>Special Session</td>
<td>25 Jun 15:30 - 17:00</td>
<td>DoD - 4</td>
<td>Mr. Michael A. Ottenberg</td>
<td>Mr. James N. Bexfield, Dr. Jacqueline R. Henningen, Dr. Daniel T. Maxwell Dr. Cyrus J. Staniec</td>
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**11651 - Risk Assessment and Analysis CoP Organizational Meeting**

As an extension of the recent MORS Risk Assessment Workshop held in the fall of 2014, MORS will be adding a Community of Practice to continue the work done in this arena. This meeting will be the first annual meeting for the CoP. Agenda topics will include, but will not be limited to: CoP organization, meeting approaches, topics of interest, and related items.
### 11774 - The Fixed-Wing Search and Rescue Aircraft Performance Assessment Tool (FWSAR APAT)

In 2010, the Royal Canadian Air Force began a major revision of their Statement of Operational Requirement (SOR) for the Fixed-Wing Search and Rescue (FWSAR) Aircraft Replacement Project. The SOR is a document that specifies the requirements that replacement aircraft must possess in order to be considered viable as search and rescue platforms. Part of the review was to recast the requirements using a capability-based approach, specifying what effects were desired of the FWSAR aircraft rather than prescribing the fleet’s characteristics, such as speed, basing, etc. The FWSAR Aircraft Performance Assessment Tool, or FWSAR APAT, is the culmination of the analysis efforts led by Defence R&D Canada’s Centre for Operational Research and Analysis in support of this activity. This tool will be used as an integral part of the evaluation of bids when these are received. This presentation will describe the tool and some of the analysis that supported its development.

### 11650 - Wargame Community of Practice Special Session

This is the annual meeting of the MORS Wargaming Community of Practice (CoP) which is actively supporting the MORS Working Group 30 Wargaming. In this meeting we will address the current military and civilian agencies that are using wargaming as a tool for analysis and how they are discovering new ideas and deriving insights to support a variety of unique military problems. Topics of discussion will include professional education, the MORS Special Workshop on Professional Games (Fall 2015), the handbook project, and other items of interest to the community. This discussion is of particular importance given the renewed interest in the use of wargames in analysis, training, and education that has been mandated by the DoD.

### Demonstrations

#### 11935 - Demo on Standard Wargame Integration and Facilitation Tool (SWIFT)

This Tutorial is for the Standard Wargame Integration and Facilitation Tool (SWIFT) developed by OSD/CAPE. The tutorial will have two parts: the first is how to play a game in SWIFT and the second is a primer on how to build a game in SWIFT.

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### Demonstrations

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### 11495 - Demonstrating the SWIFT Approach to Wargaming and Innovation

This presentation is a demonstration of the Standard Wargame Integration and Facilitation Tool at the Mark Center symposium lobby (Mark Center Conference Center, B1 level). The presentation will be performed using a live touch-screen table where viewers can experiment. The game in the demonstration is the Drive on Metz.

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<td>Demonstrations</td>
<td>23 Jun 13:30 - 15:00</td>
<td>DoD - 16</td>
<td>Mr. Robert L. Turner, Jr.</td>
<td>Mr. William J Ellerbe, Jr. Mr. Harvey H Gilbert Mr. Michael A. Ottenberg</td>
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### 12167 - MATLAB and Simulink - Data Analytics and Modeling Demonstration

MATLAB and Simulink can support Operations Research through its data analysis, optimization and multi-domain simulation tools. We will demonstrate new features in the tools for:
- Acquiring, analyzing and visualizing big data
- Parallel computing
- Optimization
- Modeling and simulation of time-based and event-based scenarios
- Investigation of routing and resource allocation problems

No prior knowledge of MATLAB or Simulink is required.

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<td>Demonstrations</td>
<td>23 Jun 13:30 - 15:00</td>
<td>DoD - 27</td>
<td>Dr. Teresa Ann Hubscher-Younger</td>
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### 12279 - JMP 12 Software for Data Visualization, Exploration and Discovery

Since 1989 JMP® has been the software that brings dynamic data visualization and deep analytics to the desktop. Using short case studies this demo will highlight many of the enhancements in the recently released (March 2015) JMP Version 12 and JMP PRO. Explore data from every angle possible and move rapidly from one visualization to another, from one discovery to the next. With JMP, you make and refine your graphs interactively, or quickly build a brand new graph. Watch your graph instantly emerge as you click and drag variables. No more switching between windows to make comparisons and explore your data. You’ll discover things you never expected, and then communicate those discoveries in a most visual way.

The analyses shown in this demo will cover:
1) small and large data sets,
2) haphazardly collected historical data and data from structured design of experiments (DOE),
3) data from real experiments and from computer simulation,
4) basic exploration with dynamically linked distributions and plots,
5) more complex multivariate modeling such as response surface methods for process optimization, and
6) advanced modeling methods such as stepwise regression, partitioning, neural nets and generalized regression now with interactive model building

These modeling methods can all use holdback validation for the honest assessment of the final model. Holdback validation significantly improves the ease and robustness of use of these methods by an analyst.

Finally, it will be shown how JMP’s “graphic for every statistic” can easily be copied and pasted into web, presentation and report creation software. Several graphics including the JMP Prediction Profiler can be copied as “flash” objects or exported as interactive HTML 5 and retain their interactivity so that viewers can ask “what if?” questions and get immediate answers without having access to the original data and analyses or JMP software.

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<td>DoD - 27</td>
<td>Dr. Thomas A. Donnelly</td>
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**11935 - Demo on Standard Wargame Integration and Facilitation Tool (SWIFT)**

This Tutorial is for the Standard Wargame Integration and Facilitation Tool (SWIFT) developed by OSD/CAPE. The tutorial will have two parts: the first is how to play a game in SWIFT and the second is a primer on how to build a game in SWIFT.

**12274 - Demonstrating Cyber Security Testing on a Low Cost Virtual Cyber Range**

In 2014, we demonstrated a Virtual Emulation Environment (VEE) that realistically emulated whole networks on a laptop with bit-level fidelity and precise timing for highly realistic, but much lower cost network/cyber testing. This year we are demonstrating an actual VEE Virtual Cyber Range (VCR) that is being delivered to network test labs within the Intelligence Community (IC) and demonstrating the system’s ability to support multi-network cyber testing and plug-and-play hardware interfaces directly to the virtual environment. The virtual network is produced by reverse engineering it from the external data of its real counterpart. The result is a clone using actual internet software and virtualized hardware that portrays servers and other devices down to their specific vendor models and places them in specific virtual geographic locations to address timing issues. IC reviewers have not been able to tell the real from the virtual packet traffic.

The baseline VEE VCR is composed of only three laptops, internet software, and the VEE software, yet it can seamlessly link live networks and devices/products with virtual networks through a virtual switch. Furthermore, the small system can virtualize several hundred servers and tens of thousands of networked devices and its capacity can be expanded by simply adding another laptop. This demonstration displays the VEE VCR and its operation, shows that no special facilities are required, describes some of the uses of the VCR by IC test organizations, and discusses the future expansions of this low-cost concept.

**12562 - How to use the Wargame Activity Repository**

Recently the Deputy Secretary of Defense identified coordination of Wargaming across the Department to be of great interest. OSD/CAPE was tasked to provide a Wargame Activity Repository to support this intent. This Tutorial describes the repository and how to use it. It is also a forum for feedback on any changes or additions the community sees as valuable.

**12311 - SAFEGUARD Demonstration**

Analysis of Integrated Air and Missile Defense (IAMD) is a common analytic task complicated by the number and types of systems, tactics and scenarios. In 2012, the Navy embarked on the development of a new multi-mission IAMD model capable of analyzing the maritime defense of sea- and land- bases against aircraft and missile raids. The newly delivered model, SAFEGUARD, represents a substantial advancement of our ability to analyze these problems, capable of modeling simultaneous air-to-air, surface-to –air and air-to-surface hard-kill/soft-kill engagement within the Fighter, Missile and Joint engagement Zones while also accounting for the management of resources, impacts of jamming and benefits of multi-unit C2. This special session will provide an overview of SAFEGUARD’s capabilities and methodology with an extended demonstration of a classified scenario.
### Poster Groups

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<td>Sarah Butterworth</td>
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**11518 - Combat Stress: A Collateral Effect in the Operational Effectiveness Loss Multiplier (OELM) Methodology**

An IDA research team designed the Operational Effectiveness Analysis (OEA) methodology to estimate a military unit’s operational effectiveness on the battlefield following a chemical, biological, radiological, or nuclear (CBRN) event. As part of the OEA effort, the team developed the Operational Effectiveness Loss Multiplier (OELM) methodology to examine the collateral effects of CBRN events on operational effectiveness. Within the OELM methodology, combat stress is viewed as a collateral effect arising from the conditions and experience of CBRN events. The potential of combat stress to degrade individual and unit operational effectiveness makes it an important aspect of the OEA and OELM research and methodologies. This poster discusses combat stress and its implications on operational effectiveness; combat and operational stress reaction (COSR) in service members; and civilian psychological casualties (CPC) and combat stress casualties (CSC) as a result of CBRN and non-CBRN events. It establishes clear definitions of terms relevant to combat stress; discusses the current data available to model and estimate CPC and CSC resulting from CBRN and non-CBRN events; and proposes further research to aid in the estimation of CSC and CPC in the future.

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**12532 - Drive on Metz: Demonstrating the SWIFT Approach to Wargaming and Innovation**

The Drive on Metz wargame sponsored by WG-30 Wargames and the Wargame CoP will use a variety of tools to support adjudication, presentation, and analysis of the game runs. One tool is the SWIFT wargame environment. SWIFT will provide a multi-media visualization of key Drive on Metz games executed on Tuesday, 23 June by using the SWIFT playback capability.

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**12179 - Investigating Interventions and Other Activities during the West African Ebola Outbreak**

The Institute for Defense Analyses (IDA) has played an integral role in the Defense Threat Reduction Agency’s (DTRA’s) threat agent modeling initiative designed to inform US Government stakeholders throughout the ongoing Ebola outbreak in West Africa. Over the course of this effort, IDA has collected a large amount of data, which has been collated in order to draw out lessons learned pertaining to the international response to this outbreak. This poster identifies key interventions and other activities, including medical and public health interventions, changes in laboratory capacity, social unrest, and aid organization activities which occurred in West Africa throughout the course of the outbreak. Four timelines, for the outbreaks in Guinea, Liberia, Sierra Leone, and other countries with exported cases, display these activities starting with the discovery of the index case in Guinea (2 Dec 2013) to present day (1 May 2015). A trend line depicts new cases by week as reported by the World Health Organization (WHO). This poster aggregates interventions and other activities with data on new cases to demonstrate how the two may be correlated.

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**12563 - OptDef: A Simulation Optimization and Analysis Tool**

OptDef is a software capability that improves the affordability, effectiveness and return on investment (ROI) of DoD Modeling and Simulation (M&S) tools. OptDef provides an external simulation optimization, analysis, and graphing capability for use with existing constructive simulation models. OptDef has been integrated with five DOD simulation tools and can be easily integrated with other tools through a flexible integration interface.

Our poster will highlight the key features and main benefits of this tool.

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**12383 - The U.S. Marine Corps Logistics Command’s Repair Optimization Materiel Evaluator (ROME)**

The U.S. Marine Corps (USMC) Logistics Command Studies and Analysis Division created ROME to evaluate repairable equipment and directly influence budget planning decisions. The USMC, fighting a global war to support and protect U.S. interests, has seven million ground equipment items and needs to rationalize annual expenditures in support of depot maintenance planning and execution. For example in FY17, the projected depot maintenance budget is $229M versus a requirement of $315M. In a growing fiscally uncertain environment, only the most mission critical equipment gets the highest priority for repair. ROME provides a solution to a problem that, once hard to quantify, is solved in less than a minute, and supports an Enterprise process that historically was solved using spreadsheets and stubby pencils. ROME is a mixed integer program implemented in the GAMS software package and solved using the IBM ILOG CPLEX optimizer.
CG A Homeland and International Operations

11827 - Analyzing the International General Aviation Pathway Into the United States
The domain of international general aviation (IGA) includes all private, corporate, and certain on-demand charter flights entering the United States from a foreign airport of departure. These flights do not have to meet the same security measures as their scheduled airline counterparts, which creates vulnerabilities that need to be addressed in safeguarding the United States from terrorists and weapons of mass destruction. In an elevated threat situation, senior government authorities will need a variety of flexible risk mitigation strategies for IGA operations. Within the Department of Homeland Security, a multi-agency working group has been formed to study the IGA problem. To support this Working Group, ENGILITY CORPORATION – under contract to the Domestic Nuclear Detection Office – has performed extensive data mining and analysis of three years of FAA data on IGA flights and has combined this with authoritative aircraft performance data. The resulting analysis illuminates the flows of IGA flights into the United States – their departure and arrival airports, the capabilities and types of aircraft used, and the frequency of flights, as well as some of non-standardized ways in which the data has been collected and how those problems have been managed. The data has been used to support a variety of modeling and simulation activities to determine different ways we can protect critical infrastructure and population centers by redirecting flights. This talk will outline the data analysis, challenges faced, and observations for similar work.

12370 - Training Local Government Leaders to Make Sound Emergency Management Decisions
Local level government leaders such as mayors, county managers and even military installation commanders serve in their capacity as government decision makers for not more than three years in a single term. This is a very short time in which to grasp the emergency management functions, resources, procedures, and threats that exist in any given community particularly when the leader is new to the community or new to emergency management practices. This critical task is often crowded out of the top priority practice; therefore, the government leader is heavily dependent on various department directors to provide him/her with enough information to make informed and sound decisions in the event of an emergency or disaster incident. A prototype program was developed to train local government leaders in using their resources effectively. In essence, this is a non-military version of a Wargame. The program incorporates three distinct elements: video scenarios, live decisions made at critical decision points and feedback on the performance using a comparison with national standards.

12371 - The Rugged Trail to Emergency Management Improvement Planning
Emergency exercises are designed to test and practice emergency plans by those who work in the facility on a regular basis. The Exercise Process is often shown as a process with these general steps: Strategic Plan, Design and Develop, Conduct and Evaluation, and Improvement Planning. This Process seems straightforward and uncomplicated, but in practice it takes a great deal of time and effort. Most organizations have a mandatory requirement to conduct an annual emergency response exercise. This requirement provides a false goal because the Exercise itself is in the middle, not the end of the Process. Analysis, evaluation and review task all occur after the Exercise. Compiling and analyzing the results are paramount to the next step: develop the Improvement Planning document. This is a job for Operations Analysts who are not often recognized as critical (or at all) in the Exercise Process. This presentation will focus on the time frame and tasks between the Exercise and the actual writing of an Improvement Planning document. It will identify some obstacles that delay and/or prevent writing the Improvement Planning documentation, the challenges confronted by the analysts, and suggestions overcoming these obstacles based on actual exercise experiences.
### CG B C4ISR and Net-Centric Operations

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<td>DoD - Auditorium</td>
<td>Connor S McLemore</td>
<td>Prof. Donald P Gaver, Jr. Dr. Patricia Anne Jacobs</td>
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**11882 - An Exploratory Campaign Analysis Tool And Real-Time Inter-Region Asset Allocation Aid**

This presentation describes an exploratory campaign analysis tool and asset allocation decision-aid capable of fast operation while accounting for uncertainty in an opponent’s plan. It can be available to commanders and analysts who have limited time or a finite budget. Reconnaissance strike complexes (RUKs) represent a common military structure among today’s militaries and are made up of and integrate (1) missiles with precision-guided sub-munitions, (2) area sensors, and (3) automated C2, a system of command and control linking sensors to shooters. The usual approach to studying the performance of RUKs is to build the RUK into a standard campaign analysis model in which each of the elements (ships, aircraft, etc.) are individually tracked and interact. This high resolution modeling approach can be computationally and administratively expensive, hence the large overhead and long run-times for standard Campaign Models. We study a lower resolution model. The attributes we track are the weapons, sensors, and command and control (C2) availability over a number of geographically divided C2 regions. The model looks at a force as a system in which the platforms each have attributes rather than trying to track individual elements. A huge variety of assets can be realistically modeled in this way. The end goal is to produce a flexible model that can be used to conduct a trustworthy rapid initial exploration of a Campaign and can continuously make “good enough” recommendations to a commander for platform allocation in a theater of war based on actual and/or uncertain information about the enemy.

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<td>DoD - Auditorium</td>
<td>Henry Marshall</td>
<td>Mr. Christopher J. Metevier Jeff Truong Dr. Robert F Wells</td>
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**12224 - Concept for a Tactical Cyber Warfare Training Prototype for Current Live Virtual and Constructive (LVC) Simulations**

Current major simulations among the Live, Virtual, Constructive, and Gaming (LVC&G) domains lack a cyber implementation with the exception of a low fidelity cyber warfare effects simulation in the One Semi-Automated Forces (OneSAF) program. This shortfall was identified as a major technology gap in the simulation community. To move towards a multi-domain cyber training solution, we conducted analysis of the problem space and developed an initial prototype to refine the user requirements as well as develop implementation architecture. The domain of cyber is very broad covering the whole range of mission command, weapon control, and information systems forcing us to pick the best focus to meet a likely Army use case. After conducting a gap analysis among stakeholders, a clear missing capability was a cyber warfare mission command service that would work in a LVC&G training environment. The goal of this research is to develop a loosely coupled software service, called Cyber Operations Battlefield Web Services (COBWebS), that provides the capability to stimulate the effects of various cyber-attacks on command and control communication between the synthetic entities and the Blue mission command systems. Our prototype leverages the Mission Command Adapter Web Service and adds cyber warfare effects modeling. Incorporating COBWebS in a LVC&G training event allows the trainee to recognize and make decisions that will minimize the attacks effects on overall mission. This presentation provides an overview of our front end analysis and conceptual prototype design to solicit feedback from the MORS community.
SAGE is a system of government owned ESRI models and scripts that use ArcMap to help analysts, planners and commanders conduct detailed map reconnaissance, terrain analysis and intelligence preparation of the battlefield.

SAGE is currently found within the Army’s DCGS-A program of record. It uses four types of input data: elevation, terrain categorization, road networks, and map imagery. Foundation tools analyze slope, aspect, terrain, road networks to create an obstacle overlay and maneuver network for a variety of vehicles. SAGE produces these foundation overlays based upon the factors found in Army documentation and established procedures. It draws out the power of map data and enables a large set of users to conduct powerful analysis on this information. SAGE demonstrates its full potential by producing all of these tactical decision aids quicker and more accurate than models and analysts who do not use SAGE. SAGE allows analysts, planners and commanders to spend more analyzing problems rather than creating presentation products.

SAGE is currently being trained at various locations across the entire world. SAGE is also taught in support of TCM-SP Tactical Engagement Team (TET) events. Although there has been a tremendous amount of success in utilizing SAGE’s capability, there are still many challenges in regards to institutional training and increased Soldier utilization.

This presentation captures the challenges and best practices for transitioning research out of the S&T community and into the hands of an end user. This presentation also showcases an engagement strategy for training across multiple echelons within the Army.
Classical game theory provides useful tools for understanding the requirements for successful operation to suppress enemy air defenses [SEAD]. In particular operation of surface-to-air missile systems [SAMs] can be modeled as a two-player zero-sum game in which both the attacking air force and the defending SAMs can follow a range of possible strategies. We develop an appropriate model and solve it for a range of parameters, particularly weapons effectiveness and conflict duration. We find that in conflict that are anticipated to last for weeks or longer, the theoretically correct strategy for defenders is often to engage very infrequently. We observe that in several recent conflicts involving US air forces, the enemy has indeed followed such a strategy. The likelihood that future enemies will attempt to avoid frequent engagements has important implications for future war planning and procurement decisions.

China developed a strategy called anti-access and area denial (A2/AD) to compete against the United States. A2/AD relies on large amounts of SAM systems, ballistic and cruise missiles, submarines, mines, and other asymmetric weapons to deter the US from operating close to China's shores. In the scenario of a conflict between China and the US over Taiwan the air battle in the area surrounding the Straits will be critical. China's new A2/AD capability significantly complicates America’s ability to generate air sorties by threatening America’s airbases in the region. Chinese ballistic and cruise missiles, particularly those armed with cluster munitions, are a significant threat to unhardened U.S. airbases. This paper models America’s sortie generation rate and basing options while under this A2/AD threat using Monte Carlo simulations, scenario analysis and publically available information. The results show that unless the US has effective anti-missile air defense units, it should prefer bases that are farther away from China – the losses in sortie generation from distance are more than made up by the increased safety of the base. This result opens a number of strategic questions for the United Sates. At present, only two small bases are outside of Chinese missile range but within sortie range. The US will have to rely on small, relatively undeveloped airbases in the Philippines or use Japan’s. Considering current technological trends, China's A2/AD strategy is likely to become more and more of a threat to America’s ability to project power into the region – putting Taiwan’s freedom at risk.
### CG D Resource/Readiness/Training

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<td>DoD - Auditorium</td>
<td>Mr. Philip Hallenbeck</td>
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#### 11530 - Defining and Quantifying Realism in Testing and Training

Many presentations on training or testing mention the need for "realism." Yet, none appear to define it or describe how it might be judged.

We present here a model to assess the realism of a simulation environment. It provides a framework to reason about and communicate realism; and to repeatably yet quickly and easily assess the factors that impact realism.

The model is based on the Mission Variables of METT-TC (Mission, Enemy, Terrain, Troops, Time, and Civil), plus the Immersive environment (the visual, aural, and other factors that lead a participant to believe the environment is "real"). Addition of risk management leads to the straightforward concept of assessing risks to realism in terms of "METT-TC+I."

The model decomposes each of these variables into factors that may influence an event’s outcome (such as weapon lethality, or visual indications of weapons fire). Each factor's risk to realism is calculated based on its probable impact on outcomes, and the likelihood it would be inadequately simulated. Users may modify these calculations to reflect risk mitigation steps.

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<td>Joseph F Adams</td>
<td>Dr. Amy Alrich, Colin Michael Doyle, Ph.D., Mr. Brandon Shapiro</td>
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#### 12225 - The Feasibility of Requiring and Resourcing Language Education for Uniformed Personnel

To satisfy a Congressional requirement, IDA was asked to assess the feasibility of requiring and resourcing foreign language and cultural education for all active duty officers and non-commissioned officers. The assessment consists of two parts. This report first examines the current requirements for foreign language proficiency and culture-oriented capabilities, focusing on DOD issuances, Service policies, and the Services' training and education enterprise. The second and primary part of this assessment estimates the marginal cost of foreign language acquisition for active duty officers and non-commissioned officers, which are derived from the IDA Language Cost Model that utilizes Defense Manpower Data Center personnel data. These cost estimates address the feasibility of requiring and resourcing foreign language and cultural education for Service Personnel, and how tradeoffs can be made by investing in pre-commissioning programs.

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<td>Mr. Jason A Southerland</td>
<td>Dr. Andrew G. Loerch, FS</td>
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#### 11667 - Using Approximate Dynamic Programming to Adapt the Army's Force Mix

The Total Army Analysis (TAA) is an annual decision forum through which the Army determines how to modify its force structure over the Future Years Defense Program. TAA seeks to identify prudent changes to the structure that will maintain or improve the Army's ability to conduct missions in support of the Defense Strategy. Essentially, TAA is a problem of sequential decision making under uncertainty. We developed an approximate dynamic programming methodology that makes sequential force structure modification decisions given uncertain demand for forces and a heuristic for satisfying that demand. We discuss a case-study application of this methodology and relevant results.
Based on the MORS Workshop on  “Affordability Analysis: How Do We Do It?” in October 2012, an Affordability Analysis Community of Practice (AA CoP) was established to work on the recommendations from the special meeting.

The recommended next steps from the October 2012 Workshop were:
• Form a team to continue working in this area
• Complete the research not conducted during the 3-day workshop and also recommended during the Leadership Outbriefs
• Develop an Affordability Analysis “How To” Manual / Guidebook / Process
• Pilot the manual / guidebook / process on a couple of projects

The first of these steps was completed with the formation of the MORS Affordability Analysis (AA) CoP in February 2013. The second next step was completed in December 2013 when the AA CoP organized the research into the Affordability Research Document.


The government / industry MORS “Big A” Affordability Analysis Process Guide was developed by representatives from the four Services; the Assistant Secretary of Defense’s (Acquisition) Office; the Secretary of Defense’s Acquisition, Technology and Logistics Office; the Joint Staff J8; Combatant Commander’s Offices; analysts from the Australia and the United Kingdom; and other Industry contributed to this joint affordability analysis process document. Besides MORS, other professional organizations also participated contributed to the development of the guide including INCOSE, NDIA Systems Engineering Division, and the International Cost Estimation and Analysis Association (ICEAA). The process guide was completed in January 2015 and is currently being tested with several pilot programs. Additionally, the work completed on the government / industry process is being incorporated into an affordability analysis course for MORS.

The purpose of the MORS AA CoP Annual Face-to-Face Meeting is to discuss (1) status of the AA CoP’s Affordability Analysis Process Guide, (2) feedback updates on the current pilot projects, (3) development of an affordability analysis course for MORS, and (4) the planned actions going forward. The MORS AA CoP is looking for new members, so please feel free to attend our meeting.

This is Part I, the start of the meeting.
Based on the MORS Workshop on “Affordability Analysis: How Do We Do It?” in October 2012, an Affordability Analysis Community of Practice (AA CoP) was established to work on the recommendations from the special meeting.

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- Develop an Affordability Analysis “How To” Manual / Guidebook / Process
- Pilot the manual / guidebook / process on a couple of projects

The first of these steps was completed with the formation of the MORS Affordability Analysis (AA) CoP in February 2013. The second next step was completed in December 2013 when the AA CoP organized the research into the Affordability Research Document.


The government / industry MORS “Big A” Affordability Analysis Process Guide was developed by representatives from the four Services; the Assistant Secretary of Defense’s (Acquisition) Office; the Secretary of Defense’s Acquisition, Technology and Logistics Office; the Joint Staff J8; Combatant Commander’s Offices; analysts from the Australia and the United Kingdom; and other Industry contributors to this joint affordability analysis process document.

Besides MORS, other professional organizations also participated contributed to the development of the guide including INCOSE, NDIA Systems Engineering Division, and the International Cost Estimation and Analysis Association (ICEAA). The process guide was completed in January 2015 and is currently being tested with several pilot programs. Additionally, the work completed on the government / industry process is being incorporated into an affordability analysis course for MORS.

The purpose of the MORS AA CoP Annual Face-to-Face Meeting is to discuss (1) status of the AA CoP’s Affordability Analysis Process Guide, (2) feedback updates on the current pilot projects, (3) development of an affordability analysis course for MORS, and (4) the planned actions going forward. The MORS AA CoP is looking for new members, so please feel free to attend our meeting.

This is Part II, the continuation of the meeting.

DOD 5000.01, 5000.02 and AR70-1 require the use of Modeling and Simulation (M&S) to be used during the acquisition lifecycle. How to leverage M&S and to what extent can be challenging for many decision makers. When properly implemented, M&S can improve systems acquisition processes by reducing time, risk and resources while increasing utility and supportability. In our experience, the traditional role of M&S has been limited to supporting system performance objectives and capabilities. Today, non-traditional modeling and simulation efforts can include rapid 3-d prototyping for form and fit tests or prototyping a user interface for requirements development. In addition, an often overlooked benefit of including M&S in the acquisition lifecycle is having developed the foundation for verified and validated New Equipment Training (NET) and sustainment training tools as a result of program M&S efforts. The US Army’s Night Vision and Electronic Sensors Directorate (NVESD) Modeling and Simulation Division (MSD) has supported various Army Program Managers (PMs) through acquisition milestone decisions. This paper will explore uses for M&S across the acquisition lifecycle of several programs. In addition, MSD will highlight the transition of a NET simulation to a fielded and sustained training solution. The MSD has also applied M&S by developing and providing modeled sensor performance characteristics as specifications to industry for development; and to support concept experiments and capabilities assessments. Simulations also support Material Solution Analyses (MSA) and design studies to identify the preferred solutions of future sensor systems. The MSD also demonstrates the use of simulations and data collection to support business case reviews (BCR) leading to decisions resulting in further development of the new sensor system. MSD’s M&S supports trade-off analyses, and system performance tests for specification adherence, and the sensor performance models are refined as industry prototypes and systems are tested, and further used in simulations.
12445 - Developing Human Performance Measures for a Gaming Environment

In the expanding gaming environment supporting U.S. Army training, the ability to measure human performance is an increasingly important capability. The measures must be based on sound human research factors and established doctrinal standards that do not necessarily take into account the constraints of precisely how data will be collected to calculate those measures. The primary locus of operator measurement is at the user interfaces (UI) including the keyboard, mouse and joystick with no input from expert live trainers or observers. Expressing measures to answer what are often subjective questions in context of a game using objective simulation data presents challenges. The Image Intensification and Thermal Equipment Trainer (IITET), a collaborative effort between the Night Vision and Electronic Sensors (NVESD) and the Army Research Institute (ARI), has addressed these challenges. Measures of Performance (MOP) were developed with traceability to the Army Research Institute’s (ARI) study of manned-unmanned teaming (MUM-T) between UAS operators and rotary wing pilots and Army tasks. The use case focused on the current RQ-7B Shadow training needs for UAS payload operators (PO) who must acquire scout and reconnaissance skills in support of MUM-T. The system architecture was developed to allow future expansion to meet the training needs of Gray Eagle operators. A key After Action Review (AAR) requirement for the NVTT-Shadow is for a PO trainee to use the system and receive training feedback without the immediate supervision of a human trainer in specific tasks and the overall accomplishment of the mission. The IITET measures, data collection methods and presentation to the student have the potential to support other sensor-intensive systems with only minimal modifications to the existing game scenarios, game entities, and other aspects of the system. This paper discusses the development of gaming metrics, the challenges of measuring in this environment, and lessons learned.

12076 - A Data-Driven Decision Aid for Early Warning Radar Modernization Planning

The United States’ early warning radars (EWRs) continue to play a vital role in strategic national defense but require modernization as part obsolescence draws near. Meanwhile, pressure on DOD budgets is forcing the Air Force to make difficult choices between new system development, operations and sustainment (O&S) of current systems, and necessary modernizations of mission critical systems such as the EWRs. The result is a complex systems engineering problem requiring an innovative approach to balancing mission effectiveness, lifecycle costs, and obsolescence schedules within a pressured acquisition budget.

Through Internal Research and Development, Raytheon has developed a methodology for modeling the complex interactions between these competing needs, resulting in a data-driven decision aid for quantitatively assessing potential EWR modernization strategies. The decision aid combines stochastic models of total ownership costs based on real-world O&S data with medium-fidelity mission effectiveness models for Ballistic Missile Defense (BMD) and Space Situational Awareness (SSA). Decision makers are presented with projected mission effectiveness metrics, cumulative O&S costs, and yearly acquisition cost requirements for candidate time-phased modernization plans. Plotted in aggregate, decision makers can rapidly identify cost-efficient modernization plans that meet budget constraints while mitigating obsolescence and maintaining or enhancing mission effectiveness against current and emerging threats.

This presentation will describe the systems engineering methodology applied to the EWR modernization problem as well as techniques employed for detailed cost and mission effectiveness modeling. Key findings and sample decision aid visualizations that highlight cost-effective modernization strategies will be discussed.
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11403 - Time-Critical-Targeting Estimation and Simulation System

Adversary efforts to improve anti-access, area denial (A2/AD) capabilities have introduced several challenges for U.S. military forces. Specifically, A2/AD capabilities necessitate that U.S. forces operate in increasingly hostile environments or at greater distances from areas of interest, making intelligence, surveillance and reconnaissance (ISR) collection increasingly difficult and potentially limiting the decision timeline available to engage hostile threats. The Time-Critical-Targeting Estimation and Simulation System (TESS) employs commercially available tools to provide a simulation that facilitates the analysis of friendly decision timelines in response to a specific time-critical threat. The initial implementation of TESS is focused on the evaluation of friendly forces’ ability to find time-critical-targets in an A2/AD scenario and combines a threat model with models of friendly ISR assets. Preliminary results identify critical factors impacting efforts to find time-critical targets and quantify the decision timeline available between threat detection and threat employment.
CG G Hybrid Warfare

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<td>Major Thomas Newlon</td>
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**12398 - Regression Analysis on the Destructive Influence of Retributive-Punishment**

There is a lack of understanding about the influence of retributive-punishment as a key factor contributing to the rise of violence targeting civilians that are relatively connected with the proponents of violence (e.g., policy-makers, rebels, and insurgents). Even more is a lack of understanding of the symbiotic linkage that exists between retributive acts of violence characteristic of state repression, retributive acts of violence linked to civil war, and ethnic/religious conflict, which has the potential to generate the prerequisite conditions that en-masse lead to a rise in sectarian violence. A symbiotic relationship emerges from the cycle of violence, when violent acts symptomatic of state repression, civil war, and ethnic conflict are premised on the retributive factors of fear, hate, and revenge.

The most significant factor compelling violence toward civilians (sectarian violence) is retribution-punishment. Yet, some scholars argue that “state repression” is the primary factor increasing human rights violations (sectarian violence). Some advocate that retributive-revenge and aggression are the determinants of civil war and human rights violations. However, this too falls short of providing a rationale for targeting “innocent” civilians for acts of violence.

To examine the phenomenon, this study employs a longitudinal design in the form of a multiple regression ‘zero-inflated model’ and a negative binomial regression. Considering other research designs this combination is best suited for measuring the same variables over a long period of time, while accounting for excessive zeros in the dataset. The overarching goal of this study is to inform policymakers on the destructive influence of retributive-punishment.

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**11625 - Campaign Analysis with a Hybrid Threat**

The Army created the Army Operating Concept (AOC) in order to describe future battlefields to inform doctrinal and force management policy decisions for Force 2025 and Beyond. The AOC anticipates that future battlefields will occur in a Complex Operating Environment (COE) where adversaries will likely consist of hybrid threats. Hybrid threats combine tactics and equipment associated with both conventional and irregular forces to create a unique form of warfare.

The Center for Army Analysis continually updates and improves the methods for conducting campaign analysis. This study looked at adopting three models to simulate the hybrid threat scenario: the Combat Sample Generator (COSAGE), Attrition Calculator (ATCAL) and Joint Integrated Contingency Model (JICM). These models were modified and applied to historical hybrid threat scenarios to validate the technique. Once validated, these programs can then be used to model modern and future theater-level warfare.

Keywords:
Army Operating Concept, Campaign Analysis, Theater Modeling, Hybrid Threat, Complex Operating Environment

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**11857 - Integrated Design for Hybrid Operations (IDHO)**

Integrated Design for Hybrid Operations (IDHO) – Joint Project in support of CJCS IW Task to further develop an approved hybrid scenario isolating the full range of IW capability and capacity requirements for the joint force. IDHO is an Integrated DoD-IA project designed for supplementing Ph IV scenarios as a start point for stabilization and reconstruction capability and capacity analyses. This effort included a joint, transparent, and collaborative approach that included the development of an integrated DoD-IA Exercise Design, and Data Development Plan. Where the products of a 3-day DoD-IA phase IV planning exercise was designed to serve as a start point for stabilization and reconstruction capability and capacity analyses. Produced phase IV supplements to include: a) data model to address post Ph III operational conditions; b) increased resolution of DoD phase IV activities; and c) key tasks for IA partners. Products include: Post Conflict Reconstruction Tool; CJTF C2 integrated DoD-IA structure; 12 Ph IV strategic papers on stabilization-reconstruction environment; a planning factor analysis tool, and force sufficiency analysis tool that enabled preliminary analyses. Insights suggested the DPS Ph IV forces have a significant shortfall, and Ph IV transition is deemed infeasible.
**12398 - Regression Analysis on the Destructive Influence of Retributive-Punishment**

There is a lack of understanding about the influence of retributive-punishment as a key factor contributing to the rise of violence targeting civilians that are relatively connected with the proponents of violence (e.g., policy-makers, rebels, and insurgents). Even more is a lack of understanding of the symbiotic linkage that exists between retributive acts of violence characteristic of state repression, retributive acts of violence linked to civil war, and ethnic/religious conflict, which has the potential to generate the prerequisite conditions that en-masse lead to a rise in sectarian violence. A symbiotic relationship emerges from the cycle of violence, when violent acts symptomatic of state repression, civil war, and ethnic conflict are premised on the retributive factors of fear, hate, and revenge.

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**DWG 1 – Human Behavior and Performance**

The Army Learning Model (ALM) is driving the reform of professional military education for Soldiers, with the intent of developing "adaptive, thinking Soldiers and leaders capable of meeting the challenges of operational adaptability in an era of persistent conflict" (U.S. Army Training and Doctrine Command, 2011). Implementation of large-scale educational reform is complex and is often unsuccessful at the level of classroom instruction where interaction between the instructor and student occurs (Clandinin & Connelly, 1998; Fullan, 2003; März & Kelchtermans, 2013).

To date, limited research has been conducted with faculty within professional military education to identify concerns in the context of ALM implementation. There is a well-established framework designed specifically to understand concerns related to educational change—the Concerns-Based Adoption Model (CBAM) Stages of Concern (SoC) (Hall, 2013). Understanding instructor beliefs, hopes, and fears is important to assessing faculty readiness to implement learner-centered, technology-enabled learning models like ALM. It also helps identify the supports that faculty require for successful implementation of ALM in the classroom. As important is the opportunity to infuse the change process with the voice of the PME instructor, who is closest to the classroom.

For successful change to occur, faculty must feel engaged and their classroom perspective respected (Craig, 2012; Fullan, 2007). I will present the CBAM as a theoretical foundation to understand instructor-specific factors impacting ALM implementation and will review recent research (McGurn, 2014) conducted with the model to illustrate how it could be applied, the data that result, and tools to interpret the results.
### 12329 - Validation of cognitive performance measurements to map physician declarative knowledge in practice

Military and civilian healthcare systems have always required high levels of performance and careful allocation of supporting resources. Today, the healthcare field faces an ever-increasing complexity in technology and procedures, as well as the impact of shifting from individual provider care to an enterprise approach that may include virtual clinicians. Within this environment, degradation of clinical knowledge and skills is inevitable, whether compared to a person’s initial knowledge or relative to new medical standards. A systematic knowledge retention program could address this decay, but fixed-interval training for all may not be the most efficient solution. This paper presents results from a multi-year effort to build dynamic models for the assessment of declarative knowledge and determination of learning interventions. It addresses both knowledge decay and relearning. Within this method, cognitive task performance and relevant features, such as the individual’s characteristics and their work environment, are mapped to observable metrics extracted from existing physician electronic records. The models were evaluated through use cases conducted with physicians representing 33 specialties using clinical data from a one-year period. For the military stakeholder, the performance modeling presented could help improve planning and delivery of continuous knowledge and skill training programs for mission readiness.

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### 12094 - On a Scale of 1 to 10, How Do You Feel About Surveys? Methods for Survey Development and Analysis

Surveys are tools commonly used to assess attitudes and behaviors of various populations and often provide the only measures available to inform critical decisions. Despite the qualitative nature of surveys, their analysis is heavily reliant on quantitative tools and techniques. This presentation covers often-overlooked methods for survey development, distribution, and analysis. The purpose of this talk is to improve quality of survey data, assessment of overall attitudes, comparisons of attitudes across sub-populations, analysis of specific question responses, and techniques for free response comments. These strategies include the use of nonparametric statistics, factor analysis, automated text parsing, and new data visualization techniques. Our objective is to highlight best practices that maximize a researcher's ability to derive accurate and actionable insights when using survey instruments.

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### 12148 - Distributed Soldier Representation: M&S Representations of the Human Dimensions of the Soldier

The Army has developed Modeling and Simulation (M&S) capabilities representing platforms such as aircraft, vehicles, and weapons system for various uses and of various fidelities. The Army has represented humans – soldiers, civilians, and threats – in its M&S as well. These representations provide physical model characteristics for mobility, delivery accuracy, lethality, and sensing, as well as behavioral representation to support tactical operations, Human Intelligence (HUMINT), and treating simulated wounded. These models rarely model the soldier as a complex system, omitting factors such as stress, human physiology, leadership, unit cohesion, and morale, to name a few. Instead, the actions of the simulated soldier are often based on a deterministic model of human behavior or based on a stochastic model where random numbers provide variability across iterations, with variability provided by a random number seed, not the model. This provides unsatisfactory simulation results, as the simulated soldiers appear robotic or even superhuman.

This paper describes the two year old Distributed Soldier Representation (DSR) research and development effort at the Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL HRED STTC). We describe our research and identify eleven areas of interest for improving soldier representation. We further describe the development of an innovative Service-Oriented Architecture (SOA) that provides a web services-based approach to integrate disparate models to address these identified representation gaps. We describe the challenges and benefits achieved, as well as the lessons learned from integrating an Effects of Stress model with One Semi-Automated Forces (OneSAF).
12177 - Developing Human Performance Measures for a Gaming Environment

In the expanding gaming environment supporting U.S. Army training, the ability to measure human performance is an increasingly important capability. The measures must be based on sound human research factors and established doctrinal standards that do not necessarily take into account the constraints of precisely how data will be collected to calculate those measures. The primary locus of operator measurement is at the user interfaces (UI) including the keyboard, mouse and joystick with no input from expert live trainers or observers. Expressing measures to answer what are often subjective questions in context of a game using objective simulation data presents challenges. The Image Intensification and Thermal Equipment Trainer (IITET), a collaborative effort between the Night Vision and Electronic Sensors (NVESD) and the Army Research Institute (ARI), has addressed these challenges. Measures of Performance (MOP) were developed with traceability to the Army Research Institute’s (ARI) study of manned-unmanned teaming (MUM-T) between UAS operators and rotary wing pilots and Army tasks. The use case focused on the current RQ-7B Shadow training needs for UAS payload operators (PO) who must acquire scout and reconnaissance skills in support of MUM-T. The system architecture was developed to allow future expansion to meet the training needs of Gray Eagle operators. A key After Action Review (AAR) requirement for the NVTT-Shadow is for a PO trainee to use the system and receive training feedback without the immediate supervision of a human trainer in specific tasks and the overall accomplishment of the mission. The IITET measures, data collection methods and presentation to the student have the potential to support other sensor-intensive systems with only minimal modifications to the existing game scenarios, game entities, and other aspects of the system. This paper discusses the development of gaming metrics, the challenges of measuring in this environment, and lessons learned.

12307 - Aerial Search Enhancements in COMBATXXI

Joint DWG 2 and WG 33 Session

Historically, the representation of aerial search in combat simulations differed little between ground based sensors and aircraft sensors. Recently, there has been compelling need to further develop aerial search in modeling and simulation (M&S). Aircraft sensors have unique, but not necessarily obvious, characteristics that require them to be modeled differently than ground based sensors. The Aerial Sensor Research Project (ASRP) was a multi-agency effort to enhance the depiction of aerial search in the Combined Arms Analysis Tool for the 21st Century (COMBATXXI), a high-resolution, entity-level, stochastic, combat simulation co-developed and used by TRAC and the United States Marine Corps, Marine Corps Combat Development Command (MCCDC).

The most significant deficiencies discovered in the legacy representation of aerial search in COMBATXXI involved the coordination between aircraft sensor field of view management and aircraft motion. Correcting these deficiencies required significant enhancements to COMBATXXI’s sensor sweep techniques, search and loitering patterns, and a graphical user interface (GUI) to assist users in conducting optimal aerial search. Enhancements to the COMBATXXI representation of aerial search have significantly expanded the range of possible questions the Army and Marine Corps can address through combat simulation.

This presentation will explain the unique aspects of aerial search, describe how these can be represented in any discrete simulation, and describe new graphical tools to assist users in modeling aerial search within COMBATXXI.
information must the detection system provide? Towards developing an effective detection method, we describe the requirements of a battlespace.

For several years, the Navy has been adding capabilities to the Synthetic Theater Operations Research Model (STORM) originally developed by the US Air Force. Similarly, the Army and Marine Corps employ a specific analytical model called the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) to evaluate major proposed changes in materiel and associated warfighting operations and tactics. The Unmanned Systems Integrated Roadmap FY2013-2038 indicates the Presidential Budget for Fiscal Year 2014 was over four billion dollars (covering research, development, test, and evaluation, procurement, and operations and maintenance). With such current initiatives and high-valued expenditures occurring with respect to unmanned systems, there is concern that expected improvements to warfighter effectiveness, through tactics, techniques, or procedures, are not well supported by analytical processes and findings. This presentation describes an investigation of STORM and COMBATXXI representations of such emerging systems and discusses modeling improvements needed to better support studies relating to the employment of unmanned systems in the future battlespace. A key issue becomes determining how to better distinguish humans and human-operated systems from autonomous systems so that the models can more correctly represent all of these systems, and their interactions, in the battlespace.
Group | Day & Time | Location | Author/Presenter | Co-Author(s) | Classification
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DWG 2 | 25 Jun 11:00 - 11:30 | Hilton - Beech A | Mr. Daniel Clinton Johnson | | UNCLASSIFIED

**Group Day & Time Location Author/Presenter Classification**

**11642 - Using guiding metaphors in algorithm development**

Computer scientists are trained to think in terms of what computers are naturally good at doing. In seeking solutions that minimally diverge from a computer’s native logic, an algorithm’s ‘learning’ consequently tends to resemble computer logic rather than human thinking. Instead of asking how a computer’s customary logic can be conformed to a problem, we instead ask “what problem is this structurally analogous to that humans solve?” The overall method is to use guiding metaphors in algorithmic design. A metaphor, owing to its origin in the Greek word μεταφορά (from μετά ‘across’ + φέρω ‘I carry’), is something that carries our thinking across from one domain to another. Insofar as two domains share structural similarity, a metaphor can suggest that the thinking of one domain be carried across to another along with desirable properties. As an example, I will discuss the development of an algorithm to guide an aircraft into an orbit around a point. By using a guiding metaphor, the algorithm gained simplicity and robustness. This approach will be contrasted with more mathematically-centric approaches (e.g., Quigley, et al. (2005)). Finally, the use of metaphors across dissimilar domains and what effects this has on the inheritance of properties will be discussed.

**WG 1 Strategic Operations National Security Analysis**

**Group Day & Time Location Author/Presenter Co-Author(s) Classification**

**11924 - Assessing the Afghan Intelligence Enterprise**

Assessing the Afghan Intelligence Enterprise
Ms. Michal Haskell
Center for Army Analysis
Keywords: Intelligence; Enterprise System; Assessments; Afghanistan; Resolute Support
Presentation Classification: SECRET//REL TO USA, NATO, RSMA
ABSTRACT: During her 2014 deployment to Afghanistan, Ms. Haskell developed and led an in-depth study of the Afghan intelligence enterprise to provide a clear assessment and metrics for the intelligence community’s use in mentoring the Afghans to close this high priority, critical gap. This presentation will discuss the methodology of assessing the intelligence enterprise, the formation of the Afghan Intelligence Enterprise TAA mission and how it is bringing together diverse components from the ISAF staff, ISAF Joint Command (IJC), NATO Special Operations Component Command- Afghanistan (NSOCC-A), and the Special Operations Advisory groups (SOAGs) and ensured they functioned as a coherent team. It will also discuss how the delivery of TAA provides a framework to maximize and optimize reduced advisor capacity as the ISAF mission transitions to Resolute Support.

**12239 - Anti-Personnel Landmines**

This presentation examines the effectiveness and efficiency of various concepts of employment (CONEMPs) for landmines and alternative systems in a conventional tactical situation (TACSIT). The study used a suite of purpose built models and simulations (M&S) operating at multiple levels of resolution and leveraged existing Intelligence Community (IC) models to examine the potential effects of landmines, direct strikes, unattended ground sensors, and combinations of these three options. The M&S suite was composed of scheduling models that use outputs from an existing campaign model, a discrete event simulation of vehicle movement, simulations of air operations, and stock-and-flow simulations of various processes. The results of the study challenged a number of long held operational assumptions and have informed a POTUS-ordered examination of the impact of landmines and possible alternatives.

Key Words: Landmines, APL, Mobile Targets, Time-Sensitive Targeting, TST, Modeling and Simulation
**11795 - Special Operations Command Pacific Prioritization Matrix: Ranking Countries in a Diverse AOR and Expansive Mission Set**

In the current environment of increasingly constrained budgets, Special Operations Command Pacific (SOCPAC) sought to better target future engagements through the development a priority matrix, identifying countries of priority within each of its mission areas, such as Counterterrorism, Countering Weapons of Mass Destruction, and Building Partner Capacity. The SOJ54 created a methodology to identify criteria of priority countries in a given mission, and then utilize multiple criteria decision analysis to rank order the countries based on their respective scores for the criteria set. The matrix is being used to inform the periodic update to the SOCPAC Supporting Campaign Plan, nested within the overall PACOM Theater Campaign Plan. In order to maintain relevancy, updating the priority matrix has been added to the regular battle rhythm of the command, to ensure it will be useful to ongoing and future planning efforts. Additionally, as this effort is further developed to incorporate specific resourcing constraints and risk assessments, the final product will not only inform strategic planning, but will also inform operational planning of engagements throughout the AOR.

**12030 - Bangsamoro Plebiscite Survey Analysis: Using Polling Data to Further the Philippine Peace Process**

In 2013, the Government of the Republic of the Philippines (GRP) signed a treaty with the Moro Islamic Liberation Front (MILF), providing for the formation of a semi-autonomous region in the southern Philippines. At the request of the Philippine Western Mindanao Command (WESMINCOM) Commander, and with the endorsement of the U.S. Joint Special Operations Task Force – Philippines (JSOTF-P) Commander, the Center for Army Analysis (CAA) conducted a public perception survey on awareness of, familiarity of, and inclination toward the Framework Agreement of the Bangsamoro (FAB), as well as public expectation of violence, in order to prepare for the planned plebiscite that would determine which areas are included in the new Bangsamoro Region. CAA funded one run of the Bangsamoro Plebiscite Survey (BPS) conducted in November 2014 and presented in February 2015. The team briefed the findings to stakeholders at: Special Operations Command Pacific (SOCPAC); JSOTF-P; the US Embassy in Manila; US Agency for International Development (USAID); WESMINCOM; the Mindanao Working Group; the Philippine Office of the Presidential Adviser to the Peace Process (OPAPP); and, The Asia Foundation. The analysis done informed stakeholders on: areas where there is a low familiarity of the FAB, the population’s primary source of information regarding the FAB, common characteristics among FAB opponents, levels of support for the FAB, and expectations of violence regarding the referendum. The organizations briefed are currently using the analysis to plan public education campaigns, and to anticipate and mitigate referendum-related violence.

**11828 - Using Bayesian Statistics to Model the Reliability of Complex Weapon Systems**

This presentation will focus on the development of a Bayesian model that can be used for assessing the reliability of a complex weapon system. The Bayesian model that has been developed is capable of utilizing pass/fail test data from component tests, full system tests, and covariate information. Developing the ability to incorporate component tests into a reliability model can greatly increase the amount of data available. Most weapon systems, focusing on nuclear weapon delivery platforms, go through full-system tests in very small quantities (4-8/yr). It is costly and diminishes overall stockpile quantities since full-system tests are usually destructive. By building a model that can also utilize component data we give ourselves the opportunity to greatly increase the data we can use for reliability calculations. The final piece of the Bayesian Reliability model is incorporating covariates into the model. These covariates can be anything from storage location, production facility, age at time of test, etc… After discussing the development of this reliability model, the focus of this presentation will shift to real-world applications focusing on how a similar Bayesian reliability model has been developed and applied to calculating the reliability of the Air-Launched Cruise Missile (ALCM).
reduction efforts we have codified new planning constructs and created a prototype Allocation and Application (A2) Optimizer to help senior leaders with a broad range of choices in a timely fashion when responding to a crisis. As part of MPAS Modernization risk strike against emerging time-critical threats.

Among the highest priority of the U.S. Strategic Command (USSTRATCOM) is the modernization of its mission-planning and analysis system. National strategic deterrence policies, emerging threats, and new technologies have led to the need for an extensive redesign of the mission-planning and analysis system. National-level directives require rapid flexible planning and decision making for strategic strike against emerging time-critical threats.

This presentation will describe the development and demonstration of an advanced mission-planning and analysis prototype with a focus on reducing the “kill-chain.” The prototype has been demonstrated to a wide USSTRATCOM and DoD audience and was used to refine requirements and reduce risk for the MPAS Modernization program (now in development). It was built around a “clean-sheet” crisis action-planning process that integrates nuclear, conventional kinetic and non-kinetic strike option planning and was designed to reduce the timeline for strategic strike. The mission planning prototype includes interfaces to emulated persistent ISR sources, interaction with planning partners, decision-making displays, and output to fire control systems. The prototype includes the capability to develop highly-automated strike options for current USSTRATCOM weapons as well as for a conceptual Conventional Prompt Global Strike (CPGS) weapon currently in a technology demonstration phase.

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
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WG 1 | 24 Jun 11:30 - 12:00 | DoD - 27 | Michael MacAndrew |  | UNCLASSIFIED

**11690 - Footprint Modeling**

As the New START Treaty and successive treaties are enacted, the number of nuclear weapons available for a targeting plan will diminish. However, the number of valuable targets in an attack plan (should a nuclear strike occur) is not likely to change. Using MIRV technology and “footprints,” or geometric shapes used to cluster targets, it may be possible to map all weapons to every target. Unfortunately due to the numerous combinations of target clusters, optimization via linear programming is not computationally feasible. Currently, AEM (a combat modeling program) incorporates a greedy heuristic to group targets and additional work has been done to include an alternate greedy method and a genetic algorithm. However, it is likely that a better solution can still be found without expanding significant computational time.

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WG 1 | 24 Jun 14:00 - 14:30 | IDA - 6709A | Dr. Benjamin G. Thengvall | Duane Brucker, USA (Ret) | SECRET

**12231 - Prototyping Future Planning Constructs and Modeling Approaches for MPAS**

The Mission Planning and Analysis System (MPAS) provides dedicated planning and analysis for all U.S. strategic nuclear forces. MPAS also provides planning and analysis to create plans for specified theater and strategic conventional forces. As part of the MPAS Modernization effort, steps are being taken to make the planning process more flexible and responsive. As the number of deployed weapons decreases and as the rate of geopolitical change increases, new planning constructs and algorithms are desired to provide senior leaders with a broad range of choices in a timely fashion when responding to a crisis. As part of MPAS Modernization risk reduction efforts we have codified new planning constructs and created a prototype Allocation and Application (A2) Optimizer to help meet these goals.

The A2 Optimizer globally solves the vehicle weapon system to facility element allocation problem assigning the best targeting solutions for each facility element within an option from a predefined set of candidate targeting solutions. Plans can be created from scratch or with measured changes versus an existing allocation. The user interface enables users to flexibly define the problem with one or more user-defined objectives and optional constraints. When multiple objectives are specified, the tool creates an efficient frontier of plans showing tradeoff curves between the objectives. The user may also monitor progress as an optimization progresses and view and analyze the generated plans.

In our presentation we will present the motivation for this work, required data and sources, our solution approach, and next steps.

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WG 1 | 24 Jun 13:30 - 14:00 | IDA - 6709A | CDR Phillip E. Pournelle, USN |  | CONFIDENTIAL/RE L TO FVEY

**12591 - Evaluating Air Defense Missile Load Strategies Using Revised Salvo Equations**

Recent publications propose to replace the use of long range SM-2 missile for more numerous Evolved Sea Sparrow missiles, effectively trading time/distance of engagement for numbers. We will examine these tradeoffs employing a Revised Salvo Equation in addition to other tradeoffs such as decoys, etc.

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WG 1 | 24 Jun 14:30 - 15:00 | IDA - 6709A | Dr. Stephen R. Riese | Mr. Bryan Heydon | SECRET

**12262 - Mission Planning and Analysis System (MPAS) Modernization - Shortening the Strategic Kill**

Among the highest priorities of the U.S. Strategic Command (USSTRATCOM) is the modernization of its mission-planning and analysis system. National strategic deterrence policies, emerging threats, and new technologies have led to the need for an extensive redesign of the mission-planning and analysis system. National-level directives require rapid flexible planning and decision making for strategic strike against emerging time-critical threats.

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12375 - Understanding Intrastate Conflict Dynamics to Assist UK Governmental Decision Making

The increased global prevalence of intrastate war since the early 1990s has led to renewed academic and governmental interest in the subject. The Defence Science and Technology Laboratory (Dstl) has used qualitative analysis to inform governmental decision making by highlighting key themes and factors which are important to different types of intrastate war. This work has highlighted that a structured way to conceptualise intrastate war is necessary for any robust analysis, but there is currently no agreed definition in use within the UK Ministry of Defence. Therefore, the Historical and Operational Data Analysis team within Dstl started a process of creating and developing an appropriate analytical framework. This paper provides a review of the academic and legal debate and recommends the basis for a bi-level taxonomy of intrastate war. The study reveals common themes and factors of assurance and deterrence that are synthesized into a robust and comprehensive strategic assessment framework. The literature on measuring effectiveness of assurance is almost nonexistent; the study contributes to the field by exploring a novel way to assess assurance through indicators of institutionalization — equating institutional strength with Alliance strength. Indicators of a strong alliance, or institutionalization that can be used for assessment purposes are identified as: increasing networking; development of formalized mutually binding contracts or agreements; and increasing delegation of authority. Like assurance, assessing deterrence effectiveness has been a challenge for analysts since the Cold War; despite scholarly disagreement upon what constitutes success or failure in deterrence, there are observable indicators that may be measured for assessment purposes. The paper examines four key areas of observable indicators: alliance communication, credibility, capability to deter, and the adversary’s decision environment. With increasing demands on Alliance resources in support of assurance and deterrence activities, pressure will continue to grow to demonstrate the effectiveness and cost benefits; a robust and comprehensive assessment framework will provide the evidence necessary to support strategic decision making.

11786 - Assessing Progress in Assurance and Deterrence

As NATO embarks on a series of immediate and longer term assurance measures to demonstrate its collective will and the solidarity of the Alliance, NATO analysts are challenged by the question of “is NATO sustaining assurance?”. This paper presents the initial findings of an ongoing study into assessing progress of assurance and deterrence measures. The study reveals common themes and factors of assurance and deterrence that are synthesized into a robust and comprehensive strategic assessment framework. The literature on measuring effectiveness of assurance is almost nonexistent; the study contributes to the field by exploring a novel way to assess assurance through indicators of institutionalism — equating institutional strength with Alliance strength. Indicators of a strong alliance, or institutionalization that can be used for assessment purposes are identified as: increasing networking; development of formalized mutually binding contracts or agreements; and increasing delegation of authority. Like assurance, assessing deterrence effectiveness has been a challenge for analysts since the Cold War; despite scholarly disagreement upon what constitutes success or failure in deterrence, there are observable indicators that may be measured for assessment purposes. The paper examines four key areas of observable indicators: alliance communication, credibility, capability to deter, and the adversary’s decision environment. With increasing demands on Alliance resources in support of assurance and deterrence activities, pressure will continue to grow to demonstrate the effectiveness and cost benefits; a robust and comprehensive assessment framework will provide the evidence necessary to support strategic decision making.

12295 - Prying Dark Networks Apart

Joint counter network doctrine incorporates elements of social network analysis, particularly centrality measures, in order to identify critical nodes and linkages the network that if severed will cause the greatest impact on the threat. The intent of this presentation is to describe and demonstrate a prototype simulation for an approach to expand existing counter threat network doctrine beyond centrality measures by reframing the problem based on the functions and capabilities dark networks. Since transnational criminal organizations are businesses, this approach attempts to model their business as series of processes enabled by capabilities to form a value stream. Adapted from Lean manufacturing Value Stream Mapping (VSM) provides insight into how products are transformed flowing through various processes, enabled by capabilities. The Value Stream Map provides a scoping and framing mechanism for analysis of the network. The Mission and Means Framework (MMF) provides a disciplined analytical framework to derive, specify and organize relevant information about the of forces by examining their interactions and determining the effects of those interactions on the capabilities of each force to accomplish tasks and operations, the same tasks and operations required to execute the processes of the Value Stream. Thus by applying this approach to network analysis, analysis gain insight into those critical capabilities that can be targeted to not only disrupt TCO networks, but their very reason to exist, the delivery of a product. Moreover, we contend that this approach could be incorporated into joint doctrine to combat terrorist networks or those of other non-state actors.
### 12233 - Hierarchical and Networked Assessment Models

Military organizational structure lends itself to a hierarchical assessment paradigm. But because military effects are often cross-functional and networked, such a paradigm may be inadequate to model secondary dependencies, especially in the context of forecasting risk. For smaller organizations, one means of incorporating secondary effects is through an integrated product team of subject matter experts. This approach can be difficult for large organizations and the very nature of subject matter expert input is prone to equity biases, assessment gaming and "soda straw" awareness. Alternatively, a hybrid hierarchical-network assessment methodology attempts to illuminate cross-functional dependencies within an assessment hierarchy. We examine different approaches and best practices for hierarchical and networked assessments.

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### 12308 - Enhancing the Analytic Utility of STORM

The Service and Combatant Commander headquarters staffs use the Synthetic Theater Operations Research model (STORM), a large-scale stochastic model to understand risk trades at the Campaign Level. Ultimately, analyses performed in STORM informs the decisions made for resourcing and, in some cases, operational planning. Each instantiation of STORM generates an enormous amount of output data which then must be distilled into analysis-currently a lengthy and manpower-intensive process. This research addresses the development of tools and methods that reduce the manpower and time required to gain crucial insights from STORM output. A second focus area is in dynamically determining the number of replications required at runtime thereby permitting an 'early termination' option for rapid convergence.

Authors: Dr. Jerry Smith

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<td>Dr. Jerry R. Smith</td>
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### 12270 - Automated Cyber Threat Analysis using VRDM

The evolution of cyber crime and advanced persistent threat of network intrusions have shown to outpace cyber defenses due to limitations of funding, technology, and willing available human intellectual capital. The current approach to network security is fragmented and human dependent, and in many cases is only as effective as the skill of the human analyst using the tools. Rule and anomaly based protection are subverted by obfuscation techniques and active response can result in in a self-induced denial of service. We present a new approach to close the gap between rapidly evolving cyber threats and network asset protection. A semantically based executable information model within a configurable information modeling framework is demonstrated as a method for rapid development of automated cyber threat analysis and response. Vector Relational Data Modeling (VRDM) is demonstrated as a method to automate the correlation between multiple cyber security systems and Global Information Network Architecture (GINA) is demonstrated as a means of process definition and automation. Intrusion detection systems (IDS) create alerts that generally require human analysis to verify. We present a configurable capability that enables the semi-sentient behavior necessary to emulate the investigative procedure of an expert cyber security analyst and then execute an appropriate response based on the results of the automated investigation. This concept is a configurable, decentralized cybersecurity integration that combines the effectiveness multiple network defense systems, makes near real time threat determinations, and establishes command links to network hardware without any programming of code.

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WG 2 Chemical, Biological, Radiological, Nuclear, and Advanced Explosives (CBRNE) Defense

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11555 - Commercial Off-the-Shelf (COTS) Equipment Modernization (MOD)

To ensure CM Units are effectively equipped to conduct their CBRNE defense missions, JPdM CBRNE A&RS initiated the COTS MOD Process to assess CM Unit requirements and/or capability gaps and fund the rapid procurement of COTS equipment to fill those requirements and/or capability gaps. The ECBC Decision Analysis Team developed an MCDM and resource allocation approach to assess potential COTS materiel solutions for the CM Unit requirements and/or capability gaps. Development of an assessment methodology was particularly challenging because CM Units have a wide range of requirements due to varied operating climates and hazards. Also, equipment under evaluation is disparate, including items in different commodity areas, such as CBRNE detectors and personal protective equipment. This presentation will describe the multi-step approach and methodologies used in the COTS MOD process, which include identifying requirements, qualitatively screening potential COTS materiel solutions, and then quantitatively assessing the selected COTS solutions using a single evaluation model.

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12111 - Impact of Non-constant Concentration Exposure on Lethality of Inhaled Hydrogen Cyanide

The toxic load (TL) model is an empirical approach in hazard assessment modeling for estimating the relationship between a chemical’s inhalation (IH) toxicity and the exposure duration. The TL is normally expressed as a function of vapor concentration (C), duration (t) and a constant—orCnt. Hypothetically, any combination of C and t that yields the same TL will give a constant biological response. These formulas have been developed and tested using controlled, constant concentration animal studies, but the validity of applying these assumptions to time-varying concentration profiles has not been tested. Experiments were designed to test the validity of the model under conditions of non-constant acute exposure—the first dataset of its kind. Over two separate studies, male Sprague-Dawley rats inhaled constant or pulsed concentrations of hydrogen cyanide (HCN) generated in a nose-only exposure system for durations ranging from 2.33 to 30 min. The observed lethality of HCN for the 21 different C versus t profiles was used to evaluate the TL model’s ability to adequately describe the HCN lethality under the conditions of non-constant IH exposure. The model was found to be applicable under the tested conditions, with the exception of the median lethality of very brief, high concentration, discontinuous exposures. The implication of these results directly extends to the substantial effort from both the DOD and the Department of Homeland Security Chemical Security Analysis Center to develop TL parameter estimates for high priority toxic industrial chemicals.

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12368 - Methodologies and Data Analysis Tools Developed to Support Verification and Validation of the Dugway Proving Ground Test Grid Safari Instrumentation

The Dugway Proving Ground Test Grid (TG) Safari Instrumentation provides the ability to test chemical and biological equipment in threat-representative, outdoor conditions while gathering real-time data from Systems Under Test and referee instrumentation. The verification and validation (V&V) ensures that the test infrastructure’s operational and technical specifications are met and serves as a basis for initial accreditation to support use of TG for Acquisition Program testing. The TG V&V involves identifying TG capabilities to subject to V&V testing, developing test methodologies, and authenticating and analyzing test data to evaluate TG test products and system performance. To support the V&V, multiple analysis methodologies and a suite of VBA- and Matlab-based tools were developed to efficiently and effectively process, visualize, and evaluate large sets of referee and performance data from the various TG systems. Examples of the capability provided by the tools include: the ability to batch process Aerodynamic Particle Sizer and lidar data sets; perform automated background subtraction; perform automated data quality checks; plot particle size distributions and counts over time; perform automatic time-drift detection and corrections; create an interactive graphical replay of temporal-spatial data; and automatically identify and graphically display discrepancies in data handled through different systems. These tools allow for near real-time feedback to support immediate adjustments to the systems or test set-up, saving time and money by reducing the likelihood of requiring retesting to complete the V&V. The presentation will provide an overview of the methodologies and tools developed to support the ongoing V&V.
### 12120 - Proposed Human Toxicity Estimates for Several Toxic Industrial Chemicals (Phases I and II)

A toxic industrial chemical/toxic industrial material (TIC/TIM) task force has been established to provide TIC prioritization and baseline TIC acquisition capability requirements and recommendations to the Joint Program Executive Office for Chemical and Biological Defense. These requirements and recommendations are intended for use by the Chemical and Biological Defense Program during routine military operations outside the continental United States. They are not intended for civil response planning. The U.S. Army Edgewood Chemical Biological Center has developed provisional human inhalation toxicity estimates for chemicals of interest to the task force. The project was designed to be a focused and expeditious assessment and not a comprehensive “all source” literature capture and analysis. The project took advantage of the extensive literature searches conducted by the National Research Council during the development of acute exposure guideline levels (AEGLs) for individual chemicals. In Phase I, toxicity estimates were produced for the following 17 selected chemicals: ammonia, chlorine, cyanogen chloride, formaldehyde, hydrogen bromide, hydrogen chloride, hydrogen cyanide, hydrogen fluoride, hydrogen sulfide, mercury vapor, methyl bromide, nitric acid, nitrogen dioxide, octamethyl pyrophosphoramide, phosgene, sulfur dioxide, and sulfuric acid. The 2 minute median effective dosages, probit slopes, and toxic load exponents (TLE) are reported for 16 of these chemicals. In Phase II, an additional 26 TICs were selected for review and development of toxicity estimates in support of the DTRA Reachback Capability. Prior to this effort, very few median effective dosages/probit slopes/TLE appropriate for military casualty estimates existed for any of the TICs reviewed.

### 12333 - Lessons Learned in Estimating Human Toxicity for Compounds of Interest (COI)

In 2007 Edgewood Chemical Biological Center (ECBC) was tasked by the Defense Threat Reduction Agency (DTRA) to execute the necessary toxicological studies and develop human toxicity estimates for five compounds of interest. Toxicity studies were done via two routes of exposure (percutaneous (PC) and intravenous (IV)) in two species: Goettingen minipigs and New Zealand white rabbits. During the course of the studies a computerized, physiologically based system of clinical sign-taking was developed. With the advent of the new system, the addition of the minipig for PC testing and guinea pig and non-human primate data from sister laboratories, it was recognized that our understanding of PC toxicity was species-specific to the rabbit, and the clinical picture of toxicity was not what had been previously thought. This briefing will present the toxicological data, the methodology for and human toxicity estimates so-developed, and the lessons learned.

### 11881 - Transportation Networks, Game Theory, and Vulnerability Mitigation

The National Planning Scenarios (NPS) are a set of 15 high consequence scenarios encompassing CBRNe (Chemical, Biological, Radiological, and Nuclear explosives) events as well as natural disasters such as earthquakes and hurricanes. The majority of scenarios will require over half of the affected population to evacuate, yet prevalent simulation tools lack a detailed transportation component. This presentation summarizes our research to mitigate the vulnerability of transportation networks so that they will be available when needed.

We extend game theoretic research [1] that established a preliminary model to characterize transportation network vulnerability. We combine algorithms from game theory and transportation engineering into a vulnerability minimization framework. This combination enables greater flexibility than traditional game theoretic approaches, which impose a single set of rules in a static setting where the game is played. Our game permits the defender to allocate finite resources to modify the game in a manner that optimizes their payoff, namely minimizing network vulnerability.

References

Wargaming What You Would Rather Not

Wargaming, whether it involves tokens on a board, SME’s in a smoke filled room, or sophisticated (at least large) computer simulations with some human in the loop (HITL) decision making, is often about predicting outcomes based on decisions we make as the “play” proceeds. In many instances, the outcomes are ones from history or at least are something within our recent experience—we have seen these outcomes, or their ilk, before. We thus can gauge “Is this wargame making sense?” and have some feeling as to the validity of what we learn from it. What then, when the potential outcomes from a wargame are things we have not experienced or hope, fervently, never to experience. These would include things like global-thermonuclear war, a continent-clearing bio weapon (smallpox as a part of the Columbian Exchange), or even chemical/biological warfare on a scale not seen since WWI. Does the rarity/severity/uniqueness of potential outcomes, impose any special considerations on how a wargame should be conducted or the interpretation of the results? This will be a discussion of available theory/thought and practice as experienced by the participants. This presentation will segue into a discussion of a recent wargame that looks at Chemical, Biological, Radiological and Nuclear (CBRN) warfare, something we hope not to see for real.

WG 3 Infrastructure Analyses, Protection and Recovery

The Military Installation Resilience Assessment (MIRA) is a multi-layered, social-ecological-system based, series of analyses that uses stakeholder input to map and evaluate mission-essential systems as a whole, considering key interconnections and feedbacks as fundamental elements rather than overlooked intricacies. MIRA is made up of four primary components: Risk Analysis, Ecological Resilience Analysis, Stakeholder Analysis, and Systems Interface Analysis. The analyses in each of these components are simplified by a couple guiding principles: 1) only assets that meet MIRA criteria are examined and 2) the Rule of Hand whereby the most important factors affecting resilience can be understood by analyzing a few, usually 3-5, key variables. MIRA uses metrics based on relative criteria that score resilience in a holistic sense, considering the overall system. Metric scores are weighted using a normalized scale of importance values and summed for each major component to assess the potential resilience of mission-essential systems. Potential sources of vulnerability are identified during the scoring of each resilience metric and/or in the risk analysis. Military projects that address MIRA results, are expected to enhance not only installation infrastructure resilience, but resilience that is directly tied to the military mission.

Understanding the Contribution of Adaptation to Making Systems Resilient

Adaptation is broadly understood to make systems more resilient. Unlike measures taken to prevent disruptions or to recover from them, quantifying the contribution of adaptation to system resilience has received little attention. In part this is because adaptive responses are often conceived of as involving extraordinary processes or features that are not involved in the ordinary functioning of the system. This conceptualization makes it difficult to place bounds on the scope of possible adaptive responses. Instead, thinking of adaptation as a continually operating process that gives rise to the properties of the system helps delimit its contribution to the system’s response to an acute disruption.

We study the effect of adaptation in a stylized model of diffusive flow through a network with capacity-limited links, regularly subjected to disruptive shocks. Disruptions cause the system to build a structure of alternative pathways which maintain some level of performance during episodes of disruption. The power of this adaptive response to confer protection against large-scale disruption is systematically explored. We consider a range of disruption frequencies and capacity costs to understand how these factors influence the tendency of the system to build redundant pathways. We find that the system achieves some trade-off between efficiency in nominal conditions and resilience to acute disruptions, but that this trade-off is generally not optimal from a system viewpoint.
### 12037 - Infrastructure Analytics – Enabling Army Stationing Analyses

**Infrastructure Analytics – Enabling Army Stationing Analyses**

The Army needs to develop infrastructure analytics that will enable fact-based decision-making across a continuum of infrastructure challenges. Infrastructure analytics can inform three decision levels including 1) the day-to-day or tactical stationing decisions, 2) installation best practices and efficiency that influence operational costs, and 3) strategic infrastructure studies, i.e., 2005 Defense Base Closure and Realignment Commission (BRAC 05) or the recent European Infrastructure Consolidation study (EIC). The repeated issues noted in After Action Reviews from strategic infrastructure studies over the last 10 years and feedback from think tanks necessitates improved analytics. This initiative will support upcoming infrastructure decisions as force reductions, modernization, readiness tradeoffs, and mounting personnel costs make the ability to maintain current infrastructure fiscally challenging.

CAA recognizes that current analytic capabilities must be revisited to meet today’s challenges. For example, today’s Army operates in a world with a greater emphasis on energy, climate change, sustainability, and infrastructure resilience than in the past; analytics need to address these concepts. CAA is conducting a focused multi-year effort to improve infrastructure analytics, synchronize efforts across users, and build a community capable of addressing infrastructure challenges. CAA’s stationing expertise and position in the analytic community uniquely positions it to develop the rigorous and objective analytics needed to provide a viable starting point for future infrastructure decisions.

Infrastructure analytics represents a strong multidisciplinary initiative to conduct statistics, simulations, optimization, data-mining, and other methods to provide the models and supporting structure needed to inform the three stationing decision levels. With a large footprint and many units to station, an infrastructure analytics initiative becomes an enabler to lower Army infrastructure costs.

### 11838 - The Impact of Revenue Portfolio on the Performance of Critical Infrastructure

**Road transportation, like many of the Nation’s critical infrastructures, rely on tax revenues. Tax revenues which fund this infrastructure are often levied in many forms, collected by numerous levels of government. Overall, we can expect that variation in tax receipts will translate to variation in road transportation funding. Variation in funding will likely affect planning regarding roadway construction, preservation and maintenance. Thus, the portfolio of taxes funding a region’s road infrastructure may determine the resilience of their roadway system. Using panel data on county-level road expenditures, this study examines variability of tax revenues allocated for road transportation using a volatility model based on portfolio theory. Additionally we explore how deviation from an ideal tax portfolio translates to system performance. This study will help to understand how the business cycle may affect critical infrastructure resilience.**

### 12284 - Protecting Water Infrastructure: Using Portfolio Decision Analysis to Select an Optimal Suite of Security Preparedness Measures

**Counterterrorism decisions for infrastructure security can be challenging due to resource constraints and the large number and scope of potential targets and threats to consider. This paper presents a multi-criteria portfolio decision analysis (PDA) model that optimizes countermeasure selection to maximize effectiveness under various counter-terrorism budget levels. In this approach, multi-criteria decision analysis (MCDA) is used to assess the total benefits of protective countermeasures when applied to key infrastructure in specific threat environments, and a budget-constrained linear programming optimization model maximizes total protective value for various funding levels, considering the effect of relationships between projects. The resulting scores, cost estimates, and synergistic or redundant interactions between projects are used to construct an efficient funding frontier that tracks how budget changes affect optimal portfolio composition. Results are presented for a case study based on literature data and author judgment optimizing protection against terrorist threats to a city-scale water storage, treatment, and distribution network.**
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<td>Thomas Sharkey</td>
<td>Jonathan Holman, John Mitchell, Huy Nguyen, Prof. William A Wallace</td>
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**11959 - On the Value of Information-Sharing in Interdependent Infrastructure Restoration**
We consider the problem of restoring multiple disrupted infrastructure networks after an extreme event. Each infrastructure has its own restoration resources that will repair damage done to its components in order to bring services back online. This work analyzes the loss in restoration effectiveness resulting from decentralized restoration efforts across infrastructures and how information-sharing can reduce this loss. Computational results based on realistic damage scenarios to infrastructures are presented.

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**12079 - Operational Models of Infrastructure Resilience**
We propose a definition of infrastructure resilience that is tied to the operation (or function) of an infrastructure as a system of interacting components and that can be objectively evaluated using quantitative models. Specifically, for any particular system we use quantitative models of system operation to represent the decisions of an infrastructure operator who guides the behavior of the system as a whole, even in the presence of disruptions. Modeling infrastructure operation in this way makes it possible to systematically evaluate the consequences associated with the loss of infrastructure components, and leads to a precise notion of “operational resilience” that facilitates model verification, validation, and reproducible results. Using a simple example of a notional infrastructure, we demonstrate how to use these models for (a) assessing the operational resilience of an infrastructure system, (b) identifying critical vulnerabilities that threaten its continued function, and (c) advising policy makers on investments to improve resilience.

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**12330 - Transportation Networks, Game Theory, and Vulnerability Mitigation**
The National Planning Scenarios (NPS) are a set of 15 high consequence scenarios encompassing CBRNe (Chemical, Biological, Radiological, and Nuclear explosives) events as well as natural disasters such as earthquakes and hurricanes. The majority of scenarios will require over half of the affected population to evacuate, yet prevalent simulation tools lack a detailed transportation component. This presentation summarizes our research to mitigate the vulnerability of transportation networks so that they will be available when needed.

We extend game theoretic research [1] that established a preliminary model to characterize transportation network vulnerability. We combine algorithms from game theory and transportation engineering into a vulnerability minimization framework. This combination enables greater flexibility than traditional game theoretic approaches, which impose a single set of rules in a static setting where the game is played. Our game permits the defender to allocate finite resources to modify the game in a manner that optimizes their payoff, namely minimizing network vulnerability.

References
12541 - Impacts of Increased Reliance on Natural Gas

"Significant improvements in extraction technology and development of new gas plays in the United States over the last decade have made available an abundant supply of inexpensive domestic natural gas. The increase in supply has resulted in an increased reliance on natural gas for power generation and manufacturing in addition to the possibility for potential export. Widespread and increased dependence on readily available and inexpensive natural gas will likely increase the potential risks to supporting and interdependent infrastructure. The potential result is an inability to link supply with demand, with national and regional implications as natural gas shortages can impact other interdependent critical infrastructure.

This presentation summarizes NISAC’s current effort to identify, model, and analyze the most probable risks associated with the Nation’s increased reliance on natural gas production and consumption by examining the ability of existing natural gas infrastructure to meet current and future demand and to assess the risk to continuity of operations. The analysis will focus on a national to regional-level, identifying specific regions or States are most likely to experience natural gas shortages due to pipeline constraints during normal and disruptive conditions."

11831 - An Agent-Based Model of the U.S. Natural Gas Infrastructure: Analysing Disruptions

We present an agent-based model of the U.S. Natural Gas infrastructure. This model has been constructed at Sandia National Laboratories and aims at representing the effects of long- and short-term shocks to the natural gas system. We use agent-based and network modeling to represent agent behaviors, such as production, consumption, and storage; investment decisions, such as construction of LNG export terminals or construction of new pipelines. We calibrate the model to available data at individual supply, local distribution, storage, and pipeline level. We analyze resulting price dynamics, local natural gas availability, and pipeline network capacity utilization. This model can be used to understand the effects of acute disruptions, such as pipeline flow constraints; chronic disruptions, such as persistently high or low demand or supply from a specific geographic area, and investment choices, such as additions of export terminals or new pipeline networks. This agent-level, geographically specific approach allows representing possible path dependencies and lock-in effects, as well as system evolution and emergent behaviors. Our approach enables investigating scenarios where no historic data exists to represent the effects of possible agent actions, system operators’ responses, and regulatory changes. We illustrate the model with stylized scenarios of supply and pipeline disruptions and quantify the impacts using such metrics as changes to the network flows, local prices, and local natural gas availability. We further discuss the ways to quantify the network resilience using these metrics.

12243 - Epidemiology by the Numbers

Global pandemics are not new, however the threat of a pandemic is made more acute with rapid international travel and the emergence of unknown pathogens. This presentation will examine the source of pathogens, the types, their modes of transmission, and their effects and models. The discussion will include actions taken to address the pathogens and if there was a hostile intent (biological warfare) in the spread of disease and implications in CWMD.
WG 4 Homeland Security, Homeland Defense and Civil Support

11720 - Aerospace Control Operational Risk Assessment due to Wind Turbine Farms near Critical Infrastructure

The presence of large wind turbine farms has been shown to significantly degrade radar tracking of aircraft. As wind turbine development expands, the North American Aerospace Defense Command (NORAD) must assess the operational risk to its aerospace control mission due to new turbine proposals near critical infrastructure. If the operational risk becomes significant, NORAD must raise its concerns through the Department of Defense (DoD). New models, specifically designed to address wind turbine interference with ground-based radars, are utilized to simulate both the losses in radar tracking continuity from wind turbine obscuration and the resulting impact this has on operations. Two analytical approaches, Monte Carlo and a convolutional “Direct Probability”, are considered to compute the probability of successfully intercepting an unauthorized aircraft. The probability of success is computed for candidate routes over a range of aircraft velocities and under various conditions (no turbines, existing turbines, and expected future turbine development) to measure the contrast in probability of success lost as a direct result of turbine development. The presentation will focus on the new model and the results of its first use in an operational risk assessment.
11709 - NORAD Arctic Surveillance Study

This study, requested by the North American Aerospace Defense Command (NORAD) Deputy Commander, aimed for a comprehensive high-level understanding of NORAD surveillance requirements and near-term options in the High Arctic. Predicated by the need to renew and upgrade the current North Warning System, the study first looks at NORAD forward fighter basing and reach in the Arctic. It then draws surveillance requirements with respect to Arctic sovereignty, aircraft identification, infrastructure defence, and cruise missile defence. These requirements are based on the time required to intercept incoming threats with forward-based NORAD fighters. Finally, it considers selected options for satisfying the identified surveillance requirements, focusing on line-of-sight and over-the-horizon radar dispositions. Maritime surveillance systems are also investigated. The study was delivered to the Commander NORAD and USNORTHCOM, and is influencing strategic decisions concerning the future of NORAD.

11825 - Analyzing the International General Aviation Pathway Into the United States

The domain of international general aviation (IGA) includes all private, corporate, and certain on-demand charter flights entering the United States from a foreign airport of departure. These flights do not have to meet the same security measures as their scheduled airline counterparts, which creates vulnerabilities that needs to be addressed in safeguarding the United States from terrorists and weapons of mass destruction. In an elevated threat situation, senior government authorities will need a variety of flexible risk mitigation strategies for IGA operations. Within the Department of Homeland Security, a multi-agency working group has been formed to study the IGA problem. To support this Working Group, ENGILITY CORPORATION – under contract to the Domestic Nuclear Detection Office – has performed extensive data mining and analysis of three years of FAA data on IGA flights and has combined this with authoritative aircraft performance data. The resulting analysis illuminates the flows of IGA flights into the United States – their departure and arrival airports, the capabilities and types of aircraft used, and the frequency of flights, as well as some of non-standardized ways in which the data has been collected and how those problems have been managed. The data has been used to support a variety of modeling and simulation activities to determine different ways we can protect critical infrastructure and population centers by redirecting flights. This talk will outline the data analysis, challenges faced, and observations for similar work.

12251 - North American Air Domain Awareness – Surveillance (NAADAS) Analysis of Alternatives (AoA) – Findings from the Effectiveness Analysis Working Group

The purpose of the North American Air Domain Awareness – Surveillance (NAADAS) Analysis of Alternatives (AoA) was to identify potential solutions to validated DoD surveillance gaps and shortfalls, and DHS requirements, and to provide DoD and DHS decision-makers with information for potential acquisition decisions. The AoA examined four individual sensor alternatives, and one Force Mix alternative, for ability to detect and track airborne objects under various natural and manmade environmental conditions. The analysis assessed alternatives for operational effectiveness, suitability, risk, and life-cycle costs. This presentation focuses on operational effectiveness as reported by the Effectiveness Analysis Working Group (EAWG) team. The study considered five suitability Measures of Effectiveness (MOEs) and four performance MOEs. Metrics measured the performance of the baseline system and alternative architectures for a variety of threats in order to quantify the degree to which each surveillance system handled these potential threats. Effectiveness was measured as additional capability to the existing suite of baseline sensors, which included the current Joint Surveillance System (JSS) and FAA radars with all planned upgrades through fiscal year 2016. The study evaluated alternatives with the potential for first-article fielding between 2014 and 2020 and projected 2020 operational capabilities. All alternatives were assessed against the same set of airborne threats. Accredited mission-level modeling tools were used to perform the analysis, and systems were modeled at comparable levels of fidelity to allow for statistically equitable comparisons. A brief discussion of modeling techniques will be included along with the overarching findings of the EAWG.
### 11899 - Heterogeneous Data Fusion in Threat Detection

This paper discusses new methods for heterogeneous information fusion in assessing the terrorism threat posed by a person under scrutiny. The information available may be qualitative or quantitative, hard or soft, and well or poorly structured. Major discrepancies may exist across information sources. Some of the information may even be maliciously false. All of the information is uncertain, sometimes highly so. One of the challenges has been to assure that realistic complex expressions of information can be represented along with its uncertainties (e.g., information with combinations of conjunctions, disc junctions, and complements). Another is to represent the various fragments of information in a way that allows subsequent fusion. A third is to provide well-structured ways to introduce the subjective human judgments that are essential in such work. Fusion itself may be accomplished with a variety of different approaches that include algebraic, Bayesian, “quasi” Bayesian, and a new entropy-maximizing method. A core concept overall is that assessment will require such a variety of approaches, the contrasting of results, and exploratory analysis to understand how conclusions vary with the most important assumptions or choices about approach. Overall, a goal is to improve the likelihood of detecting threats while simultaneously reducing the likelihood of false alarms.

### 11903 - Heterogeneous Information Fusion That Maximizes Entropy

Lead Author: John Hollywood

This paper discusses a specific new method employing convex programming for fusing disparate reports on the potential terrorist threat posed by a person under scrutiny. It is part of research carried out under the initiative discussed under [ABSTRACT 1]. The method yields estimates of threat level probabilities that are as conservative (i.e., uncertain, in an information-theoretic sense) as possible given what has been reported about a subject. This method specifically recognizes that assertions about the threat a subject poses, or factor contributing to that threat, are just that – assertions. The method accounts for the reliability of these assertions, placing more weight on the most credible and salient claims. It also has no difficulty fusing directly conflicting assertions. Further, complexity of the method grows in low-order polynomial time of the number of assertions about a person under scrutiny rather than exponentially, as is the case with other fusion methods; the method has been implemented using Microsoft Excel’s built-in Solver.

### 11741 - Identifying and Structuring the Objectives of the “Islamic State of Iraq and the Levant” (ISIL) and its Followers

This study addressed three questions:
1. What are the objectives of the leaders of ISIL?
2. What are the objectives of the followers of ISIL?
3. How are the two sets of objectives related?

To answer these questions we analyzed the transcripts of interviews and presentations of 59 subject matter experts (SMEs) and conducted a separate analysis of speeches of ISIL leaders and selected Internet sources. In both efforts we identified and structured the strategic, fundamental, and means objectives of ISIL and its followers. The results indicate that ISIL’s leaders pursue four strategic objectives: Establish a Caliphate in Iraq and the Levant, Control and Govern the Caliphate, Expand Islam and Sharia Law Worldwide, and Recreate the Power and Glory of (Sunni) Islam. The followers’ objectives can be partitioned into three strategic objectives: Humanitarian Fulfillment, Religious Fulfillment and Personal Fulfillment. The objectives identified from the SME interviews were similar to those identified from ISIL leaders’ statements and the Internet. However, the Internet search revealed many more personal objectives of ISIL followers. The results further indicate that ISIL’s leadership objectives are closely aligned with those of its followers. There also is a sharp contrast between the objectives of ISIL and those of Al Qaeda, particularly ISIL’s emphasis on occupying and controlling territories on Iraq and Syria vs. Al Qaeda’s focus on worldwide jihad.
It will identify some obstacles that delay and/or prevent writing the Improvement Planning documentation, the challenges confronted by presentation will focus on the time frame and tasks between the Exercise and the actual writing of an Improvement Planning document. This is a job for Operations Analysts who are not often recognized as critical (or at all) in the Exercise Process. This resource availability, and other factors to determine an optimal allocation solution.

Geographic modeling and linear programming combine risk exposure, projected risk exposure uncertainties, risk reduction metrics, and other factors to determine an optimal allocation solution.

This project integrates security activity modeling, risk assessment, resource optimization, and a dynamic planning process.

Operations (MSRO) based on risk reduction benefits. Now, rather than striving to complete a pre-determined number of activities, application of a risk-based view for conducting operations as opposed to a strict activity based protocol, focusing limited resources on those activities that provide the greatest risk reduction impact.

In 2015, the USCG completed implementation of a service-wide pilot project to prioritize Maritime Security Response Operations (MSRO) based on risk reduction benefits. Now, rather than striving to complete a pre-determined number of activities, Captain of the Port enforcement branches coordinate assets to maximize risk reduction across projected MSRO activity demand. Performance measurement includes a percentage of risk reduced against a specific, port-level risk reduction target considering the optimal risk reduction potential of available resources against actual MSRO activity demand.

This project integrates security activity modeling, risk assessment, resource optimization, and a dynamic planning process. Geographic modeling and linear programming combine risk exposure, projected risk exposure uncertainties, risk reduction metrics, resource availability, and other factors to determine an optimal allocation solution.

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**11627 - The Rugged Trail to Emergency Management Improvement Planning**

Emergency exercises are designed to test and practice emergency plans by those who work in the facility on a regular basis. The Exercise Process is often shown as a process with these general steps: Strategic Plan, Design and Develop, Conduct and Evaluation, and Improvement Planning. This Process seems straightforward and uncomplicated, but in practice it takes a great deal of time and effort. Most organizations have a mandatory requirement to conduct an annual emergency response exercise. This requirement provides a false goal because the Exercise itself is in the middle, not the end of the Process. Analysis, evaluation and review task all occur after the Exercise. Compiling and analyzing the results are paramount to the next step: develop the Improvement Planning document. This is a job for Operations Analysts who are not often recognized as critical (or at all) in the Exercise Process. This presentation will focus on the time frame and tasks between the Exercise and the actual writing of an Improvement Planning document. It will identify some obstacles that delay and/or prevent writing the Improvement Planning documentation, the challenges confronted by the analysts, and suggestions overcoming these obstacles based on actual exercise experiences.

**12619 - Detecting Unmanned Aircraft**

"Unmanned aircraft systems (UAS), commonly known as drones, pose a substantial and increasing risk to critical infrastructure. Drones could — accidently or intentionally — collide or interfere with aircraft, communication antennae or towers, and electric or gas delivery systems. Small, inexpensive, and commercially available drones can deliver 20-pound payloads at speeds of 40 miles per hour. These payloads could contain explosives; radiological, chemical, or biological material; and imaging, acoustic, and electronic surveillance equipment. Drones can land on rooftops, hover near windows, or fly over ground-based physical protection to deliver cyberattacks that can steal sensitive information or attack industrial control systems.

The risk posed by UAS is difficult to mitigate because they are difficult to detect with existing technology. To mitigate the risk, what information must the detection system provide? Towards developing an effective detection method, we describe the requirements of a UAS detection system, the properties and limitations of potential sensors, and the challenges of deploying sensors. We then provide recommendations for future research and development.

More research is needed to detect and characterize the communication to and from drones, especially the communication channel controlling the drones. We conclude by presenting our initial work towards detecting drone communication and identifying the location of the drone’s controller."

**12408 - Risk Basing Maritime Security Response Operations (RBMSRO) for the US Coast Guard**

The United States Coast Guard conducts daily maritime security activities, including port patrols, vessel escorts, and security zone enforcement. Traditionally, port security activity prioritization focused on maintaining minimum activity levels for various security activities. The increasing sophistication of Coast Guard risk assessment and analysis tools enables increasingly refined estimation of the risk reduction benefits of maritime port security activities. Assisting risk reduction for various port security activities permits application of a risk-based view for conducting operations as opposed to a strict activity based protocol, focusing limited resources on those activities that provide the greatest risk reduction impact.

In 2015, the USCG completed implementation of a service-wide pilot project to prioritize Maritime Security Response Operations (MSRO) based on risk reduction benefits. Now, rather than striving to complete a pre-determined number of activities, Captain of the Port enforcement branches coordinate assets to maximize risk reduction across projected MSRO activity demand. Performance measurement includes a percentage of risk reduced against a specific, port-level risk reduction target considering the optimal risk reduction potential of available resources against actual MSRO activity demand.

This project integrates security activity modeling, risk assessment, resource optimization, and a dynamic planning process. Geographic modeling and linear programming combine risk exposure, projected risk exposure uncertainties, risk reduction metrics, resource availability, and other factors to determine an optimal allocation solution.
### 12411 - Quantifying the Risk Reduction Value of Coast Guard Maritime Security Activities

The United States Coast Guard (USCG) implements an annual maritime terrorism risk assessment process, drawing on field analysts’ judgment to acquire maritime data. Field analysts utilize the Maritime Security Risk Analysis Model (MSRAM) to capture port level targets, analyze risks, and assess interagency impacts on port security. MSRAM outputs subsequently inform maritime critical infrastructure key resource list development; ports, waterways, and coastal security mission performance; FEMA’s port security grant program; and other USCG efforts.

MSRAM’s risk evaluation methodology derives its basis from the Department of Homeland Security (DHS) Risk Management Fundamentals doctrine, which asserts that risk is a function of threat (T), vulnerability (V), and consequence (C). Consistent with this definition, MSRAM applies a probabilistic risk assessment approach to compute the relative risk of maritime terrorist threats applying the DHS function as the product of estimated T, V, and C values.

The USCG developed and implemented a methodology using MSRAM data to further assess the risk reduction impacts of maritime security activities. The methodology combines MSRAM risk assessments with activity effectiveness judgments to generate risk reduction values for different activity, asset, and domain combinations. The risk reduction value of each activity are tailored to Coast Guard Captain of the Port operating areas and provide a new means for the Coast Guard to evaluate the effectiveness of its port security efforts.

### 12410 - Analyzing Maritime Risk Reduction Performance and Asset Return-on-Investment Curves

The United States Coast Guard implements an annual maritime terrorism risk assessment process, drawing on field analysts’ judgment to acquire maritime terrorism risk data. Field analysts utilize the Maritime Security Risk Analysis Model to capture port level targets, analyze risks, and assess interagency impacts on port security.

In 2015, the Coast Guard completed implementation of a service-wide pilot project to prioritize maritime security activities based on risk reduction benefits. Performance measurement includes a percentage of risk reduced against a specific, port-level risk reduction target considering the optimal risk reduction mitigation of available resources against MSRO activity demand. Sensitivity analysis provides insights towards the return-on-investment (ROI) value of resources, in terms of risk, of additional maritime security effort for a given port. Development and analysis of risk reduction ROI curves provides new insights into the relative value of modifying resource levels and maritime security activity emphasis across different ports. This information provides resource planners with new insights as to the relative value of resource efforts across multiple domains and a justification for the surging and re-leveling of maritime security resources.

### 12619 - Detecting Unmanned Aircraft

"Unmanned aircraft systems (UAS), commonly known as drones, pose a substantial and increasing risk to critical infrastructure. Drones could — accidentally or intentionally — collide or interfere with aircraft, communication antennae or towers, and electric or gas delivery systems. Small, inexpensive, and commercially available drones can deliver 20-pound payloads at speeds of 40 miles per hour. These payloads could contain explosives; radiological, chemical, or biological material; and imaging, acoustic, and electronic surveillance equipment. Drones can land on rooftops, hover near windows, or fly over ground-based physical protection to deliver cyberattacks that can steal sensitive information or attack industrial control systems.

The risk posed by UAS is difficult to mitigate because they are difficult to detect with existing technology. To mitigate the risk, what information must the detection system provide? Towards developing an effective detection method, we describe the requirements of a UAS detection system, the properties and limitations of potential sensors, and the challenges of deploying sensors. We then provide recommendations for future research and development.

More research is needed to detect and characterize the communication to and from drones, especially the communication channel controlling the drones. We conclude by presenting our initial work towards detecting drone communication and identifying the location of the drone’s controller."
In light of the recent unauthorized disclosures of classified information, increased insider threat and cyber intrusions, industrial security has come to the fore in national security discussions. In this paper, we approach personnel security clearance process as a fundamental component of industrial security operations and explore its widely noted deficiencies to identify systemic causes and associated risks. Leveraging a systems thinking perspective, we first situate personnel clearance process within the “National Industrial Security Program” (NISP), which is part of a broader security system. We then compile various performance issues in personnel clearance process as identified in publicly available government audit reports, group them into two categories (process deficiencies and gaps in enterprise operations) and explore their underlying causes. We propose that the noted performance issues can be traced back to a common systemic shortcoming: underdevelopment or misalignment of NISP governance. To provide our initial proof of concept, we propose a preliminary analytic framework for governance, by qualitatively synthesizing common elements of governance definitions from different domains into six key attributes. We define elements of these attributes and explore instances in the context of personnel clearance process, uncovering causal linkages between performance deficiencies and these attributes. With the help of a causal loop diagram, we visually portray these linkages and discuss the interdependent nature of performance problems. We argue that a resolution of the problems associated with clearance process requires a reconsideration of NISP governance and better alignment of governance attributes with the NISP mission and its requirements.
### 12347 - Electric Fire

Friendly and Threat manipulation of the electromagnetic spectrum using Electric Fires (EF) will bring a new genre of weapons to the battlefield capable of bringing effects ranging from hard to soft kill from the same weapon. In coordination with Army Staff elements, Army Cyber Command, and Fire Center of Excellence, the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMD/ARSTRAT) and the Future Warfare Center (FWC) characterized EF systems that impact Friendly and Threat equipment or forces and investigated those effects on operational tempo, overall force effectiveness, and collateral damage or EF fratricide. EF definitions, capabilities, and characteristics were determined through a series of technical interchange meetings with concept of operations and tactics, techniques, and procedures defined during a map exercises given relevant operational contexts. The outputs from the technical interchange meetings and map exercises were modeled in Joint Conflict and Tactical Simulation (JCATS) and Systems Effectiveness Analysis Simulation (SEAS) to determine Friendly and Threat effectiveness impacts. Results of scenario development, technical interchange meetings, map exercises, and constructive analysis will be presented.

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<td>Mr. Martin Goodman</td>
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### 12503 - A Construct for Categorizing and Analyzing Cyberspace Range Requirements

New demands for training the Department of Defense’s (DoD) Cyber Mission Forces have led to an intense examination by different organizations to better understand the capabilities and capacity required of cyberspace ranges and simulators to support progressive development of the force. One of those organizations, the DoD Enterprise Cyber Range Environment (DECRE) advisory group is responsible for synchronizing DoD cyber range capabilities, mitigating duplication of effort, and optimizing the use of limited resources for its member ranges. DECRE recently addressed cyberspace range environment requirements from U.S. Cyber Command (USCYBERCOM) to determine the extent that current DECRE capabilities meet USCYBERCOM requirements and to assess the gaps between the two. The assessment process revealed a distinct lack of organization of the elements required to develop and execute cyberspace range events. U.S. Strategic Command, in coordination with the four major cyber range providers, developed a methodology for categorizing the requirements to capture the myriad of capabilities needed to successfully accomplish events in a controlled, closed-loop network. The methodology proved useful in screening new requirements and developing a better understanding within the community of the scope of capabilities required to conduct continuous and consistent team training, mission rehearsal and testing in cyberspace range environment.

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<td>Mr. Christopher Patrick Bakke</td>
<td>Dr. Jeffrey J. McNeil</td>
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### 12248 - Low Cost Cyber Security Testing on a Virtual Cyber Range

In 2014, we described a Virtual Emulation Environment (VEE) that could realistically emulate whole networks on a laptop with bit-level fidelity and precise timing for highly realistic, but much lower cost network and cyber testing. This year we present examples of the actual use of that system to support multi-network cyber testing within the Intelligence Community (IC).

Because the virtual network under test is produced by reverse engineering it from its external data, the resultant virtual network is an identical clone of the real network using actual internet software and virtualized hardware. That virtual hardware portrays the servers and other devices down to the details of specific vendor models and places them in specific virtual geographic locations to address timing issues. Using VEE, the clone then emulates the real network to the extent that IC reviewers cannot tell the real from the virtual packet traffic. The baseline Virtual Cyber Range (VCR) is composed of only three laptops. One laptop operates as a virtual switch to support plug and play between virtual networks and live networks composed of a wide range of devices/products. Despite its small size the VCR virtualizes hundred servers and tens of thousands of networked devices and can be expanded by simply adding another laptop. The VCR requires minimal support with no special facilities, power, or cooling.

This briefing describes the current VEE, discusses some of the uses being made of the VEE-enabled laptops by IC test organizations, and outlines the future expansion of this concept.

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<td>Mr. Charles D. Burdick</td>
<td>Dr. Deepinder Sidhu</td>
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systems, such as decoys. To bridge this gap, analysts at COMSUBDEVRON TWELVE have developed a hex-board table game, the Low Resolution Tactical Simulation (LRTS), which provides first-order analyses of tactical scenarios at a tiny fraction of real-world cost and effort. This presentation discusses how this analysis makes explicit the best deception tactics, including insight on how to leverage deception for more successful submarine approach and attack.

Malicious network anomalies that lack a clear prior signature for detection, such as zero-day attacks or other non-standard attacks, pose a significant threat to cyber security. They are often immune to conventional safeguards, such as library-based anti-virus software packages, and can cause billions of dollars’ worth of damages, as evidenced by recent attacks at Target and Home Depot. In this work, we propose a novel approach to employ multivariate hierarchical clustering, linear regression, and expert knowledge in a self-learning outlier detection scheme to identify outliers within large amounts of highly dimensional network traffic data based solely on their current behavior, rather than previous attacks. This approach has been tested on notional attack scenarios with simulated network traffic data for a U.S. government client and has shown the ability to identify outliers with approximately 99% reduction in human analyst time.

The mission of Commander, Submarine Development Squadron (COMSUBDEVRON) TWELVE is to develop, assess and improve submarine tactics and shape the future capabilities of the submarine force. Operations Research plays a vital role in each aspect of this mission, but decreasing budgets have made it harder to gather sufficient at-sea data to appropriately support tactical development, particularly for analysis of future capabilities. Among the future capabilities most difficult to analyze are military deception (MILDEC) systems, such as decoys. To bridge this gap, analysts at COMSUBDEVRON TWELVE have developed a hex-board table game, the Low Resolution Tactical Simulation (LRTS), which provides first-order analyses of tactical scenarios at a tiny fraction of real-world cost and effort. This presentation discusses how military, civilian and contractor staffs have employed game-driven analysis to develop tactical guidance for autonomous decoy employment well before crews put to sea. As a result of these efforts, at-sea acoustic range time is more effectively used, data collection efforts are better focused and post-exercise analysis is much better informed. In addition, the presentation will show how this analysis makes explicit the best deception tactics, including insight on how to leverage deception for more successful submarine approach and attack.
that the computer will need to be brought to an IT professional to be fixed and will hopefully be noticed in the professional's analysis of the computer through more aggressive means such as DNS poisoning or host file modification. The philosophy behind these actions is the spectrum of malware infections such as RKill and ComboFix. If we are unsuccessful in the initial cleansing, we will attempt to detach the system. To achieve this cleansing, we will leverage several Free Open Source (FOSS) software products available to alleviate a wide array of malware without any programming of code.

Cleaning from the Inside Out: Deconstruction of Botnets

Botnets are formed by computers affected through an infection vector such as installing malicious software or visiting a malicious web site while using unpatched software such as Adobe Flash or Java. Once infected, these computers are typically controlled through a command and control (C&C) communication channel, e.g. Internet Relay Chat (IRC), in order to perform tasks such as: spamming, mining bitcoins, or infecting/attacking other computers. We posit that this infection vector will remain open, and unpatched, throughout the lifetime of the computer's infection.

By piggybacking the initial infection vector, we can access these computers and detach them from the botnet through benign means (cleansing), or more aggressive means like detachment by isolation (modifying the hosts file). While cleansing is clearly preferable, we entertain the option of detachment through less sophisticated means to be successful as long as communication with the botnet ceases. To achieve this cleansing, we will leverage several Free Open Source (FOSS) software products available to alleviate a wide spectrum of malware infections such as RKil and ComboFix. If we are unsuccessful in the initial cleansing, we will attempt to detach the computer through more aggressive means such as DNS poisoning or host file modification. The philosophy behind these actions is that the computer will need to be brought to an IT professional to be fixed and will hopefully be noticed in the professional's analysis of the system.

Cyberspace Operations Analysis Task Force (COATF)

Cyberspace Operations has emerged as a key analytical focus area for the DoD analytic community, both technical and operational. At this time, multiple Army, Joint, and other service Cyberspace studies and related working groups are assessing cyber impacts on strategic, operational, and tactical operations. In the Fall of 2013, the U.S. Army Space and Missile Defense Command (USASMD) and TRADOC Analysis Center (TRAC) analysis subject matter experts (SMEs) were tasked to meet and identify potential lanes of collaboration for Cyberspace analysis. Beginning in October, 2014, TRAC and USAMDC hosted a series of meetings of the Cyberspace Operations Analysis Task Force (COATF) to determine a baseline for Army cyber analysis methodologies and develop an Army analytic strategy focused on utilization of credible analysis techniques for cyberspace analysis. The briefing will review the COATF composition, objectives, process, and progress to date – to include the emerging results of the COATF Use Case Study on Defensive Cyberspace Operations Response Actions (DCA-RA) at Corps and below.

Decentralized Cybersecurity Process Automation for Distributed Threat Mitigation

The evolution of cyber crime and advanced persistent threat of network intrusions have shown to outpace cyber defenses due to limitations of funding, technology, and willing available human intellectual capital. The current approach to network security is fragmented and human dependent, and in many cases is only as effective as the skill of the human analyst using the tools. Rule and anomaly based protection are subverted by obfuscation techniques and active response can result in in a self-induced denial of service. We present a new approach to close the gap between rapidly evolving cyber threats and network asset protection. A semantically based executable model within a configurable information modeling framework is demonstrated as a method for rapid development of automated cyber threat analysis and response. Vector Relational Data Modeling (VRDM) is demonstrated as a method to automate the correlation between multiple cyber security systems and Global Information Network Architecture (GINA) is demonstrated as a means of process definition and automation. Intrusion detection systems (IDS) create alerts that generally require human analysis to verify. We present a configurable capability that enables the semi-sentient behavior necessary to emulate the investigative procedure of an expert cyber security analyst and then execute an appropriate response based on the results of the automated investigation. This concept is a configurable, decentralized cybersecurity integration that combines the effectiveness of multiple network defense systems, makes near real time threat determinations, and establishes command links to network hardware without any programming of code.
11519 - Effectiveness of OS Diversity in a Moving Target Defense Platform

Last year at MORS we introduced our prototype Multiple OS Rotational Environment for Moving Target Defense (MORE-MTD) technology. In the year since, we’ve seen a number of high profile vulnerabilities hit the internet that demonstrate the need and effectiveness of operating system (OS) diversity as part of a defense strategy. MORE-MTD would offer an unprecedented defense against the Heartbleed OpenSSL vulnerability and the most recent glibc Ghost vulnerability. Not only would our constantly rotating platform offer increased protection against an attacker being able to probe for and exploit vulnerable systems, the versatility of the environment would allow for 100% uptime during patching and remediation.

In addition to discussing these pertinent vulnerabilities and our built-in defenses against them, we will discuss how another high profile vulnerability of 2014, ShellShock, highlighted some of the weaknesses of our current design along with our mitigation strategies moving forward to improve those weaknesses.

11682 - Optimal Deployment of Network Defenses

Defense of complex information systems is a key component of future United States Air Force operations. Defense techniques ranging from static to moving target defenses provide security to the network but also utilize valuable network resources. With an ever-growing slate of defense capabilities, optimally allocating and deploying these defenses while maintaining the ability to perform the mission is critical.

An attack vector is a sequence of steps that an attacker can use to enter the information system for some purpose. A collection of open attack vectors across an information system is an attack surface. Treating this attack surface as a network of nodes and edges, this defense configuration problem (DCP) can be seen as a network interdiction problem. In this problem, the information system defender is the interdictor and the network attacker is the evader. The purpose of this presentation is to formulate and describe the DCP as well as discuss extensions into the Dynamic Posture Problem (DPP) that more accurately represents a real-world defense problem.

12166 - Using Insider Threat characteristics in cyber ISR efforts

The CERT division of Carnegie Mellon University’s Software Engineering Institute has been studying Insider Threat incidents and related behaviors for almost 15 years. In that time, their research has developed Insider Threat behavior profiles for various types of bad actors and attempted behaviors including Insider IT Sabotage, Theft of Intellectual Property, Fraud and other negative activities. On the other end of the spectrum, one mission of Cyber ISR is to identify likely external attackers and their means, methods and motivations. This presentation explores the notion that external cyber attackers will exhibit similar profiles to internal attackers. Based on this assumption, cyber ISR efforts should be able to leverage the behavioral information amassed by CERT’s research into Insider Threat activities to provide cyber ISR assets a more defined set of indicators to use in finding external attackers.
### WG 6 Battle Management Command and Control (BMC2)

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<td>11849</td>
<td>23 Jun</td>
<td>Hilton - Beech A</td>
<td>Daniel D Wilson</td>
<td>Dr. Joseph Chapa</td>
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#### 11849 - Use of Systems Dynamics Analysis (SDA) to assess the engagement effectiveness and operational sustainability of an Integrated Air & Missile Defense (IAMD) Architecture

The IAMD operational architecture includes pre-planned engagement decisions as well as sustainment (repair, replenishment, resupply, etc.) decisions which are both essential to the Air and Missile Defense Mission and the assessment of alternative deployment architectures. Our goal was to model alternative operational architectures using a combination of Discrete Event Simulation (physics-based modeling) and Systems Dynamics Analysis (SDA) to understand the information needs required for time critical decisions that drive both the engagement effectiveness and the ability of the IAMD architecture to sustain that required effectiveness over an extended campaign. This presentation discusses our approach combining operational processes, architecture models, and timeline analysis, to identify opportunities to increase performance of future IAMD architectures. In particular, the established DOTMLPF-P representation was used as an assessment methodology to investigate alternative operational architectures for both time perspectives (single engagement raid effectiveness versus sustainment of effectiveness in an extended campaign).

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<td>11885</td>
<td>23 Jun</td>
<td>Hilton - Beech A</td>
<td>Connor S McLemore</td>
<td>Prof. Donald P Gaver, Jr.</td>
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#### 11885 - An Exploratory Campaign Analysis Tool And Real-Time Inter-Region Asset Allocation Aid

This presentation describes an exploratory campaign analysis tool and asset allocation decision-aid capable of fast operation while accounting for uncertainty in an opponent’s plan. It can be available to commanders and analysts who have limited time or a finite budget. Reconnaissance strike complexes (RUKs) represent a common military structure among today’s militaries and are made up of and integrate (1) missiles with precision-guided sub-munitions, (2) area sensors, and (3) automated C2, a system of command and control linking sensors to shooters. The usual approach to studying the performance of RUKs is to build the RUK into a standard campaign analysis model in which each of the elements (ships, aircraft, etc.) are individually tracked and interact. This high resolution modeling approach can be computationally and administratively expensive, hence the large overhead and long run-times for standard Campaign Models. We study a lower resolution model. The attributes we track are the weapons, sensors, and command and control (C2) availability over a number of geographically divided C2 regions. The model looks at a force as a system in which the platforms each have attributes rather than trying to track individual elements. A huge variety of assets can be realistically modeled in this way. The end goal is to produce a flexible model that can be used to conduct a trustworthy rapid initial exploration of a Campaign and can continuously make “good enough” recommendations to a commander for platform allocation in a theater of war based on actual and/or uncertain information about the enemy.
The investment in IT networks for military command and control (C2) centers is an extension of the ubiquitous use of computer networks in all human endeavors. These computers don’t “compute” as much as communicate, mainly for control, collaboration and information. C2 centers are now state-of-the-art electronic nerve centers with a wide array of applications. While Network Operations (NETOPS) tools are employed throughout most C2 centers to monitor the health of electronic systems, far less analytical attention is paid to user-layer patterns of control orders, collaborative work and mutual information. The kinds of questions that remain unanswered include:

Who sends an e-mail to whom? Who is participating within which chat rooms? Which portals are visited most often by the most operators?
Do users send e-mail with the same frequency/quantity? Do some users dominate chat rooms? Are there important communities of interest among all portal users?
Are military networks vulnerable to traffic analysis? Do some usage patterns spread virus more rapidly? Are collaborative networks susceptible to failure or attack?

Command and Control Network Analysis (C2NA), through a growing community of practice, seeks to objectively answer these questions. Patterns unveiled by C2NA include:

- Distribution of links among nodes, “collaboration distance” between users.
- Structural cohesiveness among collaborators, “echo chamber” effects.
- Feedback or feed-forward loops that overload usage networks under stress.
- Predictable, exploitable, long time-scale patterns or trends.

This presentation shows how practitioners of C2NA use the classic Operations Research Method to provide leaders with operational decision support.

### 12635 - Command and Control Network Analysis for JOC Operations

The Joint Concept for Operating in the Information Environment will describe how the Joint Force will gain advantage in future operations. The 2014 QDR depicts a future Information Environment that is volatile, ambiguous, and complex. The Joint Force will face a range of actors, state, non-state, and others, that leverage the information environment in support of strategic and operational goals. These actors will couple traditional information strategies such as propaganda, deception, misinformation, disinformation, subversion, and advertising to recruit, gain support, or disrupt US and coalition operations. Equally important, adversaries will conduct activities in all domains of the operational environment and will increasingly select non-military targets and audiences. These strategies use symbolic communication in place of physical effect to create a greater strategic depth. The resulting strategic gains will limit decision speed for the future Joint Force and thus fundamentally abate or compromise our ability to successfully conduct operations. Therefore, the Joint Force must be able to understand and leverage the information environment beyond the current traditional construct.

The Joint Concept for Operating in the Information Environment will lead to a normalized and ingrained understanding of the IE. Improved proficiency is paramount to regaining initiative. It is critical that the Joint Force improve its ability to analyze, characterize, and monitor the information environment, thereby, improving the ability to aggressively leverage the IE to shape potential operational areas setting the conditions to gain military advantage during Joint operations.

### 12444 - ISA Design/Implementation of a VICTORY vehicle within Army COE

Introducing a new system in to the Army’s Common Operating Environment (COE) Sensor Compute Element (CE) using the Integrated Sensor Architecture (ISA) interoperability framework can pose many challenges. This paper explores the problems, solutions, and the lessons learned for building a bridge that is capable of relaying sensor data and commands bi-directionally between ISA and a Vehicle Integration for C4ISR/EW Interoperability (VICTORY) vehicle. Common problems related to data model and behavioral differences can be overcome by diligently mapping constructs from one domain to the other. There are unique challenges when two architectures align and share information. As Army systems move toward interoperability within COE, the alignment of information between differing architectures will become a more frequent design challenge for engineers and developers. Many of the challenges faced during this process are not exclusive to the two specific architectures and could apply to similar integration efforts.

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### 12171 - Joint Concept for Operating in the Information Environment

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### Group 6

**Day & Time**: 23 Jun 14:30 - 15:00

**Location**: Hilton - Beech A

**Author/Presenter**: Mr. Jeffrey R. Cares

**Co-Author(s)**: UNCLASSIFIED

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### Group 6

**Day & Time**: 24 Jun 10:30 - 11:00

**Location**: Hilton - Walnut A

**Author/Presenter**: Mr Ronald Henry Walters, Jr

**Co-Author(s)**: Mr Rick Grimes, Mr Eric Wallace

**Classification**: UNCLASSIFIED

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### Group 6

**Day & Time**: 24 Jun 11:00 - 11:30

**Location**: Hilton - Walnut A

**Author/Presenter**: Christine L Moulton

**Co-Author(s)**: John Harrell, Ms. Lana E. McGlynn

**Classification**: UNCLASSIFIED

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### Group 6

**Day & Time**: 22 - 25 June 2015 • Alexandria, VA
Warfighting Impacts Of Adversary Counter C4ISR

LT Caleb Knapp

As Navy warfighting operations become more reliant on connected system-of-systems capabilities, we have become dependent on the high bandwidth reach-back provided by satellite communications (SATCOM) to pass mission critical Information Exchange Requirements (IERs), meet critical intelligence requirements, provide command and control, and maintain common operational picture at the operational level. However, adversaries have identified this reliance as vulnerability and are developing strategies to negate this capability.

The purpose Warfighting Impacts of Adversary Counter Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) was to identify the risks and impacts that may be suffered due to the degradation or denial of SATCOM. The study assessed the impacts on multiple missions as SATCOM to forward deployed Navy vessels was degraded and denied. Impacts of the degradation of capability and capacity to pass critical IERs were assessed from both a spatial and temporal perspective in addition to detailed analysis of possible mitigation options to show mission level impacts. These mitigation options were chosen to provide multiple robust communications paths to provide alternative routes to transmit data as part of a resilient communications strategy.

Warfighting Impacts of Adversary Counter Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR)

Measuring the Operational Impact of GPS and SATCOM Degradation

Marine Corps forces are becoming increasingly reliant on the use of the Global Positioning System (GPS) and satellite communications (SATCOM). These systems provide critical command-and-control (C2) and positioning, navigation, and timing (PNT) services, and face a variety of threats that may degrade or deny their use. We develop a methodology incorporating simulation, optimization, and queuing techniques to examine the operational impact of degraded and denied GPS and SATCOM capabilities on various Marine task forces. Given projected friendly and threat capabilities, we use our methodology to examine these operational impacts in the context of realistic combat scenarios to establish an analytic base case. The methodology and base case developed in this effort will help inform future studies on how to mitigate and overcome the impact of degraded GPS service and SATCOM connectivity.

The New Fundamentals of Assessment

Key words: Assessment, Operation Assessment, Campaign Assessment, Organizational effectiveness, Decision-making

Operation Assessment has some fundamentals that have emerged from the experience of the last several years, and that are beginning to emerge in the proto-doctrinal publications that have been published in 2015. The author, a member of the doctrinal working group, has articulated a set of principles that revise the way assessment has been done. The most important of these is that the primary purpose of assessment is to make operations more effective. It is not to "measure progress" or "inform decision-making." It is not about writing a report. It does all of these things, but its purpose is to achieve our objectives more effectively; its product is a more effective operation. This brief discusses these issues and the new vision of building assessment frameworks that comes from new manuals.

Epistemological Problems with Assessment Metrics

Key words: Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Metrics, Measures, Measure of effectiveness, Measure of performance, MOE, MOP, Indicator

The metrics regime inherent in the JP 1-02 definitions of the terms, measures of effectiveness (MOEs) and measures of performance (MOPs), and explained in publications such as the Joint Staff 7's Assessment Insights and Best Practices Focus Paper have what the author terms "epistemological problems" that complicate our mental models and confuse our thinking on assessment. This brief articulates these problems and explains the need for change. It supports and explains the changes in the definitions of these terms found in Joint Doctrine Note 1-15, Operation Assessment.
### 11926 - Advanced Topics in Operation Assessment

**Key words:** Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Aggregation, Thresholds, Commander centric

We have evolved ways of doing operation assessment that have cemented some ways of doing things that are less useful than we imagine. For example, it is common to aggregate several related indicators to achieve some sort of "score" that we imagine demonstrates our progress. However, given that the purpose of operation assessment is to make operations more effective, what we are really looking for are problems needing solution or opportunities to improve the efficiency or effectiveness of our activities. Aggregation hides these sorts of details, and obstructs the reason for doing assessment. This brief discusses this issue and others to prompt some discussion and debate, and perhaps some reconsideration of the way things are done. It also posits some helpful ways to look at some assessment problems for which metrics regimes may be less useful.

### 11906 - Owning the Technical Baseline with Model-Driven Engineering

The current U.S. Air Force’s 30-year plan (America’s Air Force: A Call to the Future, July 2014) identifies Capability Development as a key area where existing practices need to be transformed in order to keep pace with the evolving operational environment. The strategy recognizes that traditional DoD methods of requirements development, acquisition oversight, and especially systems engineering are inadequate to produce results in the desired timeframe, in a manner that is receptive to more frequent decision points. In order for these types of systems to evolve and support the type of distributed participation that the strategy envisions; they must be designed and specified to expose the necessary interfaces for future growth. This adoption of an open-systems architecture approach represents a significant engineering investment that must be accounted for in acquisition processes. We believe that in order for the U.S. Air Force (and the defense community in general) to truly realize the benefits of agile Capability Development, program offices must:

1. Strive to gain deep, technical knowledge of the system modularity
2. Specify the critical interfaces to a level of detail to allow them to be implemented in software
3. Be able to act as a system integrator to verify and validate that component implementations can interoperate successfully within the overall system

In this paper, we outline a systems engineering approach using a dynamic, executable Model-Driven Engineering methodology that we believe can help the government create the systems engineering environment required to implement agile capability development and finally reap its benefits.

### 11190 - Course of Action Generation Using Modified Evolutionary Algorithm With Periodic Mutation

Course of Action (COA) generation consists of developing a series of actions which are distinguishable, feasible, and complete, and whose expected outcomes are both acceptable and suitable, as determined by the decision makers. As systems and actions become increasingly complex, so do the methods and time required for solution. Utilizing a modified Evolution Algorithm (EA) with periodic spikes and exponential cooling mutation rates, our COA generation algorithm constructs distinguishable, high value plans in a relatively short amount of time without the restriction of the search algorithm requiring knowledge of the underlying value function. The algorithm accomplishes this through independent development of multiple breeds, and subsequently randomized reintegration in multiple, independent environments, all of which creates a structure which may be exploited for parallel processing.

### WG 7 ISR and Intelligence

**Introduction by Chairs**

Introduction to WG 7 at the 83rd MORS Symposium.
### 11925 - Assessing the Afghan Intelligence Enterprise

**Keywords:** Intelligence; Enterprise System; Assessments; Afghanistan; Resolute Support  
**Presentation Classification:** SECRET//REL TO USA, NATO, RSMA  
**ABSTRACT:** During her 2014 deployment to Afghanistan, Ms. Haskell developed and led an in-depth study of the Afghan intelligence enterprise to provide a clear assessment and metrics for the intelligence community's use in mentoring the Afghans to close this high priority, critical gap. This presentation will discuss the methodology of assessing the intelligence enterprise, the formation of the Afghan Intelligence Enterprise TAA mission and how it is bringing together diverse components from the ISAF staff, ISAF Joint Command (JUC), NATO Special Operations Component Command- Afghanistan (NSOCC-A), and the Special Operations Advisory groups (SOAGs) and ensured they functioned as a coherent team. It will also discuss how the delivery of TAA provides a framework to maximize and optimize reduced advisor capacity as the ISAF mission transitions to Resolute Support.

### 11063 - ISR asset allocation in Operation Inherent Resolve

We assessed the allocation of ISR assets in the first four months of Operation Inherent Resolve, considering how ISR needs in Iraq and Syria could be most effectively balanced with other priorities around the region. Using data we collected at the Air Force Combined Air and Space Operations Center (CAOC) at EI Udeid, Qatar, on board the U.S.S. George H.W. Bush, and at NAVCENT in Bahrain, we looked in detail at the tasking and operational tempo of Navy and other ISR assets, both traditional and non-traditional. By comparing the tasking in Iraq and Syria assigned to different assets, we assessed how the operational impact of each asset evolved over time between June and October 2014, and we weighed these impacts with the potential operational impact of assigning the assets to other tasking.

### 12086 - Optimizing ISR Coverage On the African Continent

In order to accomplish its mission, the United States Africa Command (USAFRICOM) must be able to maintain situational awareness. Unmanned Intelligence, Surveillance, and Reconnaissance (ISR) assets are one of the methods that USAFRICOM may employ to maintain situation awareness. With an area roughly three times the United States, the decision on where to establish bases and with what platforms is important to maintain a persistent situational awareness in the AFRICOM area of responsibility. This project uses mixed integer linear programming to determine optimal basing locations and the allocation of launch and recovery elements (LREs) and platforms to either maximize the total coverage over given target areas or minimize the total number of sorties necessary to maintain required coverage. We also introduce weather effects based on historic weather data on the continent and use this data to maximize the total coverage with consideration of time lost due to weather. This optimization model will help to inform ISR basing and posture decisions at USAFRICOM with its limited resources and large geographical area.
11737 - Simulating Weather Effects of ISR operations in Africa

In order to accomplish its mission, the United States Africa Command (USAFRICOM) must be able to maintain situational awareness. Unmanned Intelligence, Surveillance, and Reconnaissance (ISR) assets are one of the methods that USAFRICOM may employ to maintain situation awareness. The weather on the African continent has an impact on USAFRICOM's ability maintain the ISR required for operations. This study attempts to quantify the effects of weather for various locations around the African continent in terms of days out of the year we are able to put ISR assets on a target location and hours lost due to weather effects. Using historical mission data, we first analyze the numbers and causes of ISR mission cancellations due to weather. Next we use historical weather data to simulate ISR mission cancellations and compare it to the actual mission data. The result is an ability to judge different ISR basing locations based on their susceptibility to weather effects. This simulation study will enable USAFRICOM to demonstrate the impact of maritime ISR capability off the coasts of the continent and will also help enable future posture and basing decisions for ISR assets within the command.

12223 - Quantifying the Strategic Value of Foreign Area Officers and Language Proficiency

This report documents preliminary analyses of the strategic value of Foreign Area Officers (FAOs) and military officers with language proficiency through the lens of their productivity, citation data, and evaluation scores. The Institute for Defense Analyses (IDA) conducted this assessment at the request of the Under Secretary of Defense (Personnel and Readiness) (USD (P&R)). The strategic value of FAOs and other military officers with foreign language proficiency has been documented qualitatively in numerous reports, articles, theses, and monographs. Whereas some of these documents used survey data to support the qualitative inputs, the majority of the evidence draws on perspectives derived from interviews. One of the most common and prominent assignments for FAO is to serve as Defense Attachés. Senior leaders suggested that examining the productivity of FAOs serving as attachés would yield quantitative data reflecting their value added in that setting. Such an examination is one lens through which contributions of FAOs and military officers with language proficiency can be quantitatively considered. Using several databases (Defense Source Registry, Defense Readiness Reporting System (DRRS), etc.), IDA established a roster of individuals who had served as attachés during a three year period. Using DRRS and the Language Readiness Index (LRI), IDA identified which attaches were FAOs and non-FAOs, and their levels of language proficiency. IDA then used another DIA database to examine the productivity, citation rates, and evaluations of FAOs and military officers with language proficiency. The resulting data was analyzed and reported upon using both descriptive and basic inferential statistics.

11679 - What Friends Are For: Collaborative Intelligence Analysis & Search

Intelligence analysts face a glut of information and limited time to identify which information is relevant. Also, they are unaware of other analysts with similar intelligence problems, preventing collaboration and contributing to intelligence failure. This work outlines a model to fundamentally increase search effectiveness and collaboration by using a social network of like-minded users based on user biographies and search behavior. After entering a query, the likelihood of returning a relevant document is increased by leveraging data from other, similar users. The model goes beyond standard search engine design by presenting similar analysts for collaboration and presenting relevant documents without queries. Our framework is mathematically grounded in a Markov random field information retrieval model and recent developments in recommender systems. We build and test two prototype systems on datasets from the National Institute of Standards & Technology. The first system, created in fulfillment of a Naval Postgraduate School Master's thesis, simulated users and their searches in lieu of actual user data. The results combined with computational sensitivity analyses to show significant improvements over existing search models. The improvements are shown to be robust to high levels of human error and low similarity between users. The second system, created in partnership with the University of Texas, developed the model into a production-ready, web-enabled, search engine. This system is intended for future use in actual user testing. This work has gained interest from multiple agencies to include the USMC, USN, CIA, NSA, and NRO.
**11792 - Fast Wave Equation Solver with Numerical Results**

Acoustic imaging and sensor modeling are processes that require repeated solution of the acoustic wave equation. The wave equation solutions can be computationally expensive and memory intensive for large simulation domains. Efficient and accurate numerical schemes that limit the size of the computational domain are preferred. One such scheme for speeding up the parallel solution of the wave equation (requiring no communication between processors) is the operator-based upscaling method that captures fine scale information in a coarser solution. Further, waves modeled in finite domains generally reflect off of the computational boundaries. To prevent artificial reflections from these computational edges and to keep the domain size reasonable, the perfectly matched layer (PML) and nearly perfectly matched layer (NPML) methods are often used. We validated that the solution of the wave equation is unchanged in the computational domain and exponentially decays in the NPML regions (simulating an infinite domain). Our numerical experiments show that the maximum relative reflected amplitude from the boundaries is less than 1% for the 1-D and 2-D acoustic wave equations with NPML. Furthermore, We applied NPML with the operator-based upscaling method to the acoustic wave equation to demonstrate its effectiveness in absorption.

**11841 - System-of-Systems JCIDS Capabilities-Based Assessments**

The Joint Capabilities Integration and Development System (JCIDS) provides processes for assessing material solutions across service lines and domains and in a system-of-systems context. In addition, JCIDS would include reviews of material solutions across all the phases of operations and potential theaters in order to assess mission utility aspects. A system solution may be designed for a highly contested operational environment where most detailed analysis will be focused in order to determine technical specifications, but little (if any) of the systems’ life will be spent in these stressing threat conditions. Decision makers need to include top-level priorities and effects perspective for mission utility and value-propositions by assessing a material solution as it contributes to a system-of-system. A Clear Aspect Solutions team is working on a deterministic model that is rapid and agile, to facilitate quick excursions of potential architectures, future force structures, new systems, and system upgrades all tied to an operational context of a mission area and area of interest. Speed of decision will be achieved through characterization of target signatures, attributes, and behaviors to be compared to system-of-systems attributes, capabilities, and concepts of operations in an operational threat environment. The simplified definitions of target and actor attributes will allow for quick integration of emerging threats or system changes as well as the ability to conduct capability-assessments of theaters and phases of operations not typically assessed with expensive, detailed physics-based tools. Come join in discussions for how best to accomplish this JCIDS system-of-systems assessment.

**12439 - Technology Enabled Structured Analytics (TESA: An agile analytics solution for developing critical nodes in networks generated from large, unstructured text**

A comprehensive methodology that combines a suite of hardware, software tools, and structured analytic techniques to auto-generate networks connecting entities and concepts at the sentence level across large quantities of unstructured data. The methodology utilizes a variety of structured analytic techniques and associated analytic software tools to create initial search lexicons/taxonomies of over 500,000 terms. These terms are discovered, indexed and visualized in a network graph from a corpus of over 1,000,000 documents. The integration of multiple other structured and semi-structured data sources coupled with the rapid iteration processing capability provide the all-source analyst the capability to perform desktop data engineering in support of their own analysis. We demonstrate that this technological and methodological approach provides individual analysts the ability to glean greater intelligence value from a far larger collection of data than most current methods allow.
process are not exclusive to the two specific architectures and could apply to similar integration efforts.

Introducing a new system into the Army’s Common Operating Environment (COE) Sensor Compute Element (CE) using the Integrated Sensor Architecture (ISA) interoperability framework can pose many challenges. This paper explores the problems, solutions, and the lessons learned for building a bridge that is capable of relaying sensor data and commands bi-directionally between ISA and a Vehicle Integration for C4ISR/EW Interoperability (VICTORY) vehicle. Common problems related to data model and behavioral differences can be overcome by diligently mapping constructs from one domain to the other. There are unique challenges when two architectures align and share information. As Army systems move toward interoperability within COE, the alignment of information between differing architectures will become a more frequent design challenge for engineers and developers. Many of the challenges faced during this process are not exclusive to the two specific architectures and could apply to similar integration efforts.

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### 12599 - New Uses of OPIR in Support of the Counter-IED Mission

Since 1960, the US Air Force has used a technology called Overhead Persistent Infrared (OPIR) to collect, process and communicate data for missile warning and defense from space. Today’s constellation of OPIR-equipped satellites includes the Defense Support Program and the Space Based Infrared System. Analysts from the Joint IED Defeat Organization are developing a methodology to employ OPIR to augment detection and exploitation of IED events that traditionally rely upon reporting from military units in the field. That methodology is presented here, to include assumptions, preliminary insights, and shortfalls.

### 11841 - System-of-Systems JCIDS Capabilities-Based Assessments

The Joint Capabilities Integration and Development System (JCIDS) provides processes for assessing material solutions across service lines and domains and in a system-of-systems context. In addition, JCIDS would include reviews of material solutions across all the phases of operations and potential theaters in order to assess mission utility aspects. A system solution may be designed for a highly contested operational environment where most detailed analysis will be focused in order to determine technical specifications, but little (if any) of the systems' life will be spent in these stressing threat conditions. Decision makers need to include top-level priorities and effects perspective for mission utility and value-propositions by assessing a material solution as it contributes to a system-of-system. A Clear Aspect Solutions team is working on a deterministic model that is rapid and agile, to facilitate quick excursions of potential architectures, future force structures, new systems, and system upgrades all tied to an operational context of a mission area and area of interest. Speed of decision will be achieved through characterization of target signatures, attributes, and behaviors to be compared to system-of-systems attributes, capabilities, and concepts of operations in an operational threat environment. The simplified definitions of target and actor attributes will allow for quick integration of emerging threats or system changes as well as the ability to conduct capability-assessments of theaters and phases of operations not typically assessed with expensive, detailed physics-based tools. Come join in discussions for how best to accomplish this JCIDS system-of-systems assessment.

### 12041 - Anti-Personnel Landmine Alternative (APL-A) Sensor Field Performance Data Development using the Fusion Oriented C4ISR Utility Simulation (FOCUS)

The Department of Defense is conducting studies to identify and evaluate concepts that could serve as safe and effective alternatives to Anti-Personnel Landmines (APL). The US Army Materiel Systems Analysis Activity (AMSAA) supported the Anti-Personnel Landmine and Cluster Munition (CM) Alternative Study by conducting a review of pertinent technology demonstrations, assisting in developing alternative definitions, and developing item-level performance data that can be leveraged by Mission-level and Campaign-level combat simulation models utilized in the overall study. The content of this briefing centers on the item-level performance data generated by the Fusion Oriented C4ISR Utility Simulation (FOCUS) model for APL Alternative sensor fields that were defined. Modeling methodology centers on synthesizing multiple sensor types and nodes into sensor fields that can be represented as a probability of acquisition from a specified geographic location. The end product generated by the FOCUS model is performance data at the individual sensor, node, and field level that can be easily and rapidly incorporated into combat simulations of varying levels of fidelity.
An efficient detection framework that utilizes the fusion of spectral and Signal-to-Noise Ratio (SNR) information is divided into a pixel-by-pixel grid. Each pixel also has an associated signature defined by discrete intervals, spectral bands, across a subset of optical wavelengths. Hyperspectral imagery (HSI) sensors collect contiguous data across the electromagnetic (EM) spectrum, where an area being imaged is divided into a pixel-by-pixel grid. Each pixel also has an associated signature defined by discrete intervals, spectral bands, across a subset of optical wavelengths. HSI is advantageous for target detection in that both spatial and spectral information is present; however, this large dimensionality becomes a limiting factor for many algorithms. Detection performance is further complicated by other factors: varying prevalence of absorption or noisy bands in the spectrum that need to be identified and removed to avoid increased false detections, complexity and size of the scene, and the area of the spectrum used by the sensor. This makes creating an unsupervised detector that performs well across different types of images and sensors difficult.

This presentation will showcase research performed as a part of the recent doctoral dissertation “Improving non-linear approaches to anomaly detection, class separation, and visualization”, as it pertains towards more consistently, and efficiently, identifying anomalous pixels across images. Discussion will focus mainly on three contributions, with results compared to current state-of-the-art techniques:

- A factor analysis approach with which to identify bands/data features for removal
- An efficient detection framework that utilizes the fusion of spectral and Signal-to-Noise Ratio (SNR) information
- A n-dimensional visualization technique with which to help see groups and anomalies in large data

Each KMN is a Multi-INT architecture task to be performed against a specific intelligence target. MA-SAT computes MOES for four different KMN task types: Characterize Monitor, Search, and Track. These KMN tasks are performed against nominal target classes that include bur are not limited to: sites and facilities, weapon systems, military forces (air, ground, sea), vessels (commercial and/or military), vehicles or convoys, personnel, and missiles. Each KMN task-target combination is decomposed and further specified by a set of associated essential elements of information (EEIs) or state transition cases and observables.

MA-SAT is a deterministic, expected value model. Multi-INT architecture performance input data is generated by customer-accepted physics-based simulation tools. Regional collection capacity is computed and applied as a constraint to the MOE calculations. Single and Multi-INT collection methods and orchestration resulting from tipping and cueing between INTs is explicitly modeled. Ground and Communication constraints between INTs are modeled as time delays.
WG 8 Space Acquisition, Testing and Operations

11420 - Resiliency Analysis for Space Systems

Air Force Space Command (AFSPC) defines resilience as “the ability of the system architecture to continue providing required capabilities in the face of system failures, environmental challenges, or adversary actions.” The four main considerations to determine the resiliency of architectures are the adverse events, likelihood of occurrence, capability lost, and time duration of the capability lost. Addressing all of these considerations simultaneously is a complex endeavor and can be achieved through a combination of avoidance, robustness, reconstitution, and recovery. Assessing the value of various techniques as they contribute to overall resilience of the system is a necessary step to balance of capability, affordability, and resilience. This presentation will cover the framework and methodology developed by AFSPC/A9A now AFSPC/A5XY to assess resiliency and its application in the Space Based Infrared System (SBIRS) Follow-on Analysis of Alternatives (AoA).

The SBIRS AoA working group defined an iterative three step process to support integration of resiliency concepts and solutions in the AoA efforts. This process included methods identification & analysis, building resilience in to the alternatives and assessing the resilience of each alternative. This presentation will provide an overview of each step in the process with particular focus on the final assessment step. The assessment methodology consists of five sub-processes covering threats, architectures, threat employment, system degradation, and warfighter mission effectiveness. These results were integrated with other effectiveness and cost insights to influence selection of the next generation SBIRS architecture.

11545 - The Potential for Hitting a Satellite during a Laser Counter-Artillery Engagement

This paper investigates the probability that a high-energy laser fired at an incoming projectile will inadvertently hit a background satellite, and the probable duration of that hit. An engagement is characterized by the projectile trajectory, the laser, and the spacecraft orbit, so that a probability of hit can be calculated from the geometry of the situation. Based on the single-engagement probability calculation, Monte Carlo sampling is then used to find a general probability of hit and a distribution of hit durations. The spacecraft parameters are selected randomly from a comprehensive set of 1417 orbital elements for actual operational or formerly operational sun-synchronous spacecraft. A simulation constructed to represent defense against mortars in a near-term counterinsurgency conflict gives a probability of hit of about 15 \times 10^{-9} per engagement per satellite, or 15 nanohits. The average duration of a hit is 0.73 ms. An extensive sensitivity analysis explores how these results vary as the parameters describing spacecraft, projectile, laser, and engagement are changed.

11516 - Communication Nanosatellite Study (SNaP-3)

The U.S. Army Space and Missile Defense Command, Future Warfare Center (SMDFWC) was chartered to conduct the Communications Nanosatellite (SNaP-3) Study with a focus on determining if communications nanosatellites could provide military utility to the disadvantaged warfighter. The study’s purpose is to facilitate an Analysis of Alternatives (AoA) with an initial glimpse into possible alternatives and their associated costs.

Objectives for the study were to (1) identify what types of communications coverage low earth orbit Satellite Communications (SATCOM) could provide; (2) determine coverage requirements for the Warfighter; (3) identify capabilities and limitations of alternatives which ranged from Operationally Responsive Space (ORS), Nanosatellite, and Aerial Implementations; and (4) determine impacts to Warfighter effectiveness for each alternative.

The study was conducted in conjunction with the SNaP-3 Joint Capability Technology Demonstration (JCTD) with the Transition Integrated Planning Team (IPT) members as the Senior Advisory Group (SAG). Subject matter experts identified vignettes and potential missions for communications nanosatellites. Force-on-force constructive analysis was conducted for all alternatives and Measures of Effectiveness (MoEs) metrics were extracted.

This presentation will describe the overall methodology of the study, focus on analysis results for communications nanosatellites, and give an initial insight of pitfalls and challenges while conducting the study.
### 12023 - Military Utility Assessment (MUA) – Nanosatellite Kestrel Eye

The U.S. Army Space and Missile Defense Command, Future Warfare Center (SMDFWC) has been chartered to conduct a Military Utility Assessment (MUA) of the Nanosatellite Kestrel Eye (KE) to provide insights into the potential benefits and limitations of various near term (4-6 year) nanosatellite Surveillance and Reconnaissance (S&R) technologies and to facilitate a possible future Analysis of Alternatives (AoA). The study was conducted in conjunction with the KE Joint Capability Technology Demonstration (JCTD) with the Transition Integrated Planning Team (IPT) members acting as the Senior Advisory Group (SAG). Objectives included identifying responsiveness and coverage requirements for Ground Warfighters in multiple vignettes and phases of the conflict; identifying capabilities/vulnerabilities for various alternatives ranging from Operationally Responsive Space (ORS), Nanosat, and Aerial implementations; and determining the impacts to Ground Warfighter effectiveness for various performance thresholds for each alternative. Vignettes included a strategic port/airfield surveillance mission, a Brigade Combat Team (BCT) level combined arms maneuver mission, and a company tactical mission. The study examined the military utility of providing responsive overhead imagery to the ground warfighter in a timely manner using the different alternatives. The study also examined the Rough Order of Magnitude (ROM) cost for each of the alternatives. This presentation will describe the overall study methodology and focus on analysis results.

### 11717 - Informing a Satellite Architecture Acquisition Decision Through Effectiveness Analysis.

The Office of the Secretary of Defense (OSD) initiated the Protected Satellite Communication Services (PSCS) Analysis of Alternatives (AoA) in April 2013 to determine which satellite communication architecture to invest in. OSD also directed the Services to conduct operational effectiveness analyses (OEA) to qualify and quantify the operational impact of different satellite architectures on mission success.

The TRADOC Analysis Center, in support of the Army’s OEA, assessed the operational impacts of the base case and seven alternative satellite architectures in a joint context for a mobile, dispersed Army force operating in a contested environment.

This presentation will describe the overall Army OEA study methodology used, focusing specifically on the assessment workshop methodology, execution, and analysis of results. It will also describe how the study results were used to inform the PSCS Milestone A decision.

### 12268 - Threatening Dragon: Does China Posses The A2/AD Capability to Significantly Reduce US Air Power in a Taiwan Invasion Scenario?

China developed a strategy called anti-access and area denial (A2/AD) to compete against the United States. A2/AD relies on large amounts of SAM systems, ballistic and cruise missiles, submarines, mines, and other asymmetric weapons to deter the US from operating close to China’s shores. In the scenario of a conflict between China and the US over Taiwan the air battle in the area surrounding the Straits will be critical. China’s new A2/AD capability significantly complicates America’s ability to generate air sorties by threatening America’s airbases in the region. Chinese ballistic and cruise missiles, particularly those armed with cluster munitions, are a significant threat to unhardened U.S. airbases. This paper models America’s sortie generation rate and basing options while under this A2/AD threat using Monte Carlo simulations, scenario analysis and publically available information. The results show that unless the US has effective anti-missile air defense units, it should prefer bases that are farther away from China – the losses in sortie generation from distance are more than made up by the increased safety of the base. This result opens a number of strategic questions for the United Sates. At present, only two small bases are outside of Chinese missile range but within sortie range. The US will have to rely on small, relatively undeveloped airbases in the Philippines or use Japan’s. Considering current technological trends, China’s A2/AD strategy is likely to become more and more of a threat to America’s ability to project power into the region – putting Taiwan’s freedom at risk.
### 11830 - Engineered Resilient Systems: Tools, Data, and Tradespace Methods for Analysis of Alternatives

In a geopolitical environment marked by rapidly changing threats, tactics, missions and technologies, the Institute of Systems Engineering Research (ISER), Engineer Research and Development Center (ERDC), undertakes research in support of the Office of the Assistant Secretary of Defense Research and Engineering (OASD(R&E)) sponsored Engineered Resilient Systems (ERS) program to improve the Department of Defense (DoD) lifecycle acquisition process. Engineered Resilient Systems focuses on agile and cost-effective design, development, testing, manufacturing, and fielding of trusted, assured, and easily modified systems. ERS products are engineering concepts, techniques, and design tools. The ERS goal is to achieve the needed transformation of the Defense acquisition with the contribution of systems engineering throughout a system’s lifecycle. This presentation addresses the goals of the ERS program, the lessons learned from current research, and tools developed in support of tradespace analysis for an emergent DoD system.

### 12242 - Non-traditional program requirements – A Pilot Project aimed at selected Army NIE Gaps and Opportunities.

Net-Centric Capabilities are crucial to the overall ability of our forces to accomplish current and future military objectives. We must be able to operate freely and impose our will on potential adversaries within the Cyberspace environment. Achieving desired Net-Centric capabilities requires a streamlined acquisition approach that can often result in confusion over requirements for acquisition programs that provide capabilities that cut across multiple programs, systems and Services. Engineers and analysts from Engility, are supporting a Gap Engineering Pilot Project focused on just such a cross-cutting capability for Tactical Public Key Infrastructure (TPKI). Engility SMEs are applying elements of the Missions and Means Framework (MMF) to drive functional decomposition and documentation of integrated requirements (from operational to system specification level) based on analysis of an Army Network Integration Experiment (NIE) Gap and Opportunity statement. The purpose of the Gap Engineering pilot project is to inform development of a Standard Operating Procedure to guide requirements integration and system engineering efforts for all acquisition programs involving Systems of Systems development. This effort and the resulting SOP could have significant implications for the Materiel Development and T&E community by producing end to end sets of integrated requirements in DOORS that will be used to drive SoS development. Lessons learned from the initial focus on TPKI may inform development of mission-based cybersecurity T&E.

### 11931 - Advancing the Future State of Digital Model-Centric Engineering within the Department of Defense

The current DoD acquisition of major weapons systems and information technology is a linear process that spans over a number of years. Beginning with fixed requirements and early design lock-in, the linear process is not structured for adaptability. It lends itself to disparate stove-piped organizations and data sources, which ultimately leads to redundant processes, miscommunication, errors, and rework. The emphasis of Better Buying Power 3.0 is on helping acquisition professionals think critically and make better decisions as they confront the myriad, complex situations we encounter in defense acquisition.

Transforming traditional systems engineering to a digital mode-centric environment focuses on incorporating digital practices, models and artifacts into analysis, and engineering methods, processes, tools to drive data-driven decision making throughout the acquisition lifecycle. By connecting stakeholders in a digital environment, consistent up-to-date information about the system can be shared. Decision results can be consistently analyzed, compared, and exchanged across organizational domains throughout acquisition activities, and new knowledge can be acted upon to continuously improve requirements identification and analysis through operations and sustainment. Achieving the vision of digital model-centric engineering will require changes in how the government performs engineering and conducts business. This paper outlines the vision, current challenges, and approach for advancing model-centric engineering within DoD.
11842 - Providing Senior Leaders and Operational Users with Decisionable Data

Programs in Pre-MDAP and through their initial development continually find themselves conducting trades to define the program’s requirements/specifications within the context of DoD’s other systems. As a result, most program offices are laboring to provide their Using Command and their Service HQs with data and analysis to support decisionmaking at the highest levels. Unfortunately, most of this analysis and data is technically focused making it very difficult for senior leaders to make informed decisions or provide supporting evidence to OSD and Congress for their positions. A tool or method is required that allows Program Offices to translate technical/engineering concepts and data into straightforward operational effectiveness visualizations. This tool must be rapid to support the quick turns demanded by our national decisionmakers, must be flexible for the numerous excursions that will be required to answer related questions and it must be repeatable/traceable so that it can support the program’s development life.

We will posit through a ISR case study that a deterministic tool could meet those requirements and provide a program office an overall cost savings. This presentation will look at the attributes of the problem, the attributes of the tool and conduct a case study to determine its efficacy in solving this problem. In addition, it will explore how this tool could then be used to assist the program office in making trades and decisions in conjunction with the Operational Users enhancing the probability of fielding a successful weapon system that meets the COCOM’s needs.

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11912 - Multi-INT Architecture Scenario Assessment Tool (MA-SAT)

The Multi-INT Architecture Scenario Assessment Tool (MA-SAT) is a decision support tool that currently supports the Intelligence Community (IC) acquisition process by providing the capability to compare the mission effectiveness or utility of alternative intelligence, surveillance and reconnaissance (ISR) architectures. MA-SAT employs an analytic framework that computes measures of effectiveness for a comprehensive set of 100 Key Mission Needs (KMNs) and five regional scenarios. The five scenarios test different active subsets of the 100 KMNs, capabilities at different geographic locations and associated regional weather.

Each KMN is a Multi-INT architecture task to be performed against a specific intelligence target. MA-SAT computes MOES for four different KMN task types: Characterize Monitor, Search, and Track. These KMN tasks are performed against nominal target classes that include bur are not limited to: sites and facilities, weapon systems, military forces (air, ground, sea), vessels (commercial and/or military), vehicles or convoys, personnel, and missiles. Each KMN task-target combination is decomposed and further specified by a set of associated essential elements of information (EEIs) or state transition cases and observables.

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11944 - A Framework for Developing a Digital System Model Taxonomy

Model Based Systems Engineering (MBSE) is a key capability that formalizes the use of models for systems engineering activities that span from requirements through sustainment. While MBSE has been a staple in various engineering disciplines, MBSE has not been defined and consistently applied across the acquisition lifecycle. The Digital System Model (DSM) is a related approach being developed as part of a larger effort for advancing model-centric engineering within DoD. The DSM enables the use of an analytical framework for engineering analysis capabilities and supports decision making across the acquisition lifecycle.

The DSM is an ongoing initiative in Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) to build an integrated authoritative taxonomy for organizing, tracking, and sharing the authoritative technical data, information, and algorithms across the lifecycle. This paper will define the generic framework to develop taxonomy for the DSM, and present a use case for reliability, availability, and maintainability data.

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**11846 - Mixed-Integer Programming for The Constellation Scheduling Problem**

Remote sensing systems have expanded the set of capabilities available for and critical to national security. Cooperating, high-fidelity sensing systems and growing mission applications have exponentially increased the set of potential schedules. A definitive lack of advanced tools places an increased burden on operators, as planning and scheduling remain largely manual tasks. This is particularly true in time-critical planning activities where operators aim to accomplish a large number of missions through optimal utilization of single or multiple sensor systems. Automated scheduling through identification and comparison of alternative schedules remains a challenging problem applicable across all remote sensing systems. Previous approaches focused on a subset of sensor missions and do not consider ad-hoc tasks.

We have begun development of a robust framework that leverages the Pyomo optimization modeling language for the design of a tool that assists sensor operators planning under the constraints of multiple concurrent missions and uncertainty. Our scheduling model will be formulated to address the stochastic nature of ad-hoc tasks inserted within various time scenarios. Operator experience will be used to select appropriate model objectives. Successful development of such a framework will allow for iterative development of high-fidelity mission models that consider various metrics. Creating this tool will aid time-critical scheduling by increasing planning efficiency, clarifying the value of alternative modalities uniquely provided by multi-sensor systems, and by presenting both sets of organized information to operators. Such a tool will help operators more quickly and fully utilize sensing systems, a high interest objective within the current national community.

**11942 - Readiness Kill Chain Methodology**

The U.S. Navy is tasked to provide ready, forward deployed naval forces. The Readiness Kill Chain (RKC) provides a holistic view of readiness, a means to break down institutional barriers and increase understanding of readiness production. It is a repeatable methodology to identify production barriers and their root causes, followed by collaborative development of effective solutions. This will lead to higher readiness per dollar spent, more efficient coordination across the Navy, and better trained warfighters.

The RKC is similar to a kinetic kill chain that requires an unbroken series of events to kill a target. RKC begins with an understanding of ends, ways and means. This helps us focus on forward deployed forces while analyzing the elements that are used to achieve that end. The RKC looks at everything from resourcing, policy and procurement to sustained execution of the Fleet Response Plan and finally forward deployed readiness.

The RKC methodology uses a five-step process; First, subject matter experts from multiple organizations make an overall assessment of the "as is," status of the given system. We create a process map - a pictorial representation of events, functions, stakeholders and relationships. This map highlights previously unknown gaps and barriers that exist. A "stoplight" matrix shows areas that are deficient, areas that minimally meet standards, and areas that are healthy. We use root-cause analysis to identify the originating source of the breakdown and direct efforts at that area in the kill chain. We then execute solution development and prioritization to overcome root causes.

**14275 - Using SEAS to Assess GPS Constellation Resiliency in an Urban Canyon Environment**

Satellite constellation resiliency is an important consideration gaining momentum at the top levels of the Air Force and at Air Force Space Command (AFSPC). The increased availability of threats to satellite systems is challenging the capabilities provided by space assets. We use the System Effectiveness Analysis Simulation (SEAS) to model the Global Positioning System (GPS) constellation in an urban canyon environment. The GPS provides information to a special operation force (SOF) in their effort to recover a weapon of mass destruction (WMD). By varying the type of operations and the number of satellites lost in the simulation, insight is gained into the impact of degradation through the selected top level mission metrics. Statistical difference tests and a designed experiment reveal a resiliency threshold on the number of satellites removed from the constellation. As a result, we conclude that the GPS constellation is resilient even after the loss of several satellites.
11712 - NORAD Arctic Surveillance Study

This study, requested by the North American Aerospace Defense Command (NORAD) Deputy Commander, aimed for a comprehensive high-level understanding of NORAD surveillance requirements and near-term options in the High Arctic. Predicated by the need to renew and upgrade the current North Warning System, the study first looks at NORAD forward fighter basing and reach in the Arctic. It then draws surveillance requirements with respect to Arctic sovereignty, aircraft identification, infrastructure defence, and cruise missile defence. These requirements are based on the time required to intercept incoming threats with forward-based NORAD fighters. Finally, it considers selected options for satisfying the identified surveillance requirements, focusing on line-of-sight and over-the-horizon radar dispositions. Maritime surveillance systems are also investigated. The study was delivered to the Commander NORAD and USNORTHCOM, and is influencing strategic decisions concerning the future of NORAD.

11619 - Discrete Event Modeling and Simulation of a Ballistic Missile Passive Defense Command and Control Architecture Utilizing Overhead Persistent Infra-Red (OPIR) and Radar Data

The Joint Integrated Air and Missile Defense Vision 2020 of the Chairman of the Joint Chief of Staff depicts an evolving global environment, where the rapid proliferation of ballistic missile technology continues to increase the threat to both allied and U.S. interests. This qualitative and quantitative transfer of missile technology has emboldened adversarial nations and organizations to threaten locations previously considered unreachable and has created new battle spaces no longer constrained or defined by individual combatant command boundaries. With this increasing threat, the growing demand by both US and allied forces for low density, high demand US missile defense systems assets simply cannot be met. This research proposes a methodology for assessing new passive defense measures for alerting both military and civilian populations of inbound missile threats using radar data in addition to the current OPIR impact prediction data. Through discrete event simulation modeling, this research examines both the existing and proposed passive defense emergency response architectures.

12085 - Modeling Decision Making in EADSIM v2

"Abstract: Deconfliction of multiple sensors in an Integrated Air and Missile Defense (IAMD) environment has become increasingly important to effectively engage a diverse set of inbound threats. As the spoofing and jamming capabilities of airborne and missile threat systems become more complex and robust, the perception from different IAMD systems looking at the same threat can be different. This problem is complicated by the short time span from detection to impact for most threat systems. New IAMD systems use sensor fusion to present all sensor data to an IAMD commander for his/her engagement decision. In these scenarios, the IAMD commander must decide which sensor data is most reliable based on his/her knowledge of the threat. In this analysis, the data functional descriptor (DFD) within the Extended Air Defense Simulation (EADSIM) was used to code a decision-making and deconfliction hierarchy amongst different sensors. The DFD allows the user to rank the information provided by different sensors relative to each other in order to prioritize some sensors over others. Three different scenarios were modeled involving multiple external sensor inputs into a central decision making hub trying to engage a threat system with conflicting Identification Friend or Foe (IFF). All three scenarios involved the use of cyber attack to confuse the IAMD systems, thus resulting in conflicting IFF. One scenario involved incursion of new threat in a very time-sensitive situation with conflicting IFF. The scenarios were modeled using the current military tactical data exchange network, Link-16, as well as IAMD Battle Control System (IBCS).

Keywords. Missile defense, integrated air and missile defense, IFF, Link-16, IBCS, cyber attack, sensor fusion, deconfliction, decision making, data functional descriptor, Ballistic and Cruise missiles, and Extended Air Defense Simulation (EADSIM)."
Department of Defense (DOD) leaders have recognized the limitations of relying solely on active defense systems for Ballistic Missile Defense (BMD). In an effort to address the increased proliferation of ballistic missile threats, the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMD/ARSTRAT) and the Future Warfare Center (FWC) will analyze the integration of offensive, left-of-launch capabilities along with the active defense. To accomplish this study, we will model a current day scenario coupled with notional offensive capabilities, kinetic and non-kinetic, to observe the benefits of the offense to augment the active defense. We will deploy varying levels of offensive capabilities to determine duration levels and overall defense effectiveness. We will present our process for scenario development, including threat selection and capabilities, methodology for case matrix construction, and model creation within Extended Air Defense Simulation (EADSIM).

### 11884 - Offensive Defensive Integration

**Group**: WG 9  
**Day & Time**: 24 Jun 09:00 - 09:30  
**Location**: IDA - 6709A  
**Author/Presenter**: Mr. Martin Goodman  
**Co-Author(s)**: Mr. Jonathan Francis  
**Classification**: SECRET

This paper will examine the process of developing methods and metrics that assist the air defense planner with evaluating low altitude cruise missile defense emplacement options. The use of both medium and longer range air defense systems is examined, contrasting deployment options in the protection of high value assets. The impact of redistributing or appending additional weapon system components to best protect assets is assessed. Key defense effectiveness metrics developed also provide a comparison means to resolving conflicts between defense objectives, system performance constraints, and geopolitical considerations. The methods and metrics used allow for more optimal allocation and utilization of the available weapon system resources that collectively provide a robust defense to broad attack strategies available to the adversary.

### 12028 - Evaluating Cruise Missile Defense Effectiveness

**Group**: WG 9  
**Day & Time**: 25 Jun 08:30 - 09:00  
**Location**: DoD - 17  
**Author/Presenter**: Richard D. Neckorcuk  
**Co-Author(s)**: Mr. Paul M. Chang  
**Classification**: UNCLASSIFIED

Current ICBM defenses do not have the necessary ability to engage the most sophisticated configurations that have been and can be deployed by the Russian Federation and to a lesser extent by the Chinese Peoples Republic. The least-cost configuration to redress this threat reliably is BP/GPALS; it requires putting 300-1000 buses into LEO at an overall cost of roughly of one billion dollars. Another promising technique for efficient defense is through the use of standoff RPVs (such as MQ-9 Reaper). These aircraft could fire air-air missiles at ICBMs still in boost phase. The initial procurement costs would be at least 17 times that of BP/GPALS, but it would not require placing objects into space and the RPVs would be recoverable. Both approaches warrant further research and development.
**12027 - Threat Dependence on Lower Tier Ballistic Missile Defense System Effectiveness**

Idealized lower tier defense system performance is commonly understood in terms of the defended area size and elliptical shape projection of the interceptor battlespace protecting critical assets from TBM attack. We show significant departure from idealized lower tier TBM defense system performance providing insight into the dominant effects and allowing for compensation in weapon system deployment to maximize defense of critical assets. The variability we show is often misinterpreted and may be counterintuitive ultimately affecting the system’s ability to perform its critical asset defense mission. In this presentation, we explore how variations in TBM threat range and attack azimuth can affect lower tier defended areas. We also examine defended area sensitivity to intercept altitude and engagement sensor threat detection limitations. We characterize these effects for organic weapon system performance and with the addition of remotely located TBM interceptor launchers.

**11844 - APPLICATION OF DESIGN OF EXPERIMENTS FOR A THREAT MISSILE ATTACK PLAN EFFECTIVENESS ANALYSIS**

Many threat countries use ballistic missiles to project power and influence in a region. As seen in recent conflicts, ballistic missiles are also an effective force multiplier. The ability to assess the effect of ballistic missile attacks against an employed missile defense is highly dependent on how the threat would deploy their ballistic missiles during a time of war. This deployment plan is known as a “threat missile attack plan” and is widely utilized in theater campaign models. Four key factors of typical threat missile attack plans are: the threat’s daily capacity, the typical raid size, the types of ballistic missiles in a threat country inventory, and the defender’s Air and Missile Defense (AMD) capabilities against each type of threat ballistic missile. In this study, we perform a design of experiments (DOE) case analysis in which each case examines a variation on the threat missile attack plan. We use a computer model, developed especially for this study, to assess the air defense engagements and thus the effectiveness of each variant threat missile attack plan. Along with the aforementioned factors, the two key inputs of this case analysis are the threat missile order of battle and AMD interceptor order of battle. The AMD systems’ effectiveness inputs are determined by system-on-system — that is, each threat missile type versus each AMD interceptor type — raid analyses utilizing Extended Air Defense Simulation (EADSIM) model runs. We are conducting DOE to determine the optimum missile attack plan for the red force, given a set of circumstances.

**11985 - Integrated Air and Missile Defense Simulation and Analysis**

Proliferation and advancing technology of air and missile threats is increasing demand for more and better Integrated Air and Missile Defense (IAMD). Lockheed Martin has developed a Simulation and Analysis capability to assess system performance and IAMD mission effectiveness at various levels of complexity. This includes the ability to rapidly evaluate IAMD gaps and improvements and to establish a foundation for more in depth analysis. For more detailed investigations, Lockheed Martin has developed a high fidelity, federated Simulation and Analysis capability. This analytic framework permits varied scenarios, sensor-shooter architectures and timeframes to be examined providing decision makers IAMD performance outcomes and solution options. The discussion includes features of the Lockheed Martin Integrated Air and Missile Defense Testbed and rapid IAMD analysis capabilities with example studies. Copyright 2015, Lockheed Martin Corporation. All rights reserved
### 11848 - Use of Systems Dynamics Analysis (SDA) to assess engagement effectiveness and operational sustainability of an Integrated Air & Missile Defense Architecture

The IAMD operational architecture includes pre-planned engagement decisions as well as sustainment (repair, replenishment, resupply, etc.) decisions which are both essential to the Air and Missile Defense Mission and the assessment of alternative deployment architectures. Our goal was to model alternative operational architectures using a combination of Discrete Event Simulation (physics-based modeling) and Systems Dynamics Analysis (SDA) to understand the information needs required for time critical decisions that drive both the engagement effectiveness and the ability of the IAMD architecture to sustain that required effectiveness over an extended campaign. This presentation discusses our approach combining operational processes, architecture models, and timeline analysis, to identify opportunities to increase performance of future IAMD architectures. In particular, the established DOTMLPF-P representation was used as an assessment methodology to investigate alternative operational architectures for both time perspectives (single engagement raid effectiveness versus sustainment of effectiveness in an extended campaign).

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### 11892 - Expanding Missile Defense through Multinational Experimentation

We are reminded daily of the realities that threaten our well-being. The global threat from missile attack remains credible and is becoming more dangerous as the threat continues to proliferate and mature. In this increasingly connected, fiscally constrained world, cooperation coupled with interoperability among allies on missile defense is more important than ever. We can do more together by pooling our resources and learning from each other. Our security depends on the ability of the US and allies to address missile risks before they become crises. NIMBLE TITAN (NT) is one of the only venues for the U.S. and allies to achieve this.

NT is a series of unclassified, two-year, multinational, Ballistic Missile Defense (BMD) experimentation and wargames. Participants examine regional and global BMD policy and operational concepts that are needed to conduct coalition missile defense. Over the past decade, participation has expanded from six nations to twenty-five, as like-minded nations from the Pacific, Europe and Middle East regions join the campaign. Their active participation continues to generate a learning environment, the opportunity to address multinational missile defense challenges and the ability to develop solutions.

The presentation focuses on the outcomes of the recently completed NT 14 Campaign, including an overview of the experimental campaign, objectives, design and analysis. The presentation highlights key insights, potential solutions and challenges discovered that improve collaboration, cooperation and interoperability among allies on missile defense. These discussions and discoveries build security relationships, enhance regional missile defense and strengthen deterrence.

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### 11546 - The Potential for Hitting a Satellite during a Laser Counter-Artillery Engagement

This paper investigates the probability that a high-energy laser fired at an incoming projectile will inadvertently hit a background satellite, and the probable duration of that hit. An engagement is characterized by the projectile trajectory, the laser, and the spacecraft orbit, so that a probability of hit can be calculated from the geometry of the situation. Based on the single-engagement probability calculation, Monte Carlo sampling is then used to find a general probability of hit and a distribution of hit durations. The spacecraft parameters are selected randomly from a comprehensive set of 1417 orbital elements for actual operational or formerly operational sun-synchronous spacecraft. A simulation constructed to represent defense against mortars in a near-term counterinsurgency conflict gives a probability of hit of about 15’10-9 per engagement per satellite, or 15 nanohits. The average duration of a hit is 0.73 ms. An extensive sensitivity analysis explores how these results vary as the parameters describing spacecraft, projectile, laser, and engagement are changed.

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The Long Range Precision Fires (LRPF) Analysis of Alternatives (AoA) examined potential materiel solutions to replace the Army Tactical Missile System (ATACMS), and also the implications of not replacing ATACMS. TRAC used the Advanced Warfighting Simulation (AWARS) to capture the effects of the operational environment on implementation of the ATACMS and joint force LRPF alternatives. The model represented a joint scenario during phase II operations which included fixed wing assets, fixed and mobile air defense artillery sites, indirect fire (IDF), naval IDF, and theater ballistic missiles (TBMs).

A measurement space workshop identified requirements to adequately represent phase II operations and address key study issues. AWARS improvements based on the workshop outcomes resulted in a higher level of fidelity for integrated air defense networks and TBM representation.

This presentation describes the functional area representation and AWARS model methodology used to support the phase II operation for the LRPF study.
**WG 10 Joint Campaign Analysis**

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**12150 - Assessments in an Air Force C-MAJCOM: We Can't Keep Doing It the Same Old Way**

As part of Pacific Air Forces (PACAF), the Air Force Component Major Command (C-MAJCOM) under United States Pacific Command (USPACOM), PACAF/A9 (Analyses, Assessments, and Lessons Learned) leads integrated analysis and assessment of air, space and cyberspace operations for the pacific theater across the Air Force component. In this role and in accordance with a newly published Air Force Instruction 13-103, PACAF/A9 supports both deliberate planning and crisis action planning as part of the Long Range Planning Group (LRPG) and Operations Planning Group (OPG), respectively.

Under this relatively new construct, PACAF/A9 has revamped its assessment processes to leverage the cross-functional benefits attained via the LRPG and OPG to improve what has historically been a heavily stove-piped function with A9 integration and adjudication at the end. Additionally, by interjecting assessments early into the planning process, PACAF will more clearly link its operations, activities, and actions (OAAs) to higher level plans, thereby enabling a better assessment each period. Finally, to better facilitate (usually) short assessment timelines for PACOM, PACAF/A9 will be leveraging the Army developed and PACOM mandated Strategic Management System (SMS) throughout the process. The new process is presented, as well as its advantages/issues and results of its application to the 2015 Pacific Theater Campaign Plan Assessment.

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<td>Maj. Travis John Herbranson</td>
<td>Capt. Matthew Kauffmann Lt Col Carl Pawling Mr. Richard W Roberts</td>
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**12362 - Balancing Linear Program Coefficients to Model Commanders Intent**

The Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) supports difficult Force Structure decisions with insights derived from rigorous modeling and simulation. The Combat Forces Assessment Model (CFAM), a linear optimization program in the Air Force Standard Analysis Toolkit, is the primary tool used to integrate results from numerous mission-level models and datasets to identify a campaign-level optimal mix of fighters, bombers, tankers, and other assets. By using CFAM to examine future force structures within projected or unconstrained Air Force resources, balanced against established threat scenarios, AF/A9FC supports Air Force Strategy, Planning and Programming Process decisions.

Underpinning CFAM results are a series of objective function coefficients with complex relationships learned by extensive use of the model. Analysts alter these coefficients to produce results consistent with employment CONOPS and airpower doctrine. Errors result from CFAM optimization decisions that run counter to conventional risk tolerances, such as aircraft attrition, that are resolved through iterative balancing of the coefficients, or excluding decision space. AF/A9FC is studying these complex relationships to produce guidelines that will better drive CFAM behavior to best represent the Combatant Commanders’ risk tolerances within the coefficient structure. This presentation describes initial analytical results, how risk tolerances are balanced within the coefficient structure, and the design of experiments being used to produce coefficient value guidelines that assure credible CFAM results lead to high-confidence insights informing Air Force optimized Force Structure decisions.

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**12498 - 6th Generation Flexible Weapons Analysis**

The Air Force Research Laboratory is currently working on a new weapon concept that would change the paradigm of weapons design through a common architecture to enable modular subsystems to achieve flexible weapons capability while allowing technology refresh at the pace of technology discovery in an affordable and sustainable design. This paper will review the most recent results from two phases of analysis that are helping to define the requirements for the flexible weapon program. Results will be presented from all levels of simulation across the M&S spectrum including lethality/payload design, 6-DOF(range) propulsion trades, mission and campaign level analysis, and red threat survivability analysis. The overarching objective for Flexible Weapons is to replace current inventory weapons that will not fully utilize the increased capabilities of 6th generation platforms, with a single weapons kit made up of flexible, open architecture components. The various combinations of weapons to address multiple missions must be 100% compatible with 6th generation delivery platforms (fighters, bombers, RPAs) and backwards compatible with 4th and 5th generation platforms. Desired attributes for Flexible Weapon were derived from a comprehensive review and translation of stated needs from the Global Precision Attack (GPA) Core Function Master Plan (CFMP), the Air Superiority (AS) CFMP, and Special Operations (SO) CFMP correlated with needs called out from the Air Sea Battle Limited Operational Concept, 2030+ Air Dominance Capability Based Assessment and Initial Capabilities Document, USAF Science Advisory Board 2035+ Munitions Study, and a number of...
12361 - Improvements in Modeling the Air Campaign Target Set in CFAM

The Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) supports challenging Force Structure decisions through insights often derived from rigorous modeling and simulations results. The Combat Forces Assessment Model (CFAM), a linear optimization program in the Air Force Standard Analysis Toolkit, is the primary tool used to integrate results from numerous mission-level models and datasets to identify a campaign-level optimal mix of fighters, bombers, tankers, and other assets. By using CFAM to examine future force structures within projected or unconstrained Air Force resources, balanced against established threat scenarios, AF/A9FC supports the Air Force Strategy, Planning and Programming Process decisions.

Within CFAM, force structure optimization results are highly dependent on a given air campaign target set that provides the foundation against which capability and capacity are evaluated. Though all targets for a given scenario are available as part of the Support for Strategic Analysis (SSA) products, none are explicitly designated as Air Force targets. The fundamental problem then becomes determining which types of targets to include, how many of each type, and where they are located. Currently A9FC derives the target set from Joint campaign simulation results, but using simple expected values of the stochastic results has proven to give invalid target sets. The solution discussed here overcomes this issue, creating a repeatable process for target set development. Further scenario development data requirements are highlighted as well as some advantages and disadvantages of solutions being investigated. Finally, future developments to increase model fidelity while yet providing quick-turn analytical insights will be briefly covered.

13300 - Anti-Personnel Landmine / Cluster Munition Study - Campaign Analysis

At the February 21, 2014 National Security Council (NSC) meeting on U.S. Landmine Policy, the Department of Defense was directed to address the President’s call for an analytical effort to examine the existing—and proposed alternatives to—APL and CM weapons systems, with the intent of enabling the Department to “move into the 21st Century.” To address the President’s directive, the Vice Chairman of the Joint Chiefs of Staff (VCJCS) took leadership of a cross-service effort to assess the operational impacts of APL and CM and to develop options to inform future decisions. AF/A9 served as the Air Force lead for the cross-service analytic effort. In total, the APL/CM study evaluated the operational impacts of employment of existing APL and CM capabilities as they potentially become prohibited, as well as the efficacy of proposed replacements for these systems. This presentation summarizes the campaign-level analysis of CM employment in a combined-arms scenario, highlighting important insights into the effectiveness and efficiency of CM and various mitigation options and munitions mixtures. The results of this study have been presented to the VCJCS and senior representatives from the Services and the Joint Staff, and will inform NSC deliberations regarding U.S. policies on APL and CM employment later this year.
**12377 - Integrating TAB-VAM and CFAM for Improved Tanker Attrition Campaign Analysis**

Air Refueling (AR) is a critical component of the US Air Force’s Rapid Global Mobility (RGM) core function, acting as a significant force multiplier that magnifies the capabilities of other weapon systems by significantly increasing range, loiter time, payload, and providing flexibility for basing, routing, and mission. As threat capabilities increase, analysis that supports minimizing tanker aircraft attrition in contested environments becomes critically important to assuring AR capacity and success of the overall air campaign. To assess campaign impacts of tanker ground attrition due to theater ballistic missile and cruise missile (TBM/CM) strikes, the Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) recently completed a detailed study directed Office of the Secretary of Defense Resource Management Decision 700A1.

This presentation will detail how AF/A9FC improved modeling capabilities and shortened study time required to analyze TBM/CM effects by establishing collaboration with the ongoing RAND Project Air Force (PAF) Combat Operations in a Denied Environment (CODE) study. By incorporating sensitivity analysis for TBM/CM data from RAND’s Theater Air Base Vulnerability Assessment Model (TAB-VAM) results into AF/A9FC’s Combat Forces Assessment Model (CFAM), several mutually beneficial outcomes were achieved:

- AF/A9FC improved the credibility of both models by verifying TAB-VAM TBM/CM impacts were in line with prior CFAM results.
- TAB-VAM integration with CFAM provided a fast and repeatable method to update campaign models, allowing timely assessments of rapidly evolving TBM/CM threats which inform infrastructure investment with quantifiable campaign impacts.
- Analysis of results from TAB-VAM integration with CFAM built on the defensive scope of the CODE study, providing insights on the ability to execute Support for Strategic Analysis scenarios and Combatant Commander Operational Plans.
- AF/A9FC’s study of the air campaign informed the need for a joint campaign assessment in order to steer future investment strategies that mitigate vulnerabilities of all aircraft and infrastructure to TBM/CM threats.
- Continued AF/A9FC collaboration with RAND PAF resulted in TAB-VAM and CFAM improvements that bolstered the fidelity of campaign analysis due to TBM/CM threats for both organizations.

**12618 - Multi-Dimensional Trend Analysis of Events involving the Australian Defence Force during OP Slipper**

DSTO Decade of War Research Project

Historical and Multi-Dimensional Trend Analysis of Events involving the Australian Defence Force during OP Slipper (ADF land operations in Afghanistan)

Paul Rogers (Blue Swimmer Consulting)
Dr Paul Gaertner (Head, DSTO Operations Support Centre)
Mr Mark Bottger (DSTO)

Historically there has been significant effort devoted to temporal and geospatial analyses of attacks on coalition or national forces during military operations across a wide range of regions, and in particular for forces operating in Iraq and Afghanistan. In many instances the depth of analysis is constrained by operational requirements, timelines and availability of relevant data. Whilst such work can provide some relevant operational insights, a deeper and more meaningful examination of the results often leads to many operational questions that cannot be answered by these analyses.

As a result the DSTO Operations Support Centre commenced the “Decade of War” Research Project in order to undertake a “historical and multi-dimensional trend analysis of attacks on Australian Defence Force (ADF) personnel in Afghanistan.” The purpose of the study is to extend past trend analyses by overlaying, or integrating, additional layers of context in order to provide a greater depth of understanding of events involving Australian land forces in Afghanistan via temporal, geo-spatial and statistical analysis.

The project uses events involving ADF personnel and overlays a series of additional contextual layers of information, these include:

- Social context.
- Patterns of life.
- Roles of the ADF.
- Patrol Rates.
- Threat Development/Evolution.
- Countermeasure Deployment.
- Battlefield Casualties.
### 11897 - Analytic Support to Combined Joint Task Force - Horn of Africa (CJTF-HOA)

Since 2002, The Combined Joint Task Force – Horn of Africa (CJTF-HOA) has been operating in support of Operation Enduring Freedom; the only CJTF in the U.S. Africa Command (USARFCOM) Area of Operations (AOR). CJTF-HOA was established on 19 October 2002 in response to the attacks on September 11, 2001. CJTF-HOA was originally a component of U.S. Central Command (USCENTCOM), but was transferred to USAFRICOM on 1 October 2008. Beginning in October 2011, the Center for Army Analysis (CAA) deployed analysts to Djibouti, Africa on six month rotations to support CJTF-HOA.

In the current environment of increasing budget constraints, CJTF-HOA is placing renewed emphasis upon prioritization of operations, actions, and activities (OAA). One of the most widespread types of OAA conducted by CJTF-HOA is that of military-to-military training and advising, such as pre-deployment assistance to African countries who are members of the African Union Mission in Somalia (AMISOM) in preparation for deployments to Somalia. CJTF-HOA has recently undertaken an effort to identify, assess, and prioritize its OAA so that it can better align operations and allocate resources accordingly.

Analytic efforts include: integration of operational assessments into the command decision making process; development of an operations assessment framework for the CJTF-HOA campaign plan; analysis of the level of impact from OAA using data from the CJTF-HOA Combined Information Data Network Exchange (CIDNE) database; analysis of SIGACT data from the AMISOM Force Headquarters (HQ); analysis of Public Perception Surveys, beginning in March 2013; analysis of trends associated with information sharing between CJTF-HOA and East African countries using the AFRICOM Data Sharing Network (ADSN). The insights from these analytic efforts support planning and command decisions for current operations conducted not only by CJTF-HOA, but also by our partners in East Africa.

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<td>Natalie Casey</td>
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### 12244 - Providing Sound Analysis in a Data Constrained Environment

IED’s remain a significant weapon of strategic influence and JIEDDO continues to pursue ways to attack the network, defeat the device, and train the force. The fusion of information and analysis helps drive actions toward the C-IED fight. This brief will outline the latest trends and measures of merit as they relate to a declining data environment, the Government of the Islamic Republic of Afghanistan, Afghan National Defense Security Force performance metrics, and a global overview of the IED threat.

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### 11782 - Determining Requirements for the Army’s Future Long Range Precision Fires (LRPF)

The Army Tactical Missile System (ATACMS) is the Army’s long range, deep strike missile that provides surface-to-surface, all-weather precision fires beyond current cannon and rocket ranges. Termination of the ATACMS program in 2007, due to budgetary concerns, will result in a capability gap.

The LRPF AoA was initiated by the Office of the Secretary of Defense, Cost Assessment and Program Evaluation in 2013, to examine alternatives that mitigate the capability gap resulting from the loss of capability provided by ATACMS.

The LRPF AoA study team produced several key deliverables: identification of life cycle costs and cost drivers; robust trade space analysis; operational effectiveness and sensitivity analysis of the alternatives to factors that impact operational effectiveness; and key operational capabilities to inform system requirements.

The purpose of this brief is to showcase how the LRPF study team determined the impact of Army LRPF to the Joint fight. It highlights how the study team assessed the Army LRPF as a Joint force enabler and the analytical tools used to inform future LRPF system capability requirements. The brief outlines the future LRPF’s key performance parameters and system attributes identified during the study that will assist the Joint force in accomplishing its mission objectives.

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<td>Chris Krupar</td>
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### 11796 - Campaigning Minefields: Update to the representation of minefields in JICM

In this presentation, we will give an overview of a new minefield “metering” functionality in JICM. Metering refers to reducing the flow of an attacking force by narrowing its advancing front. This theoretically allows the defender to engage advancing enemy forces in “bite size chunks.”

Prior to this change, JICM did not have an effective way to replicate the maneuver implications of attacking through a defended minefield.

We will start by reviewing the ways JICM currently represents minefields. We will discuss some modeling techniques attempted to represent metering. For example, simply narrowing the width of a route; this ends up penalizing both the attacker and the defender.

We will give an update on recommended input parameters based on feedback from the analytical community and internal testing. This discussion will include the range of recommended inputs. Setting the flow percentage too high or too low could have unintended consequences in the model.

Finally, we will review preliminary results using unclassified vignettes. We will touch briefly on any statistical test we used to see if metering impacts results.

### 12066 - Evolution of Combat Sample Development for Theater-Level Models

Campaign analysis of ground operations across different theaters and timeframes requires a model that produces consistent and reproducible combat samples that are in turn used in theater-level models. The Center for Army Analysis (CAA) has put forth considerable effort to capture the most significant, tangible effects of these operations in the combat samples for theater-level models produced by the Combat Sample Generator (COSAGE), CAA’s combat model. The combat samples produced by CAA are for use in all Attrition Calibration (ATCAL) based theater-level models (e.g., Joint Integrated Contingency Model (JICM), Synthetic Theater Operations Research Model (STORM)).

The representation of specific types and densities of combat systems in the COSAGE model has been significantly revised and improved to ensure system-on-system interactions within the combat samples. The number of terrain types has been expanded from three to four to better represent different combat environments.

This brief will summarize CAA’s efforts to enhance the quality of the COSAGE combat samples and provide a comprehensive overview of the major changes in COSAGE. The process to request combat samples will be covered as well.

### 12069 - Combat Sample Validation using Operation Iraqi Freedom

Campaign analysis of ground operations across different theaters and timeframes requires a model that produces consistent and reproducible combat samples that are in turn used in theater-level models. The Center for Army Analysis (CAA) has put forth considerable effort to capture the most significant, tangible effects of these operations in the combat samples for theater-level models produced by the Combat Sample Generator (COSAGE), CAA’s combat model. The combat samples produced by CAA are for use in all Attrition Calibration (ATCAL) based theater-level models (e.g., Joint Integrated Contingency Model (JICM), Synthetic Theater Operations Research Model (STORM)).

The COSAGE model has been significantly revised and improved to ensure system-on-system interactions within the combat samples. While input and code can be comprehensively verified through a variety of methods, a validation of the COSAGE model would not be complete without measuring the effects of its outputs on an actual campaign.

This brief will summarize CAA’s validation of the COSAGE model using a historical campaign in a theater-level model. The results from the JICM campaign will be compared to the actual historical metrics in terms of campaign timing, casualties, system losses and ammunition expenditures.
### 12068 - Measures of Effectiveness for Combat Samples in Theater-Level Models

Campaign analysis of ground operations across different theaters and timeframes requires a model that produces consistent and reproducible combat samples that are in turn used in theater-level models. The Center for Army Analysis (CAA) has put forth considerable effort to capture the most significant, tangible effects of these operations in the combat samples for theater-level models produced by the Combat Sample Generator (COSAGE), CAA’s combat model. The combat samples produced by CAA are for use in all Attrition Calibration (ATCAL) based theater-level models (e.g., Joint Integrated Contingency Model (JICM), Synthetic Theater Operations Research Model (STORM)).

CAA has transitioned from strictly system output measures such as average weapons range to broader measures such as comparisons between defensive postures in terms of overall losses. These changes have increased the utility of measures of effectiveness in assessing how well the samples will function in theater-level models. The use of measures of effectiveness to determine issues within the combat samples and their use in addressing these issues will also be covered.

This brief will summarize CAA’s efforts to standardize the measures of effectiveness used to assess the quality of the COSAGE combat samples and provide a comprehensive overview of the combat sample generation process.

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<td>DoD - 3</td>
<td>Mr. Stephen McCarty</td>
<td>Mr. Kirill Sukhorukov</td>
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### 14671 - Campaign Analysis with a Hybrid Threat

The Army created the Army Operating Concept (AOC) in order to describe future battlefields to inform doctrinal and force management policy decisions for Force 2025 and Beyond. The AOC anticipates that future battlefields will occur in a Complex Operating Environment (COE) where adversaries will likely consist of hybrid threats. Hybrid threats combine tactics and equipment associated with both conventional and irregular forces to create a unique form of warfare.

The Center for Army Analysis continually updates and improves the methods for conducting campaign analysis. This study looked at adopting three models to simulate the hybrid threat scenario: the Combat Sample Generator (COSAGE), Attrition Calculator (ATCAL) and Joint Integrated Contingency Model (JICM). These models were modified and applied to historical hybrid threat scenarios to validate the technique. Once validated, these programs can then be used to model modern and future theater-level warfare.

Keywords:
Army Operating Concept, Campaign Analysis, Theater Modeling, Hybrid Threat, Complex Operating Environment

### 12071 - C2 Metrics to Support Studies of Unit Structure

The recently completed Analysis Branch / Operational Analysis Division / Marine Corps Combat Development Command study, “Composition of the Infantry Battalion,” focused mostly on the size and composition of rifle squads but developed metrics for broader and larger-scale use. The study raised a number of issues about the effects of logistics, command, control, communication, and leadership style, beyond the scope and resources of that study. The most relevant issues that emerged from the infantry battalion study in the topic area of C2 metrics are: better metrics than simple span of control to assess likely leader effectiveness; quantifiable aspects of leadership structures that appear more effective than others; in particular, quantifiable aspects of communication methods and protocols that improve effectiveness and resilience; quantifiable aspects of approaches to decision-making about logistics that seem more effective than others; quantifiable aspects of approaches to decision-making about intelligence that seem more effective than others; and measures of the extent to which joint training improves coordinated effect. We summarize findings to date and sources cited and suggest promising applications to future assessments of unit structure and resulting effectiveness.

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12046 - From qualitative to quantitative and back again: optimizing resource-informed metrics for the strategic decision maker

Strategic assessment is a critical part of the military decision cycle. It exists to analyze performance and measure progress toward desired end states in the strategic environment in order to inform the commander’s decision process, specifically on how to sustain or modify policy, doctrine, organization, materiel, leadership and education, training, personnel, and facilities in order to further the accomplishment of theater objectives. However, most doctrine and guidance stops at outlining theater objectives, leaving theater strategic headquarters seeking optimal ways to collect the right data, ask the right questions, and link actions and the effects of those actions to the objectives they hope to impact. The result is data that is often mismatched to objectives, analysts asking the wrong questions, and metrics not informed by actual resources and actions.

This case study will walk through the process of developing not only metrics but also the supporting planning framework, with optimal linkages to performance and environmental metrics; determining those metrics by thorough problem definition; aligning performance and resources to metrics; and calculating proper thresholds and weights. Then, the quantitative to qualitative case study will walk through the process of providing the necessary context from the given data in a clear, streamlined manner to best support the decision cycle of a strategic decision maker, identify gaps and risk, and recommend resource-informed changes to the overall theater campaign. This multidisciplinary process involves analysis tools from systems design to surface optimization and recommends optimal suites of software, equations, and processes for each stage of the process.

WG 11 Land and Expeditionary Warfare

11638 - Electric Fires

Friendly and Threat manipulation of the electromagnetic spectrum using Electric Fires (EF) will bring a new genre of weapons to the battlefield capable of bringing effects ranging from hard to soft kill from the same weapon. In coordination with Army Staff elements, Army Cyber Command, and Fires Center of Excellence, the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) and the Future Warfare Center (FWC) characterized EF systems that impact Friendly and Threat equipment or forces and investigated those effects on operational tempo, overall force effectiveness, and collateral damage or EF fratricide. EF definitions, capabilities, and characteristics were determined through a series of technical interchange meetings with concept of operations and tactics, techniques, and procedures defined during a map exercises given relevant operational contexts. The outputs from the technical interchange meetings and map exercises were modeled in Joint Conflict and Tactical Simulation (jCATS) and Systems Effectiveness Analysis Simulation (SEAS) to determine Friendly and Threat effectiveness impacts. Results of scenario development, technical interchange meetings, map exercises, and constructive analysis will be presented.


Many operations research techniques are designed to explore human decision-making but what do we actually know about how we make decisions? Human decisions are embodied and bodies are embedded in physical, social and institutional environments. Research in the cognitive neurosciences suggests that decision-making behavior is a function of social, emotional and logical reasoning, it is contagious, and it is subject to mass effects. This presentation draws on these findings to develop implications for developing and using analytic approaches, focusing on issues related to understanding complex physical and social systems and interpreting emergent patterns of behavior.
12488 - Analysis of Communications Systems Reliability on Network Performance

This paper addresses two methodologies used to assess the impact of radio reliability on communications networks. The first approach analyzed the performance impact of a Brigade Combat Team network in an operational representative scenario due to variations in the mean time between essential functional failure (MTBEFF) using a discrete event simulation of the BCT network. The radio equipment reliability was addressed parametrically, using values of 50 hours, 250 hours, and 500 hours to characterize the impact MTBEFF has on network performance in terms of message completion rate and message delay. The second method employed an analytical approach to determining how radio reliability and the number of gateways between two subnets affected the end-to-end connectivity between platforms in the lower subnet and platforms in the higher subnets. Again, a parametric approach was taken to show how the reliability and number of gateways impacts the probability of a gateway failure within a 72 hour mission and the average time a gateway would be down within a 72 hour mission.

11764 - AWARS Adaptations to Represent Joint Phase II Operations for LRPF

The Long Range Precision Fires (LRPF) Analysis of Alternatives (AoA) examined potential materiel solutions to replace the Army Tactical Missile System (ATACMS), and also the implications of not replacing ATACMS. TRAC used the Advanced Warfighting Simulation (AWARS) to capture the effects of the operational environment on implementation of the ATACMS and joint force LRPF alternatives. The model represented a joint scenario during phase II operations which included fixed wing assets, fixed and mobile air defense artillery sites, indirect fire (IDF), naval IDF, and theater ballistic missiles (TBMs).

A measurement space workshop identified requirements to adequately represent phase II operations and address key study issues. AWARS improvements based on the workshop outcomes resulted in a higher level of fidelity for integrated air defense networks and TBM representation.

This presentation describes the functional area representation and AWARS model methodology used to support the phase II operation for the LRPF study.

12495 - IWEA Weaponing Optimization Framework

The Air Force Research Laboratory (AFRL) and Air Force Institute of Technology (AFIT) are teaming on a joint effort that enables the analysis of future weapons concepts through simulation experiments. Part of the integrated weapons environment for analysis (IWEA) framework includes the development of a dynamic programming inspired tool that determines which weapons to load on a set of aircraft in order to optimize an objective function within a simulation. This presentation introduces the framework, discusses the methodology and initial results for the optimization tool, and provides insight into future implementation.

11536 - Military Utility of Direct Downlink Video at the Platoon Level

A team of senior West Point cadets was asked the Army Project Manager for Unmanned Aircraft Systems to assess the military utility of providing real-time video from small unmanned aircraft systems directly to members of a platoon. The cadets gathered data on the likely cost and weight of the required equipment, then in order to gain insight into the effect of such a capability on mission success, they created a Markov chain model of a typical infantry platoon combat operation. They gathered estimates from subject matter experts of the probabilities in that model for the base case where there is no video capability and in cases with the capability to different levels: platoon leadership, squad leaders, and team leaders. We present the model, our results, and our recommendation for this video downlink capability.
11979 - Analysis of Medical Evacuation Mobility in the Armored Brigade Combat Team

The M113 has been the medical evacuation vehicle (MEV) and medical treatment vehicle (MTV) in the armored brigade combat team (ABCT) since the 1960s. The MEV and MTV must be able to rapidly reach, evacuate, and provide immediate care to injured Soldiers to ensure the survival of wounded personnel. The Army canceled the M113 program in 2009 because of shortfalls in mobility, force protection, and other significant capability gaps. The Training and Doctrine Command (TRADOC) Analysis Center (TRAC) was tasked to assess whether existing Army wheeled and tracked vehicles were suitable to perform MEV and MTV mission roles within the ABCT. Working with analysts at the Army Materiel Systems Analysis Activity (AMSAA), TRAC developed a new methodology to assess how the impacts of mobility affect evacuation times, casualty survival rates, and ABCT combat power. This new methodology integrated vehicle performance analysis from the NATO Reference Mobility Model, ArcGIS data from a Soldier wargame, and evacuation times from AMSAA's Optimal Path Model to calculate the evacuation timeline, died-of-wounds rates, and combat power over time. This presentation provides an overview of the analytic approach, the modeling and simulations used, and the analytical results.

12494 - Air Force Support for the Army, 1950 - 2015

The U.S. Air Force was a component of the U.S. Army until established as a separate service in 1947. The Air Force subsequently fought as a component of a joint force in numerous conflicts, most notably Korea, Vietnam, Desert Storm, Operation Enduring Freedom, and Operation Iraqi Freedom. Many commentators have argued that the Air Force has been excessively interested in its "independent" functions – strategic bombing and air-to-air combat – to the neglect of supporting the Army. This presentation will analyze Air Force combat operations from 1950 to 2015 using unclassified sources and a variety of different metrics in order to show that these arguments are unfounded. The overwhelming majority of Air Force combat missions were flown to support the Army, and most Air Force bombs dropped were aimed at enemy ground forces. In contrast, "independent" strategic bombardment and air superiority missions constituted only a small fraction of the Air Force effort. Moreover, the quality of Air Force support to the Army, in terms of accuracy and responsiveness, has dramatically improved over time. The presentation will conclude with a discussion of the capability and capacity of the Air Force to provide Close Air Support in future conflicts.

11691 - Using Qualitative Methods to Optimize Soldier Load, Effectiveness, and Health

The United States Army Soldiers' current head and torso protection systems are heavy, bulky, and do not integrate well with other equipment. The systems' weight limits Soldier operational effectiveness, and increases Soldier injuries. Product Manager Soldier Protection and Individual Equipment (PM SPIE) engaged the Edgewood Chemical Biological Center Decision Analysis Team (DAT) to conduct cost benefit analyses (CBAs) evaluating the trade-off between cost, risk, and Soldier's operational effectiveness and health for the Vital Torso Protection and Torso and Extremity Protection systems, and the Integrated Head Protection System. Studies quantifying the relationships between Soldier load, effectiveness, and health have not been completed as they would be complex and costly. Ultimately, the DAT and PM SPIE used quantitative and qualitative (e.g., follow-on effects, qualitative evaluation criteria) approaches to assess these relationships and recommend the best way of providing Soldiers protection that enhanced operational effectiveness, and minimized cost and negative long-term impacts.
### 12161 - Using Empirical Data to Create Planning Factors

IDA recently completed a pair of studies for CAA, the Joint Staff and the Modeling and Simulation Coordination Office that used empirical data from operations in Iraq between 2005 and 2008 to suggest planning factors that could be used in the preparation for and conduct of future overseas contingency operations. The major premise for both studies was that specific, quantifiable Blue force actions could be spatially and temporally associated with major improvements in the indicators of security. Operations and changes in violence were studied in Baghdad and the Belts (2007), the Baqubah area (2007-08), Mosul (2008), and Al-Qaim (late 2005). In addition, an accounting of counter-insurgents per population was developed for each of these locations for the periods studied and across all of Iraq as of January 2008. Finally, substantial environmental data were considered regarding how the population viewed what was unfolding. With the exception of Al-Qaim, the time frames investigated represented the incorporation of the new counter-insurgency doctrine and increased resourcing. Although the actions in Al-Qaim preceded both the doctrine and the accompanying troop surge, they incorporated much of the intent of both. This presentation will summarize the findings and key takeaways from these studies.

### 12353 - Providing Sound Analysis in a Data Constrained Environment

IED’s remain a significant weapon of strategic influence and JIEDDO continues to pursue ways to attack the network, defeat the device, and train the force. The fusion of information and analysis helps drive actions toward the C-IED fight. This brief will outline the latest trends and measures of merit as they relate to a declining data environment, the Government of the Islamic Republic of Afghanistan, Afghan National Defense Security Force performance metrics, and a global overview of the IED threat.

### 11451 - Campaigning Minefields: Update to the representation of minefields in JICM

In this presentation, we will give an overview of a new minefield “metering” functionality in JICM. Metering refers to reducing the flow of an attacking force by narrowing its advancing front. This theoretically allows the defender to engage advancing enemy forces in “bite size chunks.”

Prior to this change, JICM did not have an effective way to replicate the maneuver implications of attacking through a defended minefield.

We will start by reviewing the ways JICM currently represents minefields.

We will discuss some modeling techniques attempted to represent metering. For example, simply narrowing the width of a route; this ends up penalizing both the attacker and the defender.

We will give an update on recommended input parameters based on feedback from the analytical community and internal testing. This discussion will include the range of recommended inputs. Setting the flow percentage too high or too low could have unintended consequences in the model.

Finally, we will review preliminary results using unclassified vignettes. We will touch briefly on any statistical test we used to see if metering impacts results.
12484 - Performance Assessment of Unmanned Ground Vehicles Using Physics-based Modeling and Simulation Tools

Recognizing the increased focus on simulation tools across the DoD, the U. S. Army Engineer Research and Development Center (ERDC) has developed a suite of M&S products for the design, development, and analysis of unmanned ground vehicles (UGVs). These tools include both the Virtual Autonomous Navigation Environment (VANE), a high-fidelity high performance computer (HPC) based tool, and the Autonomous Navigation Virtual Environment Laboratory (ANVEL), a real-time, desktop simulation environment. The presented research will highlight how VANE and ANVEL can be leveraged to support the assessment, from a mission-level perspective, of the performance of UGVs. Specifically, the presented research highlights how VANE and ANVEL can be used to replicate some of the tests done during Military Utility Assessment (MUA) and Analysis of Alternatives (AoA) studies and shows how these M&S tools can enhance the testing, evaluation, and assessment of ground robotic platforms.

12525 - Player Designed Wargames

In a traditional game design process, the designer writes a set of rules, then creates components to implement mechanics in the rules, and then play tests the game to determine which aspects work well and which need to be changed. However, this process does not work in the case where a war game needs to be tailored for a specific purpose but with uncertain requirements. One solution to this problem is to develop a flexible system of components which can be used by the players to generate rules and tailor more specific units through designer guided game play. With this process the game is actually designed by the players within a designer created framework.

12489 - Reducing Residential Energy on Military Installations

The genesis for residential energy analysis is simple - West Point and nearly every other military installation need better assessment methods to rate the energy efficiency of its residential buildings. Modeling the energy consumption of these residential homes is critical in determining the most economic energy upgrades with short payback periods. These energy models also allow improvements to be made on the current utility billing program, which incentivizes residents in military housing to reduce their energy consumption. This presentation uses West Point’s residential homes as a case study to show a systematic approach that can be used to move towards large reductions in annual energy bills. West Point is using the process of modeling the energy fitness levels of their homes for energy assessments, economic energy upgrade selection, quality assurance, and creative utility billing incentives for people who do not pay for their own energy usage. Ideally, the systematic process prototyped in this case study will be used by installations around the military, resulting in a significant amount of savings.

12524 - "Forecasting Methods Selection based on Historical Demand Pattern Characteristics"

This study gives guidance to select the best forecasting method for a part’s (NIIN’s) future demand based upon its demand history. Broadly applying a forecasting method (e.g. 4 Quarter Moving Average) to a wide variety of aircraft parts results in the use of the forecasting method on demand histories for which it is poorly suited. The presenter’s work in this problem shows that reliability and operational information (especially fleet size) can be used to select a more appropriate forecasting method. If this reliability and operational information is not available, the Coefficient of Variance and Average Demand Interval of the NIIN’s demand history may be computed, from which the NIIN’s demands may be characterized as smooth, lumpy, erratic, or intermittent. Both traditional (e.g. 4 Quarter Moving Average and Single Exponential Smoothing) and less common (e.g. Croston’s and Adaptive Response Rate Single Exponential Smoothing) forecasting methods are used on each of 4435 U.S. Air Force structural NIINs to determine which provides the lowest error method. Additionally, the study proposes certain benchmark “elementary” forecasts to be used when evaluating these more complex methods. These results are grouped by demand characteristic, which shows that different forecasting methods are better suited to each demand characteristic. The results provide a simple heuristic for item managers to use to select forecasting methods from among those (potentially) available in Department of Defense forecasting programs. The proper use of this heuristic can reduce forecast errors by half (or more) when measured by the Mean Absolute Error.
WG 12 Maritime Operations

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<td>LCDR Ronald Domenic Cappellini, Jr</td>
<td>Dr. Jerry R. Smith</td>
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**12313 - Campaign Breakpoints**

Campaign analysis integrates results from multiple mission-level analyses. This integration makes it difficult to quickly respond to 'what if' excursions at the mission level by modeling, and generally resorts to expert judgment. This study uses Controlled Sequential Factorial Screening Design (CSFD) to conduct Design of Experiments (DOE) exploring the sensitivity of campaign level outcomes to system-level inputs. The DEO results are then examined to indemnify the input or sets of inputs that have the most impact on the ultimate campaign. These are then used to construct Bayesian meta-models quantitatively linking sensitive inputs to Campaign Outcomes. This methodology is applied to specific mission threads in the 2028 CC-2 Challenge 3 Campaign STORM model.

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**11913 - Improving Submarine Tactics by Applying Design of Experiments Methodology to a Simulation Study**

Submarine survival from enemy torpedo fire is a complex problem involving multiple interdependent variables. Previous work approached the problem using high fidelity Monte Carlo simulations to understand single variable dependencies. However, the complex nature of the problem and the number of variables prevented using a brute force computational approach to understand interdependencies between the variables.

This study was the first deliberate use of a Design of Experiments (DOE) methodology by Submarine Development Squadron TWELVE Tactical Analysis Group to answer multiple interdependent variables. A team of DOE experts, operations analysts and tactical subject matter experts developed a matrix of factors and then used Monte Carlo simulations to get results. These results were then assessed using the DOE framework.

This paper discusses the tactical problem, the approach to modeling, results, and future application of DOE by CSDS-12.

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**11891 - Analysis in Support of Submarine Tactical Development**

The mission of Commander, Submarine Development Squadron (COMSUBDEVRON) TWELVE is to develop, assess and improve submarine tactics and shape the future capabilities of the submarine force. Operations Research plays a vital role in each aspect of this mission, but decreasing budgets have made it harder to gather sufficient at-sea data to appropriately support tactical development, particularly for analysis of future capabilities such as unmanned vehicles. To bridge this gap, analysts at COMSUBDEVRON TWELVE have developed a hex-board table game, the Low Resolution Tactical Simulation (LRTS), which provides first-order analyses of tactical scenarios at a tiny fraction of real-world cost and effort. This presentation discusses how military, civilian and contractor staffs have employed game-driven analysis to develop tactical guidance for autonomous decoy employment well before crews put to sea. As a result of these efforts, at-sea acoustic range time is more effectively used, data collection efforts are better focused and post-exercise analysis is much better informed. The presentation will show how these efforts provide more analytical robustness on the tactical development continuum from concept to game to acoustic range.

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**12309 - Flotilla Revisited**

Employing numerous small, low cost missile corvettes during offensive maritime operations in a distant littoral environment has been written about extensively in the Naval Services’ flagship publication, “Proceedings”, under the terms ‘Flotilla’ and ‘distributed lethality’. Insights about surface warfare Flotilla operations within an integrated cross domain conflict have been distilled from more complex and detailed campaign modeling and simulation into a form designed to spur debate and highlight issues related to weaponry, resupply, and survivability during Flotilla combat operations.

This briefing has been previously presented at the Navy’s Strategy Discussion Group and RAND Navy lunch, and will be of particular interest to our Five-Eyes partners.
### 11986 - Littoral Surface Warfare Operations Modeling and Assessment

Littoral operations present multiple challenges to maritime operations. Anti-ship Cruise Missile (ASCM) attacks combined with swarm raids of small Fast Attack Craft (FAC) can overwhelm ship defenses. This presentation discusses aspects of the Anti-Air Warfare (AAW) and Anti-Surface Warfare (ASuW) missions including applied rapid simulation and analysis techniques Lockheed Martin employs to evaluate capabilities required to operate in the littoral environment.

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### 12636 - Distributed Operations: Implications for LCS

The Littoral Combat Ship (LCS) was originally conceived as a small platform that would leverage networking and unmanned systems to fundamentally change how naval combat would be conducted in some of the most demanding maritime scenarios, particularly cluttered lethal environments just offshore. In the initial concept work, severing the physical connection of combat power to a warship’s hull was a prominent source of advantage for LCS in naval combat. As a fielded program, LCS has focused on different capabilities and leverage points, and while unmanned systems and modularity are still integral to platform, they have not been as important an element to LCS’s operational prowess as originally intended. Part of the reason for this is that unmanned systems technology has not progressed enough for LCS to meet its full promise in this regard. As the technology improves, however, the opportunity still exists for LCS to become a revolutionary innovation in naval warfare. This presentation introduces a variant of Hughes’ Salvo Equations to show how distributing and reconfiguring combat power among a group of LCS platforms can dramatically improve LCS’ ability to fight, survive and fight again in high-end anti-ship missile combat.

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### 12590 - SAFEGUARD Demonstration

Analysis of Integrated Air and Missile Defense (IAMD) is a common analytic task complicated by the number and types of systems, tactics and scenarios. In 2012, the Navy embarked on the development of a new multi-mission IAMD model capable of analyzing the maritime defense of sea- and land-based aircraft and missile raids. The newly delivered model, SAFEGUARD, represents a substantial advancement of our ability to analyze these problems, capable of modeling simultaneous air-to-air, surface-to-air and air-to-surface hard-kill/soft-kill engagement within the Fighter, Missile and Joint engagement Zones while also accounting for the management of resources, impacts of jamming and benefits of multi-unit C2. This special session will provide an overview of SAFEGUARD’s capabilities and methodology with an extended demonstration of a classified scenario.

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### 11767 - Wisconsin Card Sorting Task Modified for the Military Domain

TRAC-Monterey and the Naval Postgraduate School (NPS) have developed a task to measure military decision-making performance. This new task is modeled after the Wisconsin Card task but focuses on high stakes and uncertain environments particular to military decision making conditions. Thirty-four US military officers from all branches of service completed the tasks yielding decision data for validation. This presentation will discuss the development and validation of this task as well as insights it gives to the cognitive flexibility of military decision makers.

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<td>MAJ Cardy Moten, III</td>
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### 12632 - Improving Wargaming within DoD

Discussion on the purpose and benefits of the use of wargaming within a larger cycle of research for the purposes of fostering innovation and agility.

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The USCG has a requirement to report “readiness” information to Congress. The readiness of all armed forces is currently articulated in resource C-ratings associated with the Global Status of Resources and Training System (GSORTS). Capabilities are articulated using the Defense Readiness Reporting System. USCG is developing a formal link in readiness reporting that ties capabilities and resource information in a way that articulates resilience. This presentation will address the latest developments in USCG readiness reporting, how the USCG is reporting readiness in a new framework that analyzes capabilities based assessments and resource data to enhance the decision cycle, captures operational data, and aids to determine resilience for senior commanders. Resilience is used in resourcing/sustainment of the service’s long-term strategic goals as well as provide insights to operational planners. Trend analysis is helping maximize human performance by establishing a foundation for a learning organization which will influence system thinking, development of personal skills, and a clearly articulated (and shared) vision. Key is the use of Mission Essential Tasks (METs) linked to force generation efforts as well as execution of the Coast Guard’s eleven statutory missions. Mission Essential Task Lists (METLs) provide a framework of assessment of acceptable standards of performance, for given conditions, to the operational commanders. It allows greater articulation of what the Coast Guard is ready to do, with the resources available, with a greater understanding of risks and the near and long-term impact on the service.

WG 13 Power Projection and Strike

The Air Force Research Laboratory is currently working on a new weapon concept that would change the paradigm of weapons design through a common architecture to enable modular subsystems to achieve flexible weapons capability while allowing technology refresh at the pace of technology discovery in an affordable and sustainable design. This paper will review the most recent results from two phases of analysis that are helping to define the requirements for the flexible weapon program. Results will be presented from all levels of simulation across the M&S spectrum including lethality/payload design, 6-DOF/range/propulsion trades, mission and campaign level analysis, and red threat survivability analysis. The overarching objective for Flexible Weapons is to replace current inventory weapons that will not fully utilize the increased capabilities of 6th generation platforms, with a single weapons kit made up of flexible, open architecture components. The various combinations of weapons to address multiple missions must be 100% compatible with 6th generation delivery platforms (fighters, bombers, RPAs) and backwards compatible with 4th and 5th generation platforms. Desired attributes for Flexible Weapon were derived from a comprehensive review and translation of stated needs from the Global Precision Attack (GPA) Core Function Master Plan (CFMP), the Air Superiority (AS) CFMP, and Special Operations (SO) CFMP correlated with needs called out from the Air Sea Battle Limited Operational Concept, 2030+ Air Dominance Capability Based Assessment and Initial Capabilities Document, USAF Science Advisory Board 2035+ Munitions Study, and a number of legacy weapons Operational Requirements Documents and Capability Development Documents.

The contents of the abstract are in review for public release. The draft contents were sent to the session chair for review and will be updated once approved for public release.
This presentation will discuss the results of this study and ongoing efforts. The contents of the abstract are in review for public release. The draft contents were sent to the session chair for review and will be updated once approved for public release.

The Air Force is investigating ways to improve its tactical capability for extended range missions. Technologies are being worked within the Air Force Research Laboratory that can improve the effectiveness of Counter Air, Strike, and Intelligence Surveillance and Reconnaissance missions. The goal of ACTV is to determine the capability improvements these technologies provide to meet the effectiveness and efficiency requirements of these missions. One desired option is to develop a tanker fleet capable of operating in a contested airspace to better position other Air Force mission assets. These technologies improve range, which positively impact mission effectiveness in loiter time and operational range for the mixed fleet. The ACTV program is evaluating the mission impact of new technologies on the interactions between the Tactical Tanker and the Air Force fleet.

To accomplish this, an ExtendSIM model was developed to evaluate measures of effectiveness (MoEs), relevant to the end user. These include Penetration Range, Fuel Consumed and Offloaded, etc. Improvements to MoEs were evaluated against Technical Performance Measures (TPMs) of Structural Mass Fraction and Lift over Drag improvements in a Design of Experiments (DoE) evaluating ∆MoE/∆TPMs. The TPMs are traceable to specific technologies that could achieve these improved levels. Other variables assessed include number of refueling points, fuel capacity, and vehicle fuel efficiency/speed which were assessed within the DoE to determine the beneficial impact of a tactical tanker on Air Force missions and what affect technologies have on the MoEs. This presentation will discuss the results of this study and ongoing efforts.

12265 - Mission Planning and Analysis System (MPAS) Modernization - Shortening the Strategic Kill

(Abstract is pending approval by government official. Please contact primary author for status.)
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### 12315 - Anti-Personnel Landmines

This presentation examines the effectiveness and efficiency of various concepts of employment (CONEMPs) for landmines and alternative systems in a conventional tactical situation (TACSIT). The study used a suite of purpose built models and simulations (M&S) operating at multiple levels of resolution and leveraged existing Intelligence Community (IC) models to examine the potential effects of landmines, direct strikes, unattended ground sensors, and combinations of these three options. The M&S suite was composed of scheduling models that use outputs from an existing campaign model, a discrete event simulation of vehicle movement, simulations of air operations, and stock-and-flow simulations of various processes. The results of the study challenged a number of long held operational assumptions and have informed a POTUS-ordered examination of the impact of landmines and possible alternatives.

**Key Words:** Landmines, APL, Mobile Targets, Time-Sensitive Targeting, TST, Modeling and Simulation

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<td>Dr. Craig Ewing</td>
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### 11032 - Kinetic and Directed Energy Weapons Working Together – Update on Progress Towards Integrated Weapons Environment for Analysis (IWEA) Toolkit

This paper presents an update on the progress made towards the Integrated Weapons Environment for Analysis (IWEA) tool being developed at AFRL. The IWEA program is creating an analysis environment capable of developing a single unified weapons Research and Development (R&D) strategy. Details of the paper include how we have modified and linked tools ranging from engineering to mission levels to provide an analytical environment for analysis, including the output of results to feed campaign level simulations. It will review research efforts to characterize the accuracy of this environment and show how we can perform research into automated battle management systems. It will also demonstrate the capability to develop and analyze decision logic allowing for a mixture of offensive and self-defense missions in highly contested environments; the ability to understand and predict the synergistic effects of using multiple types of energy on target vulnerability; and the ability to exploit higher fidelity data between modeling, simulation, and analysis tools representing air vehicles, battle management, weapon effectiveness, and collateral hazards.

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<td>Prof. Gerald G. Brown</td>
<td>Prof. Emily Craparo CAPT Jeffrey E. Kline, (Ret) Michael Wiederholt</td>
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### 11919 - Optimizing MK-41 Vertical Launch System Missile Loading

Naval operational planners face a number of alternate threat scenarios and must choose to load missiles on U.S. Vertical Launch System (VLS) combatants to meet mission requirements for any one of these. The ideal VLS load considers all deploying ships at once, and decides their loads and mission assignments as a unified fighting force. Missions fall into roughly six qualitative categories, each requiring some number of participating ships and some number of about nine types of missiles. Each ship may have restrictions how many and which type of missile can be accommodated. Some missiles types may be substituted for others with varying effects. We introduce a VLS Load Planner (VLP) and demonstrate it with illustrative Western Pacific scenarios including eight Forward-Deployed Naval Forces for two deployment cycles, and seven and eight West Coast combatants deployed respectively over each deployment cycle. With two example war plans, we show how to prepare for more than a hundred missions. The scheduler has complete manual control over the optimized planning mission and loading assignments, but as we have discovered is well advised to seek advice from VLP.

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22 – 25 June 2015 • Alexandria, VA
### 11845 - Our chief weapon is surprise: a study of air manoeuvre

Air manoeuvre (AM) has been a major operational tool since the start of World War Two. In 2014 Dstl was asked to provide evidence for the shape and continued development of Britain’s AM capability. In collaboration with Dstl, three primary questions were developed:

1. What are the advantages and disadvantages of the different AM methods?
2. How sustainable are AM forces?
3. What command, control and communications (C3) are needed for AM forces?

Two study methods were used to address the problem in 2014–15: an historical analysis (HA) of AM operations by all nations, and a week of manual wargaming facilitated by Dstl, in which UK 16 Air Assault Brigade staff compared different methods of inserting and supporting AM forces in a near-future scenario, in order to gain insights into both the means of delivery and the conduct of ground operations.

The HA compiled a database of over 160 AM operations, which will be described in the presentation, and compared their casualty rates with those from ground-only operations of similar size. It specifically attempted to separate casualties incurred during insertion from those in subsequent combat on the ground, and to examine the effect of achieving surprise on casualties and mission outcome.

The wargaming, undertaken in March 2015, focused on comparing parachute and helicopter insertions to capture an airfield, including the all-important questions of how to achieve surprise, which heavy equipments to prioritise, and how to sustain the forces on the ground. Emerging results will be included in the paper.

### 11929 - A Model for Informing Management on Technical Performance

We developed a methodology for assessing the quality of sets of user requirements or technical performance measures associated with achieving mission objectives. We use a mission stream analysis (e.g., Find, Fix, Track, Target, Engage) to determine if a set of metrics (e.g., KPPs, MOEs) is extensive enough to demonstrate mission objectives. Following this, we determine if the set is quantitative with objective and threshold values, and unambiguous.

This study produced three interesting products.

- A methodology for assessing user requirements (in the ORD or CDD) or a set of technical performance measures (KPPs, MOEs) for their value in determining if mission objectives are met.
- A model for reporting achievement of technical performance to the acquisition community that is both tailor able and specific to all major defense acquisition programs.
- A method for assessing systems engineering performance early in the design phase by examining the state user requirements and technical performance measures.

This presentation discusses the model for reporting achievement of technical performance to the acquisition community.

### WG 14 Air Warfare

### 11643 - Using guiding metaphors in algorithm development

Computer scientists are trained to think in terms of what computers are naturally good at doing. In seeking solutions that minimally diverge from a computer's native logic, an algorithm's 'learning' consequently tends to resemble computer logic rather than human thinking. Instead of asking how a computer's customary logic can be conformed to a problem, we instead ask "what problem is this structurally analogous to that humans solve?" The overall method is to use guiding metaphors in algorithmic design. A metaphor, owing to its origin in the Greek word μεταφόρα (from μετά 'across' + φέρω 'I carry'), is something that carries our thinking across from one domain to another. Insofar as two domains share structural similarity, a metaphor can suggest that the thinking of one domain be carried across to another along with desirable properties. As an example, I will discuss the development of an algorithm to guide an aircraft into an orbit around a point. By using a guiding metaphor, the algorithm gained simplicity and robustness. This approach will be contrasted with more mathematically-centric approaches (e.g., Quigley, et al. (2005)). Finally, the use of metaphors across dissimilar domains and what effects this has on the inheritance of properties will be discussed.
ON DETERRING CHINESE AIR SUPERIORITY OVER THE TAIWAN STRAIT

Having air supremacy is universally considered a requirement for any attempt at a crossing of the Taiwan Strait by the People’s Republic of China (PRC). Using an “acceptable losses” approach, this work looks to see if the US is able to project enough power over the strait to inflict a level of damage above which the PRC will not proceed with aggressive operations. This work calculates the 2 most probable options for the number of Chinese aircraft that may be seen over the strait (constant CAP or surge), and the factors that dictate the number of US fighters needed to achieve this threshold attrition value given a range of two key variables: acceptable attrition rate by the PRC and kill probability (Pk) values of US Beyond Visual Range (BVR) missiles. US aircraft distribution options in the theater, deployment timeline necessary to achieve these levels, and the effects Chinese offensive operations against airfields are considered.

This work concludes that a maximum dispersion model would be the most effective method of projecting a deterring force over Taiwan. Without sufficient hardened shelters or airfields, distribution best ensures aircraft longevity. The principle question, however, is not whether the US can project sufficient air power over Taiwan, but in how long it would take the US to assemble the force necessary to do so. Even low amounts of enemy aggression can prohibit the US from establishing a deterrent CAP for at least 10 days according to even the most favorable basing strategies.
12365 - Advanced Tactical Data Links

Link 16 is the most widely used Tactical Data Link in the Navy, providing situational awareness to the warfighter aboard all surface and air platforms. Prior research has shown that the capacity of Link 16 is strained by the multiple platforms and missions which utilize this Data Link. It will be further stressed in a contested environment where jamming will add an additional threat to our capability.

This study looked at the vulnerabilities, shortfalls and advantages of using advanced capabilities with Link 16 to overcome a contested environment during Air Warfare and Strike missions for one Defense Planning Scenario. System and engineering level modeling together with spreadsheet tools were used to represent challenges to Link 16 as inputs to a campaign level model. In addition, analysis was conducted to determine Fleet tactical data link requirements.

11947 - Toward Consistent & Efficient Target Detection in HSI

Hyperspectral imagery (HSI) sensors collect contiguous data across the electromagnetic (EM) spectrum, where an area being imaged is divided into a pixel-by-pixel grid. Each pixel also has an associated signature defined by discrete intervals, spectral bands, across a subset of optical wavelengths. HSI is advantageous for target detection in that both spatial and spectral information is present; however, this large dimensionality becomes a limiting factor for many algorithms. Detection performance is further complicated by other factors: varying prevalence of absorption or noisy bands in the spectrum that need to be identified and removed to avoid increased false detections, complexity and size of the scene, and the area of the spectrum used by the sensor. This makes creating an unsupervised detector that performs well across different types of images and sensors difficult.

This presentation will showcase research performed as a part of the recent doctoral dissertation “Improving non-linear approaches to anomaly detection, class separation, and visualization”, as it pertains towards more consistently, and efficiently, identifying anomalous pixels across images. Discussion will focus mainly on three contributions, with results compared to current state-of-the-art techniques:

- A factor analysis approach with which to identify bands/data features for removal
- An efficient detection framework that utilizes the fusion of spectral and Signal-to-Noise Ratio (SNR) information
- A n-dimensional visualization technique with which to help see groups and anomalies in large data

11598 - Replicating BRAWLER Air-to-Air Combat in AFSIM (Advanced Framework for Simulation, Integration, and Modeling)

Current mission level simulations don’t offer a high fidelity A2A combat model. We present details on how BRAWLER’s A2A combat fidelity was added to AFSIM. We provide an overview of BRAWLER's method of operation & compare its mental perception model, aero model, & value based decision making to modern day technologies.

We explain our surgical replication method & how we formed the BRAWLER capability into a modern OOP (C++) framework like AFSIM, inserting it into agents using artificial intelligence technologies. We show how the projection, evaluation, & execution steps of BRAWLER's alternatives fit into AFSIM behavior tree nodes. We manifest the added benefits of doing so; including the agent's access to: clustering algorithms, optimal profit allocation algorithms, route finders, heat maps, visual debugging utilities, & script access to everything.

We review the assumptions & limited scope of our first-year effort & provide visual demonstrations of our success. We consider future enhancements to create a more robust air combat agent including a more robust alternative search space, a simple min-max comparison of possible future threat states, & added considerations in the evaluation calculations. We'll also discuss challenges of this effort & our path forward.

11694 - High Energy Laser Weapons for Protection of the Future Air Dominance Platform (HEL-FAD) Study

The contents of the abstract are in review for public release. The draft contents were sent to the session chair for review and will be updated once approved for public release.
**12109 - Applying an Intelligent Course of Action Simulation for Tactics Discovery**

Next generation USAF air vehicles utilized in global strike and air dominance roles will be required to operate in increasingly contested or anti-access environments. Their missions must be completed with an acceptable level of risk, even as threats become much more capable and lethal. To improve warfighter capabilities and survivability within these environments, air vehicles will need to synergistically employ new platform capabilities enabled by several ongoing technology developments, including advanced kinetic and directed energy weapons, countermeasure systems, improved sensor capabilities, and automated pilot decision aids as well as crew interface options. The IWEA program is developing an analysis environment capable of developing a single weapons Research and Development (R&D) strategy.

Initial results from analysis of the Integrated Weapons Environment for Analysis (IWEA) Collaborative Scenario using the Zeus software, an Intelligent Course of Action (ICOA) simulation, were presented at the 2014 MORSS. The technology of interest included multiple high speed cruise missiles concepts, and a traditional cruise missile equipped with a directed energy capability. This presentation will provide a brief description of the Zeus simulation, discuss the technology concepts evaluated, and show the analysis results.

**12116 - Lessons Learned when creating an Artificial Neural Network**

In the future, strike and reconnaissance aircraft will likely be tasked to penetrate an enemy’s Integrated Air Defense System (IADS) and execute their missions without the aid of defensive escort aircraft. These aircraft will require improved combat survivability via an onboard self defense system. The goal of the Self Protection And Reactive Technology for an Advanced Combat Utility System (SPARTACUS) program is develop, evaluate, and demonstrate technologies that provide enhanced defensive system management capability of available self defense resources. The purpose of this study is to explore various processes for data generation to train artificial neural networks (ANN) for use within the SPARTACUS program.

Specifically, the analysis compares two methods of data generation to train ANNs and the resulting effectiveness of the ANNs within the confines of the Zeus software. The two methods of data generation were: data collection based on successfully accomplished specific missions, and gridded generic 1-v-1 engagements with a ground based threat or single air based threat. A comparison was also accomplished between the use of a single ANN and the use of a composite ANN. Key metrics include size of the data set, speed of data generation, speed of ANN creation, quality of ANN generated (can it accomplish the mission), and flexibility of ANN generated. This presentation will review the analysis methodology and the results of recent analyses.

**12323 - Adding Advanced Technology Capabilities into Campaign Modeling & Simulation**

The contents of the abstract are in review for public release. The draft contents were sent to the session chair for review and will be updated once approved for public release.
14643 - Anti - Personnel Landmine/ Cluster Munition Study - Campaign Analysis

At the February 21, 2014 National Security Council (NSC) meeting on U.S. Landmine Policy, the Department of Defense was directed to address the President’s call for an analytical effort to examine the existing—and proposed alternatives to—APL and CM weapons systems, with the intent of enabling the Department to “move into the 21st Century.” To address the President’s directive, the Vice Chairman of the Joint Chiefs of Staff (VCJCS) took leadership of a cross-service effort to assess the operational impacts of APL and CM and to develop options to inform future decisions. AF/A9 served as the Air Force lead for the cross-service analytic effort. In total, the APL/CM study evaluated the operational impacts of employment of existing APL and CM capabilities as they potentially become prohibited, as well as the efficacy of proposed replacements for these systems. This presentation summarizes the campaign-level analysis of CM employment in a combined-arms scenario, highlighting important insights into the effectiveness and efficiency of CM and various mitigation options and munitions mixtures. The results of this study have been presented to the VCJCS and senior representatives from the Services and the Joint Staff, and will inform NSC deliberations regarding U.S. policies on APL and CM employment later this year.

WG 15 Casualty Estimation and Force Health Protection

11511 - A Casualty Network Analysis in Non-Major Combat Operations

Understanding the causes, types and locations of military casualties likely to be incurred during non-major combat operations is essential to effectively plan for medical resources required to support those operations, yet the threats posed are varied and complex. The dynamic environment that sustains non-major combat operations creates a challenge to diagnose the factors leading to casualties in these operations. In this paper, we employ a network analytic approach to discover and explore the underlying casualty incident patterns in this complex, real-world operating environment to better understand the medical effect of health and general threats. Discovery of these casualty incident patterns proves insightful to military medical planners and commanders.

11500 - Locating Military Aeromedical Evacuation and Escort Assets To Maximize Expected Covering of Casualty Demand

Military aeromedical evacuation (medevac) systems save lives by responding to casualty incidents and transporting the most urgent casualties to a medical treatment facility (MTF) via a fleet of evacuation assets. There are distinguishable classes of evacuation assets that demand specialized system operations. This paper examines the medevac and escort asset location problem in which non-weaponized evacuation assets must be accompanied by an armed escort asset. In a military medical systems, the delay from waiting for busy escort assets to become available increases the response time to time-sensitive casualties. This paper introduces an integer programming (IP) model to locate distinguishable types of evacuation assets as well as escort assets to maximize the expected coverage of casualty demand. Busy probabilities of the evacuation assets are included to reflect crowded military medical systems in which assets are not always available for service. The IP model includes alpha-reliability constraints in which the distribution of escort assets must satisfy minimum levels to ensure availability. The IP model is applied to a realistic military data set to provide meaningful insight into difficult asset location management decisions. A broad sensitivity analysis is included to illustrate the impact of system parameters and the robustness of military asset locations.
### 11660 - Multi-Injury Casualty Stream Simulation in a Shipboard Combat Environment

Accurate casualty stream forecasts are essential for estimating personnel and materiel requirements for future naval combat engagements. The scarcity of recent naval combat data makes accurate forecasting difficult. Furthermore, current forecasts are based on single injuries only, even though empirical evidence indicates most battle casualties suffer multiple injuries. These anticipated single-injury casualty streams underestimate the needed medical resources. This paper describes a method of simulating realistic multi-injury casualty streams in a maritime environment by combining available shipboard data with ground combat-blast data. The simulations, based on the Military Combat Injury Scale, are expected to provide a better tool for medical logistics planning.

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<td>Mr. Edwin William DSouza</td>
<td>Mr. Michael R. Galameau, Mary Lawnick, Dr. Ross Vickers, Mr. Vern F Wing, Mr. James M. Zouris</td>
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### 11692 - Development of a Tool Suite for the Medical Planner - the Medical Planners’ Toolkit (MPTk)

Effective military medical planning relies on three interrelated capabilities: the ability to accurately estimate the distribution of specific illnesses and injuries that comprise a population of casualties; the ability to generate daily casualty estimates for a scenario; and the ability to estimate the medical resources necessary to support an operation’s theater hospitalization requirements. The Naval Health Research Center (NHRC) has previously partnered with various Department of Defense agencies to develop software tools that perform each of these functions. These tools were the Patient Condition Occurrence Frequency tool, the Combat Intensity Rate Calculator and Injury Type tool, and the Expeditionary Medicine Requirements Estimator. While each of these tools performed one piece of the medical planning workflow, there was still a need for an integrated solution that allowed seamless information transmission between the tools.

The Defense Health Agency tasked NHRC to combine these three independent tools into a single desktop application to create an end-to-end solution for medical support planning across the range of military operations. The resulting product is the Medical Planners’ Toolkit (MPTk), a powerful tool suite that enables the medical planner to perform all of these functions within an integrated environment. This presentation provides an overview of the MPTk development process, including an introduction to each component tool’s functionality, a discussion of the challenges presented when integrating the individual tools into a single seamless workflow, and a review of future development plans.

This work was supported by the Defense Health Agency (DHA) and the Chief of Naval Operations (N81), under Work Unit No. N1213. The views expressed in this work are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. U.S. Government Work (17 USC 105). Not copyrighted in the U.S. Approved for public release; distribution is unlimited.

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### 11847 - Verification, Validation, and Accreditation of the Medical Planners’ Toolkit

This paper describes the Verification, Validation, and Accreditation process of the Medical Planners’ Toolkit (MPTk) that was developed at the Naval Health Research Center. In support of medical planning and programming analysis, MPTk is accredited for use within the Department of Defense by medical planners, systems analysts, material developers, clinicians, and logisticians to standardize the process for: (a) management of combat, humanitarian assistance (HA), and disaster response (DR) patient condition occurrence frequency distribution tables; (b) estimation of casualties in HA and DR missions and in ground, shipboard, and fixed-base combat operations, as well as the patient streams resulting from these operations; and (c) estimation of the Role 3 expeditionary medical requirements for operating rooms, intensive care unit and ward beds, evacuations, Critical Care AIR Transport Team, and blood products based on anticipated patient loads.
## 11957 - Determining Future Resourcing Options for the Marine Corps Wounded Warrior Regiment

The U.S. Marine Corps (USMC) Wounded Warrior Regiment (WWR) was established in 2007 to provide and facilitate non-medical care to combat and non-combat wounded, ill, and injured (WII) Marines, and Sailors attached to Marine units and their family members to assist them to return to active duty or transition successfully to civilian life. WWR must comply with existing law, regulations, and Commandant Marine Corps (CMC) direction regarding care coordination and support which it provides. Since its inception, the Regiment has cared for nearly 30,000 resident and non-resident WII with staffing costs paid largely by Overseas Contingency Operations (OCO) funding. As combat operations in Afghanistan came to an end and OCO funding continues to decline, Headquarters Marine Corps (HQMC) Programs & Resources Department (P&R), Program Analysis & Evaluation (PA&E) Division was asked to determine the enduring WWR requirement and to develop resourcing options for meeting that enduring requirement. This paper describes (1) WWR organization and services; (2) how the services provided to the WII were cataloged and their costs determined; (3) how future demand for those services was estimated; (4) how options for funding and staffing were developed using a PA&E developed resourcing model, and, lastly, (5) how those options were explained to senior Marine leaders.

## 11603 - Scope and Coverage Evaluation of the Defense Health Agency Medical Logistics Division ICD-9 Code Subset

Problem Statement: For many years, analysts have used a standardized list of patient conditions developed by the Defense Medical Standardization Board, now known as the Defense Health Agency Medical Logistics (DHA MEDLOG) Division, for medical modeling and simulation. This subset of International Classification of Diseases, 9th Revision (ICD-9) diagnostic codes was compiled before the advent of modern health encounter databases and was intended to provide a comprehensive description of the illnesses and injuries likely to afflict U.S. service personnel during military deployments.

Approach: Naval Health Research Center (NHRC) compared their hybrid database, which describes medical encounters from recent contingency operations, to the Clinical Classification Software (CCS; 2014), a diagnosis and procedure categorization scheme developed by the Agency for Healthcare Research and Quality. Using the hybrid data and CCS, NHRC analysts performed a gap analysis to determine if the current list needs to be augmented with additional ICD-9 codes and how does the current list compare to actual empirical data sources.

Results: When comparing the individual ICD-9 codes, this updated candidate set represents nearly a twofold improvement (82% vs. 42%). When comparing the CCS categories, an increase from 82% to 92% was observed.

Conclusions: The DHA MEDLOG Division list lacked some high-frequency in the hybrid database which is an authoritative reference source of healthcare encounters in the expeditionary setting. This report details the analysis and provides the candidate updated list along with a formal mapping schema designed to broaden the scope and coverage of the NHRC ICD-9 set.
### 11663 - Multiple Injury Wound Patient Condition Occurrence Frequency Distribution Development

Multiple injury wound (MIW) patients require a significantly different medical load than less severely injured patients. Consequently, it is important for medical planners to account for the increased workload resulting from MIW patients. As a result, the Naval Health Research Center (NHRC) was tasked with developing an updated list of MIW conditions to reflect recent empirical data. A methodology was derived for classifying MIW patients by the number and severity of injuries suffered using the highly detailed NHRC tri-service Expeditionary Medical Encounter Database (EMED). The severity information allowed for the removal of noise in the data, which included minor severity injuries that have little effect on a patient’s course of treatment. This produced combinations of injuries that frequently occurred together and a subject matter expert panel was convened to determine the most clinically appropriate MIW conditions to include in the updated list. Each of these conditions had a treatment profile created to simulate MIWs within the Joint Medical Planning Tool (JMPT). In addition, a methodology was developed for simulating MIWs within the Patient Condition Occurrence Frequency (PCOF) tool and the Medical Planners’ Toolkit. The addition of MIWs to the growing suite of NHRC-developed tools will better simulate the medical logistics of treating these severely wounded patients.  

This work was supported by Office of the Assistant Secretary of Defense for Health Affairs (OASD/HA) under Work Unit No. N1215. The views expressed in this work are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. U.S. Government Work (17 USC 105). Not copyrighted in the U.S. Approved for public release; distribution is unlimited.

### 11948 - Medical Modeling and Simulation for War Game Support

The Marine Corps Warfighting Laboratory (MCWL) explores future service concepts of operation with war gaming and other assessment techniques to identify the capabilities necessary to support those concepts. The Marine Corps’ Expeditionary Force 21 concept represents a return to the traditional Marine Corps role of assault from the sea in an austere environment. The Expeditionary Medicine Branch of the Technology Division at MCWL desired a more rigorous assessment of medical requirements in the Expeditionary Force 21 concept than is typically achieved through table-top war gaming. To that end, the Expeditionary Medicine 2015 war game was designed to incorporate casualty estimates and assessments of patients’ clinical needs from modeling and simulation tools developed at the Naval Health Research Center. This presentation describes: the war game scenario, the process of casualty estimation in the context of the war game, the model of casualty treatment and evacuation, the integration of model results and game play; and the postgame analysis results.  

This work was supported by Marine Corps Warfighting Laboratory under Work Unit No. N1215. The views expressed in this work are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. U.S. Government Work (17 USC 105). Not copyrighted in the U.S. Approved for public release; distribution is unlimited.
**12132 - Department of Defense Suicide Event Report Data Quality Assessment**

DoD experienced an increased rate of suicide deaths from 2001 through 2012. For example, DoD’s active Component rate has increased from 16.1 per 100,000 service members per year in 2008 to 22.7 per 100,000 service members per year in 2012.

The Department of Defense Suicide Event Report (DoDSER) is the system of record for health surveillance related to suicide ideations, attempts, and deaths. The DoD Inspector General conducted an evaluation of DoDSER to assist DoD in decreasing the number of “don't know” responses on DoDSER suicide death submissions by identifying changes to policy, training, or oversight. Incomplete data (“don't know” responses) about suicide risk factors and contributing stressors may hinder senior leaders from developing and implementing effective suicide prevention programs.

The DoD Inspector General’s report had seven observations and sixteen recommendations. Four of the observations related to DoDSER policy and practices across all Services, two observations related to data sharing with the Department of Veterans Affairs, and one observation related to Military Criminal Investigative Organizations’ participation in the DoDSER data collection process. The evaluation showed that it was possible to significantly decrease the “don’t know” responses by using existing data from medical records and law enforcement investigations.

**12472 - Using Qualitative Methods to Optimize Soldier Load, Effectiveness, and Health**

The United States Army Soldiers’ current head and torso protection systems are heavy, bulky, and do not integrate well with other equipment. The systems’ weight limits Soldier operational effectiveness, and increases Soldier injuries. Product Manager Soldier Protection and Individual Equipment (PM SPIE) engaged the Edgewood Chemical Biological Center Decision Analysis Team (DAT) to conduct cost benefit analyses (CBAs) evaluating the trade-off between cost, risk, and Soldier’s operational effectiveness and health for the Vital Torso Protection and Torso and Extremity Protection systems, and the Integrated Head Protection System. Studies quantifying the relationships between Soldier load, effectiveness, and health have not been completed as they would be complex and costly. Ultimately, the DAT and PM SPIE used quantitative and qualitative (e.g., follow-on effects, qualitative evaluation criteria) approaches to assess these relationships and recommend the best way of providing Soldiers protection that enhanced operational effectiveness, and minimized cost and negative long-term impacts.

**11800 - Lessons Learned in Estimating Human Toxicity for Compounds of Interest (COI)**

In 2007, Edgewood Chemical Biological Center (ECBC) was tasked by the Defense Threat Reduction Agency (DTRA) to execute the necessary, prerequisite toxicological studies and develop human toxicity estimates for five compounds of interest. Toxicity studies were done via two routes of exposure (percutaneous (PC) and intravenous (IV)) in two species: Goettingen minipig and New Zealand white rabbit. During the course of the studies it was recognized that the “time-honored” clinical sign-taking methodology was species-specific to the rabbit (the traditional animal of choice for PC testing) and was not based on the underlying physiology. To rectify this, a computerized, physiologically based system of clinical sign-taking was developed. With: 1) the implementation of the new system, 2) the addition of the minipig for PC testing, and 3) guinea pig and non-human primate data from sister laboratories, it was recognized that our understanding of PC toxicity for many COI was species-specific to the rabbit, and the clinical picture of PC toxicity was not what had been previously thought—necessitating the retraction of some human toxicity estimates that had been previously put forward. This briefing will present: 1) the toxicological data for the five COI, 2) the methodology for and the human toxicity estimates so-developed, and 3) the lessons learned in the process.
response. These formulas have been developed and tested using controlled, constant concentration animal studies, but the validity of exposures. The implication of these results directly extends to the substantial effort from both the DOD and the Department of.

Dawley rats inhaled constant or pulsed concentrations of hydrogen cyanide (HCN) generated in a nose-only exposure system for of the model under conditions of non-constant acute exposure—the first dataset of its kind. Over two separate studies, male Sprague-

IDC recently completed a pair of studies for CAA, the Joint Staff and the Modeling and Simulation Coordination Office that used empirical data from operations in Iraq between 2005 and 2008 to suggest planning factors that could be used in the preparation for and conduct of future overseas contingency operations. The major premise for both studies was that specific, quantifiable Blue force actions could be spatially and temporally associated with major improvements in the indicators of security. Operations and changes in violence were studied in Baghdad and the Belts (2007), the Baqubah area (2007-08), Mosul (2008), and Al-Qaim (late 2005). In addition, an accounting of counter-insurgents per population was developed for each of these locations for the periods studied and across all of Iraq as of January 2008. Finally, substantial environmental data were considered regarding how the population viewed what was unfolding. With the exception of Al-Qaim, the time frames investigated represented the incorporation of the new counter-insurgency doctrine and increased resourcing. Although the actions in Al-Qaim preceded both the doctrine and the accompanying troop surge, they incorporated much of the intent of both. This presentation will summarize the findings and key takeaways from these studies.

A toxic industrial chemical/toxic industrial material (TIC/TIM) task force has been established to provide TIC prioritization and baseline TIC acquisition capability requirements and recommendations to the Joint Program Executive Office for Chemical and Biological Defense. These requirements and recommendations are intended for use by the Chemical and Biological Defense Program during routine military operations outside the continental United States. They are not intended for civil response planning. The U.S. Army Edgewood Chemical Biological Center has developed provisional human inhalation toxicity estimates for chemicals of interest to the task force. The project was designed to be a focused and expeditious assessment and not a comprehensive “all source” literature capture and analysis. The project took advantage of the extensive literature searches conducted by the National Research Council during the development of acute exposure guideline levels (AEGLs) for individual chemicals. In Phase I, toxicity estimates were produced for the following 17 selected chemicals: ammonia, chlorine, cyanogen chloride, formaldehyde, hydrogen bromide, hydrogen chloride, hydrogen cyanide, hydrogen fluoride, hydrogen sulfide, mercury vapor, methyl bromide, nitric acid, nitrogen dioxide, octamethyl pyrophosphoramide, phosgene, sulfur dioxide, and sulfuric acid. The 2 minute median effective dosages, probit slopes, and toxic load exponents (TLE) are reported for 16 of these chemicals. In Phase II, an additional 26 TICs were selected for review and development of toxicity estimates in support of the DTRA Reachback Capability. Prior to this effort, very few median effective dosages/probit slopes/TLE appropriate for military casualty estimates existed for any of the TICs reviewed.

The toxic load (TL) model is an empirical approach in hazard assessment modeling for estimating the relationship between a chemical’s inhalation (IH) toxicity and the exposure duration. The TL is normally expressed as a function of vapor concentration (C), duration (t) and a constant—or Cnt. Hypothetically, any combination of C and t that yields the same TL will give a constant biological response. These formulas have been developed and tested using controlled, constant concentration animal studies, but the validity of applying these assumptions to time-varying concentration profiles has not been tested. Experiments were designed to test the validity of the model under conditions of non-constant acute exposure—the first dataset of its kind. Over two separate studies, male Sprague-

The toxic load (TL) model is an empirical approach in hazard assessment modeling for estimating the relationship between a chemical’s inhalation (IH) toxicity and the exposure duration. The TL is normally expressed as a function of vapor concentration (C), duration (t) and a constant—or Cnt. Hypothetically, any combination of C and t that yields the same TL will give a constant biological response. These formulas have been developed and tested using controlled, constant concentration animal studies, but the validity of applying these assumptions to time-varying concentration profiles has not been tested. Experiments were designed to test the validity of the model under conditions of non-constant acute exposure—the first dataset of its kind. Over two separate studies, male Sprague-Dawley rats inhaled constant or pulsed concentrations of hydrogen cyanide (HCN) generated in a nose-only exposure system for durations ranging from 2.33 to 30 min. The observed lethality of HCN for the 21 different C versus t profiles was used to evaluate the TL model’s ability to adequately describe the HCN lethality under the conditions of non-constant IH exposure. The model was found to be applicable under the tested conditions, with the exception of the median lethality of very brief, high concentration, discontinuous exposures. The implication of these results directly extends to the substantial effort from both the DOD and the Department of Homeland Security Chemical Security Analysis Center to develop TL parameter estimates for high priority toxic industrial chemicals.
WG 15 Strategic Deployment and Distribution

11605 - Policy for Service of Military and Civilian Patients

Military Treatment Facilities (MTF) often face conflicting requirements. They must serve military members, but also treat civilian and retirees on a space available basis. Simulation offers one method to project effects of admission policy changes on target populations. Our analyst team modeled a military psychiatric ward that wants to increase civilian psychiatric ward inpatient admission rates without degrading its ability to treat active duty service members. The facility we modeled is a twelve room inpatient psychiatric unit that admits both active duty service members and civilians. Once 8 of the 12 rooms are filled, civilians are currently referred to local civilian hospitals. We examined if changing the current admission policies at the psychiatric ward degrades its ability to accommodate active duty service members by using data provided by the hospital and developing a simulation model to determine the average rates of admissions and referrals based on different policies. We provided this information to psychiatric ward leadership to inform their policy decision.

WG 16 Strategic Deployment and Distribution

11535 - DODX Railcar Stationing Plan

Prior to OIF, DOD-owned chain flatcars were prepositioned at installations to provide fort-to-port movement of Army rolling stock in the event of a national emergency. Since OIF, the cars have been in “free-running” status, meaning they have been used to move DOD cargo for all purposes, to include routine day-to-day operations; essentially, the Army has not adhered to a stationing plan for the past 12 years. SDDCTEA developed and recommended the Army implement the DODX Railcar Stationing Plan to improve the fort-to-port portion of a major contingency deployment; the improvement, as validated by detailed analysis, results from optimal positioning of DOD-owned railcars. Analysts determined the requirement using the Army's Rapid Expeditionary Deployment Initiative (REDI), determined railcar starting conditions using data provided by industry and individual installations, and built an Integer Program to "match" railcars to requirements such that requirements are satisfied and empty-car positioning distances are minimized.

12138 - Defense Logistics Agency (DLA) Materiel Forecasting in Support of Operational Planning

The Defense Logistics Agency (DLA) is developing the capability to forecast materiel requirements in support of Operations Plans (OPLANS). Recent efforts have focused on developing the capability to predict Class IX (repair parts) requirements. This project has the potential to support budgeting, transportation requirements planning, development of unit/equipment supply priorities, and acquisition decisions.

The process begins when a Combatant Command provides DLA with a Time-Phased Force Deployment Data (TPFDD), which describes unit types and arrival dates. This information is fed into the Logistics Supportability Analysis Tool (LSAT), which determines the types and quantities of equipment associated with each of the unit types and weapon systems as well as applies equipment usage rates. Next, Class IX parts usage rates are determined using either service-provided rates or historic demand data. The end result is a list of equipment, National Stock Numbers (NSNs) and quantities, associated weapon system, estimated costs, and weight and cube data (if available).

The next step in the process combines the forecasted contingency demand with DLA’s standard forecast and supply planning cycles embedded in SAS code (emulating inventory and stock processes) to identify items that are in danger of reaching stock-out conditions. These items are further screened based upon parts criticality, commonality of parts across multiple systems, as well as other considerations to identify high risk parts. A DLA then develops a plan to mitigate the potential risk.

This presentation will describe details of the materiel requirements forecast process.
### 11575 - Case Study of Tracing Model Results Through AMP Versions

The Analysis of Mobility Platform (AMP) is the program of record for military transportation analysis. Given a baseline scenario, we compared the differences between the railcar usage between AMP 14.2.2 (October 2012) and AMP 14.7 (January 2015). Challenges included updating a scenario to ensure model assumptions were consistent between the two versions, isolating changes in a multi-modal, end-to-end scenario, and ensuring that similar closure was maintained. Once the baseline was complete, additional tools were required to evaluate not just railcar usage over time, but why the usage changed over time. Specific tools were applied such as adding tracing code, SQL scripts for comparing run files, and specialized graphs using the Tableau software package. Each of these had their challenges and benefits. Specific examples of differences and how we quantified the impact of each will be presented. Finally, the presentation will conclude with lessons learned for tracking and evaluating impacts of model changes in the future.

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<td>Dr. Charles N. Van Groningen</td>
<td>Mary Duffy Braun, Mr. Adam Szymanski, Mr. Evan VanderZee, Ph.D.</td>
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### 12219 - Combining Simulation and Optimization to Increase Insights: USMC Maritime Prepositioning Force (MPF) Exercise Simulation and OptDef

Simulation and optimization individually are useful tools. By putting the two together we get a very powerful methodology. This research uses a simulation modeling USMC Maritime Prepositioning Force (MPF) exercises in ExtendSim and an optimization tool (OptDef) to increase the insight gained over using a simulation or optimization individually. We start by demonstrating the methodology with a small scale model and then increase the size of the model to test the robustness of the technique. We also cover the pros and cons of using this combination and lessons learned through integrating these tools.

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<td>Mr. Walter DeGrange</td>
<td>Dr. Benjamin G. Thengvall</td>
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### 11779 - A Platform for Planning Optimization Development at USTRANSCOM

The United States Transportation Command (USTRANSCOM) manages global mobility operations to support the other combatant commands. Current mission planning comprises stove-piped legacy systems and manual processing steps to allocate and schedule resources to deliver requirements. Delivery is complicated by a volatile environment that often deters missions from executing as planned. Several models are under development to address these issues, applying advanced optimization approaches to maximize the effectiveness, efficiency, and robustness of mission plans.

The development of these capabilities requires rigorous analysis that considers planning algorithm performance and operational feasibility. MIT Lincoln Laboratory supports the Joint Distribution Process Analysis Center in building a platform to conduct such analysis. The platform provides for model-based simulation of a variety of end-to-end planning and execution scenarios, supports a plug-and-play design for comparison of alternate algorithms, and emulates USTRANSCOM’s to-be data exchange architecture. This talk will provide an overview of this analysis platform. Its key analytical and architectural components will be reviewed, with an emphasis on its ability to provide quantitative results to inform the global mobility enterprise.

*This work was sponsored by USTRANSCOM under Air Force Contract No. FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the United States Government.*
Specifically, this study refines and enhances the methodology utilized to quantify OE impacts to the MAF, and then implements this and Costing of Advanced Technologies and any supporting OE infrastructure as applied to existing Defense Planning Scenarios. Operational Energy (OE) impacts to the mobility air forces (MAF). These include Airlift Fleet capabilities, Aerial Refueling operations, will build upon this methodology while increasing the data fidelity where required. These enhancements will better quantify the expand the demonstrated MS&A capabilities through tool improvement, development and corresponding analysis. Continued efforts threats. FY14, OSD/OEPP funded AFRL/RQQD under the multi-year Operational Energy Capability Improvement Fund (OECIF) to Systems Engineering to research, develop, and create alternatives to validated models of APODs and SPODs in the logistics system. The alternatives will approximate the range of potential operational conditions that need to be considered in the supply chain logistics network. The USMA team conducted research and stakeholder analysis on how APODs and SPODs are operated, modeled operations within APODs and SPODs using ProModel, created alternatives, and recommended actions to improve process efficiency.

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<td>Dr. Amy Bednar Barret Crawford Dr. Simon R. Goerger James Kelly Krishawn Tillett Raphael Waruinge</td>
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**11343 - Modeling Aerial and Sea Points of Debarkation**

For the past 13 years the United States has been at war between two theaters, Afghanistan and Iraq. One of the factors that make the United States Military the best in the world is the ability to sustain combat operations. This is accomplished through the use of Aerial Ports of Debarkation (APODs) and Sea Ports of Debarkation (SPODs). These ports are used to send and receive military cargo to units in support of emergent and established theatres of operation. Several constraints limit the type of cargo transported and the rate of the cargo in transition from one location to another. The Engineering Research and Development Center’s (ERDC) Military Logistics program wishes to enhance understanding of the roles and processes that APODs and SPODs play in the military logistics system by building a validated model of the two ports. The effects and processes of these models are to be integrated into a larger logistics planning tool with the intent to inform decision makers on ways to employ more resilient and optimized supply chain for existing and emergent areas of operation. ERDC has requested a team of Cadets from the United States Military Academy in the Department of Systems Engineering to research, develop, and create alternatives to validated models of APODs and SPODs in the logistics system. The alternatives will approximate the range of potential operational conditions that need to be considered in the supply chain logistics network. The USMA team conducted research and stakeholder analysis on how APODs and SPODs are operated, modeled operations within APODs and SPODs using ProModel, created alternatives, and recommended actions to improve process efficiency.

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<td>24 Jun 11:30 - 12:00</td>
<td>IDA Bldg 4900 Room 720</td>
<td>Mr. Matthew M. Aylward</td>
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**11862 - Retrograde Planning & Execution in RC(SW)**

Forward deployed analysts from the Current Operations Analysis Support Team (COAST) supported the retrograde of personnel and equipment from Regional Command (Southwest) (RC(SW)). This support, which ran from October of 2011 to September of 2014, resulted in analytical tools tailored to the planning and execution tasks confronting members of the RC(SW) staff. These tools became the lingua franca for the RC(SW) staff; the Retrograde & Redeployment Decision Data (R2D2) tool dealt with equipment retrograde and the Combatant, Coalition, and Civilian Personnel Oracle (C3PO) tool dealt with personnel retrograde. Admirable as they are for their sophistication and flexibility, the great impact of these tools was only possible because of the cultural/organizational climate created by the planning staff. The success of R2D2/C3PO shows once again that timely support to an engaged decision maker yields great dividends. Of note, R2D2 also interfaced with Excel based tools that the MARCENT Fusion Cell used; an idea consistent the philosophy of ‘give me your data once, and I’ll show how we can re-use it to answer many questions’. The proposed presentation will summarize tool development (as noted above), then dive into the workings of R2D2/C3PO/SharePoint, interfaces with other planning tools and systems of record, concluding with some lessons learned. The authors would also like to provide a live demonstration of how the tools work with the underlying macros.

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<td>Mrs. Lee Ann Rutledge</td>
<td>Kristi Greenwell Mr. John G Sletten, USAF (Ret) Ms. Janet E. Williamson</td>
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**12241 - Quantifying Operational Energy Effects within a Contested Environment**

In FY13, OSD/OEPP funded AFRL/RQQD to develop a methodology to quantify counter-energy impacts for the Airlift fleet and the larger logistics system as a whole. Future Airlift concepts were employed to assess their capability for mitigating counter-energy threats. FY14, OSD/OEPP funded AFRL/RQQD under the multi-year Operational Energy Capability Improvement Fund (OECIF) to expand the demonstrated MS&A capabilities through tool improvement, development and corresponding analysis. Continued efforts will build upon this methodology while increasing the data fidelity where required. These enhancements will better quantify the Operational Energy (OE) impacts to the mobility air forces (MAF). These include Airlift Fleet capabilities, Aerial Refueling operations, and Costing of Advanced Technologies and any supporting OE infrastructure as applied to existing Defense Planning Scenarios. Specifically, this study refines and enhances the methodology utilized to quantify OE impacts to the MAF, and then implements this methodology within an appropriate scenario.

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11084 - A Graph Coloring Approach to the Deployment Scheduling and Unit Assignment Problem

In this research, we address one of the external factors of personnel inventory behavior in the U.S. military, deployments. The configuration of persistent unit deployments has the ability to affect everything from individual perceptions of service palatability to operational effectiveness. There is little evidence to suggest any analytical underpinnings to U.S. Army deployment scheduling and unit assignment patterns. This paper shows that the deployment scheduling and unit assignment (DSUA) problem can be formulated as an interval graph such that modifications to traditional graph coloring algorithms provide an efficient mechanism for dealing with multiple objectives.

WG 17 Logistics, Reliability and Maintainability

12126 - Integrating Supply Chain Processes: A Framework to Improve Service Parts Management and Establish Forward-Looking Metrics

It is well understood that managing service-parts, which contain the intermittently-demanded parts, is very challenging for the supply chain manager. Too often, supply chain managers fall into the reactionary trap of having to scramble and expedite processes to generate these parts for the operator of the revenue-generating machine when the demand occurs. Many service parts can be acquired by more than one process. For example, the part may be stocked at a central warehouse and merely needs to be shipped to the location of the revenue-generating machine, or may be procured via multiple suppliers, or could be repaired from a previously failed part, or could be taken from another revenue-generating machine (i.e. cannibalized), or may be a candidate for 3D printing, etc. We leverage the utility of the block diagram from reliability theory to integrate these supply chain processes, where the rows represent the supply chain processes, and the columns represent the service parts. This construct allows us to model the supply chain’s expected readiness (to generate service parts for the operator). We also leverage the utility of the bipartite graph to capture the expected resupply time of all the service parts. Using five notional parts and four notional supply chain processes, we show how the supply chain processes are integrated and that the frameworks provide the supply chain manager with (1) new, forward-looking metrics that link to the operations of the revenue-generating machines and (2) a methodology to advance his/her desire to make proactive decisions on supply chain processes to advance the firm’s cost-effectiveness.

11670 - The Design of Responsive Sea-Based Logistics Delivery Systems

The United States Navy uses sea-based logistics to provide the operational and tactical sustainment of forces operating on and from the sea. Sea-based logistics will transform a set of vessels into floating distribution centers that are responsible for fulfilling supply orders from troops on shore. Vital components of sea-based logistics include selective offloading capabilities in high-space-utilization environments, delivery of emergent requests for tailored resupply packages, ship-to-objective logistics via aerial delivery, and cargo transfer at sea. In addition, sea-based logistics operate in a challenging and uncertain environment. Thus, our research is interested in developing models to quantify and evaluate sea-based logistics system design in the face of imperfect visibility. We focus on two important sea-based logistics decisions. First, we develop models that describe the propagation of uncertainty over time when selective offloading in dense storage environments is required. Second, given imperfect information about the location of assets, we are interested in determining which items, and in what quantity, to pre-stage that balances the costs with the rewards of pre-staging. We prove structural results about the property of optimal pre-staging policies and find that due to the presence of imperfect location visibility, the recommended pre-staging policy is different than the one that is recommended with perfect visibility.

22 – 25 June 2015 • Alexandria, VA
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**12131 - PNG: Better Inventory Control for Highly Variable Demands**

LMI developed the PNG inventory control solution to manage items with infrequent demand (isolated spikes in demand) as well as items with frequent, but highly variable demand. Such items account for the majority of stocked hardware at the Defense Logistics Agency (DLA). Forecasting demands for these items—their variability—led to years of bad outcomes for DLA: excess inventory for some items, backorders for others, and excessive buyer workload. Implementation of PNG (a software package of two inventory solutions, Peak Policy and Next Gen) shifted DLA from trying to forecast individual items to a portfolio or risk management approach to inventory control. PNG presents a three-way tradeoff between customer service, inventory value, and replenishment workload. DLA makes a single decision that aligns with its objectives—without separate investments in forecasted demands, safety stock, or order quantities. Since DLA implemented PNG in January 2013, the agency has achieved its inventory-related goals for better customer service and reduced buyer workload, with no increase in inventory and recurring savings of nearly $400 million per year—all from buying more of what sells and less of what doesn’t. We have also extended PNG to guide buys and repairs for repairable items, and we will present preliminary results.

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**12181 - Using Simulation and Optimization for Marine Corps Logistics**

The logistics and maintenance supply chains within the U.S. Marine Corps (USMC) share challenges faced by most supply chains, among them variability and inadequate part availability. Military supply chains also have specialized issues, like very long lead times because parts aren’t even made. For example, one struggle of the Logistics Command (LOGCOM) maintenance process is the unknown amount of repair a vehicle might need when it’s sent back to the depot for maintenance, making it harder to predict what parts will be needed for the repair and order them far enough in advance.

CANA Advisors is developing a simulation model in ExtendSim to investigate portions of the USMC supply chain. With this model, we will be able to investigate cycle times, process bottlenecks, and analyze sensitivity of the system. This can help decision-makers focus the improvement efforts they sponsor. To enable sensitivity analyses, we will use OptDef, a program offered by OptTek that provides an optimization and analysis wrapper for simulation models.

Our MORSS presentation will describe the problem scope and solution space, show the simulation model progress we have to date, the advances offered by using the OptDef wrapper, and discuss the analyses completed and potential analyses we hope to perform.

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**12238 - Assessing Risk in a Global Supply Chain**

This presentation stems from the MORS October 2014 “How Risk Assessments Inform National Security Decision Making” meeting and specifically the Logistics Supply Chain Risk working group. The problem focuses on how to apply a risk management approach and quantitative techniques to assess and manage risk within a global supply chain. This presentation will focus on a risk management approach that has been further developed, the quantitative techniques that have adapted to identify risk events and potential impact, and discuss event detection and post event recovery. Data set up to support quantitative analysis, methods used, and an example problem will reinforce the approach discussion and provide insight into results. The presentation will end with a summary of conclusions and recommendations for additional research.
12149 - Forecasting Method Selection Based on Historical Demand Pattern Characteristics

This study gives guidance to select the best forecasting method for a part’s (NIIN’s) future demand based upon its demand history. Broadly applying a forecasting method (e.g., 4 Quarter Moving Average) to a wide variety of aircraft parts results in the use of the forecasting method on demand histories for which it is poorly suited. The presenter’s work in this problem shows that reliability and operational information (especially fleet size) can be used to select a more appropriate forecasting method. If this reliability and operational information is not available, the Coefficient of Variance and Average Demand Interval of the NIIN’s demand history may be computed, from which the NIIN’s demands may be characterized as smooth, lumpy, erratic, or intermittent. Both traditional (e.g., 4 Quarter Moving Average and Single Exponential Smoothing) and less common (e.g., Croston’s and Adaptive Response Rate Single Exponential Smoothing) forecasting methods are used on each of 4435 U.S. Air Force structural NIINs to determine which provides the lowest error method. Additionally, the study proposes certain benchmark “elementary” forecasts to be used when evaluating these more complex methods. These results are grouped by demand characteristic, which shows that different forecasting methods are better suited to each demand characteristic. The results provide a simple heuristic for item managers to use to select forecasting methods from among those (potentially) available in Department of Defense forecasting programs. The proper use of this heuristic can reduce forecast errors by half (or more) when measured by the Mean Absolute Error.

12310 - Logistics Supportability Study

The ability to resupply ships and their embarked aircraft with fuel and ordnance is of critical importance for day-to-day operations as well as the conduct of any Campaign. Like any wartime operation, sea-based logistics are subject to risk from enemy forces. This analysis focuses on the warfighting impacts of fuel savings initiatives for ships and aircraft in the CC-2 2028 Challenge 3 campaign. In addition, this analysis explores options to support extended at-sea combat.

Authors – LT Ben Peterman, Mr. Alex Trempe

11815 - Software Reliability Risk Assessment and Risk Mitigation

Software is growing larger and becoming more complex in Army systems. The safety, welfare, and effectiveness of our soldiers directly depend on the ability of software to perform as intended and operate reliably in adverse training and combat conditions. Reliability issues have resulted in millions of dollars spent on correcting software systems that failed to meet cost and schedule requirements.

AMSA performed a study that assessed the effectiveness of various software development methods and best practices in use by recent, software-intensive Army systems. The methods were evaluated to identify those best suited for reducing software reliability risk. Criteria for tailoring the methods to specific program circumstances were established through analysis of the various types of software applications and developmental environments currently in use.

The study found that there is very little focus on designing for software reliability in current Army systems and there does not appear to be a formal, thorough software reliability initiative in place across the Army. As a result, most of the systems examined experienced either schedule slippage, test event failure, or both. There are many opportunities for improvement and software-intensive systems may achieve lower reliability risk by implementing many of the reliability-oriented metrics, methodologies, and best practices available.
### 11657 - A Monte Carlo Approach to Readiness Driven Stochastic Optimization in Naval Aviation Activity Based Costing Systems

Activity Based Cost Systems are often used to describe budget requirements, overhead costs and organizational goals in a wide variety of programmatic support activities. In such systems, allocation levels are determined by the relationship between resourcing and programmatic goals. This relationship is often based on a subjective prioritization of the activity categories resulting in inaccurate goal forecasting. This paper will show that activity based costing systems can achieve cost savings and readiness improvements by incorporating Monte Carlo analysis to identify key drivers and by applying stochastic optimization algorithms to the results to lower costs and raise readiness. Specifically, the process and framework is applied to Naval Aviation activity based cost systems within the Air Systems Support engineering and logistics programs across every naval aircraft type/model/series. The resulting findings suggest that application of this method can provide significant improvements in both cost and readiness not only for naval aircraft but for a wide array of organizations and commercial entities.

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### 11829 - Using Bayesian Statistics to Model the Reliability of Complex Weapon Systems

This presentation will focus on the development of a Bayesian model that can be used for assessing the reliability of a complex weapon system. The Bayesian model that has been developed is capable of utilizing pass/fail test data from component tests, full system tests, and covariate information. Developing the ability to incorporate component tests into a reliability model can greatly increase the amount of usable data. Most weapon systems, focusing on nuclear weapon delivery platforms, go through full-system tests in very small quantities (4-8/yr). Full-system tests are costly and usually diminish overall stockpile quantities through destructive testing. By building a model that can also utilize component data we give ourselves the opportunity to increase the data we can use for reliability calculations. The final piece of the Bayesian Reliability model is incorporating covariates into the model. These covariates can be anything from storage location, production facility, age at time of test, etc... After discussing the development of this reliability model, the focus of this presentation will shift to real-world applications focusing on how a similar Bayesian reliability model has been developed and applied to calculating the reliability of the Air-Launched Cruise Missile (ALCM).

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### 12035 - Analysis of Communications Systems Reliability on Network Performance

This paper addresses two methodologies used to assess the impact of radio reliability on communications networks. The first approach analyzed the performance impact of a Brigade Combat Team network in an operational representative scenario due to variations in the mean time between essential functional failure (MTBEFF) using a discrete event simulation of the BCT network. The radio equipment reliability was addressed parametrically, using values of 50 hours, 250 hours, and 500 hours to characterize the impact MTBEFF has on network performance in terms of message completion rate and message delay. The second method employed an analytical approach to determining how radio reliability and the number of gateways between two subnets affected the end-to-end connectivity between platforms in the lower subnet and platforms in the higher subnets. Again, a parametric approach was taken to show how the reliability and number of gateways impacts the probability of a gateway failure within a 72 hour mission and the average time a gateway would be down within a 72 hour mission.

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11808 - The Spectrum of Modularity: The Impact of a Flexible Surface Combatant

Modularity is an ambiguous term with a spectrum of meanings and without a standard design metric. Today, naval planners and ship designers focus on the small picture of the platform, itself, and not on the big picture of mating the platform to the future fleet demands. The modular ship concept has been around since the 1970s and many countries have experimented with different aspects of modularity for platforms but few have come close to a fully modular ship and even fewer have experimented with a truly modular fleet. Modularity has potential to make ships more resilient and adaptive but is very different from the current status quo and can, potentially, impact the fleet in unexpected ways. These impacts of modularity include the compatibility of different fleet missions, the number of ships necessary to provide required capabilities and capacities in a specific fleet architecture, the impact to industry with longer lasting ships, impact to acquisition of follow-on ships, and the relative cost of a broader, resilient, flexible, modular, adaptive strategy. Careful consideration of these different areas can act as the foundation of a standardized method meant to aid designers and decision makers on the subsequent impact of choices on the appropriate modularity to implement at the mission, platform and fleet level. This paper will examine the platform and fleet-wide impacts of a notional modular surface combatant on acquisition, mission readiness, maintenance, and service life in order to lay the foundation of a standardized method intended to support designers and decision makers.

11534 - Advanced Framework for Simulation, Integration, and Modeling (AFSIM) Real Time Mission Level Logistics Processes for Repair and Resupply, with Demonstration

The Advanced Framework for Simulation, Integration, and Modeling (AFSIM) is gaining momentum within government and industry as a flexible, extensible simulation tool for operations analysis. Recently the framework has been extended to address exchange of goods and services between simulated entities to permit logistics analysis in the context of mission-level simulation. This mechanism has been implemented compatible with the DIS protocol, enabling the exchange to occur between AFSIM or non-AFSIM platforms in a distributed simulation environment.

Presentation will describe how entities broadcast the availability of products or services, how other entities which desire may request them, and the interaction needed to negotiate the type, quantity, and rate of exchange.

Demonstration provides a scenario to illustrate supply/receive operations. An island base will support air sorties for strike operations, with on-island fuel tanks and parts depot requiring sea-based resupply. Metrics will be gathered on the baseline scenario and sensitivity to loss of some sea-based resupply.

11080 - How to use “Safety Factor” to Determine Reliability of Mechanical/Structural Components

In the design of many systems, some of the components are mechanical/structural. The probability that these components will fail is strictly a function of the stresses they will encounter during operation and their inherent strength. The probability of failure of these components is not a function of time of operation like electrical, electronic, and electromechanical parts. This means that characterizing and calculating their reliability cannot use the traditional measures of “mean-time-between-failure”. Organizations in space systems have, for many years, used various techniques of “safety factors” or “factors of safety” to characterize the design of mechanical/structural systems in terms of margin in design to mitigate the risks of withstanding overstressing. We applied engineering and analytical methods for mapping safety factor to reliability (the probability that a system/subsystem will perform its intended function during a specified period under specified conditions).
11656 - Challenges and Benefits of incorporating Reliability Engineering into Tradespace Analysis

Tradespace analysis is a DoD Engineered Resilient Systems initiative focus area that employs science, engineering, and design tools to produce solutions for a wide range of operational contexts. To date, tradespace research emphasizes performance. However, non-functional requirements such as reliability, availability, and maintainability have received minimal consideration, despite their direct influence on program-level concerns such as operation and support as well as affordability. This presentation summarizes our research to identify a systematic strategy to incorporate reliability engineering into tradespace analysis for the Future Vertical Lift (FVL) initiative. We extend recent research [1] that established a preliminary model characterizing the relationship between reliability investment and life-cycle support costs to develop a subsystem-level reliability investment model. This more detailed formulation can provide quantitative guidance on how investments in reliability improvement should be divided when subsystems do not contribute equally to essential function failures that render a system not mission capable.

References

11601 - USMC DEPOT REPAIR OPTIMIZATION - Repair Optimization Materiel Evaluator

The Repair Optimization Materiel Evaluator (ROME) model has received VV&A from DC I&L and DC P&R. It has been designated as the Marine Corps model to support Life Cycle Support Managers as they develop the Marine Corps’ depot maintenance solutions for the Enterprise Lifecycle Maintenance Program. ROME allows analysts to build scenarios that incorporate various input combinations to create realistic and appropriate depot repair induction plans and allows for “what-if” analyses that provide accurate, up-to-date results that inform POM and financial decisions for the Marine Corps Enterprise. The ROME implementation assists life cycle support managers by putting a quantitative basis behind the depot maintenance induction plan and the annual POM and budget submissions. ROME recommends the repair of Marine Corps equipment that optimizes readiness and warfighting capability based on the funding controls. The scientific method used in the ROME further validates and supports the Marine Corps depot maintenance funding requests.

Maj Antonio DeMarco, USMC, created the Repair Optimization Materiel Evaluator (ROME). At the heart of the ROME model is a mixed integer mathematical program. The program is implemented in the GAMS software package and is solved using the IBM ILOG CPLEX optimizer. ROME evaluates repairable equipment considering budget constraints, cost of repair and importance of the equipment to the Marine Corps and optimizes the use of available fiscal resources to provide recommended depot maintenance funding options.

11799 - Military Wheeled Vehicle Weight Estimation With Condition Based Maintenance Sensor Data

ABSTRACT: Knowing military wheeled vehicle cargo weights is important for both operation planning and estimation of vehicle reliability, mobility and maintainability. Due to the limitation and practicability of physically weighing each truck frequently across a fleet, truck cargo weight estimation has been an engineering barrier and a technical challenge.

In this analysis, three engineering approaches have been studied based upon data availability and precision requirements. The first method is based upon a power demand and power supply mobility model which estimates one optimal vehicle weight so that power demands from rolling resistance, slope climbing, aero drag and acceleration would equal to engine power output. The second method is based upon an empirical energy efficiency model with field vehicle engine sensor data. This method identifies vehicle energy coefficients and the major input factors. As one key input factor, vehicle weight can be projected from a 2 dimensional or 3 dimensional empirical coefficient model. The last method is by leveraging the latest data mining and machine learning technology. A few supervised machine learning methods have been compared and combined for best estimation results, such as: a dynamic neural network, a non-linear regression, a nearest neighbor classification and a Naive Bayes and support vector method.

This research concludes with practical application tips to select a best method for military truck operation weight estimation with acceptable precision depending on data availabilities.
### 12286 - Suitability Analysis of Continuous-Use Reliability Growth Projection Models

Substandard system reliability is one of the leading causes of increased Operations and Maintenance (O&M) costs as noted in several recent National Research Council reports. Between 2006 and 2011, Director Operational Test & Evaluation noted 26 of 52 Department of Defense acquisition programs failed to meet reliability thresholds, but were approved, leading to degraded operational performance, increased O&M costs, and increased safety risks for personnel involved. As a system is developed from prototype to final product, structural changes and design flaws are corrected, leading to an increase in system reliability, called reliability growth. Due to the nature of the system changes, standard forecasting methods cannot be applied, and a class of reliability growth models is used to estimate the change in reliability over multiple stages. Despite the significant impact of reliability growth projection, little research has been accomplished on comparing the robustness of various reliability growth models. A simulation is developed to create realistic reliability growth testing data based on historical reliability tests. Using data created via reliability testing simulation, reliability growth projection models are compared based on accuracy and predictive tendencies. Statistical analysis is used to determine which projection models are robust to violations of model assumptions as well as potential hazards in reliability growth program modeling and implementation.

### 11752 - Decision-makers Don't Trust Your Dashboard: Applying contemporary lessons from psychology, graphic design, marketing, and management science to make your data achieve its purpose.

With uncertainty in their operational and fiscal environments, and ubiquitous “streaming” data, military decision-makers must ask more and better questions and receive quicker and tailored answers in order to win in a complex world. They need the quick and intuitive truth provided by information dashboards. But can decision-makers trust the dashboard? Conversely, can the analyst trust that his dashboard will be interpreted and used correctly?

This research considers a decision-maker not only to be a supervisor who makes organization-level decisions, but also the subordinate whose daily decisions provide the information that feeds the dashboard. The subordinate’s decisions are impacted greatly by his trust in the system that captures, analyzes, and presents to his supervisor the data which his actions produce. As a case study in how trust influences decisions, this research explores the Fleet Insight Toolkit (FIT). AMSAA developed FIT, a dashboard-like environment, to provide near-real-time, visually-based, self-directed, and scalable analytics for ground fleet readiness. The toolkit derives information from many sources, including both Soldier-entered and sensor-collected data. FIT communicates relevant Condition Based Maintenance (CBM) data and metrics to vehicle operators, maintainers, unit commanders, Army staff, and everyone in between. FIT provides an accessible example to discover the way dashboard designers and users may interact with their data to inform decisions.

We conclude this research with practical advice to help build trust in your data and analysis for decision-makers at all echelons. We investigate the true purposes of a dashboard and discuss ways to keep it relevant, useful, and honest.
11441 - PLANS (Planning Logistics Analysis Network System) Training Scenario Use Case Exploring Force Projection

As the U.S. military places more emphases on operations in A2AD environments, the ability to establish and sustain logistic support is a major issue. Logistics commanders need tools that take into account environmental and operational factors to help plan for requirements, resources, and capabilities. To facilitate strategic and operational planning, the US Army Engineer Research and Development Center is currently developing the online program, PLANS (Planning Logistics Analysis Network System). PLANS will be used to analyze a set of early entry alternatives to optimize effectiveness and efficiencies adapting to environmental conditions such as weather, bathymetry, terrain, and sea state in support of austere entry. PLANS allows for comparison of early entry alternatives. This presentation will focus on a training scenario use case exploring force projection. The use of different austere ports as well as degraded bridges will be analyzed with viable courses of action in a dynamic environment impacted by weather, enemy and neutral force activities, and sustained operations.

11510 - Multi-Criteria Logistics Modeling for Military Humanitarian Assistance and Disaster Relief Aerial Delivery Operations

Given that it is not always feasible to reach an affected area via land or sea within the first week following a natural disaster, aerial delivery provides the primary means to rapidly supply the affected population. In this work, we proffer a multiple criteria decision analysis (MCDA) framework to optimize the military humanitarian assistance/disaster relief (HA/DR) aerial delivery supply chain network. The model uses stochastic, mixed-integer, weighted goal programming to optimize network design, logistics costs, staging locations, procurement amounts, and inventory levels. The MCDA framework enables decision-makers to explore the trade-offs between military HA/DR aerial delivery supply chain efficiency and responsiveness, while optimizing across a wide range of real-world, probabilistic scenarios to account for the inherent uncertainty in the location of global humanitarian disasters as well as the amount of demand to be met.

11945 - Operations Research Impacts on Air Force Strategic Commodity Sourcing

The Air Force has implemented a new focus to source strategically its commodity requirement, employing strategic contracts to reduce contract actions, reduce lead times, and reduce prices. These actions provide more responsive support and save money. To help with this mission, the AF Sustainment Center positioned a small team of analysts in its Enterprise Sourcing Strategy Flight charged with finding strategic opportunities, measuring the impacts of strategic sourcing in an actionable way, and helping to implement these capabilities in standard operating processes. The team developed inventory models that identify where there are supply chain opportunities to pursue that would provide potential savings. The models are simplifications of a full inventory model to allow for faster calculation and larger data sets. In addition, the models are not concerned with modeling inventory directly, rather how an inventory solution impacts funding. The driving business need is to identify the funding opportunities from sourcing opportunities that drive improvement factors in the supply system.

The team has helped to implement the models in standard tools, including web-based tools, which are applied by the using community as part of their standard business processes. To date, users have reported budgetary requirement reductions of more than $196M and avoided more than $313M in spending that was planned for the year of execution.
### 12093 - Frenemies: Why the Warfighter Should Care about Logistics

By re-imagining our supply chain and its relationship with the front line warfighter, we can reduce the risk to the warfighter caused by outdated supplies and equipment, long lead times to fielding equipment, shortages of key items, and the unnecessary missions and risk associated with excessive excess. In 1969 General Carter Bowie Magruder, one of the top logisticians in the army, compiled a list of reoccurring logistics problems he had seen through his 27 years of service (which included WWII, WWI and Korea). While General Magruder clearly and accurately identifies ongoing problems within our current military supply system, and forecasts problems that would occur during future logistics support to a large scale conflict, some of the problems he identified as unsolvable, have been tackled successfully in today’s commercial markets. By comparing and contrasting these reoccurring military logistics problems with emerging competitive logistics strategies in commercial markets there are ample opportunities to restructure our understanding and implementation of Military Logistics.

In recent history, companies across multiple markets have re-imagined their strategy on logistics to take advantage of emergent supply chain theory and new technology. In doing so they have changed their supply chains, from a necessity, to a tactical advantage allowing them to better capitalize on competitor’s weaknesses to efficiently and accurately meet more demand. Understanding the strategic and potentially tactical advantages to the warfighter could help revolutionize our supply system from the brute force push system used in World War II to a modern, proactive supply system that takes advantage of the advances in supply chain theory and technology developed in commercial markets over the last forty years to better meet the warfighter’s needs. One of the key cornerstones of this process is by engaging and empowering the war fighter not just as a customer of the supply system but as a key stakeholder with a central role in the logistics ecosystem.

### 12337 - The Extra-Small Base Camp (ESBC) Manpower Model: A baseline model to assist ERDC in the assessment and evaluations of candidate solutions for the Force Protection- Basing STO-D

Recognizing the need to synchronize force protection across all of the services, the Department of Defense commissioned the following Capabilities-Based Assessments (CBAs): 1) Integrated Unit Base Installation Protection (IUBIP) and 2) Army Base Camps in Full Spectrum Operations. The primary findings of the IUBIP CBA was that “future joint operations must possess ‘seamless’ protection capabilities to protect personnel, assets and information critical to strategic, operational and tactical level mission success.” The primary finding of the Base Camps CBA was the need to address the inefficiency of the Army to develop safe, cost effective base camps that “support the operational Army in a contingency environment.”

Although both assessments did an excellent job in addressing shortcomings, they did not cover or address several significant areas. For example, in 2011 the Army Science Board (ASB) concluded that “there is currently no model to measure the troop-to-task hour improvement for building outposts.” Furthermore, if a troop-to-task model did exist, the ASB determined that it could help reflect the impacts of specific technologies in various operational areas. The ESBC Manpower Model will assist various agencies in finding and implementing feasible DOTMLPF solutions that will address the Force Protection- Basing STO-D and help ASA (ALT) meet the DOD requirement to minimize the ESBC construct and de-construct times.

This presentation captures the challenges of developing a baseline model for various agencies to utilize and reference while accurately capturing the complexities of the problem it is trying to represent.
11428 - Implications of UAV Operator Manpower Policies on Crew Quantity, Effective Time on Station and Personnel Cost

A recent article (“Exclusive: U.S. Drone Fleet at ‘Breaking Point,’ Air Force Says”), published on the web stated that the “Air Force has enough MQ-1 Predator and MQ-9 Reaper drones. It just does not have the manpower to operate the machines.” Since 2000, there has been a dramatic increase in the use of long endurance Unmanned Air Vehicles (such as the RQ-4B, Global Hawk, MQ-1 Predator, and MQ-9 Reaper) to support military operations. Because these UAVs have flight endurances of 14 to 30 hours, they are typically used to provide 24/7 coverage over the areas of interest (AOI). This in turn drives the number of personnel required to support operations. Operator utilization is driven by policies such as crew rest, flight duty day and maximum flying time. For the USAF, these policies are documented in Air Force Instruction 11-202 Volume 3, Chapter 2.

The purpose of this paper is to assess the impact of these manpower policies on the ability of a notional UAV system to provide coverage over an extended period. Effective Time on Station (ETOS) is the parameter used to assess a UAV system’s (the set of deployed vehicles, ground control stations, personnel, etc.) ability to provide the required coverage.

Until recently, modeling and simulation tools have not been available to support requirement trade studies or analyses that forecast the relationship between operational performance, availability, support resources (spares, support equipment, facilities, manpower) and Operations and Support (O&S) costs. Using an object-oriented simulation engine, ETOS can be modeled using the desired surveillance coverage requirement and the inherent reliability and maintainability characteristics, the scheduled maintenance requirements and the necessary support resources of the UAV system.

This presentation will examine the implications of manpower policies on the ability to generate effective time on station and the cost of providing that surveillance coverage.

Note: In keeping with this year’s theme of “growth through personnel development”, Northrop Grumman uses the creation and presentation of a paper at the MORS symposium, as a mentoring opportunity. Junior engineers are partnered with a senior member of the technical staff to perform the analysis. This builds relationships, fosters knowledge transfer and through the attendance of the symposium creates an excitement about their analytical field.

11683 - USMC Equipment to Maintainer Ratio: A SME-Driven Approach

The USMC logistics community has long sought a planning ratio between pieces of equipment and the type and number of Marines necessary to operate and maintain that equipment. This ratio may be used to establish manpower requirements for a set of equipment, in support of mission planning and force structuring. Previous approaches required accurate and complete data about the number of hours required to maintain and operate equipment. This type of data tended to be unavailable, untrusted, and ill-suited across the many types of equipment. Inherently, several long-term efforts are underway to improve this data. We present an interim, alternative approach which integrates the current, as-is, equipment-to-Marine (E2M) ratios with qualitative subject matter expertise (SME) inputs. SMEs are used to generally characterize equipment for criticality, and total duration of equipment operation and maintenance. The as-is E2M ratios are weighted according to the SME characterization of the equipment. This weighting allows for equipment-specific ratio differentiations, such as that between trucks and radios. We develop a software tool that allows a user to first select or build a set of equipment, with the tool then estimating the type and quantity of Marines necessary to support that set of equipment. The tool has been embraced within USMC maintenance and supply communities, and is continuing further development for force integration.

Further, our approach demonstrates integrating quantitative analysis with qualitative data. This shows that as data problems continue to plague may of our analyses, achievable solutions can be offered in lieu of ‘perfect’ data.
**12058 - A Prototype Network Optimization for the Distribution of Navy Cruise Missiles**

Due to the significant increase in uncertainty in budgetary and operational environments, the Naval Supply Systems Command (NAVSUP) must still ensure that our management of supply chains produces optimal mission readiness and performance. One example in particular is the management of the cruise missile supply chain. Sustaining (or enhancing) performance with declining budgets requires deep re-examination of the how this supply chain operates, challenging the status quo, and finding new ways of working. This presentation highlights a pilot study focused on minimizing cruise missile redistribution costs. By leveraging historical data and supply chain network diagrams, we developed a prototype model using a Commercial-Off-The-Shelf supply chain optimization software. The modeling and subsequent analysis showed a potential reduction in unnecessary missile redistribution costs. Even though this was a prototype model with limited scope and preliminary results, it demonstrated a clear value in using Operations Research techniques to improve NAVSUP’s ammunition positioning decisions. We continue to evaluate assess ways to utilize advanced analytic techniques to ensure all ammunition assets are optimally positioned to meet warfighter requirements effectively and efficiently, and to develop viable models to resolve shortcomings.

**12412 - Right-Sizing Peacetime Aircraft Availability to Support Wartime Capabilities**

The Campaign Analyses Division of Headquarters Air Force, Studies, Analyses, and Assessments (AF/A9FC) informs challenging Force Structure decisions through rigorous analytical insights supporting the Air Force Strategy, Planning and Programming Process decisions. Central to Air Force success is assuring proper peacetime support levels needed to maintain forces at required readiness levels from which a timely ramp up to, and sustainment of, wartime requirements and return to peacetime operations can be seamlessly executed without damaging the logistics enterprise. With the logistics community facing increasing budget reduction pressures, developing tools to improve the AF capability to meet logistics demands is essential. This presentation describes AF/A9’s Aircraft Availability (AA) model development efforts that support the Air Force AA Working Group’s year-long, multi-command, multi-functional look at the role of AA generation capability in meeting peacetime, contingency, and wartime flying requirements. It details the three phases of this effort to: (1) define the problem, variables and trade space; (2) describe an analytic methodology that captures and quantifies AA-related enterprise- and installation-level processes and interrelationships; and (3) construct a parallel, two-perspective modeling approach to provide enterprise-level AA predictions, given flying hour demands and specified resourcing levels and the ability to realize those demands at the base level. The current testing regime designed to demonstrate the utility of this approach is described, along with how constructing a potential AA-resource trade space can be used to inform AF decisions. Also discussed are future efforts to institutionalize AF/A9’s Aircraft Availability (AA) model within the logistics community. Briefing materials associated with this topic will be unclassified.

**12415 - Commercial Off-the-Shelf (COTS) Equipment Modernization (MOD)**

To ensure CM Units are effectively equipped to conduct their CBRNE defense missions, JPdM CBRNE A&RS initiated the COTS MOD Process to assess CM Unit requirements and/or capability gaps and fund the rapid procurement of COTS equipment to fill those requirements and/or capability gaps. The ECBC Decision Analysis Team developed an MCDM and resource allocation approach to assess potential COTS materiel solutions for the CM Unit requirements and/or capability gaps. Development of an assessment methodology was particularly challenging because CM Units have a wide range of requirements due to varied operating climates and hazards. Also, equipment under evaluation is disparate, including items in different commodity areas, such as CBRNE detectors and personal protective equipment. This presentation will describe the multi-step approach and methodologies used in the COTS MOD process, which include identifying requirements, qualitatively screening potential COTS materiel solutions, and then quantitatively assessing the selected COTS solutions using a single evaluation model.
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**12424 - Development of a Suite of Logistics Planning Tools to Support Campaign Planning, Modeling, and Simulation**

The Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) is leading an effort to develop the Expeditionary Site Selection Tool (ESST), a suite of logistics planning models and tools designed to be a fully functional and integrated suite for use at Headquarters Air Force, Major Commands, and Numbered Air Forces by operational and analytical planners. ESST provides commanders, planners, and analysts a more complete logistics view of the planned operations for each beddown location, along with the ability to look at theater-wide implications. This presentation will detail how the development of this suite of planning tools will allow the ability to evaluate the feasibility and capability of an installation’s infrastructure to perform the proposed mission, allowing assessment of the effects of augmenting infrastructure with prepositioned equipment and air or surface movement. The suite includes connection to a standardized Geospatial Information System (GIS). This enables the planner to build operational requirements and assess logistics support with visibility of the other functional domains, reducing duplication of effort, identifying conflicts, reducing “go/no go” decision-making time, using the most current available data from multiple sources to support decisions.

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**11648 - Corrosion Predictive Analysis for a Conditions Based Maintenance Approach**

Currently, the US Army uses a vehicle type and usage based maintenance model to predict when maintenance repair parts will be needed. Moving to a conditions based maintenance model will improve the predictive analysis on when parts need to be replaced more often due to corrosion, will provide maintenance planners with better predictions in a new deployed environment, will provide military planners with a tool to determine the best location for fleet storage, will provide a planning tool to extend the life of a vehicle by vehicle rotation, and will allow vehicle designers to find potential corrosion hot spots long before the vehicle is used by Soldiers. In support of the conditions based model, we present a probabilistic analysis tool to assist with pitting corrosion risk management of equipment/infrastructure that is subject to dynamic corrosive degradation processes and mitigation schemes. This tool fits very well into the collaborative efforts of multiple Army organizations working together to create the end goal of conditions based maintenance. We also will discuss how conditions based maintenance could be used for the Army’s Stryker vehicle as an example of the potential advantages of this model.

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**11759 - Reliability Test and Evaluation (T&E) efficiencies**

The importance of incorporating test efficiencies into the Army acquisition process has increased rapidly due to budget constraints and the need to quickly provide enhanced capabilities to our Soldiers. Army Materiel Systems Analysis Activity (AMSAA) has leveraged computer-based modeling and simulation (M&S) and targeted testing to reduce test time and to improve Return on Investment (ROI) costs. In support of Department of the Army Test and Evaluation (T&E) Efficiencies Task Force reliability initiatives, AMSAA and the Army Evaluation Center (AEC) developed a guidance framework that can be applied to Army programs to obtain testing efficiencies while maintaining or increasing system reliability levels. The framework suggests eight key elements (e.g., system model, test conduct, risk assessment, etc.) that are essential to develop a robust reliability program with high T&E efficiencies.
WG 18 Manpower and Personnel

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**12237 - Manning Analysis of Sexual Assault Prevention and Response Personnel**

The Research and Analysis Branch within the Operations Division of Headquarters Air Force, Office of the Vice Chief of Staff, Sexual Assault Prevention and Response (AF/CVSO) provides Air Force senior leaders with analytical insights and the latest research on sexual assault in the military. This presentation will describe the analytical efforts taking place within AF/CVSO to ensure proper employment of SAPR personnel.

SAPR personnel, including the Sexual Assault Response Coordinator (SARC), the Victim Advocate (VA), and the Volunteer Victim Advocate (VVA), are responsible for providing response resources to victims of sexual assault as well as giving SAPR training to installation employees. Integer programming is used to determine an ideal allocation of SAPR personnel across the Air Force. A variety of constraints, objective functions and weighting schemes are considered.

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**12236 - Sexual Assault Prevention and Response Analytics**

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Analytical efforts include congressional and presidential reports, commander kneeboards, surveys, focus groups, and research projects within the Air Force and in collaboration with civilian organizations. Kneeboards provide metrics on various factors including reporting, demographics, and incident details. These data points inform policy changes and Sexual Assault Prevention and Response Program adjustments. Additionally, surveys are designed and implemented to produce statistical information regarding the health and well-being of a particular Air Force population. Several research topics of interest include the characteristics and behaviors of perpetrators, victim treatment, and manning of sexual assault prevention and response personnel.

Briefing materials associated with this topic will be unclassified.

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**11818 - Moneyball for the Military**

Why is the “Moneyball” concept made famous by the Oakland A’s and later Brad Bitt relevant to the military? In part, because Major League Baseball and the U.S. military share three key characteristics. First, both organizations are in a position where they have to make important and frequent personnel decisions. At Solarium 2015 Gen. David G. Perkins mentioned that the Army alone makes upwards of 100,000 personnel decisions a month. The second unique characteristic that these organizations share surrounds the amount of data each of these organizations have on their members. In contrast to most commercial organizations, data is collected on members from the time they join the organization till the time they retire. Lastly, each organization must optimize performance in the face of constraints and an environment that is constantly changing. The U.S. Military is faced with attracting and retaining the highest quality service members while operating within a resource constrained budget and an every changing threat landscape.

The advanced analytical techniques that underlie the “Moneyball” approach offer the U.S. military an opportunity to gain value from the wealth of data they are already collecting. The techniques can be used to answer complex questions and identify new courses of action for personnel strategies in recruiting, training, and/or retention. Incorporation of these analytical methods provides a framework for operational decisions that are data driven, defendable, and can be traced back to the risk they impose to our nation’s future security.
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**11673 - Simulating the recruiting process for policy analysis**

Recruits are sequentially assessed and classified into specific military occupations by each service. In this paper we describe the classification problem, construction of a simulation model of the recruiting and classification process and show how we can simulate the classification of service accession cohorts with varying levels of aptitude and other characteristics into service skill classification requirements. We discuss applications of this model to problems, such as determining the levels at which each of the services would begin to have difficulty classifying its recruits against skill requirements.

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**11823 - Probability Management Model of Navy Recruiting Resource Allocation**

The mission of Navy Recruiting Command (NRC) is to provide the Navy supply chain with the raw materials (recruits) necessary to meet the manpower requirements of the Navy. Meeting that mission requires a combination of resources (recruiters, advertising, incentives, support functions, etc.) tempered by environmental conditions (civilian unemployment; available, qualified population; etc.). Over the years NRC has developed models that help predict the resources required to meet their mission under forecast environments. These models have been largely deterministic models that produce point solutions based on statistical averages for given set of resource and policy proposals.

The authors adapted an existing Navy recruiting resource-allocation model by incorporating the techniques of probability management using the Excel-based SIPMath™ tools developed by ProbabilityManagement.org. The model incorporates the parameters of an econometric enlistment supply model to forecast the production of new contracts, accessions, total budget and changes in the Delayed Entry Program stock. Rather than provide point estimates of these forecasts, the probability management model explicitly incorporates the model’s uncertainty as expressed in the supply model parameters’ standard errors. The model then provides useful information for decision makers. For example – rather than forecasting that a given combination of resources will result in X new contracts – the model provides a mean forecast and calculates the probability that the Navy will achieve new contracts target.

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**11587 - Assessment of Competing Methods for Test Question Validation**

This work evaluates several methods used for test question validation. The purpose of validating test questions is to remove overly difficult or confusing multiple choice questions and questions that do not discriminate well between test takers who know the material and those who do not. Using test instruments that appropriately measure the test taker's knowledge is important at all levels of performance evaluation. One of the methods currently in use is based on classical measures and statistical hypothesis testing. In contrast, some civilian testing industries employ the biserial method which uses the correlation between an individual's overall score and his/her question responses for question validation. These methods, in addition to alternate hypothesis test and nonparametric methods developed in this work, are assessed for varying sample sizes and test scenarios. All methods' performances are demonstrated on sample tests and Monte Carlo simulations are used to further explore their theoretical performance. Power curves resulting from the simulations are beneficial as they provide visual tools for decision makers to select the method/settings which most appropriately balance the risks and benefits of the resulting decisions.
### 12218 - Analysis of the US Army ROTC Order of Merit Score Model as Predictor of Officer Performance

In 2005, the Assistant Secretary of the Army for Manpower and Reserve Affairs (ASA M&RA) directed ROTC to establish an objective Order of Merit Model to provide Cadets with better understanding of their relative rank in the Cohort. This model has been used for branching since 2006. This study determined the relative value of each of the OMS Model criteria as a predictor of performance as an Officer. Did performance in the 15 different criteria of the OMS Model correlate to Officer Performance? How did GPA performance compare to Army Physical Fitness Test performance as a predictor of performance. Are we considering and weighting correctly the right criteria?

This study used ROTC branching Cohorts from FY 06/07. Of the 5,000 Cadets in these active duty cohorts, 2,900 Cadets remained on Active Duty currently and/or had their performance assessed (completed Captain Key Developmental assignment). The purpose of this study was to categorize each of the OMS criteria as a predictor (good or bad performance in criteria resulted in greater likelihood of good or bad performance as an Officer), and rank each of the criteria as a predictor. The study also ranked each of the criteria as a predictor for overall continued service. The ranking method employed was a novel and straightforward regression analysis of the OMS criteria and Officer performance data. The end result was an effective and easily understandable means to help a understand the relative effectiveness of the OMS criteria as a performance predictor for Officers.

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### 11744 - The Feasibility of Requiring and Resourcing Language Education for Uniformed Personnel

To satisfy a Congressional requirement, IDA was asked to assess the feasibility of requiring and resourcing foreign language and cultural education for all active duty officers and non-commissioned officers. The assessment consists of two parts. This report first examines the current requirements for foreign lanuage proficiency and culture-oriented capabilities, focusing on DOD issuances, Service policies, and the Services' training and education enterprise. The second and primary part of this assessment estimates the marginal cost of foreign language acquisition for active duty officers and non-commissioned officers, which are derived from the IDA Language Cost Model that utilizes Defense Manpower Data Center personnel data. These cost estimates address the feasibility of requiring and resourcing foreign language and cultural education for Service Personnel, and how tradeoffs can be made by investing in pre-commissioning programs.

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### 11974 - Aligning Officer Personnel Requirements with a Sustainable Career Lifecycle using Historical Continuation Rates

The US Army is at a criitical juncture in determining a supportable military personnel structure that is limited by mandated end strengths throughout the Future Years Defense Program (FYDP). Grade creep over the past decade has necessitated efforts to drive the grade structure back down, but these efforts have only achieved partial success. Additional personnel structure adjustments must be made in order to drive near-term force-shaping personnel policies, such as accessions, promotions, and separations. Many of these structure adjustments must be forecasted prior to force management decisions by Army Senior Leaders. In addition, personnel analysts must align requirements by grade with a feasible inventory. Analysts must identify the sustainable standards of grade using historical continuation behavior while accounting for future personnel management policies. In order to properly align structure requirements for the Active Component (AC) Army Competitive Category (ACC), personnel analysts developed a steady state forecasting model that uses historical continuation rates. The model uses sixteen years of historical monthly continuation rates as a foundation to determine future continuation behavior. The model provides flexibility by dynamically responding to changes in future Officer management policies such as accessions, promotions, and separations. The forecasted 30-year inventory is then used to recommend future personnel structure requirements. The results of this analysis are currently being used to drive Active Army Officer management decisions that will shape the future Active Army Officer Corps. This presentation discusses the iterative process used to align requirements with a feasible 30-year inventory based on continuation rate modeling.

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**11521 - Assessing Risk Associated with Staffing Options for Coast Guard Units**

In order to make fully-informed staffing decisions, Coast Guard leaders must be aware of the risks associated with those decisions. Presently, no comprehensive risk assessment accompanies Coast Guard staffing options. This paper proposes a six-category risk model on which staffing risks can be reported and measured. These risk categories are employee satisfaction, employee performance, component failure rate associated with maintenance, simultaneity of operations, single points-of-failure, and overall mission achievement. Regression analysis of Organizational Assessment Survey data, literature review of human performance as it relates to work hours, a special case of the linear programming assignment problem, and literature review of maintenance techniques are among the methods used to measure the risks. Chief among the challenges faced in developing the risk model was sparse component failure data from which to correlate with maintenance practices. Analysis results show that risks generally increase at low staffing levels and decrease at optimal staffing levels.

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**12062 - Approximate Dynamic Programming Algorithms for United States Air Force Officer Sustainment**

The United States Air Force (USAF) officer sustainment system involves making accession and promotion decisions for nearly 64 thousand officers annually. We formulate a discrete time stochastic Markov decision process model to examine this military workforce planning problem. The large size of the motivating problem suggests that conventional exact dynamic programming algorithms are inappropriate. As such, we propose two approximate dynamic programming (ADP) algorithms to solve the problem. We employ a least-squares approximate policy iteration (API) algorithm with instrumental variables Bellman error minimization to determine approximate policies. In this API algorithm, we use a modified version of the Bellman equation based on the post-decision state variable. Approximating the value function using a post-decision state variable allows us to find the best policy for a given approximation using a decomposable mixed integer nonlinear programming formulation. We also propose an approximate value iteration algorithm using concave adaptive value estimation (CAVE). The CAVE algorithm identifies an improved policy for a test problem based on the current USAF officer sustainment system. The CAVE algorithm obtains a statistically significant 2.8% improvement over the currently employed USAF policy, which serves as the benchmark.

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The U.S. Army is expected to expand and contract as necessary to meet changing threat, economic, and political conditions. Current analytic methods focus on combat requirements in developing resource constrained operational force designs. These tend to rely on simulation of static force structures with fixed readiness policies. Additionally, the Army’s force structure analysis models have no direct linkage to cost, instead relying on manpower limits. This type of approach is ill-suited to consider the cost vs. benefit tradeoff of the Army, or the overall size and composition of the Army and how it should adapt over time. We propose a multi-stage optimization model to determine dynamic force size while accounting for uncertainty of future force demands. We begin by providing a method to approximate force demand as a discrete empirical distribution amenable to a stochastic optimization framework. Next, we develop a strategic level stochastic linear program of the Army to include the total workforce, operational and institutional forces, deployment policies, and costs. Solution methods are evaluated and presented as a computational study. Finally, we offer insights for further development and potential use of this approach to augment future force structure analysis.
12230 - Forecasting Air Force Officer Sustainment
The Air Force models officer sustainment for each career field in order to understand how retention behavior will affect the force over a 30-year career. Modeling officer sustainment allows the Air Force to assess the overall health of the force, manage the force, and determine accession requirements for each career field. An inaccurate officer sustainment projection results in a manning imbalance within and/or across career fields; therefore, forecasting accurate officer sustainment will maximize resources across the portfolio of officer career fields. This presentation provides a methodology to forecast officer sustainment and evaluate the forecasting accuracy across the portfolio given various forecasting assumptions.

11769 - Analytical Approach to All-Army Volunteer Assessment
The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) conducted the All-Volunteer Army Assessment in an effort to answer a question posed by the TRADOC Commander: “In today's environment, what size all-volunteer Army can America support?” TRAC analyzed environmental influencers such as medical and legal disqualifiers that affect the enlistment of the target U.S. population, ages 17-24. Many of these factors influenced the quality as well as the quantity of Soldiers accessed into the Army. Analysis was based on historical data collected from government and industry sources for each disqualifying factor, demographics for the target population, and propensity to serve in the military. This presentation will describe the analytic scope, methodology, disqualifying factors, and proportions used to determine rough-order estimations of the Army in 2025.

11930 - Valuing Military Compensation and Retirement Modernization Commission
In February the MCRMC released its proposed changes to military benefits. Among the most contentious recommendations submitted was a proposal to move to a blended retirement system. The proposal consists partly of a defined benefit plan in addition to other non-annuity benefits with various vesting points, in contrast to the current pure defined benefit system which cliff vests at 20 years. The proposal relied upon valuations which disenfranchised a large contingent of the active military population. While we hold that proposed package as a constructive development in compensation reform, we endeavored to revalue the package under parameters that we believed were more representative of real world levels. Using actuarial techniques we revalue the proposed packages under parameter levels which we believe would better preserve member value. This resulted in a revised blended benefit package which still observed the blended plan’s structure, however made up of different continuation pay schedule in order to achieve a package which preserved member value while reducing costs to the DoD.

11686 - Advanced Analytical Approaches for an Agile Workforce
Both government and contractors are facing significant challenges in staffing. Decreasing budgets and increasing complexity drive these challenges but they are made more complex by changing workforce demographics and preferences, rapid technological advancement, and the need for increased cross-functional skills. These drivers also necessitate increased flexibility in staffing and deployments. But moving with this type of agility is a challenge given current personnel planning and practices. This presentation will demonstrate analytical techniques that have been used to help both improve forecasting of dynamic manpower requirements and to develop the levers for force shaping and staffing that can meet these requirements from a manpower planning and deployment perspective. Techniques will include projecting future needs at a detailed level, gap analysis and strategies to address gaps, optimizing manpower deployments, determining policy and force-shaping levers, and others. An advanced workforce model that is based on inputs and outcomes will also be discussed in detail including the use of this model to optimize variables such as manpower cost, readiness, location / deployment, supply, and risk. The presentation will also include organizational factors that contribute to agility including structure, training, policies, and other elements as well as how these factors are represented in the manpower modeling. Examples from both military and civilian agencies will be examined.
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**10849 - Dashboard Decision-Making: Breaking the PowerPoint Paradigm to Enhance Assessment in the Complex Environment of Manpower Reductions**

PowerPoint habitually serves as the backdrop to guide discussion when leaders convene, and for good reason. It is an accessible, versatile, and universally understood means of communication. When presenting analysis and/or large amounts of information, however, an alternative dashboard approach can substantially improve the process. Synonymous to automotive displays, users configure a meeting dashboard to show a wide variety of applicable information and graphics. PowerPoint slides give way to a single Excel display as the backdrop to guide discussion, with relevant data readily brought forward. Direct database inputs enable adjustments to reflect in real time, and the interactive nature of its user fields add flexibility to adjust outside pre-established agendas. This two part presentation first examines the dashboard concept and its diverse applications. Illustrative examples are provided by manpower reduction and function prioritization dashboards. Part two then closes by transitioning from concept to execution, exploring best-practices for preparation and implementation.

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**11550 - Dashboard Decision-Making: Breaking the PowerPoint Paradigm to Enhance Assessment in the Complex Environment of Manpower Reductions**

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<td>Ms. Christina Achampong</td>
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**11932 - Mission-Driven Manpower Allocation: A Decision Analysis Approach**

In contrast with the Post 9-11 surge - today's defense agencies are all too familiar with resource decreases, while demands increase. Combining prioritization and optimization models, NSA Analysis & Production employs a decision analysis approach for mission-driven manpower allocation. We first refine requirements by identifying mission delegation opportunities. We execute a rigorous prioritization model to establish mission value. Finally, we apply optimization techniques to select a manpower allocation portfolio that maximizes mission value, subject to constraints and dependencies. A previous prioritization model has been successfully leveraged to motivate non-pay resource allocations. This developing work experiments with internal debate over the feasibility of using the same model to inform both manpower and mission resource decisions. An objective, repeatable resource decision model with strategic focus will ensure continued mission success in the constrained environment of the foreseeable future.
### 12576 - Bringing Civilian brains to the front line: Delivering high readiness deployable Analysts and Scientific Advisors for the future

Readiness in the context of UK’s Defence Science and Technology Laboratory’s (Dstl) Scientific Support to Crisis and War (SSCW) project is defined as ‘the provision of trained and prepared Operational Analysts (OA) and Scientific Advisors (SCIAD), held at readiness to deploy as embedded advisors to operational commanders and Headquarters (HQ)’. Since the end of operations in Afghanistan this year the UK MODs Support to Operations group within Dstl has refocused on the future and has rapidly developed a process for recruiting, training and holding deployable OAs and SCIADs at readiness to support the next operation, whatever it may be. In particular, our new deployable OA assessment centre, readiness tracking database with individual technical passport, and our Frontline OA training Week have all been designed, developed and tested in short timeframes. This enables the UK MOD to generate the required readiness capability quickly and adaptably given the uncertainty around future needs. We have utilised support from our colleagues in other nations including the US, Canada, Australia and the Netherlands to ensure we can deliver what we aim to be a world leading capability.

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### 11512 - The U.S. Army Medical Department Uses Goal Programming to Optimize Workforce Planning Decisions

Given the large number of specialties in the U.S. Army Medical Department (AMEDD), determining the appropriate number of accessions, promotions, and personnel inventory needed to support a 30-year lifecycle for each medical specialty is a complex task. In this work, we proffer the Objective Force Model, a deterministic, mixed-integer linear weighted goal programming model to optimize workforce planning for the AMEDD. We also describe two stochastic optimization variants, which incorporate probabilistic components associated with uncertain officer continuation rates. We employ a discrete event simulation model to verify and validate the results of the deterministic model. The OFM provides tremendous value to the AMEDD in terms of time, requiring only seconds to solve rather than months; this enables them to conduct quick “what if” analyses for decision support, which was impossible to do manually.

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### 12134 - Measuring Operational Demand

Each quarter, AF/A1PF (Force Management and Enterprise Readiness Analysis Division) releases a list of stressed career fields, which includes a formulation intended to reflect the level of operational demand (ops demand) on those stressed career fields. This formulation is based on two main factors: Air Expeditionary Force (AEF) tempo band posturing and percentage of a career field currently deployed. With the transition from the traditional AEF construct to AEF teaming in 2014, A1PF’s ops demand model became obsolete. A1PF is taking this transition period to re-think how to accurately measure ops demand on career fields.

A1PF is using a heuristic technique to investigate a suite of metrics that will more accurately represent operational demand on a career field. These metrics are based on a literature review of Deploy-to-Dwell (D2D) and Mobilization-to-Dwell (M2D) policy as well as meetings with Career Field Managers (CFMs) and Functional Area Managers (FAMs). Two critical questions that must be answered are: what measurement timeframe is valid, and how should the data be aggregated?

This project is in work and is estimated to be complete in May 2015. Thus far, investigation has revealed a lack of standardization in how D2D/M2D is calculated across the DoD and USAF, as well as the need to both represent the average D2D/M2D and distribution of D2D/M2D values.

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<td>Capt. Eric Alexander Newman</td>
<td>Major Ryan Marc Harrell</td>
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### WG 19 Readiness

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<td>Eric Williams, USN (Ret)</td>
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#### 11939 - Readiness Kill Chain Methodology

The U.S. Navy is tasked to provide ready, forward deployed naval forces. The Readiness Kill Chain (RKC) provides a holistic view of readiness, a means to break down institutional barriers and increase understanding of readiness production. It is a repeatable methodology to identify production barriers and their root causes, followed by collaborative development of effective solutions. This will lead to higher readiness per dollar spent, more efficient coordination across the Navy, and better trained warfighters.

The RKC is similar to a kinetic kill chain that requires an unbroken series of events to kill a target. RKC begins with an understanding of ends, ways and means. This helps us focus on forward deployed forces while analyzing the elements that are used to achieve that end. The RKC looks at everything from resourcing, policy and procurement to sustained execution of the Fleet Response Plan and finally forward deployed readiness.

The RKC methodology uses a five-step process; First, subject matter experts from multiple organizations make an overall assessment of the “as is,” status of the given system. We create a process map - a pictorial representation of events, functions, stakeholders and relationships. This map highlights previously unknown gaps and barriers that exist. A “stoplight” matrix shows areas that are deficient, areas that minimally meet standards, and areas that are healthy. We use root-cause analysis to identify the originating source of the breakdown and direct efforts at that area in the kill chain. We then execute solution development and prioritization to overcome root causes.

### 12391 - Analytical Approach to All-Army Volunteer Assessment

The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) conducted the All-Volunteer Army Assessment in an effort to answer a question posed by the TRADOC Commander: "In today's environment, what size all-volunteer Army can America support?"

TRAC analyzed environmental influencers such as medical and legal disqualifiers that affect the enlistment of the target U.S. population, ages 17-24. Many of these factors influenced the quality as well as the quantity of Soldiers accessed into the Army. Analysis was based on historical data collected from government and industry sources for each disqualifying factor, demographics for the target population, and propensity to serve in the military.

This presentation will describe the analytic scope, methodology, disqualifying factors, and proportions used to determine rough-order estimations of the Army in 2025.
### 12567 - Data Readiness, insights into the application of “Big Data” technologies within DOD

Technologies for managing large sets of data have matured significantly over the last decade. In principle, data aggregated from across the enterprise will reduce the time required to do deep, rapid analysis. This has opened new possibilities for the military. Operations Research (OR) community but has also highlighted challenges in both policy and enterprise systems architecture which must be overcome in order to facilitate “Big Data” analytics. The OR community has a unique opportunity to be at the forefront of translating data into actionable information that is able to support good decision making. The question is how to take advantage of these technologies within the DOD IT infrastructure. To help address this question, the Marine Corps has sponsored a “Big Data” proof of concept in an attempt to harness the inherent scalability of modern data technologies. During this effort which attempted to leverage large volumes of data from both logistics and manpower information systems, Data readiness emerged as a key issue which must be addressed in order to realize the promise of big data technologies. This paper reviews the lessons learned during this proof of concept and examines what it means to be “Data Ready”.

### 11609 - Optimal medium-term fleet planning incorporating deployment, flying and maintenance constraints

We consider the development of an optimal fleet management plan for a fleet of naval combat helicopters. The fleet must have a certain number embarked on ships at all times, and meet monthly and annual flying requirements for both the embarked and ashore fleet components. The aircraft need to be regularly maintained, with both phased and depot-level maintenance incorporated. We also ensure a balance of flying hours across the fleet, in order to manage an orderly withdrawal from service. We seek to maximize the serviceability of the fleet while prescribing a monthly flying and maintenance plan over a period of up to three years that meets the above requirements. We present an integer-linear program and preliminary results for a small naval helicopter fleet.

### 11668 - Using Approximate Dynamic Programming to Adapt the Army’s Force Mix

The Total Army Analysis (TAA) is an annual decision forum through which the Army determines how to modify its force structure over the Future Years Defense Program. TAA seeks to identify prudent changes to the structure that will maintain or improve the Army’s ability to conduct missions in support of the Defense Strategy. Essentially, TAA is a problem of sequential decision making under uncertainty. We developed an approximate dynamic programming methodology that makes sequential force structure modification decisions given uncertain demand for forces and a heuristic for satisfying that demand. We discuss a case-study application of this methodology and relevant results.

### 12141 - Assessing Risk in Navy Readiness

Development of Navy Program Objective Memoranda requires the service to assess risk in all aspects of the Navy program, including force readiness. Unlike capability assessments, which are directly linked to well-specified performance requirements, readiness is often driven by ambiguous requirements that struggle to achieve validity in the early phases of the Planning Programming Budgeting and Execution. Consequently, despite the fact that Navy readiness requirements are determined by performance/pricing models, there are lingering concerns regarding the actual impact of underfunding readiness accounts. This project will provide a more effective approach for conducting risk assessments of Navy force readiness. It will begin with a clear delineation of the readiness requirements as stated in strategic documents such as the Defense Strategic Guide and the Defense Planning Guidance; consider CNO’s commitment to meeting those requirements (as stated in CNO’s Navigation Plan); and conduct analyses regarding the likelihood of the Navy program to meet those requirements.
12267 - Unified Engagement (UE) 14 Blue Play Continuity: Expanding on the Foundation Established in UE10

Before Unified Engagement (UE) 14, the last time the UE wargame came to the Pacific theater was in 2010. Then it was only the second ever UE in the Pacific and the first ever to designate a directorate responsible for producing an assessment deliverable within the wargame to inform Blue CC decisions. UE10 laid the foundation for including an assessment capability within the Blue Combined and Joint HQ staff, and this standard was adhered to in UE12 while it was in the European theater.

From the start of UE’s 2014 return to the Pacific, A9, the Analyses and Assessments Directorate within Pacific Air Forces (PACAF), set out to deliver on the promise to use the experience from UE10 to expand on the foundation for assessment participation and experimentation within the wargame. As UE executed over the course of 18+ months and culminated in CAPSTONE completing in February of this year, we revalidated previous findings, made new discoveries, refined our methods, improved our integration, re-established ourselves as a Joint and Combined directorate, and produced an Assessment Annex to the OPORD.

Breaking ground in UE10 with a solid foundation from which to build on the concept of “conducting Blue Assessments in a wargame,” we gleaned knowledge in UE14 and now are able to envision the next iteration of assessment experimentation for future UEs.

12397 - Using Additive Manufacturing to Improve Parts Support in the Aerospace and Defense Sustainment Supply Chain

Many defense supply chains fail to provide support of those seemingly insignificant parts that can ground weapon systems. One alternative is to invest large sums of money for huge inventories of parts. While buying at least one of everything is an option, the strategy can still fall victim to a lack of suppliers who are ready, willing and able to produce the desired part. The reason is that many airframes are quite old and were originally produced with now aging technologies. For example, the B-52 has been in service since 1952 and many of the original suppliers are no longer in business. One possible solution that holds promise is Additive Manufacturing. Additive Manufacturing promises to revolutionize the way we make things and will fundamentally change the way supply chains work.

While this technology is over 30 years old, it is still changing and evolving. Many Chief Supply Chain Officers see this new technology as significant and possibly disruptive to their current supply chain network configurations. However, of these supply chain leaders have not considered where the technology would best be utilized. It is important that a plan be thought out on where this technology could be employed to solve current manufacturing problems and develop plans for how best to leverage it into the future.

This paper analyzes how Additive Manufacturing could be used in the aerospace and defense supply chains. The current state of the technology is covered as it relates to where it could be inserted to address unique sustainment issues such as aging aircraft, low demand items, vanishing vendors, and ‘cold start’ production runs. It also reviews other unique issues for the aerospace and defense industry and possible impacts to supply chains. Finally, a cost/benefit framework is presented for determining the economic feasibility of this technology now and into the future.

12143 - Measuring Operational Demand

Each quarter, AF/A1PF (Force Management and Enterprise Readiness Analysis Division) releases a list of stressed career fields, which includes a formulation intended to reflect the level of operational demand (ops demand) on those stressed career fields. This formulation is based on two main factors: Air Expeditionary Force (AEF) tempo band posturing and percentage of a career field currently deployed. With the transition from the traditional AEF construct to AEF teaming in 2014, A1PF’s ops demand model became obsolete. A1PF is taking this transition period to re-think how to accurately measure ops demand on career fields.

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This project is in work and is estimated to be complete in May 2015. Thus far, investigation has revealed a lack of standardization in how D2D/M2D is calculated across the DoD and USAF, as well as the need to both represent the average D2D/M2D and distribution of D2D/M2D values.
Currently COMPACAF uses a tool titled the Warfighter Capability Assessment (WCA) which provides a staff-level forecast of the Pacific Air Forces (PACAF) capability to "fight tonight", respond to crises, and execute the OPLAN all prior to the time-phased force and deployment data (TPFDD) flow. (Inputs come from functional subject matter experts, Defense Readiness Reporting System (DRRS), Status of Resources and Training System (SORTS), MAJCOM databases, and wing-level inquires.) This brief will cover the current WCA, to provide insight, and then move on to the steps taken to produce a joint version (geared toward the JFACC). The main focus will address the flow of information and authorities (between sister services) and new forecast capabilities.

Technologies for managing large sets of data have matured significantly over the last decade. In principle, data aggregated from across the enterprise will reduce the time required to do deep, rapid analysis. This has opened new possibilities for the military Operations Research (OR) community but has also highlighted challenges in both policy and enterprise systems architecture which must be overcome in order to facilitate "Big Data" analytics. The OR community has a unique opportunity to be at the forefront of translating data into actionable information that is able to support good decision making. The question is how to take advantage of these technologies within the DOD IT infrastructure. To help address this question, the Marine Corps has sponsored a "Big Data" proof of concept in an attempt to harness the inherent scalability of modern data technologies. During this effort which attempted to leverage large volumes of data from both logistics and manpower information systems, Data readiness emerged as a key issue which must be addressed in order to realize the promise of big data technologies. This paper reviews the lessons learned during this proof of concept and examines what it means to be "Data Ready".

In this research, we address one of the external factors of personnel inventory behavior in the U.S. military, deployments. The configuration of persistent unit deployments has the ability to affect everything from individual perceptions of service palatability to operational effectiveness. There is little evidence to suggest any analytical underpinnings to U.S. Army deployment scheduling and unit assignment patterns. This paper shows that the deployment scheduling and unit assignment (DSUA) problem can be formulated as an interval graph such that modifications to traditional graph coloring algorithms provide an efficient mechanism for dealing with multiple objectives.
12103 - US Coast Guard Readiness, Risk, and Resilience; Coast Guard Resources and Capabilities Evaluation System (CG-RACE)

The USCG has a requirement to report “readiness” information to Congress. The readiness of all armed forces is currently articulated in resource C-ratings associated with the Global Status of Resources and Training System (GSORTS). Capabilities are articulated using the Defense Readiness Reporting System. USCG is developing a formal link in readiness reporting that ties capabilities and resource information in a way that articulates resilience. This presentation will address the latest developments in USCG readiness reporting, how the USCG is reporting readiness in a new framework that analyzes capabilities based assessments and resource data to enhance the decision cycle, captures operational data, and aids to determine resilience for senior commanders. Resilience is used in resourcing/sustainment of the service’s long-term strategic goals as well as provide insights to operational planners. Trend analysis is helping maximize human performance by establishing a foundation for a learning organization which will influence system thinking, development of personal skills, and a clearly articulated (and shared) vision. Key is the use of Mission Essential Tasks (METs) linked to force generation efforts as well as execution of the Coast Guard’s eleven statutory missions. Mission Essential Task Lists (METLs) provide a framework of assessment of acceptable standards of performance, for given conditions, to the operational commanders. It allows greater articulation of what the Coast Guard is ready to do, with the resources available, with a greater understanding of risks and the near and long-term impact on the service.

12065 - Balancing Cost and Availability: Adapting an Air Force Iso-Cost Model for the Army

The 2015 National Defense Authorization Act (NDAA) established a National Commission on the Future of the Army (NCOFA) to study Army force structure issues, with a focus on the mix of active and reserve component forces (AC-RC mix), and report to Congress. This commission was patterned on the National Commission on the Structure of the Air Force, which had been established by the 2013 NDAA. In support of that commission, the Air Force created an analytic methodology (referred to as “Saiful Charts”) for assessing AC-RC mix in the context of the Air Force. As a result of the success of this methodology, the Center for Army Analysis (CAA) developed a version of the methodology to assess AC-RC mix for Army force structure.

This adapted methodology uses linear iso-cost curves derived from home-station and deployed cost estimates to reflect the cost differences between active and reserve component forces. It combines these iso-cost curves with linear reflections of potential demands and force generation constraints to highlight alternative force mixes with similar costs that can better meet demands, or force mixes that can meet similar demands with lower average annual lifecycle costs. In order to test the adapted methodology and draw broad initial conclusions, CAA analyzed fourteen different force elements including combat, combat service, and combat service support units.

12566 - An Integrated Approach to Developing Integrated Requirements

Today’s defense acquisition system relies on a clear understanding of warfighter requirements as the basis for developing, acquiring, testing and evaluating, and fielding systems to satisfy them. For this system to function properly, warfighter/operational requirements must be: based on solid operational analysis; decomposed to a level sufficient for deriving system requirements; clearly linked to the mission/concept/conops first analyzed to determine operational requirements; and, stated unambiguously using a commonly understood language. T&E involvement must begin early enough to understand the meaning and intent, and advise on likely achievability and affordability of warfighter requirements before they are finalized and published. Armed with the knowledge gained, Evaluators can begin development of the draft TEMP focusing first on the Mission requirements that must be achieved. The resulting Mission Based framework can be used to drive planning for DT, LFTE, and OT events that are integrated to most efficiently produce the data needed to properly inform acquisition decision makers. The Missions and Means Framework (MMF) offers a proven structure to specify the elements of operational mission sets using a common structure and language that facilitates mutual understanding between requirement developers and T&E professionals. Presentation will propose an outline of actions and agency responsibilities for formally implementing a mission based approach to guide execution of the defense acquisition system for all defense acquisition programs.
**WG 20 Analytic Support to Training and Education**

**12188 - Effective use of M&S throughout the acquisition of EOIR Sensors**

The seamless process developed by the NVESD Modeling and Simulation Division, provides end to end system design, evaluation, testing, and training of EO/IR sensors. By combining both in-house subject matter expertise and government developed and maintained software and test procedures NVESD ensures that EO/IR sensor developmental and operational testing and evaluation are accurately represented throughout the lifecycle of an EO/IR system. This process allows for both theoretical and actual sensor testing. A sensor can be theoretically designed and modeled using government developed software and then seamlessly input into the wargames for operational analysis. After theoretical design, prototype sensors can then be measured in a laboratory environment then modeled and into wargames for further evaluation. The measurement process to high fidelity modeling and simulation can then be repeated again and again throughout the entire life cycle of an EO/IR sensor as needed, to include LRIP, Full rate production, and even after Depot Level Maintenance. This is a prototypical example of how an engineering level model and higher level simulations can share models to mutual benefit. Specific examples to be discussed are use of the process described above in the acquisition and training of the LRAS3 and the Light, Medium, and Heavy Thermal Weapon Sights.
### 11365 - Home Station Training Realism Improvement One Data Set at a Time

One objective of the Army’s Combined Arms Center for Training (CAC-T) and National Simulation Center (NSC) is to improve Home Station training realism. NSC Capability Developers influence improvements with operational requirements and validation test criteria for materiel solutions. Knowledge of user experience informs their elicitation of operational requirements and their identification of test criteria. NSC personnel are forming multidisciplinary teams and collecting simulation and survey data, and observations, for quantitative and qualitative analysis that increases their knowledge on Army unit usage of modeling and simulation in training exercises. The knowledge informs the NSC Capability Developers on modeling and simulation functionality updates that improve realism for Home Station Training, as well as, on subsequent updates to user guide and best practices documentation. Exercises occur daily in the Integrated Training Environment (ITE) and provide the NSC opportunity for collecting data and acquiring knowledge on user experience. The NSC challenges reside in the continuous collection and cataloguing of data, the continuous identification of metrics, the timely analysis of quantitative and qualitative data, the real-time updates to metrics as data arrives, and the development of validation tests.

The NSC is looking at how to automate the collection of data from exercises that occur in the ITE and how to automate incorporation of new data to metrics so that running estimates of user experience are concurrent with user activities. The NSC research and assessment of a few data samples from exercises demonstrates the potential for quantitative and qualitative descriptions of user experience that inform development of requirements and test criteria.

The NSC challenges are at the intersection of Operations Research Analysis and the quantitative and qualitative analytics of Knowledge Management. The work within the NSC challenges addresses the objective to improve Home Station training realism. Release of this information does not imply any commitment or intent on the part of the U.S. government to provide any additional information on any topic presented herein. This briefing is provided with the understanding that the recipient government will make similar information available to the U.S. government upon request.

### 12324 - Leadership Flight Simulators

Just as Soldiers hone their marksmanship skills in the Engagement Skills Trainer and pilots in flight simulator, leaders must also train to improve their critical thinking and decision making abilities. The ability to understand the higher order effects of decisions over time is a significant challenge for leaders. It is often the case that rational decisions made with the best intentions meet short term objectives, but ultimately cause more harm than good over the long term. One potential solution to this challenge is the development of “management flight simulators” for leaders; or a “Leadership Flight Simulator”. These simulations are developed to help leaders understand the long term consequences of their decisions. Scenarios can be developed to allow leaders to simulate multiple years’ worth of decision making experience in a short time, providing the learning that is often only associated with experience. This project develops a proof of concept web-based “Leadership Flight Simulator”. A series of micro-lessons are identified and one is developed into a leader development training scenario and web-based simulation, utilizing a system dynamics methodology. In this scenario, the user must make critical decisions each week over a year-long deployment. In the simulation, the user is provided feedback along the way and is also allowed to see how the decisions impact the area of operations over the long term. Ultimately, these scenarios can be developed using Army Lessons Learned and easily accessed and utilized for training in all three domains of the Army’s Leader development model.
### 12348 - CyberDefense Maturity Model: The Skills Development Process of CyberDefense Teams

One of the challenges in defining goals and expectations for cyberdefense team arises from lack of models that explain the relationship between a team skill level and their effect on a threat present in the space they are protecting. This is important for the owner of the defended space as it helps him/her understand what resources are available, the impact of threat actions in a network and their effect on other activities that depend on the network. We establish a relationship between team skill level and their effect on a threat. This paper takes an empirical approach to examine the problem. It is based on opinions, views and experiences of professionals in the field of cybersecurity, in addition to data collected from cyberdefense exercises. Based on these sources, we examine the interrelationship among mitigation, hardening and detections activities and a team skills development process. We then establish how team skill level dictates their efficiency to affect a threat.

By formalizing these relationships, we can define the connection between cyberdefense activities and a threat freedom to operate in a space. This model can be used to perform cost-benefit analysis based on desired skill level outcome or as a foundation to develop team certification and training programs.

### 12255 - Low Cost Cyber Defense Exercises (CDX) on a High Fidelity Virtual Cyber Range

In 2014, we reported on the recent availability of a Virtual Emulation Environment (VEE) that could realistically emulate whole networks on a laptop with bit-level fidelity and precise timing for highly realistic training. This year we are presenting the seamless integration of VEE with virtualized systems (Virtual Cyber Range) to support major Intelligence Community (IC) supported Cyber Defense Exercise (CDX). These are similar in scope and complexity to CDX that have been conducted in previous years, but without the need to assemble significant amounts of servers and related hardware in an environmentally controlled area and without major requirements for power, space, maintenance, and specialized software.

Exercise planners have the option to build a notional network in VEE, but far more interesting is the ability to use actual network traffic to reverse engineer specific networks and then clone them with high-fidelity virtual hardware creating a highly realistic, large scale network training and exercise environment that is efficient enough to run on a few laptops. Furthermore, the system allows multiple teams (Blue, Red, and White) of humans in the loop to operate independently within the same network allowing near real-time assessment of the progress of the exercise with options ranging from scripted attacks to full free play. The combination of minimal hardware requirements and rapid network configuration has reduced CDX planning time from months to days. This briefing describes how the VEE is now being used for lower cost, high fidelity CDX’s and outlines options for future expansions of the concept.

### 12367 - Prying Dark Networks Apart

Joint counter network doctrine incorporates elements of social network analysis, particularly centrality measures, in order to identify critical nodes and linkages the network that if severed will cause the greatest impact on the threat. The intent of this presentation is to describe and demonstrate a prototype simulation for an approach to expand existing counter threat network doctrine beyond centrality measures by reframing the problem based on the functions and capabilities dark networks. Since transnational criminal organizations are businesses, this approach attempts to model their business as series of processes enabled by capabilities to form a value stream. Adapted from Lean manufacturing Value Stream Mapping (VSM) provides insight into how products are transformed flowing through various processes, enabled by capabilities. The Value Stream Map provides a scoping and framing mechanism for analysis of the network. The Mission and Means Framework (MMF) provides a disciplined analytical framework to derive, specify and organize relevant information about the of forces by examining their interactions and determining the effects of those interactions on the capabilities of each force to accomplish tasks and operations, the same tasks and operations required to execute the processes of the Value Stream. Thus by applying this approach to network analysis, analysis gain insight into those critical capabilities that can be targeted to not only disrupt TCO networks, but their very reason to exist, the delivery of a product. Moreover, we contend that this approach could be incorporated into joint doctrine to combat terrorist networks or those of other non-state actors.
discusses recommendations for the incorporation of this type of analytical support to training across the military training enterprise. For costs incurred as well as costs avoided. This paper describes the current state of the data collection and analysis activity and Benefit Analysis guide and GAO recommendations. Cost data are considered broadly from a return on investment (ROI) perspective simulation-based collective training. Performance data are collected using a survey-based methodology using the U.S. Army's Cost Simulation Office (AMSO), and DA G3/5/7. This continuing effort is collecting data on both the performance and cost aspects of continued under the Program Executive Office (PEO) Simulation Training and Instrumentation (STRI), the Army Modeling and the auspices of the Simulation to Mission Command Interoperability (SIMC) Overarching Integrated Product Team (OIPT) and made both by the U.S. Congress and the Government Accountability Office (GAO). Progress has been made by an effort begun under how that value relates to the performance of the unit as well as what the costs are of using simulation. This observation has been resulting from the simulations are beneficial as they provide visual tools for decision makers to select the method/settings which most appropriately balance the risks and benefits of the resulting decisions.

### 11586 - Assessment of Competing Methods for Test Question Validation

This work evaluates several methods used for test question validation. The purpose of validating test questions is to remove overly difficult or confusing multiple choice questions and questions that do not discriminate well between test takers who know the material and those who do not. Using test instruments that appropriately measure the test taker's knowledge is important at all levels of performance evaluation. One of the methods currently in use is based on classical measures and statistical hypothesis testing. In contrast, some civilian testing industries employ the biserial method which uses the correlation between an individual's overall score and his/her question responses for question validation. These methods, in addition to alternate hypothesis test and nonparametric methods developed in this work, are assessed for varying sample sizes and test scenarios. All methods' performances are demonstrated on sample tests and Monte Carlo simulations are used to further explore their theoretical performance. Power curves resulting from the simulations are beneficial as they provide visual tools for decision makers to select the method/settings which most appropriately balance the risks and benefits of the resulting decisions.

### 11989 - Measuring and Analyzing the Value of Simulation in Collective Training

It is commonly assumed that simulation is a value-added and even essential component to all categories of military training including collective training of Mission Planning and related tasks. It may be impossible today to imagine such training without the use of simulation. Despite this reality, there is a continuing need to better understand the true value that is added by the use of simulation, how that value relates to the performance of the unit as well as what the costs are of using simulation. This observation has been made both by the U.S. Congress and the Government Accountability Office (GAO). Progress has been made by an effort begun under the auspices of the Simulation to Mission Command Interoperability (SIMC) Overarching Integrated Product Team (OIPT) and continued under the Program Executive Office (PEO) Simulation Training and Instrumentation (STRI), the Army Modeling and Simulation Office (AMSO), and DA G3/5/7. This continuing effort is collecting data on both the performance and cost aspects of simulation-based collective training. Performance data are collected using a survey-based methodology using the U.S. Army's Cost Benefit Analysis guide and GAO recommendations. Cost data are considered broadly from a return on investment (ROI) perspective for costs incurred as well as costs avoided. This paper describes the current state of the data collection and analysis activity and discusses recommendations for the incorporation of this type of analytical support to training across the military training enterprise. The importance of building and maintaining a measurement community of practice (COP) is also discussed.

### 11588 - Assigning Training Delivery Modes for Enlisted Career Field Tasks

Air Education and Training Command recommends training delivery modes for all tasks within enlisted career fields in the Air Force. Determining the appropriate level for task training (on the job training, academics, etc.) is essential for ensuring Airmen are well trained and prepared to execute their critical missions. Currently, a mathematical process assigns training delivery using fixed classification thresholds on subject matter expert survey responses. A new methodology was proposed to assign training delivery using sample statistics from the survey responses. This work evaluates not only the structure of the models used for training delivery assignment, but also the optimal thresholds to be used with these models. Assessment of the current and proposed models highlight inherent assumptions and limitations and further analysis of survey design and responses identifies concerns with elements in both methodologies. To address these concerns, an alternative method for task delivery classification is developed incorporating a nonparametric approach. Historical data is used to demonstrate the advantages and disadvantages of each method and sensitivity analysis of a cost function is used to optimize thresholds across all 150 enlisted career fields.
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**12325 - Sexual Assault Prevention and Response Analytics**

The Research and Analysis Branch within the Operations Division of Headquarters Air Force, Office of the Vice Chief of Staff, Sexual Assault Prevention and Response (AF/CVSO) provides Air Force senior leaders with analytical insights and the latest research on sexual assault in the military. This presentation will describe the analytical efforts taking place within AF/CVSO. Analytical efforts include congressional and presidential reports, commander kneeboards, surveys, focus groups, and research projects within the Air Force and in collaboration with civilian organizations. Kneeboards provide metrics on various factors including reporting, demographics, and incident details. These data points inform policy changes and Sexual Assault Prevention and Response Program adjustments. Additionally, surveys are designed and implemented to produce statistical information regarding the health and well-being of a particular Air Force population. Several research topics of interest include the characteristics and behaviors of perpetrators, victim treatment, and Manning of sexual assault prevention and response personnel. Briefing materials associated with this topic will be unclassified.

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**12064 - At the Nexus of Military Operations Research and Sports Analytics**

Since the World War II era, the field of operations research has grown and spread to a variety of military, government, and business sector applications. With modern computing and growing expectations that operations researchers are able to leverage all of the world’s data in order to craft insightful analysis on a moments notice, the need to grow data literate analysts becomes greater every day. There is perhaps no more data-rich environment than the world of sports. Many difficult and interesting military operations research problems can be recast in a sports analytics context. We present how military operational assessments could be improved by borrowing ideas from how odds-makers rate sports teams, and we demonstrate how tournament prediction simulations are related to air mobility operations. We discuss recent experiences with a special topics course offered at the US Air Force Academy and demonstrate the opportunity that exists at the nexus of military operations research and sports analytics.

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\[ James P Franciosi, MD \]
\[ Lorie Ramos Ingraham \]
\[ Yaela Marks, Ph.D. \]
\[ Jim Miller \]
\[ Lloyd N Werk, MD, MPH \]
\[ Tim Wysocki, Ph. D., A.B.P.P. \]

**11983 - Validation of cognitive performance measurements to map physician declarative knowledge in practice**

Military and civilian healthcare systems have always required high levels of performance and careful allocation of supporting resources. Today, the healthcare field faces an ever-increasing complexity in technology and procedures, as well as the impact of shifting from individual provider care to an enterprise approach that may include virtual clinicians. Within this environment, degradation of clinical knowledge and skills is inevitable, whether compared to a person’s initial knowledge or relative to new medical standards. A systematic knowledge retention program could address this decay, but fixed-interval training for all may not be the most efficient solution. This paper presents results from a multi-year effort to build dynamic models for the assessment of declarative knowledge and determination of learning interventions. It addresses both knowledge decay and relearning. Within this method, cognitive task performance and relevant features, such as the individual’s characteristics and their work environment, are mapped to observable metrics extracted from existing physician electronic records. The models were evaluated through use cases conducted with physicians representing 33 specialties using clinical data from a one-year period. For the military stakeholder, the performance modeling presented could help improve planning and delivery of continuous knowledge and skill training programs for mission readiness.
**WG 20 Event Schedule**

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### 11750 - How to train your dragon: Analytical support to British Electronic Warfare exercises

The UK Armed Forces’ Land Electronic Warfare (EW) capability is provided by 14 Signal Regiment (EW) and Y Sqn Royal Marines. For several years, Dstl’s C4ISR Analysis Group has provided support to these units’ pre-deployment and contingent operations training at validation exercises such as Ex Dragon’s Talon. The Dstl analysis delivers objective measures of performance which are acknowledged by commanders as being critical to the success of the training. This presentation will describe the role of tactical EW in UK doctrine and on recent operations. It will explain how units train for deployment, the high-tempo analysis provided by Dstl, and the benefit this brings to exercising units. The analytical tools and metrics will be described, using examples both of established techniques and ad-hoc analysis to answer short-notice questions. The presentation will also discuss the UK’s renewed emphasis on readiness for contingent operations after a decade of operations in Afghanistan, and the challenges this has raised for training and analysis.

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**WG 21 Operational Energy**

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### 12540 - Optimal Power System Restoration

This talk considers how to restore electric power systems after a natural or man-made disaster. Such a restoration is extremely challenging from a computational standpoint as it combines a complex logistics problem with activation problems over a complex physical system. We present a four-step approach which allows us to separate the logistic and restoration aspects, while ensuring an overall high quality restoration. The approach, which heavily exploits hybrid optimization, is validated on benchmarks using realistic power system data. The experimental results show significant improvements over the practice in the field and the critical role of hybrid optimization to find high-quality solutions in reasonable time. (Joint work with Carleton Coffrin and Pascal Van Hentenryck)

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### 12539 - Optimal Resilient Distribution Grid Design using a 3-phase Unbalanced AC Power Flow

"Modern society is critically dependent on the services provided by engineered infrastructure networks. When natural disasters (e.g. Hurricane Sandy) occur, the ability of these networks to provide service is often degraded because of physical damage to network components. One of the most critical of these networks is the electrical distribution grid, with medium voltage circuits often suffering the most severe damage. However, well-placed upgrades to these distribution grids can greatly improve post-event network performance. Recently, we developed an optimal electrical distribution grid resilient design problem as a two-stage, stochastic mixed-integer program with damage scenarios. To preserve computational tractability, we have developed two variations of this problem that approximate the 3-phase AC power flow equations. The first relies on a multi-commodity flow representation (Yamangil, Bent, Backhaus 2015). The second relies on the linearized distribution flow of Baran and Wu (1989), Linearized Distribution Flow. In both cases, we further enhance the model by incorporating L-shaped infeasibility cuts using a well-known power flow simulator, GridLabD. Our experiments show that, unless the network impedance profile is drastically modified, our algorithms remain tractable and our models are a good approximation of the post-disaster voltage profiles."
12538 - Simulating transient flows, storage, and recovery on disrupted petroleum-infrastructure networks: algorithm and application by federal agencies

We are developing a modeling capability to simulate flows of energy commodities across infrastructure networks. The capability, titled NetFlow Dynamics (NFD), consists of flow algorithms and infrastructure network models. The algorithms are applicable to several energy commodities (e.g., petroleum fuels, natural gas). They use a nonlinear form of a diffusion equation to calculate transient commodity flows and storage levels. A primary use of NFD is to examine how disruptions affect infrastructure performance. Analysts can specify disruptions by decreasing capacities of elements of the infrastructure network, and NFD simulates adaptive responses. These adaptive responses are subject to physical constraints (e.g. pipeline topologies and capacities), and are intended to represent operational business decisions, and economic market behaviors. This work initiated with the Department of Homeland Security and the National Infrastructure Simulation Center developing a model of U.S. petroleum infrastructure (NTFM) that has been used in planning for major earthquakes and hurricanes, and to analyze impacts of real world events including refinery closures and accidents. The Department of Energy is evaluating NFD for use in several program areas, including network vulnerability determinations, critical infrastructure impact analysis, energy restoration and response actions, and energy security analysis both foreign and domestic. DOE envisions using NFD and NTFM to highlight areas for data analysis and to provide improved situational awareness to decision makers. Simulations will show which systems and components are most likely to provide capability (by virtue of geographic location, transit capabilities, surge capacity/inventory) to mitigate disruptions and portray how the network recovers to equilibrium.

11887 - Energy Storage Saves Fuel for Forward Operating Base

In times of war, the military relies on Forward Operating Bases (FOBs) to support the warfighters and provide a platform for force projection on the battlefield. These FOBs rely on fuel to power the generators that supply electricity to the ever growing types of equipment required for mission operations and support services. Delivering fuel to FOBs is a life threatening endeavor. Adversaries have learned that disrupting the fuel supply to a FOB can potentially render it useless. The Department of Energy Office of Electricity (DOE/OE), Sandia National Laboratories (SNL), Product Manager Force Sustainment Systems (PdM FSS) and the Base Camp Integration Lab (BCIL) partnered to explore the benefits of incorporating energy storage systems (ESS) into a microgrid configured FOB to help reduce fuel consumption and ultimately reduce convoy casualties. Several energy storage vendors were selected to develop prototype ESS. SNL conducted initial functional and burn-in testing. Then the ESS were sent to the BCIL for individual performance evaluations. Four electro-chemical ESS technologies comprised of lead acid, lithium-ion and zinc-bromide were tested. SNL developed models using Matlab/SIMULINK combined with operational simulations to predict the fuel savings that could be achieved with ESS used for generator deferral. Energy load profiles from the BCIL FOB operations were used in the models for analyses. The models were used to predict fuel savings. Other ESS applications such as “renewables firming” and “spinning reserve” are currently being investigated in order to optimize the ESS sizing and operations.
12536 - Military Wheeled Vehicle Weight Estimation With Condition Based Maintenance Sensor Data

"Knowing military wheeled vehicle cargo weights is important for both operation planning and estimation of vehicle reliability, mobility and maintainability. Due to the limitation and practicality of physically weighing each truck frequently across a fleet, truck cargo weight estimation has been an engineering barrier and a technical challenge.

In this analysis, three engineering approaches have been studied based upon data availability and precision requirements. The first method is based upon a power demand and power supply mobility model which estimates one optimal vehicle weight so that power demands from rolling resistance, slope climbing, aero drag and acceleration would equal to engine power output. The second method is based upon an empirical energy efficiency model with field vehicle engine sensor data. This method identifies vehicle energy coefficients and the major input factors. As one key input factor, vehicle weight can be projected from a 2 dimensional or 3 dimensional empirical coefficient model. The last method is by leveraging the latest data mining and machine learning technology. A few supervised machine learning methods have been compared and combined for best estimation results, such as: a dynamic neural network, a non-linear regression, a nearest neighbor classification and a Naive Bayes and support vector method.

This research concludes with practical application tips to select a best method for military truck operation weight estimation with acceptable precision depending on data availabilities."

12271 - Will the Global Oil Market Meet Wartime Demand?

Is the global oil market robust enough to meet U.S. military requirements in a heightened operational or wartime environment in the Pacific theater? The answer to this question is not one for which there is universal agreement within the Department of Defense (DoD). There are two prevailing arguments: 1) that the global oil market is robust enough to support “blue sky” and wartime demands without interruption and, 2) wartime demand for oil will be disruptive and there will be delays and/or shortages at specific times and places where it is most needed. Future planning for war reserve, contracting and investments to hedge risk are heavily dependent upon which argument prevails. In this research we explore the extent to which we may count on the assumption of uninterrupted oil supply during wartime, or what we refer to as a “blue sky” presumption, and present data that provides some indication as to whether or not we may rely upon such a conjecture. We identify gaps in our understanding of how oil may or may not flow during wartime and pose several remaining critical questions that should be answered to improve war planning and reduce the risk of operational disruption during war.

12198 - Identifying Optimal Hybrid Energy Technology Sets for USMC Deployments

The USMC Expeditionary Energy Office (E2O) is collaborating with Sandia National Laboratories (Sandia) to develop a capability to assist decision makers in identifying feasible hybrid power technology sets for use in potential future Marine Corps deployments. The solution sets consist of an optimal trade space of diesel generators, photovoltaics (PV) and battery storage that best satisfies the power demands for deployed units with the lowest cost while providing reliable power, maximizing silent watch, and reducing fuel-use as much as possible. The Sandia-developed Microgrid Design Tool (MDT) which employs a genetic algorithm was used to perform the multi-objective optimization across the conflicting criteria. By modeling a variety of potential unit deployments, decision makers can get insights to which energy technology sets would be most useful to the Marine Corps. When results are rolled up across sets of units representative of Marine Expeditionary Brigade and Marine Expeditionary Unit configurations, decision makers obtain acquisition insights about the quantity and type of energy systems in which to invest. This approach is proving useful for other areas besides acquisition, such as requirements validation, energy system design, as well as operational energy planning.
11615 - Optimal Size Tradeoffs between Batteries and Photovoltaics for Expeditionary Energy Operations

This research addresses the problem of sizing batteries and photovoltaics (PV) used in conjunction with a generator in expeditionary contexts. It is commonly assumed that spending on PV and battery storage will save fuel. However, there is a limit to the benefits, and not all combinations of sizes of PV and batteries are optimal in the Pareto sense. Here we develop a simplified power network model containing a constant load, a generator, PV, and batteries that allows us to derive analytical formulas for the optimal tradeoffs of PV and battery size. A number of insights can be drawn from this model: (1) due to large round-trip losses of roughly 25%, batteries typically do not save fuel by allowing the generator to alternate between high power (where it runs most efficiently) and turning off, (2) batteries can save fuel when the load is small compared to the power rating of the generator, (3) batteries typically do not save fuel when power from the PV plus the lowest recommended generator power output never exceeds the load (unless as before, the load is relatively small), (4) batteries can save fuel when this sum exceeds the load, and (5) it is more fuel efficient to discharge the batteries when the PV can supply the balance of the power than at night when the generator is able to pick up the entire load.

11836 - Small Unit Power Operational Benefit Analysis and Decision Support Tool

Small unit power (SUP) equipment research and analysis in support of PEO Soldier’s Project Manager Soldier Warrior (PM SWAR) will be presented. The presentation includes an operational benefit analysis and a recommended decision support tool that helps commanders employ effective dismounted tactical power management strategies. The operational benefit analysis examines four tactical scenarios and considers a naïve power management strategy and a SUP enabled power management strategy. Major findings include: specific conservation and generation strategies for each tactical scenario; the importance of proper solar blanket employment; the benefits of using conformal batteries; and the impact of inefficient PRC 154 battery swaps in the naïve case.

12537 - Reducing Residential Energy on Military Installations

The genesis for residential energy analysis is simple - West Point and nearly every other military installation need better assessment methods to rate the energy efficiency of its residential buildings. Modeling the energy consumption of these residential homes is critical in determining the most economic energy upgrades with short payback periods. These energy models also allow improvements to be made on the current utility billing program, which incentivizes residents in military housing to reduce their energy consumption. This presentation uses West Point’s residential homes as a case study to show a systematic approach that can be used to move towards large reductions in annual energy bills. West Point is using the process of modeling the energy fitness levels of their homes for energy assessments, economic energy upgrade selection, quality assurance, and creative utility billing incentives for people who do not pay for their own energy usage. Ideally, the systematic process prototyped in this case study will be used by installations around the military, resulting in a significant amount of savings.
### 11572 - Atmospheric Forecasting Tools Being Developed For Renewable Energy

Reducing military energy demands can be done through a blended method of changing habits, improving technology and utilizing existing technology more effectively. Alternate energy sources, such as solar and wind, have been making healthy strides towards ‘user-friendly’ and more cost-effective technologies. Each of the military services has published a commitment toward integrating these renewable energies into their way of doing business. The Army Research Laboratory (ARL) is also contributing to the effort through its affiliation with the Department of Energy (DOE) project to Advance Solar Power Forecasting, and the construction of decision aid technologies.

In this presentation, a brief summary of the multiple atmospheric forecasting techniques, currently under development for civilian and military solar power energy applications, will be described. These techniques include several Nowcasting methods and an observational approach. An introductory explanation of a near real-time decision aid will conclude the presentation.

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### 14634 - Estimating Damage to Electric Power Distribution Caused by Hurricanes

Each year the Electric sector faces challenges from hurricane winds damaging local distribution systems directly and indirectly. Gaps exist in the current knowledge of the relative magnitude of the threats that the Electric sector routinely encounters in comparison with the probable impacts. Since commercial electric power is a lifeline sector, necessary for many other sectors to continue to operate, estimating the impacts prior to the storm making landfall is of great value.

To enhance the prediction techniques, a tool called HEADOUT (Hurricane Electrical Assessment Damage Outage) was developed to quickly (within a few minutes) produce estimations of the potential number of electric customers that will experience a loss of commercial electrical power as a storm makes landfall. The tool uses data inputs from the National Hurricane Center (NHC); therefore, simulations can be updated in real time as NHC provides 6-hour updates for an approaching hurricane. Using NHC data, the HEADOUT Tool develops detailed wind speed contours of the approaching tropical storm/hurricane and applies a fragility curve—a statistical tool representing the probability of exceeding a given damage state (or performance) as a function of an engineering demand parameter. This fragility curve is a proxy of determining the damage to the electrical distribution grid and potential of customers without electricity, without detailed knowledge of the electric distribution network in the area of storm landfall. The HEADOUT tool can also consider the impacts of storm surge on the electric sector.

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### 12541 - Impacts of Increased Reliance on Natural Gas

"Significant improvements in extraction technology and development of new gas plays in the United States over the last decade have made available an abundant supply of inexpensive domestic natural gas. The increase in supply has resulted in an increased reliance on natural gas for power generation and manufacturing in addition to the possibility for potential export. Widespread and increased dependence on readily available and inexpensive natural gas will likely increase the potential risks to supporting and interdependent infrastructure. The potential result is an inability to link supply with demand, with national and regional implications as natural gas shortages can impact other interdependent critical infrastructure.

This presentation summarizes NISAC’s current effort to identify, model, and analyze the most probable risks associated with the Nation’s increased reliance on natural gas production and consumption by examining the ability of existing natural gas infrastructure to meet current and future demand and to assess the risk to continuity of operations. The analysis will focus on a national to regional-level, identifying specific regions or States are most likely to experience natural gas shortages due to pipeline constraints during normal and disruptive conditions."

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**11831 - An Agent-Based Model of the U.S. Natural Gas Infrastructure: Analysing Disruptions**

We present an agent-based model of the U.S. Natural Gas infrastructure. This model has been constructed at Sandia National Laboratories and aims at representing the effects of long- and short-term shocks to the natural gas system. We use agent-based and network modeling to represent agent behaviors, such as production, consumption, and storage; investment decisions, such as construction of LNG export terminals or construction of new pipelines. We calibrate the model to available data at individual supply, local distribution, storage, and pipeline level. We analyze resulting price dynamics, local natural gas availability, and pipeline network capacity utilization. This model can be used to understand the effects of acute disruptions, such as pipeline flow constraints; chronic disruptions, such as persistently high or low demand or supply from a specific geographic area, and investment choices, such as additions of export terminals or new pipeline networks. This agent-level, geographically specific approach allows representing possible path dependencies and lock-in effects, as well as system evolution and emergent behaviors. Our approach enables investigating scenarios where no historic data exists to represent the effects of possible agent actions, system operators’ responses, and regulatory changes. We illustrate the model with stylized scenarios of supply and pipeline disruptions and quantify the impacts using such metrics as changes to the network flows, local prices, and local natural gas availability. We further discuss the ways to quantify the network resilience using these metrics.

**12416 - Quantifying Operational Energy Effects within a Contested Environment**

In FY13, OSD/OEPP funded AFRL/RQQD to develop a methodology to quantify counter-energy impacts for the Airlift fleet and the larger logistics system as a whole. Future Airlift concepts were employed to assess their capability for mitigating counter-energy threats. FY14, OSD/OEPP funded AFRL/RQQD under the multi-year Operational Energy Capability Improvement Fund (OECIF) to expand the demonstrated MS&A capabilities through tool improvement, development and corresponding analysis. Continued efforts will build upon this methodology while increasing the data fidelity where required. These enhancements will better quantify the Operational Energy (OE) impacts to the mobility air forces (MAF). These include Airlift Fleet capabilities, Aerial Refueling operations, and Costing of Advanced Technologies and any supporting OE infrastructure as applied to existing Defense Planning Scenarios. Specifically, this study refines and enhances the methodology utilized to quantify OE impacts to the MAF, and then implements this methodology within an appropriate scenario.
**WG 22 Experimentation**

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**12327 - Expanding Missile Defense through Multinational Experimentation: Design & Assessment Methods**

We are reminded daily of the realities that threaten our well-being. The global threat from missile attack remains credible and is becoming more dangerous as the threat continues to proliferate and mature. In this increasingly connected, fiscally constrained world, cooperation coupled with interoperability among allies on missile defense is more important than ever. We can do more together by pooling our resources and learning from each other. Our security depends on the ability of the US and allies to address missile risks before they become crises. NIMBLE TITAN (NT) is one of the only venues for the US and allies to achieve this.

NT is a series of unclassified, two-year, multinational, Ballistic Missile Defense (BMD) experimentation and wargames. Participants examine regional and global BMD policy and operational concepts that are needed to conduct coalition missile defense. Over the past decade, participation has expanded from six nations to twenty-five, as like-minded nations from the Pacific, Europe and Middle East regions join the campaign. Their active participation continues to generate a learning environment, the opportunity to address multinational missile defense challenges and the ability to develop solutions. The presentation focuses primarily on the design, analysis and outcomes of the recently completed NT 14 Campaign. It describes the objectives development, experiment and wargame constructs design process, and data collection and assessments methodology; and highlights key findings. The presentation concludes with a request for recommended improved designs and assessment methods, leveraging the expertise in the working group.

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<td>Dr. Reginald L. Hobbs, Sr.</td>
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**12319 - A Multi-Genre Approach to QOI on an Emulated Tactical Network**

Operations on a tactical network are negatively affected by disconnected, intermittent, and limited network resources. Under these disadvantaged network conditions, military analysts are challenged with gathering the most relevant, timely data from multiple information nodes while simultaneously attempting to minimize network impact. Quality of Information (QOI) techniques address these competing challenges by leveraging relationships across multi-genre (social, information, and telecommunication) networks to transfer the right data at the right time. Our experimentation consisted of the transmission of data between information nodes in an emulated tactical network to gauge the impact of network performance on timeliness, accuracy, relevancy, and other extrinsic metrics associated with the information sources. The underlying task consisted of image retrieval from simulated checkpoints within an area of operation to locate and identify a person or object of interest. Several transcoding options of the images required the software agents to infer the most appropriate answer to a query based on the answer set, available bandwidth, and network latency. We conducted numerous iterations under different network traffic and routing conditions to establish a baseline for quality responses. The experimental treatments incorporated semantic information delivery, knowledge representation with inference, and diversity caching technologies to automatically select the highest quality response from the appropriate information source node, given the network conditions and the specific query.

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**12024 - Studies to Characterize Deposition and Resuspension from Transit Passengers**

The Argonne Below Ground Model (BGM) has been developed to provide a comprehensive simulation capability for analysis of airborne chem/bio threats to subways at both a system and station level. We have recently adapted BGM to assess whether (aboveground) passenger rail transit could potentially facilitate rapid regional transport of a bioagent following a covert release. Conclusions derived from these simulations depend largely on the rates of deposition and subsequent resuspension (“shedding”) of bioagent particles from the passengers; however, data upon which these rates are based are very limited. To verify and validate these simulations requires that the treatment of the deposition and resuspension processes within the BGM fomite transport component be validated. Specifically, quantitative measurements of the key process parameters – deposition velocity and resuspension rate – need to be carried out for conditions that approximate as closely as possible those experienced by the passengers. We are currently planning experimental studies to measure the influence of particle size, passenger activity, and passengers’ clothing material on the deposition and resuspension of particles from passengers in train cars and train car surfaces. A brief review of prior measurements will be followed by an overview of the experiment including the scenarios to be tested, potential simulants to be released, measurements to be performed, and subsequent data analysis to obtain the desired parameters.

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The Army’s NIE occurs biannually at the Brigade Modernization Command, Fort Bliss, TX, with analytical support from the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center-White Sands Missile Range (TRAC-WSMR), NM. The NIE informs and shapes the technological requirements for collaborative, synchronized, real-time information across all echelons of the Future Force 2025. Shaping of the Future Force requires a transition from the current Command Post’s Army Battle Command System to a common operating environment, which includes the CP-CE Version 1: a web-enabled suite of applications collectively referred to as the Ozone Widget Framework.

This study developed a methodology that recorded Soldier qualitative observations while using the Ozone Widget Framework and converted these observations into quantitative data. An analyst developed predictive model, the Soldier-Widget Preference Estimator, used weighted Soldier preference feedback and demographic data which established a quantitative baseline for use in subsequent NIEs for comparative performance.

This briefing will discuss TRAC’s approach to developing this Soldier feedback methodology as well as how this technique supports NIE analysis; presenting results and their benefit to the Army.

System Engineers rely on a variety of models to help understand different viewpoints in several domains throughout a system’s life-cycle. These domain models include operational simulations; life-cycle cost models, physics-based computational models, and many more. Each of these models has their own unique set of inputs and outputs. Model inputs represent value properties that define a system alternative configuration or environmental conditions that represent uncertain factors within the system boundary. Model outputs represent measures of performance or effectiveness that allow us to assess alternatives and understand the tradeoffs among several objectives. In order to illuminate the tradeoffs that exist in a complex system design problem we propose an approach that approximates model input and output behavior using the functional form of statistical metamodels. After performing an experimental design we can fit a metamodel that has a functional form known as a response surface. We utilize contour profilers that show horizontal cross sections of multiple response surfaces to visualize where key trade decisions exist. Our purpose is to illuminate trade decisions across several different viewpoints by integrating metamodels that approximate the behavior of multiple domain models. Our research supports the tradespace analytics pillar for the development of the Engineered Resilient System (ERS) Architecture. ERS is a Department of Defense initiative developed by the US Army Engineered Research Development Center. The purpose of ERS is to leverage information technology to create a digital thread of architectural decisions accessible to multiple communities of interest to inform better manufacturing options during a system’s life-cycle.

The MC-130J is part of the Air Force’s modernization plans for replacement of proceeding MC-130s that date back 50 years. The first MC-130J was completed in late 2009 and the Air Force Special Operations Training Center has begun the training program. Currently the Air Force is identifying a terrain following/terrain avoidance (TF/TA) radar system for the aircraft. The 413th Flight Test Squadron at Hurlburt Field wisely chose to employ design of experiments (DOE) methods for the test and evaluation of the TF/TA radar system, and the savings in test points are nearly 65%.

The DOE application was laden with constraints typical of real-world, practical problems. But DOE offers numerous solutions to the challenges faced everyday by testers. This paper outlines the process of iterating through test plan options for several test objectives and constraints. The resulting test plans offer several experimental design alternatives customized for each test objective -- a split-plot design to accommodate test variables that cannot vary randomly from run-to-run, an optimal design to accommodate multiple level categorical variables, and a traditional central composite design for a segment with continuous numeric variables.
### 12089 - Going Where No Test Has Gone Before: Rigorous DT&E Using Design of Experiments

The Air Force's Small Diameter Bomb II (SDB II) / GBU-53/B provides our warfighters with an unparalleled capability to strike both fixed/stationary and moving targets in all weather. Equipped with millimeter wave and infrared radars, semi-active laser guidance, as well as the GPS-aided inertial navigation system employed in the SDB, SDB II provides greater effectiveness with fewer aircraft at risk. Currently in the Engineering & Manufacturing Development Phased (post Milestone B), the Office of the Secretary of Defense (OSD) Director of Operation Test and Evaluation (DOT&E) has directed an additional government developmental test (DT) program prior to a Milestone C decision. The additional DT program certainly has an effect on the program cost and schedule, so are the benefits of such a program quantifiable? The 780th Test Squadron at Eglin AFB has teamed with the SDB II System Program Office to identify a use of the additional DT flight tests that maximizes the information gain on system performance while balancing program office and operational test (OT) considerations. Design of experiments (DOE) methods were used for test planning and vast improvements were realized with a tangible opportunity to enhance requirements verification and shorten OT – which would get the system to the warfighter sooner.

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### 11870 - Multi-Objective Evaluation of Experimental Designs

In this paper we introduce a novel approach to develop excellent designs for computer experiments. The determination of "better" focuses on the design properties of orthogonality, space-filling, and imbalance, which serve to produce more tractable analysis of the data. Past attempts to develop objective assignment of weights to multiple properties of an experimental design remain unresolved. While many construction methods for experimental designs employ equal or balanced weighting between two or more metrics, we propose a multi-objective decision analysis technique -- swing-weight matrices -- to combine disparate metrics into a unified value for designs. We further incorporate non-linear valuation of the metrics through the use of exponential curves that quantifies diminishing or increasing returns. Our process begins with an initial random Latin hypercube to which we iteratively apply orthogonalization and improvement techniques to create a nearly-orthogonal experimental design. Discussion in the paper presents questions and properties that help determine the parameters that define this weighting model and how it impacts design performance. We offer this innovation to practitioners who encounter difficult experimental conditions.

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### 11837 - Measuring Situational Awareness at the Small Unit Tactical Level

The purpose of this study is to propose and validate a method to measure the value of situational awareness at the small-unit tactical level. Currently, the Situational Awareness Global Assessment Technique (SAGAT) is widely considered the best method for measuring situational awareness. Research on situational awareness is largely focused at the command post and above level, and implementations of SAGAT do not address operations at the small-unit level. In today's Army, technology is an increasingly critical component of modern warfare used to increase the information provided to decision makers on and off the battlefield. The question remains as to whether or not increasing this information will increase the likelihood of making a well-rounded decision or if the additional information will overwhelm the decision maker. In order to accomplish the purpose of this project, we conducted a controlled experiment using the Nett Warrior system and VBS2 tactical simulation program, incorporating a modified form of SAGAT and the principles of cognitive engineering and human factors studies to measure a user's situational awareness. This study finds that the principles of a modified SAGAT can measure situational awareness at the small-unit tactical level. Additionally, the experiment validates that Nett Warrior increases situational awareness of soldiers in tactical operations. Future work on the topic includes a planned field test of the Nett Warrior system in which cadets will utilize the technology to accomplish a small-unit training mission.
### WG 23 Measures of Merit

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#### 12510 - How to use “Safety Factor” to Determine Reliability of Mechanical/Structural Components

In the design of many systems, some of the components are mechanical/structural. The probability that these components will fail is strictly a function of the stresses they will encounter during operation and their inherent strength. The probability of failure of these components is not a function of time of operation like electrical, electronic, and electromechanical parts. This means that characterizing and calculating their reliability cannot use the traditional measures of “mean-time-between-failure”. Organizations in space systems have, for many years, used various techniques of “safety factors” or “factors of safety” to characterize the design of mechanical/structural systems in terms of margin in design to mitigate the risks of withstanding overstressing. We applied engineering and analytical methods for mapping safety factor to reliability (the probability that a system/subsystem will perform its intended function during a specified period under specified conditions).

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#### 11418 - MRAP Manufacturability Assessment Metric

During Operation Iraqi Freedom (OIF) Operation Enduring Freedom (OEF) the need for better protection for personnel traveling in military wheeled vehicles became critically apparent. In order to meet this need, the DoD authorized expedited acquisition of the Mine Resistant Ambush Protected (MRAP) wheeled vehicle from multiple contractors. The acquisition program ultimately proved to be very successful in meeting mission requirements; however the program costs were excessively high in relation to a typical non-expedited DoD acquisition program for a wheeled vehicle. A case study related to the “manufacturability” of one version of the MRAP vehicle, the Navistar MaxxPro, was performed in 2014 by the CAVS Extension (CAVS-E) at Mississippi State University in collaboration with the Institute for Systems Engineering Research (ISER) at the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC). Among the documented lessons was the need for a general “manufacturability assessment” methodology that could be used early and throughout the Defense Acquisition Lifecycle, from “concept to available for use”, to better control costs and contribute to enhanced engineered resilience of military platforms. This presentation discusses several of the lessons learned from the MRAP program and outlines a framework for manufacturability metric assessing the manufacturability of all components required for the final assembly of a DoD acquisition item. The Engineered Resilient Systems (ERS) program is working to integrate this manufacturability metric into a tradespace tool for use by DoD acquisition professionals.

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#### 12512 - Measuring and Analyzing Multiple Perspectives of System Resilience in a Tradespace Tool

Many effective Department of Defense systems are trusted and effective in a wide range of operational contexts with the ability to respond to changing conditions through modified tactics, appropriate reconfiguration, or replacement. Understanding, measuring, and assessing these characteristics is critical in a resource constrained environments. As part of Engineered Resilient Systems, this work lays the foundations for resiliency analysis through the development of modular, composable, and scalable analytical constructs and processes. The analytical methods are derived from existing ontological bases, and seek to promote consistency and comparability between analyses. The work focuses on evaluating ‘Robustness of fielded system capabilities and capacity with respect to operational requirements’ and ‘Flexibility of a designed system to engineering change’. The development philosophy strives to enable design and development of resiliency analyses that are transparent, intuitive, rational, and quantifiably traceable. This presentation provides a methodology overview and the results of an example acquisition program to illustrate how analysts can use resilience metrics in analysis of alternatives to facilitate senior leader understanding of the possible impacts of system resiliency.
## 12543 - Determining the Effectiveness of Modern Surface-to-Surface Missiles in Targeting Air Defense Artillery Systems that Utilize the Shoot-and-Scoot Tactic

Indirect fire was introduced so that artillery systems could fire from hidden positions to reduce their exposure to hostile counter-artillery fire. However, the development of counter-battery radars decreased the viability of these hidden positions. Therefore, units developed techniques such as "shoot and scoot" to improve survivability once again. This technique emphasized mobility inhibiting the threat's ability to determine an accurate location. Traditionally, the Air Defense Artillery (ADA) systems primary survivability concern was from targeted enemy aircraft. Now, large quantities of long-range precision strike surface-to-surface missiles (SSM) are increasing survivability concerns in the ADA community. This paper looks at the effect of the employing 'shoot and scoot' tactics on the survivability of ADA systems on a modern battlefield. The methodology utilizes basic weaponeering equations (Single-Shot Probability of Kill) and the Joint Weaponeering System (JWS) model to determine the reduced effectiveness of modern SSM in targeting ADA systems that did and did not utilize the "shoot-and-scoot" tactic.

**Keywords.**
Missile defense, theater ballistic missile, Shoot and Scoot, Patriot, Accelerated Improved Interceptor Initiative, (AI3), Air Defense Artillery, Counter Rocket, Artillery and Mortar (C-RAM), Indirect Fire Protection Capability (IFPC), Counter-Battery Radars, Ballistic and Cruise missiles, and Extended Air Defense Simulation (EADSIM).

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In the late 1990s, military innovators espoused a concept of warfare that leveraged a new but poorly understood “Information Age” enabled by technology. Now, after more than a decade and a half, the conceptual underpinnings of NCW have been cast aside while the hardware remains. A new wave of innovation is washing through the defense industry, ushering in what many are calling a “Robotics Age,” which will leverage IT every bit as much as did the Information Age. While industry and academia struggles to develop these new vehicles, their focus is narrowed just as much on engineering vehicles as NCW enthusiasts were preoccupied with IT hardware. How forces will fight with these new platforms is taking a backseat to vehicle products – just as NCW theory did to IT investment.

Some view Robotics Age warfare as an outgrowth or maturation of Network Centric Warfare. Unfortunately, most of the claims of NCW were simply asserted, not tested. For example, the claim that networking necessarily improves performance throughout a force was accepted as fact but never proven, as data from NCW forces under combat conditions do not exist. This paper uses human individual and networked performance data from another high-stakes competitive pursuit – professional baseball – to make an initial inquiry into this question. The paper looks at the distribution of 38 performance metrics and compares them using the Multivariate Homogenous Polya family of distribution, which was originally employed by Bolmarchic (2003) to explore various types of platform centric historical combat data sets.

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## 12548 - New Fundamentals of Assessment

Key words: Assessment, Operation Assessment, Campaign Assessment, Organizational effectiveness, Decision-making. Operation Assessment has some fundamentals that have emerged from the experience of the last several years, and that are beginning to emerge in the proto-doctrinal publications that have been published in 2015. The author, a member of the doctrinal working group, has articulated a set of principles that revise the way assessment has been done. The most important of these is that the primary purpose of assessment is to make operations more effective. It is not to “measure progress” or “inform decision-making.” It is not about writing a report. It does all of these things, but its purpose is to achieve our objectives more effectively; its product is a more effective operation. This brief discusses these issues and the new vision of building assessment frameworks that comes from new manuals.
### 12549 - Epistemological Problems with Assessment Metrics

**Key words:** Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Metrics, Measures, Measure of effectiveness, Measure of performance, MOE, MOP, Indicator

The metrics regime inherent in the JP 1-02 definitions of the terms, measures of effectiveness (MOEs) and measures of performance (MOPs), and explained in publications such as the Joint Staff J7’s Assessment Insights and Best Practices Focus Paper have what the author terms “epistemological problems” that complicate our mental models and confuse our thinking on assessment. This brief articulates these problems and explains the need for change. It supports and explains the changes in the definitions of these terms found in Joint Doctrine Note 1-15, Operation Assessment.

### 12547 - Advanced Topics in Operation Assessment

**Key words:** Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Aggregation, Thresholds, Commander centric

We have evolved ways of doing operation assessment that have cemented some ways of doing things that are less useful than we imagine. For example, it is common to aggregate several related indicators to achieve some sort of “score” that we imagine demonstrates our progress. However, given that the purpose of operation assessment is to make operations more effective, what we are really looking for are problems needing solution or opportunities to improve the efficiency or effectiveness of our activities. Aggregation hides these sorts of details, and obstructs the reason for doing assessment. This brief discusses this issue and others to prompt some discussion and debate, and perhaps some reconsideration of the way things are done. It also posits some helpful ways to look at some assessment problems for which metrics regimes may be less useful.

### 12519 - Assessing Progress in Assurance and Deterrence

As NATO embarks on a series of immediate and longer term assurance measures to demonstrate its collective will and the solidarity of the Alliance, NATO analysts are challenged by the question of “Is NATO sustaining assurance?”. This paper presents the initial findings of an ongoing study into assessing progress of assurance and deterrence measures. The study reveals common themes and factors of assurance and deterrence that are synthesized into a robust and comprehensive strategic assessment framework. The literature on measuring effectiveness of assurance is almost non-existent; the study contributes to the field by exploring a novel way to assess assurance through indicators of institutionalism—equating institutional strength with Alliance strength. Indicators of a strong alliance, or institutionalization that can be used for assessment purposes are identified as: increasing networking; development of formalized mutually binding contracts or agreements; and increasing delegation of authority. Like assurance, assessing deterrence effectiveness has been a challenge for analysts since the Cold War; despite scholarly disagreement upon what constitutes success or failure in deterrence, there are observable indicators that may be measured for assessment purposes. The paper examines four key areas of observable indicators: alliance communication, credibility, capability to deter, and the adversary’s decision environment. With increasing demands on Alliance resources in support of assurance and deterrence activities, pressure will continue to grow to demonstrate the effectiveness and cost benefits; a robust and comprehensive assessment framework will provide the evidence necessary to support strategic decision making.
12184 - Holistic Portfolio Optimization using Directed Mutations

Long-range military portfolio planning [1] often involves mixed-integer, multi-objective, non-linear portfolio optimization, a notoriously difficult class of problems. The “Holy Grail” of these decision problems requires holistic optimization over both the combinatorial design of individual systems in the portfolio and the integer counts of these systems through time (i.e., “what type” and “how many”). Genetic Algorithms (GAs) offer an attractive approach due to their ability to address non-linearity, multiple competing objectives, and non-convexity. Unfortunately, GAs can have difficulty converging on coordinated integer solutions. This research presents the novel use of objective function gradients to guide genetic operators more efficiently towards optimal solutions. Impressive speedups over zeroth-order GAs are demonstrated on a test-bed of 1, 2, and 3-dimensional problems. The results are then applied to a hypothetical portfolio consisting of vehicles, UAVs, and soldiers, optimizing over cost (RDT&E, Purchase, O&S) and non-linear system-of-systems performance measures as assets are acquired and modernized over time.


12526 - INFORM Iraq Model

We present a mathematical model that relates nation building measured through a state’s infrastructure to measure and track the shock effects of “war” and “non-war” activities through the system. At the time this model was constructed, we considered “war” activities to be the three circles of war: national war, insurgency violence, and civil war. The model is a dynamic system’s model that allows the decision maker to see the impact of decisions or the impact of shocks throughout the system over time. There is applicability to other countries and activities.

12527 - Multi-attribute Decision Making in Dark Network Analysis

In this article, the authors present background and analysis on the Koch brother’s dark money network. An AHP/TOPSIS hybrid model is used to find the key nodes of the network. The analysis of the key nodes leads to improved targeting strategies against the network. Game theory applications using kinetic versus non-kinetic strategies in dealing with the network is developed after using AHP to obtain cardinal utility from the ordinal ranking originally provided. These methods provide additional metrics and analysis that can be employed in dealing and analyzing any dark network.

12514 - Quantifying the Risk Reduction Value of Coast Guard Maritime Security Activities

The United States Coast Guard (USCG) implements an annual maritime terrorism risk assessment process, drawing on field analysts’ judgment to acquire maritime data. Field analysts utilize the Maritime Security Risk Analysis Model (MSRAM) to capture port level targets, analyze risks, and assess interagency impacts on port security. MSRAM outputs subsequently inform maritime critical infrastructure key resource list development; ports, waterways, and coastal security mission performance; FEMA’s port security grant program; and other USCG efforts.
12513 - Measures of Effectiveness for Combat Samples in Theater-Level Models

"Campaign analysis of ground operations across different theaters and timeframes requires a model that produces consistent and reproducible combat samples that are in turn used in theater-level models. The Center for Army Analysis (CAA) has put forth considerable effort to capture the most significant, tangible effects of these operations in the combat samples for theater-level models produced by the Combat Sample Generator (COSAGE), CAA's combat model. The combat samples produced by CAA are for use in all Attrition Calibration (ATCAL) based theater-level models (e.g., Joint Integrated Contingency Model (JICM), Synthetic Theater Operations Research Model (STORM)).

CAA has transitioned from strictly system output measures such as average weapons range to broader measures such as comparisons between defensive postures in terms of overall losses. These changes have increased the utility of measures of effectiveness in assessing how well the samples will function in theater-level models. The use of measures of effectiveness to determine issues within the combat samples and their use in addressing these issues will also be covered.

This brief will summarize CAA's efforts to standardize the measures of effectiveness used to assess the quality of the COSAGE combat samples and provide a comprehensive overview of the combat sample generation process."

12515 - Measuring and Analyzing the Value of Simulation in Collective Training

"It is commonly assumed that simulation is a value-added and even essential component to all categories of military training including collective training of Mission Planning and related tasks. It may be impossible today to imagine such training without the use of simulation. Despite this reality, there is a continuing need to better understand the true value that is added by the use of simulation, how that value relates to the performance of the unit as well as what the costs are of using simulation. This observation has been made both by the U.S. Congress and the Government Accountability Office (GAO). Progress has been made by an effort begun under the auspices of the Simulation to Mission Command Interoperability (SIMCI) Overarching Integrated Product Team (OIPT) and continued under the Program Executive Office (PEO) Simulation Training and Instrumentation (STRI), the Army Modeling and Simulation Office (AMSO), and DA G3/5/7. This continuing effort is collecting data on both the performance and cost aspects of simulation-based collective training. Performance data are collected using a survey-based methodology using the U.S. Army's Cost Benefit Analysis guide and GAO recommendations. Cost data are considered broadly from a return on investment (ROI) perspective for costs incurred as well as costs avoided. This paper describes the current state of the data collection and analysis activity and discusses recommendations for the incorporation of this type of analytical support to training across the military training enterprise. The importance of building and maintaining a measurement community of practice (COP) is also discussed."
11998 - From qualitative to quantitative and back again: optimizing resource-informed metrics for the strategic decision maker

Strategic assessment is a critical part of the military decision cycle. It exists to analyze performance and measure progress toward desired end states in the strategic environment in order to inform the commander’s decision process, specifically on how to sustain or modify policy, doctrine, organization, materiel, leadership and education, training, personnel, and facilities in order to further the accomplishment of theater objectives. However, most guidance stops at theater objectives, leaving theater strategic headquarters seeking optimal ways to collect the right data, ask the right questions, and link actions and the effects of those actions to the objectives they hope to impact.

This qualitative and quantitative case study will walk through the process of developing not only metrics but the supporting planning framework, with optimal linkages to performance and environmental metrics; determining those metrics by thorough problem definition; aligning performance and resources to metrics; and calculating proper thresholds and weights. Then, the quantitative to qualitative case study will walk through the process of providing the necessary context from the given data in a clear, streamlined manner to best support the decision cycle of a strategic decision maker, identify gaps and risk, and recommend resource-informed changes to the overall theater campaign. This multidisciplinary process involves analysis tools from systems design to surface optimization and recommends optimal suites of software, equations, and processes for each stage of the process.

WG 24 Test and Evaluation (T&E)

12448 - Effective use of M&S throughout the acquisition of EOIR Sensors

The seamless process developed by the NVESD Modeling and Simulation Division, provides end to end system design, evaluation, testing, and training of EO/IR sensors. By combining both in-house subject matter expertise and government developed and maintained software and test procedures NVESD ensures that EO/IR sensor developmental and operational testing and evaluation are accurately represented throughout the lifecycle of an EO/IR system. This process allows for both theoretical and actual sensor testing. A sensor can be theoretically designed and modeled using government developed software and then seamlessly input into the wargames for operational analysis. After theoretical design, prototype sensors can then be measured in a laboratory environment then modeled and into wargames for further evaluation. The measurement process to high fidelity modeling and simulation can then be repeated again and again throughout the entire life cycle of an EO/IR sensor as needed, to include LRIP, Full rate production, and even after Depot Level Maintenance. This is a prototypical example of how an engineering level model and higher level simulations can share models to mutual benefit. Specific examples to be discussed are use of the process described above in the acquisition and training of the LRAS3 and the Light, Medium, and Heavy Thermal Weapon Sights.

12162 - Cybersecurity Test and Evaluation and the National Cyber Range

Now more than ever, Program Managers (PM) must ensure that cybersecurity be given careful consideration throughout the system lifecycle. Specifically this includes identifying cybersecurity requirements early in the acquisition and systems engineering lifecycle. Initiating a focus on cybersecurity earlier will provide PMs the opportunity to give careful consideration, upfront, to related cybersecurity testing activities that can be integrated into the engineering planning and design phases. Results of informal cybersecurity testing can then be applied to influence design and development efforts and to posture programs for success in Developmental Test (DT) and Operational Test (OT). The Deputy Assistant Secretary of Defense (DASD) Developmental Test and Engineering (DT&E) has collaborated with key systems engineering stakeholders to develop disciplined processes that will assist Program Managers (PM) in implementing an incremental and iterative phased approach to develop cyber secure systems. The National Cyber Range (NCR), under the purview of the Test Resource Management Center (TRMC), is a resource that can be leveraged by PMs to support cybersecurity testing. This presentation will provide an overview of the cybersecurity test and evaluation phased approach and the NCR.
12414 - Design of Experiments DOES Apply to Your Test Program: Real World, Complicated Problems Require a Design to Fit the Problem and not a Problem fit to the Design

The MC-130J is part of the Air Force’s modernization plans for replacement of proceeding MC-130s that date back 50 years. The first MC-130J was completed in late 2009 and the Air Force Special Operations Training Center has begun the training program. Currently the Air Force is identifying a terrain following/terrain avoidance (TF/TA) radar system for the aircraft. The 413th Flight Test Squadron at Hurlburt Field wisely chose to employ design of experiments (DOE) methods for the test and evaluation of the TF/TA radar system, and the savings in test points are nearly 65%. The DOE application was laden with constraints typical of real-world, practical problems. But DOE offers numerous solutions to the challenges faced everyday by testers. This paper outlines the process of iterating through test plan options for several test objectives and constraints. The resulting test plans offer several experimental design alternatives customized for each test objective – a split-plot design to accommodate test variables that cannot vary randomly from run-to-run, an optimal design to accommodate multiple level categorical variables, and a traditional central composite design for a segment with continuous numeric variables.

11567 - An Organizing Principle for Cybersecurity Assessments

A best practice to achieve consistency in the execution of the six steps for cybersecurity test of major acquisition programs is to have a core organizing principle that provides a common context to analyze, synthesize, and understand the information gathered in those steps. This paper proposes a mechanism to achieve that consistency through a two-stage analytic structure to provide mission context for cybersecurity systems and operations. The first stage is an ontology that defines the relationships among the elements (tasks, operators, systems, etc.) of the cybersecurity mission space. The second stage is implementation of that ontology leveraging standing taxonomies for the elements. The implementation provides an initial taxonomization of the mission space that is expected to be common across all cybersecurity test and evaluation efforts and hooks further analysis specific to the program under test.

12413 - Going Where No Test Has Gone Before: Rigorous Developmental Test and Evaluation Using

The Air Force’s Small Diameter Bomb II (SDB II) / GBU-53/B provides our warfighters with an unparalleled capability to strike both fixed/stationary and moving targets in all weather. Equipped with millimeter wave and infrared radars, semi-active laser guidance, as well as the GPS-aided inertial navigation system employed in the SDB, SDB II provides greater effectiveness with fewer aircraft at risk. Currently in the Engineering & Manufacturing Development Phased (post Milestone B), the Office of the Secretary of Defense (OSD) Director of Operation Test and Evaluation (DOT&E) has directed an additional government developmental test (DT) program prior to a Milestone C decision.

The additional DT program certainly has an effect on the program cost and schedule, so are the benefits of such a program quantifiable? The 780th Test Squadron at Eglin AFB has teamed with the SDB II System Program Office to identify a use of the additional DT flight tests that maximizes the information gain on system performance while balancing program office and operational test (OT) considerations. Design of experiments (DOE) methods were used for test planning and vast improvements were realized with a tangible opportunity to enhance requirements verification and shorten OT – which would get the system to the warfighter sooner.
**12341 - Home Station Training Realism Improvement One Data Set at a Time**

One objective of the Army’s Combined Arms Center for Training (CAC-T) and National Simulation Center (NSC) is to improve Home Station training realism. NSC Capability Developers influence improvements with operational requirements and validation test criteria for materiel solutions. Knowledge of user experience informs their elicitation of operational requirements and their identification of test criteria.

NSC personnel are forming multidisciplinary teams and collecting simulation and survey data, and observations, for quantitative and qualitative analysis that increases their knowledge on Army unit usage of modeling and simulation in training exercises. The knowledge informs the NSC Capability Developers on modeling and simulation functionality updates that improve realism for Home Station Training, as well as, on subsequent updates to user guide and best practices documentation.

Exercises occur daily in the Integrated Training Environment (ITE) and provide the NSC opportunity for collecting data and acquiring knowledge on user experience. The NSC challenges reside in the continuous collection and cataloguing of data, the continuous identification of metrics, the timely analysis of quantitative and qualitative data, the real-time updates to metrics as data arrives, and the development of validation tests.

The NSC is looking at how to automate the collection of data from exercises that occur in the ITE and how to automate incorporation of new data to metrics so that running estimates of user experience are concurrent with user activities. The NSC research and assessment of a few data samples from exercises demonstrates the potential for quantitative and qualitative descriptions of user experience that inform development of requirements and test criteria.

The NSC challenges are at the intersection of Operations Research Analysis and the quantitative and qualitative analytics of Knowledge Management. The work within the NSC challenges addresses the objective to improve Home Station training realism. Release of this information does not imply any commitment or intent on the part of the U.S. government to provide any additional information on any topic presented herein. This briefing is provided with the understanding that the recipient government will make similar information available to the U.S. government upon request.

**12253 - Low Cost Cyber Security Testing on a Virtual Cyber Range**

In 2014, we described a Virtual Emulation Environment (VEE) that could realistically emulate whole networks on a laptop with bit-level fidelity and precise timing for highly realistic, but much lower cost network and cyber testing. This year we present examples of the actual use of that system to support multi-network cyber testing within the Intelligence Community (IC).

Because the virtual network under test is produced by reverse engineering it from its external data, the resultant virtual network is an identical clone of the real network using actual internet software and virtualized hardware. That virtual hardware portrays the servers and other devices down to the details of specific vendor models and places them in specific virtual geographic locations to address timing issues. Using VEE, the clone then emulates the real network to the extent that IC reviewers cannot tell the real from the virtual packet traffic. The baseline Virtual Cyber Range (VCR) is composed of only three laptops. One laptop operates as a virtual switch to support plug and play between virtual networks and live networks composed of a wide range of devices/products. Despite its small size the VCR virtualizes hundred servers and tens of thousands of networked devices and can be expanded by simply adding another laptop. The VCR requires minimal support with no special facilities, power, or cooling.

This briefing describes the current VEE, discusses some of the uses being made of the VEE-enabled laptops by IC test organizations, and outlines the future expansion of this concept.
### 11999 - Methodologies and Data Analysis Tools Developed to Support Verification and Validation of the Dugway Proving Ground Test Grid Safari Instrumentation

The Dugway Proving Ground Test Grid (TG) Safari Instrumentation provides the ability to test chemical and biological equipment in threat-representative, outdoor conditions while gathering real-time data from Systems Under Test and referee instrumentation. The verification and validation (V&V) ensures that the test infrastructure’s operational and technical specifications are met and serves as a basis for initial accreditation to support use of TG for Acquisition Program testing. The TG V&V involves identifying TG capabilities to subject to V&V testing, developing test methodologies, and authenticating and analyzing test data to evaluate TG test products and system performance. To support the V&V, multiple analysis methodologies and a suite of VBA- and Matlab-based tools were developed to efficiently and effectively process, visualize, and evaluate large sets of referee and performance data from the various TG systems. Examples of the capability provided by the tools include: the ability to batch process Aerodynamic Particle Sizer and lidar data sets; perform automated background subtraction; perform automated data quality checks; plot particle size distributions and counts over time; perform automatic time-drift detection and corrections; create an interactive graphical replay of temporal-spatial data; and automatically identify and graphically display discrepancies in data handled through different systems. These tools allow for near real-time feedback to support immediate adjustments to the systems or test set-up, saving time and money by reducing the likelihood of requiring retesting to complete the V&V. The presentation will provide an overview of the methodologies and tools developed to support the ongoing V&V.

### 11751 - Reliability Test and Evaluation (T&E) efficiencies

The importance of incorporating test efficiencies into the Army acquisition process has increased rapidly due to budget constraints and the need to quickly provide enhanced capabilities to our Soldiers. Army Materiel Systems Analysis Activity (AMSAA) has leveraged computer-based modeling and simulation (M&S) and targeted testing to reduce test time and to improve Return on Investment (ROI) costs. In support of Department of the Army Test and Evaluation (T&E) Efficiencies Task Force reliability initiatives, AMSAA and the Army Evaluation Center (AEC) developed a guidance framework that can be applied to Army programs to obtain testing efficiencies while maintaining or increasing system reliability levels. The framework suggests eight key elements (e.g., system model, test conduct, risk assessment, etc.) that are essential to develop a robust reliability program with high T&E efficiencies.

### 12154 - Estimating the Tradeoffs between the Decision Tools Used to Determine Target Location Error

The purpose of this analysis is to improve the quality of decision making for target location error testing. Target Location Error (TLE) is a metric used in testing to determine the effectiveness of targeting pods and other aircraft sensors. It is defined as the error between sensor generated coordinates and the true target location. At the platform level, this characterization includes all errors associated with the aircraft targeting solution and is typically used in an operational setting to determine the coordinate generating capability of aircraft. Simplifying the TLE performance in a summary table decision tool enables effective real-time targeting decisions; however, these simplifications have the potential to inaccurately bias a platform’s capacity to meet mission requirements. The accuracy of TLE affects multiple platforms’ ability to achieve desired mission effects in a constrained operating environment and is a critical tool for expeditious planning and execution. This analysis will address issues regarding the accuracy cost of oversimplification and the usability cost of impractically complex models in relation to TLE; specifically delving into the tradeoffs between the two as well as weighing in on the recommended approaches and test methodologies based on the levels of testing required. The aim is to design tests to allow optimal decision making for operators and planners by making evident compromises that are inherent to a variety of decision models.
Design of experiments is a widely used tool in the test and evaluation world. The size and power of experimental designs depend heavily on an accurate estimation of the signal to noise ratio. This analysis focuses on evaluating the impact of different levels of fidelity in signal estimation. It is often the case that the desired signal, or delta, is determined through informal discussion with subject matter experts. This analysis provides information on the value of formal modeling approaches to characterize the signal. The context for this work is determining the delta of interest for delivery accuracy of laser guided bombs. Determining the signal in this case requires a conversion from the top level objective, expressed in probabilities, to the value that will be measured, expressed in feet. Furthermore, if the objective is multifaceted, there may be multiple signals of interest that are constrained to a single design, for example: increasing the probability of a mobility kill while reducing the probability of collateral damage. Informal approaches to making this complex conversion will be compared to models of varying fidelity using sample size and power of the designed experiments as the comparison metric.

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 24 | 25 Jun 09:00 - 09:30 | DoD - 8 | 1st Lt. Andrew James Keith | Maria Phillips | SECRET

**12153 - Analyzing the Impact of Model Fidelity on Signal Estimation for Designed Experiments**

Historically, a range of military analyses, tests, evaluations, and M&S disciplines have been confounded by an absence of requisite context information. These can be seen as ill-posed problems, and they occur when an analysis is under-specified, under-determined, or under-constrained. Thus in principle, an answer does not even exist, although an analyst may make unwarranted explicit or implicit assumptions in order to force conclusions.

The past decade has seen increased focus on the “Mission” of materiel under study based on entity tasks requisite to the successful prosecution of a mission. We argue that this approach is what’s required to provide the community with key context information. Missions are about entities (people/material) executing tasks at multiple levels-of-war, sometimes individually, but often in teams. A useful descriptor for contemplating mission execution in the large is in task networks.

This abstraction, when instantiated, forms a collection of task networks. However, when it comes to Integrated DT, LFT&E and OT or Mission Capability-Based T&E, the T&E and analysis communities rarely develop such detailed task networks even though the information embodied in these networks is requisite to avoid an ill-posed and hence unsolvable problem.

We will illustrate an overall macro construction of task networks, together with the additional factors key to integrating a range of analyses. In a subsequent presentation (Britt Bray), task networks will be illustrated in detail. And in a final presentation (Chris Wilcox), an integrated T&E strategy will be developed based on the previously established operational mission context.

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 24 | 25 Jun 10:30 - 11:00 | DoD - 24 | Paul Hamilton Deitz, Ph.D. | | UNCLASSIFIED

**12075 - Military Systems Analyses in an Ill-Posed World: Defining the Problem**

This presentation will illustrate why missing context is a major impediment in the integration of many Test, Analysis, and Evaluation issues which face the DoD by describing and analyzing a previously developed case study that was generated for survivability analysis of the Joint Light Tactical Vehicle (JLTV).

The case study describes a BCT level operational scenario used for context. It documents the process of analyzing and decomposing the mission described into the relevant tasks. The result is an operational thread of tasks linked from the BCT level all the way down to the platform/system level.

The presentation illustrates decomposition of the mission to associated tasks from highest (BCT) level to the system/soldier level – all within the context of the operational scenario. This process facilitates determination of conditions impacting performance and effectiveness along with minimum measures of performance and effectiveness (MoPs and MoEs). Tasks at the lowest level are typically assigned to a single entity (person/platform) and the combination of conditions and standards (expressed as MoPs and MoEs) associated with them represent the minimum required level of capability for successful task performance/accomplishment.

We will use this case study to illustrate and demonstrate the value and relevance of establishing and documenting these task networks to facilitate integrated test and evaluation planning especially with respect to determining and establishing C4ISR metrics to support evaluation of system or system of systems effectiveness.

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 24 | 25 Jun 11:00 - 11:30 | DoD - 24 | Mr. Britt Bray | Paul Hamilton Deitz, Ph.D. Mr. Christopher M. Wilcox | UNCLASSIFIED

**12135 - Military Systems Analyses in an Ill Posed World: Illustrating a Solution**

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 24 | 25 Jun 11:00 - 11:30 | DoD - 24 | Paul Hamilton Deitz, Ph.D. | | UNCLASSIFIED
12380 - Military Systems Analyses in an Ill-Posed World: Shaping the T&E Strategy

In the preceding papers, the importance of “context” in the definition of a problem was explored. This paper explores how mission context, in the form of task networks, can be used to design and execute a truly integrated and continuous test and evaluation (T&E) program not reliant on assumptions to determine the impact of system performance on operational capability. The most recent Chairman of the Joint Chiefs of Staff Instruction (CJCSI) on the Joint Capabilities Integration and Development System defines capability as, “The ability to execute a specific course of action.” Previous versions of this definition had included expanding “execute” to “performance of a set of tasks.” Decomposing the paragraph above, a capability is made up of a task, (what is being done), plus the desired course of action, (why it is being done). A task network can be used to represent the tasks performed by Soldiers in the accomplishment of their missions. The context for each task should include the desired course of action, standards, conditions, means and ways. This fully describes the operational capabilities needed to execute the mission. Through the task network and context, the technical performance of the system can be linked to the operational capabilities desired meeting the need of T&E. The additional benefits of this linkage of evaluation measures to tasks/context and means is an integrated and continuous T&E strategy is built. Integrated T&E is supported by identifying test conditions applying to both developmental and operational testing allowing for combining of data.

12165 - Slogan-Based T&E: Words Have Meaning

ABSTRACT. The T&E community has been searching for the right framework to use in developing test and evaluation (T&E) programs. Various approaches have been suggested with some being used very successfully today. These approaches use terms like mission, task, or capability as a foundation to develop a framework of the elements and relationships used in planning and execution of T&E programs. These T&E approaches provide a good set of tools but their application-focused interpretation of terms has limited their use across the acquisition community.

A quote attributed to Socrates states, “The beginning of wisdom is the definition of terms.” This paper creates a shared wisdom across the acquisition community by: (1) defining the purposes of a framework from various stakeholder viewpoints; (2) providing a set of definitions for commonly used terms including: capability, mission, task, attribute, etc.; and (3) linking these terms together based on their relationships in support of the stakeholder purposes. Purposes and definitions are taken from existing authoritative regulations, instructions and guidance.

These purposes, definitions and relationships create a T&E framework that provides for continuous assessment of system development from design, through subsystem DT, system DT, and operational testing. The T&E measures provided are then used to define and execute the evaluation of both the operational capability achieved and the technical performance of the materiel system. An integrated and continuous T&E strategy is built which scopes a robust and adequate T&E program allowing for combining of data and the assessment of development risk throughout the program.

12098 - Software Reliability Risk Assessment and Risk Mitigation

Software is growing larger and becoming more complex in Army systems. The safety, welfare, and effectiveness of our soldiers directly depend on the ability of software to perform as intended and operate reliably in adverse training and combat conditions. Reliability issues have resulted in millions of dollars spent on correcting software systems that failed to meet cost and schedule requirements.

AMSAA performed a study that assessed the effectiveness of various software development methods and best practices in use by recent, software-intensive Army systems. The methods were evaluated to identify those best suited for reducing software reliability risk. Criteria for tailoring the methods to specific program circumstances were established through analysis of the various types of software applications and developmental environments currently in use.

The study found that there is very little focus on designing for software reliability in current Army systems and there does not appear to be a formal, thorough software reliability initiative in place across the Army. As a result, most of the systems examined experienced either schedule slippage, test event failure, or both. There are many opportunities for improvement and software-intensive systems may achieve lower reliability risk by implementing many of the reliability-oriented metrics, methodologies, and best practices available.
WG 25 Analysis of Alternatives (AoA)

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<td>DoD - 14</td>
<td>Dr. Simon R. Goerger</td>
<td>Dr. Tommer Ender, Dr. Valerie B. Sitterle</td>
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11592 - Measuring and Analyzing Multiple Perspectives of System Resilience in a Tradespace Tool

Many effective Department of Defense systems are trusted and effective in a wide range of operational contexts with the ability to respond to changing conditions through modified tactics, appropriate reconfiguration, or replacement. Understanding, measuring, and assessing these characteristics is critical in a resource constrained environments. As part of Engineered Resilient Systems, this work lays the foundations for resiliency analysis through the development of modular, composable, and scalable analytical constructs and processes. The analytical methods are derived from existing ontological bases, and seek to promote consistency and comparability between analyses. The work focuses on evaluating ‘Robustness of fielded system capabilities and capacity with respect to operational requirements’ and ‘Flexibility of a designed system to engineering change’. The development philosophy strives to enable design and development of resiliency analyses that are transparent, intuitive, rational, and quantifiably traceable. This presentation provides a methodology overview and the results of an example acquisition program to illustrate how analysts can use resilience metrics in analysis of alternatives to facilitate senior leader understanding of the possible impacts of system resiliency.

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<td>Dr. Jean Charles Domercant</td>
<td>Professor Dimitri Mavris</td>
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11819 - A Complexity Based Real Option Analysis of Alternatives for Military Systems

The timely, affordable acquisition of weapons systems to deliver capabilities to the war fighter is vital to national defense. However, the government faces unique challenges in applying traditional financial valuation methods during an analysis of alternatives due to the non-profit, public nature of national defense. Traditionally, the success of an acquisition program is judged using cost, schedule, and performance as the main criteria. In the past, when budgetary resources for defense spending were readily available, performance was the dominant criterion. As time progresses, however, budgetary constraints become even tighter making the evaluation of life cycle cost in relation to operational effectiveness and risk even more important when addressing capability gaps.

An Architecture Real Options Complexity-Based Valuation Methodology is introduced to provide a valuation methodology suitable for selecting military Systems-of-Systems architectures for acquisition. This becomes of increased importance as systems grow in complexity while acquisition budgets become more constrained. ARC-VM utilizes Real Options as a financial framework to account for time-valued capability levels and the discounting of architectural complexity, which is considered a key driver of cost, schedule, and performance in the early stages of design. This requires the development of a mathematically rigorous measure of military system and System-of-System architecture complexity based on leading principles being explored and cultivated in the field of complexity science.

Complexity is then monetized for use in the real option framework. Overall, this provides decision makers the ability to judge when additional effectiveness is worth an additional investment of resources.
### 12331 - Challenges and Benefits of incorporating Reliability Engineering into Tradespace Analysis

Tradespace analysis is a DoD Engineered Resilient Systems initiative focus area that employs science, engineering, and design tools to produce solutions for a wide range of operational contexts. To date, tradespace research emphasizes performance. However, non-functional requirements such as reliability, availability, and maintainability have received minimal consideration, despite their direct influence on program-level concerns such as operation and support as well as affordability. This presentation summarizes our research to identify a systematic strategy to incorporate reliability engineering into tradespace analysis for the Future Vertical Lift (FVL) initiative. We extend recent research [1] that established a preliminary model characterizing the relationship between reliability investment and life-cycle support costs to develop a subsystem-level reliability investment model. This more detailed formulation can provide quantitative guidance on how investments in reliability improvement should be divided when subsystems do not contribute equally to essential function failures that render a system not mission capable.

**References**


### 11636 - Enduring Principles of Operational Capability Requirements Studies

As the Air Force center of expertise for operational capability requirements analysis, the Office of Aerospace Studies (OAS) has the unique responsibility of assisting study sponsors across the Air Force in planning and conducting Capabilities-Based Assessments (CBAs), Analyses of Alternatives (AoAs), and other types of capability requirements studies. These studies serve as the analytical foundation for identifying capability gaps and requirements. Since the 1990s, this office has been involved in hundreds of such studies and has learned what it takes to effectively plan and conduct them. Though the studies have evolved over time, there are principles that continue to underpin good studies. This paper describes these enduring principles and offers some recommendations for planning and conducting a capability requirements study.

### 11745 - An integrated approach that simultaneously models value and cost uncertainties to better identify value and risks

System engineers often use value modeling to capture a composite perspective of multiple stakeholders with conflicting objectives to help understand trade-offs among several design alternatives. Uncertainties are inherent in many forms during a system’s life-cycle and must be considered during any design decision. These uncertainties include stakeholder concerns, technological maturity, adversary and competition actions, scenarios, costs, schedules, and many more. Uncertainty and risk analysis are often performed after analyzing a value model. As a result, our decisions become biased toward deterministic solutions that we select before understanding their risks. To eliminate this cognitive bias, we propose an approach that integrates uncertainty modeling with value modeling in order to help understand value and risk while we analyze alternatives. By assigning probability distributions to uncertain independent variables and cost components, we can perform Monte Carlo simulations to propagate these uncertainties through the value and cost models and examine cumulative distribution functions in order to identify dominant solutions. We can then use tornado diagrams to identify which value measures and cost components explain the majority of the alternatives’ value and cost variations. Integrating both value measure and cost uncertainties simultaneously will better facilitate value and risk identification to help system engineers perform trade-off analysis during design decisions throughout the life-cycle.
The SBIRS AoA working group defined an iterative three step process to support integration of resiliency concepts and solutions in the system architecture. The process is necessary step to balance of capability, affordability, and resilience. This presentation will cover the framework and methodology developed by AFSPC/A9A now AFSPC/A5XY to assess resiliency and its application in the Space Based Infrared System (SBIRS) Follow-on Analysis of Alternatives (AoA).

The SBIRS AoA working group defined an iterative three step process to support integration of resiliency concepts and solutions in the AoA efforts. This process included methods identification & analysis, building resilience in to the alternatives and assessing the resilience of each alternative. This presentation will provide an overview of each step in the process with particular focus on the final assessment step. The assessment methodology consists of five sub-processes covering threats, architectures, threat employment, system degradation, and warfighter mission effectiveness. These results were integrated with other effectiveness and cost insights to influence selection of the next generation SBIRS architecture.

### 12157 - Cost Analysis Tool for Evaluating Financial Impacts of Radiation Portal Monitor Alternatives

Cost Analysis Tool for Evaluating Financial Impacts of Radiation Portal Monitor Alternatives

In response to the terrorist attacks of 2001, the U.S. Department of Homeland Security (DHS) deployed over 1,500 Radiation Portal Monitor (RPM) systems to scan cargo entering the nation through seaports or across land borders. DHS’s Domestic Nuclear Detection Office (DNDO) works cooperatively with U.S Customs and Border Protection to sustain this capability. This includes evaluating solutions that target operational efficiencies, while maintaining a robust detection capability.

A cost analysis tool (based in Microsoft Excel) has been developed that supports the evaluation of solutions that may replace or augment the fielded RPM systems. Variables such as capital expenditures, recurring annual maintenance costs, out-year costs, as well as characteristics of RPM performance and specific operating environments, are analyzed to explore the financial implications associated with the solutions proposed.

The tool provides a rough order of magnitude of several metrics commonly associated with a Cost-Benefit Analysis (CBA) such as Net Present Value (NPV) and Return on Investment (ROI). For alternatives whose lifecycle cost savings outweigh the capital expenditure in a discounted cash flow analysis, the break-even point is also calculated.

### 12345 - Cost and Affordability Analysis - Long Range Precision Fires (LRPF) Analysis of Alternatives (AoA)

The Office of the Secretary of Defense, Cost Assessment and Program Evaluation (OSD CAPE), initiated the LRPF AoA in 2013. The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) established a study team to examine alternatives that could mitigate the capability gap resulting from the cancellation of the Army Tactical Missile System (ATACMS) program and the 2019 moratorium against cluster munitions. Trade space analysis within the alternatives was a key aspect of the study.

The study team examined tradeoffs between schedule, performance, and cost for all the alternatives. The LRPF Cost Team focused on calculating the life cycle cost estimate (LCCE) and average procurement unit cost (APUC) for alternatives based on predetermined production schedules. With these schedules, some of the alternatives exceeded the affordable budgetary projections. The LRPF Cost Team then modified the production schedules for every alternative causing all of the annual procurement cost estimates to remain below the annual affordable budgetary projections. This step provided decision makers more tradeoffs: they could choose any alternative and still spend less than the annual affordable budgetary projections, but with changes to the LCCE, APUC, and/or procurement timeline.

This presentation will discuss how the LRPF Cost Team studied cost and affordability as well as how the results were incorporated with the aged inventory analysis. It will include the methodologies for the initial estimates and sensitivity analysis. Limitations, assumptions, various challenges, and lessons learned for this study will also be addressed.

### 11910 - Resiliency Analysis for Space Systems

Air Force Space Command (AFSPC) defines resilience as “the ability of the system architecture to continue providing required capabilities in the face of system failures, environmental challenges, or adversary actions.” The four main considerations to determine the resilience of architectures are the adverse events, likelihood of occurrence, capability lost, and time duration of the capability lost. Addressing all of these considerations simultaneously is a complex endeavor and can be achieved through a combination of avoidance, robustness, reconstitution, and recovery. Assessing the value of various techniques as they contribute to overall resilience of the system is a necessary step to balance of capability, affordability, and resilience. This presentation will cover the framework and methodology developed by AFSPC/A9A now AFSPC/A5XY to assess resiliency and its application in the Space Based Infrared System (SBIRS) Follow-on Analysis of Alternatives (AoA).
### 11781 - Small-Scale Wargaming to Support Long Range Precision Fires Analysis

The Army Tactical Missile System (ATACMS) is the Army’s long range, deep strike missile that provides surface-to-surface, all-weather precision fires beyond current cannon and rocket ranges. Termination of the ATACMS program in 2007, due to budgetary concerns, will result in a capability gap.

The LRPF AoA was initiated by the Office of the Secretary of Defense, Cost Assessment and Program Evaluation in 2013, to examine alternatives that mitigate the capability gap resulting from the loss of capability provided by ATACMS. The AoA examined the impact of ATACMS during large scale, traditional theater operations as a part of the Joint force. ATACMS and other LRPF AoA alternatives provide highly accurate, quick response, and effective fire against a variety of targets to the Joint Force Commander, providing flexibility during targeting operations. While robust combat modeling focused on the role of LRPF in setting conditions for the Joint Force Commander early in a campaign, the execution of a small-scale wargame was essential to supporting a holistic assessment of the role of LRPF throughout the ground maneuver operations phase and its role as an enabler to the ground commander.

The focus of this brief is the use of a seminar wargame to identify the impacts of ATACMS to a ground maneuver commander supporting a Joint operation. The wargame assessed how a Corps staff integrates long range precision fires into their scheme of maneuver or crisis action plan. The results provided insights into the risk associated with losing the Army’s long range precision fires capability.

### 11577 - Using Qualitative Methods to Optimize Soldier Load, Effectiveness, and Health

The United States Army Soldiers’ current head and torso protection systems are heavy, bulky, and do not integrate well with other equipment. The systems’ weight limits Soldier operational effectiveness, and increases Soldier injuries. Product Manager Soldier Protection and Individual Equipment (PM SPIE) engaged the Edgewood Chemical Biological Center Decision Analysis Team (DAT) to conduct cost benefit analyses (CBAs) evaluating the trade-off between cost, risk, and Soldier’s operational effectiveness and health for the Vital Torso Protection and Torso and Extremity Protection systems, and the Integrated Head Protection System. Studies quantifying the relationships between Soldier load, effectiveness, and health have not been completed as they would be complex and costly. Ultimately, the DAT and PM SPIE used quantitative and qualitative (e.g., follow-on effects, qualitative evaluation criteria) approaches to assess these relationships and recommend the best way of providing Soldiers protection that enhanced operational effectiveness, and minimized cost and negative long-term impacts.

### 12276 - Cyber Perceptions – Creating a Structure for Intangible Requirements

Though Cyber Superiority is a recent addition to the Air Force core function portfolio, it shares many characteristics with those core functions which effectively use the JCIDS process to identify, analyze, mature, acquire, and field capabilities that support Service and Joint warfighter functions. While some may posit that there are unique or special characteristics to Cyber Superiority, that make it inconsistent with traditional requirements based acquisition; the authors identify how Cyber Superiority is not only consistent with other Service core functions, but also how it is easily integrated into existing JCIDS processes so that emergent Cyber Superiority capabilities can be effectively assessed with respect to mission requirements, and how those capabilities can be fielded in a manner that effectively brings them to bear in order to deter and defeat the cyber threats faced by Combatant Commanders today and in the future.

The lessons observed from Cyber Superiority oriented Capabilities Based Assessments (CBAs) highlight obstacles and opportunities to effectively integrate current knowledge into JCIDS and Service capability requirements processes, while identifying and addressing those information and documentation shortfalls which can be characteristic of the Cyber Superiority realm. The authors address best practices which may be utilized to mitigate and address those challenges associated with this immature core function in order that subsequent acquisition decisions may be evaluated and realized.
### 11840 - Making AoAs Meaningful and Relevant (WG-25)

Analysis of Alternatives (AoAs) are costly, lengthy and many times inconclusive putting the decisionmaker in the unenviable position of deciding the correct materiel solution and critical requirements with conflicting or confusing data. We will look at a case study to show how AoAs can be shortened and provide decisionmakers with concrete, decisionable data converting this sometimes box checking exercise into a productive and desired analysis.

Aspect is a new tool that is inexpensive, shortens the process and allows the Operational User to understand the myriad of technical approaches in practical operational terms providing senior decisionmakers with discernible criteria to make determinations that will ensure the User receives an operationally beneficial weapon system. In addition, Aspect provides the ability to narrow the candidate solutions requiring detailed, expensive physics modeling and analysis providing an overall cost savings. Also, Aspect has the ability to quantify previously subjective assertions. Many of these parameters such as crew sizes, number of radios or other similar system characteristics are normally analyzed separately by analogy where Aspect completes the analysis as part of the system as a whole and with the ability to view the cost-benefits of each individual parameter. Lastly, AoAs tend to focus on the most difficult scenarios such as Phase 2 in stand-off theaters while never looking at the system’s capabilities in other operating environments, where in fact, the system may spend most of its life such as Phase 0 or 1.

### 11921 - Obtaining Stakeholder Agreement on What a System Must Do to be Judged Effective in Accomplishing Mission Objectives

We developed a methodology for assessing the quality of a set of technical performance measures associated with achieving mission objectives. We use a mission stream analysis (e.g., Find, Fix, Track, Target, Engage) to determine if a set of metrics (e.g., KPPs, MOEs) is extensive enough to demonstrate mission objectives. Following this, we determine if the set is quantitative with objective and threshold values and unambiguous.

This study produced three interesting products.
- A methodology for assessing user requirements (in the ORD or CDD) or a set of technical performance measures (KPPs, MOEs) for their value in determining if mission objectives are met.
- A model for reporting achievement of technical performance to the acquisition community that is both tailorable and specific to all major defense acquisition programs.
- A method for assessing systems engineering performance early in the design phase by examining the state user requirements and technical performance measures.

This presentation discusses how the methodology could be used in the Post AoA Review or Pre-EMD RFP Review to decide if all the stakeholders agree on what the system needs to do to be judged effective in accomplishing objectives.

### 11778 - Determining Requirements for the Army’s Future Long Range Precision Fires (LRPF)

The Army Tactical Missile System (ATACMS) is the Army’s long range, deep strike missile that provides surface-to-surface, all-weather precision fires beyond current cannon and rocket ranges. Termination of the ATACMS program in 2007, due to budgetary concerns, will result in a capability gap.

The LRPF AoA was initiated by the Office of the Secretary of Defense, Cost Assessment and Program Evaluation in 2013, to examine alternatives that mitigate the capability gap resulting from the loss of capability provided by ATACMS.

The LRPF AoA study team produced several key deliverables: identification of life cycle costs and cost drivers; robust trade space analysis; operational effectiveness and sensitivity analysis of the alternatives to factors that impact operational effectiveness; and key operational capabilities to inform system requirements.

The purpose of this brief is to showcase how the LRPF study team determined the impact of Army LRPF to the Joint fight. It highlights how the study team assessed the Army LRPF as a Joint force enabler and the analytical tools used to inform future LRPF system capability requirements. The brief outlines the future LRPF’s key performance parameters and system attributes identified during the study that will assist the Joint force in accomplishing its mission objectives.
11749 - Getting top marks whilst delivering bad news (analytical support to the UK Joint Forces Command C4ISR capability audit)

The C4ISR Capability Audit enables the UK Defence Authority for C4ISR to assess how effectively UK Defence can conduct Military Tasks out to 2030, given funded capabilities within the Defence Plan. This output provides evidence, critical data and mitigating options to decision makers in MoD Head Office to inform the capability planning process and future programme definition. Specifically, Dstl applies qualitative and quantitative analysis to support the audit process in order to accurately identify capability gaps for producing decision quality analysis.

This presentation will describe the full range of analytical methods used by Dstl within the Capability Audit process. Such methods include assessment of capability against scenarios, the use of qualitative analysis to provide key insight to decision makers and the development of information management processes. The latter in particular was introduced to improve stakeholder engagement across a complex network and has had the additional benefit of reducing study time and project costs in the delivery of the audit output.

11820 - Investigation into Affordable Configurations for Fractionable / Composable Munitions in Various Threat Environments

This study found an affordable solution to eliminate targets within Anti Access / Area Denial (A2/AD) operational environments through the use of fractionable / composable munitions. The study examines the effectiveness and cost of a missile system that physically fractions into components yet composes functions between these displaced components in order to surpass A2/AD challenges. These shared functions included important factors such as seeking, tracking, countermeasures, and system reliability. The study examined three scenarios with different threat levels (low, medium, high) which resulted in lower subsystem success and reliability with increasing threat level. The probability of kill requirement of 0.95 was the critical constraint and was calculated by factoring physical fractionation success, systems detection, effectiveness of countermeasures, communications, and reliability of the fusing/detonation of the explosive payload. Volume and cost were also critical estimated factors which primarily contributed to the objective of affordability. These considerations were formulated and then compiled into a single optimization program utilizing a calculus-based optimization for continuous design variables and a genetic algorithm for discrete variables. For a high threat environment with a requirement to hit ten targets, the study showed an optimal configuration that is estimated to cost $15.96M in total. In addition, sensitivities were explored for various configurations to help determine affordable trends. These sensitivities showed that a highly fractionated system is more affordable for the higher threat scenario whereas a more traditional system is desirable for a low threat scenario.
### WG 26 Cost Analysis

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#### 11909 - Cost and Affordability Analysis - Long Range Precision Fires (LRPF) Analysis of Alternatives (AoA)

The Office of the Secretary of Defense, Cost Assessment and Program Evaluation (OSD CAPE), initiated the LRPF AoA in 2013. The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) established a study team to examine alternatives that could mitigate the capability gap resulting from the cancellation of the Army Tactical Missile System (ATACMS) program and the 2019 moratorium against cluster munitions. Trade space analysis within the alternatives was a key aspect of the study. The study team examined tradeoffs between schedule, performance, and cost for all the alternatives. The LRPF Cost Team focused on calculating the life cycle cost estimate (LCCE) and average procurement unit cost (APUC) for alternatives based on predetermined production schedules. With these schedules, some of the alternatives exceeded the affordable budgetary projections. The LRPF Cost Team then modified the production schedules for every alternative causing all of the annual procurement cost estimates to remain below the annual affordable budgetary projections. This step provided decision makers more tradeoffs: they could choose any alternative and still spend less than the annual affordable budgetary projections, but with changes to the LCCE, APUC, and/or procurement timeline. This presentation will discuss how the LRPF Cost Team studied cost and affordability as well as how the results were incorporated with the aged inventory analysis. It will include the methodologies for the initial estimates and sensitivity analysis. Limitations, assumptions, various challenges, and lessons learned for this study will also be addressed.

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#### 11585 - Life Cycle Cost Analysis for Tradespace Generation and Visualization

With the increase in tradespace analytics for DoD acquisition decision making, there is an ever increasing demand for Life Cycle Cost (LCC) methodologies to support these efforts. Many current approaches are not appropriate to generate cost parameters for millions of design instantiations across a fully enumerated tradespace dataset. Additionally, to fully harness the power of the tradespace, the uncertainty of the LCC data must be included in the dataset and visualization. The Engineered Resilient Systems (ERS) program is developing LCC methodologies and tools to support tradespace assembly and visualization to inform decision making, particularly in pre-milestone A programs. The ERS-LCC research tackles the cost data generation, uncertainty propagation and cost visualization aspects of tradespace analytics. The LCC module consists of a set of cost models of various methodologies and fidelities. Uncertainty modeling is applied to each cost consideration, and the LCC data are then integrated to the ERS tradespace architecture for visualization and exploration.

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#### 11809 - Decision Analysis as a Valuation Methodology for Open System Architectures

In 2004, the Open Systems Joint Task Force released their findings on a new design paradigm for defense acquisition – Open System Architectures (OSA). An OSA is a simple concept; emphasize modularity early in design, with the stipulation that modules connect to system architecture through well-defined interfaces, whose standards are widely available and conform, where possible, to existing commercial standards. This provides the flexibility for systems to be incrementally upgraded in response to changes in requirements or new technologies, rather than undergo significant redesign work. Moreover, OSA programs are better able to capitalize on the innovation and economies of scale afforded by commercial markets, increase competition among vendors, and facilitate reuse of components/subsystems across programs. Though the OSA initiative is conceptually simple, it has proven difficult to implement. This stems, in part, from the difficulty of answering a basic question – how does one quantify the value of making a component/subsystem upgradeable? To correct for this shortcoming, this work proposes a new valuation methodology which leverages the principles of classical decision analysis, augmented with modern methods of technology forecasting to establish the options available for subsequent upgrade decisions. In addition, the probabilistic theory of maximum entropy is used to capture the uncertainties inherent in forecasting the evolving properties of maturing technologies, independent of the forecasting technique used to produce those estimates. The result will provide an estimate of the expected cost and effectiveness afforded by opening a component/subsystem to future upgrades, thereby integrating OSA decisions into the existing analysis of alternatives framework.
### 11661 - Rapid Data Generation (RDG) Cost Benefit Analysis (CBA)

The U.S. Army Materiel Systems Analysis Activity (AMSAA) is conducting a Cost Benefit Analysis (CBA) of Rapid Data Generation (RDG) Common Data Production Environment (CDPE) to support Headquarters Department of the Army (HQDA) G-8. The RDG CDPE provides a web portal and a discoverable metadata catalog of metacards to allow Modeling and Simulation (M&S) users to search and retrieve available datasets. The datasets do not physically reside on the CDPE portal. RDG CDPE data providers will generate, store, and update metacards relating to their available datasets. The portal will assist users in retrieving desired data. The initial releases of RDG CDPE provide data for orders of battle, terrain, and weather.

AMSAA developed a study plan to gather information from at least one major M&S data consumer in each of the six Army M&S communities of Acquisition, Analysis, Experimentation, Intelligence, Test and Evaluation, and Training. AMSAA interviewed M&S data consumers to determine their processes required to prepare for M&S events and the costs of that preparation in both time and money. AMSAA also provided the M&S data customers with an overview of RDG current and future capabilities and asked to determine any potential savings due to RDG. The CBA is identifying what processes are most costly in M&S event preparations and determining a return on investment provided by RDG for the M&S communities. Results will be presented on both quantitative and qualitative benefits provided by the RDG CDPE.

### 12160 - Cost Analysis Tool for Evaluating Financial Impacts of Radiation Portal Monitor Alternatives

Cost Analysis Tool for Evaluating Financial Impacts of Radiation Portal Monitor Alternatives

In response to the terrorist attacks of 2001, the U.S. Department of Homeland Security (DHS) deployed over 1,500 Radiation Portal Monitor (RPM) systems to scan cargo entering the nation through seaports or across land borders. DHS’s Domestic Nuclear Detection Office (DNDO) works cooperatively with U.S Customs and Border Protection to sustain this capability. This includes evaluating solutions that target operational efficiencies, while maintaining a robust detection capability.

A cost analysis tool (based in Microsoft Excel) has been developed that supports the evaluation of solutions that may replace or augment the fielded RPM systems. Variables such as capital expenditures, recurring annual maintenance costs, out-year costs, as well as characteristics of RPM performance and specific operating environments, are analyzed to explore the financial implications associated with the solutions proposed. The tool provides a rough order of magnitude of several metrics commonly associated with a Cost-Benefit Analysis (CBA) such as Net Present Value (NPV) and Return on Investment (ROI). For alternatives whose lifecycle cost savings outweigh the capital expenditure in a discounted cash flow analysis, the break-even point is also calculated.

### 11425 - How User Behavior and Performance Affects the ROI of Enterprise IT Programs

Large organizations often assume they need to invest in Information Technology (IT) systems that are utilized by the maximum number of users in order to achieve the best Return on Investment (ROI), but that assumption may not apply in an enterprise IT environment. Unlike a consumer environment, where user acceptance directly relates to sales, in an enterprise environment it is unclear whether an organization will see the greatest benefit by providing systems that receive the most usage from employees. For example, Defense Connect Online, an online meeting service, saw so much usage that its licensing costs are now unaffordable, indicating that at some point the cost of providing the service to more users was greater than the benefit gained. Additionally, many plans assume that targeting “average” users will result in the maximum ROI. In reality, it often results in services too advanced for most users, while concurrently not meeting the needs of top-tier performers. Therefore, a better question is, “Would we get a better ROI from focusing on the needs of a smaller population of the highest performers, less complex IT projects to appeal to the most people, or focus on strategic objectives instead of users?” This study seeks to answer this question by gathering data on both user behavior and performance, and comparing it to productivity gains and operating costs. The resulting analysis will not only allow for a better understanding of user behavior in an enterprise environment, but will also provide key insights into improving IT investment strategies.
### 12051 - Force Structure Influence on Indirect Personnel Costs

As the fiscal environment of the U.S. government continues to be constrained the Air Force (AF), along with her sister services, will need a systematic methodology to plan and implement force structure and budget reductions in sound logical ways. Support costs represent a significant proportion of the AF budget, totaling over $38 billion in fiscal year 2014, and understanding the behavior of these costs can provide leadership with insights required to inform strategic management decisions. Unfortunately, historical research on support costs has centered around an aggregate tooth-to-tail ratio, which can lead to biased presumptions based on a single level of analysis rather than a comprehensive understanding based on evidence from multiple levels in an organization. The purpose of this research is to understand the tooth-to-tail relationship across the assorted hierarchical views of the Air Force organization by applying a multilevel modeling approach.

### 12040 - Economic Impact Analysis – Assessing the Impact on Local Communities due to Stationing Actions

The Department of Defense (DoD) has conducted several rounds of Base Realignment and Closures (BRAC) with the last round being conducted in 2005. Since then the U.S. Army has reduced its force size, which has created excess infrastructure capacity on many Army installations. Due to budget constraints, DoD has asked Congress to authorize another round of BRAC. One of Congress’ BRAC criterion that must be considered is the economic impact of realignment or closure actions on surrounding local communities. The Army must also consider economic impact for any day-to-day stationing actions outside of a BRAC.

The Center for Army Analysis (CAA) has extensive experience with stationing analyses from prior BRAC rounds. CAA has conducted considerable analysis in the recent European Infrastructure Consolidation (EIC) effort. CAA developed tools that were used for stationing analysis during BRAC 2005 and modified them for use in EIC. CAA recognizes that its stationing tools must be revised to meet today’s challenges and is conducting a focused multi-year effort to do so. As a part of this effort, CAA is developing an Economic Impact Tool (EIT). During BRAC 2005, DoD utilized commercial software to estimate the economic impact by accounting for the employment and population changes to a community. CAA initiated a project with the George Mason University’s Operations Research Department to develop EIT to account for differences across Army Installations. We will explore multiple attributes of economic impact using authoritative databases and a documented and verified methodology.

### 11658 - Army Aviation - Program Replacement Costs and Influence on Sustainment Expectations (AA-PRECISE)

Budget reductions warrant efficient use of resources in order to meet growing national security requirements. Operational dominance is, in part, achieved by materiel fleets that augment Soldier combat capabilities. Fleet managers counter obsolescence by modernizing and preserving readiness through Operations and Sustainment (O&S) funding. Withholding obsolescence, fleets with increasing O&S costs reach a point when replacement is more practical than continuing sustainment; too soon and Economic Useful Life (EUL) is forfeited, too late and unnecessary sustainment costs are realized.

While standing guidance provides a range of ages at which to replace or upgrade systems, indicating that fleets degrade over time, historical analyses have not been holistic or sufficiently detailed to assess the impact of redirecting funds between acquisition and O&S costs. Using a real options approach, this analysis seeks to identify a cost-minimizing replacement strategy for a particular fleet using historical data. Modeling the dynamics between procurement and sustainment costs informs the length of time that planners should expect to maintain a platform and identifies when O&S costs become excessive.
11761 - Optimization Modeling in Support of Formational Capability Portfolio Reviews: Challenges and Lessons Learned

Capability Portfolio Reviews (CPRs) have been implemented by the U.S. Army to more effectively allocate resources in a constrained fiscal environment. These CPRs involve analysis of a “Warfighting Function, formation-based, or special topic capability portfolio... in order to focus investments to the most critical capability gaps and to achieve balance across doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) investments.” Since 2012, the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) has provided analytic support to three formation-based CPRs: the Infantry Brigade Combat Team (IBCT) CPR in 2012, the Armored Brigade Combat Team (ABCT) CPR in 2013, and the Stryker Brigade Combat Team (SBCT) CPR in 2014. TRAC supported trades analysis for each CPR by applying optimization modeling to analyze the effects of materiel procurement schedule modifications on the acquisition of future capabilities. This analysis helped the TRADOC Capability Managers identify an investment strategy that maximized the attainment of priority formation capabilities and minimized risk.

TRAC has gained insight into how optimization modeling can best be used to support formation-based CPRs and the challenges encountered with these types of efforts. This presentation will provide an overview of the CPR process, discuss TRAC’s optimization modeling approach, and describe several key challenges and lessons learned to benefit other analysts who choose to apply similar optimization techniques in the conduct of studies.

HQ TRADOC Tasking Order: TRADOC TASKORD IN141216 Capability Portfolio Review (CPR), Fort Eustis, VA.

12078 - Estimating Program Management Administration Costs for AF Acquisition Programs

12118 - Individual Cost Assessment Model

The Individual Cost Assessment Model, or ICAM, is a Java-based discrete-event simulation that models a population of individual Airmen through hypothetical careers from accession to end-of-life and computes the annual and total life-cycle cost for the three Air Force components. ICAM models major career events, such as accession, PCS, promotions, deployments, component changes, separations, and retirements tabulating pay, compensation, and benefits over time. It accounts for the major cost elements, such as base pay, allowances, benefits, health care, and retirement. ICAM has the ability to accept user inputs for experimentation to predict the cost implications of pay and compensation changes, such as deployment length and rates, pay changes, retirement policy, or transition rates. ICAM has been informing AF decisions. Examples include cost implications of changes to rated service commitments, changes in policy on repaying separation incentive pay, cost differences between force mix options, and cost comparisons between ARC categories of employment to name a few. ICAM is supported by a working group with subject matter experts representing different cost, personnel, and analytic organizations from the Air Force. AFRC/A9 is continuing model development to build a higher-fidelity model to account for more cost elements, Airmen parameters, and policy. ICAM the latest model included into the Air Force Standard Analytical Toolkit (AFSAT).
11655 - A Monte Carlo Approach to Readiness Driven Stochastic Optimization in Naval Aviation Activity Based Costing Systems

Activity Based Cost Systems are often used to describe budget requirements, overhead costs and organizational goals in a wide variety of programmatic support activities. In such systems, allocation levels are determined by the relationship between resourcing and programmatic goals. This relationship is often based on a subjective prioritization of the activity categories resulting in inaccurate goal forecasting. This paper will show that activity based costing systems can achieve cost savings and readiness improvements by incorporating Monte Carlo analysis to identify key drivers and by applying stochastic optimization algorithms to the results to lower costs and raise readiness. Specifically, the process and framework is applied to Naval Aviation activity based cost systems within the Air Systems Support engineering and logistics programs across every naval aircraft type/model/series. The resulting findings suggest that application of this method can provide significant improvements in both cost and readiness not only for naval aircraft but for a wide array of organizations and commercial entities.

11711 - Formulation of a New Complex Fleet Modernization Challenge for the Capability Portfolio Analysis Tool (CPAT)

The Capability Portfolio Analysis Tool (CPAT) [1] is currently being adapted to model the fleet of logistics and support systems under the U.S. Army Program Executive Office Combat Support & Combat Service Support (PEO CS&CSS) to provide rigorous analytical capability in support of current modernization and investment decisions. Originally developed and applied in partnership with the PEO Ground Combat Systems (GCS), CPAT optimizes complex fleet modernization problems spanning dozens of mission areas and programs over several decades to provide the maximum performance while respecting schedule, budget, and programmatic constraints. Since its last presentation at the 82nd MORS Symposium, the CPAT model has changed considerably to incorporate new behaviors and business rules involving: system age, recapitalization, partial mission fulfillment, and the overall size of the CS&CSS fleet, which is an order of magnitude larger than the GCS fleet. We provide an overview of the challenges posed by the CS&CSS fleet and demonstrate the unique insights CPAT provides for complex portfolio management questions.


12108 - Hephaestus – USAF Aircraft Costing Model for Force Planning & Analysis

Title: Hephaestus – USAF Aircraft Costing Model for Force Planning & Analysis
Douglas W. Cho, Ph.D.
Senior Analyst, Headquarters USAF, A9RI

Hephaestus was developed as an integrative tool for combining all components of significant Air Force aircraft system costs over their life cycles towards the goal of providing standardized annual cost information on the aircraft of concern over selected planning periods to the force planning community within the Air Staff. Since the model’s initial birth in 2007, it has served as one of the key aids to Air Force’s force planning process and has gone through numerous upgrades and changes to make it efficient and current with the Air Force environment from which the data originate. Most notable characteristic of Hephaestus is its ability to simulate various buy options for new-development aircraft systems such as F-35A and Long Range Strike bomber so as to enable preview of the mid-to-long term resource impact of various force structure options. Hephaestus input data sources cover other Air Force agencies, such as AFCAA (Air Force Cost Analysis Agency) and major program offices, as well as OSD CAPE (Cost Analysis Program Evaluation) database.
11520 - Function Points in Software Cost Estimating

As software based systems continue to grow in size and complexity, they are becoming more difficult to understand. Improvement of coding tools allows software developers to produce large amounts of software to meet an ever-expanding need from users. As systems grow, a method to understand and communicate software size will need to be utilized. Function Point Analysis is a structured technique of problem solving. It is a method to break software systems into smaller components, so they can be better understood and analyzed. The purpose of this presentation is to provide an in-depth look at estimating software cost using the Function Points (FP) model as opposed to a more traditional Source Lines of Code (SLOC) based model. The presentation will discuss what a Function Point is and the processes to determine the number of Function Points for software cost estimation purposes. The presentation will also discuss the advantages and disadvantages of both the SLOC and Function Point models.

12193 - Growing Cost Analysis Capability in the Department of Energy: Lessons Learned

The Department of Energy (DOE) has a portfolio of large, complex, and unique capital asset construction projects taking place at remote secure sites operated via cost reimbursable contracts through Management & Operating (M&O) contractors. The variations in technical scope and acquisition strategies associated with these projects present a challenge in finding the “common ground” necessary to develop credible cost estimating relationships. Historical standard construction cost estimating benchmarks and trends found within Department of Defense (DOD) acquisition programs are not consistent with DOE experience, and thus do not serve as analogies to provide insight for estimation. As a result, the DOE is adjusting cost estimating policy, guidance, and developing a framework to formalize and build cost estimating relationships (CERS) necessary to enable informed decision making. This presentation will provide a review of recent changes in policy and guidance that have been implemented in a manner consistent with the GAO Cost Estimating and Assessment Guide (GAO-09-3SP). The discussion of this evolving cost estimating framework will include a brief review of data repositories (PARS II, FIMS), explanation of the data collection, normalization, and mapping process, and explain how the resulting data is being used to support acquisition decisions (i.e. Critical Design reviews). This discussion will focus on both development of the “most likely” cost point estimate as well as the cost risk and uncertainty analysis used as a basis for developing credible estimates. Future activities will continue by maturing CERS and data normalization efforts, actively integrating lessons learned and received during this presentation and from DOE leadership.

11573 - Planning the Future: Methodologies for Estimating U.S. Nuclear Stockpile Cost

The cost estimation methodology presented in this paper provides planning estimates for Life Extension Programs (LEPs) for the nuclear weapons managed by the National Nuclear Security Administration (NNSA). The estimates contain planned costs, by each stockpile system, for the U.S. nuclear deterrent for 25 years. The cost model used to produce these estimates is divided into two parts: development and production. Development costs are estimated using complexity factors derived from comparisons with prior system LEPs, along with a modified Rayleigh distribution informed by historic cost actuals. Production costs are based on anticipated production schedules and quantities, along with a variation of the Crawford model for learning curves. The estimates generated with this methodology are updated and published annually in NNSA’s strategic planning document called the Stockpile Stewardship and Management Plan (SSMP).
WG 27 Decision Analysis

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**11614 - Holistic Portfolio Optimization using Directed Mutations**

Long-range military portfolio planning [1] often involves mixed-integer, multi-objective, non-linear portfolio optimization, a notoriously difficult class of problems. The “Holy Grail” of these decision problems requires holistic optimization over both the combinatorial design of individual systems in the portfolio and the integer counts of these systems through time (i.e., “what type” and “how many”). Genetic Algorithms (GAs) offer an attractive approach due to their ability to address non-linearity, multiple competing objectives, and non-convexity. Unfortunately, GAs can have difficulty converging on coordinated integer solutions. This research presents the novel use of objective function gradients to guide genetic operators more efficiently towards optimal solutions. Impressive speedups over zeroth-order GAs are demonstrated on a test-bed of 1, 2, and 3-dimensional problems. The results are then applied to a hypothetical portfolio consisting of vehicles, UAVs, and soldiers, optimizing over cost (RDT&E, Purchase, O&S) and non-linear system-of-systems performance measures as assets are acquired and modernized over time.


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**11380 - Building the Comprehensive Core Capability Risk Assessment Framework**

The Comprehensive Core Capability Risk Assessment Framework (C3RAF) is an effort with MAJCOM Core Function Leads and AF/A5/8/9 to assess the Air Force’s 47 core capabilities and their interdependencies in order to provide senior decision makers with a comprehensive understanding of Enterprise Risk within future scenarios and where investments, divestures, or maintenance actions will have the most impact. The Air Force core capabilities support 12 core functions, 5 core missions, and 3 effects. The effort begins by first developing metrics to assess capability and capacity of each of the core capabilities and then providing an annual assessment using these metrics to inform the Strategic Planning and Programming Process. Each of the core capabilities will have a “goal” metric developed to measure its forecasted capability and capacity to support Air Force missions in future scenarios (Risk to Mission). Where possible we will also develop a standard goal measure to gauge forecasted force readiness (Risk to Force). Once a metric is developed the only change needed for any future assessment will be the placement of the success/failure endpoints (goals), which is determined by the requirements delineated in the specific future plan.

**11740 - Identifying and Structuring the Objectives of the “Islamic State of Iraq and the Levant” (ISIL) and its Followers**

This study addressed three questions:
1. What are the objectives of the leaders of ISIL?
2. What are the objectives of the followers of ISIL?
3. How are the two sets of objectives related?

To answer these questions we analyzed the transcripts of interviews and presentations of 59 subject matter experts (SMEs) and conducted a separate analysis of speeches of ISIL leaders and selected Internet sources. In both efforts we identified and structured the strategic, fundamental, and means objectives of ISIL and its followers. The results indicate that ISIL’s leaders pursue four strategic objectives Establish a Caliphate in Iraq and the Levant, Control and Govern the Caliphate, Expand Islam and Sharia Law Worldwide, and Recreate the Power and Glory of (Sunni) Islam. The followers’ objectives can be partitioned into three strategic objectives: Humanitarian Fulfillment, Religious Fulfillment and Personal Fulfillment. The objectives identified from the SME interviews were similar to those identified from ISIL leaders’ statements and the Internet. However, the Internet search revealed many more personal objectives of ISIL followers. The results further indicate that ISIL’s leadership objectives are closely aligned with those of its followers. There also is a sharp contrast between the objectives of ISIL and those of Al Qaeda, particularly ISIL’s emphasis on occupying and controlling territories on Iraq and Syria vs. Al Qaeda’s focus on worldwide jihad.
**11589 - Assigning Training Delivery Modes for Enlisted Career Field Tasks**

Air Education and Training Command recommends training delivery modes for all tasks within enlisted career fields in the Air Force. Determining the appropriate level for task training (on the job training, academics, etc.) is essential for ensuring Airmen are well trained and prepared to execute their critical missions. Currently, a mathematical process assigns training delivery using fixed classification thresholds on subject matter expert survey responses. A new methodology was proposed to assign training delivery using sample statistics from the survey responses. This work evaluates not only the structure of the models used for training delivery assignment, but also the optimal thresholds to be used with these models. Assessment of the current and proposed models highlight inherent assumptions and limitations and further analysis of survey design and responses identifies concerns with elements in both methodologies. To address these concerns, an alternative method for task delivery classification is developed incorporating a nonparametric approach. Historical data is used to demonstrate the advantages and disadvantages of each method and sensitivity analysis of a cost function is used to optimize thresholds across all 150 enlisted career fields.

**11693 - Using Multi-Criteria Decision Making to Inform the Chemical and Biological Defense Program Program Objective Memorandum**

Faced with limited resources, Chemical and Biological Defense Program (CBDP) programmers need to determine which CBDP efforts (e.g., Programs of Record, new starts, and unfunded requirements) to resource in the Program Objective Memorandum. The Joint Requirements Office for Chemical, Biological, Radiological, and Nuclear Defense (CBRND) and the Joint CBRND Program Analysis and Integration Office collaborated with the Edgewood Chemical Biological Center Decision Analysis Team to develop the CBDP Assessment Tool (CAT). The CAT uses resource allocation methodologies to organize and assess CBDP portfolio efforts. Results provide a data-informed method for framing trade-off discussions, and supplement professional experience with data and analytical techniques. The CAT provides a framework for performing independent assessments in accordance with Department of Defense (DoD) Directive (DoDD) 5160.05E, and is consistent with DoD’s Capability Portfolio Management Concept, DoDD 7045.20. This paper will describe the tool’s evolution and process, as well as challenges and limitations to date.

**12285 - Protecting Water Infrastructure: Using Portfolio Decision Analysis to Select an Optimal Suite of Security Preparedness Measures**

Counterterrorism decisions for infrastructure security can be challenging due to resource constraints and the large number and scope of potential targets and threats to consider. This paper presents a multi-criteria portfolio decision analysis (PDA) model that optimizes countermeasure selection to maximize effectiveness under various counter-terrorism budget levels. In this approach, multi-criteria decision analysis (MCDA) is used to assess the total benefits of protective countermeasures when applied to key infrastructure in specific threat environments, and a budget-constrained linear programming optimization model maximizes total protective value for various funding levels, considering the effect of relationships between projects. The resulting scores, cost estimates, and synergistic or redundant interactions between projects are used to construct an efficient funding frontier that tracks how budget changes affect optimal portfolio composition. Results are presented for a case study based on literature data and author judgment optimizing protection against terrorist threats to a city-scale water storage, treatment, and distribution network.
11707 - Decision Analysis in the US Army's Capabilities Needs Analysis: Applications of Decision Analysis Methods to Capabilities Resource Allocation and Capabilities Developments Decisions

The application of multi-attribute decision analysis in the Army’s Capabilities Needs Analysis (CNA) is described. The CNA’s two primary purposes require trade-offs and prioritization of more than 1000 program capabilities and 800 capability gap alternatives to provide Capabilities Based Assessment (CBA) recommendations across more than 20 proponents to inform Army planning and programming processes for Program Objective Memorandum (POM) development. The paper expounds upon: the objective hierarchy and value model hierarchy used to analyze multiple conflicting objectives; the development of an additive value model to recommend highest valued alternatives including selection of measures and development of value functions and their scales; the use of a modified Delphi method to refine the analysis results; and the implementation of an open architecture web-based tool to collect and analyze data and socialize results. To date, results of the value model implementation and prioritizations achieved acceptance across decision makers and stakeholders. Detailed sensitivity analysis and analysis of implementation of the mathematical model indicate additional refinement is required to improve preference precision and wide acceptance in the community of practice.

11514 - Multi-Objective, Auto-Optimization Modeling for Resource Allocation Decision Making in the Military Health System

In this work, we proffer the Multi-Objective Auto-Optimization Model – a resource allocation-based optimization model that adjusts resources (system inputs) automatically – which provides decision-makers with a decision-support tool for re-allocating resources in large health systems that are centrally controlled and funded, such as the Military Health System. The necessity to efficiently balance and re-allocate system resources among hospitals in a hospital network is paramount, especially as health systems experience increasing demand and costs for health services. In these systems, inputs are fixed at certain levels and may only be adjusted within medical treatment facilities, while outputs must be maintained. We provide a mathematical formulation and example solutions from a case study using real-world data from sixteen U.S. Army hospitals. We also find utility in the use of multi-start evolutionary algorithms to store multiple optimal solutions for consideration by decision-makers.

11895 - Prioritizing Verification and Validation by Quantifying the Value of Decreasing Uncertainties

The Air Force Research Laboratory Integrated Weapons Environment for Analysis (IWEA) program is enabling risk-informed technology investment decisions within the weapons enterprise by generating mathematically rigorous confidence assessments to accompany its weapon effectiveness analyses. The overall confidence is characterized by combining aleatory and epistemic uncertainties for all independent component simulations and evaluating relevant use-cases. In an effort to characterize the confidence of weapon effectiveness analysis results at the engineering and engagement level, researchers desire to consider all aspects contributing to uncertainty, including:

- How well do the predictive methodologies represent the real world systems?
- What unknowns or uncontrollable variables affect our results?
- Which codes/variables are largest contributors to uncertainty?
- What is the ‘value’ of decreasing uncertainties?

The research team has conducted a series of proof of concept experiments to consider each of the aspects identified above. This paper will present the results of a proof of concept using a Design of Experiments (DOE) approach to allow the analyst to determine which codes/variables in a series of codes are the largest contributors to uncertainty, even in the absence of available quantitative uncertainty data. The paper will describe a method for quantitatively determining the value of decreasing uncertainties, provide the results from a small example problem involving two codes in series, and present plans for generalizing the methodology for larger problems of interest.
The Army needs to develop infrastructure analytics that will enable fact-based decision-making across a continuum of infrastructure challenges. Infrastructure analytics can inform three decision levels including 1) the day-to-day or tactical stationing decisions, 2) installation best practices and efficiency that influence operational costs, and 3) strategic infrastructure studies, i.e., 2005 Defense Base Closure and Realignment Commission (BRAC 05) or the recent European Infrastructure Consolidation study (EIC). The repeated issues noted in After Action Reviews from strategic infrastructure studies over the last 10 years and feedback from think tanks necessitates improved analytics. This initiative will support upcoming infrastructure decisions as force reductions, modernization, readiness tradeoffs, and mounting personnel costs make the ability to maintain current infrastructure fiscally challenging.

CAA recognizes that current analytic capabilities must be revisited to meet today’s challenges. For example, today’s Army operates in a world with a greater emphasis on energy, climate change, sustainability, and infrastructure resilience than in the past; analytics need to address these concepts. CAA is conducting a focused multi-year effort to improve infrastructure analytics, synchronize efforts across users, and build a community capable of addressing infrastructure challenges. CAA’s stationing expertise and position in the analytic community uniquely positions it to develop the rigorous and objective analytics needed to provide a viable starting point for future infrastructure decisions.

Infrastructure analytics represents a strong multidisciplinary initiative to conduct statistics, simulations, optimization, data-mining, and other methods to provide the models and supporting structure needed to inform the three stationing decision levels. With a large footprint and many units to station, an infrastructure analytics initiative becomes an enabler to lower Army infrastructure costs.

**12460 - Infrastructure Analytics – Enabling Army Stationing Analyses**

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 27 | 25 Jun 08:30 - 09:00 | IDA Bldg 4900 Room 720 | Mr. Nathan Dietrich | LTC Garrett Durand Heath Dr. Greg Parnell Dr. Bill Tarantino | UNCLASSIFIED

The purpose of this analysis is to improve the quality of decision making for target location error testing. Target Location Error (TLE) is a metric used in testing to determine the effectiveness of targeting pods and other aircraft sensors. It is defined as the error between sensor generated coordinates and the true target location. At the platform level, this characterization includes all errors associated with the aircraft targeting solution and is typically used in an operational setting to determine the coordinate generating capability of aircraft. Simplifying the TLE performance in a summary table decision tool enables effective real-time targeting decisions; however, these simplifications have the potential to inaccurately bias a platform’s capacity to meet mission requirements. The accuracy of TLE affects multiple platforms’ ability to achieve desired mission effects in a constrained operating environment and is a critical tool for expeditious planning and execution. This analysis will address issues regarding the accuracy cost of oversimplification and the usability cost of impractically complex models in relation to TLE; specifically delving into the tradeoffs between the two as well as weighing in on the recommended approaches and test methodologies based on the levels of testing required. The aim is to design tests to allow optimal decision making for operators and planners by making evident compromises that are inherent to a variety of decision models.

**11389 - Technology Enabled Structured Analytics (TESA): An agile analytics solution for developing critical nodes in networks generated from large, unstructured text**

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 27 | 25 Jun 09:00 - 09:30 | IDA Bldg 4900 Room 720 | Mr. Kent Weaver | Mr. Mark Russell Mr. Jim Shonborn | SECRET

**14707 - Estimating the Tradeoffs between the Decision Tools Used to Determine Target Location Error**

**Group** | **Day & Time** | **Location** | **Author/Presenter** | **Co-Author(s)** | **Classification**
---|---|---|---|---|---
WG 27 | 25 Jun 09:30 - 10:00 | IDA Bldg 4900 Room 720 | Maria Phillips | 1st Lt. Andrew James Keith | SECRET
11807 - Decision Analysis as a Valuation Methodology for Open System Architectures

In 2004, the Open Systems Joint Task Force released their findings on a new design paradigm for defense acquisition – Open System Architectures (OSA). An OSA is a simple concept; emphasize modularity early in design, with the stipulation that modules connect to system architecture through well-defined interfaces, whose standards are widely available and conform, where possible, to existing commercial standards. This provides the flexibility for systems to be incrementally upgraded in response to changes in requirements or new technologies, rather than undergo significant redesign work. Moreover, OSA programs are better able to capitalize on the innovation and economies of scale afforded by commercial markets, increase competition among vendors, and facilitate reuse of components/subsystems across programs. Though the OSA initiative is conceptually simple, it has proven difficult to implement. This stems, in part, from the difficulty of answering a basic question – how does one quantify the value of making a component/subsystem upgradeable? To correct for this shortcoming, this work proposes a new valuation methodology which leverages the principles of classical decision analysis, augmented with modern methods of technology forecasting to establish the options available for subsequent upgrade decisions. In addition, the probabilistic theory of maximum entropy is used to capture the uncertainties inherent in forecasting the evolving properties of maturing technologies, independent of the forecasting technique used to produce those estimates. The result will provide an estimate of the expected cost and effectiveness afforded by opening a component/subsystem to future upgrades, thereby integrating OSA decisions into the existing analysis of alternatives framework.

12373 - Delivering Systems That Work: Institutionalizing Performance Measures across the DOD Acquisition Life Cycle

This presentation details how the Office of the Deputy Assistant Secretary of Defense for Systems Engineering uses metrics and quantitative analysis to shape program plans, monitor execution, and assess technical risk in support of the acquisition decision-making process. We discuss our analysis of defense, industry, and academia recommendations for process and product performance measures. Based on these analyses, we developed a set of expected performance measure categories and an assessment framework to analyze acquisition programs’ performance. Over the last year, we assessed performance measures on a variety of programs to identify best practices and improve Systems Engineering Plans (SEP). Given our framework, we provided guidance and mentored the programs on performance measures, including Agile metrics, software maturity metrics, and test readiness metrics. The framework also serves as the basis for enterprise benchmarking, including software parametric statistical analyses.

12206 - Integration of Decision Analysis with System Model

To help ensure successful acquisition of DoD systems that deliver needed capabilities on time and within cost constraints, it is of utmost importance that analysts, scientists and engineers across all specialty disciplines work from a common framework, the system model, as the single source of truth. These disciplines all benefit from systems engineering (SE) best practices such as functional decomposition, requirements engineering and data management, but maximum utility is only realized when all specialists use and refine a common data source.

Decision analysts, working in conjunction with system analysts using specialized M&S tools, use this centralized repository for much of their data needs. Decision Makers are then afforded the ability to see traceability from high level Decision Analysis visualizations to the actual engineering models and system designs that are driving the value space and trade study results. This presentation will discuss an approach to addressing this topic piloted at the US Army Armament, Research, Development and Engineering Center that integrated a SE model, implemented in the SysML language, with a Multi Objective Decision Analysis (MODA) methodology. Within this approach, system behaviors, traced to stakeholder requirements, become the basis for the decision criteria. The logical architecture becomes the basis of product structural elements, and the system alternatives under analysis are developed and documented as physical architectures with associated capabilities. The presentation will close with lessons learned on best practices for MODA as it pertains to integration with operational and system analyses, system modeling and architectures.
11762 - Optimization Modeling in Support of Formational Capability Portfolio Reviews: Challenges and Lessons Learned

Capability Portfolio Reviews (CPRs) have been implemented by the U.S. Army to more effectively allocate resources in a constrained fiscal environment. These CPRs involve analysis of a “Warfighting Function, formation-based, or special topic capability portfolio... in order to focus investments to the most critical capability gaps and to achieve balance across doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) investments.”

Since 2012, the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) has provided analytic support to three formation-based CPRs: the Infantry Brigade Combat Team (IBCT) CPR in 2012, the Armored Brigade Combat Team (ABCT) CPR in 2013, and the Stryker Brigade Combat Team (SBCT) CPR in 2014. TRAC supported trades analysis for each CPR by applying optimization modeling to analyze the effects of materiel procurement schedule modifications on the acquisition of future capabilities. This analysis helped the TRADOC Capability Managers identify an investment strategy that maximized the attainment of priority formation capabilities and minimized risk.

TRAC has gained insight into how optimization modeling can best be used to support formation-based CPRs and the challenges encountered with these types of efforts. This presentation will provide an overview of the CPR process, discuss TRAC’s optimization modeling approach, and describe several key challenges and lessons learned to benefit other analysts who choose to apply similar optimization techniques in the conduct of studies.


11346 - Subject Matter Expert (SME) and Social Network Analysis (SNA) Enabled Multi-Criteria Prioritization Model (MCPM)

A decision maker relies on analysis and Subject Matter Experts (SME) to optimally choose appropriate courses of actions (COAs). While there are many Multi-Criteria Prioritization Models (MCPM), this is the first that integrates SME inputs and social network analysis (SNA) metrics to prioritize a list of potential COAs (Figure 1). The MCPM is a user-adjustable (Figure 2) weighted linear model to prioritize a list of objectives. SME input was enabled through a questionnaire developed by a team including a social scientist, SMEs and analysts. SMEs assigned values to a set of objective attributes. SNA metrics associated with the objectives and their network were calculated through analysis of classified message traffic. Through a simple example, we validate that this method can be used in other situations.

12505 - The Standardization of Air Force Analysis Software

Learning software to perform analyses for the USAF requires a large investment in time and resources. As USAF analysts change duty station locations, analysis software can vary, often requiring personnel to learn new analysis software in order to perform their duties. This learning process detracts from mission effectiveness as analysts spend time learning software that could instead be used to perform analysis as part of a mission. Researching and implementing a standardized, force wide set of analysis software packages has the potential to help save the Air Force time and money by limiting the amount of time analysts spend learning new software. We construct a MODA model to determine the best software packages to use using software attribute data derived from analyst community inquiry as well as personally conducted research. Our model is able to produce a list of recommended software packages for standardized use for Air Force analysts.
12269 - Analysis of US Airpower deployment strategy in the Western Pacific and its implications on deterring Chinese air superiority over the Taiwan Strait

Having air supremacy is universally considered a requirement for any attempt at a crossing of the Taiwan Strait by the People’s Republic of China (PRC). Using an “acceptable losses” approach, this work looks to see if the US is able to project enough power over the strait to inflict a level of damage above which the PRC will not proceed with aggressive operations. This work calculates the 2 most probable options for the number of Chinese aircraft that may be seen over the strait (constant CAP or surge), and the factors that dictate the number of US fighters needed to achieve this threshold attrition value given a range of two key variables: acceptable attrition rate by the PRC and kill probability (P(k)) values of US Beyond Visual Range (BVR) missiles. US aircraft distribution options in the theater, deployment timeline necessary to achieve these levels, and the effects Chinese offensive operations against airfields are considered.

This work concludes that a maximum dispersion model would be the most effective method of projecting a deterring force over Taiwan. Without sufficient hardened shelters or airfields, distribution best ensures aircraft longevity. The principle question, however, is not whether the US can project sufficient air power over Taiwan, but in how long it would take the US to assemble the force necessary to do so. Even low amounts of enemy aggression can prohibit the US from establishing a deterrent CAP for at least 10 days according to even the most favorable basing strategies.

12213 - Generating robust and flexible operational airlift schedules using stochastic simulation-based and schedule comparison measures

The End-To-End Modeling II (ETEM II) project, in collaboration with Lincoln Laboratory and MIT, is enhancing the Analysis of Mobility Platform (AMP) to produce schedules for the Agile Transportation for the 21st Century (AT21) program at USTRANSCOM that are more robust (able to accommodate changes to a mission’s execution with no impact on other missions) and flexible (able to repair a mission’s schedule with minimal impact on other missions) to real world changes. AMP currently uses a deterministic process to produce schedules that are cost-efficient, while assuming that execution occurs under expected conditions. The ETEM II team has designed robustness and flexibility heuristics to generate candidate schedules in the AMP schedule optimizer, and designed a stochastic AMP simulation that varies departure delays using a probabilistic model based on analysis of a large Global Decision Support System (GDSS) data set. Through (a) multiple stochastic simulations of candidate schedules, (b) an edit distance metric for directly assessing the impact of stochasticity on the resultant executed schedules and (c) statistical performance measures, the enhanced system will iteratively generate, assess and compare candidate schedules until one is found that sufficiently balances solution quality with robustness/ flexibility. We present the architecture, heuristics, data analysis, stochastic model and metrics. The ETEM II effort has completed its initial design phase and will complete development by early 2016. We summarize our initial findings and discuss our path forward to achieve robust and flexible AT21 scheduling using AMP.
Group | Day & Time | Location | Author/Presenter | Co-Author(s) | Classification
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WG 28 | 23 Jun 13:30 - 14:00 | Hilton - Aspen | Dr Jia Xu | David Merrell, David Orletsky | UNCLASSIFIED

**12145 - Global Mobility Network Analysis: An Application of the Scientific Python Stack**

The objective of this research is to characterize the robustness of the Air Mobility Command’s en-route base network. In this talk we describe our computational method to solve for cargo throughput on a global scale, given different network and air fleet configurations. A global framework affords us a strategic perspective on the effects of base closures and capacity changes. An important methodological thrust is our application of contemporary computational tools and agile, collaborative development methods. Built on the expansive scientific Python tool stack, this work highlights the value of modern computational tools in model development and policy analysis. This seminar will include an interactive demonstration using the Jupyter literate programming environment, which fuses code development, documentation, web applications and dynamic visualizations.

Group | Day & Time | Location | Author/Presenter | Co-Author(s) | Classification
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WG 28 | 23 Jun 13:30 - 14:00 | DoD - 17 | Mr. Charles D. Burdick | Dr. Deepinder Sidhu | UNCLASSIFIED

**12258 - Low Cost Cyber Defense Exercises (CDX) on a High Fidelity Virtual Cyber Range**

In 2014, we reported on the recent availability of a Virtual Emulation Environment (VEE) that could realistically emulate whole networks on a laptop with bit-level fidelity and precise timing for highly realistic training. This year we are presenting the seamless integration of VEE with virtualized systems (Virtual Cyber Range) to support major Intelligence Community (IC) supported Cyber Defense Exercise (CDX). These are similar in scope and complexity to CDX that have been conducted in previous years, but without the need to assemble significant amounts of servers and related hardware in an environmentally controlled area and without major requirements for power, space, maintenance, and specialized software.

Exercise planners have the option to build a notional network in VEE, but far more interesting is the ability to use actual network traffic to reverse engineer specific networks and then clone them with high-fidelity virtual hardware creating a highly realistic, large scale network training and exercise environment that is efficient enough to run on a few laptops. Furthermore, the system allows multiple teams (Blue, Red, and White) of humans in the loop to operate independently within the same network allowing near real-time assessment of the progress of the exercise with options ranging from scripted attacks to full free play. The combination of minimal hardware requirements and rapid network configuration has reduced CDX planning time from months to days. This briefing describes how the VEE is now being used for lower cost, high fidelity CDX’s and outlines options for future expansions of the concept.

Group | Day & Time | Location | Author/Presenter | Co-Author(s) | Classification
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WG 28 | 23 Jun 14:00 - 14:30 | DoD - 18 | Mr. Darrell R. Bearce | | UNCLASSIFIED

**11597 - Advanced Framework for Simulation, Integration, and Modeling (AFSIM) Real Time Mission Level Logistics Processes for Repair and Resupply, with Demonstration**

The Advanced Framework for Simulation, Integration, and Modeling (AFSIM) is gaining momentum within government and industry as a flexible, extensible simulation tool for operations analysis. Recently the framework has been extended to address exchange of goods and services between simulated entities to permit logistics analysis in the context of mission-level simulation. This mechanism has been implemented compatible with the DIS protocol, enabling the exchange to occur between AFSIM or non-AFSIM platforms in a distributed simulation environment.

Presentation will describe how entities broadcast the availability of products or services, how other entities which desire may request them, and the interaction needed to negotiate the type, quantity, and rate of exchange. Demonstration provides a scenario to illustrate supply/receive operations. An island base will support air sorties for strike operations, with on-island fuel tanks and parts depot requiring sea-based resupply. Metrics will be gathered on the baseline scenario and sensitivity to loss of some sea-based resupply.
Due to the significant increase in uncertainty in budgetary and operational environments, the Naval Supply Systems Command (NAVSUP) must still ensure that our management of supply chains produces optimal mission readiness and performance. One example in particular is the management of the cruise missile supply chain. Sustaining (or enhancing) performance with declining budgets requires deep re-examination of the how this supply chain operates, challenging the status quo, and finding new ways of working.

This presentation highlights a pilot study focused on minimizing cruise missile redistribution costs. By leveraging historical data and supply chain network diagrams, we developed a prototype model using a Commercial-Off-The-Shelf supply chain optimization software. The modeling and subsequent analysis showed a potential reduction in unnecessary missile redistribution costs. Even though this was a prototype model with limited scope and preliminary results, it demonstrated a clear value in using Operations Research techniques to improve NAVSUP's ammunition positioning decisions. We continue to evaluate ways to utilize advanced analytic techniques to ensure all ammunition assets are optimally positioned to meet warfighter requirements effectively and efficiently, and to develop viable models to resolve shortcomings.
The Department of Defense has an opportunity to make the intellectual capital encoded in its many different models and simulations more broadly available to the analysis and engineering communities via deploying these models to a cloud-based infrastructure. This enterprise level sharing of models enables distributed users to call them via a web-based interface for remote execution and analysis of particular scenarios. This capability also opens up the possibility of distribute and cloud-based simulation. Many models are already embedded in existing domains. This paper proposes integration by casting off the simulation execution machinery of the component simulations and simply integrating their internal models as Discrete Event Systems Specification (DEVS) models. An execution engine enables integration of models in different languages via message-based distributed and parallel execution of the simulation across a network. Computing technologies to include the actor model of computation, reactive systems, and time-warp parallel discrete event simulation enable this approach. Initial development and testing has been done for a soldier-level situation awareness model.

### 12344 - Development of a Live, Virtual, and Constructive (LVC) Risk Reduction Test Bed (RRTB) to mitigate future training technology needs

One of the big obstacles facing research organizations is how to effectively develop innovative technologies that transition into the Programs of Records (PoRs). From the other perspective Program Managers (PMs) are looking for technology developments that mitigate the technology risks of their near and long term projects. To attempt to solve this quagmire created by this mismatch the Army Research Lab (ARL) Simulation and Training Technology Center (STTC) partnered with Program Executive Office for Simulation Training and Instrumentation Command (PEO-STRI) Program Manager for Constructive Simulation (PM ConSIM), to develop a new process to bridge the transition gap. The partnership created a program called the Risk Reduction Test Bed (RRTB) which initially replicated the Live Virtual Constructive Integrating Architecture (LVC-IA) baseline which is confronted with numerous technology challenges and is representative of many of today’s simulation environments. This program has quickly become a model for technology maturation and transition between these two organizations. The process consists of a technology gaps analysis of the problem space followed by selecting the candidate solutions that are feasible and provide the greatest returns to the PoRs. Finally prototypes are developed and metrics are collected for evaluation for possible transition. In addition to the LVC-IA risk-reduction research, several STTC-sponsored projects have been successfully executed following this process such as the implementation of cyber effects in training systems and scenario generation for multi federation LVC systems. The RRTB process, test bed, and success stories will be overviewed in this presentation.

### 11595 - Replicating BRAWLER Air-to-Air Combat in AFSIM (Advanced Framework for Simulation, Integration, and Modeling)

Current mission level simulations don’t offer a high fidelity A2A combat model. We present details on how BRAWLER’s A2A combat fidelity was added to AFSIM. We provide an overview of BRAWLER’s method of operation & compare its mental perception model, aero model, & value based decision making to modern day technologies. We explain our surgical replication method & how we formed the BRAWLER capability into a modern OOP (C++) framework like AFSIM, inserting it into agents using artificial intelligence technologies. We show how the projection, evaluation, & execution steps of BRAWLER’s alternatives fit into AFSIM behavior tree nodes. We manifest the added benefits of doing so; including the agent’s access to: clustering algorithms, optimal profit allocation algorithms, route finders, heat maps, visual debugging utilities, & script access to everything.

We review the assumptions & limited scope of our first-year effort & provide visual demonstrations of our success. We consider future enhancements to create a more robust air combat agent including a more robust alternative search space, a simple min-max comparison of possible future threat states, & added considerations in the evaluation calculations. We’ll also discuss challenges of this effort & our path forward.
12057 - A Performance Pricing Model (PPM) for Base Operating Support (BOS) Functions

An important problem that has not been fully solved is how to estimate a continuous relationship between funding and output for military installations, and how to use this information in budgetary decision making. Often output is measured as categories. For example, the Marine Corps Installations Command (MCICOM) uses Common Output Levels of Service (COLS). There are four levels of service, with COLS1 being the highest level of service and COLS4 being the lowest level of service. In this presentation, we show how data on COLS funding requirements can be used to estimate the continuous effect of funding on output as measured by the probabilities of achieving COLS1, COLS2, COLS3 and COLS4 at different levels of funding. We use the ordered probit model and a simple regression model [See Greene (2003), 5th edition, Econometric Analysis, Prentice Hall, page 736] to estimate the probabilities.

12378 - Integrating TAB-VAM and CFAM for Improved Tanker Attrition Campaign Analysis

Air Refueling (AR) is a critical component of the US Air Force’s Rapid Global Mobility (RGM) core function, acting as a significant force multiplier that magnifies the capabilities of other weapon systems by significantly increasing range, loiter time, payload, and providing flexibility for basing, routing, and mission. As threat capabilities increase, analysis that supports minimizing tanker aircraft attrition in contested environments becomes critically important to assuring AR capacity and success of the overall air campaign. To assess campaign impacts of tanker ground attrition due to theater ballistic missile and cruise missile (TBM/CM) strikes, the Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) recently completed a detailed study directed Office of the Secretary of Defense Resource Management Decision 700A1. This presentation will detail how AF/A9FC improved modeling capabilities and shortened study time required to analyze TBM/CM effects by establishing collaboration with the ongoing RAND Project Air Force (PAF) Combat Operations in a Denied Environment (CODE) study. By incorporating sensitivity analysis for TBM/CM data from RAND’s Theater Air Base Vulnerability Assessment Model (TAB-VAM) results into AF/A9FC’s Combat Forces Assessment Model (CFAM), several mutually beneficial outcomes were achieved:
- AF/A9FC improved the credibility of both models by verifying TAB-VAM TBM/CM impacts were in line with prior CFAM results.
- TAB-VAM integration with CFAM provided a fast and repeatable method to update campaign models, allowing timely assessments of rapidly evolving TBM/CM threats which inform infrastructure investment with quantifiable campaign impacts.
- Analysis of results from TAB-VAM integration with CFAM built on the defensive scope of the CODE study, providing insights on the ability to execute Support for Strategic Analysis scenarios and Combatant Commander Operational Plans.
- AF/A9FC’s study of the air campaign informed the need for a joint campaign assessment in order to steer future investment strategies that mitigate vulnerabilities of all aircraft and infrastructure to TBM/CM threats.
- Continued AF/A9FC collaboration with RAND PAF resulted in TAB-VAM and CFAM improvements that bolstered the fidelity of campaign analysis due to TBM/CM threats for both organizations.
Remote sensing systems have expanded the set of capabilities available for and critical to national security. Cooperating, high-fidelity sensing systems and growing mission applications have exponentially increased the set of potential schedules. A definitive lack of advanced tools places an increased burden on operators, as planning and scheduling remain largely manual tasks. This is particularly true in time-critical planning activities where operators aim to accomplish a large number of missions through optimal utilization of single or multiple sensor systems. Automated scheduling through identification and comparison of alternative schedules remains a challenging problem applicable across all remote sensing systems. Previous approaches focused on a subset of sensor missions and do not consider ad-hoc tasks.

We have begun development of a robust framework that leverages the Pyomo optimization modeling language for the design of a tool that assists sensor operators planning under the constraints of multiple concurrent missions and uncertainty. Our scheduling model will be formulated to address the stochastic nature of ad-hoc tasks inserted within various time scenarios. Operator experience will be used to select appropriate model objectives. Successful development of such a framework will allow for iterative development of high-fidelity mission models that consider various metrics. Creating this tool will aid time-critical scheduling by increasing planning efficiency, clarifying the value of alternative modalities uniquely provided by multi-sensor systems, and by presenting both sets of organized information to operators. Such a tool will help operators more quickly and fully utilize sensing systems, a high interest objective within the current national community.

Combat models are used in major assessments such as Quadrennial Defense Reviews for Naval system acquisition and future force structure decisions. For several years, the Navy has been adding capabilities to the Synthetic Theater Operations Research Model (STORM) originally developed by the US Air Force. Similarly, the Army and Marine Corps employ a specific analytical model called the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) to evaluate major proposed changes in materiel and associated warfighting operations and tactics. The Unmanned Systems Integrated Roadmap FY2013-2038 indicates the Presidential Budget for Fiscal Year 2014 was over four billion dollars (covering research, development, test, and evaluation, procurement, and operations and maintenance). With such current initiatives and high-valued expenditures occurring with respect to unmanned systems, there is concern that expected improvements to warfighter effectiveness, through tactics, techniques, or procedures, are not well supported by analytical processes and findings. This presentation describes an investigation of STORM and COMBATXXI representations of such emerging systems and discusses modeling improvements needed to better support studies relating to the employment of unmanned systems in the future battlespace. A key issue becomes determining how to better distinguish humans and human-operated systems from autonomous systems so that the models can more correctly represent all of these systems, and their interactions, in the battlespace.
11776 - Aerial Search Enhancements in COMBATXXI

Historically, the representation of aerial search in combat simulations differed little between ground based sensors and aircraft sensors. Recently, there has been compelling need to further develop aerial search in modeling and simulation (M&S). Aircraft sensors have unique, but not necessarily obvious, characteristics that require them to be modeled differently than ground based sensors. The Aerial Sensor Research Project (ASRP) was a multi-agency effort to enhance the depiction of aerial search in the Combined Arms Analysis Tool for the 21st Century (COMBATXXI), a high-resolution, entity-level, stochastic, combat simulation co-developed and used by the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) and the United States Marine Corps, Marine Corps Combat Development Command (MCCDC).

The most significant deficiencies discovered in the legacy representation of aerial search in COMBATXXI involved the coordination between aircraft sensor field of view management and aircraft motion. Correcting these deficiencies required significant enhancements to COMBATXXI’s sensor sweep techniques, search and loitering patterns, and a graphical user interface (GUI) to assist users in conducting optimal aerial search. Enhancements to the COMBATXXI representation of aerial search have significantly expanded the range of possible questions the Army and Marine Corps can address through combat simulation.

This presentation will explain the unique aspects of aerial search, describe how these can be represented in any discrete simulation, and describe new graphical tools to assist users in modeling aerial search within COMBATXXI.

12326 - Individual Cost Assessment Model

The Individual Cost Assessment Model, or ICAM, is a Java-based discrete-event simulation that models a population of individual Airmen through hypothetical careers from accession to end-of-life and computes the annual and total life-cycle cost for the three Air Force components. ICAM models major career events, such as accession, PCS, promotions, deployments, component changes, separations, and retirements tabulating pay, compensation, and benefits over time. It accounts for the major cost elements, such as base pay, allowances, benefits, health care, and retirement. ICAM has the ability to accept user inputs for experimentation to predict the cost implications of pay and compensation changes, such as deployment length and rates, pay changes, retirement policy, or transition rates. ICAM has been informing AF decisions. Examples include cost implications of changes to rated service commitments, changes in policy on repaying separation incentive pay, cost differences between force mix options, and cost comparisons between ARC categories of employment to name a few. ICAM is supported by a working group with subject matter experts representing different cost, personnel, and analytic organizations from the Air Force. AFRC/A9 is continuing model development to build a higher-fidelity model to account for more cost elements, Airmen parameters, and policy. ICAM the latest model included into the Air Force Standard Analytical Toolkit (AFSAT).

12358 - Optimal medium-term fleet planning incorporating deployment, flying and maintenance constraints

We consider the development of an optimal fleet management plan for a fleet of naval combat helicopters. The fleet must have a certain number embarked on ships at all times, and meet monthly and annual flying requirements for both the embarked and ashore fleet components. The aircraft need to be regularly maintained, with both phased and depot-level maintenance incorporated. We also ensure a balance of flying hours across the fleet, in order to manage an orderly withdrawal from service. We seek to maximize the serviceability of the fleet while prescribing a monthly flying and maintenance plan over a period of up to three years that meets the above requirements. We present an integer-linear program and preliminary results for a small naval helicopter fleet.
### 11734 - Tactical Effects of DOD Anti-Personnel Landmine/Cluster Munition Employment Policy on USMC Operations Using COMBATXXI.

The United States has recently changed policy regarding the use of Anti-Personnel Landmines and Cluster Munitions (APL/CM). The effects of this change in policy were the subject of an ongoing study conducted by the USMC Operations Analysis Division in support of a larger joint study effort. One facet of the study was to explore the tactical level implications on operations using the entity-level combat simulation, COMBATXXI.

This presentation focuses primarily on the methodology used in the development, testing, and analysis of a new tactical scenario to include the selection of a salient aspect of an approved larger scenario, subject matter expert elicitation, data and model validation testing, behavioral development, and output analysis.

### 12115 - Applying an Intelligent Course of Action Simulation for Tactics Discovery

Next generation USAF air vehicles utilized in global strike and air dominance roles will be required to operate in increasingly contested or anti-access environments. Their missions must be completed with an acceptable level of risk, even as threats become much more capable and lethal. To improve warfighter capabilities and survivability within these environments, air vehicles will need to synergistically employ new platform capabilities enabled by several ongoing technology developments, including advanced kinetic and directed energy weapons, countermeasure systems, improved sensor capabilities, and automated pilot decision aids as well as crew interface options. The IWEA program is developing an analysis environment capable of developing a single weapons Research and Development (R&D) strategy.

Initial results from analysis of the Integrated Weapons Environment for Analysis (IWEA) Collaborative Scenario using the Zeus software, an Intelligent Course of Action (ICOA) simulation, were presented at the 2014 MORSS. The technology of interest included multiple high speed cruise missiles concepts, and a traditional cruise missile equipped with a directed energy capability. This presentation will provide a brief description of the Zeus simulation, discuss the technology concepts evaluated, and show the analysis results.

### 11888 - Army H-60 and H-47 Helicopters Historical Brownout Accident Analysis

Current military operating environments include helicopter landings into unimproved sites and recurring weather phenomena which create dust clouds, obscuring aircrew vision and introducing additional flight hazards. This helicopter dusty-landing profile, known as brownout, has caused hundreds of accidents in recent decades, resulting in injuries, fatalities, and millions of dollars of destroyed aircraft. Dust-penetrating sensor technologies that enable aircrews to maintain situational awareness may be used to reduce risk in brownout conditions. A Defense Acquisition initiative directed an Army analysis of alternatives to determine applicability, practicality, and appropriateness of integrating this capability with Army Aviation, specifically the H-60 Black Hawk and H-47 Chinook helicopters.

The analysis of helicopter brownout accidents includes two efforts: historical examination and forecast modeling. Historical analysis encompasses 30 years of accident trend identification and assessment to determine environmental factors, root causes, and accident type distribution. Modeling uses a Monte Carlo simulation based upon a Poisson distribution of potential accidents, incorporating aircraft types and quantities, flight environments, and expected operations tempo in future defense scenarios. The results of the forecast modeling are converted to equivalent constant year costs of aircraft loss and damage, and associated accident casualty estimation (non-cost effects). This enables a preliminary cost-benefit assessment for the technologies as a snapshot of the current state of the art.

The presentation will include the overall historical brownout accident examination and trends, the methodology of accident distribution analysis, and considerations used in forecasting brownout accidents and casualties.
### 12409 - Coast Guard Patrol Modeling: Deterrence, Maritime Domain Awareness, & Public Presence

The United States Coast Guard applies maritime resources towards the execution of its Ports, Waterways, and Coastal Security mission using a defined set of maritime security activities. Maritime security activities, such as security zone enforcement and vessel escorting, have a clear security purpose and associated tactical procedures. These activities and their value towards maritime security are measurable through a variety of activity-based techniques. However, the value of Coast Guard asset presence to support maritime domain awareness, convey positive public image, and create adversarial deterrence are not so easily measured.

An effort quantifying the relative value of Coast Guard presence for different operating areas provides the Coast Guard with a better understanding of the benefits of differing patrol levels across its areas of responsibility. This modeling effort details an approach for modeling the relative importance of Coast Guard presence in terms of deterrence, domain awareness, and public image. Information provides a foundational model for a better understanding of how the Coast Guard might measure the value of its assets’ presence during patrol activities.

### 11766 - Environmental Sensing in COMBATXXI to Facilitate Representation Improvements of STA and Maneuvers in Urban Operations

Improved representation of the urban fight within combat models is increasingly becoming a critical requirement for the U.S. Army. Simulating the changing characteristics of urban operations presents many challenges for modeling and simulation tools. One important challenge to resolve is the ability to provide entities with critical knowledge about the environment in order to improve their interactions in urban settings and more effectively accomplish mission goals. Within the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) simulation, a representation for sensing environmental objects was developed to allow entities to survey potential hostile environment and identify cover and concealment features to support optimized mission execution, maneuvers, and engagements. Entities will have improved environmental sensing, critical knowledge gathering, and knowledge management and sharing capabilities.

This presentation will describe initial modeling efforts to support sensing of critical environmental objects to improve the simulations of search and target acquisition process and maneuvers within complex urban environments.

### 11628 - Human-In-The-Loop Simulation to Determine the Effectiveness of a Future Army Capability

The Maneuver Support Battle Lab (MSBL) at Fort Leonard Wood, MO is devoted to the development and evaluation of emerging concepts for the Army’s Engineer, Military Police, and Chemical Corps Regiments. One method used to determine operational effectiveness of a system under evaluation is through modeling capabilities with simulation software and assessing various metrics through Human-In-The-Loop (HITL) vignettes.

A recent study used modeling software to simulate terrain and Active Duty Soldiers to assess the merits of an enhanced and updated sensor package on a small Unmanned Aircraft System (UAS). This study provided a comparative analysis between the existing UAS sensor and an updated sensor (a future materiel solution) which currently exists only in a partial functional prototype. Information provided by using each sensor in simulated and real terrain permitted a comparative assessment on the impact in a participant’s ability to identify various critical items found during common Army Engineer missions.

Results from the study indicate an increase in detecting these critical items when using the updated sensor vs. the baseline in the both the real and simulated terrain environment. Sensitivity analysis indicate that the updated sensor’s operational effectiveness is not impacted by varying weights on the performance measures. The participants fully agree that the updated sensor is worth continuing for research and development, as it has considerable operational advantages over the current baseline sensor.
**12359 - Improvements in Modeling the Air Campaign Target Set in CFAM**

The Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) supports challenging Force Structure decisions through insights often derived from rigorous modeling and simulations results. The Combat Forces Assessment Model (CFAM), a linear optimization program in the Air Force Standard Analysis Toolkit, is the primary tool used to integrate results from numerous mission-level models and datasets to identify a campaign-level optimal mix of fighters, bombers, tankers, and other assets. By using CFAM to examine future force structures within projected or unconstrained Air Force resources, balanced against established threat scenarios, AF/A9FC supports the Air Force Strategy, Planning and Programming Process decisions.

Within CFAM, force structure optimization results are highly dependent on a given air campaign target set that provides the foundation against which capability and capacity are evaluated. Though all targets for a given scenario are available as part of the Support for Strategic Analysis (SSA) products, none are explicitly designated as Air Force targets. The fundamental problem then becomes determining which types of targets to include, how many of each type, and where they are located. Currently A9FC derives the target set from Joint campaign simulation results, but using simple expected values of the stochastic results has proven to give invalid target sets. The solution discussed here overcomes this issue, creating a repeatable process for target set development. Further scenario development data requirements are highlighted as well as some advantages and disadvantages of solutions being investigated. Finally, future developments to increase model fidelity while yet providing quick-turn analytical insights will be briefly covered.

**11681 - Modeling Dynamic Tactical Behaviors in COMBATXXI using Hierarchical Task Networks**

Defining accurate representations of group behaviors in simulations is an expensive, time-consuming task. One reason for this is that previously produced behaviors are often not reusable within other scenarios or simulations. Using Hierarchical Task Networks (HTNs) to model military behaviors is a promising technique for addressing this problem. HTNs provide a methodology for linking tactical behaviors, and offer a potential system for representing the military decision-making process at the tactical level. This paper presents the results of an investigation into the use of HTNs within the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) model. COMBATXXI provides military planners a detailed representation of combat operations, and supports analysis efforts by providing insights into the effectiveness of weapon systems, unit organizations, and tactics. The use of HTNs within COMBATXXI is a relatively new concept; many aspects of HTN implementation have not been researched in depth. This presentation describes development and testing of HTNs capable of executing a security formation behavior and for coordinating the execution of other ground combat related behaviors. The HTN-controlled behaviors were demonstrated in a simulated version of a United States Marine Corps live fire training range. Composability and dynamic features of these behaviors eased the scenario development process and added tactical realism to the test scenario.
### 12339 - Optimal Security Force Assistance Strategies through Stochastic Linear Programming and Discrete Event Simulation

Security Force Assistance (SFA) exists in complex operational environments that cultivate interactions between social, economic, cultural, and other population-centric factors. Strategy planners must be comfortable with the concept that, when it comes to strategic focus, resources, and funding for these missions, more is not necessarily better. Specifically, variables that define a nation’s absorptive capacity and economic strength diminish the effectiveness of SFA operations when certain aspects of these operations violate their constraints. This idea is strikingly apparent in simple exploratory data analysis of potential relationships between global SFA and Security Cooperation (SC) expenditure and SFA/SC effectiveness variables found in comprehensive, open-source databases such as the State Fragility Index and the RAND Security Cooperation Prioritization and Propensity Tool.

The lack of an apparent relationship between SFA/SC funding and effectiveness motivates analysis of redistribution with respect to strategic focus and resources, thereby inviting a stochastic linear programming model with the objective of maximizing SFA/SC effectiveness as subject to constraints described by absorptive capacity and economy. Once optimality is achieved for any of the 107 countries whose data are available for this analysis, results compile to parameterize a similar model that informs region and/or Commanabtant Command (COMCOM) level strategies for enabling the realization of these optimal national SFA/SC strategies.

Optimal SFA/SC strategies, once defined, feed a regression model that maps normalized SFA/SC propensity values to State Fragility Index data. This time-series database interacts with target SFA/SC effectiveness to drive a discrete event simulation model for approximating the time required for the optimal SFA/SC strategy to manifest itself in any given nation.

### 12363 - Balancing Linear Program Coefficients to Model Commanders Intent

The Campaign Analyses Division of Headquarters Air Force Studies, Analyses, and Assessments (AF/A9FC) supports difficult Force Structure decisions with insights derived from rigorous modeling and simulation. The Combat Forces Assessment Model (CFAM), a linear optimization program in the Air Force Standard Analysis Toolkit, is the primary tool used to integrate results from numerous mission-level models and datasets to identify a campaign-level optimal mix of fighters, bombers, tankers, and other assets. By using CFAM to examine future force structures within projected or unconstrained Air Force resources, balanced against established threat scenarios, AF/A9FC supports Air Force Strategy, Planning and Programming Process decisions.

Underpinning CFAM results are a series of objective functions with complex relationships learned by extensive use of the model. Analysts alter these coefficients to produce results consistent with employment CONOPS and airpower doctrine. Errors result from CFAM optimization decisions that run counter to conventional risk tolerances, such as aircraft attrition, that are resolved through iterative balancing of the coefficients, or excluding decision space. AF/A9FC is studying these complex relationships to produce guidelines that will better drive CFAM behavior to best represent the Commanabtant Commanders’ risk tolerances within the coefficient structure. This presentation describes initial analytical results, how risk tolerances are balanced within the coefficient structure, and the design of experiments being used to produce coefficient value guidelines that assure credible CFAM results lead to high-confidence insights informing Air Force optimized Force Structure decisions.

### 11777 - Behavior Validation Methodology for COMBATXXI

Many models and simulations employ model behaviors intended to replicate movement or decisions of entities within the simulation. In FY 2014, TRAC and Army Research Lab constructed a framework for measuring the validity of the behaviors used in COMBATXXI, an M&S system developed and used by TRAC. This framework establishes the pedigree of individual entity behaviors and creates an easily searchable database that meets the growing needs of the military simulation community. This presentation will describe the framework and some results of its application to COMBATXXI.
### 12355 - Determining an Economic Force Size for the U.S. Army (A Stochastic Programming Approach to Force Structure Analysis)

The U.S. Army is expected to expand and contract as necessary to meet changing threat, economic, and political conditions. Current analytic methods focus on combat requirements in developing resource constrained operational force designs. These tend to rely on simulation of static force structures with fixed readiness policies. Additionally, the Army's force structure analysis models have no direct linkage to cost, instead relying on manpower limits. This type of approach is ill-suited to consider the cost vs. benefit tradeoff of the Army, or the overall size and composition of the Army and how it should adapt over time. We propose a multi-stage optimization model to determine dynamic force size while accounting for uncertainty of future force demands. We begin by providing a method to approximate force demand as a discrete empirical distribution amenable to a stochastic optimization framework. Next, we develop a strategic level stochastic linear program of the Army to include the total workforce, operational and institutional forces, deployment policies, and costs. Solution methods are evaluated and presented as a computational study. Finally, we offer insights for further development and potential use of this approach to augment future force structure analysis.

### 11645 - Facilitating human in the loop pattern recognition

A human observer carries a rich array of expectations as a function of experience which inform the recognition of patterns from data. By designing an analysis strategy from the ground up with a human as part of the process, we allow a computer to do what it is good at doing in order to facilitate using a human in the loop to do what humans are good at doing. By making a human part of the designed execution, the presentation of data can elicit the actioning of the innate human pattern recognition capacities and habits. To do this, we must be cognizant of the conditions where human pattern recognition works best. We are motivated to look for and recognize patterns with 'medium' size and speed phenomena. This unconscious activation is best illustrated by music. If the tempo of a song is too slow or too fast, it doesn't cohere in our minds as music. Design considerations that cater to this will be discussed. Principally because of the function of experience and language-mediated interpretation of objects and actors, human pattern recognition ability often outstrips that of a computer under certain conditions. Designing a system with a human as part of the algorithmic execution requires planning, but can result in getting the best of both worlds.

### 11721 - An Efficient Alternative to Monte Carlo using Statistical Convolution

The presence of large wind turbine farms has been shown to significantly degrade radar tracking of aircraft. As wind turbine development expands, the North American Aerospace Defense Command (NORAD) must assess the operational risk to its aerospace control mission due to new turbine proposals. If the operational risk becomes significant, NORAD must raise its concerns through the Department of Defense. New models, specifically designed to address wind turbine interference with ground-based radars, are utilized to simulate both the losses in radar tracking continuity from wind turbine obscuration and the resulting impact this has on operations. Two analytical approaches, Monte Carlo and a convolutional "Direct Probability", are considered to compute the probability of successfully intercepting an unauthorized aircraft. The presentation will highlight the efficiency of calculating the “Direct Probability” using statistical convolutions of individual probability density functions (PDFs) over the calculation of numerous Monte Carlo trials, where each trial samples only one value from each PDF.
The objective of the study is to determine the technical feasibility of this integrated capability to improve representation of human decision-making in today's combat simulations. This presentation describes an investigation into the integration of a knowledge representation and reasoning approach to improve the fixed-logic and scripted behaviors typical of entities in today's combat simulations. This research uses a simulation modeling USMC Maritime Prepositioning Force (MPF) exercises in ExtendSim and an optimization tool (OptDef) to integrate the insights gained using a simulation or optimization individually. We start by demonstrating the methodology with a small scale model and then increase the size of the model to test the robustness of the technique. We also cover the pros and cons of using this combination and lessons learned through integrating these tools.

Representation of human decision-making remains an under-implemented and challenging area of combat modeling. In a computer model of combat, we need to be able to represent the knowledge possessed by human decision-makers and the processes they perform to understand the current state of the battlespace and to make determine actions progressing toward achievement of mission objectives, all occurring in a highly dynamic environment. In the computer science field of artificial intelligence, there continue to be advances in knowledge representation and reasoning that offer opportunities to improve the fixed-logic and scripted behaviors typical of entities in today's combat simulations. This presentation describes an investigation into the integration of a knowledge representation scheme and automated reasoner into an existing combat model, the Combined Arms Analysis Tool for the 21st Century (COMBATXXI), used by the U.S. Army and U.S. Marine Corps to conduct analyses of new force structures, systems, and tactics. The objective of the study is to determine the technical feasibility of this integrated capability to improve representation of human decision-making in the model.

Just as Soldiers hone their marksmanship skills in the Engagement Skills Trainer and pilots in flight simulator, leaders must also train to improve their critical thinking and decision making abilities. The ability to understand the higher order effects of decisions over time is a significant challenge for leaders. It is often the case that rational decisions made with the best intentions meet short term objectives, but ultimately cause more harm than good over the long term. One potential solution to this challenge is the development of "management flight simulators" for leaders; or a "Leadership Flight Simulator". These simulations are developed to help leaders understand the long term consequences of their decisions. Scenarios can be developed to allow leaders to simulate multiple years' worth of decision making experience in a short time, providing the learning that is often only associated with experience. This project develops a proof of concept web-based "Leadership Flight Simulator". A series of micro-lessons are identified and one is developed into a leader development training scenario and web-based simulation, utilizing a system dynamics methodology. In this scenario, the user must make critical decisions each week over a year-long deployment. In the simulation, the user is provided feedback along the way and is also allowed to see how the decisions impact the area of operations over the long term. Ultimately, these scenarios can be developed using Army Lessons Learned and easily accessed and utilized for training in all three domains of the Army's Leader development model.

Course of Action (COA) generation consists of developing a series of actions which are distinguishable, feasible, and complete, and whose expected outcomes are both acceptable and suitable, as determined by the decision makers. As systems and actions become increasingly complex, so to do the methods and time required for solution. Utilizing a modified Evolution Algorithm (EA) with periodic spikes and exponential cooling mutation rates, our COA generation algorithm constructs distinguishable, high value plans in a relatively short amount of time without the restriction of the search algorithm requiring knowledge of the underlying value function. The algorithm accomplishes this through independent development of multiple breeds, and subsequently randomized reintegration in multiple, independent environments, all of which creates a structure which may be exploited for parallel processing.

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<thead>
<tr>
<th>Group</th>
<th>Day &amp; Time</th>
<th>Location</th>
<th>Author/Presenter</th>
<th>Co-Author(s)</th>
<th>Classification</th>
</tr>
</thead>
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<td>Mr. Walter DeGrange</td>
<td>Dr. Benjamin G. Thengvall</td>
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<td>Mr. Curtis L. Blais</td>
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**12352 - Combining Simulation and Optimization to Increase Insights: USMC Maritime Prepositioning Force (MPF) Exercise Simulation and OptDef**

Simulation and optimization individually are useful tools. By putting the two together we get a very powerful methodology. This research uses a simulation modeling USMC Maritime Prepositioning Force (MPF) exercises in ExtendSim and an optimization tool (OptDef) to increase the insight gained over using a simulation or optimization individually. We start by demonstrating the methodology with a small scale model and then increase the size of the model to test the robustness of the technique. We also cover the pros and cons of using this combination and lessons learned through integrating these tools.

**11680 - Investigating Integration of Knowledge Representation and Automated Reasoning in Entity Behavior and Decision Making in the Combined Arms Analysis Tool for the 21st Century (COMBATXXI)**

**12156 - Leadership Flight Simulators**

**11192 - Course of Action Generation Using Modified Evolutionary Algorithm with Periodic Mutation**
### Group: 11822 - Modeling the Asia Pacific Environment

The Asia Pacific region is both large and crowded. Over two billion people call less than 15% of the 2.5 million square mile region of interest home. From the basics of daily meals to the complexities of world commerce, many of these people’s livelihoods are dependent on accessible seas. Countless surface vessels ply the waters fishing and moving raw materials, finished products, people, and petroleum in and out of over a third of the world’s busiest seaports. In addition, through consistently overcast skies, the region hosts over 30% of the world’s busiest airports with air congestion rivaling that of North America. An illustrative model that included these commercial and civilian activities was constructed and executed to help understand the complexity and scope of Phase 0 challenges found in the Asia Pacific region. The same model might also identify underlying assumptions and provide insights to decision makers investigating the management of potential regional conflicts as they escalate through later phases. This presentation gives an overview of the model content and analysis findings.

### Group: 11797 - Systems Analysis for Test and Training Instrumentation

U.S. Army Test and Training instrumentation systems depend on imbedded methodology and data to accurately represent battlefield effects. Efforts such as the Mobile Automated Instrumentation Suite (MAIS) and the Simulated Area Weapons Effects – Multiple Integrated Laser Engagement System (SAWE-MILES) have developed independent solutions for methodology and data. These inconsistent methods and data amongst the various instrumentation systems raise questions about the credibility of operational tests and warfighter training.

The U.S. Army Materiel Systems Analysis Activity (AMSAA) is working with the test and training system community to apply the discipline of systems analysis throughout the acquisition life cycle of future test and training instrumentation systems. Specifics include requirements analysis, methodology research and development, and system sustainment via data development. By applying systems analysis early in the life cycle, issues can be identified early to create credible and sustainable instrumentation systems at a lower cost. This briefing will cover the work that has been completed along with what is planned to make this vision a reality.

### Group: 12119 - The Argonne Below Ground Model: A Comprehensive Simulation Capability For Analysis of Subway Threats

Although evidence of the vulnerability of subways to a biological attack had existed for decades, the 1995 Aum Shinrikyo Tokyo subway chemical attack focused public attention on the potential threat posed by chemical and biological agents to subway patrons. Subsequent successful and unsuccessful attacks on subways around the world since then have further heightened concerns and demonstrated the need for informed response planning.

The Argonne Below Ground Model (BGM) has been developed to provide a comprehensive simulation capability for analysis of subway threats at the system level as well as specific stations. BGM predicts the movement and spread of a chemical or biological agent within an underground subway system as well as the amount of material released to the environment through station entrances, street-level vents, and tunnel portals. BGM also incorporates an agent-based population effects component to assess the health consequences of an attack, to be described in a related presentation. BGM has been used to simulate most of the subway systems in the U.S. along with regional aboveground–passenger rail transit.

The presentation will begin with an overview of BGM and then focus on its validation through studies carried out in subways in Washington D.C; Boston, and New York City. Selected examples of the application of BGM to address questions concerning optimal detector architecture, detector performance, and efficacy of response strategies will also be presented.
12400 - Military Systems Analyses in an Ill-Posed World: Defining the Problem

Historically, a range of military analyses, tests, evaluations, and M&S disciplines have been confounded by an absence of requisite context information. These can be seen as ill-posed problems, and they occur when an analysis is under-specified, under-determined, or under-constrained. Thus in principle, an answer does not even exist, although an analyst may make unwarranted explicit or implicit assumptions in order to force conclusions.

The past decade has seen increased focus on the “mission” of materiel under study based on entity tasks requisite to the successful prosecution of a mission. We argue that this approach is what's required to provide the community with key context information. Missions are about entities (people/material) executing tasks at multiple levels-of-war, sometimes individually, but often in teams. A useful descriptor for contemplating mission execution in the large is in task networks. This abstraction, when instantiated, forms a collection of task networks. However, when it comes to Integrated DT, LFT&E and OT or Mission Capability-Based T&E, the T&E and analysis communities rarely develop such detailed task networks even though the information embodied in these networks is requisite to avoid an ill-posed and hence unsolvable problem.

We will illustrate an overall macro construction of task networks, together with the additional factors key to integrating a range of analyses. In a subsequent presentation (Britt Bray), task networks will be illustrated in detail. And in a final presentation (Chris Wilcox), an integrated T&E strategy will be developed based on the previously established operational mission context.

11384 - Modeling Aerial and Sea Ports of Debarkation

For the past 13 years the United States has been at war between two theaters, Afghanistan and Iraq. One of the factors that make the United States Military the best in the world is the ability to sustain combat operations. This is accomplished through the use of Aerial Ports of Debarkation (APODs) and Sea Ports of Debarkation (SPODs). These ports are used to send and receive military cargo to units in support of emergent and established theatres of operation. Several constraints limit the type of cargo transported and the rate of the cargo in transition from one location to another. The Engineering Research and Development Center’s (ERDC) Military Logistics program wishes to enhance understanding of the roles and processes that APODs and SPODs play in the military logistics system by building a validated model of the two ports. The effects and processes of these models are to be integrated into a larger logistics planning tool with the intent to inform decision makers on ways to employ more resilient and optimized supply chain for existing and emergent areas of operation. ERDC has requested a team of Cadets from the United States Military Academy in the Department of Systems Engineering to research, develop, and create alternatives to validated models of APODs and SPODs in the logistics system. The alternatives will approximate the range of potential operational conditions that need to be considered in the supply chain logistics network. The USMA team conducted research and stakeholder analysis on how APODs and SPODs are operated, modeled operations within APODs and SPODs using ProModel, created alternatives, and recommended actions to improve process efficiency.
## 11896 - Prioritizing Verification and Validation by Quantifying the Value of Decreasing Uncertainties

The Air Force Research Laboratory Integrated Weapons Environment for Analysis (IWEA) program is enabling risk-informed technology investment decisions within the weapons enterprise by generating mathematically rigorous confidence assessments to accompany its weapon effectiveness analyses. The overall confidence is characterized by combining aleatory and epistemic uncertainties for all independent component simulations and evaluating relevant use-cases. In an effort to characterize the confidence of weapon effectiveness analysis results at the engineering and engagement level, researchers desire to consider all aspects contributing to uncertainty, including:

- How well do the predictive methodologies represent the real world systems?
- What unknowns or uncontrollable variables affect our results?
- Which codes/variables are largest contributors to uncertainty?
- What is the ‘value’ of decreasing uncertainties?

The research team has conducted a series of proof of concept experiments to consider each of the aspects identified above. This paper will present the results of a proof of concept using a Design of Experiments (DOE) approach to allow the analyst to determine which codes/variables in a series of codes are the largest contributors to uncertainty, even in the absence of available quantitative uncertainty data. The paper will describe a method for quantitatively determining the value of decreasing uncertainties, provide the results from a small example problem involving two codes in series, and present plans for generalizing the methodology for larger problems of interest.

## 12124 - Review of Transport and Dispersion Experiments in Subway Systems

Argonne National Laboratory (ANL) has led a series of transport and dispersion experiments in Washington DC and Boston from 2007 to 2012. These tests were the first large scale tests to measure transport and dispersion of gases and aerosols in modern subways and, in total, represent a comprehensive database on aerosol and gas transport results in subways comprising over 100 separate tracer releases.

The motivations for these experiments were multifold: (1) to more fully understand the phenomenology of transport and dispersion in subways, (2) to provide requisite validation data for the ANL Below Ground Model (BGM), a computation tool developed by ANL to provide a comprehensive simulation capability for analysis of CBR airborne threats to subways, and finally (3) to provide real data to directly assess requirements for chemical and biological detection in subways. The presentation will provide an overview of this testing program, examples and synopses of the resulting data, and lessons learned from both the data themselves and in the execution of such large-scale urban experiments. We will also briefly review follow experiments that have occurred in New York and London including proposed studies.

## 12142 - Assessing Risk in Navy Readiness

Development of Navy Program Objective Memoranda requires the service to assess risk in all aspects of the Navy program, including force readiness. Unlike capability assessments, which are directly linked to well-specified performance requirements, readiness is often driven by ambiguous requirements that struggle to achieve validity in the early phases of the Planning Programming Budgeting and Execution. Consequently, despite the fact that Navy readiness requirements are determined by performance/pricing models, there are lingering concerns regarding the actual impact of underfunding readiness accounts. This project will provide a more effective approach for conducting risk assessments of Navy force readiness. It will begin with a clear delineation of the readiness requirements as stated in strategic documents such as the Defense Strategic Guide and the Defense Planning Guidance; consider CNO’s commitment to meeting those requirements (as stated in CNO’s Navigation Plan); and conduct analyses regarding the likelihood of the Navy program to meet those requirements.
### 11883 - Multi-Objective Evaluation of Experimental Designs

In this paper we introduce a novel approach to develop excellent designs for computer experiments. The determination of "better" focuses on the design properties of orthogonality, space-filling, and imbalance, which serve to produce more tractable analysis of the data. Past attempts to develop objective assignment of weights to multiple properties of an experimental design remain unresolved. While many construction methods for experimental designs employ equal or balanced weighting between two or more metrics, we propose a multi-objective decision analysis technique — swing-weight matrices — to combine disparate metrics into a unified value for designs. We further incorporate non-linear valuation of the metrics through the use of exponential curves that quantifies diminishing or increasing returns. Our process begins with an initial random Latin hypercube to which we iteratively apply orthogonalization and improvement techniques to create a nearly-orthogonal experimental design. Discussion in the paper presents questions and properties that help determine the parameters that define this weighting model and how it impacts design performance. We offer this innovation to practitioners who encounter difficult experimental conditions.

### 11713 - Urban Clearing Operations within the Advanced Warfighting Simulation (AWARS) - A Proof of Principle.

Operations during the last 10 years required combat units to operate in and conduct tactical-level urban-clearing operations. The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) operates and maintains AWARS, a model used to analyze combat operations depicted in TRADOC operational and tactical scenarios. TRAC will enhance AWARS' ability to represent urban-clearing operations with greater fidelity in anticipation of the continued requirement to conduct analysis of urban operations. Key to this model enhancement is improved representation of building-clearing times. TRAC combined an operations research technique known as Subject Matter Expert Elicitation with combat experience to provide a range of probable values for building-clearing times. This approach served as a proof of principle and will later be refined, implemented, and expanded upon in accordance with analytic requirements. This presentation will describe the analysis methodology, the model, intended model implementation, and areas for further research.
Data Centric Modeling/Simulation (DCMS) is a platform independent, device independent, paradigm shifting framework for model interactions. The idea behind DCMS is to keep current models intact, with little to no code changes for the current model, and still allow them to be connected to other models. This framework allows for an expansive array of new models to be developed by combining other models together that were previously near impossible for most developers.

Current modeling and simulation work is usually built by core software development teams over the course of months to years depending on the scale of the model or simulation. There are many disparate models that have been developed, but they are specific to what they do. Because of this, interest in model-to-model interaction has become a hot topic in many fields.

One such model, the Argonne Below Ground Model (BGM), predicts the transport and dispersion of a chemical or biological agent within an underground subway system as well as the amount of material released to the environment through station entrances, street-level vents, and tunnel portals. Users of other models, such as those developed by Los Alamos and Sandia National Laboratories, would benefit from integration with the BGM model, but currently cannot since the direct model-to-model interaction is too costly. This is where the DCMS framework comes into play.

With the DCMS framework, models can be combined with relative ease compared to current methods of tightly coupling them in code. By focusing on the data required from each model and using a managing layer to handle the data transfer, little to no modification of logic is needed to combine models. By treating the data as a first class citizen and using a communication layer, DCMS is able to easily integrate the models.

This does not mean DCMS only applies to already developed models, but it also applies to a new idea for future models. By using the DCMS framework, ‘micro-modeling’ can occur. This allows for smaller models to be developed but interconnected by the controlling layer. Using micro-models allows analysts to ask for specific micro models, and which can be easily developed since micro-models take less time to develop, and then can be readily integrated in with the current system of models.

The DCMS framework is also allows analysts to construct models in situations they were not able to before. Often, new questions are raised during a study and analysts are required to ask model builders to modify or enhance the currently developed model. By giving the DCMS framework to analysts along with a list of already developed micro models, analysts are able to pick and choose which models they want to put together. This allows them to run simulations specific to their new questions.

DCMS provides numerous benefits to analysts. Using DCMS with micro-models allows analysts to create highly customized simulations that can answer specific questions. Since DCMS allows models to address specific problems, modifications and new models required by analysts are more cost effective. Also, the development of models can be distributed amongst various organizations that have specific expertise in the required capability of the model. Finally, DCMS allows for models to be distributed across multiple hardware platforms which can reduce execution time and provide a capability for modeling larger datasets without the need for a high performance computing system. All of these benefits, and more, lead to the overall goal of reducing the amount of time, effort and money needed to build large scale, highly customizable models and simulations.
### 11908 - Improving Submarine Tactics by Applying Design of Experiments Methodology to a Simulation Study

Submarine survival from enemy torpedo fire is a complex problem involving multiple interdependent variables. Previous work approached the problem using high fidelity Monte Carlo simulations to understand single variable dependencies. However, the complex nature of the problem and the number of variables prevented using a brute force computational approach to understand interdependencies between the variables. This study was the first deliberate use of a Design of Experiments (DOE) methodology by Submarine Development Squadron TWELVE. Tradespace analysis tools provided a robust and powerful capability to support exploration while simulations provided a synthesis of degraded GPS service and SATCOM connectivity. The methodology and base case developed in this effort will help inform future studies on how to mitigate and overcome the impacts of degraded GPS service and SATCOM connectivity.

### 12343 - Measuring the Operational Impact of GPS and SATCOM Degradation

Marine Corps forces are becoming increasingly reliant on the use of the Global Positioning System (GPS) and satellite communications (SATCOM). These systems provide critical command-and-control (C2) and positioning, navigation, and timing (PNT) services, and face a variety of threats that may degrade or deny their use. We develop a methodology incorporating simulation, optimization, and queuing techniques to examine the operational impact of degraded and denied GPS and SATCOM capabilities on various Marine task forces. Given projected friendly and threat capabilities, we use our methodology to examine these operational impacts in the context of realistic combat scenarios to establish an analytic base case. The methodology and base case developed in this effort will help inform future studies on how to mitigate and overcome the impacts of degraded GPS service and SATCOM connectivity.

### 12261 - Modeling Officer strength by Year Group to meet Requirements during a Drawdown

Faced with reductions in end strength and a fiscally constrained environment, the US Army is adjusting personnel policy to meet requirements throughout the Future Years Defense Program (FYDP). Personnel analysts must identify the proper mix of personnel levers such as accessions, separations, and promotions that will allow the Army to not only meet drawdown target gates but to sustain a proper inventory beyond the FYDP. The methodology and forecasting model to be presented was developed to model Army Competitive Category (ACC) Officers over a 2-5 year time span in order to sustain the US Army's future fighting force during a drawdown. The model uses sixteen years of historic monthly continuation rates derived from the Total Army Personnel Database (TAPDB) to simulate future continuation behavior by year group. The model provides analysts an understanding of the effects that current policy decisions will have in meeting future requirements in order to more accurately forecast personnel strength.

### 11634 - Who Put These Simulations In My Tradespace Analysis Tools?!

Tradespace analysis tools provide a robust and powerful capability to support exploration while simulations provide a synthetic environment capable of representing many aspects of military operations. When combined, there are endless possibilities; however, mapping capabilities to the user gaps are a nontrivial endeavor. This presentation focuses on the results of the second phase of the OSD Engineered Resilient Systems (ERS) Research Thrust effort to enhance the interface developed between a tradespace analysis tool, the ERS Tradespace tool based on the Framework for Assessing Cost and Technology (FACT), with a distributed simulation management tool, Executable Architecture Systems Engineering (EASE). It discusses the benefits, the methodology employed, the technical lessons identified in connecting disparate systems with dissimilar semantics, and the unexpected challenge in helping the user realize potential uses. It concludes with an illustration of how these connected tools enable a quicker means to manipulate attributes of a system under analysis within the ERS Tradespace, and with an abridged set of viable designs, launch a simulation environment to further analyze the proposed systems within the context of a force modeling suite of simulations.
12405 - Discrete Event Modeling and Simulation of a Ballistic Missile Passive Defense Command and Control Architecture Utilizing Overhead Persistent Infra-Red (OPIR) and Radar Data

The Joint Integrated Air and Missile Defense Vision 2020 of the Chairman of the Joint Chief of Staff depicts an evolving global environment, where the rapid proliferation of ballistic missile technology continues to increase the threat to both allied and U.S. interests. This qualitative and quantitative transfer of missile technology has emboldened adversarial nations and organizations to threaten locations previously considered unreachable and has created new battle spaces no longer constrained or defined by individual combatant command boundaries. With this increasing threat, the growing demand by both US and allied forces for low density, high demand US missile defense systems assets simply cannot be met. This research proposes a methodology for assessing new passive defense measures for alerting both military and civilian populations of inbound missile threats using radar data in addition to the current OPIR impact prediction data. Through discrete event simulation modeling, this research examines both the existing and proposed passive defense emergency response architectures.

12205 - Secret Benefits of Modeling and Simulation

Modeling and simulation (M&S) is touted as having many benefits. It uses in projects can test the feasibility and constraints of systems prior to their complete development, allows stakeholders to study the effects of extreme conditions that could not be easily tested in a physical environment, and identifies the components of the systems that are most sensitive to changes in the operating conditions or surrounding assumptions.

Other benefits of the use of M&S also exist, but are rarely discussed at the outset of a project. M&S can help to solidify a common vision of the system in question with all involved parties by showing the results of assumptions that are made in the planning process. It can also require communication of all planning parties ahead of the original schedule, allowing for faster discovery of discrepancies or inconsistencies in requirements or the planned execution of requirements.

This presentation will explore several case studies where these benefits helped to make the system in question successful through enhancing communication and collaboration with all involved parties ahead of system development and deployment.

12250 - The Application of Systems Modeling in support of Trade Studies

Trade Studies requires team interaction, sharing of data, information, and knowledge that must be collected, analyzed, and put into a form useful to support objectives. It is almost always an archeological dig to corral all of the legacy information needed, and it is an equally daunting task to synthesize it in order to understand and communicate back out to the IPT how this data, information, and knowledge is being used in support of analysis, and decisions that need to be made. This is all needed to frame the problem and to organize the decision analysis and trades. Once this is accomplished, models need to be built, configured, and run. The input and output data to and from models and simulations need to be managed and the results need to be analyzed and reported while remaining in sync with an ever changing program.

This talk will present a case study for an integrated systems engineering approach that uses SysML to capture, and communicate the data, information, and knowledge necessary to support a trade study. This presentation will also explain how the system model was used to store the input data and feed it into analytical models that are run as part of the trade study. The presentation will end with lessons learned and an example showing the interaction of data and models.
Military analysts have applied an analytic hierarchy of engineering, engagement, mission area, and campaign for two decades. The level of a model or simulation is determined by its purpose—what types of questions and issues can it adequately address. The level is driven by both the breadth and resolution of the model or simulation.

Different modeling techniques affect a model's resolution. We propose a simple schema of six factors that may be used to describe a model's resolution:

1) Modeled entities
2) Sequencing of events (mission chains)
3) Uncertainty
4) Entity decision autonomy
5) Spatial and temporal state changes
6) Supporting missions and environment

We contend describing a model or simulation in this simple schema may help communicate the model's characteristics. Addition, prescribing these six factors can improve describing the modeling requirements and make model development more consistent across its breadth.

This paper presents an update on the progress made towards the Integrated Weapons Environment for Analysis (IWEA) tool being developed at AFRL. The IWEA program is creating an analysis environment capable of developing a single unified weapons Research and Development (R&D) strategy. Details of the paper include how we have modified and linked tools ranging from engineering to mission levels to provide an analytical environment for analysis, including the output of results to feed campaign level simulations. It will review research efforts to characterize the accuracy of this environment and show how we can perform research into automated battle management systems. It will also demonstrate the capability to develop and analyze decision logic allowing for a mixture of offensive and self-defense missions in highly contested environments; the ability to understand and predict the synergistic effects of using multiple types of energy on target vulnerability; and the ability to exploit higher fidelity data between modeling, simulation, and analysis tools representing air vehicles, battle management, weapon effectiveness, and collateral hazards.

Recognizing the increased focus on simulation tools across the DoD, the U. S. Army Engineer Research and Development Center has developed a suite of M&S products for the analysis of unmanned ground vehicles (UGVs). These tools include the Virtual Autonomous Navigation Environment (VANE), a high-fidelity high performance computer based tool, and the Autonomous Navigation Virtual Environment Laboratory (ANVEL), a real-time, desktop simulation environment.

The presented research will highlight how VANE and ANVEL can be leveraged to support the performance assessment of UGVs. Specifically, the presented research highlights how VANE and ANVEL can be used to replicate some of the tests done during Military Utility Assessment and Analysis of Alternatives studies. This research focuses on ANVEL's mobility modeling capabilities to analyze the mobility of UGVs and the impact of payload and platform configuration on mobility performance. This research also focuses on sensor tradeoff studies and performance evaluation for vehicle mounted perception systems for autonomous UGVs.
**11576 - Case Study of Tracing Model Results Through AMP Versions**

The Analysis of Mobility Platform (AMP) is the program of record for military transportation analysis. Given a baseline scenario, we compared the differences between the railcar usage between AMP 14.2.2 (October 2012) and AMP 14.7 (January 2015). Challenges included updating a scenario to ensure model assumptions were consistent between the two versions, isolating changes in a multi-modal, end-to-end scenario, and ensuring that similar closure was maintained. Once the baseline was complete, additional tools were required to evaluate not just railcar usage over time, but why the usage changed over time. Specific tools were applied such as adding tracing code, SQL scripts for comparing run files, and specialized graphs using the Tableau software package. Each of these had their challenges and benefits. Specific examples of differences and how we quantified the impact of each will be presented. Finally, the presentation will conclude with lessons learned for tracking and evaluating impacts of model changes in the future.

**12300 - Informing Up and Down the Modeling Hierarchy**

Military analysts have applied an analytic hierarchy of engineering, engagement, mission area, and campaign for at least two decades. Each level addresses different questions. Even with fast computers, you cannot simply link engineering models together to conduct campaign analysis. Analysts often state that the various levels inform each other. Higher resolution models are used to inform performance in more aggregate models. Similarly, the more aggregate models are used to tune higher resolution models for broader issues not included in those more detailed models. This presentation discusses the challenges in making these inferences between model levels including why these choices require analyst involvement. To inform a more aggregate model, the analyst needs to develop representative values without the associated details. Techniques including averaging and regression apply. Tuning a more detail model often involves insert degrades for broader factors that are not included in the more detailed model.

**11907 - Owning the Technical Baseline with Model-Driven Engineering**

The current U.S. Air Force’s 30-year plan (America’s Air Force: A Call to the Future, July 2014) identifies Capability Development as a key area where existing practices need to be transformed in order to keep pace with the evolving operational environment. The strategy recognizes that traditional DoD methods of requirements development, acquisition oversight, and especially systems engineering are inadequate to produce results in the desired timeframe, in a manner that is receptive to more frequent decision points. In order for these types of systems to evolve and support the type of distributed participation that the strategy envisions; they must be designed and specified to expose the necessary interfaces for future growth. This adoption of an open-systems architecture approach represents a significant engineering investment that must be accounted for in acquisition processes. We believe that in order for the U.S. Air Force (and the defense community in general) to truly realize the benefits of agile Capability Development, program offices must:

a. Strive to gain deep, technical knowledge of the system modularity
b. Specify the critical interfaces to a level of detail to allow them to be implemented in software
c. Be able to act as a system integrator to verify and validate that component implementations can interoperate successfully within the overall system

In this paper, we outline a systems engineering approach using a dynamic, executable Model-Driven Engineering methodology that we believe can help the government create the systems engineering environment required to implement agile capability development and finally reap its benefits.
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| WG 28 | 25 Jun 14:30 - 15:00 | DoD - 15     | David M Smalenberger | Dr. Richard F. Deckro, FS  
LTC Brian Joseph Lunday, Ph.D. | UNCLASSIFIED |

**11984 - Modeling Complex System Behavior Using the SIGMA Distribution and IAF Framework**

This research proposes the use of the Synchronous Interactive Gaussian Mixture Aggregate (SIGMA) distribution and its Implementation Assistance Framework (IAF) in order to leverage selected benefits of classical models with the complexity that can be addressed via simulation. Whereas classical modeling techniques often enable analytical solutions, improved modeling resolution to better emulate reality often diverts the results from closed-form solutions. In the extreme, simulation models enable the study of complex and interconnected systems over a temporal domain. Within this context, we demonstrate the advantages of the SIGMA distribution and its IAF for modeling the complex dynamics of interacting agents, retaining non-trivial scaling properties at varying time horizons, supplying trended trajectories, and providing episodes of activity clustering. We further discuss how these attributes in such a framework may enable a better understanding of various military areas of interest such as human behavior modeling, and threat and regional stability assessments, as well as non-military applications such as random variable generation for complex distributions.

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**11647 - Reducing Residential Energy on Military Installations**

The genesis for residential energy analysis is simple - West Point and nearly every other military installation need better assessment methods to rate the energy efficiency of its residential buildings. Modeling the energy consumption of these residential homes is critical in determining the most economic energy upgrades with short payback periods. These energy models also allow improvements to be made on the current utility billing program, which incentivizes residents in military housing to reduce their energy consumption. This presentation uses West Point's residential homes as a case study to show a systematic approach that can be used to move towards large reductions in annual energy bills. West Point is using the process of modeling the energy fitness levels of their homes for energy assessments, economic energy upgrade selection, quality assurance, and creative utility billing incentives for people who do not pay for their own energy usage. Ideally, the systematic process prototyped in this case study will be used by installations around the military, resulting in a significant amount of savings.

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**12197 - Specialized Tools for Enterprise OPNET Modelling**

This presentation introduces how a specialized set of tools can be created to facilitate the use of Riverbed SteelCentral (formerly VNE Server and OPNET Network Planner) in an enterprise ORMS environment. Currently Riverbed’s Network Modelling applications are problematic to use in a dynamic, highly collaborative ORMS environment where numerous models are concurrently developed by multiple modelers. By developing tools and techniques, modeling teams can create a scalable environment allowing for the rapid development of reliable network models.

The case study illustrates how a robust set of tools were created to work in conjunction with Riverbed SteelCentral Suite. These tools allowed for configuration management of models, increased efficiency by the automatic of routine tasks, and ability to scale network model development across multiple modelers.
12247 - Identifying Optimal Hybrid Energy Technology Sets for USMC Deployments

The USMC Expeditionary Energy Office (E2O) is collaborating with Sandia National Laboratories (Sandia) to develop a capability to assist decision makers in identifying feasible hybrid power technology sets for use in potential future Marine Corps deployments. The solution sets consist of an optimal trade space of diesel generators, photovoltaics (PV) and battery storage that best satisfies the power demands for deployed units with the lowest cost while providing reliable power, maximizing silent watch, and reducing fuel-use as much as possible. The Sandia-developed Microgrid Design Tool (MDT) which employs a genetic algorithm was used to perform the multi-objective optimization across the conflicting criteria. By modeling a variety of potential unit deployments, decision makers can get insights as to which energy technology sets would be most useful to the Marine Corps. When results are rolled up across sets of units representative of Marine Expeditionary Brigade and Marine Expeditionary Unit configurations, decision makers obtain acquisition insights about the quantity and type of energy systems in which to invest. This approach is proving useful for other areas besides acquisition, such as requirements validation, energy system design, as well as operational energy planning.

12605 - An Experimental Design Approach that Illuminates System Design Trade Decisions among Several Viewpoints

System Engineers rely on a variety of models to help understand different viewpoints in several domains throughout a system’s life-cycle. These domain models include operational simulations; life-cycle cost models, physics-based computational models, and many more. Each of these models has their unique set of inputs and outputs. Model inputs represent value properties that define a system alternative configuration or environmental conditions that represent uncertain factors within the system boundary. Model outputs represent measures of performance or effectiveness that allow us to assess alternatives and understand the tradeoffs among several objectives. In order to illuminate the tradeoffs that exist in a complex system design problem we propose an approach that approximates model input and output behavior using the functional form of statistical metamodels. After performing an experimental design we can fit a metamodel that has a functional form known as a response surface. We utilize contour profilers that show horizontal cross sections of multiple response surfaces to visualize where key trade decisions exist. Our purpose is to illuminate trade decisions across several different viewpoints by integrating metamodels that approximate the behavior of multiple domain models. Our research supports the tradespace analytics pillar for the development of the Engineered Resilient System (ERS) Architecture. ERS is a Department of Defense initiative developed by the US Army Engineered Research Development Center. The purpose of ERS is to leverage information technology to create a digital thread of architectural decisions accessible to multiple communities of interest to inform better manufacturing options during a system’s life-cycle.

12321 - Global Mobility Network Analysis: An Application of the Scientific Python Stack

The objective of this research is to characterize the robustness of the Air Mobility Command’s en-route base network. In this talk we describe our computational method to solve for cargo throughput on a global scale, given different network and air fleet configurations. A global framework affords us a strategic perspective on the effects of base closures and capacity changes. An important methodological thrust is our application of contemporary computational tools and agile, collaborative development methods. Built on the expansive scientific Python tool stack, this work highlights the value of modern computational tools in model development and policy analysis. This seminar will include an interactive demonstration using the Jupyter literate programming environment, which fuses code development, documentation, web applications and dynamic visualizations.
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**12215 - Data Readiness, insights into the application of “Big Data” technologies within DOD**

Technologies for managing large sets of data have matured significantly over the last decade. In principle, data aggregated from across the enterprise will reduce the time required to do deep, rapid analysis. This has opened new possibilities for the military Operations Research (OR) community but has also highlighted challenges in both policy and enterprise systems architecture which must be overcome in order to facilitate “Big Data” analytics. The OR community has a unique opportunity to be at the forefront of translating data into actionable information that is able to support good decision making. The question is how to take advantage of these technologies within the DOD IT infrastructure. To help address this question, the Marine Corps has sponsored a “Big Data” proof of concept in an attempt to harness the inherent scalability of modern data technologies. During this effort which attempted to leverage large volumes of data from both logistics and manpower information systems, Data readiness emerged as a key issue which must be addressed in order to realize the promise of big data technologies. This paper reviews the lessons learned during this proof of concept and examines what it means to be “Data Ready”.

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**12178 - Development of a Multivariate Analysis Technique for Rapid Outlier Detection in High Volume, Highly Dimensional Data**

Outlier detection in highly dimensional data is challenging because the any sparsity in data can render traditional proximity measures ineffective by themselves. In applications characterized by highly dimensional data, such as cybersecurity, outlier detection is often based on lookups from libraries representing past behavior. In this work, we propose a novel approach to employ multivariate hierarchical clustering, linear regression, and expert knowledge in a self-learning outlier detection scheme to identify outliers within large amounts data based solely on their current characteristics, rather than any previously defined business rules. This approach has been tested on highly dimensional data related to malicious code detection and audit readiness applications for U.S. government clients and has shown the ability to identify outliers with approximately 99% reduction in human analyst time.

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**11413 - Royal Australian Navy: navigating our way into navigational data**

In the past few years evidence based decision making has become one of the catch cries of the big data phenomenon. This has seen both Google and Facebook efforts leading to open source software to analyse big data sets as part of the Hadoop ecosystem. Additionally, the role of data scientist has been declared as the sexiest job of the 21st century. The Royal Australian Navy (RAN) has a vast array of information available via electronic navigational display systems. Amongst other things, this includes: position; velocity; water depth; weather information; and maritime traffic information. With recent Navy 2-star sponsorship, all vessels are required to submit their navigational log files to the Defence Science and Technology Organisation for analysis; this could amount to 1 terabyte of plain text data each year. Demonstrating the value of this data, we have undertaken three rapid studies. The first study provided the RAN with analysis of patrol boat speed profiles categorized by activity. The second study concerned patrol boat wharf-space usage in Darwin. And the final study (ongoing) seeks correlations between navigational and meteorological data and precursors of hull damage. These studies contribute to evidence-based decision making for patrol boat replacement. These examples lead to a discussion of military big data challenges in Australia, and the techniques we propose to overcome them. These include the use of big data techniques, heuristic methods for pattern recognition and statistical data exploration. Finally, we share our vision of how RAN’s future could be enhanced by embracing big data.
**12281 - Improving Information Access and Analytic Time for Analysts**

How many of us use Expedia or Orbitz or Kayak to book our travel reservations online? Those services disrupted the travel agency industry some 15 years ago by making it easy to find vacations based on prices, times, and availabilities that were all easy to access, sort, review, and choose across multiple sources. That same technology is now available for defense and intelligence analysts, budgeteers, and administrators. Instead of spending 90% of the time searching for, aggregating, and reformatting information, time is now spent making informed assessments based on that information, and creating more refined products, with the needed information pre-sorted and ready for use in a web-browser based interface that is point-and-click easy. This system has been developed and is being used by thousands of Intelligence Community members. Prior to this, analysts had to request permission to the tens of databases containing the information, each approved by the database supervisor. The query then had to be reentered onto each database, often in different format on a different interface, with results returned similarly.

Now, all of the results are listed in a simple prioritized way. Enabling analysts to focus on reading, analyzing knowledge and knowledge gaps, and making an informed report, with citation reporting simplified.

The presenters will detail the creation of the tool that aggregates all active intelligence requirements across all disciplines from 13 agencies, across all disciplines (SIGINT, OSINT, etc.) and presents results seamlessly in a single web-based interface, at the appropriate clearance levels.

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**12390 - Leveraging the Power of DoD Supercomputers to Advance Research, Studies, and Analysis**

This presentation discusses resources available to DoD analysts, researchers, scientists and engineers provided through the DoD High Performance Computing Modernization Program (HPCMP) and the Air Force Research Laboratory. In addition, the HPCMP mission will be discussed in terms of vision and dedication to solving DoD's most computationally complex problems. Examples will be presented to illustrate how High Performance Computing hardware, software, and domain expertise have been applied to support projects ranging from scientific research to system development and test.

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**12095 - On a Scale of 1 to 10, How Do You Feel About Surveys? Methods for Survey Development and Analysis**

Surveys are tools commonly used to assess attitudes and behaviors of various populations and often provide the only measures available to inform critical decisions. Despite the qualitative nature of surveys, their analysis is heavily reliant on quantitative tools and techniques. This presentation covers often-overlooked methods for survey development, distribution, and analysis. The purpose of this talk is to improve quality of survey data, assessment of overall attitudes, comparisons of attitudes across sub-populations, analysis of specific question responses, and techniques for free response comments. These strategies include the use of nonparametric statistics, factor analysis, automated text parsing, and new data visualization techniques. Our objective is to highlight best practices that maximize a researcher’s ability to derive accurate and actionable insights when using survey instruments.
12302 - Bayesian Enterprise Analysis Model (BEAM) Challenges

Air Force A9 is developing the Bayesian Enterprise Analytic Model (BEAM) to evaluate DoD capabilities. By enterprise, we mean more aggregate than campaign level simulations. We are searching for the best force structure across multiple scenarios with adaptive adversaries. Within a scenario, each side cycles through

1) Adjudicating mission engagement or combat
   a. Determine the probability distribution of engagements
   b. Evaluate the outcome of those engagements

2) Updating for the outcome of the prior cycle,

3) Evaluating status and progress,

4) Predicting adversary missions,

5) Assessing force requirements,

6) Allocating assets to missions, and

7) Assigning missions according to the strategy.

Our aggregation involves only general regions without precise positions. We further decompose the problem by evaluating effects by domain (land, sea, air, space) and limit interactions between other domain effects regions to the overall status. With these regions, we propose two steps in adjudicating combat. This presentation after presenting the intended modeling approach discusses four challenges in developing this model at a more aggregate level than a campaign simulation:

1) Appropriate aggregation of systems and units,

2) Evaluating the impact of intelligence,

3) Appropriate time steps, and

4) Implementing alternative strategies.

Suggestions and wisdom from our fellow MORSians are welcome.

12535 - Extreme Computing Environment for Electronic Warfare Modeling and Simulation

The Naval Research Laboratory has been developing an Electronic Warfare (EW) Modeling and Simulation tool for the past 15+ years called Interactive Scenario Builder. It is a mission planning and tactical decision making application that focuses on modeling the Radio Frequency (RF) environment in order to predict EW system performance. It is designed for directly answering what-if questions for the warfighter, providing reach-back mission support for forward deployed units, and for test and evaluation (T&E) use by system engineers. Currently much of the analysis process is manually driven, relying on the user to instrument different parameters by a manual set-run-set process and each run could take minutes to hours in order to complete. In order to determine an answer it could be a long and laborious process that could fail to give the optimum solution. Argonne National Lab in coordination with NRL has developed a generic framework for both increasing parallelization and allowing for automated usage of existing large-scale cluster computing resources within Builder and other EW modeling toolsets. This was done by utilizing the SWIFT scripting framework to abstract away the overhead needed to utilize cluster and supercomputer resources. This method also abstracts away the specifics of the cluster resources so the framework can be utilized in existing closed and/or classified HPC environments without ANL/NRL developers needing access to the specific systems. This is extremely useful in this context because many of the scenarios these EW models are meant to analyze are classified at various levels.
**12312 - ENVIRONMENTAL SENSING IN COMBATXXI TO FACILITATE REPRESENTATION IMPROVEMENTS OF STA AND MANEUVERS IN URBAN OPERATIONS**

Improved representation of the urban fight within combat models is increasingly becoming a critical requirement for the U.S. Army. Simulating the changing characteristics of urban operations presents many challenges for modeling and simulation tools. One important challenge to resolve is the ability to provide entities with critical knowledge about the environment in order to improve their interactions in urban settings and more effectively accomplish mission goals. Within the Combined Arms Analysis Tool for the 21st Century (COMBATXXI) simulation, a representation for sensing environmental objects was developed to allow entities to survey potential hostile environment and identify cover and concealment features to support optimized mission execution, maneuvers, and engagements. Entities will have improved environmental sensing, critical knowledge gathering, and knowledge management and sharing capabilities.

This presentation will describe initial modeling efforts to support sensing of critical environmental objects to improve the simulations of search and target acquisition process and maneuvers within complex urban environments.

**12067 - Making the Leap from Analysis to Analytics**

In his 1982 book, Megatrends, John Naisbitt noted, "We are drowning in information but starved for knowledge." The explosion in big (high volume, velocity, and variety) data on military networks only exacerbates this situation. Analytics help organizations close the gap between information and knowledge by multiplying the effectiveness of data analysis. This presentation provides an overview on making the transition from analyzing data to providing analytic tools that continuously provide the knowledge organizations need to make better decisions. Topics include: the big-data learning paradigm; how data architecture, data science, and software engineering must be integrated to build analytic tools; an overview of how freely available open-source software can (and is) being used on military networks (NIPR/SIPR/JWICS) to rapidly field analytic tools; and lessons learned from developing and deploying analytics in support of Defensive Cyber Operations (DCO) for Army Cyber Command.

**12604 - An Efficient Alternative to Monte Carlo using Statistical Convolution**

The presence of large wind turbine farms has been shown to significantly degrade radar tracking of aircraft. As wind turbine development expands, the North American Aerospace Defense Command (NORAD) must assess the operational risk to its aerospace control mission due to new turbine proposals. If the operational risk becomes significant, NORAD must raise its concerns through the Department of Defense. New models, specifically designed to address wind turbine interference with ground-based radars, are utilized to simulate both the losses in radar tracking continuity from wind turbine obscuration and the resulting impact this has on operations. Two analytical approaches, Monte Carlo and a convolutional “Direct Probability”, are considered to compute the probability of successfully intercepting an unauthorized aircraft. The presentation will highlight the efficiency of calculating the “Direct Probability” using statistical convolutions of individual probability density functions (PDFs) over the calculation of numerous Monte Carlo trials, where each trial samples only one value from each PDF.
12117 - Lessons Learned when creating an Artificial Neural Network

In the future, strike and reconnaissance aircraft will likely be tasked to penetrate an enemy’s Integrated Air Defense System (IADS) and execute their missions without the aid of defensive escort aircraft. These aircraft will require improved combat survivability via an onboard self defense system. The goal of the Self Protection And Reactive Technology for an Advanced Combat Utility System (SPARTACUS) program is develop, evaluate, and demonstrate technologies that provide enhanced defensive system management capability of available self defense resources. The purpose of this study is to explore various processes for data generation to train artificial neural networks (ANN) for use within the confines of the Zeus software. The two methods of data generation were: data collection based on successfully accomplished specific missions, and gridded generic 1-v-1 engagements with a ground based threat or single air based threat. A comparison was also accomplished between the use of a single ANN and the use of a composite ANN. Key metrics include size of the data set, speed of data generation, speed of ANN creation, quality of ANN generated (can it accomplish the mission), and flexibility of ANN generated. This presentation will review the analysis methodology and the results of recent analyses.

12606 - Modeling Complex System Behavior Using the SIGMA Distribution and IAF Framework

This research proposes the use of the Synchronous Interactive Gaussian Mixture Aggregate (SIGMA) distribution and its Implementation Assistance Framework (IAF) in order to leverage selected benefits of classical models with the complexity that can be addressed via simulation. Whereas classical modeling techniques often enable analytical solutions, improved modeling resolution to better emulate reality often divorces the results from closed-form solutions. In the extreme, simulation models enable the study of complex and interconnected systems over a temporal domain. Within this context, we demonstrate the advantages of the SIGMA distribution and its IAF for modeling the complex dynamics of interacting agents, retaining non-trivial scaling properties at varying time horizons, supplying trended trajectories, and providing episodes of activity clustering. We further discuss how these attributes in such a framework may enable a better understanding of various military areas of interest such as human behavior modeling, and threat and regional stability assessments, as well as non-military applications such as random variable generation for complex distributions.

12202 - Geospatial Analysis Methods using R and Google Earth

Novel methods for geospatial data visualization and analysis using R and Google Earth will be presented. Methods presented will include a spatial point density algorithm, temporal tendency algorithm, spatial tile chart plotting, and animations using Google Earth. Vignettes from previous analysis, both from deployed environments and traditional studies, will be included. The presentation will include discussion of state of the art spatial packages in R.

WG 30 Wargaming

11497 - Improving Wargaming within DoD

Discussion on the purpose and benefits of the use of wargaming within a larger cycle of research for the purposes of fostering innovation and agility.
### 12082 - A Framework for Designing Models, Simulations and Wargames

All models and simulations – including wargames – have a physical and social context as well as a structure that includes positions, events, rules, and moves. As the model or simulation is run or played to its conclusion, we observe patterns of behavior and outcomes. However, as designers, we do not always precisely specify the logic of our design in a way that clearly articulates the relationship between the context of the design, design structure, patterns of behavior, and results. Failing to do so increases the cost of development, and makes it difficult to replicate, compare it to other iterations or analyses, and to analyze and interpret results. Borrowing from methods used in policy analysis, I outline a general framework that can guide the process of design and make it easier to more clearly specify and describe design, patterns of emergent behavior, and outcomes.

### 11677 - Drive on Metz - Study Plan

WG-30 Wargames and the Wargame CoP are sponsoring the 'Drive on Metz' wargame at MORSS83. The purpose of the game is to expose the MORS community to the use of a wargaming method for analysis, education, and training. The commercial game 'Drive on Metz' was selected because it is UNCLASSIFIED and is easy to learn and execute in a short period of time. Previous MORSS provided opportunities for MORS members to become familiar with the tool. This MORSS will demonstrate how to integrate professional games into a formal analysis. This WG-30 session will present a formal study design to include the use of the game to answer an analytical question. Questions with corresponding measures of performance, research design, tools and methods, data collection plans, and post-processing methods will be included in the presentation.

### 12257 - Wargaming What You Would Rather Not

Wargaming, whether it involves tokens on a board, SME's in a smoke filled room, or sophisticated (at least large) computer simulations with some human in the loop (HITL) decision making, is often about predicting outcomes based on decisions we make as the “play” proceeds. In many instances, the outcomes are ones from history or at least are something within our recent experience—we have seen these outcomes, or their ilk, before. We thus can gauge “Is this wargame making sense?” and have some feeling as to the validity of what we learn from it. What then, when the potential outcomes from a wargame are things we have not experienced or hope, fervently, never to experience. These would include things like global-thermonuclear war, a continent-clearing bio weapon (smallpox as a part of the Columbian Exchange), or even chemical/biological warfare on a scale not seen since WWI. Does the rarity/severity/uniqueness of potential outcomes, impose any special considerations on how a wargame should be conducted or the interpretation of the results? This will be a discussion of available theory/thought and practice as experienced by the participants. This presentation will segue into a discussion of a recent wargame that looks at Chemical, Biological, Radiological and Nuclear (CBRN) warfare, something we hope not to see for real.
**11067 - Assessing the analytical utility of matrix games**

“Matrix games” were first developed by Chris Engle in the early 1990s as a free-form alternative to more rigid, rules- and capabilities-based games. Game play resembles an extended discussion of sorts, in which players take turns making arguments about an action they wish to take (or something else they wish to occur), and the effects they expect it to have if successful. The success of this is then determined by various means, and the effects adjudicated and applied. Matrix games require relatively little overhead or preparation time, can be conducted in a few hours, and are easily repeated.

This paper offers an overview of the ways in which matrix games are conducted, and potential variations in approach and format. It then offers a preliminary assessment of their analytical strengths, weakness, constraints, and potential sources of systematic bias; the role of facilitators; instrumenting and documenting games for subsequent analysis; and the integration of subject matter experts into game play. It concludes by pointing to the ways in which such games can be used to facilitate discussion, assist in scenario development, support course of action analysis, map out decision space, or conducted as a compliment to other wargaming and operational analysis tools.

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**11980 - Player Designed Wargames**

In a traditional game design process, the designer writes a set of rules, then creates components to implement mechanics in the rules, and then play tests the game to determine which aspects work well and which need to be changed. However, this process does not work in the case where a war game needs to be tailored for a specific purpose but with uncertain requirements. One solution to this problem is to develop a flexible system of components which can be used by the players to generate rules and tailor more specific units through designer guided game play. With this process the game is actually designed by the players within a designer created framework.

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**11498 - Consistent Theme Analysis of Long Term Wargame Efforts**

This presentation will examine the results of consistent theme analysis conducted on multiple games series executed by OSD Net Assessment over the course of more than a decade.

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**12021 - COIN Wargame Enhancements: Leveraging Quantifiable Components**

For several years, the Center for Army Analysis (CAA) has conducted strategic-level wargames to assess the sufficiency and composition of national security forces. Recent enhancements to the COIN wargame include: accounting for variable combat readiness among host nation security forces (using Markov chains); building a simulator to replicate the tabletop game’s probabilistic outcomes; and, developing a mathematical model (based upon conditional probabilities) that forecasts insurgent-attributed civilian casualties based upon host nation and coalition troop movements. These enhancements have improved the analytical rigor of the wargaming process, broadened the scope of research questions that it can address, and added a level of predictive power to the analysis. This presentation will discuss their underlying mathematical models, methodologies, and derived insights.
### 12314 - CASSANDRA Analytical Requirements

CASSANDRA is a table top exercise run by the Joint Requirements Office-CBRN Defense that is conducted periodically as part of larger risk assessment intended to help prioritize investments for the Chemical and Biological Defense Program. It is structured around a defense planning scenario into which adversary chemical and biological use is inserted, serving as the focus of discussion for the Services to examine existing and projected capabilities against various chemical and biological weapons. Computer simulation is used to provide quantitative assessments of the impact of CB use to help inform the discussion. This presentation will describe the CASSANDRA process, the steps required to insert adversary CB activity, define attacks, and assess impact. The presentation will also discuss analytical capability gaps that have been revealed through the CASSANDRA process.

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### 11890 - Board Gaming for Submarine Tactical Development

It has been said that “war gaming is at once the grandfather and the orphan of Operations Research (OR)” (Hanley, On Wargaming). Before modern OR methods were developed, organizations like the Naval War College configured tiled floors in large rooms to lay out paper search arcs and wooden speed leaders, push scale models and roll n-sided dice to explore and analyze naval warfare. Modern computer simulation techniques have made these techniques seem quaint and anachronistic to today’s analysts. Commander, Submarine Development Squadron (COMSUBDEVRON) TWELVE, faced with increasingly austere analysis budgets and decreasing opportunities to experiment at real-world acoustic ranges, has resurrected the spirit of pre-computer gaming to develop experimental tactics, explore new technologies and support concept development with classic methods of board gaming. This presentation covers the design and use of the Low Resolution Tactical Simulation (LRTS), a hex-board tactics simulation that combines real-world data, representations of existing platforms and emerging tactics with time-honored gaming principles to quickly and economically provide first-order analyses for the US submarine force tactical development.

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### 12072 - C2 Metrics to Improve Tactical Wargames

The recently completed Analysis Branch / Operational Analysis Division / Marine Corps Combat Development Command study, “Composition of the Infantry Battalion,” focused mostly on the size and composition of rifle squads but developed metrics for broader and larger-scale use. The study raised a number of issues about the effects of logistics, command, control, communication, and leadership style, beyond the scope and resources of that study. In particular, our review indicated that communication protocols, confusion and delay are factors that significantly affect performance; that these factors can be added to wargames fairly easily; and that they have mostly been glossed over, although some games have included them with substantial benefits to the analysis. Unit structure and logistics considerations interact with these variables and can also be included at least partially without undue extra effort.

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### 11775 - Small-Scale Wargaming to Support Long Range Precision Fires Analysis

The Army Tactical Missile System (ATACMS) is the Army’s long range, deep strike missile that provides surface-to-surface, all-weather precision fires beyond current cannon and rocket ranges. Termination of the ATACMS program in 2007, due to budgetary concerns, will result in a capability gap. The LRPF AoA was initiated by the Office of the Secretary of Defense, Cost Assessment and Program Evaluation in 2013, to examine alternatives that mitigate the capability gap resulting from the loss of capability provided by ATACMS. The AoA examined the impact of ATACMS during large scale, traditional theater operations as a part of the Joint force. ATACMS and other LRPF AoA alternatives provide highly accurate, quick response, and effective fire against a variety of targets to the Joint Force Commander, providing flexibility during targeting operations. While robust combat modeling focused on the role of LRPF in setting conditions for the Joint Force Commander early in a campaign, the execution of a small-scale wargame was essential to supporting a holistic assessment of the role of LRPF throughout the ground maneuver operations phase and its role as an enabler to the ground commander. The focus of this brief is the use of a seminar wargame to identify the impacts of ATACMS to a ground maneuver commander supporting a Joint operation. The wargame assessed how a Corps staff integrates long range precision fires into their scheme of maneuver or crisis action plan. The results provided insights into the risk associated with losing the Army’s long range precision fires capability.

### 11812 - A Methodology for Determining Critical Decision Points in COA Analysis of Wargames

Today’s military is engaged in complex conflicts and operations across the globe. Military planning is crucial to achieving military objectives, and is made increasingly challenging due to the dynamically changing operating environment. This strains the decision making process because Courses of Action, COAs, must be evaluated continuously. Currently, COA evaluations require wargaming outputs to be matched with multi-attribute decision making, MADM, methods to arrive at an order. However, time constraints influence the decision making process by limiting decision space evaluation, resulting in reduced enumeration of COA alternatives and severely limiting COA development and analysis. A largely unsearched decision space represents a potential for wasted opportunity, while full enumeration represents a sizeable time investment in a time constrained process. The research objective is to create a methodology that identifies critical decision points within a COA, in order to provide a sufficient search of the decision space with minimal time investment. Through experimentation, it will be shown that measuring position, capability and awareness during agent based simulations can be utilized to determine critical decision points. Furthermore, it will be shown that identification of critical decision points will allow a statistically significant sampling of the decision space. It is expected, that this methodology will afford decision makers time by directing their efforts, allowing them to keep up with a continuously evolving operating environment. This will inform a limited decision space evaluation, hastening the decision making process and allowing decision makers to keep pace with a dynamic battlespace.
### 11894 - Expanding Missile Defense through Multinational Experimentation & Wargames: Design & Assessment Methods

We are reminded daily of the realities that threaten our well-being. The global threat from missile attack remains credible and is becoming more dangerous as the threat continues to proliferate and mature. In this increasingly connected, fiscally constrained world, cooperation coupled with interoperability among allies on missile defense is more important than ever. We can do more together by pooling our resources and learning from each other. Our security depends on the ability of the US and allies to address missile risks before they become crises. NIMBLE TITAN (NT) is one of the only venues for the U.S. and allies to achieve this. NT is a series of unclassified, two-year, multinational, Ballistic Missile Defense (BMD) experimentation and wargames. Participants examine regional and global BMD policy and operational concepts that are needed to conduct coalition missile defense. Over the past decade, participation has expanded from six nations to twenty-five, as like-minded nations from the Pacific, Europe and Middle East regions join the campaign. Their active participation continues to generate a learning environment, the opportunity to address multinational missile defense challenges and the ability to develop solutions.

The presentation focuses primarily on the design, analysis and outcomes of the recently completed NT 14 Campaign. It describes the objectives development, experiment and wargame constructs design process, and data collection and assessments methodology; and highlights key findings. The presentation concludes with a request for recommended improved designs and assessment methods, leveraging the expertise in the working group.

### 12256 - MakeGoal: A Training Game for Navy Recruiting District Leaders

Effectively allocating recruiting resources in order to ensure recruiting goals are met while maintaining recruiter quality of life is a challenging problem. The relatively high turnover of recruiting district leaders and lack of data driven training tools serve to compound this problem. This research produced a proof of principle web-based game intended to train Navy recruiting leaders on the use of analytics to enable decision making. Players seek to meet their district recruiting goals by allocating recruiters to stations while also trying to maintain recruiter quality of life. The game makes use of actual recruiting data and uses a poisson regression model to determine a players expected recruit production each turn. The general methodology employed could be applicable to other settings where the need exists to identify an areas potential in order to set production goals and allocate resources.

### 11659 - Training Local Government Leaders to Make Sound Emergency Management Decisions

Local level government leaders such as mayors, county managers and even military installation commanders serve in their capacity as government decision makers for not more than three years in a single term. This is a very short time in which to grasp the emergency management functions, resources, procedures, and threats that exist in any given community particularly when the leader is new to the community or new to emergency management practices. This critical task is often crowded out of the top priority practice; therefore, the government leader is heavily dependent on various department directors to provide him/her with enough information to make informed and sound decisions in the event of an emergency or disaster incident. A prototype program was developed to train local government leaders in using their resources effectively. In essence, this is a non-military version of a Wargame. The program incorporates three distinct elements: video scenarios, live decisions made at critical decision points and feedback on the performance using a comparison with national standards.
**WG 30**

**11801 - Innovation Games: Using Wargaming to Improve Technology Innovation in Research and Development**

Wargaming has a long history as a vehicle for exploring complex issues at the nexus of human behavior, technological change, and strategy. Wargames are widely used by military forces for analyzing operational issues, and increasingly by industry in developing commercial strategies and conducting competitor analysis. However, wargames are an under-utilized tool for user-centered design of new technologies. This paper will examine how wargames can inform what is often referred to as the “fuzzy front end” of technology innovation – the earliest stage of development characterized by iterative rounds of idea generation and conceptual analysis. Specifically, case studies of three “innovation wargames” run by the U.S. Army will be used to illustrate applications of wargaming in participatory design of new military technologies, user research, and concept refinement. These games helped the Army science and technology (S&T) community better understand warfighter needs in small unit operations and generate new ideas for technologies that could enhance the capabilities of Soldiers and small units across a range of kinetic and non-kinetic operations. The key insight that emerges from these case studies is that wargaming provides a singularly valuable and visceral tool for connecting scientists and engineers with warfighter needs. In doing so, wargames have the potential to greatly improve the quality of research and development efforts, saving both time and money. The case studies will address the design of innovation games, discuss how each game influenced Army S&T planning, and examine best practices for using wargames to inform technology innovation efforts.

**WG 31**

**12022 - The Argonne Below Ground Model: Passenger Dynamics, Exposure and Fomite Transport**

The Argonne Below Ground Model (BGM) has been developed to provide a comprehensive simulation capability for analysis of airborne chem/bio threats to subways at both a system and station level. To assess health consequences of an attack, BGM also incorporates an agent-based population effects component in which movement of each person in the system is independently modeled, allowing their individual exposures, resulting health effects and patron responses to be assessed. In a chemical attack, passengers may react in response to the characteristics of the agent and their level of exposure, and their collective reaction may subsequently influence system operators’ responses, potentially resulting in station evacuation and altered or halted train operation. Although passengers would generally be unaware of a biological attack, bio-particles may deposit on passengers’ clothing and then be shed (re-aerosolized) throughout their trip and even after they exit the subway. In effect, passengers may become mobile sources of bioagent (“fomite transport”). In addition, bio-particles deposited on station or train car floors may be resuspended by the action of passengers’ footsteps, or they may adhere to the passengers’ shoes and be re-deposited elsewhere. The presentation will describe the dynamics of passenger movements in subways; passenger exposure and response to chem/bio agents; and agent transport by the passengers. Examples of the model results for various transit systems will also be presented.
11934 - Enhancing Resource Protection and Operational Availability using in-situ Icing Threat Identification and Avoidance Technologies

The fidelity of weather intelligence is inversely proportional to the time of interest (i.e., forecasts for longer periods into the future generally have less precision and accuracy than shorter term forecasts), often times forcing operators to make go/no-go decisions based on sub-optimal information. Unlike their manned counterparts, most Remotely Piloted Aircraft (RPAs) lack the ability to visually survey their operational surroundings to assess environmental threats; this decreased situational awareness often times drives the use of overly conservative tactics, techniques and procedures, assuring platform viability at the expense of mission availability. This paper presents an innovative solution to the problem of decreased situational awareness associated with RPA operations, specifically relative to the threat of in-flight icing. State-of-the-art sensor technologies have been coupled with fuzzy-logic techniques to provide in-situ measures of atmospheric parameters necessary to assess the probability of aircraft icing. These tailored (i.e., platform specific) threat assessments are downlinked in real-time to operators for action. Quantified benefits of this new technology act to reduce the area of massive no-fly zones based on limited a priori knowledge of the state of the environment, and include: enhanced in-flight decision support, increased operational efficiency and availability, heightened RPA resource protection, and increased on-station ISR coverage times. Analytic case studies highlighting the utility of this innovative approach will be presented, along with discussions relative to pilot feedback.

11852 - Complex Military Mission Environment (CM2E) Model

Today’s military operates in an interconnected and complex world. The pace and global impact of actors pursuing varied and often conflicting objectives add to the complexity. These complex environments are primarily defined by the human domain and impacted by cyberspace, public opinion, religion, and culture as well as the infrastructure, political, economic, and legal systems. One of the many challenges of experimentation in complex environments is the ability to simulate and measure abstract factors (e.g., political, social, cultural, and economic) of an operational environment.

The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) designed a model that decomposed the operational environment into two key components: (1) the abstract factors and their interactions that best represent the complex environment; and (2) the actors conducting actions that impact those factors. Over the past 2 years, the TRAC team decomposed the Joint doctrinal operational variables of PMESII into a conceptual model of 900 observable and measurable variables with 810,000 potential interactions. Further review of social science theory, military doctrine, and operational experience from Iraq and Afghanistan enabled TRAC to reduce the modeling construct into a universal and validated subset of 69 variables and 672 interactions. TRAC derived simple algebraic models describing the strength and direction of these variable interactions through regression analysis on empirical data. These inter-operable models represent a complex environment and provide the experimental space for complex military missions.

The second key component was developed in a closed-form modeling construct using a newly developed TRAC application called N Equals X/Discrete Event Simulation (NEX/DES) engine. The actors and their actions are decomposed and simulated in the form of highly adaptable decision tables. The hypothesized and measured effects of those actions are integrated into the complex environment model. This modeling capability provides an adaptive and simple analytic tool for hypothesis testing, experimentation, and comparative analysis.

This briefing will discuss TRAC’s approach to developing this capability as well as how this capability is aimed at being an easy to adapt, closed-form model that is designed and used by analysts.
recently completed a pair of studies on surge operations, changes in violence, and environmental data in Baghdad and the Belts. Monitor an array of environmental data (political, economic, military, social) to see if conditions in an area were worsening. IDA explains over 80% of variability in IED activity. IDA developed, and US Forces Iraq adopted, an "Instability Forecasting model" to some "best practices" on how to develop community resilience assessment frameworks to perform community resiliency assessments. In this presentation we will provide a comparison of some of the existing frameworks, there is no "one size fits all" solution to how these assessments should be made. Multiple frameworks exist or are under development. Community. Once an initial state is assessed, one can then do assessments of the range of disruptive events you want to be resilient to. In general, the effort to make a city or country more resilient must start with an assessment of the basic state of the conditions in the community. There are a number of ongoing efforts to develop approaches and methodologies to make cities and regions more resilient to disruptive events. Two examples are the Rockefeller Foundation’s 100 Resilient Cities Centennial Challenge and the United Nation’s Hyogo Framework for Action. In the first, the focus is on making 100 cities from around the world more resilient at the city level and the second is on making countries more resilient to natural disasters and climate change. In general, the effort to make a city or country more resilient must start with an assessment of the basic state of the conditions in the community. Once an initial state is assessed, one can then do assessments of the range of disruptive events you want to be resilient to and the desired end state. For the purposes of this presentation, we will use the word “community” to apply at both the city and country levels. There is no “one size fits all” solution to how these assessments should be made. Multiple frameworks exist or are under development to perform community resilience assessments. In this presentation we will provide a comparison of some of the existing frameworks, focusing on what are the requirements for a robust and adaptable framework for performing community resiliency assessments. While there is no single framework that can meet the needs for all community resilience assessments, we shall provide recommendations on some “best practices” on how to develop community resilience assessment frameworks
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**11666 - Utilizing Socially Impacted Analytical Measures to Support Resiliency Assessments for National Security Studies**

There are a number of global initiatives that are assessing how resilient countries and regions will respond to various disruptive events, such as natural disasters, climate change, and social unrest. These initiatives are utilizing different metrics to assess how well the countries can respond to the disruptions. In some cases, the initiatives rely on “self-assessments” completed by internal agencies, which can lead to issues in assessing the validity of the results. This can also lead to issues on how external groups (e.g., donor countries and non-governmental organizations) determine how they might respond in a given situation.

The goal of these analyses is to provide an objective assessment as possible. Some of the metrics being used are based on directly measurable factors (e.g., life expectancy) while others (e.g., governmental transparency) are highly subjective and may require considerable interpretation. In both cases, these resiliency metrics will be linked to underlying, contextually-driven social, cultural, and environmental features of the country or region being studied.

One major global initiative is the United Nation’s Hyogo Framework for Action (HFA), which was begun in 2005 with the goal to make countries more resilient to natural disasters and climate change. Achieving these goals ultimately benefits United States (US) national interests because if countries are more resilient they are less likely to be reliant on US, international, or foreign support. The HFA has completed its first 10-year plan and self-assessments have been generated of the progress made in meeting the HFA goals. Argonne has conducted an analysis of the HFA self-assessments using a number of objective measures from different sources. In this presentation we will present the results from those assessments and discuss how similar kinds of analyses could be used to support other resiliency assessments in the future.

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**11453 - Optimal Security Force Assistance Strategies through Stochastic Linear Programming and Discrete Event Simulation**

Security Force Assistance (SFA) exists in complex operational environments that cultivate interactions between social, economic, cultural, and other population-centric factors. Strategy planners must be comfortable with the concept that, when it comes to strategic focus, resources, and funding for these missions, more is not necessarily better. Specifically, variables that define a nation’s absorptive capacity and economic strength diminish the effectiveness of SFA operations when certain aspects of these operations violate their constraints. The lack of an apparent relationship between SFA/SC funding and effectiveness motivates analysis of redistribution with respect to strategic focus and resources, thereby inviting a stochastic linear programming model with the objective of maximizing SFA/SC effectiveness as subject to constraints described by absorptive capacity and economy. Optimal SFA/SC strategies, once defined, feed a regression model that maps normalized SFA/SC propensity values to State Fragility Index data. This time-series database interacts with target SFA/SC effectiveness to drive a discrete event simulation model for approximating the time required for the optimal SFA/SC strategy to manifest itself in any given nation. This analysis provides decision makers with the opportunity to gain deeper understanding of the environments within their sphere of influence and to compile their gained knowledge to facilitate a higher-level strategy that anticipates variability.
12582 - Estimating Damage to Electric Power Distribution Caused by Hurricanes

Each year the Electric sector, one of the 16 critical infrastructures monitored by the Department of Homeland Security, faces challenges from hurricane winds damaging local distribution systems directly and indirectly through downed trees, etc. Gaps exist in the current knowledge of the relative magnitude of the threats that the Electric sector routinely encounters in comparison with the probable impacts. Since commercial electric power is a life-line sector, necessary for many other sectors to continue to operate, estimating the impacts prior to the storm making landfall is of great value. Structured assessments and tools would provide greater understanding of hurricane threats to the Electric sector in the Gulf Coast and Mid-Atlantic States, thus providing a critical source of planning data to decision makers.

To enhance the prediction techniques, a tool called HEADOUT (Hurricane Electrical Assessment Damage Outage) was developed to produce estimations of the potential number of electric customers that will experience a loss of commercial electrical power as a storm makes landfall. The HEADOUT Tool was developed using ESRI’s ArcMap, spatial analysis software, as a platform. The tool uses data inputs from the National Hurricane Center (NHC); therefore, simulations can be updated in real time as NHC provides 6-hour updates for an approaching hurricane. Using NHC data, the HEADOUT Tool estimates the wind speeds of the approaching hurricane and applies a fragility curves—a statistical tool representing the probability of exceeding a given damage state (or performance) as a function of an engineering demand parameter. This fragility curve is a proxy of determining the damage to the electrical distribution grid and potential of customers without electricity.

The development of the HEADOUT Tool was twofold, in that it helped to facilitate the research and validation of fragility curves. An empirical analysis of three different fragility curves was tested against over 20 historical tropical cyclones. Data for these events were collected by the authors and the result of HEADOUT were compared to the number of electric customers that lost power as reported by electric utility companies. The results of the analysis show one of the fragility curves to be a great improvement over previously used curves. The results also serve to provide a baseline to continue testing and improving the fragility curves.

11993 - Army H-60 and H-47 Helicopters Historical Brownout Accident Analysis

Current military operating environments include helicopter landings into unimproved sites and recurring weather phenomena which create dust clouds, obscuring aircrew vision and introducing additional flight hazards. This helicopter dusty-landing profile, known as brownout, has caused hundreds of accidents in recent decades, resulting in injuries, fatalities, and millions of dollars of destroyed aircraft. Dust-penetrating sensor technologies that enable aircrews to maintain situational awareness may be used to reduce risk in brownout conditions. A Defense Acquisition initiative directed an Army analysis of alternatives to determine applicability, practicality, and appropriateness of integrating this capability with Army Aviation, specifically the H-60 Black Hawk and H-47 Chinook helicopters. The analysis of helicopter brownout accidents includes two efforts: historical examination and forecast modeling. Historical analysis encompasses 30 years of accident trend identification and assessment to determine environmental factors, root causes, and accident type distribution. Modeling uses a Monte Carlo simulation based upon a Poisson distribution of potential accidents, incorporating aircraft types and quantities, flight environments, and expected operations tempo in future defense scenarios. The results of the forecast modeling are converted to equivalent constant year costs of aircraft loss and damage, and associated accident casualty estimation (non-cost effects). This enables a preliminary cost-benefit assessment for the technologies as a snapshot of the current state of the art.

The presentation will include the overall historical brownout accident examination and trends, the methodology of accident distribution analysis, and considerations used in forecasting brownout accidents and casualties.
12288 - GEAR: A User-Friendly Platform for Spatial Decision Analysis

The ever-growing availability of geospatial information is providing new opportunities to apply decision analyses using spatial data for a broad spectrum of use cases. Currently, there is a lack of GIS-based decision-analytic tools that integrate this decision driven process within a widely accessible, robust geoframework environment, designed for user-friendly interaction. Here, we present the newly developed GEAR (“Geocentric Environment for Analysis & Reasoning”) platform for supporting complex decision analytic capabilities such as cognitive filtering of key mission factors, dynamic modeling of diverse data, and Multi-Criteria Decision Analyses (MCDA). These support military decision making that often involves consideration of multiple, conflicting geospatial factors and dynamic state variables. Implemented concepts from decision analysis provide a flexible, quantitative, and transparent process for comparing and prioritizing geospatial alternatives, taking into account mission-specific criteria, tradeoffs, potential scenarios, and risk preferences. The assimilation of decision analysis into GEAR improves existing gaps in the data-to-decision workflow by integrating and normalizing disparate sources of information, incorporating real-time data, and allowing for nonlinear, iterative, and adaptable model development to support rapid changes in the Battlespace Environment, mission objectives, and availability of data sources. Through the proposed workflow, a user can ingest and modify heterogeneous data types, exploit temporally tagged data sources, create multi-criteria decision analysis models, and visualize the final process results in an iterative and collaborative workspace. A sample case study is presented.

14701 - Modeling the Asia Pacific Environment

The Asia Pacific region is both large and crowded. Over two billion people call less than 15% of the 2.5 million square mile region of interest home. From the basics of daily meals to the complexities of world commerce, many of these people’s livelihoods are dependent on accessible seas. Countless surface vessels ply the waters fishing and moving raw materials, finished products, people, and petroleum in and out of over a third of the world’s busiest seaports. In addition, through consistently overcast skies, the region hosts over 30% of the world’s busiest airports with air congestion rivaling that of North America. An illustrative model that included these commercial and civilian activities was constructed and executed to help understand the complexity and scope of Phase 0 challenges found in the Asia Pacific region. The same model might also identify underlying assumptions and provide insights to decision makers investigating the management of potential regional conflicts as they escalate through later phases. This presentation gives an overview of the model content and analysis findings.

11664 - Assessing the Ability of Countries and Regions to Respond to Climate Change and Natural Disasters

The threats from climate change impacts and sudden natural disasters, including extreme weather events, are forcing countries and regions to consider how they might cope with these disruptive events. Natural disasters, such as tornadoes or earthquakes, occur abruptly over a time scale of minutes to days and cover spatial areas that are generally limited (~ a few hundred square miles.). Climate change impacts will occur gradually over time scales of years to decades, but cover larger spatial areas. Thus, plans for coping with these events will have to be developed at country and regional levels.

In a previous MORS presentation, we discussed ongoing activities focused on helping countries develop plans to respond to natural disasters and climate change. We described some of the techniques used to develop those plans and to assess the progress being made in achieving the goals.

In this presentation we will present results from an analysis of data from countries that are participants in the Hyogo Framework for Action (HFA), a United Nations (UN) effort that begin 2005 with the goal to make countries more resilient to natural disasters and climate change impacts. We will present results using the HFA self-assessment data combined with other data that can address both the will of the countries to prepare for climate change impacts and natural disasters as well as their potential ability to accomplish their goals. These kinds of assessments are important from a National Security perspective because many of the countries are in regions where the potential for conflict is already high. These assessments are also important because it is recognized that the resources required may far out strip the ability of the countries to respond without external resources from donor countries.
WG 31 Special Operations and Irregular Warfare

WG 31 - Multi-Criteria Logistics Modeling for Military Humanitarian Assistance and Disaster Relief Aerial Delivery Operations

Given that it is not always feasible to reach an affected area via land or sea within the first week following a natural disaster, aerial delivery provides the primary means to rapidly supply the affected population. In this work, we proffer a multiple criteria decision analysis (MCDA) framework to optimize the military humanitarian assistance/disaster relief (HA/DR) aerial delivery supply chain network. The model uses stochastic, mixed-integer, weighted goal programming to optimize network design, logistics costs, staging locations, procurement amounts, and inventory levels. The MCDA framework enables decision-makers to explore the trade-offs between military HA/DR aerial delivery supply chain efficiency and responsiveness, while optimizing across a wide range of real-world, probabilistic scenarios to account for the inherent uncertainty in the location of global humanitarian disasters as well as the amount of demand to be met.

WG 32 Special Operations and Irregular Warfare

WG 32 - The New Fundamentals of Assessment

The New Fundamentals of Assessment
Adam Shilling, PhD
Center for Army Analysis
Key words: Assessment, Operation Assessment, Campaign Assessment, Organizational effectiveness, Decision-making
Operation Assessment has some fundamentals that have emerged from the experience of the last several years, and that are beginning to emerge in the proto-doctrinal publications that have been published in 2015. The author, a member of the doctrinal working group, has articulated a set of principles that revise the way assessment has been done. The most important of these is that the primary purpose of assessment is to make operations more effective. It is not to "measure progress" or "inform decision-making." It is not about writing a report. It does all of these things, but its purpose is to achieve our objectives more effectively; its product is a more effective operation. This brief discusses these issues and the new vision of building assessment frameworks that comes from new manuals.

WG 32 - Epistemological Problems with Assessment Metrics

Epistemological Problems with Assessment Metrics
Adam Shilling, PhD
Center for Army Analysis
Key words: Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Metrics, Measures, Measure of effectiveness, Measure of performance, MOE, MOP, Indicator
The metrics regime inherent in the JP 1-02 definitions of the terms, measures of effectiveness (MOEs) and measures of performance (MOPs), and explained in publications such as the Joint Staff J7’s Assessment Insights and Best Practices Focus Paper have what the author terms "epistemological problems” that complicate our mental models and confuse our thinking on assessment. This brief articulates these problems and explains the need for change. It supports and explains the changes in the definitions of these terms found in Joint Doctrine Note 1-15, Operation Assessment.
### 11916 - Advanced Topics in Operation Assessment

**Advanced Topics in Operation Assessment**  
**Author:** Adam Shilling, PhD  
**Center for Army Analysis**  
**Key words:** Assessment, Operation Assessment, Organizational effectiveness, Decision-making, Aggregation, Thresholds, Commander centric  

We have evolved ways of doing operation assessment that have cemented some ways of doing things that are less useful than we imagine. For example, it is common to aggregate several related indicators to achieve some sort of "score" that we imagine demonstrates our progress. However, given that the purpose of operation assessment is to make operations more effective, what we are really looking for are problems needing solution or opportunities to improve the efficiency or effectiveness of our activities. Aggregation hides these sorts of details, and obstructs the reason for doing assessment. This brief discusses this issue and others to prompt some discussion and debate, and perhaps some reconsideration of the way things are done. It also posits some helpful ways to look at some assessment problems for which metrics regimes may be less useful.

### 12569 - Detecting Cheaters, Curbstoners, and Anomalies - A data driven approach to survey vetting

As we remove "boots on the ground" from places like Afghanistan, the Philippines, and the Horn of Africa, commanders must increasingly rely on alternate data points to inform assessments. Public Perception data is a key piece of information used by many commands and agencies worldwide to make decisions. Due to documented cases of fraudulent activities and the often strange behavior of public perception data, concerns about quality and usefulness of survey data linger in the minds of many decision makers and analysts. This paper proposes using data driven and statistical approaches to detect and identify abnormal interviewer behavior. A scoring system is proposed to quantify the quality and risk associated with data from each individual interviewer. The methodology was applied and tested using both the Gallup World Poll as well as the ISAF ANQAR survey.

### 11941 - Multi-attribute Decision Making in Dark Network Analysis

In this article, the authors present background and analysis on the Koch brother’s dark money network. An AHP/TOPSIS hybrid model is used to find the key nodes of the network. The analysis of the key nodes leads to improved targeting strategies against the network. Game theory applications using kinetic versus non-kinetic strategies in dealing with the network is developed after using AHP to obtain cardinal utility from the ordinal ranking originally provided. These methods provide additional metrics and analysis that can be employed in dealing and analyzing any dark network.
Since 2002, The Combined Joint Task Force – Horn of Africa (CJTF-HOA) has been operating in support of Operation Enduring Freedom; the only CJTF in the U.S. Africa Command (USAFRICOM) Area of Operations (AOR). CJTF-HOA was established on 19 October 2002 in response to the attacks on September 11, 2001. CJTF-HOA was originally a component of U.S. Central Command (USCENTCOM), but was transferred to USAFRICOM on 1 October 2008. Beginning in October 2011, the Center for Army Analysis (CAA) deployed analysts to Djibouti, Africa on six month rotations to support CJTF-HOA.

In the current environment of increasing budget constraints, CJTF-HOA is placing renewed emphasis upon prioritization of operations, actions, and activities (OAA). One of the most widespread types of OAA conducted by CJTF-HOA is that of military-to-military training and advising, such as pre-deployment assistance to African countries who are members of the African Union Mission in Somalia (AMISOM) in preparation for deployments to Somalia. CJTF-HOA has recently undertaken an effort to identify, assess, and prioritize its OAA so that it can better align operations and allocate resources accordingly.

Analytic efforts include: integration of operational assessments into the command decision making process; development of an operations assessment framework for the CJTF-HOA campaign plan; analysis of the level of impact from OAA using data from the CJTF-HOA Combined Information Data Network Exchange (CIDNE) database; analysis of SIGACT data from the AMISOM Force Headquarters (HQ); analysis of Public Perception Surveys beginning in March 2013; analysis of trends associated with information sharing between CJTF-HOA and East African countries using the AFRICOM Data Sharing Network (ADSN). The insights from these analytic efforts support planning and command decisions for current operations conducted not only by CJTF-HOA, but also by other U.S. partners in East Africa.

### 11559 - Analytic Support to Combined Joint Task Force - Horn of Africa (CJTF-HOA)

Since 2002, The Combined Joint Task Force – Horn of Africa (CJTF-HOA) has been operating in support of Operation Enduring Freedom; the only CJTF in the U.S. Africa Command (USAFRICOM) Area of Operations (AOR). CJTF-HOA was established on 19 October 2002 in response to the attacks on September 11, 2001. CJTF-HOA was originally a component of U.S. Central Command (USCENTCOM), but was transferred to USAFRICOM on 1 October 2008. Beginning in October 2011, the Center for Army Analysis (CAA) deployed analysts to Djibouti, Africa on six month rotations to support CJTF-HOA.

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### East Africa Theater Security Cooperation Effects Assessment

Presidential Policy Directive 23 (PPD23) summarizes the United States policy on Security Sector Assistance. The US Government is tasked with informing this policy with rigorous analysis, assessments, and evaluations.

Combined Joint Task Force – Horn of Africa (CJTF-HOA) is tasked with Theater Security Cooperation (TSC) for the countries in the East Africa region. The CJTF-HOA campaign plan is in line with the objectives and effects outlined in the USAFRICOM East Africa campaign plan (EACP); quarterly, the Commander’s staff assesses each Line of Effort. The requirement for measurable security assistance objectives, appropriate data collection of impacts and results of TSC programs will improve the efforts to inform decision-making processes. These assessments of performance against measures of effectiveness will be used in resource allocation to maximize the impact of limited resources.

This paper will show operational analyses used in support of assessing the effects of the CJTF-HOA and the USAFRICOM East Africa campaign plan along with the effects of the Intermediate Military Objectives in the individual County Cooperation Plans for the African Union Mission to Somalia (AMISOM) Troop Contributing Countries. This paper will also discuss the analyses on the AMISOM HQ Significant Activities database and the impact and results of Al Shabaab terrorist activities. It will explain the analysis of TSC mission assessments recorded in Combined Information Data Network Exchange (CIDNE) on Secure Internet Protocol Router (SIPR) and the assessment of Key Leader Engagements recorded in International Distributed Unified Reporting Environment (INDURE) on Non-secure Internet Protocol Router (NIPR) and integrated into CIDNE.

### Integrated Design for Hybrid Operations (IDHO)

Integrated Design for Hybrid Operations (IDHO) – Joint Project in support of CJCS IW Task to further develop an approved hybrid scenario iso assessing the full range of IW capability and capacity requirements for the joint force. IDHO is an Integrated DoD-IA project designed for supplementing Ph IV scenarios as a start point for stabilization and reconstruction capability and capacity analyses. This effort included a joint, transparent and collaborative approach that included the development of an integrated DoD-IA Exercise Design, and Data Development Plan. Where the products of a 3-day DoD-IA phase IV planning exercise was designed to serve as a start point for stabilization and reconstruction capability and capacity analyses. Produced phase IV supplements to include: a) data model to address post Ph III operational conditions; b) increased resolution of DoD phase IV activities; and c) key tasks for IA partners. Products include: Post Conflict Reconstruction Tool; CJTF C2 integrated DoD-IA structure; 12 Ph IV strategic papers on stabilization-reconstruction environment; a planning factor analysis tool, and force sufficiency analysis tool that enabled preliminary analyses. Insights suggested the DPS Ph IV forces have a significant shortfall, and Ph IV transition is deemed infeasible.
### 11871 - Combat Vehicle Engagement Distribution Analysis

AMSAA develops system and item-level performance assessments for land combat vehicles by weighting outputs of holistic survivability metrics (i.e. Probability of vehicle survival and crew protection) utilizing a standard ground vehicle attack distribution. These performance estimates are provided to several analytical organizations and acquisition decision makers of Army programs. The current Army standard attack distribution, the Combat Vehicle-Combat Performance Operational Assessment (CV-CPOA), was developed in the late 1980’s and has several limitations including the absence of attack distributions for modern day irregular warfare. As a result, AMSAA has undertaken a study to assess the utility of the CV-CPOA attack distributions given today’s conventional and irregular warfare environment. AMSAA is analyzing and characterizing attack information from current theatres of operation as well as results of combat simulations by key Army agencies. These “current” attack distributions and their respective performance metrics will be compared to legacy CV-CPOA distributions to determine if new land vehicle attack distributions are warranted for conventional and irregular warfare studies. Results of AMSAA’s analysis (revised land vehicle attack distribution) will be provided to the Army analytical community to support land vehicle lethality and survivability performance assessments and combat modelers to support operational effectiveness assessments.

### 14701 - Modeling the Asia Pacific Environment

The Asia Pacific region is both large and crowded. Over two billion people call less than 15% of the 2.5 million square mile region of interest home. From the basics of daily meals to the complexities of world commerce, many of these people’s livelihoods are dependent on accessible seas. Countless surface vessels ply the waters fishing and moving raw materials, finished products, people, and petroleum in and out of over a third of the world’s busiest seaports. In addition, through consistently overcast skies, the region hosts over 30% of the world’s busiest airports with air congestion rivaling that of North America. An illustrative model that included these commercial and civilian activities was constructed and executed to help understand the complexity and scope of Phase 0 challenges found in the Asia Pacific region. The same model might also identify underlying assumptions and provide insights to decision makers investigating the management of potential regional conflicts as they escalate through later phases. This presentation gives an overview of the model content and analysis findings.

### 12144 - Using Empirical Data to Develop Planning Factors

IDA recently completed a pair of studies for CAA, the Joint Staff and the Modeling and Simulation Coordination Office that used empirical data from operations in Iraq between 2005 and 2008 to suggest planning factors that could be used in the preparation for and conduct of future overseas contingency operations. The major premise for both studies was that specific, quantifiable Blue force actions could be spatially and temporally associated with major improvements in the indicators of security. Operations and changes in violence were studied in Baghdad and the Belts (2007), the Baqubah area (2007-08), Mosul (2008), and Al-Qaim (late 2005). In addition, an accounting of counter-insurgents per population was developed for each of these locations for the periods studied and across all of Iraq as of January 2008. Finally, substantial environmental data were considered regarding how the population viewed what was unfolding. With the exception of Al-Qaim, the time frames investigated represented the incorporation of the new counterinsurgency doctrine and increased resourcing. Although the actions in Al-Qaim preceded both the doctrine and the accompanying troop surge, they incorporated much of the intent of both. This presentation will summarize the findings and key takeaways from these studies.
In the current environment of increasingly constrained budgets, Special Operations Command Pacific (SOPAC) sought to better target future engagements through the development a priority matrix, identifying countries of priority within each of its mission areas, such as Counterterrorism, Countering Weapons of Mass Destruction, and Building Partner Capacity. The SOJ54 created a methodology to identify criteria of priority countries in a given mission, and then utilize multiple criteria decision analysis to rank order the countries based on their respective scores for the criteria set. The matrix is being used to inform the periodic update to the SOPAC Supporting Campaign Plan, nested within the overall PACOM Theater Campaign Plan. In order to maintain relevancy, updating the priority matrix has been added to the regular battle rhythm of the command, to ensure it will be useful to ongoing and future planning efforts. Additionally, as this effort is further developed to incorporate specific resourcing constraints and risk assessments, the final product will not only inform strategic planning, but will also inform operational planning of engagements throughout the AOR.


The assessment process is a key part of the planning process and is progressively becoming more incorporated into operations, actions, and activities (OAA) planning. Assessment products aim to inform SOPAC Commander decision-making to optimize the Command’s portfolio of programs and OAA, and to streamline proven processes. The assessments also determine information and capability gaps, which inform collection and reporting requirements. SOPAC is applying this methodology to Counterterrorism (CT) and Counter Weapons of Mass Destruction (CWMD) functional plans and objectives. By analyzing each mission area, the methodology is being tailored for elements of CT and CWMD. This approach will better link assessments to OAA and minimize reporting requirements by maximizing the ability to leverage existing efforts and reporting.

The brief will provide an overview of SOPAC’s functional assessment process and highlight best practices that distinguish the command’s assessment products. It will also cover other analytical efforts that complement this process, to include historical OAA data analysis and approaches for capturing and analyzing both quantitative and qualitative data to inform assessments.
11853 - Complex Military Mission Environment (CM2E) Model

Today’s military operates in an interconnected and complex world. The pace and global impact of actors pursuing varied and often conflicting objectives add to the complexity. These complex environments are primarily defined by the human domain and impacted by cyberspace, public opinion, religion, and culture as well as the infrastructure, political, economic, and legal systems. One of the many challenges of experimentation in complex environments is the ability to simulate and measure abstract factors (e.g., political, social, cultural, and economic) of an operational environment.

The U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) designed a model that decomposed the operational environment into two key components: (1) the abstract factors and their interactions that best represent the complex environment; and (2) the actors conducting actions that impact those factors. Over the past 2 years, the TRAC team decomposed the Joint doctrinal operational variables of PMESII into a conceptual model of 900 observable and measurable variables with 810,000 potential interactions. Further review of social science theory, military doctrine, and operational experience from Iraq and Afghanistan enabled TRAC to reduce the modeling construct into a universal and validated subset of 69 variables and 672 interactions. TRAC derived simple algebraic models describing the strength and direction of these variable interactions through regression analysis on empirical data. These inter-operable models represent a complex environment and provide the experimental space for complex military missions.

The second key component was developed in a closed-form modeling construct using a newly developed TRAC application called N Equals X/Discrete Event Simulation (NEX/DES) engine. The actors and their actions are decomposed and simulated in the form of highly adaptable decision tables. The hypothesized and measured effects of those actions are integrated into the complex environment model. This modeling capability provides an adaptive and simple analytic tool for hypothesis testing, experimentation, and comparative analysis.

This briefing will discuss TRAC’s approach to developing this capability as well as how this capability is aimed at being an easy to adapt, closed-form model that is designed and used by analysts.

12480 - Using “Environmental Data” for Counterinsurgency and Building Partnership Capacity Campaign Assessment

As the COIN Field Manual notes, “Counterinsurgency is comprehensive civilian and military efforts designed to simultaneously defeat and contain insurgency and address its root causes.” The FM notes that “To truly counter an insurgency, counterinsurgents must gather, analyze, and disseminate civil information pertaining to the population.” We had a wide variety of very good data sources in Iraq to collect this kind of “environmental data” covering all aspects of how the populace views the insurgency, their living conditions, the economy, and the government. A “tipping scale” that IDA developed to enable more quantitative analysis of polling data (or any other type of environmental data relevant to a COIN campaign) was used. The IDA tipping scale (based on whether or not the indicator indicates support for the Host Nation Government or insurgents) was also used in other studies, including a “Key Environmental Variables” study that used tipped scaled data on security, blue force activity, political, and quality of life factors to explain over 80% of variability in IED activity. IDA developed, and US Forces Iraq adopted, an “Instability Forecasting model” to monitor an array of environmental data (political, economic, military, social) to see if conditions in an area were worsening. IDA recently completed a pair of studies on surge operations, changes in violence, and environmental data in Baghdad and the Belts (2007), the Baqubah area (2007-08), and Mosul (2008). The 2007-2008 military surge operations in Iraq were successful in making the population feel more secure. They also resulted in some short term improvement in support for the Government of Iraq and a “window of opportunity” for the Government to improve infrastructure and take other steps to gain support. The Gov’t of Iraq did not make improvements and though popular support for insurgents did not return, support for the government fell over the next few years. This briefing will also address development of a COIN and Building Partnership Capacity Planner’s Guide.
### 12289 - Data Assimilation into Agent Based Simulations

Data assimilation is a major challenge for agent based modeling of society. "Bigdata" is a great resource for information on a society, but our ability to turn it to use in analysis is only at the early stages. Agent based models, because they can model human motivation, can help to both explain what is happening in the Bigdata and forecast what will happen next. However, the technology to assimilate big data into agent based models needs further development before agent based simulation can be leveraged. This talk presents the results of an effort to assimilate the data of one agent based simulation into another, using tags and a combination of adaptive agents and robotic agents. The purpose of these simulation runs is to test the capacity of a mimicking system to assimilate data by emulating a simulated system that is completely known, as opposed to real world data which is incomplete. Knowing that the system is functioning on the more fundamental level of assimilation is prerequisite to functioning on incomplete "real world" data.

The author's SISTER simulation is used for the test. SISTER is a simulation of trade in its most basic form. In thirty percent of the runs, a standard of trade (money) arises from barter. For the test, we run some of the runs that result in money and some that do not through the mimicking simulation, to test the ability of the mimic to emulate the same system that was input.

### 14606 - A Methodology for Determining Critical Decision Points in COA Analysis of Wargames

Today's military is engaged in complex conflicts and operations across the globe. Military planning is crucial to achieving military objectives, and is made increasingly challenging due to the dynamically changing operating environment. This strains the decision making process because Courses of Action, COAs, must be evaluated continuously. Currently, COA evaluations require wargaming outputs to be matched with multi-attribute decision making, MADM, methods to arrive at an order. However, time constraints influence the decision making process by limiting decision space evaluation, resulting in reduced enumeration of COA alternatives and severely limiting COA development and analysis. A largely unsearched decision space represents a potential for wasted opportunity, while full enumeration represents a sizeable time investment in a time constrained process.

The research objective is to create a methodology that identifies critical decision points within a COA, in order to provide a sufficient search of the decision space with minimal time investment. Through experimentation, it will be shown that measuring position, capability and awareness during agent based simulations can be utilized to determine critical decision points. Furthermore, it will be shown that identification of critical decision points will allow a statistically significant sampling of the decision space. It is expected, that this methodology will afford decision makers time by directing their efforts, allowing them to keep up with a continuously evolving operating environment. This will inform a limited decision space evaluation, hastening the decision making process and allowing decision makers to keep pace with a dynamic battlespace.

### 11629 - The Value of a Whisper in Changing the Attitudes and Opinions of a Population

This research seeks to develop a planning aid to facilitate the disruption of a dark network by triggering a cascade of influence in a competing environment by which individuals accept and spread a negative message to other individuals in the network as fast and efficient as possible. This research combines efforts from several fields to include; social network analysis, influence theory, agent based modeling and epidemiology to target a dark network imbedded in a larger population. Presented is the progress and efforts to identify the key individuals in a network to ensure the dissemination of a rumor reaches and triggers a cascade eroding confidence and trust in the dark network.
### 11893 - Leveraging All Shortest Paths Information for Rapid Social Network Analysis

This presentation proposes and demonstrates the utility of storing the information about the shortest path lengths between all node pairs in a social network to enable more rapid analyses of selected node and network measures. Knowledge of the shortest path lengths, or geodesics, between all node pairs in a social network is required to compute a number of measures that help characterize the network. A priori processing of this information enables faster subsequent computations of measures that depend on the shortest path lengths. This presentation reviews several algorithms that compute a matrix of shortest path lengths for weighted and unweighted networks. Analysis of measure computations on randomly generated networks, both with and without the stored information, demonstrates the importance of preprocessing and retaining the all shortest paths information.

### 11832 - Spatio-Temporal Extension and Analysis Framework

Analyzing problems with complex spatio-temporal relationships and strong network components such as disease progression, social network analysis, and population sentiment is a difficult and challenging component in GEOINT and social science operations. Although the data for these type of analyses are available, they come from disparate sources that provide different, overlapping and perhaps contradictory information. Moreover, the analysis still relies on the knowledge and skills of experts. Although a number of commercial off the shelf (COTS) systems are available for geospatial computation, visualization and analysis, the set of robust tools with true spatio-temporal and graph-based analysis capabilities is limited.

A recently completed research project by Adventium Labs and Texas A&M University created the Spatio-Temporal Extension and Analysis Framework (STEAF) to address these challenges. STEAF exposes cutting edge spatio-temporal analysis capabilities within existing and emerging COTS GIS tools using a simple and familiar interface. STEAF applies advanced spatio-temporal analysis techniques and combines information from different, heterogeneous data sources. To date, STEAF has been used in a number of spatio-temporal analysis and prediction scenarios including investigations into the driving factors behind wildfire spread, predictions of animal populations and movements, and the distribution and drivers of vector-borne illnesses.

This talk will present the research results and describe STEAF’s contributions to making advanced spatio-temporal and graph-based statistical analyses available to social scientists and GEOINT professionals.

### 12282 - A Linguistic Approach to Examining the Resonance of Extremist Messages on Arabic Social Media

This article investigates possible resonance of extremist messages on social media using a linguistic comparison approach. Prior research on social media chatter—particularly Twitter—has focused on sentiment expressed towards entities, based on network metrics such as retweets or mentions. This study however, proposes a new methodology: comparing the linguistic makeup of extremist messages with country level twitter chatter. The study uses corpus analysis software to compare public messages of known violent extremist organizations (VEOs) to national Twitter data. The degree of match between VEOs’ language and a nations’ Twitter chatter may potentially gauge the resonance of VEOs’ messages. Preliminary investigations comparing Egyptian Twitter use and ISIL public messaging show low levels of matches. This analysis has the potential to be expanded to include a variety of extremist groups and corresponding Middle East and North African (MENA) nations.
11624 - Developing Frameworks for Community Resilience Assessments

There are a number of ongoing efforts to develop approaches and methodologies to make cities and regions more resilient to disruptive events. Two examples are the Rockefeller Foundation's 100 Resilient Cities Centennial Challenge and the United Nation’s Hyogo Framework for Action. In the first, the focus is on making 100 cities from around the world more resilient at the city level and the second is on making countries more resilient to natural disasters and climate change.

In general, the effort to make a city or country more resilient must start with an assessment of the basic state of the conditions in the community. Once an initial state is assessed, one can then do assessments of the range of disruptive events you want to be resilient to and the desired end state. For the purposes of this presentation, we will use the word “community” to apply at both the city and country levels.

There is no “one size fits all” solution to how these assessments should be made. Multiple frameworks exist or are under development to perform community resiliency assessments. In this presentation we will provide a comparison of some of the existing frameworks, focusing on what are the requirements for a robust and adaptable framework for performing community resilience assessments. While there is no single framework that can meet the needs for all community resilience assessments, we shall provide recommendations on some “best practices” on how to develop community resilience assessment frameworks.

11666 - Utilizing Socially Impacted Analytical Measures to Support Resiliency Assessments for National Security Studies

There are a number of global initiatives that are assessing how resilient countries and regions will respond to various disruptive events, such as natural disasters, climate change, and social unrest. These initiatives are utilizing different metrics to assess how well the countries can respond to the disruptions. In some cases, the initiatives rely on “self-assessments” completed by internal agencies, which can lead to issues in assessing the validity of the results. This can also lead to issues on how external groups (e.g., donor countries and non-governmental organizations) determine how they might respond in a given situation.

The goal of these analyses is to provide as objective of an assessment as possible. Some of the metrics being used are based on directly measurable factors (e.g., life expectancy) while others (e.g., governmental transparency) are highly subjective and may require considerable interpretation. In both cases, these resiliency metrics will be linked to underlying, contextually-driven social, cultural, and environmental features of the country or region being studied.

One major global initiative is the United Nation’s Hyogo Framework for Action (HFA), which was begun in 2005 with the goal to make countries more resilient to natural disasters and climate change. Achieving these goals ultimately benefits United States (US) national interests because if countries are more resilient they are less likely to be reliant on US, international, or foreign support. The HFA has completed its first 10-year plan and self-assessments have been generated of the progress made in meeting the HFA goals. Argonne has conducted an analysis of the HFA self-assessments using a number of objective measures from different sources. In this presentation we will present the results from those assessments and discuss how similar kinds of analyses could be used to support other resiliency assessments in the future.
11453 - Optimal Security Force Assistance Strategies through Stochastic Linear Programming and Discrete Event Simulation

Security Force Assistance (SFA) exists in complex operational environments that cultivate interactions between social, economic, cultural, and other population-centric factors. Strategy planners must be comfortable with the concept that, when it comes to strategic focus, resources, and funding for these missions, more is not necessarily better. Specifically, variables that define a nation’s absorptive capacity and economic strength diminish the effectiveness of SFA operations when certain aspects of these operations violate their constraints. The lack of an apparent relationship between SFA/SC funding and effectiveness motivates analysis of redistribution with respect to strategic focus and resources, thereby inviting a stochastic linear programming model with the objective of maximizing SFA/SC effectiveness as subject to constraints described by absorptive capacity and economy. Optimal SFA/SC strategies, once defined, feed a regression model that maps normalized SFA/SC propensity values to State Fragility Index data. This time-series database interacts with target SFA/SC effectiveness to drive a discrete event simulation model for approximating the time required for the optimal SFA/SC strategy to manifest itself in any given nation. This analysis provides decision makers with the opportunity to gain deeper understanding of the environments within their sphere of influence and to compile their gained knowledge to facilitate a higher-level strategy that anticipates variability.

11700 - Security and Wellbeing in Mauritania

Several years have passed since the most recent of Mauritania’s coups. However, while the political situation has calmed, the country faces new concerns with Islamist extremists operating throughout the Sahel and the Ebola outbreak in its neighbors to the south. This paper uses recent data from a nationwide, representative survey of adult Mauritanians to explore the concerns and wellbeing of modern Mauritania. Questions include topics related to security, Ebola and essential services, as well as examining the existing media landscape and how it relates to military information support operations (MISO).

11701 - Inter-community Relations and Security in Kenya

The International Criminal Court (ICC) has charged the current President of Kenya Uhuru Kenyatta with crimes against humanity for his alleged involvement in violence after the 2007 election. The election violence killed more than 1,000 Kenyans and President Kenyatta is the first serving head of state to be tried by the ICC. At the same time, security in the Kenyan capital, Nairobi, and areas in Coast Province, have been affected by terrorist violence perpetrated by the Islamist al-Shabaab group.

In November 2014, D3 Systems conducted a nationally representative survey of Kenyans in order to understand Kenyans’ opinions of: the ICC case against President Kenyatta; attitudes towards the Kenyan President himself; relations between members of different ethnic groups and tribes; and Kenya’s role in military operations in east Africa to combat al-Shabaab.

Using the data collected in November, this study examines the opinions 1,000 Kenyans age 18+ on current domestic political and security issues. The paper investigates the attitudes of Kenyans across a wide cross-section of demographic variables – including tribal/ethnic group identity, age, education level, income, and occupational status – to analyze the influence of these variables on relations between ethnic groups, views of the Kenyan President and the ICC, and the impact of sending Kenyan troops to Somalia.
The Integrative Model of Organizational Trust as a Framework for Understanding Trust in Government

We assess the applicability of Mayer, Schoorman, and Davis' (1995) Integrative Model of Organizational Trust for modeling citizens' trust in their government using country-level survey data collected in four Western Trans-Sahel countries (Burkina Faso, Senegal, Mali, and Nigeria) in 2010. Although the original model focused on trust between individuals, our fundamental supposition is that the model also applies to individuals' trust in an organizational-level entity: government. Our findings also suggest there are two separate dimensions to ability and benevolence/integrity associated with trust in government, as well as the existence of a new term that we hypothesize is related to government reputation.

Multiple social science perspectives state that trust is critical to human interaction. For example, psychologists suggest 'trust is one of the most important components—and perhaps the most essential ingredient—for the development and maintenance of ... well-functioning relationships' (Simpson, 2007a, p. 587). Similarly, commentators from the field of international relations have stated that trust within the international system is 'the underpinning of all human contact and institutional interaction' (Blind, 2006, p. 3).

Organizational management perspectives reach a similar conclusion about the cross-disciplinary importance of trust studies (e.g., Colquitt, Scott, & LePine, 2007). Even American military perspectives from the counterinsurgency battlefields of Iraq and Afghanistan suggest that generating trust between American service members and local populations is more important than kinetics and force. For example, David Kilcullen, the noted Australian counterinsurgency expert, states that trust building in the counterinsurgency context is the military's 'true main effort: everything else is secondary' (Kilcullen, 2010, p. 37).

As a result of these growing perspectives, researchers have called for more relevant, cross-cultural, macro-level investigations of trust (e.g., Bachmann, 2011; Li, 2011; Mishra & Mishra, 2013). This manuscript is the first to explore the utility of Mayer, Davis, and Schoorman's (1995) Integrative Model of Organizational Trust for understanding citizen trust in government. Mayer et al.'s Integrative Model of Organizational Trust has been used to explain interpersonal trust outcomes in the business world (Davis, Schoorman, Mayer, & Tan, 2000), the medical community (Schoorman, Mayer, & Davis, 1996), psychology (Simpson, 2007a; 2007b), and others (e.g., Colquitt, Scott, & LePine, 2007). Despite the overwhelming utility of the Mayer model for understanding interpersonal trust generation in multiple contexts, it has, to our knowledge, never been used to understand citizen trust in government. This is surprising since Mayer and colleagues (e.g., Schoorman, Mayer, & Davis, 2007) claim that their model is robust for understanding an individual's trust in organizations, though they tend to think of trust in business organizations as opposed to governments. As Mayer and colleagues noted, 'the 1995 framework is fairly robust across levels of analysis' (Schoorman, Mayer, & Davis, 2007, p. 345). From their perspective, the same variables that impact trust between people 'also affect the extent to which an organization will be trusted' by people (Schoorman, Mayer, & Davis, 2007, p. 345).

This paper is organized as follows. In the next section, we describe Mayer et al.'s Integrative Model of Organizational Trust and how elements of the framework can be applied to understanding citizen trust in government. We also discuss existing research on trust in government that, despite not using the Mayer model as an organizing framework, appears to support the Mayer et al. concept. Subsequently, we describe our analysis of survey data from four countries in the Trans-Sahel region of Africa (Senegal, Nigeria, Burkina Faso, and Mali) where we assess whether the Integrative Model of Organizational Trust is appropriate for understanding citizen reports of trust in government. Finally, we conclude with a discussion of our results and recommendations for future research.

**11334 - Modeling Trust in Government: Empirically Assessing Mayer et al.'s Integrative Model of Organizational Trust**

The Integrative Model of Organizational Trust as a Framework for Understanding Trust in Government

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### 12637 - Wisconsin Card Sorting Task Modified for the Military Domain

TRAC-Monterey and the Naval Postgraduate School (NPS) have developed a task to measure military decision-making performance. This new task is modeled after the Wisconsin Card task but focuses on high stakes and uncertain environments particular to military decision making conditions. Thirty-four US military officers from all branches of service completed the tasks yielding decision data for validation. This presentation will discuss the development and validation of this task as well as insights it gives to the cognitive flexibility of military decision makers.

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### 12322 - Economic Impact Analysis— Assessing the Impact on Local Communities due to Stationing Actions

The Department of Defense (DoD) has conducted several rounds of Base Realignment and Closures (BRAC) with the last round being conducted in 2005. Since then the U.S. Army has reduced its force size, which has created excess infrastructure capacity on many Army installations. Due to budget constraints, DoD has asked Congress to authorize another round of BRAC. One of Congress’ BRAC criterion that must be considered is the economic impact of realignment or closure actions on surrounding local communities. The Army must also consider economic impact for any day-to-day stationing actions outside of a BRAC.

The Center for Army Analysis (CAA) has extensive experience with stationing analyses from prior BRAC rounds. CAA has conducted considerable analysis in the recent European Infrastructure Consolidation (EIC) effort. CAA developed tools that were used for stationing analysis during BRAC 2005 and modified them for use in EIC. CAA recognizes that its stationing tools must be revised to meet today’s challenges and is conducting a focused multi-year effort to do so. As a part of this effort, CAA is developing an Economic Impact Tool (EIT). During BRAC 2005, DoD utilized commercial software to estimate the economic impact by accounting for the employment and population changes to a community. CAA initiated a project with the George Mason University’s Operations Research Department to develop EIT to account for differences across Army Installations. We will explore multiple attributes of economic impact using authoritative databases and a documented and verified methodology.

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### 11859 - Hybrid Model for Security Sector Assistance (SSA) Assessments

Objective: "Determine the benefits for the Joint Force adopting an approved IA assessment framework by examining the Criminal Justice Sector Assessment and Rating Tool (CJSART), Defense Sector Assessment and Rating Tool (DSART), Holistic Engagement Evaluation and Assessment Rating Tool (HEART), Measuring Progress in Conflict Environment (MPICE), Maritime Security Sector Reform (MSSR), and Organization for Economic Co-Operation and Development (OECD) methodologies" in support of Joint Irregular Warrior 2015 (JIW-15), also known as Elegant Potential 15 (EP-15). Built an evaluation scheme for the candidate interagency planning frameworks, and provided a supportable down-selection and recommended Hybrid Model for Security Sector Assistance (SSA) Assessments. This effort utilized a value-focused thinking (VFT) process that: Reaffirmed Presidential Policy Directive (PPD-23) reference to address the need for common interagency assessments; Leveraged elements of other frameworks that provide more scenario pertinent detail; Provided a common foundation for USG agencies to assess a country’s security and justice context and make strategic program recommendations. Provided framework coverage evaluation method; an extensive assessment database; a descriptive down-selection process based upon relevant themes, scenario relevance, and best of breed ‘hybrid’ assessment recommendation. Provided visualization approach for demonstrating how frameworks overlap according to the structure of the framework, and for illustrating the down-selection process-criteria and resulting product recommendation.
**12139 - Factor Score Evaluation of the U.S. Army's Global Assessment Tool (GAT)**

The Global Assessment Tool (GAT) is an online survey designed to give Soldiers and their family members a depiction of their mental health in five key areas: emotional, family, social, physical, and spiritual fitness. The scoring scale for the GAT is based on a five-point and six-point Likert scale, eleven-item interval scale, and dichotomous forced-response questions. TRADOC Analysis Center (TRAC) conducted research to improve the scoring method for Soldiers’ responses to GAT questions to allow future analysts to build models that are prescriptive as well as descriptive in nature. Currently, respondents’ scores are computed by an aggregated mean of sub-scale scores for each factor. This method has inconsistencies in reliability when the variability of the data is not taken into account. TRAC addressed this issue by developing more refined scoring methods through exploratory and confirmatory factor analysis, and computing the degree of indeterminacy of the estimated factor scores to account for the data variability. This presentation will discuss TRAC’s approach and discuss a new scoring method that provides a significant improvement over the existing method used to find scores for each factor.

**11702 - Afghanistan: After the Presidential Transition**

Another disputed election in Afghanistan produced a compromise result in 2014, with Ashraf Ghani sworn in as president and his challenger, Abdullah Abdullah, awarded a newly created position as CEO of the Afghan government. How do Afghans view this outcome, the departure of most Western forces and the position of their country as it embarks on its “transformation decade”? ACSOR Surveys, D3 Systems, and Langer Research Associates have collaborated on a national poll in Afghanistan, fielded in late October and early November 2014, to examine these and related attitudes. Our goal is to continue to enrich public understanding of Afghanistan, as well as to share insights into the methodological and operational challenges of conflict-zone research.