

# TUESDAY PRESENTATION DETAILS

**1:00 - 1:30 Tues**

**040**

Schneider, Hubert  
Anglin, Dale  
Baumgarten, Erik  
Dinh, John  
Hall, Mark  
Raytheon

**Track 1**

## **Raytheon Reference Architecture (RA): Enabling Timely & Affordable Customer Solutions**

The complexity of Command and Control in today's information-driven world demands robust, well designed systems to orchestrate the timely exchange of information, employment of resources, and collaboration between units. Customers are demanding architecture-based solutions for their mission needs. Raytheon has made significant investments in a corporate level, enterprise-wide initiative called RayMAP (Raytheon Mission Architecture Program) to respond to these demands. RayMAP coordinates Reference Architecture (RA) efforts across multiple business units and programs. These RAs are being used to promote commonality, reuse, interoperability, increased responsiveness and affordability in systems and enterprises. Using the Raytheon Enterprise Architecture Process (REAP), standardized architectures can be defined, described, evolved, and assessed throughout Raytheon and was used to develop several RAs. A key Raytheon RA is the Command and Control Reference Architecture (C2 RA) developed using REAP and an activity based methodology. C2 RA artifacts have been captured in the Unified Modeling Language using Rhapsody as a modeling tool. The C2 RA is easily tailored, is extensible, and can be applied to Department of Defense (DoD) and non-DoD situations and solutions. This paper describes the process Raytheon used to tailor and evolve the C2 RA to build more timely and affordable customer solutions, including lessons learned.

**017**

Lenahan, Jack  
Nash, Mike  
Charles, Phil  
SPAWAR

**Track 8**

## **Beyond Reactive Planning: Self Adaptive Software and Self Modeling Software in Predictive Deliberation Management**

The purpose of this paper is to examine an approach to planning which extends beyond the traditional reactive planning state space. We present the following hypothesis: predictive deliberation management using self adapting and self modeling software will be required to provide mission planning adjustments after the start of a mission. Self adaptive software evaluates its own behavior and changes behavior when the evaluation indicates that it is not accomplishing what the software is intended to do, or when better functionality or performance is possible<sup>1</sup>. Self modeling systems construct their own abstractions as a basis of computational intelligence<sup>2</sup>. In order to provide a proper process context for the evolution of software toward this level of autonomy, and in alignment with the proposed planning maturity models<sup>3</sup>, we put forth a concept of a NCW C2 Software Maturity Model. This new C2 software maturity model will take software beyond the service oriented paradigm into a new era of software designing its own replacements or modifications in order to satisfy new command and control requirements.

## 1:00 - 1:30 Tues

004

Barton, Robert  
BAE Systems PLC - Future Systems  
Whittington, Dick  
Salamander Organization

### Track 6

#### Informing high level trades - some novel techniques

In the increasingly complex acquisition environment that characterises Defence, the ability to make good trade off decisions is often limited by time and resource. The resulting outcome can often be disastrous in the area of command and control improvements, many of which are relatively low in real cost terms but can have disproportionately high impact on Military Capability. Trade - off techniques have tended to rely on spread sheets and military judgement, with OA not always playing the definitive role that it should. The analysis and decision process is then compounded by the need to maintain big ticket items on long commitments, forcing "salami slicing", cancellation of small - medium scale projects (often the command and control elements) and an inability to compare "apples with oranges", or as some observers have put it "apples and Wednesdays"! Over the last two years a number of new techniques have been developed which generate a set of consistent views which, in turn, enable a much more objective basis for analysis, quality trade - off and decision making. These have been developed by direct working with the customer, to ensure that they represent practical solutions. The use of SMEs to help develop the tools and techniques has increased responsiveness and encouraged innovation. The paper will outline the work undertaken and the types of visualisation and decision aids that have been developed showing how these have been used in practice to gradually enhance the overall process.

116

Ng, Ee Chong  
DSO National Laboratories  
Thunholm, Peter  
National Defence College, Sweden  
Cheah, Mervyn  
Future Systems Directorate, Singapore  
Tan, Kin Yong  
Future Systems Directorate, Singapore  
Chua, Nancy  
Defence Science and Technology Agency, Singapore  
Chua, Ching Lian  
DSO National Laboratories, Singapore

### Track 7

#### Exploring alternative Edge versus Hierarchy C2 Organizations using the ELICIT platform with Configurable Chat System

The Edge Organisation is a subject that warrants much research and experimentation within the C2 research community. By combining the ELICIT Multiplayer Intelligence Game with the use of CHAT, we designed an experiment to test the effect of different rules of information-sharing, communication, and decision-making on the performance and behaviour of three different permutations of Edge versus Hierarchical Organizations. Our main findings suggest that when an intelligence organization is tasked to analyze incoming data and decide on an interpretation of these data, the edge organization outperformed both the traditional hierarchy and the edge-hierarchy hybrid over decision speed, decision accuracy and level of shared correct awareness of the threat situation. The hybrid organization and the traditional hierarchy performed equally well on decision accuracy and shared awareness, but the former made decisions faster than the latter. One possible explanation for our results is that in the hierarchical structure, the processing of information takes place in two different levels subsequent to each other in time, but in the

Edge there is only one processing level. Through this experiment we also demonstrated how intra-organizational behavior and command chain leadership issues can be addressed through introduction of different CHAT configurations to complement the ELICIT platform.

**1:00 - 1:30 Tues**

**112**

van Veen, Maarten  
van Fenema, Paul  
Grant, Tim  
NLDA

**Track 3**

**User Perspectives on the Design Logic in Military Training Simulators**

In our ICCRTS 2007 paper 'On Regarding 21st Century C2 Systems and their Users as Fallible ePartners' we argued that there is a limit to what can be done to eliminate errors in C2 systems, and we should view human actors and the system together as electronic partners. The development and use of C2 systems has become, over the past decades, a complex area of inquiry with different thoughts on how to dominate in a coordinated fashion in warfare. Designers of increasingly sophisticated C2 systems follow a certain logic that becomes 'blackboxed' into the technology. We want to open this black box and investigate what decisions designers made and how users make sense of them. We take the emerging field of Modeling & Simulation as our principal object of study. Technically sophisticated simulators have become an indispensable method for tactical military training. This study seeks to initiate a discourse on (dis)advantages, choices, interpretations and constraints associated with complex information systems in military modeling & simulation. To this end we are conducting a comprehensive, qualitative study on the use of a simulator for constructive training. This paper describes our research approach and summarizes our initial findings.

**042**

Warne, Leoni  
DSTO

**Track 2**

**The Human Terrain of NCO**

This paper follows on from the paper presented at ICCRTS 2004: Warne et al "The Future Warrior", [www.dodccrp.org](http://www.dodccrp.org). It discusses the outcomes of an Interview Program investigating the human dimension of Network(er) Centric Operations (NCO). This paper gives an overview of the findings in terms of the skills and attributes required for the 'networker' in NCO, as perceived by the warfighters themselves. The interviews indicate that issues of trust, teaming skills, skills in communicating and handling information; knowledge of Joint and Coalition capabilities, tempo tolerance, cultural awareness and sensemaking skills were most highly valued. Furthermore, several issues not previously identified in the literature emerged in interviews with the Australian Defence Force (ADF) including the importance of: prior operational experience, Joint, Coalition and CIMIC training/exercise experience, developing informal and social networks underpinned by strong relationship building skills and the ability to tolerate ambiguity. These and other human characteristics and behaviours are linked to the tenets of NCO in an attempt to better understand the human requirements in the NCO environment. This work has led to the creation of a Model of the Human Dimension of NCO which is the subject of a later paper.

## 1:00 - 1:30 Tues

163

Desouza, Kevin  
Roy, Sumit  
Lin, Yuan  
University of Washington

### Track 5

#### **Performance Measures for Edge Organizations: A Preliminary Report**

Taking an information-processing view of organizations, we address the need for building a robust set of performance measures for Edge Organizations (EOs). Alberts and Hayes in *Power to the Edge: Command, Control in the Information Age* conceptualized EOs as information-intensive entities whose performance is directly related to their ability for agile information processing. We ask the question, how can we measure the information-processing capacities of EOs? To this end, in this research-in-progress paper, we examine (1) the technical dimension of information flows, (2) the human-dimension of information flows, and (3) the socio-technical dimensions of information flows. The technical dimension represents movement of information between two machine nodes and can be informed by drawing on performance measures for telecommunications network theory. The social dimension represents the movement of information between two human nodes for which we examine the literature on social networks for performance measures. Finally, the socio-technical dimension represents movement of information between human and technical nodes or vice versa. To develop measures for these information flows we must not only extend, and customize, the performance measures from telecommunications networks and social networks, but also draw on measures in the disciplines of decision sciences, information sciences, and organizational science, among others.

097

Louvieris, Panos  
Mashanovich, Natasha  
Collins, Catherine  
White, Gareth  
Faulkner, Mark  
Levine, Jerry  
Henderson, Stewart  
University of Surrey

### Track 9

#### **Exploring Joint Usability and Decision Effectiveness using a Networked-Enabled Virtual Collaborative Working and Visualisation Environment for Military Planning**

This paper concerns the use of a Collaborative Working and Visualisation Environment (CWVE), i.e. using virtual collaborative desks (VCDs), for the development of shared situational awareness using a common operational picture to support collaborative military planning in joint command and control situations. Joint usability, critical task and situational awareness assessment methods are employed to determine the effectiveness of this CWVE in supporting commanders' joint decision making. With reference to the British Army's seven questions estimate process and intelligence preparation of the battlefield, together with employing a small military judgement panel for the simulation experiment, the research focuses on the how effectively networked VCDs highlight commander's critical information requirements and their purpose including the commander's evolving requests for information during planning; and, how collaborative technologies might improve joint decision effectiveness in the specification and delivery of planning products, such as: the decision support overlay, decision support matrix and the synchronisation matrix within a distributed HQ environment in order to enable distributed working. As a result of this research a joint usability framework has been developed. This research has military significance in terms of enabling synchronised joint decision making in resilient agile distributed HQ groups and thereby reducing security risk of commander and staff.

**1:30 - 2:00 Tues**

**029**

Hone, Geoffrey  
Whitworth, Ian  
Farmilo, Andy  
Cranfield University

**Track 1**

**The Awareness-Order-Action cycle and Battle-space Awareness**

We have argued (Hone, Whitworth, Martin; 2006) that Awareness is best considered in terms of Battle-space Awareness, but also seen as a component of a larger Awareness-Order-Action (AOA) cycle. A key factor in the AOA cycle was the influence of culture and doctrine on multi-force and multi-national operations. At a time when a number of “Cycle” models (e.g. OODA, ODOA, OPAM, RUDE) are in use – and many of which are probably best related to specific aspects of combat – we believe that insufficient attention is being paid to fostering a general awareness of the battle-space, or to integrating such awareness into a generic model of the combat process (particularly from the viewpoint of ground and littoral combat). Developed from the 3-Q model of awareness (Hone, Martin and Ayres, 2006), the AOA Cycle is offered as a means of exploring the way in which information flow, as well as the influences of culture and doctrine, can affect combat events. This requires a new approach to the assessment of awareness, and in particular to the separate awareness of “Blue” versus “Red” forces, and such an approach can be enabled by the 3-Q model amongst others.

**044**

Jagiello, Jerzy  
Tay, Nicholas  
Eronen, Marko  
DSTO

**Track 8**

**A Robotic Middleware**

A software middleware concept has been applied to the robotic software development process in order to overcome problems with interoperability and portability of software components between different vendor robotic platforms. An architecture has been proposed and a prototype was built. The architecture is designed to allow control of motion and perception, and provide a common interface for communication. Additionally the architecture provides the ability to use agents for specialized and complex tasks. Experimentation with the prototype demonstrated the applicability and value of the middleware approach in the robotic domain. In providing a high level interface to hide the particular details of specific platforms the middleware allows development of re-usable software components which can be used across different platforms. The middleware also enhances the interoperability between robotic platforms.

**011**

Gill, Kate  
Dstl

**Track 6**

**Towards a Model of Capability Trading for UK Defence**

*Trading* is the defence term for altering the Balance of Investment (BOI) between military capability components to maximise effectiveness. Trading is a social activity, and as such the trading activity needs to consider the individual’s contribution as well as the activity process itself. The trading process has taken place in the military domain for many years and is well documented and traceable. However, the effectiveness of the process and the success of the trading decision are less well observed and documented. Military capability is delivered using a combination of factors (e.g. equipment, training, logistics and information). In the UK military context, these factors are collectively known as the Defence Lines of Development (DLOD). Trading is the mechanism used to adjust the levels of investment in each of the

DLODs to achieve the required military capability outcome in the most effective way. This paper examines the problem space of trading and outlines the findings of an initial exploration of the practical experiences of trading practitioners, using personal confidence rating as a metric. An emerging model is proposed, which could be used for low fidelity long-term projections of trading decisions in support of long term BOI assessment.

**1:30 - 2:00 Tues**

**080**

Duncan, Matthew  
Jobidon, Marie-Eve  
Defence Research and Development Canada Toronto

**Track 7**

**Spontaneous Role Adoption and Self-synchronization in Edge Organizations Using the ELICIT Platform**

This research used the ELICIT platform (Parity, 2006a) to investigate spontaneous role adoption and self-synchronization in Edge organizations. Behavioural indicators associated with explicit roles in a Hierarchical organization (e.g., Team Leader, Team Member, etc) were compared with the same indicators derived from members of an Edge organization (e.g., no explicit roles or structure). The extent to which behavioural indicators from subjects in the Edge organization matched those in the Hierarchical organization would signal spontaneous adoption of Hierarchical roles by Edge members. On the other hand, the extent to which behavioural indicators in the Edge organization failed to match any found in the Hierarchical organization would signal the formation of Edge-specific role adoption. Subjects in a Hierarchical organization were given explicit instructions on role function. Behavioural indicators were found that effectively clustered members by role (i.e., indicators which grouped Team Members, Team Leaders, and the Cross-team Coordinator into separate clusters). These role-specific indicators were then compared to indicators drawn from members of an Edge organization who were given no explicit role instructions. This paper reports the results of this research which indicate that spontaneous role adoption and self-synchronization can occur in Edge organizations and that the ELICIT platform can be used to assess it.

**115**

Staal, Odd Martin  
Nielsen, Martin Normann  
Brathen, Karsten  
Norwegian Defence Research Establishment

**Track 3**

**Experimentation with Network Enabled Joint Tactical Training**

This paper describes the Joint Air Defence Training Simulation (JADE) II, an experimental synthetic exercise performed in late October 2007. The exercise provided training for an Anti-Air Warfare (AAW) organization including two naval frigate AAW teams, an air surveillance and combat management team at a Control and Reporting Centre (CRC) and two combat aircraft pilots, training air-maritime cooperation and coordination procedures. The synthetic exercise was enabled by interconnecting stand-alone training simulation systems and their voice and tactical data link systems, creating the JADE II Joint Tactical Training Capability Prototype (JJTTCP). The JADE II experiments evaluated the JJTTCP's ability to provide relevant and cost-effective training. For this purpose, a set of subjective and objective data were collected. The paper outlines the experimental setup employed to measure training effectiveness, and describes the JJTTCP. The results of the JADE II experiment were positive, indicating that a network enabled training capability, like the one described, can provide relevant and realistic joint tactical training. The training can be improved in terms of reduced cost and increased availability and it can increase the value of live joint exercises. In addition, it enables trainees to explore and understand network enabled concepts of their domain, and the command and control organization and functions in and adjacent to their domain.

**1:30 - 2:00 Tues**

**084**

West, Bruce  
Army Research Office  
Bowman, Elizabeth  
Rivera, Brian  
Army Research Laboratory

**Track 2**

**The Human Dimension of Networks**

This paper describes a research plan that will examine the linkage between the physical and human (cognitive and social) domains of a network as they relate to human decision-making. This strategy has three components: theory, computation/simulation and experiment/observation. We will extend the most recent methods of statistical physics to non-stationary, renewal stochastic processes that appear to be characteristic of the interactions among nodes in complex networks and we will pursue the phenomenon of synchronization, whose mathematical formulation has recently provided insight into how complex networks reach accommodation and cooperation. The theoretical analyses of complex networks often elude analytic solutions and require large-scale simulation and computation to analyze the underlying dynamic process. We will use agent-based modeling to simulate the dynamics of such complex networks, particularly models of dynamic decision-making under conflicting constraints and with incomplete information. We will develop decision-making scenarios from which to extract large amounts of data for analysis, for the development of theoretical models and the construction of large-scale computer simulations, as well as, optimal data processing techniques to guide the theoretical analysis. We expect that the theory, computation/simulation and experiment/observation components will inform and refine one another in an iterative way through intense collaboration.

**075**

Bay, John  
Air Force Research Laboratory

**Track 5**

**Disruptive Effects of Net-Centricity on Command and Control**

This paper explores the potential for net-centric operating environments to disrupt traditional practices in command and control. We conclude that at least two major disruptive effects are likely: information non-attribution and control decentralization. Information non-attribution reverses the assumption that commands are issued from an individual entity to an individual entity. In net-centric worlds, orders will be issued to a resource pool, and information will be gleaned from an infosphere. The military command hierarchy must therefore get accustomed to issuing orders to “nobody in particular,” and commanders will lack an individual subordinate with whom to attribute the responsibility. Conversely, they must accept information from the infosphere without the trust inherited from known reliable providers. Control decentralization is a tendency for decision-making to migrate to the “edges” of the organization, where the most direct sensors and effectors are physically located. Net-centricity directly empowers those closest to the action by giving them access to information of quality and quantity that is potentially equal to or better than that available in command centers. Together, these effects of net-centricity suggest disruptive changes in command and control practices that must be modeled and explored as the vision of net-centric command and control becomes a reality.

## 1:30 - 2:00 Tues

141

Grande, Darby  
Stelzer, Emily  
Patterson, Michael  
Tyler, Sherman  
Levchuk, Georgiy  
Aptima  
Lee, John  
Hoffman, Joshua  
University of Iowa

### Track 9

#### Supporting Adaptive C2 Structures in Time-critical Environments

As technological advances allow automation of many operations, human operators supervise systems with increasing breadth of scope. In these complex environments, decisions regarding resource assignment to tasks, goal prioritization and coordination strategies during unexpected events become unwieldy as the problem spaces grow. In this paper, we describe the development of technology to support teams of operators controlling teams of unmanned vehicles (UVs) in their global resource planning and re-planning. These teams include a several coordinating Littoral Combat Ships, a mixture of autonomous vehicle types, typically with a range of differing capabilities, and management by multiple human operators attempting to achieve several high-level goals. Using the results of a Cognitive Work Analysis, we extend our work in organization design and analysis to give real-time support to the operators.

## 2:00 - 2:30 Tues

058

Heier, Jeff  
MITRE

### Track 1

#### Mashup the OODA Loop

This paper provides an overview of several Web 2.0 applications and how they can be constructed via mashups to augment current Army Command and Control (C2) processes via the Observe, Orient, Decide, and Act (OODA) Loop concept. As defined by Wikipedia, a mashup is a Website or application that combines the content from more than one source into an integrated presentation. The benefits include (1) faster correlation of current data, (2) an ability to obtain previously unavailable data, and (3) an authoring environment that encourages end users (soldiers) to develop and share applications without having to wait during the traditional lengthy software development cycle.

099

Landsman, Seth  
Mulgund, Sandeep  
MITRE

### Track 8

#### Design Patterns for Net-Centric Applications

Numerous efforts are now under way to define techniques for exposing data in a net-centric manner. Such efforts will provide C2 decision-makers with access to unprecedented amounts of real-time operational information, helping to make possible the net centric vision of improved mission effectiveness through shared situation awareness and self-synchronization. However, relatively little attention is being paid to strategies for consuming and exploit that data effectively and efficiently. Guidance such as the DoD's Net-Centric Data Strategy (NCDS) suggests how best to expose mission data in a net-centric environment, but what are the right approaches for building user-facing tools and capabilities? Such capabilities will make it possible to transform, visualize, and realize shared sensemaking over net-centric data. As the diversity and



number of entities needed to realize effective C2 for complex endeavors grows, establishing agile and practical design guidance for building user-facing capabilities becomes critical. This paper discusses an effort to establish design patterns – identifiable, repeatable prescriptions for solving commonly occurring software design problems – for realizing agile net-centric consumer applications. The effort described herein centers on the development of a User Defined Operational Picture (UDOP) capability, a collaborative tool that enable agile consumption of net-centric data sources to support time-critical decision-making in crisis situations.

**2:00 - 2:30 Tues**

**255**

McEver, Jimmie  
Martin, Danielle  
Hayes, Richard  
Evidence Based Research

**Track 6**

**Operationalizing C2 Agility: Approaches to Measuring Agility in Command and Control Contexts**

Modern military operations are characterized by highly dynamic environments, complex strategic, operational, and tactical situations, a rich and evolving mix of allies and adversaries, inherent and sometimes massive uncertainty, and high risk. This combination of factors requires that military forces must continually transform and adjust to remain highly effective in extremely fluid environments. This capability, known as agility, is emerging as a key attribute of the forces and organizations that will enable them to respond to the nature of modern operations. In an everyday language sense, agility as a concept is well understood. However, operational definitions of agility, needed to enable unambiguous recognition and measurement of the different aspects of agility have been lacking. This paper lays the groundwork for a unifying approach for measuring and experimenting with agility and its enabling factors by suggesting definitions of agility and its associated attributes that are amenable to measurement, and describing potential approaches to agility measurement and description.

**079**

Ruddy, Mary  
Meristic  
Nissen, Mark  
Naval Postgraduate School

**Track 7**

**New Software Platform Capabilities and Experimentation Campaign for ELICIT**

ELICIT is the Experimental Laboratory for Investigating Information-sharing Collaboration and Trust. A project of the Command and Control Research Program (CCRP) within the Office of the Assistant Secretary of Defense (NII), the ELICIT project developed an online multi-user software platform for conducting experiments in information-sharing and trust. The initial version of the software allowed researchers to model and experiment with a limited set of Command and Control (C2) organizations, processes and approaches in a computer-instrumented environment. The ELICIT software has since been enhanced to allow organization type to be configurable, thereby allowing researchers to experiment with a wider variety of C2 organizations, processes and approaches. In addition, the software has been further enhanced to support software agents as well as human participants, greatly expanding the avenues for research. Although the introduction and use of ELICIT remain relatively recent events, considerable research has been conducted already using this experimentation platform, and the C2 Research Community is gaining commensurate experience and insight into sound research design. Building upon such research and experience, we develop a multidimensional campaign for continued experimentation using the ELICIT platform. The campaign is populated with recent studies and guides future researchers toward high-payoff research areas that can be addressed using ELICIT.

**2:00 - 2:30 Tues**

**142**

Oh, Regine  
Sanchez, Susan  
Lucas, Thomas  
Wan, Hong  
Purdue University

**Track 3**

**Efficient Experimental Design Tools for Exploring Command and Control Organizational Structures**

Armed forces around the world are considering radical transformations to their structures and strategies because of the information revolution and the changing global environment. Senior leadership continually face decisions on how best to structure, modernize, organize, and employ forces in an increasingly uncertain future. For many of these problems analytical methods are not applicable, and large-scale experimentation is not feasible. Simulation provides a valuable tool for addressing these types of problems. One key characteristic of these decisions is the large number of factors, and interactions between factors that impact decision makers. Traditional simulation approaches are not designed to deal with this many factors, therefore the results are often incorrect or misleading. In this paper we introduce and implement efficient design of experiments techniques to analyze C2 organizational models and pursue optimal settings for different performance measures. This allows analysts to rapidly identify the important factors within the simulation, employ an experimental design to fully explore the simulation space efficiently, and design the systems with desired optimal performances with the simulation model. This effort dramatically increases the breadth and depth of insights possible when the simulation output data are analyzed, while reducing the time required for performing a study.

**125**

Oros, Carl  
Naval Postgraduate School

**Track 2**

**Mitigating C2 Complexity through Semantic Communications: A Model-based Communication Network Approach**

Fundamental to the concept of Network Centric Warfare lies the precept that shared awareness, collaboration, and self-synchronization can be attained through the networking of knowledgeable, geographically and hierarchically dispersed entities. The DoD GIG Architecture Vision is the prime policy directive chosen to realize this goal. Consistent with the tenants of NCW, the GIG architecture framework envisions highly responsive, agile, adaptable, and information-centric operations. These desirable net-centric attributes are prescribed to be implemented via a Smart Pull methodology. However, a pull architecture not only must contend with the demands of disseminating diverse, timely information to numerous entities, but more importantly it must address the cognitive bandwidth limitations inherent to users searching for, discovering, and pulling contextually relevant, mission critical information. This paper provides an alternative operationalized Model-based C2 network approach where entities share a dynamic model of the environment and information is smartly Pushed via VIRT services to relevant entities when user defined Conditions of Interest occur. Mission thread semantics are used to generate an ontology that supports a contextually rich data structure capable of supporting the information requirements of diverse actors and entities united in the endeavor.

## 2:00 - 2:30 Tues

109

Liu, Jing  
Zhou, Wei  
Chen, Honghui  
Luo, Xueshan  
National University of Defense Technology

### Track 5

#### Assessment of Hierarchical Command and Control organization structures

Assessment of C2 organization structures becomes very important now. On the one hand, the suggestion to develop newly networked organization structures seems to be accepted by most people; on the other hand, almost all the C2 organization structures are actually pyramid hierarchical ones. Concerning a specified military organization, whether its C2 structure is suitable or not? How to select a “better” structure for it from several candidates? Many issues require to be answered. In this paper, we propose a methodology to quantitatively analyze hierarchical C2 organization structures. Firstly, we associate the assessment with the task that the assessed military organization is expected to perform by mapping the task into the group military units that are needed to perform it directly. Secondly, we suppose that a military organization with a good C2 structures can responses tasks quickly and forms the required group units cooperating effectively. Then by affecting the information transmitting speed and the communicating quality of the different group units the C2 structure affect the organization’s reactivity and cooperation efficiency respectively. The approach is based on multi-dimensional tree (MDT) that is introduced to describe the C2 hierarchical structures of military organizations.

171

Regal, Robert  
Pacetti, Don  
SPAWAR

### Track 9

#### Extreme C2 and Multi-Touch, Multi-User Collaborative User Interfaces

The purpose of this paper is to introduce two things, the concept of Extreme C2 and a technological implementation for this collaborative, net-centric concept. Extreme C2 is a concept that applies elements of the eXtreme Programming (XP) concept. This collaborative development technique can increase the adaptability and quality of software, something of high value in the complex domain of enterprise software. When fused with net-centric concepts, Automated Battle Management Aids (ABMAs) and new human interface techniques, the application of this concept to C2 should be able to produce similar benefits for planning in military operations, particularly complex, multi-faceted operations. This concept will be demonstrated through the use of a multi-touch, multi-user interface screen built on top of net centric services. The paper will provide the results of a case study from a SPAWAR Charleston experiment about Operationalizing FORCEnet. We will evaluate the impact of Extreme C2 with Multi-Touch Multi-User (MTMU) technology on metrics like agility and speed of decision.

## 2:30 - 3:00 Tues

038

Czarnecki, Jonathan  
Naval War College, Monterey

### Track 1

#### The Failed Thermostat: The Illusion of Control in an Information-Rich Age

The concept of command and control is central to modern warfare. Command is a legal and behavioral term referring to a designated individual leader’s responsibility and accountability for everything the leader’s unit of command does and does not do. Control is a regulatory and scientific term denoting the

ability to manage that which is commanded. This paper investigates the use of certain types of control with operating environments that overwhelm commanders' abilities to do their job – lead and succeed in battle.

**2:30 - 3:00 Tues**

**167**

Schneider, John  
AgileDelta

**Track 8**

**Efficient XML: Taking Net-Centric Operations to the Edge**

As the military shifts toward network-centric operations, the vision of sharing common information objects between command centers, aircraft, maritime vessels and mobile land forces over a single global network seems closer than ever. One of the fundamental challenges of achieving this vision is bridging the gaps between enterprise C2 systems that can use net-centric web technologies and tactical C2 systems that require more efficient data representations. Efficient XML addresses this challenge by optimizing net-centric web technologies for environments with limited bandwidth, processing power and/or battery life. Efficient XML is the basis for the emerging World Wide Web Consortium (W3C) standard for Efficient XML Interchange (EXI) and independent measurements indicate it can make XML data small and fast enough for the most demanding tactical applications. The U.S. Navy's 2006 Joint Rapid Architecture Experiment (JRAE) and the U.S. Air Force's 2006 Joint Expeditionary Force Experiment (JEFX) independently assessed the utility of Efficient XML for military applications, measuring XML data transfer speeds over 100 times faster using less than 1% the bandwidth. This paper describes the challenges we face using XML on tactical networks, describes how Efficient XML addresses these challenges and provides real-world results achieved during JRAE '06 and JEFX '06.

**026**

Farmilo, Andy  
Whitworth, Ian  
Hone, Geoff  
Cranfield University

**Track 6**

**Analysis and planning using the HTA Tool**

At the 12th ICCRTS, an approach to agile planning was presented (Farmilo, Whitworth and Hone, 2007), that made use of the planning function in THE HTA TOOL – a freeware task analysis tool developed at Cranfield University. The capability of the tool has now been extended so as to provide the ability to handle high-level analyses of complex operations, such as multi-force or multinational. Different forces (and/or different nationalities) can be color-coded so that individual patterns of actions, tasks, or responsibilities, can be easily identified, traced throughout the analysis, and related to other force components. A second extension to the tool has enabled the non-availability of particular assets to restrict the scope of the planning function in a way that indicates the relative merits of these assets. The proposed use is not intended to replace existing tools designed for detailed planning, but the paper will discuss the direct benefits of using this type of computerized application, look at examples of mission planning and how these utilize the additional features of the tool.

**2:30 - 3:00 Tues**

**144**

Manso, Marco  
EDISOFT  
Nunes, Paulo  
CINAMIL

**Track 7**

**ELICIT and the Future C2: Theoretical Foundations for the Analysis of ELICIT Experiments**

ELICIT, a research and experimentation programme developed for the CCRP, is a game-based simulation that provides a network-centric environment for a small group or organization using one of two different C2 approaches: Hierarchy and Edge. This paper provides the theoretical foundations for the analysis of ELICIT experiments, using NCW tenets and theory and the C2 Conceptual Reference Models recently developed by ASD-NII/OFT (2006, Alberts and Hayes) and NATO SAS-050 Research Group (2006, NATO SAS-050) as a conceptual framework. A mapping between ELICIT and these reference models variables and metrics is presented regarding the relevant domains: Information (richness, reach, security and interactions), Cognitive and Social (individual and shared awareness and understanding and quality of interactions).

**155**

Borgers, Erik  
Spaans, Mink  
Voogd, Jeroen  
TNO Defence  
Hieb, Michael  
George Mason University  
Bonse, Remco  
Utrecht University

**Track 3**

**Using a Command and Control Language to Simulate Operations in a Multi-Agent Environment**

One of the most effective tools in planning complex operations between different organizations is a simulation of what is to be done. Given a common intent, a simulation provides a basis for understanding the different elements of an operation, and thus enables flexibility as a plan is developed and implemented. The state of the art in simulation is with multi-agent environments. Our work is in developing the abilities of agents so that they reason and act correctly in the simulation. We describe an agent engine called 2APL and its communication protocols. One of the most critical problems in simulating military operations is communicating the intent of what is to be achieved to an agent. This intent can be transmitted effectively between humans, but is problematic when working with agent implementations, due to the large amount of interpretation a human performs. We use a language called the Command and Control Lexical Grammar (C2LG), derived from a body of work called Battle Management Language for its precision and C2 semantics. In this paper, we present our experience in using the C2LG and assess the language for use with simulation agents for developing more effective simulations for Complex Endeavors.

## 2:30 - 3:00 Tues

245

Versailles, David

Research center of the French Air Force

### Track 2

#### **Sharing awareness and problem solving: introducing the concepts of embodied knowledge, epistemic and pragmatic action**

This contribution will elaborate on the interpretation of shared awareness on the basis of the asymmetry between information and knowledge. It will sketch the main elements associated to the implementation of knowledge computation in the C2 cycle on the basis of the aspects associated to knowledge assets codification and contextualization. Even though the concepts of situation awareness and shared awareness have become now a commonplace in the scientific literature, the concept of awareness remains often considered as a “buzzword” labeling a range of cognitive processes. Relevant definitions may be divided into two classes corresponding to State vs. Process duality. Endsley’s conceptual contribution focuses on individual appreciations and confronts “situation awareness” to “situation assessment”. Defining and modeling SA has recently evolved to take into account team cognition specificities and to consequently build up team situation awareness (TSA). Teamwork requires information gathering, information sharing, knowledge mobilization and team convergence toward a concrete action. Networking and computational capabilities available at all levels of the military systems on a battlefield and in the C2 chain have come to a turning point where creation, formalization, and distribution of information may be assessed as problem solving features and integrated into a broader investigation of decision making.

176

Ntuen, Celestine

Gwang-Myung, Kim

Park, Eui

North Carolina A&T State University

### Track 5

#### **Evaluation of Organizational Designs with Network-Centric Philosophy**

The concept of network-centric warfare (NCW) is an evolving construct that has altered the military organizational landscapes. In the asymmetric information domains, there are few studies that actually relate the daily agitations of each of the command centers to the vulnerability of the entire C2 structure. In addition, there are no existing studies that use daily events and incidents to understand the vulnerabilities of each organizational structure. This paper reports on the use of network and organizational theories to derive vulnerabilities of organizational structures based on probabilistic events on each C2 center. Vulnerability is calculated as a function of information surprisal. The results of an empirical study comparing organizational structure designs in terms of vulnerabilities are presented.

## **2:30 - 3:00 Tues**

**188**

Gustavsson, Per M.  
Saab  
Hieb, Michael  
George Mason University  
Eriksson, Patric  
More, Philip  
De Montfort University  
Niklasson, Lars  
University of Skövde

### **Track 9**

#### **Machine Interpretable Representation of Commander's Intent**

The Network-Centric approach envisioned in the Global Information Grid enables the interconnection of systems in a dynamic and flexible architecture to support multi-lateral, civilian and military missions. Constantly changing environments require commanders to plan for missions that allow organizations from various nations and agencies to join or separate from the teams performing the missions, depending on the situation, as missions unfold. The uncertainty within an actual mission, and the variety of potential organizations that support the mission after it is underway, makes Command Intent (CI) a critical concept for the mission team. With new and innovative information technologies, CI can now be made available to the team of organizations in a coalition environment. Using a flexible and linguistically based approach for representing CI allows Intent to be interpreted and processed by all participants – both humans and machines. CI representations need to be able to express mission team's purpose, the anticipated End-State of the mission and desired key tasks. In this work, the expression of CI is developed to enable the structure and dynamics of collaboration support.

## **3:30 - 4:00 Tues**

**175**

Ntuen, Celestine  
North Carolina A&T State University

### **Track 1**

#### **The Process of Sensemaking in Complex Human Endeavors**

This paper presents an approach to organizing the sensemaking process. The approach uses a set of cognitive constructs that translates tacit knowledge to the focal knowing of the objective world. The sensemaking process is also viewed as a robust method for developing training tools for the battle staffs critical thinking skills for various levels of problem complexities. At each stage of the sensemaking process, we have attempted to illustrate the efficacy of the available sensemaking constructs and paradigms. In addition to training application, the sensemaking process can be used to support knowledge representation for constructive modeling and simulation of sensemaking tasks.

**246**

Nitsche, Thomas  
FGAN/FKIE

### **Track 8**

#### **Efficient Information Publishing in Service-Oriented C2IS based on Subject Managers**

In this paper we introduce the concept of subject managers. In a service-oriented C2 Information System (C2IS), subject managers handle all the information providers of a specific subject, ranging from data in raw form (e.g., weather or intelligence) to evaluated form (e.g., politics or economics). An important class of information is georeferenced information. In this special case the concept of subject managers coincides with that of region services. In order to handle the potential information overload, a user of the C2IS can

thus locate the appropriate information providers within the overall Global Information Grid (GIG) that are relevant for his current mission and can efficiently subscribe to them.

### **3:30 - 4:00 Tues**

**027**

Whitworth, Ian  
Hone, Geoff  
Farmilo, Andy  
Cranfield University

#### **Track 6**

##### **Assessing the Order Process**

Key to the success of an operation is clear, accurate, complete and timely dissemination of orders, plans to effect those orders, and the encapsulation of command intent. A focal requirement within current army doctrine is that orders are recorded and passed in written form, yet our investigations have found that this is frequently not the case, neither within exercises or live missions. Other forms of communication, particularly verbal, are used to varying degrees although this appears to have led to a lack of consistency in approach. The situation for multi-national and multi-force efforts is even less clear. At the 12th ICCRTS an approach to assessing the transmission of command intent was presented (Hone, Whitworth and Farmilo, 2007). This approach, including the assessment software, have received positive feedback, particularly for their ease of use. This paper will discuss its potential application as an impartial method of post-exercise assessment in the training of junior officers and cadets. Plans to research into the use of different forms of communication for transmitting orders, and the implications for multinational and coalition operations will also be described.

**202**

Brickner, Michael  
Sheffer, Dganit  
Pamam Human Factors Engineering  
Sirkis, Amit, Israel Defense Forces

#### **Track 7**

##### **Better decision making through representation and reduction of uncertainty in C3I information system**

Battle Management Systems (BMS) have enhanced the availability of battlefield information. Yet, commanders may not always be aware of BMS limitations and may consider displayed information as an undivided representation of the world; whereas, in reality BMS information tends to be uncertain (e.g., incomplete, only partially accurate). Some sources of uncertainty may be anticipated and presented to the operator (e.g., information acquisition time). It was hypothesized that displaying this uncertainty may enhance commanders' decision-making. Two training and six experimental scenarios presented realistic urban battlefield simulations, while maintaining a well controlled experimental setup. Each scenario contained five, forced-choice, decision point. Decisions could be good, medium or bad, based on operational outcomes. Before each decision the operator could opt to ask for additional information (e.g., from an unmanned aerial vehicle [UAV]). Sixteen company or brigade commanders of the Israel Defense Forces were divided into an experimental uncertainty group and a control group for the five hour experiment. Uncertainty representations did not produce better overall decisions; however, in seven out of 30 decision points it had a significant positive effect. Using additional information significantly improved decisions, nevertheless, several subjects rarely requested any additional information, resulting in poor performance. Subjects rated the experimental setup as realistic and relevant and expressed a desire to be presented with uncertainty information as an optional information layer on BMS.



**3:30 - 4:00 Tues**

**105**

Levchuk, Georgiy  
Grande, Darby  
Levchuk, Yuri  
Aptima  
Pattipati, Krishna  
UCONN  
Kott, Alexander  
DARPA

**Track 3**

**Mission Plan Recognition: Developing Smart Automated Opposing Forces for Battlefield Simulations and Intelligence Analyses**

A key challenge for battlefield simulation is the estimation of enemy courses of action (COAs). Current adversarial COA development is a manual time-consuming process prone to errors due to limited knowledge about the adversary and its ability to adapt. Development of decision aids that can predict adversary's intent and range of possible behaviors, as well as automation of such technologies within battlefield simulations, would greatly enhance the efficacy of training and mission rehearsal solutions. In this paper, we describe the development of OPFOR agents that can intelligently learn BLUEFOR's mission plan. This knowledge will allow OPFOR agent to reason about the intent of BLUE and counteract accordingly to prevent/influence the future BLUEFOR's operations by affecting current operations, challenging BLUE's resources, and preparing OPFOR for future battles.

**077**

Vick, Shon  
Cantu, Osbaldo  
Mashariki, Amen Ra  
Steen, Christopher  
Johns Hopkins University Applied Physics Laboratory

**Track 2**

**Expanding the Dynamic Collaboration in Teams of Portal and Non-Portal Based Users Using Semantic Based Tools and Constructs**

Collaboration is integral to effective C2. Previous JHU/APL research focused on dynamic collaboration within a portal environment between homogeneous users. This paper details continued research on how both non-homogenous, disadvantaged users, operating in a mobile environment as well as portal based users could share information for effective C2. It also addresses how the effectiveness of this integration could be enhanced using semantic tools and constructs. The work on non-portal based applications treats the effect of team members operating with unequal capabilities potentially using different devices. It explores the adoption of RSS, mobile devices, and other technologies. Various architectures are explored including the Java 2 Micro Edition (J2ME) and associated technologies for evaluation of collaboration tools and technologies. The portal based work is centered on a geo-spatial display and an associated messaging system. Various directions enhancing collaboration were considered that would enable integrating deeper semantic content into the information shared for C2. Such tools for future evaluation are Wikis, Blogs and semantic based messengers. Among the benefits with the provision of semantic meta-data are personalized presentation of content (e.g. based on personal preferences), intelligent search, improved interoperability between systems (e.g. integration of several applications in a federated process, or with the support of smart agents).

## 3:30 - 4:00 Tues

226

Park, Chulwoo  
Pattipati, Krishna  
University of Connecticut  
Kleinman, David  
Naval Postgraduate School

### Track 5

#### **Holonic scheduling concepts for C2 organizational design for MHQs with MOC**

The purpose of this paper is to present a C2 holonic reference architecture (HRA) that is applicable to Navy maritime headquarters (MHQ) with maritime operations center (MOC) for assessing, planning and executing multiple missions and tasks across a range of military operations. The control architecture consists of three levels: strategic level control (SLC), operational level control (OLC) and tactical level control (TLC). In addition to coordination within each level, two specific coordination layers are identified at the SLC-OLC and the OLC-TLC interfaces. The SLC-OLC interface layer resolves coordination issues associated with selecting and managing multiple missions (simultaneous or sequential), while the OLC-TLC interface layer is used to resolve coordination and synchronization issues associated with asset allocation and task scheduling for each mission. The proposed architecture conforms with the concepts of centralized assessment and guidance, distributed and collaborative planning, and decentralized execution in that it employs centralized decision making at the strategic level, collaborative planning at the operational level, and negotiation mechanisms at the tactical level. We employ Markov decision process (MDP) approach to decide on missions to be executed and their sequences at the SLC-OLC layer (coordination of future plans), while group technology and a nested genetic algorithm-based multi-objective optimization techniques for asset allocation and task scheduling at the OLC-TLC layer (coordination of future operations and current operations).

191

Lincourt, David  
Peukert, Hans  
Kowalkiewicz, Marek  
SAP

### Track 9

#### **Situational Common Operating Picture for Collaborative Sensemaking**

Timely, accurate and relevant information is a key contributor to making good decisions in complex endeavors. Thereby, it is often necessary to put structured and unstructured information originating from multiple entities and sources into a certain context – often the whole is more than the sum of its parts. Combining information from different sources can help answer different questions such as what? (for instance road “diamond” unavailable) why? (contextualization with news that roads are clogged due to an evacuation), to whom (contextualization with re-assignment of sustainment responsibilities), etc. In certain situations decision makers are only able to detect certain patterns if they are exposed to different information. Pre-defining such patterns or scenarios generically proves difficult. Often they have to react to unexpected, critical circumstances that cannot be pre-modeled. Hence, a system to support agile collaborative sensemaking in such situations by fulfilling ad-hoc information demands must provide means to identify relevant information blocks and contextualize information on the fly. We propose that decision makers need to be able to interact with the system in a non-technical way, with an intuitive user interface and an easy to use situational Common Operating Picture composite application.

**4:00 - 4:30 Tues**

**228**

Marsay, David  
QinetiQ

**Track 1**

**Complexity concepts for Command and Intelligence**

While it is generally recognized that an understanding of complexity is essential to the development of effective Command and Intelligence, there are no accepted, credible, models or metaphors to draw upon. This paper discusses the desiderata for such models and metaphors emerging from current work on command battlespace management (CBM) and ISTAR, describes a tentative model of complexity based on a school playground, and gives some deductions for the nature of uncertainty, collaboration, adaptation and consideration of effects, with particular attention to the implications for all-source intelligence problem analysis, multi-hypothesis testing, target identification and classification.

**050**

Christensson, S Anders  
Swedish National Defence College

**Track 4**

**Instruction sets to use and test a transformation towards an agreed end non-failing state**

For a joint force commander to find the instructions set to civilian and military organizations that transform a failing state towards an agreed end state is a problem. The overwhelming amount of dynamics, interactions and generative capabilities hidden in this, is a cognitively difficult task to grasp for commanders and practitioners. One difficulty is to represent the initial scene for the failing state. To use this expressed terminology so that practitioners can use it to follow the development in the dynamics, interactions and generative capabilities. To allow practitioners to experiment with their instructions sets and elaborate with these instructions sets as they are incrementally testing them in order to meet expressed end state for the non-failing state. A possible solution to support this process of finding the instructions set has been developed. During several explorative exercises the incremental designed systems has been used and proven to be supportive in qualitative terms. Practitioners have in qualitative terms expressed their experiences of its use through out planning in four different exploratory exercises.

**184**

Moon, Il Chul  
Kim, Eunice  
Carley, Kathleen  
Carnegie Mellon University

**Track 6**

**Automated Influence Network Generation and the Node Parameter Sensitivity Analysis**

An influence network is a directed graph extensively used for Effects-Based Operation. It contains nodes that represent events and links that encode causal relationships among events. It propagates the likelihood of each event through promotion or inhibition by its parents. As a subject matter expert often builds this network by hand, we helped simplify the influence network generation in Organization Risk Analyzer. The resulting influence network is generated from a multi-mode, multi-plex organizational network structure, and the generation scheme is based on assessing event flows and evaluating the factors on task management of the organization. To support the soundness of such network generation, we provide sensitivity analysis of baseline probabilities, a major parameter of the model, by bootstrap sampling of the leaf nodes and propagating different levels of as-signed parameters. Finally, we provide an example of analysis by utilizing the introduced generation method and a dataset from 1998 US embassy bombing in Kenya.

**4:00 - 4:30 Tues**

**016**

Tolk, Andreas  
Old Dominion University  
Diallo, Saikou  
Virginia Modeling Analyses & Simulation Center

**Track 7**

**Community-of-Interest (COI) Model-based Languages enabling Composable Net-Centric Services**

Net-centric services shall be designed to collaborate with other services used within the supported Community of Interest (COI). This requires that such services not only be integratable on the technical level and interoperable on the implementation level, but also that they are composable in the sense that they are semantically and pragmatically consistent and able to exchange information in a consistent and unambiguous way. In order to support Command-and-Control with Composable Net-centric Services, the human-machine interoperation must be supported as well as the machine-machine interoperation. This paper shows that techniques of computer linguistic can support the human-machine interface by structuring human-oriented representations into machine-oriented regular expressions that implement the unambiguous data exchange between machines. Distinguishing between these two domains is essential, as some requirements are mutually exclusive. In order to get the “best of both worlds,” an aligned approach based on a COI model is needed. This COI model starts with the partners and their respective services and business processes, identifies the resulting infrastructure components, and derives the information exchange requirements. Model-based Data Engineering leads to the configuration of data exchange specifications between the services in form of an artificial language comprising regular expressions for the machine-machine communication. Computer linguistic methods are applied to accept and generate human-oriented representations, which potentially extend the information exchange specifications to capture new information not represented in the system requirements. The paper presents the framework that was partially applied for homeland security applications and in support of the joint rapid scenario generation activities of US Joint Forces Command.

**218**

Dean, David  
Vincent, Alasdair  
Mistry, Beejal  
Dstl  
Spaans, Mink  
Petiet, Peter  
TNO

**Track 3**

**A process for placing the human at the centre of the constructive simulation**

This paper will describe different aspects of human behaviour and characteristics that can be represented by modelling techniques, based on ongoing work within the UK Defence Science and Technology Laboratory (Dstl), the Nederland’s Organisation for Applied Scientific Research (TNO) and the US Naval Postgraduate School (NPS). It will then propose how these characteristics can be used within a range of different types of constructive simulation, in particular agent based models. Importantly, it will also consider an integrated process of experimentation and analysis to validate and maintain development of human factors representations within constructive simulations.

**4:00 - 4:30 Tues**

**086**

Sturm, John  
NuParadigm Government Systems

**Track 2**

**Potential Benefits & Implications of Privacy Protection and Anonymity for Command & Control through “Hidden Communications Services”**

As the style of warfare has changed to support sudden regional conflicts and ad hoc humanitarian missions for disaster relief (e.g., Hurricane Katrina), so has the style of Command & Control (C2) needed to incorporate civilian intelligence sources (non-government organizations-NGOs) and embrace government authorities. It is difficult to predict in advance what sources of intelligence will be used, and if one is communicating with “small civilian cells”; the Internet might be the only available channel. However, the need still exists to protect the sources & methods employed for intelligence gathering from disclosure. Likewise the deployment of military resources, such as naval vessels, needs to be protected even if serving civilian aid. One possible method of protecting intelligence and C2 communications would be through the creation of a “Hidden Communications Web Service” in which the source and destination of IP messaging was kept hidden/anonymous, but authentication and authorization for access could be maintained as needed. The concept of “Onion Routing” (Tor) was developed several years ago by Goldschlag, Reed, and Syverson at the Naval Research Laboratory to provide anonymity on the Internet and has led to many “civilian” implementations world-wide through open-source software (e.g., Tor).

**096**

Grant, Timothy  
Netherlands Defence Academy  
Essens, Peter  
van der Kleij, Rick  
TNO

**Track 5**

**Reducing Operational Planning Cycle Time Using BPR and Concurrent Engineering**

This paper reports on on-going research aimed at contributing to the development of a new conceptual model of planning by reducing the cycle time for operational planning by an order of magnitude or more. Experience in other domains show that this should be feasible using technologies such as intelligent planning and scheduling, simulation, and concurrent engineering. Business process re-engineering methods and cycle time reduction techniques are applied to the illustrative example of the Royal Netherlands Army’s Decision Making Process. The results show that it is not sufficient to flatten or to plan concurrently at all levels of the organizational hierarchy. The planning process within each unit must itself be streamlined. The paper investigates incremental and radical measures for reducing the cycle time of the planning process. It makes recommendations for comparing a variety of planning processes, for further study of specific radical measures, and for concept development and experimentation.

**205**

Zhao, Ying  
Kotak, Chetan  
Zhou, Charles  
Quantum Intelligence

**Track 9**

**Semantical Machine Understanding**

Semantical Machine Understanding is the foundation for automatic sense and decision making of multinational, multicultural, and coalition applications. We show an innovative semantical machine understanding system that can be installed on each node of a network and used as a semantic search engine. Innovations of such a system include 1) text mining: extract concepts and meaning clusters based

on contexts using pattern recognition and machine learning; 2) meaning learning: extract knowledge patterns that link human labeled meaning to raw data. The knowledge patterns can be applied to predict future data; and 3) collaborative meaning search: incorporate humans and machines to form a collaborative network to search and enhance the meaning iteratively. In this paper, we also show the feasibility of using a semantic search architecture and discuss the two ways it is drastically different from current search engines: 1) indexes embedded in agents are distributed and customized to the learning and knowledge patterns of their own environment and culture. This allows data providers to maintain their own data in their own environment, but still share indexes across peers; 2) Semantic machine understanding enables discovery of new information rather than popular information.

#### **4:30 - 5:00 Tues**

**074**

Genik, Lynne  
Lefebvre, Julie  
DRDC  
Froh, Mike  
RatworX

#### **Track 1**

### **Coalition Computer Network Defence (CND) Common Operating Picture (COP)**

#### **Concept**

This paper defines a conceptual Coalition Computer Network Defence (CND) Common Operating Picture (COP), its concept of operations, and identifies research challenges for providing such a capability. A Coalition CND COP consists of two aspects of information assurance (IA) in a coalition environment: technologies for secure information exchange and the automated exchange of multinational CND information; this paper focuses on the latter. Situational awareness (SA) is a vital part of CND, providing an understanding of the status of networks. CND SA encompasses IA information including available information technology (IT) services, IT infrastructure, vulnerabilities, safeguards, exploits, threats, alarms, and incidents. All of this information can contribute to a Coalition CND COP. We identify four reasons for automating the information exchange: human resistance to sharing, rapid events, a large information exchange volume, and information complexity. Scenarios involving a Coalition CND COP are presented to illustrate improved operational capabilities, including clearer SA, more efficient use of resources, and more effective CND action. It is shown that even a small amount of information sharing can have significant benefits. Finally, a number of research areas supporting a Coalition CND COP capability are detailed and prioritized.

**031**

Hansberger, Jeff  
ARL

#### **Track 4**

### **The Distributed Cognitive Components of C2**

Distributed cognition (Hutchins, 1995a) is a theoretical framework that explains cognitive activities embodied and situated within the work setting and the artifacts used in the environment. Distributed cognition emphasizes the distributed nature of cognitive phenomena across individuals, tools/technologies, and internal/external representations. The unit of analysis goes beyond the cognitions of a single individual and focuses on the functional system as a whole. Distributed cognition examines the relation between individuals, the task environment, and artifacts used for task completion. Among some of the distributed cognitive attributes are: 1) Coordination across agents; 2) situation assessment; 3) mental models; 4) memory demands; 5) adaptability; and 6) workload management. Command & Control (C2) systems can greatly benefit when examined and analyzed as a distributed cognitive system through its emphasis on these cognitive attributes of the system. The theoretical and analytical implications of applying this approach to C2 systems will be discussed based on recent application and analysis to a series of C2 experiments.

**4:30 - 5:00 Tues**

**186**

Taylor, Richard  
DSTO

**Track 6**

**Computability Issues of Efficiency and Effectiveness of Organisational Models**

Building on methods from computability theory we show that any useful question about the efficiency or effectiveness of computational organisational models can have no solution method, algorithm, or program that generates correct answers for all such models and their inputs. Bounds on the extent to which a given method can generate correct answers are also provided. One way to ensure computable methods apply is to define an organisational question the resolution of which limits the operation of an organisational model to a finite time. In this case however we show that there is no way in general of speeding up the analysis apart from simply running the organisation, or a model of it, for the specified time.

**018**

Kingston, Gina  
Hew, Patrick  
DSTO

**Track 7**

**Designing “Killer Applications” of NCW – A process to support creation and innovation**

Research on Network-Centric Warfare (NCW) has largely focused on the development, implementation and impact of the supporting technical network. However, there are very few published examples of war fighting advantages arising from NCW perspectives, particularly of paradigm changes in warfare arising from innovative, network-centric concepts. This paper presents initial thoughts on a process for developing network-centred concepts for the future military, from case studies in the Australian context. In the authors' experience, it is not enough to develop a single concept; but necessary to articulate the landscape of possible options. The authors had to rethink their tools and thinking processes as a result, drawing upon the software development field for its experience in new product development.

**256**

Robledo, Luis  
Godoy, Eduardo  
Chilean Army

**Track 10**

**SIGEN: Simulation for Training and Management on Emergency Situations**

SIGEN is a modern network simulation software designed by the Chilean Army Simulation Center, the Northern Catholic University, and sponsored by the National Emergency Office from the Ministry of Internal Affairs, which allows management training between the components of an organization, through the interaction of their different roles under a given initial situation, and monitoring their reactions from further specific missions, reports or given information. This tool is designed to work with organizations and institutions in emergency management, under strenuous situations, allowing real time and after-action reviews.

**4:30 - 5:00 Tues**

**065**

Nyamekye, Kofi  
Integrated Activity-Based Simulation Research

**Track 2**

**Information Content for Adaptive Network Performance for C4ISR Systems-of-Systems: Queuing Theory and Axiomatic Design Approach**

The paper presents information content for adaptive network performance for C4ISR systems-of-systems (SOS) using queuing theory and axiomatic design approach. The paper first summarizes the network types or configurations, the network classifications and the network properties. It also emphasizes that the network infrastructure is part of integrated systems-of-systems design and not as stove-piped systems. Drawing on the previous author's work, the paper emphasizes that the axiomatic design, integrated with Service-Oriented Architecture-Based Department of Defense Architecture Framework (SOA)-Based DODAF, establishes the scientific framework for designing integrated C4ISR systems-of-systems (SOS), of which the network infrastructure is a subsystem. The queuing models are presented for the network performance, and information content from AXIOM 2 of axiomatic design, is employed for the network optimization. The effect of information overload, on the network performance for the Net-Centric SOS, is also presented. The paper discusses that the Service-based modeling and simulation, and experimental tests are needed to generate the data for the queuing models for network performance and optimization of the C4ISR SOS. Intelligent decouplers that can provide extra bandwidths in the network to reduce information overload, and thus permit the network to dynamically adjust itself to uncertainties, has been discussed. The Design Navigation Method has been discussed for experimental and simulation design, and for optimization, under scenarios of multi-functional requirements (FRs) and interaction effects among the design parameters (DPs). Such an integrated queuing modeling and axiomatic design approach, is critical for designing and operating complex civil-military endeavors.

**244**

Shilling, Chris  
Slavin, David  
Pfizer International  
Shamir, Eitan  
Kings College  
Linkov, Igor  
USA Engineer RDC

**Track 5**

**Enabling Organizational Innovation: Scientific Process and Military Experience**

Increasing information richness and the changing socio-political environment in recent years have resulted in changes in corporate structure and organization. The growing challenges of organizational and technological complexities require the development of new organizational concepts. The effects of a combination of high complexity and high uncertainty have been recognized before in military settings. To take advantage of new technologies and manage information complexity, a theory of Network Centric Operations was developed. Mission Command and Network Centric Operations formulate organizational structure across functional domains (physical, informational, change this cognitive and social), in a way that is also applicable in a business setting. In response to an increase in decision complexity and regulations, academia has developed risk assessment and multi criteria decision analysis tools for use in military and industrial settings. We believe that the combination of military science with multi-criteria decision analysis and risk assessment has the potential to dramatically improve the credibility, efficiency and transparency of strategic and tactical decisions in industrial settings. This paper summarizes the military concepts of MC and NCO, and links them with mental modeling, risk assessment and decision analysis tools. Application of the combined framework for the pharmaceutical industry is also discussed.



## 4:30 - 5:00 Tues

219

McCubbin, Christopher  
Cost, R.Scott  
Dale, Markus  
Worley, Paul  
Bankman, Daniel  
Johns Hopkins University Applied Physics Laboratory

### Track 9

#### **Extending Service Oriented Architectures to Edge Networks with Active Metadata and Swarming**

Much work has been done on perfecting Service-Oriented Architectures (SOAs) in the case of connected networks and networks which have full-time access to centralized service directories. Networks which have sparse connectivity, mobile nodes, and limited bandwidth cannot use this model for a SOA. Many of today and tomorrow's tactical networks will have these limitations. We have designed and built a SOA which combines the advantages of swarming technology and active metadata, extending SOA and service invocation capability to these tactical edge networks. Autonomous mobile nodes within our swarming architecture also have the capability to reconfigure the edge network topology to optimize service response time, while at the same time completing complementary tasks such as area search. Our architecture is modeled on the successful Representational State Transfer (REST) architecture for Web Services. Metadata and service invocation are there for every lightweight and are capable of easily being transported through the limited-capability swarming network. Service responses can either be transmitted via direct link, if one exists, or can be transported via mobile swarming nodes for network delay-tolerance. We present the results of testing our architecture in a Chem Bio scenario during an officially-sponsored autonomy experiment.

## 5:00 - 5:30 Tues

111

Joseffson, Anders  
Marklund, Joakim  
Swedish Armed Forces Headquarters  
Hansson, Lars-Åke  
Swedish Defence Research Agency

### Track 1

#### **IDC2—a new C2 concept within the framework of a Network Based Defence Concept**

The purpose of this paper is to introduce a network based Command and Control (C2) concept for the design and development of C2 methods, developed with and for the tactical levels of command, in the Swedish Armed Forces (SwAF). The concept - Integrated Dynamic Command and Control (IDC2) - contributes to the SwAF's ongoing transformation towards a network oriented capability. The purpose of IDC2 is to increase efficiency and adaptability in a networked C2 environment, ultimately to better realise operational outcomes. This is achieved through timely and adequate holistic understanding, within and between all levels of command, regarding what is to be achieved and why, greater flexibility in C2 and the choice of C2 method. IDC2 emphasize improved dialogue to gain a deeper understanding, through new means of communication. Integrated C2 involves synchronization of adequate C2 activities. Thereby, the synergy of the collective intellectual capacity contributes to a more comprehensive situational understanding, which supports adaptability and increased precision in the execution of operations. The Manoeuvrist Approach and Mission Command still remain central pillars of the SwAF Approach to Operations, and IDC2 is a concept to improve the approach through a robust, network-based infrastructure for exchange of information in a non hierarchical way.

**5:00 - 5:30 Tues**

**055**

Valaker, Sigmund  
Braathen, Karsten  
FFI

**Track 4**

**An Exploratory Study of Transactive Memory System Development in a Geographically Distributed Temporary Organization**

As part of measuring training effectiveness of distributed simulation based training and exploring the impact of communication condition on military organizing, we conducted an exploratory investigation of transactive memory system (TMS) development in a distributed temporary organization comprising one Control and Report Center (CRC) and two frigate Anti-Air Warfare (AAW) teams. The JADE II joint tactical training capability prototype facilitated this investigation. TMS have been proposed as an important way in which organizations enable information processing. However, there is to our knowledge little research on TMS development in a military context. Specifically, whether exposing an organization to multiple training sessions in a short period of time would enhance a TMS were investigated in this study. Furthermore the impact of perceived task complexity, safety organizing and perceived media richness on TMS was investigated. The impact of TMS on mutual understanding and perceived situation awareness was also measured. The tentative findings suggest that differences in routines and vocabulary between CRC and the AAW organization on joint tasks necessitated this kind of training. Being able to make unforeseen events and coordination problems into an occasion for learning and develop shared vocabulary and routines seem to be particularly important for this kind of temporary and distributed organizations.

**030**

Hone, Geoffrey  
Whitworth, Ian  
Farmilo, Andy  
Cranfield University  
Swift, David  
HQ Land Forces

**Track 6**

**The Case for Coarse-grained After Action Review in Computer Aided Exercises**

With rare exceptions, the use of a machine mediated instructional overlay is under-exploited in Computer Aided Exercises (CAX), such as Virtual and Constructive variants of simulation. In the latter, flagging, replay and alternating eye-points are well understood and widely used. Thereafter, however, the Exercise Controller (EXCON) is usually faced with a comprehensive log of every event that occurred during the CAX as his only after action resource to inform feedback to his trainees – a potential morass of data. Conversely, while such data may provide an exhaustive summary of what happened, it often provides little assistance to the EXCON as to why it occurred as it did – at least, not within a short enough time-frame likely to be of use in a training context, as contrasted with Operational Analysis of “War Gaming” where longer delays are generally more acceptable. The authors discuss two simple tool-based approaches that can enable an EXCON to offer a very fast, albeit, coarse grained, assessment of trainee performance in a CAX, so that trainees can better appreciate the consequences of their decisions. The first of these approaches can also be run as a trainee commander starts to prepare plans, thus allowing the EXCON to render a “before-and-after” judgment. It is argued that this will enhance the learning effectiveness of the After Action Review (AAR) in CAX.

**5:00 - 5:30 Tues**

**137**

Uruguay, André  
Lessa, Nilton  
Santos, Carmen  
Instituto de Estudos Avançados  
Costa, Paulo  
George Mason University

**Track 7**

**C2OLISEU—A Meta-Model for Research and Development of Complex Network Centric Operations**

Complexity in net-centric systems is a clear and increasingly present trend in C2 development. Yet, support for research and development inside the dynamics of complex net-centric systems has been relatively shy. Addressing this issue, the present work introduces C2OLISEU, a meta-model designed to express concepts associated with network-centric systems operations, providing a meta-model that encompasses the four key domains of network centric operations: social, cognitive, information and physical. For the social and cognitive domains, a set of basic concepts is derived from well-established paradigms in computational organization theory and artificial intelligence. Concepts within the information domain are conveyed via a subset of the DoDAF framework's concepts for the operational and systemic views of C2 architectures. Finally, as a means to consistently support the physical domain, the meta-model includes a preliminary set of C2 metrics derived from the classic principles of war. We argue that C2OLISEU metrics will help to better characterize complex and adaptive systems trajectories, thus enabling the study of edge organizations. Further, by using concepts derived from DoDAF, the C2OLISEU meta-model greatly improves the understanding of research results by both systems engineers and managers, thus eliminating unwanted cognitive entropy and fostering the innovation process.

**063**

Lofdahl, Corey  
BAE Systems

**Track 3**

**Synthesizing Information for Senior Policy Makers using Simulation: Working through an EBO example with system dynamics**

Modern computer systems have made ever-increasing amounts of processing power available to senior governmental decision makers, but this technology has at times overwhelmed them with large amounts of hard-to-interpret data. Modeling and simulation generally, and System Dynamics (SD) specifically, addresses data overload by “boiling down” the data and synthesizing information at the macro-level. This capability is demonstrated by showing that SD applies to Effects Based Operations (EBO) problems and by addressing an EBO example problem. In so doing, specific requirements are detailed and defined including visualization, quantification, data acquisition, system complexity, system integration, and model Verification, Validation, and Accreditation (VV&A). The paper concludes that, given the large amount of work that has gone into developing the SD methodology, current policy-tool development efforts that address fundamentally similar policy questions are likely to prove unsuccessful. An alternate path of using system dynamics as the policy tool of first choice, identifying requirements and gaps based on that effort, and then developing tools informed by those gaps will likely prove more successful.

## 5:00 - 5:30 Tues

207

Masi, Denise  
Fischer, Martin  
Garbin, David  
Noblis

### Track 2

#### GETS Survivability Analysis

The ability to communicate during emergencies is essential for government personnel. The mission of the National Communications System (NCS) includes planning for and provisioning National Security/Emergency Preparedness (NS/EP) communications for the federal government under all circumstances, including crisis or emergency, attack, recovery, and reconstitution. In support of its mission, NCS runs several emergency telecommunications priority service programs for federal government users, including the Government Emergency Telecommunications Service (GETS) and is currently investigating the need to evolve the GETS program toward IP capability. This study is an analysis of the survivability objectives for Next Generation Network (NGN) GETS Voice Services. We used IP-SURVIV, a Noblis Survivability Analysis tool, to analyze throughput and connectivity of a network topology similar to major ISP backbone as network elements are disabled. Three failure scenarios were analyzed: random electronics failures, directed / terrorist attacks, and natural disasters. Throughput and connectivity were examined under each scenario, and worst case results will be incorporated into survivability objectives for the network service providers.

100

Herranz, Joaquín  
Desouza, Kevin  
Roy, Sumit  
University of Washington

### Track 5

#### Coordination Strategies for Edge Organizations

This paper provides a critical analysis of coordination strategies related to Alberts and Hayes' (2003) conceptualization of Edge Organizations (EOs). According to Alberts and Hayes (2003), EOs offer a high-contrast alternative form of coordination when compared to hierarchical structures for command and control (C2). In this view, EOs resemble networks in their form and in their decentralized, adaptive, and dynamic functioning. This paper examines and extends current theoretical understanding of coordination strategies for EOs by providing a three-part analytical critique. The first part examines the EO concept from the critical perspective of organization theory. The second part questions the notion of EOs as an archetypical network form that is best able to combat terrorist organizations. We argue that terrorist organizations represent a range of organizational forms rather than a single network form. Consequently, EOs should likewise represent an adaptive range of organizational forms and coordination strategies. The third part provides a conceptual framework that builds upon the previous critiques and identifies a range of coordinating strategies for EOs that would enable leaders to use an analytical model in determining the strategic and operational trade-offs associated with different coordination strategies in multi-actor complex endeavors. We argue that the effectiveness and efficiency of the EO is related to its coordinating strategy. Consequently, the EO needs to be agile enough to choose the right coordinating strategy given the conditions of its internal and external environments. The internal environment includes the work and task allotments, while external environment considers the issues of coalition partners, goals, strategies, etc. Our paper contributes to building a more robust EO framework by providing a critical analysis of coordination strategies related to Alberts and Hayes' (2003) re-conceptualization of military organizations as EOs.

**5:00 - 5:30 Tues**

**225**

Loomis, Jeremy  
Porter, Rob  
Hittle, Audie  
Desai, Chetan  
White, Russ  
ProLogic

**Track 9**

**Net-centric Collaboration and Situational Awareness with an Advanced User-Defined Operational Picture (UDOP)**

Historically, government organizations have developed “operations centers” as hubs for command and control functions. Over the past decade there has been significant interest in shared situational awareness and collaboration as well as improvement in networking capabilities, which has resulted in concepts and terms such as Common Operational Picture, Common Relevant Operational Picture, and User-Defined Operational Picture. These ‘pictures’ make operational information available directly to an individual’s desktop (outside the operations centers). This paper defines and introduces the technology concepts for a User-Defined Operational Picture (UDOP) that enable collaboration by providing visual situational awareness to end-users working within an operational Network-Centric environment that is offering an increasing number of web service-enabled information sources. UDOPs are created, visualized, augmented, tailored, and shared by the organization to enhance situational awareness and support collaborative and hierarchical decision-making. The UDOP architecture supports 2D, 3D, and 4D (3D + time) visualization using COTS technologies. Implementation of a robust and flexible UDOP system relies on several key system design patterns that include Service Oriented Architecture (SOA), plug-in mechanisms, layer/filter models, and loose coupling. This paper will also describe one reference implementation of a UDOP system by reviewing an operationally deployed capability called Global Awareness Presentation Services (GAPS).

# WEDNESDAY PRESENTATIONS

11:30 - 12:00 Wed

007

Moffat, James  
Dstl

## Track 1

### **The Response to Hurricane Katrina: A Case Study of Changing C2 Maturity**

In work with NATO colleagues, I have developed a Maturity Model of NATO Network Enabled Capability (NEC) Command and Control (C2). This model consists of a number of levels of increasing C2 Maturity, ranging from Conflicted C2 to Agile C2, which reflect the NEC journey towards the 'NEC Mature' state, through increasing levels of agility. To validate this Maturity Model, I examined the case study of Hurricane Katrina, based on the following authoritative reports in the public domain. The US House of Representatives created a bipartisan committee to investigate the preparation for and response to Hurricane Katrina. In addition there was an independent report to the President led by the Department for Homeland Security. A report commissioned by the US Government examined the implications for the US Army and National Guard. In terms of our Maturity model, examples were observed of all Maturity Levels, during the build up to and immediate aftermath of the landfall of the hurricane, with the balance towards the Conflicted end. These maturity levels also changed over time in general. The key factors marking out these differing Maturity Levels were identified, where possible, and are consistent with the current NATO NEC C2 Maturity Model.

146

Hutchins, Susan  
Kendall, Anthony  
Bordetsky, Alex  
Naval Postgraduate School

## Track 4

### **Understanding Patterns of Team Collaboration Employed To Solve Unique Problems**

'Macrocognition' is a nascent area of knowledge engineering that focuses on understanding how cognition emerges in natural environments. One goal for studying macrocognition is to understand the complexity entailed in inter- and intra-individual cognition. The goal of the research reported here is to better understand how team collaboration influences and facilitates the team's task performance. In this paper we describe our analysis of several complex team collaboration tasks: (a) firefighters from the Fire Department of New York on September 11, 2001, (b) air warfare teams on an Aegis ship, and (c) the team collaboration entailed in conducting Maritime Interdiction Operations. Team communications that transpired during three complex problem solving situations were analyzed to understand how teams collaborate to create new knowledge and decide on a course of action during complex, one-of-a-kind problems. Communications were analyzed using definitions of cognitive processes included in a conceptual model of team collaboration. These processes include: (1) individual knowledge building, (2) developing knowledge interoperability, (3) developing team shared understanding, and (4) team consensus. The way the team's cognitive behavior maps to the model of team collaboration is discussed along with differences in patterns of collaboration for different decision-making domains.

**11:30 - 12:00 Wed**

**212**

Hodicky, Jan  
Frantis, Petr

**University of Defence Brno**

**Track 8**

**Virtual Reality Devices in C2 Systems**

The situational awareness and decision making support is the main objective of C2 system. Thus, the presentation layer architecture of C2 systems is one of the most important features for common understanding of a battlefield situation. The commander should have the option to choose the appropriate form of data presentation and interaction in the C2 system. The current state of the art in presenting of information is set by the US Force XXI Battle Command Brigade and Below (FBCB2) system and its new presentation layer component Command and Control in 3 dimensions (C3D) that renders the battlefield information into a 3 dimensions (3D) environment in real time. The paper deals with the Czech approach to the improvement of presentation layer in the currently used C2 system. It involves using an existing virtual reality presentation engine (designed for virtual simulators) as an additional presentation layer. This work has already been started as a defense research project that plans to deliver results in 2008. The currently developing presentation layer extends the 3D visualization of the battlefield situation and adds virtual reality (VR) device integration, supporting an interaction within the C2 system. The architecture utilizes head-mounted display, data gloves and motion tracking systems. The paper describes the current situation in this outgoing project, and then discusses the technical aspects of the solution.

**130**

Powell, Walter  
Laskey, Kathryn Blackmond  
Adelman, Leonard  
Dorgan, Shiloh  
Johnson, Ryan  
George Mason University  
Klementowski, Craig  
Yost, Rick  
VIECORE  
Visone, Daniel  
Braswell, Kenneth  
TEC

**Track 7**

**Evaluation of Advanced Automated Geospatial Tools: Agility in Complex Planning**

In an era of limited funding, a rapid development and procurement process is necessary to provide warfighters with performance-enhancing tools. It is essential to accurately assess the value of the tools we develop, and to use this assessment to shape future research and development efforts. To assist its research and development efforts, the U.S. Army Topographic Engineering Center (TEC) is sponsoring a series of experiments to evaluate the value of its suite of Advanced Automated Geospatial Tools (AAGT), the Battlefield Terrain Reasoning and Awareness – Battle Command (BTRA-BC) Tools. The first experiment in this series, which was presented at the 12th ICCRTS, demonstrated the benefits of an AAGT in a strictly terrain analysis scenario. Building upon the results of the first experiment, the second experiment will evaluate the value of an AAGT in a more complex planning environment and with a scenario that requires more complex decision making. This paper discusses the scope of the second experiment, its hypotheses, and the experimental design.

**11:30 - 12:00 Wed**

**128**

Woodley, Robert  
Gosnell, Michael  
Noll, Warren  
21st Century Systems

**Track 3**

**Adding Culture to Command Decisions**

It is well understood that local culture can drastically affect the types of responses to various military actions in foreign countries. However, attempting to predict culturally-influenced reactions is extremely difficult or narrow in scope (based off specific previous experiences). This work proposes a dynamic game-theoretic framework with culturally-defined probabilistic payoff matrices to predict inter-cultural threat responses. It will be shown that initial payoff matrices can be constructed from the World Values Survey (WVS) data. WVS provides standardized data collected from some 80 countries over the 6 occupied continents. Specific political action questions in the WVS are used to create culturally-specific probabilistic response tendencies for non-force, non-lethal force, or lethal force responses. These responses are combined to provide the initial game-theoretic payoff matrices which are then used in simulations. The results of various dynamic cultural interactions are discussed in relation to potential command decisions based on the potential for indicated types of responses.

**083**

Bowman, Elizabeth  
Thomas, Jeffrey  
ARL

**Track 2**

**C2 of Unmanned Systems in Distributed ISR Operations**

This paper describes a series of experiments to investigate issues of human-robot teaming and network centric operations. Experiment objectives were coordinated to address issues within and among the physical, communications, information, and human (cognitive/social) domain layers of the network. Objectives spanned the cognitive, social, and physical domains of the network. In the cognitive domain, researchers tested a predictive performance tool for robotic operators and measured operator situational awareness and workload during missions as these conditions related to reliance upon unmanned surveillance technologies. In the social domain, we documented the ad hoc development of social, task, and knowledge networks during missions. These human dimensions of the network were juxtaposed to the agile computing infrastructure operating over a Future Force surrogate network and an 802.11 network. Results show that many challenges exist across the layers of the network domain architecture. Primary among these is to develop a mobile ad hoc network (MANET) to support mobile and extended vehicle/dismount ranges in a variety of terrain conditions. In the cognitive/social domain, we need to understand what information Soldiers need from a network, when this information is of maximum use, and what form the information should take for maximum situational awareness and decision making.



























































































































