14 September 2004

MILITARY OPERATIONS RESEARCH SOCIETY

MORS Workshop

Operations Analysis Support to Network Centric Operations

27-29 January 2004

Booz Allen Hamilton

McLean, Virginia

Chairs: Dennis Baer and Kirk Michealson

Technical Chairs: Dr. David Alberts and Dr. Richard Hayes

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EXECUTIVE SUMMARY

As Network Centric Operations (NCO) are being developed, the analytic community is being called upon to support the military services with assessments of needs and capability gaps to support decisions concerning options under consideration by the United States Armed Forces and its coalition partners. Many organizations are interested and involved in employing and analyzing Network Centric Operations. With the emergence of "Information Age" warfare, the Operations Analysis (OA) community recognizes it must play a leadership role in creating and refining needed metrics, processes, methodologies, models and simulations. The OA Community acknowledges an urgent need to share its efforts, successes and failures in developing the key capabilities required for analytically rigorous assessments of NCO. On 27-29 January 2004, MORS held a workshop on *Operations Analysis Support to Network Centric Operations* at the Booz Allen Hamilton Conference Center in McLean, VA. The goal of the meeting was to bring together a multi-disciplined group of analysts, operators and engineers from across service organizations to: share their work; develop a common view of the state of practice; expose members of the broader analytic community to their needs; and, identify shortfalls and recommend solutions for improving the state of practice.

The mini-symposium on the first day featured presentations calibrating the state of the practice of operations analysis support to NCO. VADM Arthur Cebrowski, USN (Ret.), Director, Office of Force Transformation provided the keynote address on "Transforming Defense and Implementing Network Centric Warfare." Next the Services presented their perspective with an overview of the challenges and progress to date using operations analysis to support NCO, including highlighting context issues and what is needed from the analytical community, and identifying some of the broad and difficult analytical questions they have observed. Finally, the Technical Co-Chairs presented briefs to frame the workshop discussions – one on the NCO definition and one on NCO differences among countries.

The mini-symposium was followed by a two-day workshop. The participants met in six working groups: 1) *Measures of Merit*; 2) *Processes and Methodologies*; 3) *Assessment Tools*; 4) *NCO and Force Transformation*; 5) *NCO and Coalition Forces*; and, 6) *Applying NCO to Actual Events*. A Synthesis Panel was formed to collect and summarize insights from each of the working groups.

From their perspective, the working groups were tasked to report on the state of the practice of applying operations analysis in support of NCO; identify the key issues, shortfalls and gaps; describe the future challenges; list the extent of collaboration among the Services, Coalition countries and United States Agencies; and develop recommendations. The highlights of these reports are presented in this section, while the details are provided in the "Workshop Summary" section.

For the state of the practice using the OA Process, the measures were evaluated as frequently being used, but inconsistent in their application; the maturity of an "NCO OA Process" was considered consistent with the state of the understanding of NCO – immature; and it was concluded that, in the context of NCO, the tools were used infrequently. Current measures, tools and practices are understandably grounded in what we know and the decision process we

support, however, applying operations analysis in the area of NCO is in its infancy. In applying operations analysis to NCO concepts, discussions revealed that the OA process is currently limited by sparse relevant data, the real-world operation is a dynamic environment and the data is not clean or consistent. Warfighting systems do not output analytically-ready data, and data collection must be pre-planned due to the numerous organizations involved and their focus on real-world operations.

Network Centric Operations can be characterized as possessing four key domains (physical, information, cognitive and social). In general, applying OA across the four domains was considered fair or poor: physical – fair; information – fair; cognitive – poor; and, social – poor. Overall, while there is an apparent need for research into these emerging concepts, there is limited evidence that the OA community is committed to expanding its analysis into the cognitive and social domains. Current scientific approaches that address the physical domain well only address a subset of the relevant operational space and apparently do not represent the other domains.

Highlights of the working group findings from the Synthesis Group were:

WG 1: ***Measures of Merit (MOMs)*** – The findings focused on the assessment that the MOMs for NCO, especially for understanding a networked "cause and effect" relationship, are a work-in-progress. However, previous MOMs for the physical domains for warfighting missions are well understood and remain relevant.

WG 2: ***Processes and Methodologies*** – The findings focused on the NCW conceptual framework and the gap between the concept of sense-making and current Military Decision Making Process (MDMP). It is also suggested that a multi-disciplinary program of research should be initiated to explore the importance, and effective representation, of the cognitive and social domains to be undertaken. This knowledge should then be used as a foundation for exploring empirically the important hypotheses related to network centric operational theory and concepts.

WG 3: ***Assessment Tools*** – The findings were along three dimensions: "better" data; improvement in NCO assessment tools; and, the networking of assessment tools in order to achieve synergy in the application of a tool set.

WG 4: ***NCO and Force Transformation*** – To effect Force Transformation it was concluded that the further we move away from assessing transformations that are focused on a single Service, tactics, and material ("old" missions, etc.), the fewer OA tools are available to the analyst for information, cognitive and social domain related assessments.

WG 5: ***NCO and Coalition Forces*** – It was discussed that the OA timelines are not fast enough to keep pace with technology and other developments. The experience of the UK's embedded OAs needs to be assessed and their example, maybe, followed. However, the inclusion of civilian agencies also must be addressed.

WG 6: ***Applying OA to Actual NCO Events*** – It was found, because policies and doctrine to incorporate analysis is lacking, along with the non-use of embedded analysts, that OA becomes an afterthought. If these findings and the data domain are improved, then the assessment of actual NCO events will be improved.

Based on the issues, findings, shortfalls and gaps, the Synthesis Group developed a high-level set of *actionable* recommendations from the working group deliberations and discussions with the participants. They are:

- Add a MORS Symposium working group or composite group dedicated to Network Centric Operations. NCO is much more than C4ISR and Information Operations (IO). This new working group or composite group could be charged to examine the OA toolkit and processes in order to better focus on the NCO problem. At the 72nd MORSS, it is proposed that the CG B Chair discuss this issue with the leadership from Working Groups 5-10, providing recommendations to the MORS Working Group/Composite Group Committee Chair and the Vice President (Meeting Operations).
- Create a center(s) of excellence within services and JFCOM for NCO assessments to capture and share results and data of experiments, training, analysis and experience.
- Enable (e.g., thru agreements, business practices) the networking of analysts working NCO, and provide reach-back for tools, data, and previous studies.
- Establish a "business model" that enables services to conduct operations analysis in support of "born joint" NCO concepts and that is underpinned by a set of approved tools and data.
- Conduct follow-on MORS special meetings to share NCO analysis and experimentation results. Two options were recommended:

  - A 2-day or 3-day Mini-Symposium to educate the community in the area of NCO analyses. Training and education was seen to be critically important to transformation overall, and specifically, to the operations analysis practice in support of NCO.
  - A second 3-day Workshop to discuss the issues more fully. It was suggested that we provide foundation presentations during the morning of the 1st day and outbriefs during the afternoon of the 3rd day – this would leave two full days for discussion and further debate. During this initial workshop, the working groups felt they only "scratched" the surface in their discussions.

In summary, the participants believed that the OA process developed in the Industrial Age has continued applicability to NCO in the Information Age. We are only beginning to understand the practices that should be followed to perform credible NCO analyses. In addition, we know there are NCO considerations that remain challenging. However, it was judged that we do not do a satisfactory job in documenting, sharing and learning from NCO analyses performed.

With the arrival of terrorism, other asymmetric threats, rogue nations and increased concern for homeland defense, NCO presents an opportunity for Force Transformation. Although these are daunting challenges, if the recommendations of this workshop are implemented successfully, they will provide a basis for improving the operations analysis process and empowering the OA community to address the most critical analytical challenges to support NCO and Force Transformation.

WORKSHOP SUMMARY

BACKGROUND

A MORS Workshop on *Operations Analysis Support to Network Centric Operations* was held at the Booz Allen Hamilton Conference Center in McLean, Virginia, on 27-29 January 2004. 152 analysts and decision makers participated. Of these, 94 were existing or former members and 58 were new to MORS or non-members. Among these were 26 foreign personnel from the United Kingdom, Canada, Australia, Netherlands, Denmark, Sweden and Israel.

WORKSHOP DESCRIPTION

Mini-Symposium Overview (1st Day) –

The mini-symposium on the first day featured papers to bring us up to speed on the state of the practice of operations analysis support to NCO. After the welcome and introductions by the MORS President (LTC Willie McFadden, USA), Host (Mr. Steve Starner, BAH) and General Co-Chairs (Mr. Dennis Baer, Northrop Grumman IT and Mr. Kirk Michealson, Lockheed Martin Advanced Concepts), VADM Arthur Cebrowski, USN (Ret.), Director, Office of Force Transformation provided the keynote address on "Transforming Defense and Implementing Network Centric Warfare."

Next the Services were invited to provide, from their perspective, an overview of the challenges and progress to date using operations analysis to support NCO, including highlighting context, issues and what is needed from the analytical community, and identifying some of the broad analytical and difficult questions they have observed. The Service presentations were provided by COL Steven Mains (Joint Forces Command, J9, Lessons Learned Group), Mr. Michael Bauman, FS (Director TRADOC Analysis Center, Fort Leavenworth, KS), Dr. Michael Bell (Senior Analyst, FORCEnet Requirements Branch, Office of the CNO) and Dr. George Cran (NEC Programme Leader, Defence Science and Technology Laboratory, UK Ministry of Defence).

Dr. Richard Hayes, President of Evidence Based Research, Inc. and Workshop Technical Co-Chair, provided the Framework Presentations. The first offered a foundation of Network Centric Operations in a brief titled "C2 in the Information Age: The Last Mile of Transformation," while the second discussed the conceptual differences between the United States and Coalition Countries with respect to NCO and Transformation.

The final sessions of the day were presentations that offered guidance for the remaining two days of the workshop. Dr. Jerry Kotchka, FS (Lockheed Martin Integrated Systems and Solutions) provided a review of the operations analysis process, Ms. Sue Iwanksi (Northrop Grumman IT) followed with an overview of the MORS *Analyzing Effects-Based Operations* Workshop, and LtCol Greg McIntyre (Air Force Studies and Analyses Agency (AFSAA)) offered an overview of the MORS *Operations Research Methods for Information Operations* Workshop.

Workshop Overview (2nd & 3rd Days) –

The mini-symposium was followed by a two-day workshop. The participants met in six working groups: 1) *Measures of Merit*; 2) *Processes and Methodologies*; 3) *Assessment Tools*; 4) *NCO and Force Transformation*; 5) *NCO and Coalition Forces*; and, 6) *Applying NCO to Actual Events*. A Synthesis Group was formed to examine insights across all six working groups and to help bring together a consistent set of workshop findings.

A listing of the acronyms used in this final report is provided in Appendix A, the Terms of Reference for this special meeting is contained in Appendix B, a directory of the working group leadership, an energetic group of people, is provided in Appendix C, and the papers presented are provided in Appendix D.

NCO DEFINITION

A common definition of Network Centric Operations was developed by the Technical Co-Chairs (Dr. David Alberts, OSD (NII), and Dr. Richard Hayes). Network Centric Operations (NCO) involves the development and employment of mission capability packages that are the embodiment of the tenets of Network Centric Warfare (NCW) in operations across the full mission spectrum. These tenets state that a robustly networked force improves information sharing and collaboration, which enhances the quality of information, the quality of awareness, and improves shared situational awareness. This results in enhanced collaboration and enables self-synchronization improving sustainability and increasing the speed of command, all of which ultimately result in dramatically increased mission effectiveness.

The principles of Effects Based Operations (EBO) go hand-in-hand with NCO because warfare, particularly effective warfare, has always been effects-based. Sun Tzu, Genghis Khan, Napoleon, Eisenhower, and Schwarzkopf all would be familiar with the principles that 1) warfare should include all the instruments of national power; and, 2) that each instrument should be applied in a way that maximizes its desirable impact, minimizes undesirable ones, and complements actions taken in other arenas. These basic principles, which define the essence of EBO, occur in a context that makes them particularly relevant today. First, we have the means to gather, integrate and apply more data, information and knowledge than analysts and policy makers in earlier eras – we are in the Information Age. The tenets of NCW address these means and postulate how they can increase mission effectiveness. The seven tenets of NCW are: a robustly networked force; information sharing; collaboration; quality of information; shared situational awareness; self-synchronization; and, sustainability and speed of command. Second, we live in a world that is more tightly coupled than ever before, creating opportunities and challenges for direct and indirect, desirable and undesirable effects.

NCO encompasses Networked Enabled Capability (NEC) (UK, Australia), Networked-Based Defense (Sweden), and concepts from other nations also based upon operationalizing the tenets of NCW.

KEYNOTE AND SERVICE PRESENTATIONS

VADM Arthur Cebrowski, Director, Force Transformation, provided the keynote address. Some of the presentation highlights participants could consider for their working group discussions included: 1) speed and agility should be achieved over optimization; 2) the warfighter advantage exploits behavioral change and new doctrine to enable self-synchronization, speed of command and increased combat power; 3) information sharing is a new source of power; and, 4) measuring values, attitudes and beliefs should be considered. During his presentation, he also issued a challenge to the MORS Community – to create tools that could be used for NCO and transformation.

After the Keynote Presentation, the Services provided a brief overview of the state of the practice of applying operations analysis to Network Centric Operations from their perspective.

COL Steven Mains (JFCOM, J9, Deputy Director, Lessons Learned Group) provided the Joint Staff perception. Some of the highlights from his presentation were:

- Data is found – Information is made.
- Collection does not equal knowledge. A huge "frame rate" could be counterproductive.
- Networks do not produce knowledge. Networks pass data between people that can turn it into information and information between people that can turn it into knowledge.
- Knowledge is the key to Network-Centric Operations

Mr. Michael Bauman, FS, Director, TRADOC Analysis Center, presented the Army point of view highlighting the analysis completed for the Future Combat System (FCS) including:

- The FCS program and focused Army investments in new modeling have advanced the Army's ability to model and analyze *network-enabled operations* (aka NCO).
- The military OA community still faces challenges:
  - The complexity of NCO scenarios, overwhelming data and ambiguous cause-and-effect relationships.
  - Metrics are needed that are useful to analysts and decision makers, but that also resonate with warfighters.
- The "business model" to enable OA in support of joint operations, to include NCO, is still an exploratory work-in-progress.
  - A means to generate data for joint system concepts is evolving.
  - A mechanism to achieve authoritative representation of future joint concepts is much less mature.

Dr. Michael Bell, Senior Analyst, FORCEnet Requirements, N61, followed with the Navy's status with their NCO system, FORCEnet. Some highlights were:

- Demonstrated FORCEnet's value of analytical framework:
  - Connects FORCEnet capabilities and NCW Framework.
  - Capabilities are under revision.
  - Quantitative measures partially successful and improvements have been proposed.

- Improved representation of how knowledge is achieved in C4ISR campaign analysis

The final presentation was on the Coalition perspective. Dr. George Cran, UK MoD Network Enabled Capability (NEC) Programme Leader, presented the United Kingdom view. Dr. Cran highlighted the operations analysis issues for NEC:

- Bringing together future military thinking with future technological capabilities across the spectrum of operations and levels of command.
- Thinking out of the box – doing better things.
- Bringing all lines of development into the analysis, especially people issues.
- Bringing practicalities to the vision: drawing operational lessons learned and experimentation into the analysis.
- Enhancing the tool-set to reflect NEC with greater fidelity.
- Conducting Balance of Investment studies between 'hard' systems and information systems.

FRAMEWORK PRESENTATIONS

The Technical Co-Chairs, Dr. David Alberts and Dr. Richard Hayes, provided two framework discussions. The first, titled *C2 in the Information Age: The Last Mile of Transformation*, was intended to provide a common definition of Network Centric Operations for the working groups. Some of the discussion points included the value of the NCO Metrics Framework, the prerequisites for transformation, power to the edge, making it happen — becoming an "edge" organization, and the OSD (NII) initiatives for building, populating and protecting the network. The second, titled *Network Centric Operations: Differences in Perspective*, was offered to present the network centric differences among the United States, United Kingdom, Sweden, Australia and NATO.

RELEVANT PREVIOUS WORKSHOPS

Representatives from two of the relevant previous MORS Workshops provided an overview of their meeting's objectives and recommendations, and then offered the participants some points to consider as they were preparing to meet in their working groups.

As one of the Technical Co-Chairs for the *Analyzing Effects-Based Operations* Workshop, Ms. Sue Iwanski passed along the following take-away thoughts:

- The term "Indicators of Success" was used for EBO since it expands beyond traditional Measures. NCO may also require non-traditional Measures.
- Fundamental Sciences were considered to be useful for EBO.
- The EBO tool chest was envisioned to include easily manipulated, specialized modeling and simulation tools, computational social science tools, data mining, colored Petri nets, neural networks, and specialized tools developed in particular application areas.
- Networks are targets in EBO. Information exchange is vital to NCO.

As the Chair for the *Operations Research Methods for Information Operations* Workshop, Dr. Richard Deckro prepared a list of points to consider for the participants:

- Build MOEs and Battle Damage Assessments for NCO
  - Extend into EBO MOEs for NCO use
  - What should a NCO "JMEMS" look like?
  - Does the NCO framework help?
- What do Commanders need to use NCO as a "primary arrow" in their quiver?
  - Leadership understanding
  - Tools
  - Intelligence
- What are the needs of the human element?

GOALS AND OBJECTIVES

Many organizations are attempting to analyze, understand, and employ Network Centric Operations. The analytic community needs to support the military services, joint community, and other stakeholders with assessments as NCO is being developed. The community should play a leadership role in creating and refining the metrics, processes, methodologies, models and simulations necessary to understand the emerging area. The community should share efforts, successes and failures in the key capabilities. As a first step, the goal of the meeting was to provide an opportunity to bring a multi-disciplined team of analysts, operators and engineers from those organizations together to share their work, develop a common view of the state of practice, expose members of the broader analytic community to their needs, identify shortfalls and potential solutions.

The overall objectives of the workshop were to provide an assessment and a roadmap to revitalize the state of the analytical practice as it relates to NCO, and to recommend priorities for any initiatives identified. In other words, to assess:

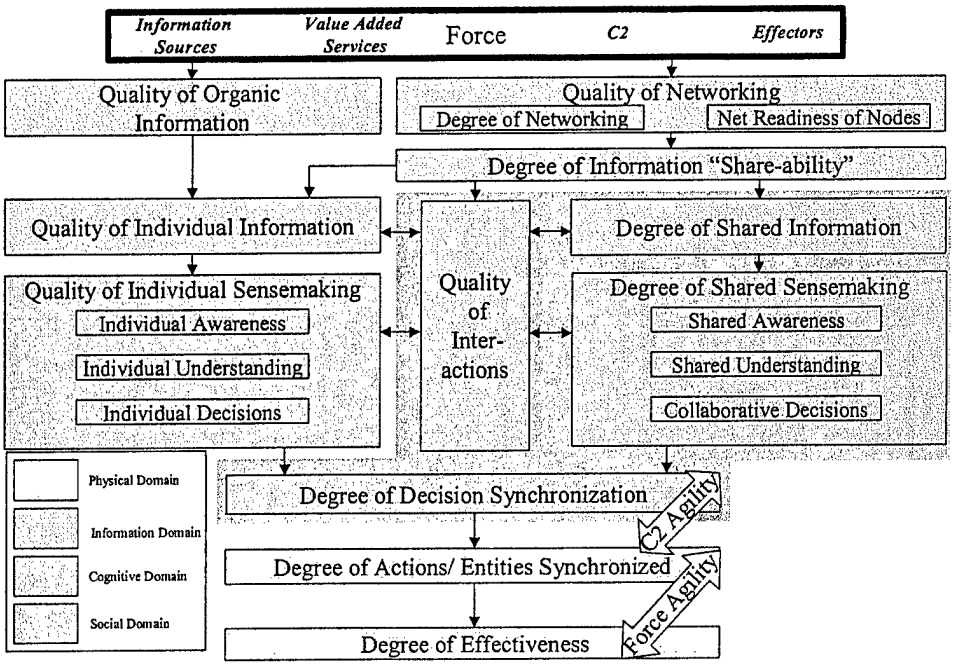
- "State of Health" – Provide an assessment of the state of analytical practice related to NCO.
- "Findings" – Provide a roadmap to revitalize that state.
- "Recommendations" – Recommend priorities for any initiatives identified in the roadmap.

Some specific objectives for the Working Groups were as follows:

- ***WG 1: Measures of Merit.*** A great deal of work has gone into developing a conceptual framework for Network Centric Warfare. An extensive body of literature exists and robust discussion continues. Measures of merit have been addressed often in this context. Several approaches have been proposed for measuring the effectiveness of Network Centric Operations. Much of the discussion has focused on measures of performance for the network that enables NCO. One reason for this inclination is that, relative to other areas of NCO theory, data is readily available. However, NCW is not simply a new communications system with embedded decision support. Therefore, it is important to examine the impact of NCW technologies and practices across the physical, information, cognitive and social domains. To devise metrics for these other aspects of NCO, several approaches were considered for the workshop. The Network Centric Operations Conceptual Framework

(Figure 1) was the starting place. Discussions on cognitive and social aspects also were reviewed to ensure that the appropriate measures and metrics were considered.

Figure 1 – NCO Conceptual Framework



- ***WG 2: Processes and Methodologies***. There were three objectives: (1) use the NCO Conceptual Framework to assess operations analysis ability to evaluate NCO enabling capabilities, (2) identify areas of weakness in both the NCO Conceptual Framework and the OA Process, and (3) recommend near and longer term actions that will improve the operations analysis community to support NCO related research, analyses, and implementation.

- ***WG 3: Assessment Tools***. The objective of this working group was to assess various models across the four Network Centric Warfare domains. Models are a set of algorithms and data, with supporting infrastructure that manages output, random number generation, etc. For each major algorithm that models an important aspect of NCO, whether contained in the existing tools or those under development, the modeling process was examined to determine if it is mature, developing, immature or unknown. The working group also discussed if research is needed to increase understanding of how specific NCO aspects can be assessed or new algorithms developed. For data, an insight gained from a model is the combination of the data and the model's transformations of input data into output. Given all of the existing and proposed tools that may be used for NCO, the state of the data required to make these tools "study ready" was assessed.

- ***WG 4: NCO and the Force Transformation Process.*** Working Group 4 examined how operations research methods can be applied to NCO in the context of the Force Transformation Process. Transformation will only happen when the eight "key elements" (concepts, leadership, education, culture, training, organization, process and technology) co-evolve to take full advantage of information age technologies, capabilities, and opportunities. The key task for the Force Transformation group was to understand how OA techniques can be applied across the eight "key elements" of transformation and balance the transformation process.

- ***WG 5: NCO and Coalition Forces.*** There were three major objectives of this working group: (1) to review and discuss papers that address current practice in the areas of tools, studies, and experimentation or live events, (2) to discuss each individual country's state of practice of OA in support of NCO, to identify good and bad points and to identify future directions, and (3) to assess collaborative efforts among coalition partners to determine shortcomings and to recommend ways to improve collaborative OA efforts. Papers were presented in three groups: (1) country study overviews, (2) tools, and (3) experiments and live events.

- ***WG 6: Applying NCO to an Actual Event.*** This working group examined the application of Network Centric Operations in support of recent operations in Afghanistan and Iraq. The working group reviewed the data for Operations Desert Storm and Iraqi Freedom to look for the limiting factors, the tools and techniques, and the different ways that operations analysis can help take information and enable events.

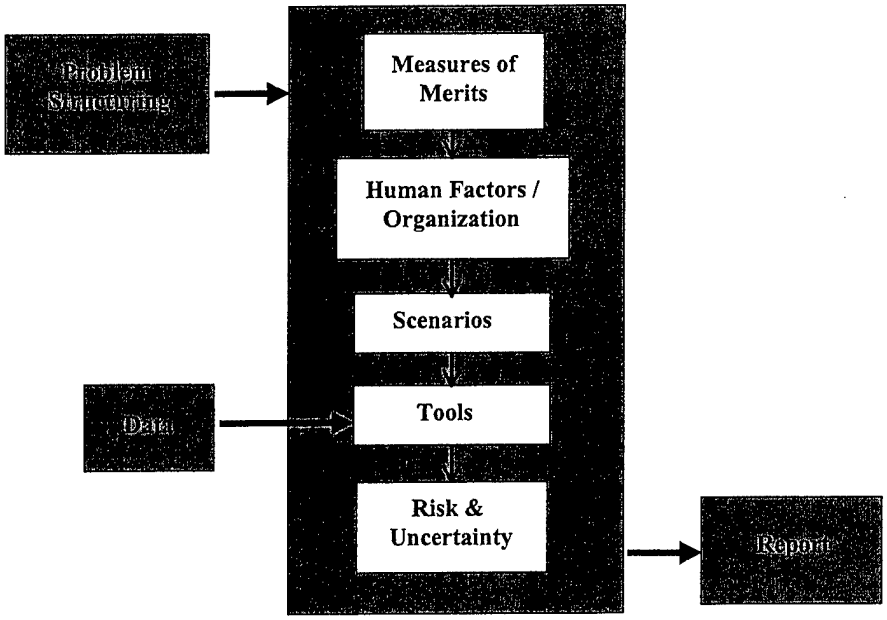
BROAD OBSERVATIONS

A few broad observations of the workshop were noted. First, there exists a need to include service senior analytical leaders and experienced analysts in MORS workshops to enhance interactions, findings, recommendations, and to mentor more junior participants. Second, a joint business model is needed that enables services and joint commands to collaboratively conduct operations analysis in support of emerging NCO concepts. This will facilitate the initiation of OA activity early in the planning process. Third, networking of operations analysis centers and operation analysts along with adequate reach-back should provide a significant improvement in support of decision makers. An environment of trust is needed among analysts and between the analyst and decision maker, however. Finally, NCO analysis will not be addressed by a single measure of merit (MOM) but by a set of MOMs.

STATE OF THE PRACTICE

The working groups were asked, if possible, to provide their "State of Health" in two contexts: the Operations Analysis Process (Figure 2) and the Network Centric Warfare four key domains (Figure 3). Additionally, the seven tenets of NCO in relation to the framework were evaluated by the *Processes and Methodologies* Working Group and the eight key elements of transformation were considered by the *Force Transformation* Working Group.

Figure 2 – Operations Analysis Process



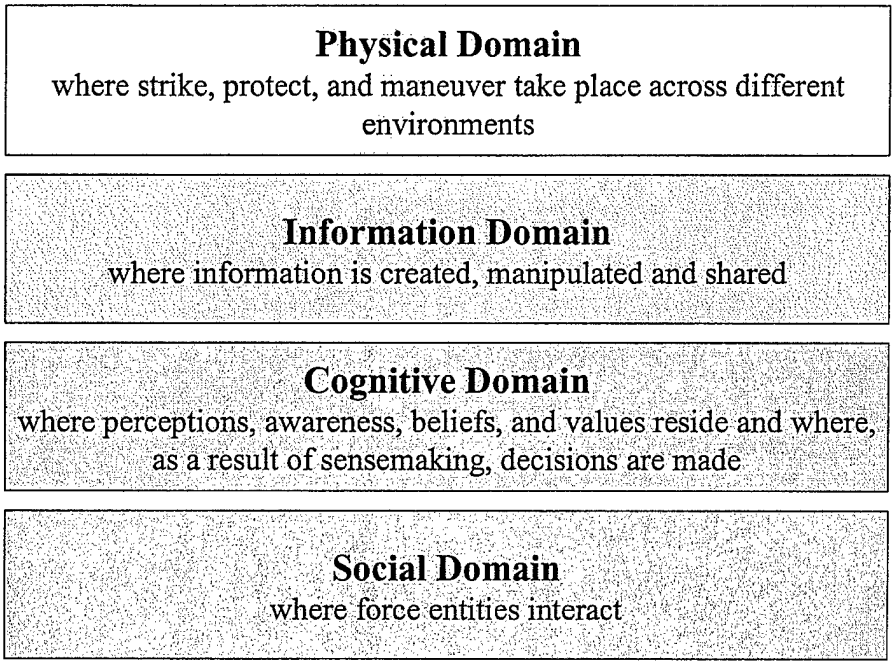
Within the OA Process, the measures were evaluated as frequently being used, but inconsistent in their application; the maturity of an "NCO OA Process" was considered consistent with the state of the understanding of NCO....immature; and it was the conclusion that, in the context of NCO, the tools were used infrequently. Current measures, tools and practices are understandably grounded in what we know and the decision process we support, but applying operations analysis in the area of Network Centric Operations is in its infancy. The United States Army's Future Combat System and the Navy's FORCEnet activities are initial efforts.

In applying operations analysis to NCO events, discussions highlighted the perceptions that: the OA process is currently limited by available and valid data, the real-world operation is a dynamic environment and the data is not clean or consistent, warfighting systems do not output analytically-ready data, and data collection must be pre-planned due to the numerous organizations involved and their focus on the real-world operation.

Network Centric Operations can be represented using four key domains shown in Figure 3 (physical, information, cognitive, and social). The state of health for OA, in relation to these domains, was estimated as deficient or poor. Even at the physical level of modeling and analysis, it appears that the Operations Analysis community continues to focus on the warfare (combat) portion of NCO and not on the larger set of military missions (e.g., OOTW) – as observed in the scarcity of methods for these situations. In general, applying OA across the four domains was considered fair or poor: physical – fair; information – fair; cognitive – poor; and social – poor. Overall, the OA community seems to be uncomfortable with expanding its analysis into the cognitive and social levels. Scientific approaches of the past that addressed the physical domain well apparently do not represent the other domains as well, and usually are limited in focus to key physical interactions associated with combat and combat support

operations. Methods from other disciplines, such as medicine, genetics, sociology, psychology, political science, and cultural anthropology fields, should be considered as potential sources of knowledge that could inform the OA process and community.

Figure 3 – NCW Four Key Domains



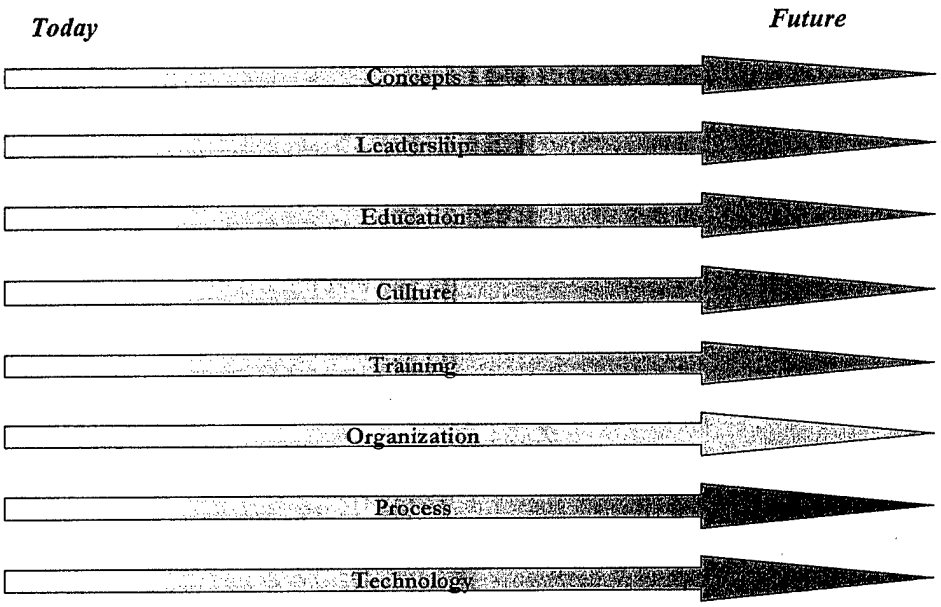
Additionally, the seven tenets of Network Centric Operations in relation to the framework were appraised to distinguish what OA capabilities can be done reasonably well from among those OA capabilities that are consistently deficient:

- Robustly networked force — Fair
- Information sharing — Fair
- Collaboration — Poor
- Quality of information — Good
- Shared situational awareness — Fair
- Self-synchronization — Poor
- Sustainability and speed of command — Poor

The major discussion points on these seven tenets dealt with information sharing, collaboration and cultural issues. For information sharing, the community has ideas today on how to represent and analyze the movement of information, but the issues associated with dynamic networks and Information Assurance caused the evaluation of the "state of the practice" to be only "fair". It also was felt that understanding and modeling of collaboration, especially at the social level, was very weak. Finally, cross-cultural issues (i.e., across agencies, NGOs, etc.) could benefit from "technology transfer" from other fields of research.

Transformation is clearly about moving from an industrial age force to an information age force. The *Force Transformation* working group took the view that transformation will only happen when the eight "key elements" (Figure 4) co-evolve to take full advantage of information age technologies, capabilities, and opportunities. The key task for the working group was to understand how OA techniques can be applied across the eight "key elements" of transformation and balance the transformation process.

Figure 4 – Transformation ... Co-Evolution of Key Elements



The operations analysis community is marginally engaged in current short-term transformation efforts. Short-term transformation is occurring through operational units buying/using information technology systems and through the prototyping efforts of the Concept Development and Experimentation (CD&E) program. Analysts are engaged in the "lessons learned" teams deployed to *Operations Enduring Freedom* (*OEF*) and *Operation Iraqi Freedom* (*OIF*) and this is encouraging. However, analysts are not involved early enough in the CD&E process. Frequently, the analyst is not called upon until a concept is ready to enter the experimentation phase of development. Feeding back the lessons of recent operations into the design of standing collection plans and analysis techniques for future operations would create an environment of continuous learning.

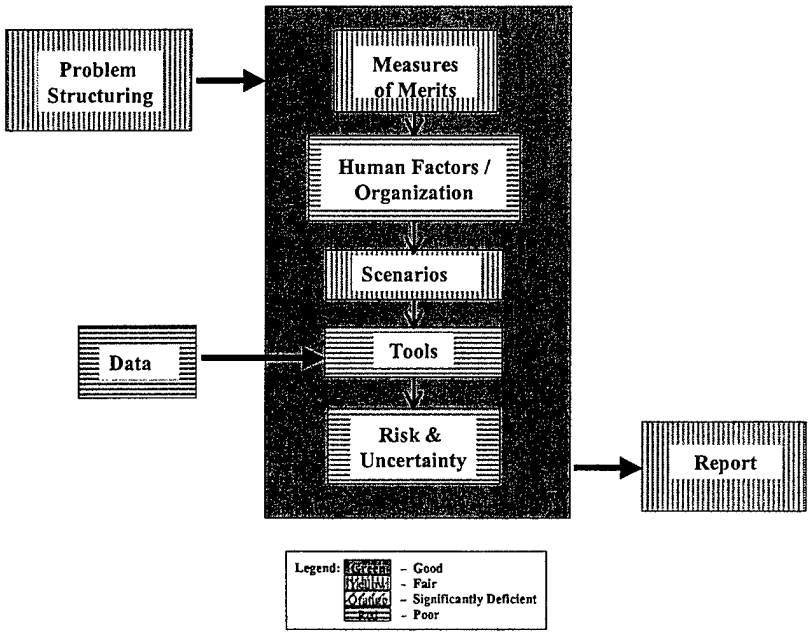
There is an overabundance of (sometimes conflicting) guidance governing US DoD transformation efforts. Some of this guidance is informed by analysis, but additional analysis will be critical. Conflicting guidance makes it tough to develop an innovative, effective transformation program. The transformation of how the US DoD does business is ongoing and will provide the foundation and governance for realizing NCO. This will be a precursor to any significant long-term deliberate force transformation being achieved. Moreover, Service efforts are not linked. While they are not being conducted in isolation, each would benefit from greater collaboration.

The current budgeting feedback system (Joint Requirements Oversight Council (JROC) Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities (DOTMLPF)) does not foster transformation. Some may argue that this system is actively hostile to the notion of trading off platform-centric programs for network-centric programs.

The analysis community has not been proactively engaged in the transformation process. We do have some analytically-derived principles (primarily from the Command and Control Research Program (CCRP) body of work), but we need to actively translate these principles into sound analysis practice. How do we integrate across the eight disparate elements? This requires us to fundamentally examine how we are currently conducting analysis.

Over five years ago at the MORS Mini-Symposium and Workshop on "Analyzing C4ISR for 2010," a template for the NATO Code of Best Practice for Assessing Command and Control was developed and evaluated. This template was used to evaluate the OA process for NCO and the Synthesis Group's overall assessment is contained in Figure 5. There seems to be an overall decrease in the adequacy of the process, due mainly to a feeling that NCO as a whole may be more difficult to evaluate then C4ISR alone.

Figure 5 – Overall Assessment of Applying OA to NCO



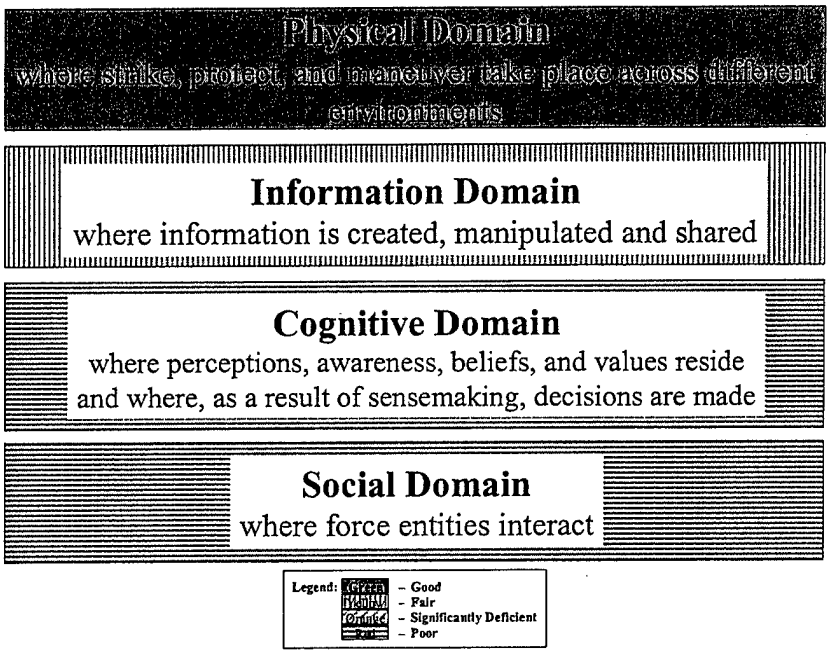
With inputs from each of the working groups, the Synthesis Group's overall qualitative assessment across the NCW four key domains is provided in Figure 6. The physical domain is assessed to be in much better "health" from the application of the OA process than the other three domains.

KEY ISSUES

The participants were asked to consider the key issues for each of their working group areas.

For metrics, a catalog is needed to enhance OA support to NCO. There are several ways to organize NCO measures that make intuitive sense but examples of specific measures within these categories are hard to find. "Traditional" measures are necessary but not sufficient to address the needs of analysts in the NCO area. Measures of attrition do not apply to all situations in NCO analysis. In general, qualitative measures should be accepted for some purposes. Currently accepted metrics generally focus on degrees of achievement of desirable properties related to systems. A more holistic set of metrics that address unfavorable developments, which may not be associated with specific systems, could also be useful.

Figure 6 – Overall Assessment of the NCW Four Key Domains



Measuring NCO "effectiveness" may require generation of non-traditional MOEs to evaluate changes in performance related to the cognitive and social domains. However, traditional warfighting MOEs remain applicable as we use NCO to do the same missions differently. A major consideration is to initiate the development of NCO measures of merit as new NCO concepts and experiments are developed.

In the area of operations analysis processes and methodologies, System of Systems (SoS) architecture analysis may be pivotal to assessing Network Centric Operations. Yet, the classical OA pyramid of modeling & simulation, the disciplined OA process, and even the detailed process described in the recent book *NATO Code of Best Practices for Assessment* (DoD CCRP, 2002) do not explicitly address the role of architecture related analyses in the assessment of SoS. This lack of process clarity is evident as the OA community is challenged more and more with complex, SoS solutions (e.g., DOTMLPF) for meeting the capability needs for NCO. Furthermore, since the NCO framework emphasizes "Quality of Individual Sense-making" and "Quality of Shared Sense-making" as the major processes in the cognitive domain, the lack of processes and methodologies for operations analysis using sense-making and cognitive modeling

make the NCO framework a challenge to operationalize. A major issue was the gap between sense-making and decision making, along with a lack of knowledge as to the "state of the analysis" for sense-making and cognitive modeling.

Tools to support the assessment of Network Centric Operations must address a wider set of outputs than attrition, and as a result, traditional combat modellers are unlikely to have understanding of the issues required to model NCO properly. Discussions led to the revelation that there are few tools to examine the relationship between the quality of the decisions and the amount of data that is available to the decision maker. Transforming a force to Network Centric Operations raises serious concerns about the force's reliance on the network. Tools need to be developed to assess the vulnerabilities related to this reliance on the network. Also, if coalition operations are to be undertaken in the future then (at least) campaign level models must be able to capture the issues related to information flows among members of the allied forces. This is especially important as forces have different levels of 'network compliance' in both their hardware and training/doctrine.

Model/tool development projects also must include access to relevant expertise in the social and cognitive domains. The term Network Centric Operations is sometimes misleading. At a closer look, it is really Human Centric and Network Enabled. Addressing the Human issues is necessary to conduct proper assessment of NCO.

The "data domain" (both real blue and red data – current and projected) is still too stove-piped. Each working group assessed that the data domain remains an area for significant improvement. The need for "standard, approved" data for friendly, unfriendly and neutral forces – both current and projected – would be a major enrichment. Overall, the assessment tools for NCO were judged to need improvement – the OA tools for the physical domain are more adequate then the information, cognitive or social domains.

In the area of Force Transformation, a specific example of the analyst being on the sideline is in the joint experimentation community where the analyst is not brought in until relatively late in the experiment design phase. This often can lead to an experimental design that does not support the questions of interest. This type of behavior is symptomatic of the broader problem of project sponsors not being engaged with the analysis community in some circumstances. The result can be a lack of ownership of the results of the analysis performed in support of the study. The next step to integrating analysts into concept development and experimentation (CD&E) is the design of experiment campaigns. An analyst's experience, critical thinking, understanding of available models and measures of merit can be a valuable resource. The analyst can assist in the design of objectives, data collection and analysis techniques that assist in the analysis of individual events as well as analysis between events.

As the analytical focus of NCW moves from a tactical level to operational and strategic levels, the nature of the system components and interactions under investigation becomes more complex because of the increasing focus on interactions between humans instead of technology. In general, there is a shift from quantitative objective measurements to qualitative subjective measurements. Traditional OA tools do not support the upper end of the spectrum well. The representation of complex adaptive systems across the four domains of NCO and the eight

elements of transformation can be supported by the softer system techniques. The operations analysis community should look to other disciplines that have developed techniques for dealing with the complexity of systems centered on the human.

Trade-off studies between material solutions have traditionally been a rich area for OA techniques. However with the emerging need to trade-off between platforms, networks, information, and other resource investments, a set of common metrics that can serve as a basis for comparison is always difficult to determine. Currently, studies can provide at best an assessment of risk associated with each option, but not definitive options for a decision maker to consider. Thus there is still a large component of "intuition" in the investment decisions being made.

Collaboration among Coalition nations needs to be improved. Although discussions within this Workshop identified previous significant involvement and sharing of allied countries' operations analysis capabilities to support NCO, it was judged that collaboration among Coalition nations remains insufficient due to multi level security, OA resources, and other factors. Similar constraints (e.g., security) will also impact information sharing among analysts.

In applying OA to an actual NCO event, it was brought out that the Center for Army Analyses (CAA) had to overcome some inertia to get its analysts accepted into the combatant command. Even with analysts in the field, typical staff officers and leaders are unfamiliar with the tools and capabilities brought by a trained analyst. UK analysts were well embedded into deployed UK forces and have a history of being so. That model for employment of analysts could serve as an example for the US program.

Additionally, the deployed OA assets were not aware of each other's efforts. Teams went into theater, often on short notice, and did not have time to contact other agencies prior to deployment to become familiar with and coordinate efforts. Lack of collaboration between teams (in some cases) prevented sharing techniques and data.

As recommended in the MORS Workshop on the "Combat Analyst," there is a need to *consistently deploy* and *network* analysts with the operational forces. Information sharing will get more difficult due to increasing reliance on SIPRNET and similar activities and will constrain collaboration among analysts as well as operators. The deployment and networking of operations analysts with sufficient reach-back capabilities is a major issue that should be addressed as NCO concepts and tactics are developed.

SHORTFALLS AND GAPS

After discussing the key issues, the working groups were asked to consider their shortfalls and gaps in applying OA to support NCO.

Most metrics in current use for NCO fall into the physical and information domains. This is not to say that existing measures in these domains fill all the needs there, but there is more choice (and understanding) in these two areas than in the cognitive and social domains. Additionally, useful measures are constantly being developed for analytical efforts but they are not widely

disseminated across the OA community. This is due in part to the fact that most analysis is conducted on a bilateral basis, at best. More multilateral projects among the Services and with Coalition partners would help. Joint staff and JFCOM studies, while joint in nature, do not necessarily involve the Services and Allies sufficiently to achieve cross-pollination across the OA community.

The current tools and practices do not address or capture collaboration, self-synchronization, or agility – key characteristics of NCO. Furthermore, a shortfall in tool creation and application is data availability. Data for creating/populating models is difficult to acquire. The sources, classification, accessibility, and releaseability issues hinder the productiveness of the tools. Also, results that are classified are not as beneficial to the community as a source of common information than those which are more easily distributed.

Data needs to be gathered, collected, and analyzed by social scientists working collaboratively with the traditional military OA community. NCO is Human Centric, and those who study humans need to assist in gathering the data because they may recognize behaviors and characteristics that engineers and analysts may not recognize. The human dimensions of NCO are not currently adequately captured and explored.

Analysts need to engage early in transformation initiatives to structure the research issues, help define the question, and assess the value-added of experimentation efforts. Applying the OR method and current tools will add great value. Involvement of the decision maker in the OA process creates ownership of analysis and starts with formulation of the question by the sponsor with analyst support.

Current OA methods do not lend themselves to studies of complex, adaptive systems that cross the four key NCW domains (problems that are at the core of defense transformation). Legacy simulation tools are not especially helpful in this area. Also, there is not a coordinated effort to integrate across/co-evolve the eight key elements of transformation (concepts, leadership, education, culture, technology, organization, process, training).

Several shortfalls in the area of Collaboration Efforts were highlighted:

- Lack of accepted OA tools to assess NCO within the social and cognitive domains
- Lack of pre-NCO baseline performance analysis
- Lack of analysis on key features of NCO (important to the international community)
- NCO is stove-piped (e.g. by service, by country, by discipline)
- International sharing of data
- OA analysis timelines are not fast enough to meet the pace of technology and DOTMLPF development
- Developing the correct measures of merit
- Cannot adequately represent all the benefits of NCO in combat models (e.g. self-synchronization & op-tempo)
- OA is overly focused on military to the exclusion of civilian agencies
- OA must be careful to represent the balance, to include unintended consequences and characterizing risks and benefits

- Need to choose OA events with mutual benefits within the international community

Finally in the area of applying OA to actual NCO events, the shortfalls discussed were: warfighting systems are not designed to capture OA data, the instrumentation to capture data had to be developed and implemented "on the fly," warfighting systems are often non-interoperable – so data being collected would not be in any kind of standard format, and classification and releasability problems.

SYNTHESIS GROUP FINDINGS

After participation within the working groups and detailed discussions in their meetings, the Synthesis Group submitted their findings.

WG 1: ***Measures of Merit (MOMs)*** – The findings focused on the assessment that the MOMs for NCO, especially for understanding a networked "cause and effect" relationship, are a work-in-progress. However, previous MOMs for the physical domains for warfighting missions are well understood and remain relevant.

- MOMs must both enable the analyst and inform the client; these may be starkly different for Network Centric Operations Analysis (NCOA) than for traditional OA. MOMs for NCOA are a work-in-progress.
- Survivability-related MOMs are increasingly relevant to military operations and remain so for NCOA as well (at all levels, i.e., MOPs, MOEs).
- A combination of MOMs is necessary for OA of networked "cause-and-effect" relationships.

WG 2: ***Processes and Methodologies*** – The findings focused on the NCW conceptual framework and the gap between sense-making and decision making. It also was suggested that the relationship between cognitive modeling and sense-making modeling needs to be addressed.

- The NCO framework emphasizes "Quality of Individual Sense-making" and the "Quality of Group Sense-making" versus decision making.
- Many in the NCO community assert that cognitive modeling is an **essential part** of the solution to modeling sense-making.
- The lack of processes and methodologies for OA using sense-making and cognitive modeling make the NCO framework a challenge to operationalize.

WG 3: ***Assessment Tools*** – The findings were along three dimensions: "better" data, improvement in NCO assessment tools, and the networking of assessment tools in order to achieve synergy in the application of a tool set.

- Some tools exist, but the data domain (both real blue and red data) is still too stove-piped.
- The methods to change information to knowledge seem to exist within the models, but are not well understood.
- Networking assessment tools is necessary but not sufficient; we must learn to "do better things," not "do things better."
- The networked force must be treated as a holistic entity not as a sum of discrete elements.

WG 4: ***NCO and Force Transformation*** – To effect Force Transformation it was concluded that the further we move away from assessing transformations that are focused on a single

Service, tactics, and material ("old" missions, etc.), the fewer OA tools are available to the analyst for information, cognitive and social domain related assessments.

WG 5: ***NCO and Coalition Forces*** – It was discussed that the OA timelines are not fast enough to keep pace with technology and other developments. The experience of the UK's embedded OAs needs to be assessed and the example, maybe, followed. However, the inclusion of civilian agencies, such as the Department of Homeland Security, also must be addressed.

- OA analysis timelines are not fast enough to meet the pace of technology and DOTMLPF development.
- OA is overly focused on military to the exclusion of civilian agencies.
- Need to consider new level of embedded analysis (OA in-theater with data mining and assessment tools) to provide real time feedback on NCO effectiveness.

WG 6: ***Applying OA to Actual NCO Events*** – It was found, because policies and doctrine to incorporate analysis is lacking, along with the minimal use of embedded analysts, that OA becomes an afterthought. If these findings and the data domain are improved, then the assessment of actual NCO events will be improved.

- Lack of joint and some Service doctrine to incorporate analysis in a JTF limits OA support of NCO.
- Reliance on non-embedded analysts makes OA an afterthought in JTFs.
- OA currently limited by available & valid data
- Time and data constraints limit the tool set

FUTURE CHALLENGES

The working group participants were asked to assess their future expected challenges.

The primary challenge for measures of merit is to keep up with the rapidly changing scope of NCO. Agility is a desirable feature (for which measures are needed) in NCO. The metrics set should be agile as well. Not only do we need more and better measures for NCO, we need to rigorously address the issue of sufficiency. How much is enough? The answer may differ from one situation to the next. Development of standards for NCO analysis, including metrics, faces the challenge of incorporating the terminology and practices of the social sciences in order to establish measures in the social and cognitive domains.

In order to represent NCO accurately, a new set of models or a new way of interoperating between them needs to be created and all aspects of NCO need to be represented. This means networking not only two battalions but also all actors involved in the operation including reach-back capabilities. This is the essence of NCO, and the capabilities cannot be explored if they are not represented. Essentially, the tools that need to be developed need to be able to adapt to changing and emerging concepts. In a complex, network centric world the analysis challenges will continue to evolve. We should not adopt a mindset of getting the tools and processes "right" – we need an ethos of continuously examining our tools and processes to make them better.

What is the next transformational capability or technology on the horizon? Analysts can and should be engaged in this effort, and clearly must look beyond the bounds of defense industries

for promising opportunities. By taking a broad look at the eight "key elements" of transformation (and beyond) we may uncover areas for further investigation. This is not a one-player game – we also must think about areas that potential adversaries can exploit and work them in to our future scenarios and operating concepts. Using Palm Pilots™ on the battlefield is an example of bottom-up approaches that have been attempted by tactical and operational forces. These may not be officially sanctioned. Some may have great value, some may have minimal impact, and some may be downright dangerous. Analysts need to engage in the effort to assess these "bottom-up" initiatives.

Coalition warfare analysis is lacking in today's assessment tools. In the United States, "Joint" is making some headway, but most operations in the future will include Coalition forces. Throughout recent history, the ability to share information in a Coalition environment has been difficult though necessary. Other issues that need to be addressed in the Coalition environment are language and systems interoperability. NCO most certainly is about fostering collaboration and networking to a wide degree. We must expand our network of analysts to include interagency, Coalition, and non-governmental partners.

On the battlefield, if we don't do anything, the information-sharing problem will actually get worse because the planning, execution and analysis processes are conducted increasingly on the SIPRNET. This can have the effect of excluding our Coalition partners. Over-classification of planning, deployment, execution and sustainment products can exacerbate the information-sharing problem. This adds to the declassification work that the staff Foreign Disclosure Officers must do prior to transferring products to coalition info sharing systems like CENTRIX (Combined Enterprise Regional Information Exchange System).

The warfighting culture needs to be changed to accept more analysis. This will require changes in doctrine and training and experience of leaders. As analysts do more collection and analysis in the field, the procedures for data collection will mature, but emphasis on collecting data should start in the planning phase.

EXTENT OF COLLABORATION

As with the State of the Practice, each of the working groups were asked to provide a self-assessment of the level of collaboration among the Services, Coalition Forces and US Agencies where operations analysis has been applied to NCO.

The level of collaboration among (and *within*) the Services was assessed as inconsistent. Collaboration between services is varied and has two dimensions: between operators and between analysts. Collaboration between analysts was good with the Joint Lessons Learned Team because they were located at all Combatant and Component Headquarters – so contact was easy. Collaboration between Service teams at disparate sites was very infrequent. Most were completely unaware of the others' existence.

The collaboration with the US Agencies was difficult to assess because the majority of the attendees did not know of examples. Working Group 6 discussed that the *OIF* Phase IV planning involved almost every major agency in the US government; however, none of these

agencies had the collaborative capabilities and expertise to contribute effectively and in a timely manner.

For the Coalition Forces, participants considered collaboration to be infrequent and inconsistent. A spectrum of change of military forces in the international community exists from status quo to modernization through transformation of forces. Nations are at different points in the spectrum with respect to NCO, but all are committed to moving away from the status quo end of the spectrum. The participation in various multinational forums is evidence of the commitment. It was noted that most collaboration with Coalition forces is on a bilateral basis. Many of the activities are modest events between coalition partners (e.g., entropy work, agent based modeling, S&T assessment, an assessment of decision making in collaborative environments, development of a conceptual model, and working groups to discuss interoperability). The conclusion is that there still is a need for significant collaborative analytical events between Coalition partners.

COALITION COUNTRIES

The *NCO and Coalition Force* Working Group assessed the state of the practice, the "good and bad" of applying OA to support NCO, and the future challenges for four Coalition partners: UK, Canada, Sweden, and Australia.

UNITED KINGDOM – The UK believes that a networked force will allow improved situational awareness, agility and synchronisation. Although a range of Concepts has been developed for NEC (covering areas such as the development of a Joint Operational Picture, collaborative planning, mission organised force elements, effects based planning and enhanced tempo) the main focus of NEC investment is currently in the arena of experimentation.

The OA community has a wide array of tools available to undertake analysis in support of NEC activities. These cover the spectrum from discrete event simulation, classical OA tools, sampling and surveys through to multi dimensional criteria analysis, picture models and soft systems methodologies. The UK has confidence in the tools for assessing issues such as picture quality and timeline comparisons at the tactical level, and is moving towards analysis of some of the cognitive issues associated with situational awareness. There are, however, still significant gaps in the assessment of the quality of information products at the higher level. There are also limitations in aggregating information and knowledge factors between low-level models and high-level models and hence difficulties in the calibration of tools at the Campaign level. Current analysis often fails to represent the baseline case (for example not accounting for the many stove-piped stand-alone systems that currently contain the data used by decision makers) and the resultant limitations in showing the true worth of integrated solutions.

The future challenges are to increase the availability of tools and metrics for addressing issues such as quantification of information quality and to develop tools within the cognitive domain to handle adaptive behaviour and/or emergent properties. A key problem, which must be addressed, is how to deal with Balance of Investment issues above the immediate NEC level, where nations have to trade networked enabled capabilities at the expense of platforms or other hardware.

CANADA – While there have been some NCO-related initiatives within Canada, such as the development of an Integrated ISR Architecture, currently there is no national decision regarding the adoption of NCO. A high-level departmental symposium scheduled for Fall 2004 is expected to resolve this and, hopefully, result in the development of a roadmap for the way ahead. Meanwhile, a series of UAV experiments at the Canadian Forces Experimentation Centre, using some OA tools, are working towards proving the NCO case.

The use of planned experiments in examining the merits of NCO has proven useful. For instance, difficulties with communications, TTP's, and UAV icing, which may not have been discovered otherwise, were discovered through experimentation. However, the pace of experimentation has provided challenges for the completion of OA before resources are committed to the next in the series of UAV experiments.

Future challenges remain for Canada in the area of NCO. For instance, in view of Canada's participation in international coalitions, questions remain about the impact of such considerations as language, culture, policy differences, technology and TTP. Also, the role of human factors and the cognitive domain for NCO need to be explored. Importantly, especially in view of Canada's participation in coalition warfare, the issue of how trust is transmitted across an NCO environment between coalition partners needs to be explored. Moreover, questions exist about the use of NCO across the full spectrum of violence (i.e. during low intensity conflict, peace support operations, etc.).

SWEDEN – The current main NCO-related OA effort at the Swedish Defence Research Agency (FOI) is the support to the Swedish Network-based Defence experimentation program, where FOI is tasked to evaluate the ongoing system demonstrator program. FOI also supports the long-term planning process within the Swedish Armed Forces Headquarters, providing analysis in support of the Long-term Parliamentary Defence Decision 2004. FOI was tasked with developing and providing coarse cost estimates of alternative network structures, coupled to different future force structures. The main emphasis has been on the network components necessary to ensure a joint networking capability. Early in that work we pointed to the basic balance of investment between networking soldiers, platforms and C2 systems, respectively.

Given limited resources and a general lack of large, suitable simulation models, they are forced to focus more on soft OA methods, literature studies and simple models. They take a broad view of the role of networks in the field of Defence Analysis, which can be outlined in the following four aspects: Networks as enablers, Networks as threats, Networks as targets, Networks as tools. The first, networks as *enablers*, is of course the main aspect, and encapsulates all their current efforts to leverage the power of networks in developing new military capabilities and concepts of operation. The second aspect covers the idea that various criminal and terrorist groups are effectively *early adopters* of networking. If you believe this, a better understanding of network forms of organization and related concepts of operation is required not only to transform our armed forces, but also to understand the character of future conflicts in general. The third aspect raises the obvious fact that in network-centric operations, your networks will be prime targets for enemy attack. More broadly, it recognizes that *all* our values at risk in future conflicts are increasingly networks *per se*; civilian infrastructure is largely an interconnected set of co-

dependent networks. The proper way to identify, evaluate and then mitigate these new vulnerabilities is, however, far from obvious.

The fourth aspect ties it all together and starts with the simple question: Do they as OR analysts have the proper tools and the necessary understanding to deal with all other aspects of network centric operations in the future? Project Metanet is a multi-year competence-building activity to incorporate recent findings from such diverse areas as complexity studies, bioinformatics, and Social Network Analysis, into work at the Swedish Defence Research Agency.

AUSTRALIA – Network Centric Warfare (NCW) is recognised as a key element in maximizing the Australian Defence Force (ADF) military effectiveness both the Chief of Defence Forces vision for the ADF, *Force 2020* and *Future Warfighting Concepts*, documents. The latter document describes NCW as such: "Network-centricity will help us to link national, ADF and coalition sensors, engagement systems and decision makers into an effective and responsive whole. At its core, NCW seeks to provide the future force with the ability to generate tempo, precision and combat power through shared situational awareness, clear procedure, and the information connectivity needed to synchronize our actions to meet the commander's intent.

To better understand and assess the benefits and vulnerabilities of networked operations, and to provide timely advice to our senior decision makers on balance of investment (e.g. NCW versus weapons), we need to carry out operations analysis (OA) using a range of tools. In Australia, we are defining the concept of NCW via concept development and experimentation. We have found that small scale experiments in the form of seminar war games and matrix games to be particularly useful for gaining insights into NCW. We also are developing agent-based techniques for modeling NCW. The value of quantifiable metrics for knowledge assessment is also recognized. Our current advantage is in our comparatively good understanding of information exchange, skills in conducting small-scale experiments and using systems of systems approach to analyze NCW. On the other hand, we note that many more tools have yet to be developed to assess the benefits of NCW.

Some of the challenges include the inclusion of social network analysis techniques in our NCW analysis, the need to broaden OA capability to multi-disciplinary areas, including social and cognitive modeling. A proper representation of knowledge, e.g. via fusion of data into knowledge, remains elusive.

RECOMMENDATIONS

First, the Synthesis Group developed a set of *actionable* recommendations from the working group discussions and their findings.

- A MORS Symposium working group or composite group dedicated to NCO is needed. NCO is much more than C4ISR and Information Operations. This new working group or composite group could be charged to examine the OA toolkit and processes in order to better focus on the NCO problem. At the 72nd MORSS, it is proposed that the CG B Chair discuss this issue with the leadership from Working Groups 5-10, providing recommendations to the

MORS Working Group/Composite Group Committee Chair and the Vice President (Meeting Operations).

- Create a center(s) of excellence within services and JFCOM for NCO assessments to capture and share results and data of experiments, training, analysis and experience.
- Enable (e.g., thru agreements, business practices) the networking of analysts working NCO and provide reach-back for tools, data, and previous studies.
- Establish a "business model" that enables services to conduct operations analysis in support of "born joint" NCO concepts and that is underpinned by a set of approved tools and data.
- Conduct follow-on MORS special meetings to share NCO analysis and experimentation results. There were two options recommended:

  - A 2-day or 3-day Mini-Symposium to educate the community in the area of NCO analyses. Training and education was seen to be critically important to Transformation overall, and specifically, to the operations analysis practice in support of NCO.
  - A second 3-day Workshop to discuss the issues more fully. It was suggested to provide foundation presentations during the morning of the 1st day and outbriefs during the afternoon of the 3rd day – this would leave two full days for discussion and further debate. During this initial workshop, the working groups felt they only "scratched" the surface in their discussions.

Each of the working groups individually suggested some additional recommendations.

For the Measures of Merit Working Group, one recommendation was to take a functional area, such as fires, and add a qualitative dimension beyond existing metrics in the physical domain. Next develop metrics related to fires that address content for the information domain and then learn how to deal with measuring functions related to fires in the cognitive and social domains. Another recommendation was to consider using "negative" measures of merit to examine phenomena that indicate problems are developing.

For Processes, Methodologies and Assessment tools, the first recommendation (and challenge) was offered by VADM Cebrowski during his keynote address – develop tools for NCO. Other recommendations included to: invest in tool development for assessing C4ISR systems, continue research on sense-making and cognitive modeling, consider revising the NCO framework to focus on "Quality of Individual Decision making" (to enable decision superiority), allow sense-making and cognitive modeling to compete with other modeling techniques in the implementation of NCO modeling, and identify expertise in social network analysis tools and appropriate representation of cognitive processes to integrate them expertise into current and future tools. Additionally, the issues of accessibility, releasability, and classification must be resolved.

In the area of Force Transformation, it was recommended to expand the analysis community beyond the traditional competencies and include disciplines with expertise in the eight key elements of the force (concepts, leadership, education, culture, technology, organization, process, training). Also, suggest continuing to utilize cross-disciplinary analysis teams to address complex NCO issues. As we begin to make headway on NCO analysis techniques we must

share new problem solving approaches and bring additional disciplines into the OA "mainstream."

For the Coalition Forces, the recommendations were derived primarily from the 'future challenges' identified by each individual country and agreed to by the entire group as applicable to all coalition countries. These recommendations included:

- Ensure lessons learned teams have OA team members.
- Develop processes to collect data from real world operations, experiments and training, and provide feed-back into NCO analysis.
- In the social and cognitive domain issues of NCO, develop OA methods and metrics for assessment and create opportunities for experiments
- Assess biological and other adaptive systems network analysis tools for applicability to NCO.
- Advocate the use of case study methodology in the analysis of NCO; improve the rigor of analysis of case studies and experiments (hypothesis testing, analysis plans, collection and dissemination).
- Develop quantitative techniques for assessing the quality of information.
- Conduct an assessment of interoperability requirements in NCO (joint, Coalition, and interagency).
- Conduct an increased emphasis on NCO model validation.
- Conduct analysis on attack and defense of networks.

When applying OA to actual NCO events, recommendations focused on developing doctrine, plans and processes to network OAs and include them early in the planning. These included developing products and processes to facilitate NCO information sharing in order to network analysts with collaborative capabilities, developing methodologies/tools to enhance OA support within time constraints of the actual event, networking analysts so that they can exchange techniques and data, and coding billets in the SJFHQ for OA analysts.

Finally, the participants made other general suggestions:

- Develop a code of best practices for NCO.
- Encourage continued training and education related to NCO concepts, and supporting analyses (models, simulations, experiments)
  - Analysts should examine what knowledge and processes can be drawn from non-traditional disciplines
  - Training and education was seen to be critically important to transformation overall, and specifically to the OA practice in support of NCO. This was the same for government, military and industry; and was felt to be the same internationally as well as in US
  - OA needs to get back to its multi-disciplinary roots. Need to seek out social sciences as well as the hard sciences and engineering fields for ways to abstract and approach squishy, and seemingly intractable problems.

- Expand tool kit and develop more flexible processes to examine robustly networked problems and complex adaptive systems.

- Refine existing tools (better, faster, cheaper) to meet compressed decision cycles.
- Reinvigorate the use of war gaming for analysis (only tool that can represent the complex adaptive system – need a thinking, adaptive adversary that is allowed to win)
- Rely less on formal events and more on real world data collection and exploitation.
- Address the fundamental questions: (1) What is the war fighting value of information? (2) Is there a candidate list of metrics for conduction NCO analysis? (3) What are the fundamental characteristics of the NCO problem?
- For the OA community to improve the state of practice in NCO, some additional steps are recommended.
  - It is recommended that the resources needed to develop and sustain improvements should come through case-studies and experimentation initiatives in diverse operational contexts and scales.
- Given the identified need to adapt paradigms, techniques, etc., from the social and biological sciences, recommend the services pursue complexity science, complex adaptive systems applications to NCO - OA problems at the tactical and operational levels, including developing or adapting metrics and tools from non-military / social science contexts. Further recommend MORS consider the opportunity of 'networking' professionally across other communities of practice to formalize exchanges and build more interdisciplinary tools and practices.
- Visible and more enduring forums, beyond a single workshop, might assist in advancing the OA community's efforts with respect to education / training -- what some refer to as "knowledge sharing". In the spirit of improving awareness, increasing documentation, and broadening relationships, perhaps a NCO-OA "Community of Practice or Interest" could be chartered. This would provide a means for bringing together folks from various communities -- CCRP, MORS, and Coalition countries, as well as multidisciplinary scientific groups -- so they could COLLABORATIVELY (and virtually) engage and "network" around the various issues via questions/discussion groups, key links, papers and studies / POCs, aligning across various dimensions of the problem (e.g., key themes / needs identified in the workshop dialogue / construct).
- Recommend creating disincentives and incentives aimed at 'changing the behavior' of the OA community to better respond to NCO related analysis needs. Developing and advocating a Code of Best Practice for NCO may address this, but only to a limited extent. To accelerate the state of practice in NCO OA will still require overcoming rather steep "cultural" barriers where mindsets (and investments) are wedded to "traditional" practices and tools. Recognition of "great work" in NCO OA may be something the MORS Awards Committee could consider.

OTHER CONSIDERATIONS

In the area of applying operations analysis to Network Centric Operations, the participants offered a couple of other considerations.

It is easy to get the impression that "faster is better" always applies in NCO. A higher OPTEMPO is one of the advertised benefits. Speed is certainly better in the information domain, and in the physical domain once an action has begun. However, this may not always apply in the cognitive and social domains. A higher OPTEMPO may not be the answer in all cases. In a

broader context, the issue to be addressed might be "Who is deciding when and where to engage and who is in a reactive mode?"

Analysts need to portray their subjects of analysis in terms of applicable architectures. This will facilitate assessing the degree of their impact on capabilities. The Operations Analysis Process should be updated and expanded to reflect where/how architecture analysis and the more classical pyramid of Modeling and Simulation fit together in an evolutionary concept development or exploratory analysis of NCO.

Finally, it was proposed to document lessons learned from initial NCW studies.

SYNTHESIS GROUP SUMMARY

The Synthesis Group summarized their findings thus:

The good news is that the OA process developed in the Industrial Age has continued applicability to Network Centric Operations (NCO) in the Information Age. We are only beginning to understand the practices that should be followed to perform credible NCO analyses. In addition, we know there are NCO considerations that remain challenges. The bad news is that we do not do a satisfactory job in documenting, sharing, and learning from NCO analyses performed.

The worse news is, that with the arrival of terrorism, other asymmetric threats, rogue nations, and increased concern for homeland defense, NCO provides an opportunity for Force Transformation. Although these are daunting challenges, there is some better news that is implicit in this workshop itself. If the recommendations of this workshop are implemented successfully, they will provide a basis for improving the operations analysis process and empowering the OA community to address the most critical analytical challenges to support NCO and Force Transformation.

SPONSOR BRIEF COMMENTS

The MORS Sponsors were briefed on the results of the Workshop and provided some additional comments:

- The Synthesis Group recommended that centers of excellence be created within services and JFCOM for NCO assessments to capture and share results and data of experiments, training, analysis and experience. The Sponsors believed that separate centers for NCO should not be created, but NCO should be the principle that ties other centers together.
- The Synthesis Group provided an overall qualitative assessment of the current "state of the health" of applying the Operations Analysis Process across the four key NCW domains. The Sponsors further discussed the cognitive and social domains: 1) each commander reacts in different ways; 2) these domains focus on behaviors; 3) excursions should be analyzed for different leadership styles; and, 4) these domains should be included in designing experiments.

WORKING AND SYNTHESIS GROUP REPORTS

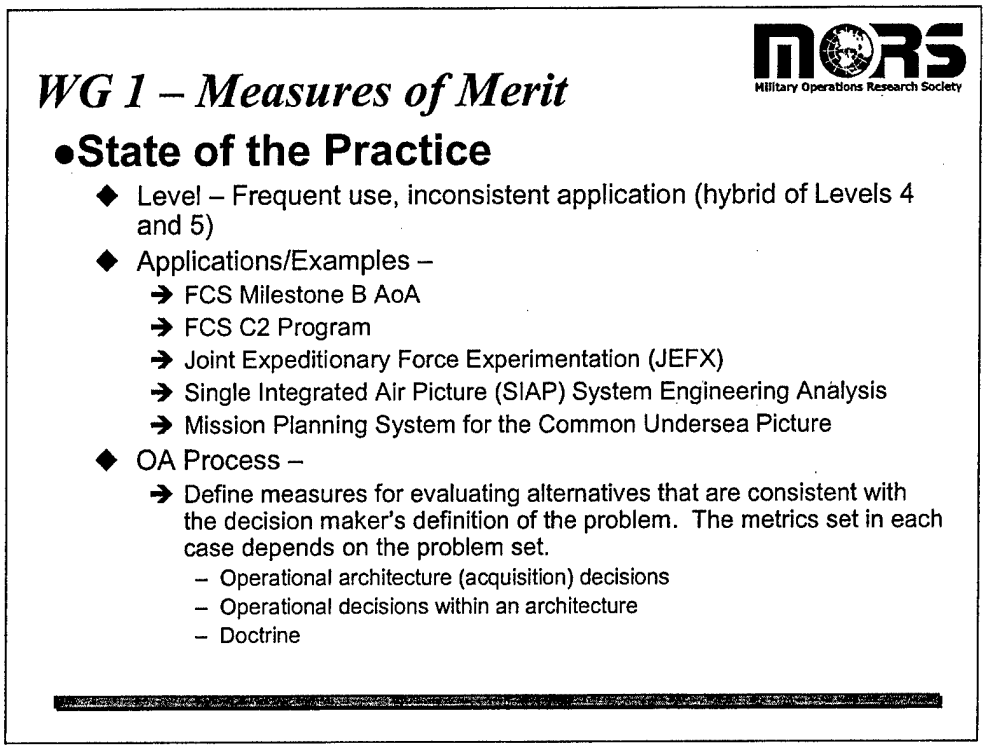
Working Group 1 — *Measures of Merit*
Working Group 2 — *Processes and Methodologies*
Working Group 3 — *Assessment Tools*
Working Group 4 — *NCO and Force Transformation*
Working Group 5 — *NCO and Coalition Forces*
Working Group 6 — *Applying NCO to Actual Events*
Synthesis Group

Operations Analysis Support to Network Centric Operations

Military Operations Research Society (MORS) Workshop

WG #1: Measures of Merit

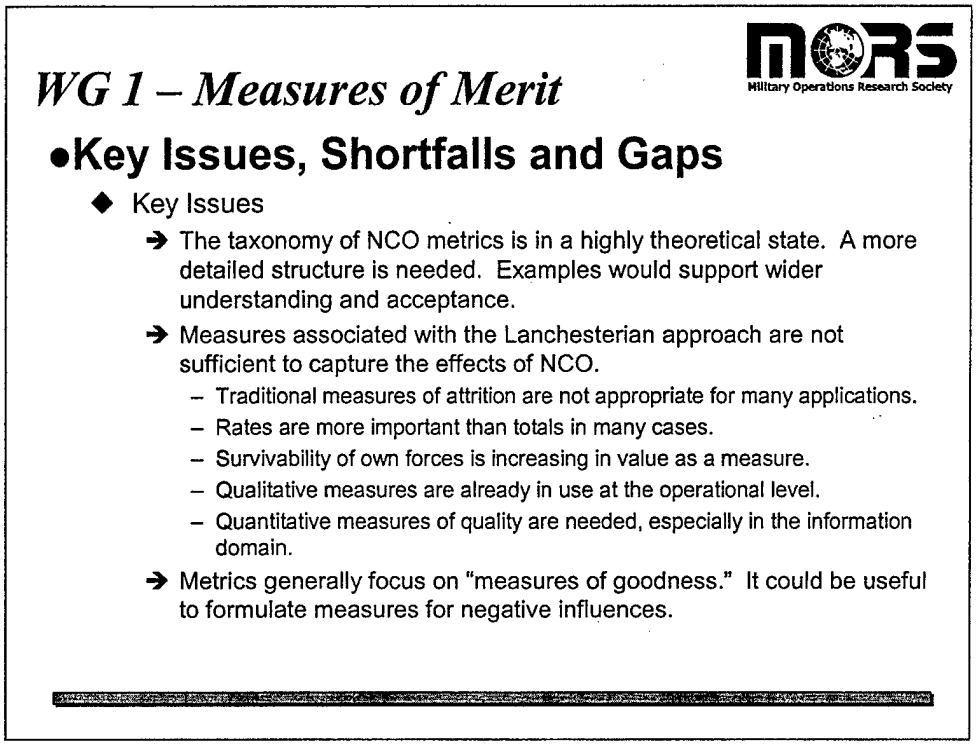
Outbrief



Working Group 1 was polled to establish the level of OA use in support of NCO. The result was a hybrid score between Level 4 (Inconsistent Use) and Level 5 (Frequent Use) – call it a 4.5 (Frequent Use, Inconsistent Application).

Army, Navy and Joint programs are cited as examples of OA applications to NCO.

The selection of Measures of Merit (MoMs) falls into the analysis area in the OA process. Measures are chosen that are appropriate to the question being addressed.



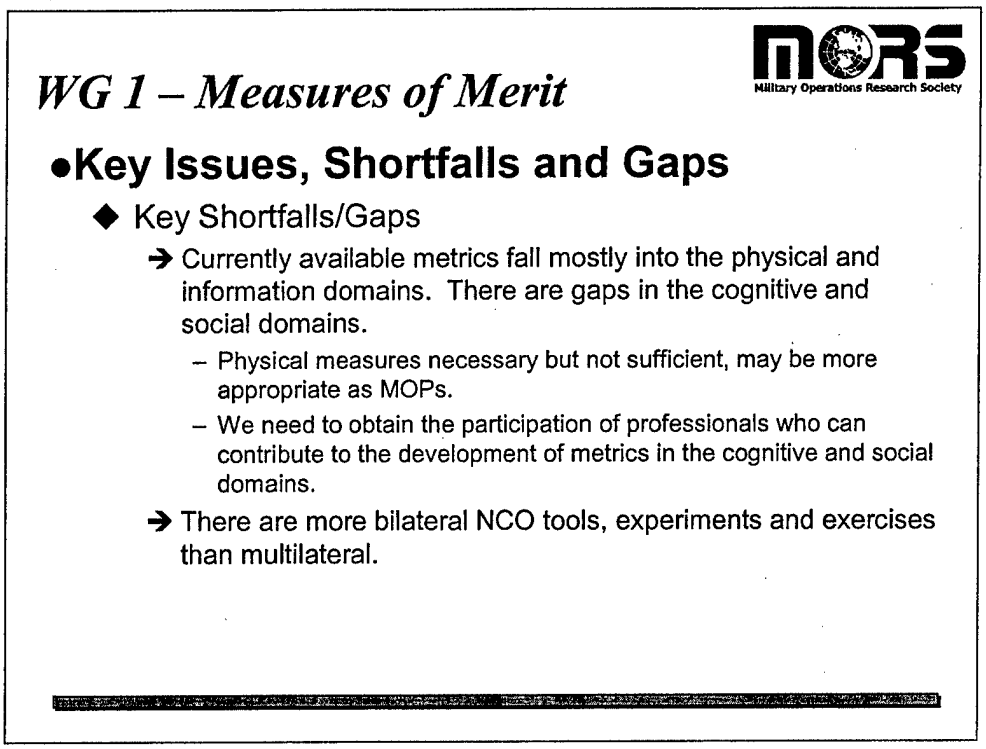
A taxonomy of metrics is needed to enhance OA support to NCO. There are several ways to organize NCO measures that make intuitive sense but examples of specific measures within these categories are hard to find.

"Traditional" measures are necessary but not sufficient to address the needs of analysts in the NCO area. Measures of attrition, such as LER, do not apply to all situations in NCO analysis. The number of enemy kills may not be a strong indicator of success. A qualitative aspect, such as that offered by the number of High Priority Targets (HPTs) killed may be more servicable.

Survivability of own forces has increased in importance as an NCO measure. This standard can be applied to enemy forces as well, i.e., average survival time of an HPT.

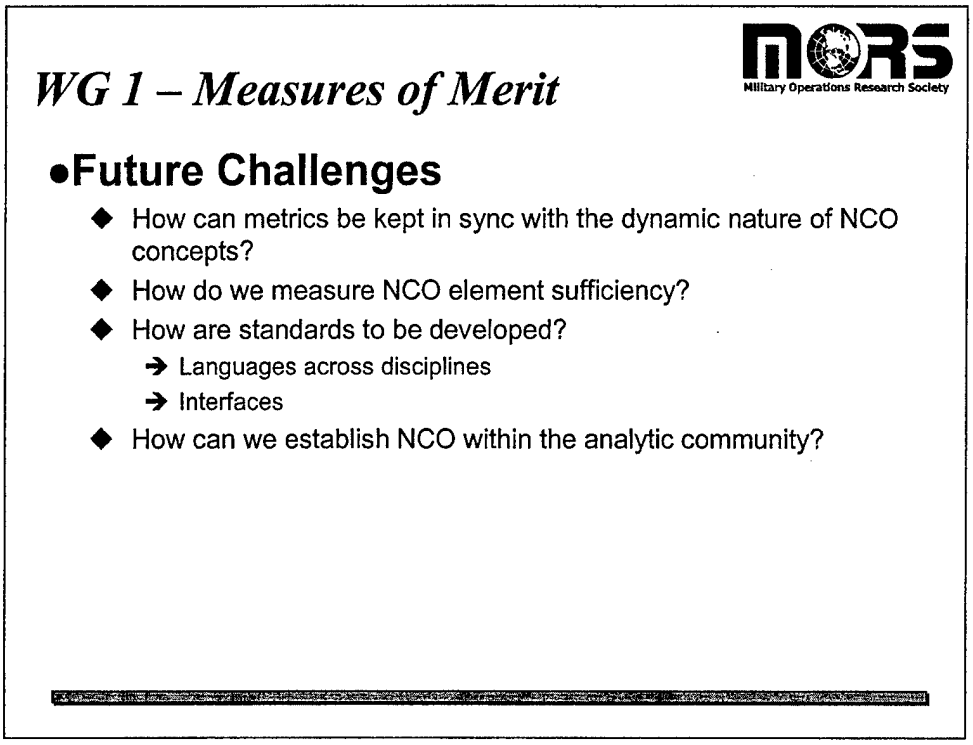
In general, qualitative measures should be accepted for some purposes. Qualitative assessments (red, orange, blue, green) were used in this workshop.

Metrics generally focus on degrees of achievement of desirable properties related to systems. Additional metrics that address unfavorable developments, which may not be associated with specific systems, could be useful.



Most metrics in current use for NCO fall into the physical and information domains. This is not to say that existing measures in these domains fill all the needs there, but there is more choice (and understanding) in these two areas than in the cognitive and social domains. The participation of social scientists should be sought to assist in addressing this need.

Useful measures are constantly being developed for analytical efforts but they are not widely disseminated across the OA community. This is due in part to the fact that most analysis is conducted on a bilateral basis, at best. More multilateral projects are needed among the services and with coalition partners. Joint staff and JFCOM studies, while joint in nature, do not necessarily involve the services and allies sufficiently to achieve cross pollenization across the OA community.



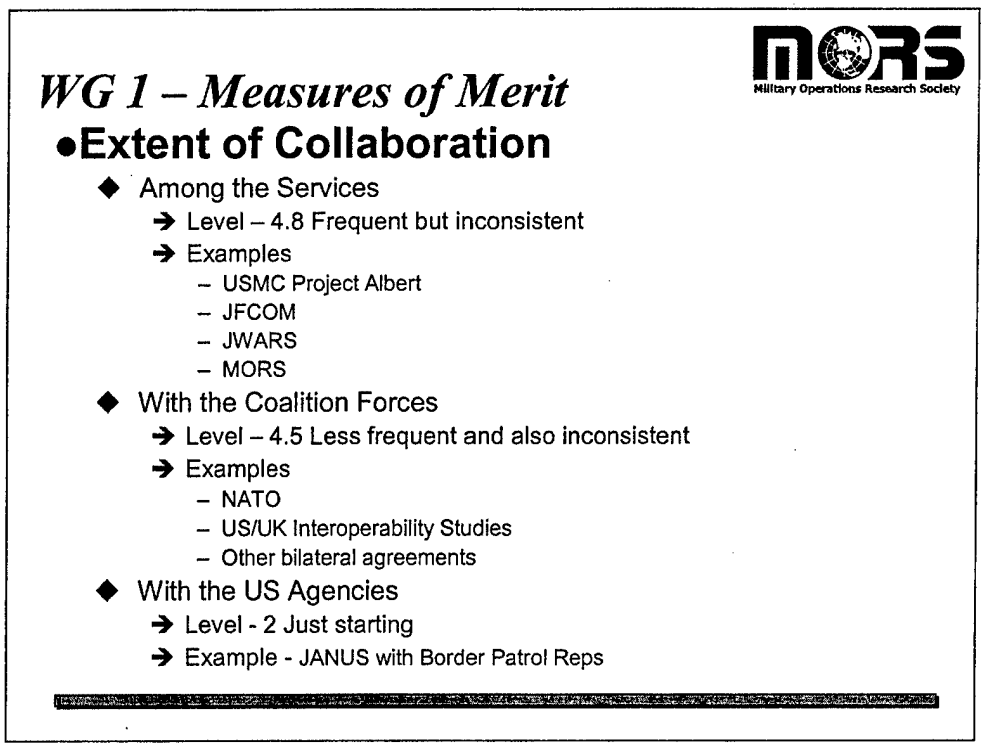
The primary challenge for measures of merit is to keep up with the rapidly changing scope of NCO. Agility is a desirable feature (for which measures are needed) in NCO. The metrics set should be agile as well.

Not only do we need more and better measures for NCO, we need to rigorously address the issue of sufficiency. How much is enough? The answer may differ from one situation to the next.

Development of standards for NCO analysis, including metrics, faces the challenge of incorporating the terminology and practices of the social sciences in order to establish measures in the social and cognitive domains.

To avoid analytical stovepiping, which could occur within the NCO domains, standards for dealing with the interfaces among the domains are needed.

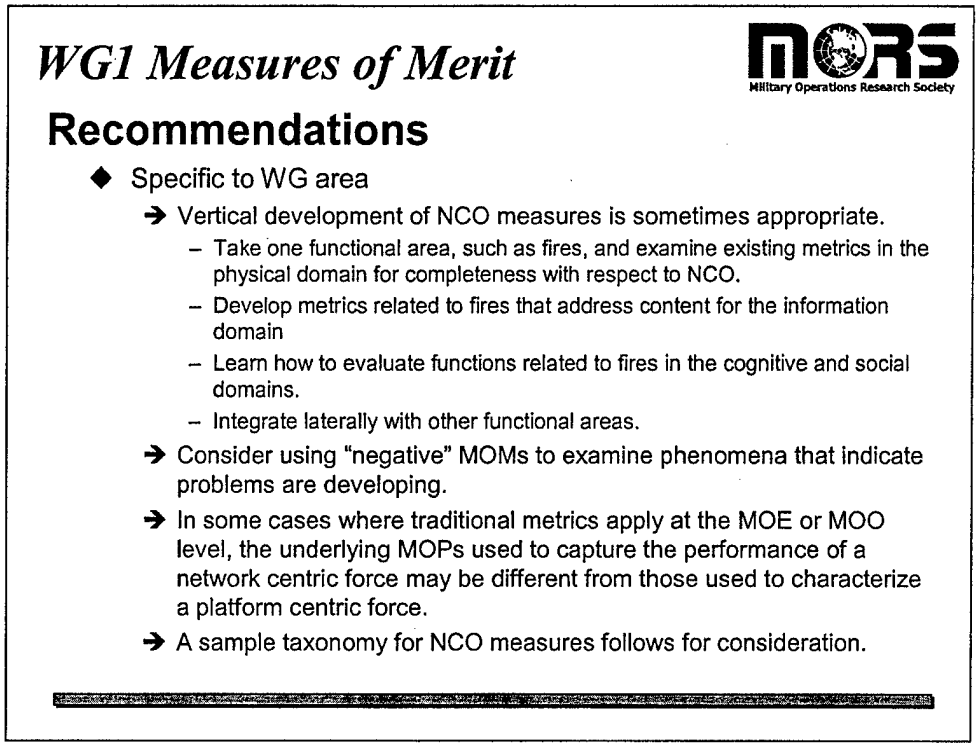
We need to find a way to establish a community of practice for NCO.



Working Group 1 was polled again to rate the extent of collaboration in NCO analysis. Again, we felt more comfortable with hybrid ratings.

In retrospect, it is interesting that we selected JFCOM as an example of inter-service collaboration. Individuals from all the services are assigned to JFCOM and certainly collaborate within the command, but is this enough?. While these individuals bring a service oriented perspective to their JFCOM duties, they ultimately speak for JFCOM, not their parent services.

It was noted that most collaboration with coalition forces is on a bilateral basis. We had a difficult time finding examples of interagency collaboration.



Many of the members of the working group have not been involved in NCO conceptual development at the higher levels. They feel more comfortable applying NCO principles to a restricted scope first, then integrating with other functional areas.

Instead of always focusing on metrics that are intended to measure how well the force is doing, it could be useful to define measures that provided an indication of a trend toward an unfavorable direction. Such measures would probably not focus on how well the force is doing in accomplishing its assigned tasks, but on environmental, cultural, economic or other indicators of developments that could make the job more difficult for the force.

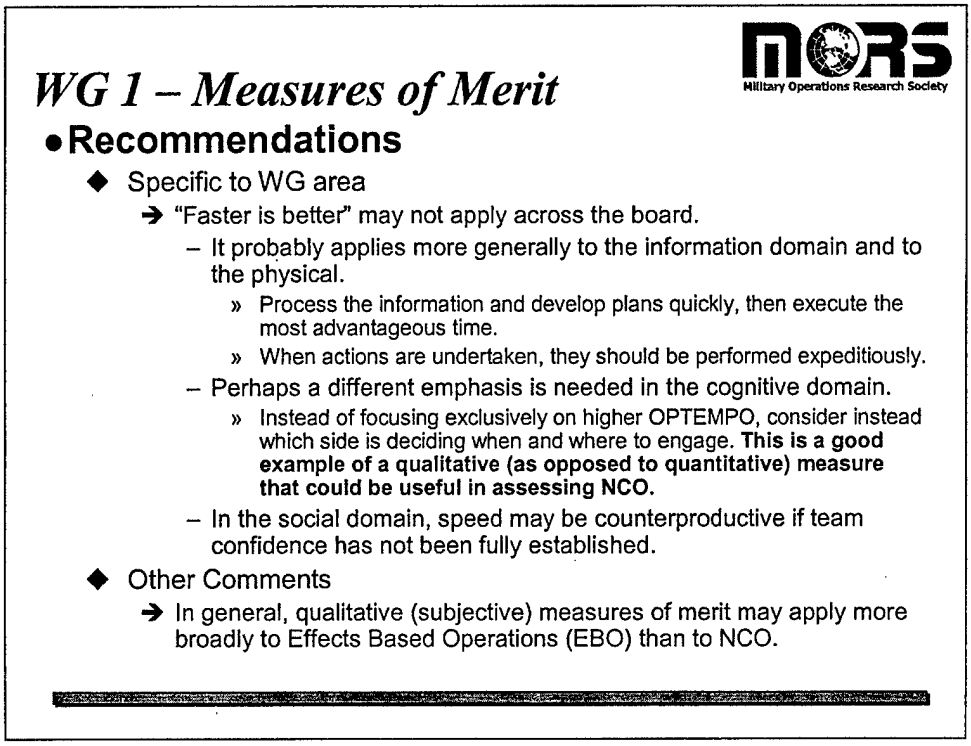
There may be a common measure for comparing the performance of a network centric force with that of a platform centric force at the MOE level, but the MOPs that are used to assess each of the two forces may be different. This may be indicative of differing concepts of operations.

Sample Taxonomy of NCO Measures

Military Operations Research Society

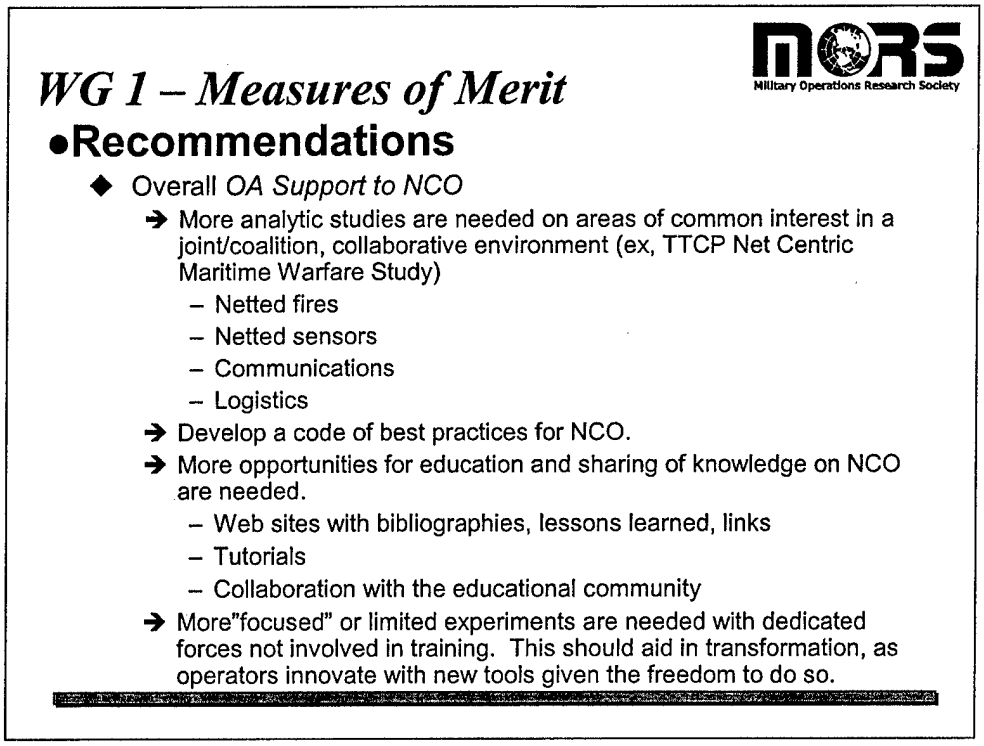
		Measure of Success	Activity/Process
Policy/ Outcome	Policy Effectiveness	Normalcy	
	Process 9		Observation/Verification
Force Effectiveness	Mission Effectiveness	Degree of Agility	
	Process 8		Execution
	Sustainability / Tempo	Extent Commander's Intent Achieved	
	Process 7		Coordination
	Self-Synchronized Forces	Degree of Synergy Among Units	
	Process 6		Planning/Tasking
C2 Effectiveness	Enhanced Collaboration	Degree of Commonality of Purpose	
	Process 5		Interaction
	Improved Shared Awareness	Degree of Common Perception	
	Process 4		Cognitive Analysis
Performance	Improved Quality of Info	Degree Relevant Info Available	
	Process 3		Augmentation/Redirection
	Shared Information	Degree Relevant Info Available	
	Process 2		Distribution
	Robust Network	Connectivity	
Dimensional Parameters	Process 1		Network Management
	Nodes/Links	Bandwidth	

Several members of Working Group 1 collaborated to produce a table that relates measures and processes to the supposed benefits of NCO. Each process is a link between a pair of benefits. The benefits are arranged in ascending order, from least to greatest. Concepts discussed by plenary speakers were incorporated. Hopefully, this initial attempt will stimulate more development.

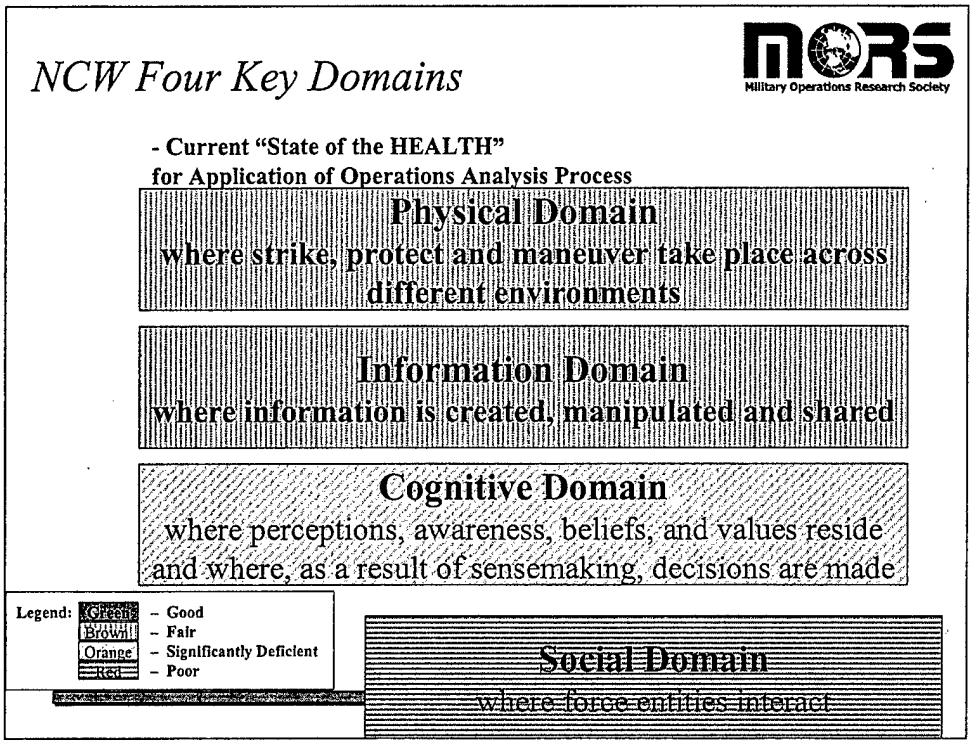


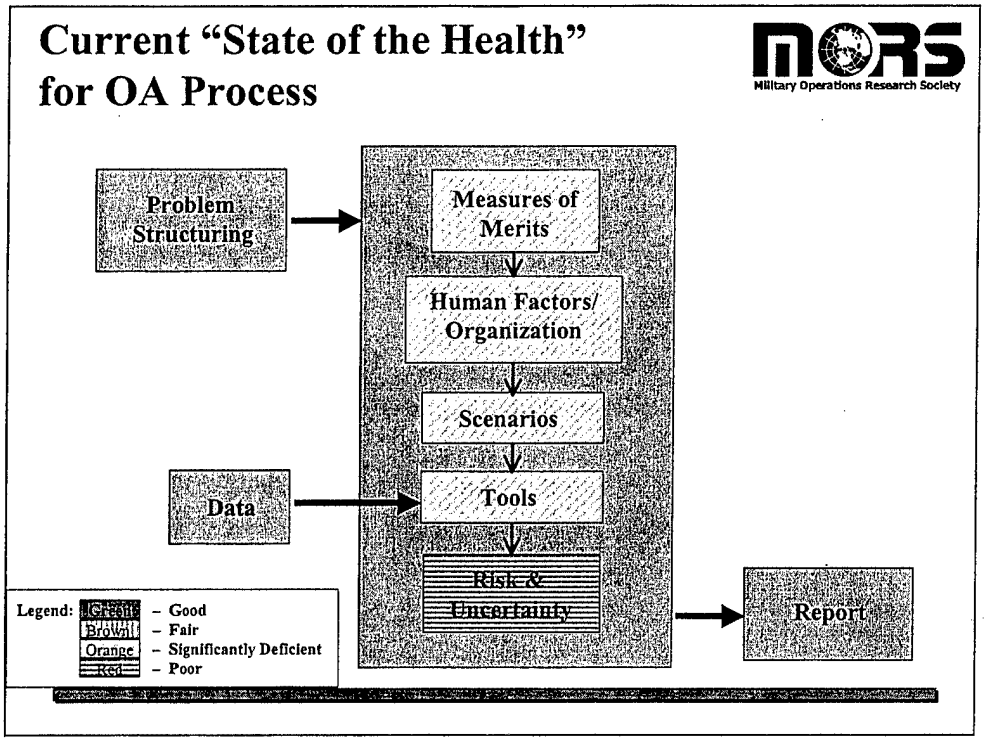
It is easy to get the impression that "faster is better" always applies in NCO. A higher OPTEMPO is one of the advertised benefits. Speed is certainly better in the information domain, and in the physical domain once an action has begun. However, this may not always apply in the cognitive and social domains. A higher OPTEMPO may not be the answer in all cases. In a broader context, the issue to be addressed might be "Who is deciding when and where to engage and who is in a reactive mode?"

This is a good example of a qualitative (as opposed to quantitative) measure that could be useful in assessing NCO. However, such subjective measures of merit may apply more broadly to Effects Based Operations than to NCO. NCO and EBO are linked in recent writing on the theory of information age warfare. This interface may be the most fertile area for developing qualitative metrics. Other aspects of NCO cannot adequately be characterized without quantitative measures.



The members of Working Group 1 believe addressing these issues would enhance NCO analysis across the board and allow them as individuals to participate more effectively.


NCW Four Key Domains
MORS
Military Operations Research Society
- Current "State of the HEALTH"
for Application of Operations Analysis Process
Physical Domain
where strike, protect and maneuver take place across different environments
Information Domain
where information is created, manipulated and shared
Cognitive Domain
where perceptions, awareness, beliefs, and values reside and where, as a result of sensemaking, decisions are made
Legend:
Green – Good
Brown – Fair
Orange – Significantly Deficient
Red – Poor
Social Domain
where force entities interact


Current "State of the Health" for OA Process
Military Operations Research Society
Problem Structuring
Measures of Merits
Human Factors/ Organization
Scenarios
Data
Tools
Risk & Uncertainty
Report
Legend:
Green – Good
Brown – Fair
Orange – Significantly Deficient
Red – Poor

WG 1 – Measures of Merit

Military Operations Research Society

- **Briefings Presented During WG1 Sessions**
  - NCO Conceptual Framework – Dr. Daniel T. Maxwell, EBR
  - IERs, the Pk's of Network Modeling – Mr. Peter M. Kerekanich, TRAC
  - WIN-T Analysis of Alternatives, Emerging Results – Mr. Steve Herndon, TRAC
  - NC Measures of Merit from a Queueing Theory Perspective – Dr. Ralph S. Klingbeil, NUWCDIVNPT
  - Quantifying Information Availability for Situational Awareness – LTC Stephen R. Riese, TRAC

Briefs presented during the Working Group 1 sessions led to lively discussions. Dr. Dan Maxwell set the stage by describing the current state of the NCO concept. Mr. Pete Kerekanich then gave us a micro level (MOP) look at the WIN-T program, examining network performance. He was followed by Mr. Steve Herndon, who shifted the focus to the MOE level, illustrating the difference in operational outcomes with and without WIN-T. Dr. Ralph Klingbeil gave us a Navy perspective. It was interesting to note that his queuing theory approach could accommodate both changes in the red behavior and the changes to blue CONOPS without the need to find new MOPS. LTC Steve Riese closed the presentations with a stimulating brief on the effect on a commander's behavior of a lack of information about red deployment (or lack of confidence in the common operating picture).

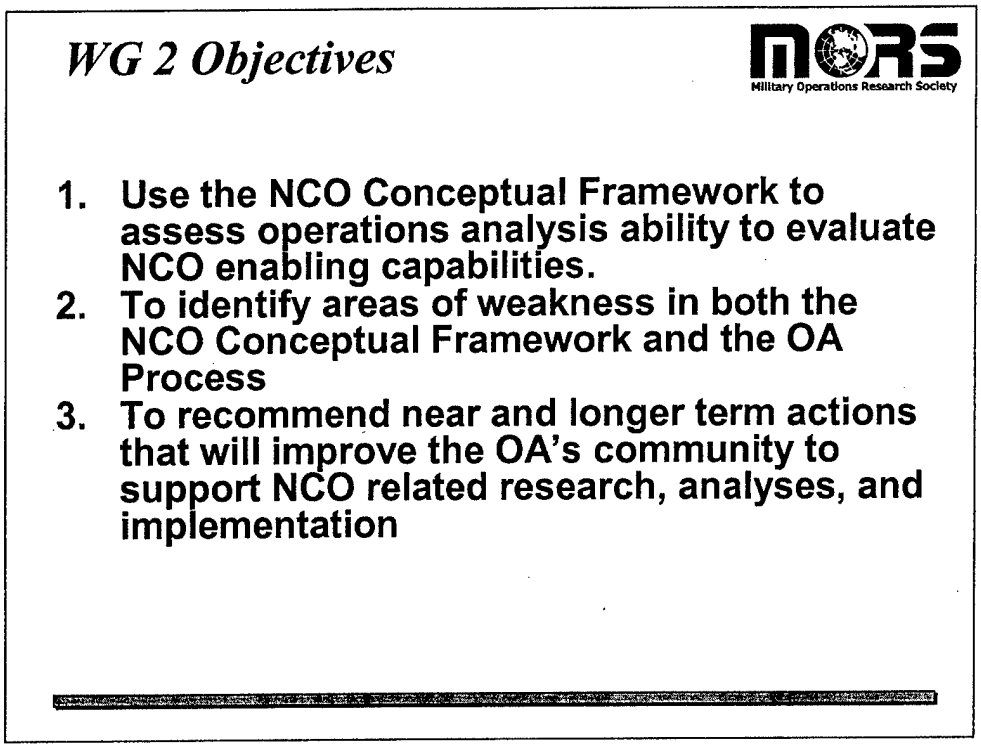
The metrics used for evaluation of NCO capability in these briefs were thought provoking.

Operations Analysis Support to Network Centric Operations

Military Operations Research Society (MORS) Workshop

WG #2: Operations Analysis Methods and Process

Outbrief

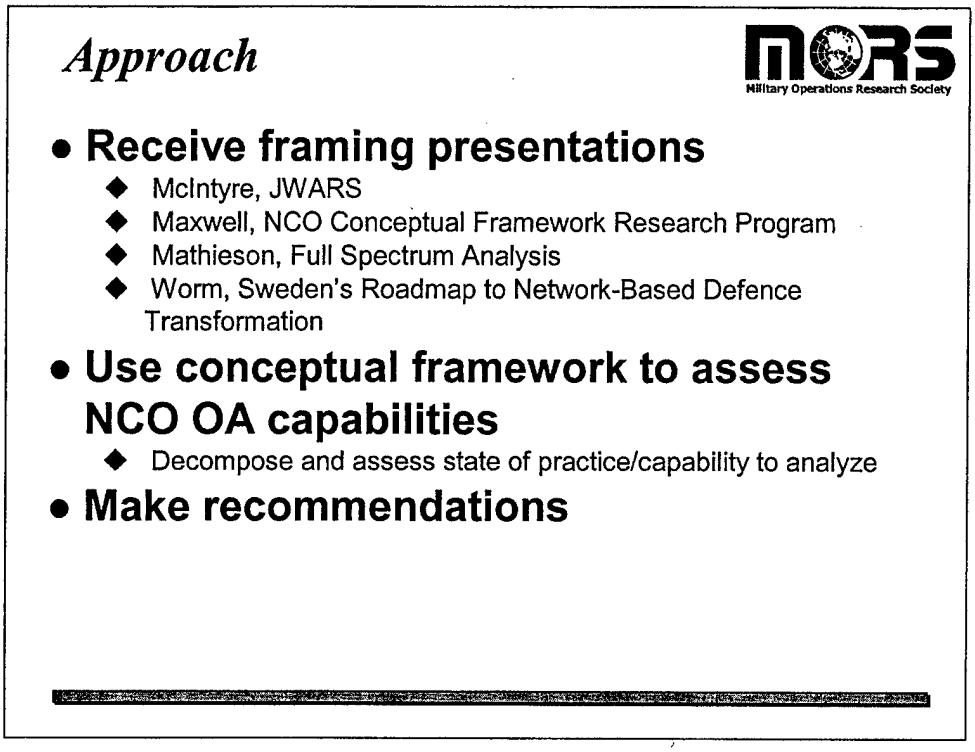


The Overall objective of Working Group 2 was to focus on the operations analysis process as it relates to network centric operations and related operational concepts.

The NCO Conceptual Framework, although still a work in progress, served both as a guide and a "point of departure" for discussions.

This approach was not an endorsement of the framework, but it did validate its value as a communications vehicle for discussing NCO -- an area of thought that currently lacks formal and unambiguous terms of reference.

Additionally, the framework highlighted topic areas inside of operational analysis that fall short for supporting net-centric operations, developing future network centric concepts, and efficiently equipping the force of the future.



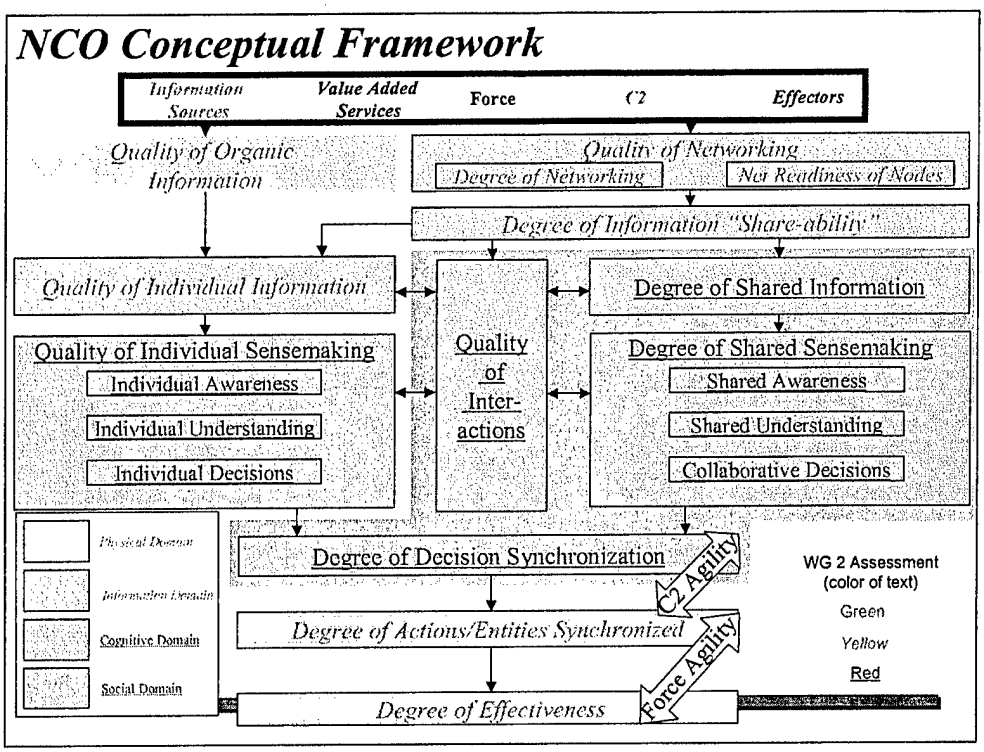
WG-2 was composed of about 25 very experienced analysts, both military and civilian.

Essentially, the WG attempted to make an assessment, albeit somewhat subjective, of the state of knowledge and practice in the OA community for dealing with the challenges of NCO. (NCO was recognized to span the entire spectrum of missions for which military forces may be applied to in the future.) These assessments are summarized in subsequent charts.

The group also solicited each member to provide one (uncensored) observation from their perspective as to the "state" of the practice, and one long-term and one short-term recommendation to the OR community. **These were collated into a set of bullets that are contained in the backup section of this presentation.**

The Backup section of this presentation also contains a set of "commented" slides with relevant observations about the strengths and weaknesses of the conceptual framework, and OA practice relative to the highlighted NCO concepts.

Note: UK (Graham Mathieson) use of the term "Full spectrum analysis" in his title refers to the inclusion of a wide spectrum of "human factors."



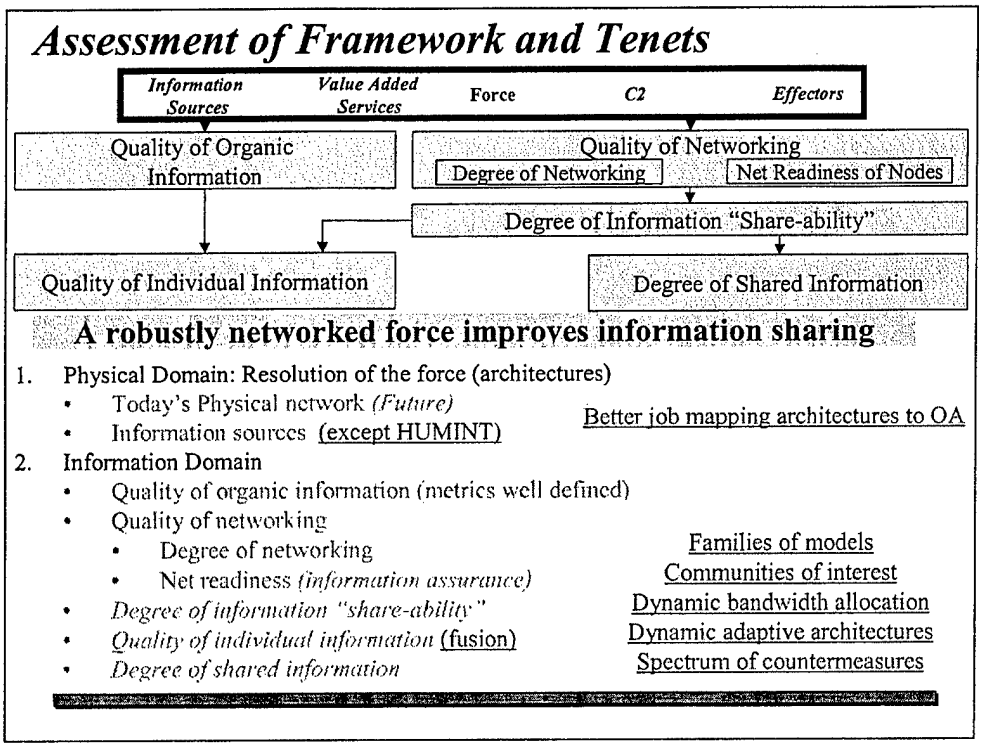
Legend: The color of text in each box was changed to either green, orange (italic) or red (underlined) as per the definitions on the next chart for the "state of the OA practice" assessments. The purpose of the color coding was to present a general assessment of the state of the OA practice overall in to support the key NCO concepts identified in the framework.

Describe how each high-level capability (and corresponding high-level measure) fits into the domains. How are information services provided, etc? Right now, the framework is not fully populated to support analyses. Sensemaking terminology need a lot more consideration.

Color Meaning

Military Operations Research Society

- Green – know how to do. Have to adapt models. No new research.
- *Orange – know how to do but would be serious model development. Some research involved. May be able to adapt methods including from other disciplines.*
- Red – Significant research and major modeling development. (we don't have a clue)



This chart exemplifies how the WG systematically decomposed the top-level Framework model and recorded their assessments as to the state of the OA practice. In doing so, the group also considered the 7 tenets of NCO in relation to the framework. Discussion for this example led to distinguishing what OA capabilities can be done reasonably well from those OA capabilities that are deficient.

Physical Domain: Resolution of the force (architectures)

- Today's Physical network *(Future)*
- Information sources (except HUMINT)
- Better job mapping architectures to OA

Information Domain

Quality of organic information (metrics well defined)

Quality of networking

Degree of networking

Net readiness *(information assurance)*

Degree of information "share-ability"

Quality of individual information (fusion)

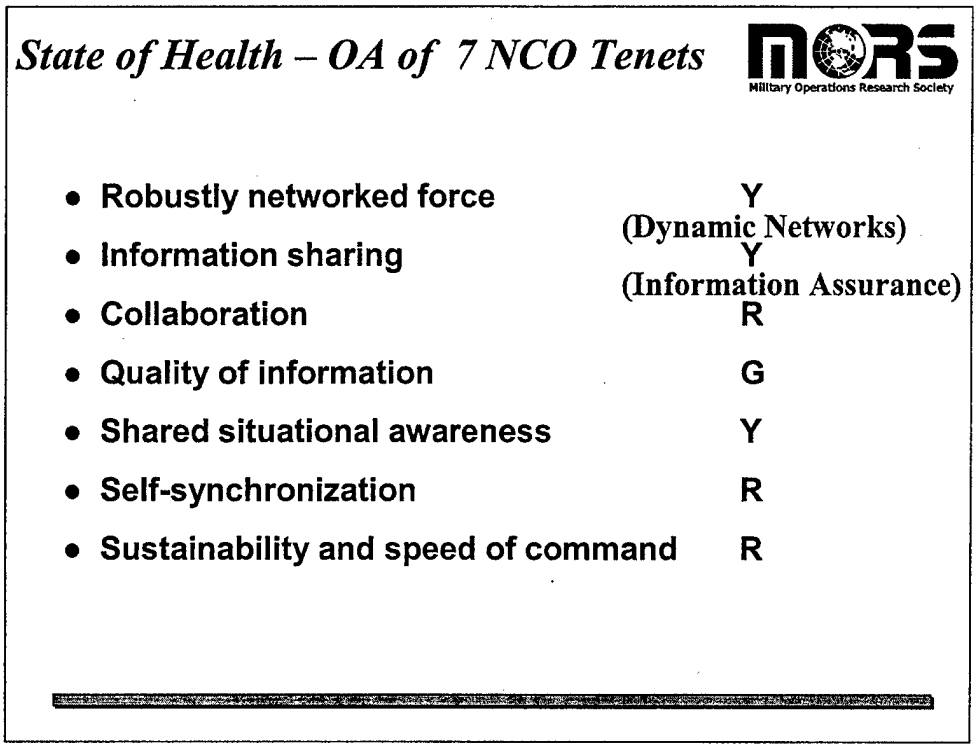
Degree of shared information (multi-level security sharing across coalitions)

Families of models

Communities of interest

Dynamic bandwidth allocation

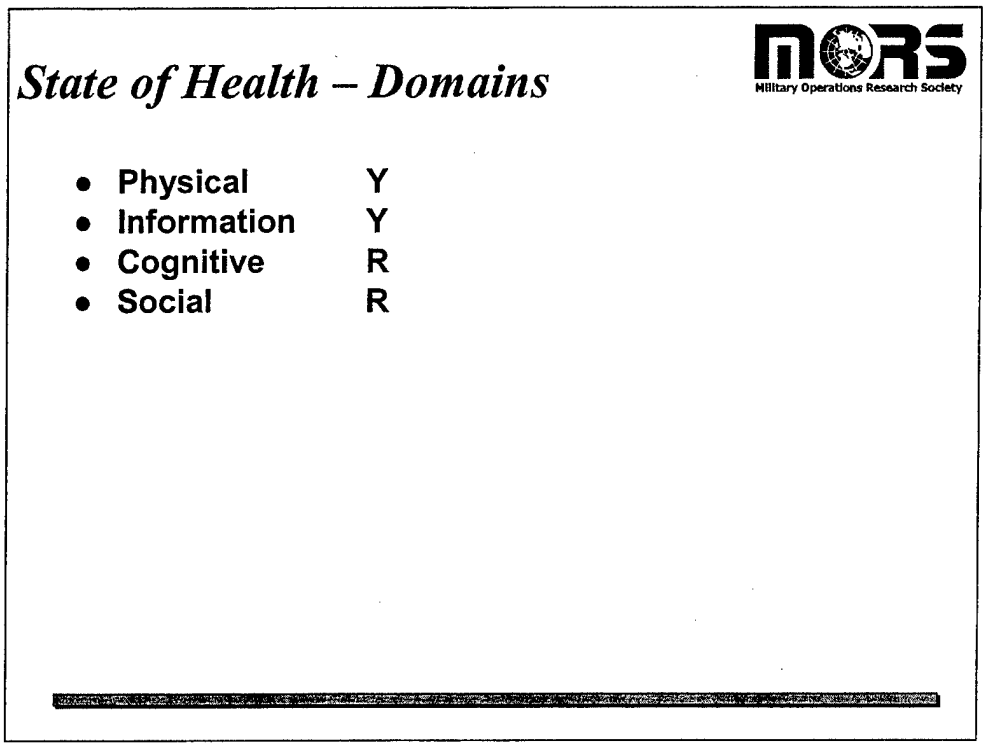
Dynamic adaptive architectures



Info sharing: The community has ideas today on how information moves around the battlespace, but the issues of Information Assurance (IA) precipitated the evaluation of the "state of the practice" to be degraded from green to yellow.

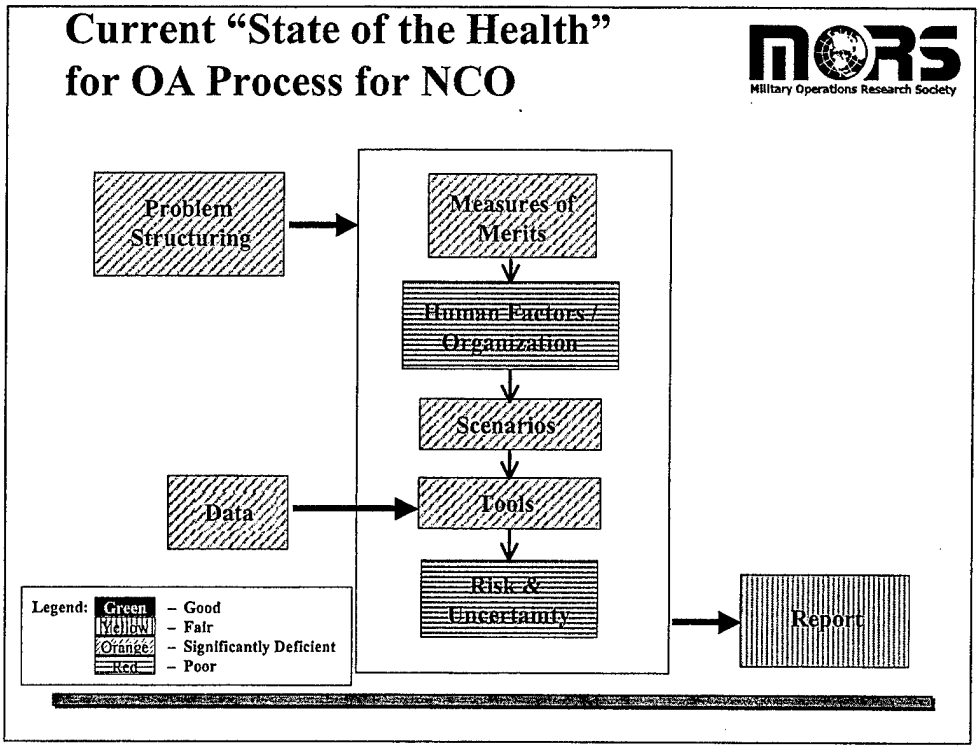
Understanding and modeling of collaboration — especially at the social level, is very weak.

Cross-cultural issues (across agencies, NGOs, etc.) will require "technology transfer" to be improved.



The state of health for OA in support of NCO is weak overall. Even at the physical level of modeling and analysis, the fact that the OA community continues to focus on the warfare (combat) portion of NCO and not on the larger set of military missions (e.g., OOTW) is seen in the scarcity of methods for these situations. The physical and information domains were also rated yellow by the group because OA practitioners do not generally embrace the complexity and emergence involved in NCO and continue to attempt to reduce the problem to linear dynamics.

Overall, the MORS OA community is uncomfortable with expanding their analysis into the cognitive and social levels. Scientific approaches of the past that addressed the physical domain well seemingly don't represent these other domains well. The OA community needs to consider methods from other disciplines. Medicine, genetics, sociology, political science and cultural anthropology fields are examples of fields with increasing relevance to future OA.



Problem Solving: Analysts and the decision makers they support often don't know what the relevant problem and questions are right now. Today there are different facets of problems we need to deal with; how do we address these methodologically, how do we address these culturally and resource wise. There are not unlimited resources and there are cultural barriers to approaching this new class of problems.

Scenarios: Know how to do, but the OA community hasn't begun to explore yet. OA could help the process of defining scenarios by asking the right questions.

Tools (deferred this block to the tools WG).

Data: If we thought about data differently, we could exploit resources that already exist. We don't take a robust enough approach.

Reporting: In many cases, OA analysts are operating in a realm where decision making tempo is shorter than we can address the questions with analysis.

State of the Practice

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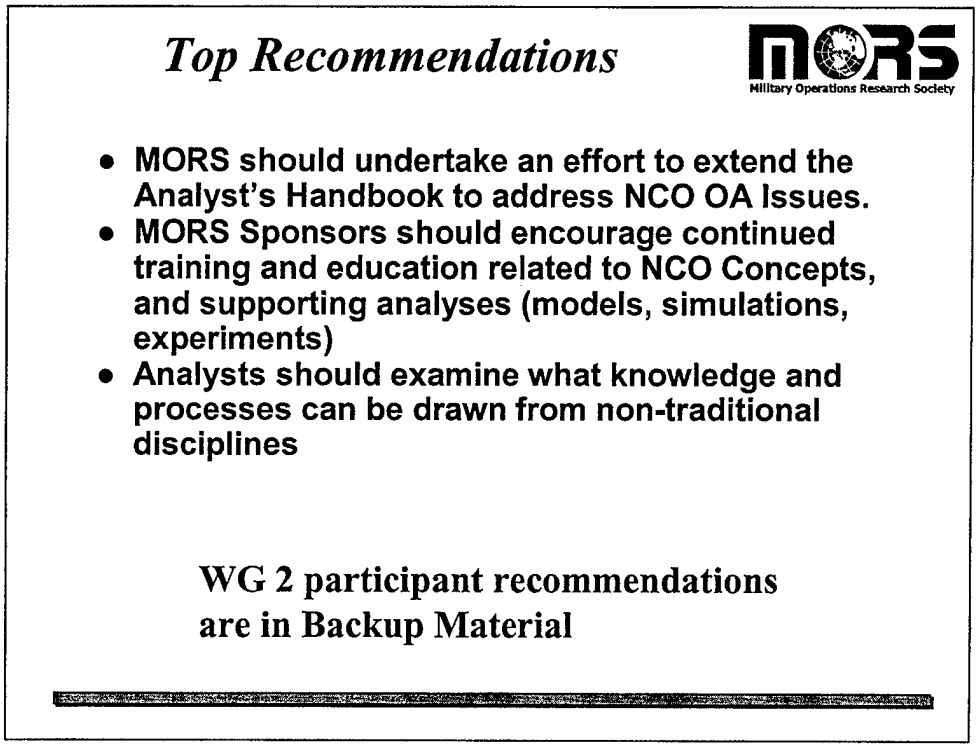
- **The maturity of an "NCO OA process" is consistent with the state of the understanding of NCO....immature**
  - Current tools and practices are understandably grounded in what we know and the decision process we support.
  - Some of that foundation is essential

WG 2 participant comments on state of the practice are in Backup Material

Need to ensure that there is value in what we have been doing to what we need to be doing. (Need to discern what to shed and what to keep.)



Recommendation 1: Given all the on-going changes, how will we update this handbook? Will be soliciting input regarding this.

Recommendation 2: Training and education was seen to be critically important to transformation overall, and specifically to the OA practice in support of NCO. This was the same for government, military and industry; and was felt to be the same internationally as well as in the US.

Recommendation 3: OA needs to get back to its multi-disciplinary roots. Need to seek out social sciences as well as the hard sciences and engineering fields for ways to abstract and approach squishy, and seemingly intractable problems.

State of the Practice (1/2)

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1. Trying to teach "old dogs new tricks." Modifying legacy models that are not information centric to account for information in the modeling and simulation process. If and when the old models can be modified, the outcomes can only be measured in terms of attrition.
2. "We" will not achieve revolutionary results using the same analysts. As we design these inherently complex systems, people with fixed mental models of operations will not perceive the non-linear results. The majority of the lead analysts in the workshop have 20+ years experience in OA.
3. Current tools and practices do not address or capture collaboration, self-synchronization or agility – key characteristics of NCO.
4. The community continues to use tools and assumptions which appear to be invalid in today's warfighting environment, and then conduct verification and validation of new tools by comparing outputs with existing tools.
5. Practice needs to be matured in terms of analyzing the "entry-fee" to NCO, i.e., assessing infostructure in terms of enabling NCO.
6. M&S development is taking too long and not amenable for quick turn around or cost effective strategic analysis, i.e., JWARS. Network M&S tools for NCO are missing [lacking].

These two slides contain the input of the 28 working group members most important individual observations about the state of the practice.

State of the Practice (2/2)

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7. The OA community is not focusing on the full breadth of military missions – but rather, it is continuing to focus on analyzing *what we already know*, i.e., the "W" (or workforce) part of "O".
8. There also is a scarcity of research to model non-warfare aspects of NCO.
9. SoS architecture analysis is pivotal to assessing NCO. Yet the classical OA pyramid of modeling and simulation, the OA process (as described on day-1) and even the detailed process described in the recent book NATO Code of Best Practices for Assessment (DoD CCRP, 2002) -- do not explicitly address the role of architecture analysis in the assessment of Systems of Systems (SoS). This lack of process clarity is evident as the OA community is challenged more and more with complex, SoS solutions (DOTMLPF) for meeting the capability needs for NCO.
10. NCO, CBA and EBO together create a large analysis space and scenario space. The amount of funding and other resources for analysis doesn't increase accordingly. What must change to deal with this large 'space'?
11. The use of NCW consideration in OA is embryonic. The US Army FCS and Navy FORCEnet activities are initial efforts.
12. (Shared) awareness/understanding is not dominated by (shared) situation information but by a combination, in roughly equal parts, of (shared) history, experiences and situation information.

Short-Term Recommendations (1/2)

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1. **Analysts need to portray their subjects of analysis in terms of applicable architectures. This will facilitate assessing the degree of their impact on capabilities.**
2. **Use USAF – AFSAA SEAS tool in conjunction with JWARS.**
3. **Develop an OA community strategy document that includes priority efforts.**
4. **Invest in tool development for assessing C4ISR systems.**
5. **Most military and civilian ORSA lack adequate training about knowledge and data management. This will be chronic if not fatal for analysis of info-based NCO. We need to institutionalize the requirement that ORSA's are managers of data, not just users. Address this problem in the short-term with training.**
6. **Need to prioritize efforts in respect to NCO representation and measurement for all the different uses of analysis, e.g., experimentation, training, resource allocation, etc.**
7. **Produce NCO analysis that is 75% correct but timely, plenty accurate for inferring strategic insights.**

These slides contain a set of individual short term recommendations identified by all of the group members regarding OA for NCO. These were synthesized, and in some cases deferred to other groups because of the focus of the group.

Short-Term Recommendations (2/2)

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8. **Update and expand the OA process to reflect where/how architecture analysis and the more classical pyramid of M&S fit together in a evolutionary concept development or exploratory analysis of NCO.**
9. **Document lessons learned from initial NCW studies.**

Long-Term Recommendations

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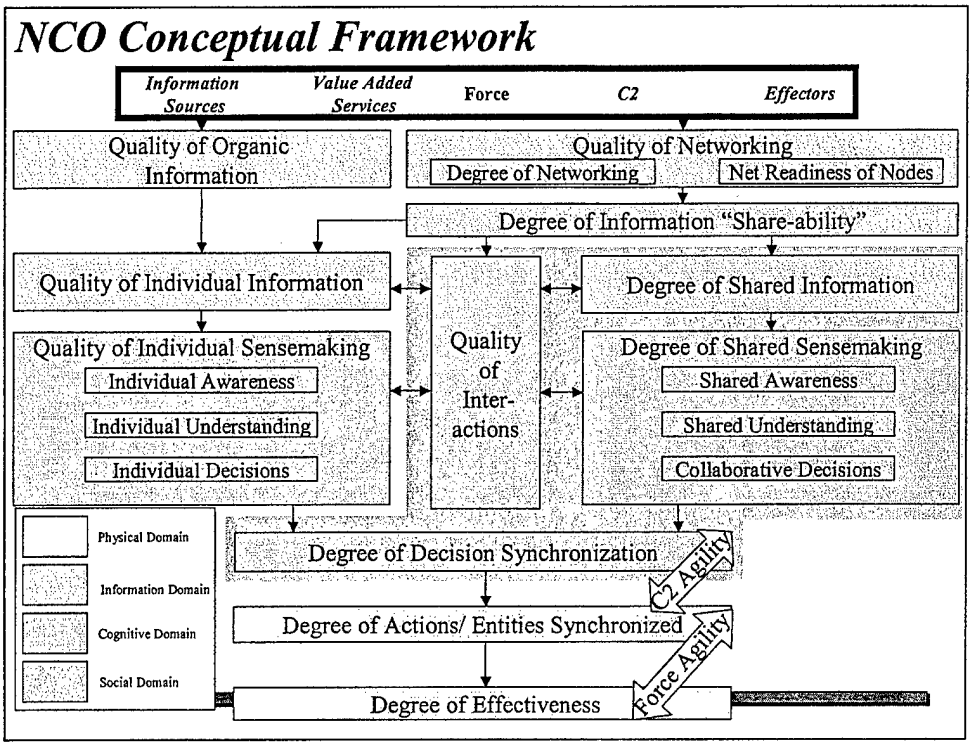
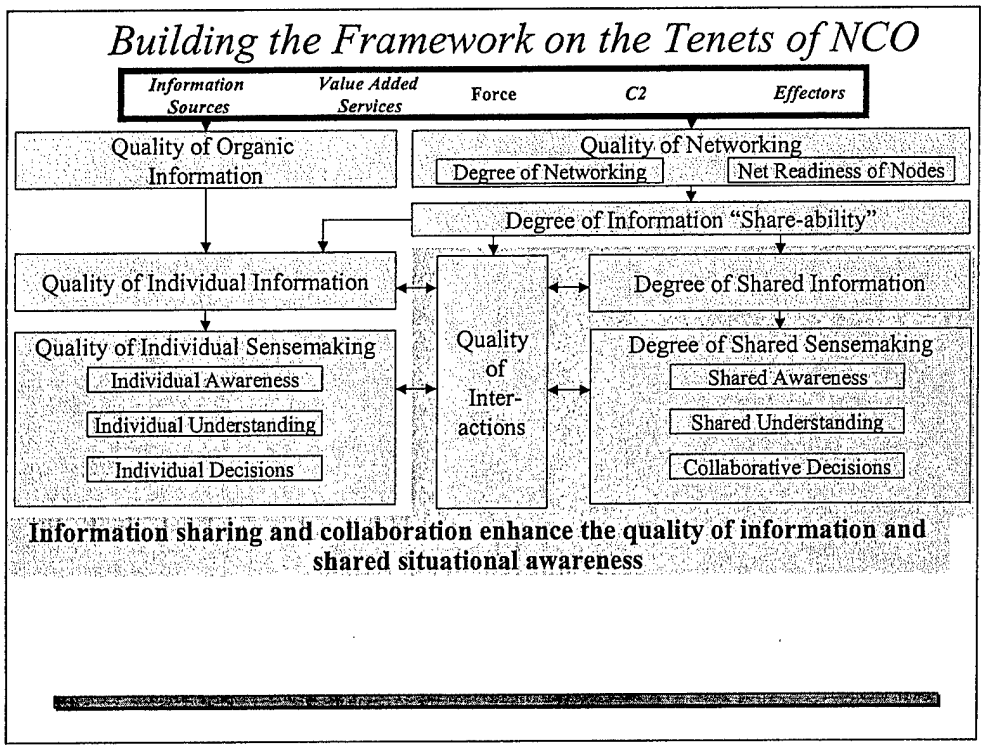
1. **Stress that new modeling efforts should be built on an information paradigm. Measurable outcomes should consider "soft factors" such as C2, leadership, will to fight, etc.**
2. **Incorporate agent-based simulations in M&S tools.**
3. **Ensure OA data collection requirements are included in the on-going development of the Joint National Training Capability (JNTC).**
4. **Educate military analysts on the NCO Conceptual Framework.**
5. **Formulate a coherent plan for addressing collective NCO analysis requirements. Need the plan to coordinate efforts, ensure consistency in NCO representation, and to ensure consistent measurement of effects.**
6. **Consider modifying the JWARS - Operational Requirements Document (ORD) to specify requirements to model NCW.**

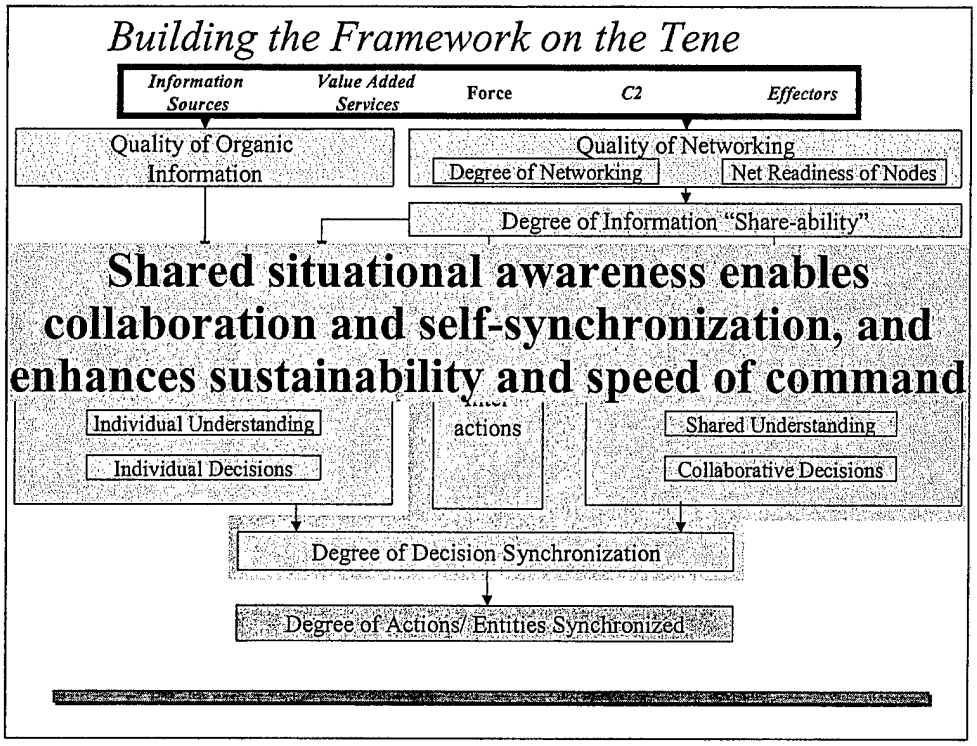
These slides contain a set of individual long term recommendations identified by all of the group members regarding OA for NCO. These were synthesized, and in some cases deferred to other groups because of the focus of the group.



Will describe how each high-level capability (and corresponding high-level measure) fits into the domains.



- Quality of Individual Sensemaking
  - Lack ability to implement theories of individual sensemaking in cognitive models to capture agent interaction
  - *Currently implemented by rule sets*
  - *Critically dependent on context*
  - *Sensemaking may not be mature enough to support decision making*
  - *Approaches from other disciplines that may be useful*
  - *Currently embed sensemaking in simulations using rules/Man-in-loop/algorithm for a decision*
  - Criteria required by decision makers to address sub-steps or just analyze decisions (models vs. war-games)?
  - Should we consider Sensemaking vs. Decision Making as part of the framework (per DoD Joint Ops concept NOV 2003)?
  - Need more research on Cognitive modeling (to address the non-automated processes)
  - Modeling situational awareness
  - Analysis of results of Individual Sensemaking
  - Quality of Interactions
  - Must model modes of interaction
  - Clarification on the context
  - Address types of networks (formal, informal, etc.)
- Degree of Shared Sensemaking
  - Corollary to individual sensemaking but allows for different outcomes (emerging group behavior)
  - Difficult to understand the group dynamics to implement in simulations
  - Very context sensitive
  - Significantly increased interactions within the group (randomness/complexity)
  - Bound the problem by Jointness through US-only to Coalition (Joint modeling is an example)
  - Need increased input from sister services to sensitivity
- Analysis of results of Shared Sensemaking



Degree of Decision Synchronization

Evaluating States vs. outcome (robustness, agility, etc.) must be supported by MOEs

Performance vs. scenario space

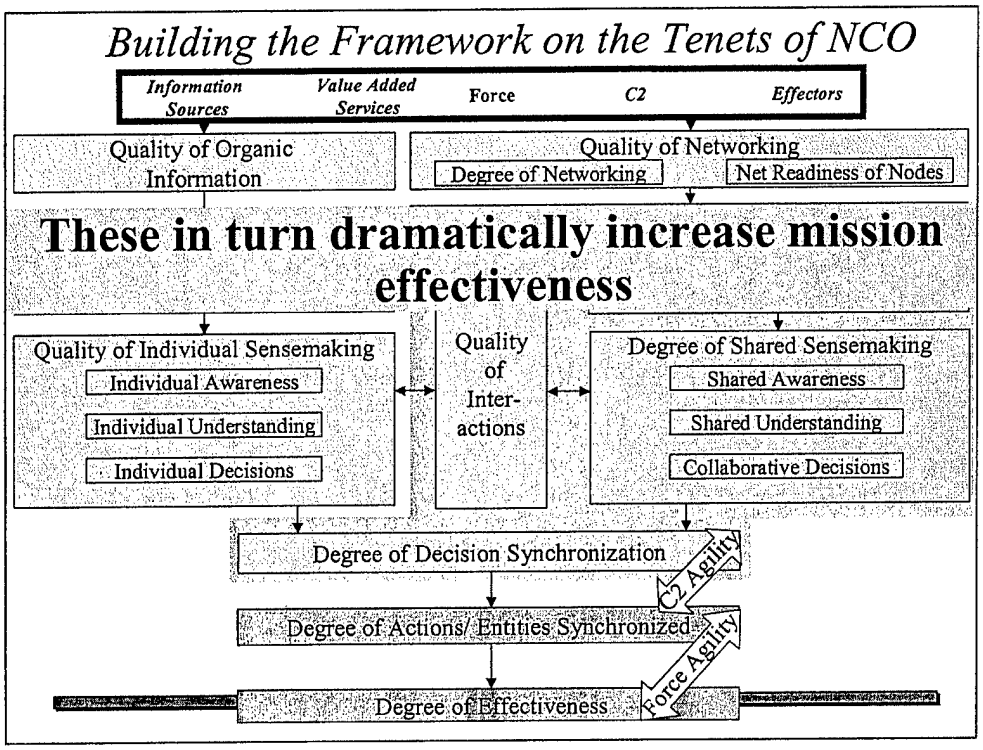
Models are available for Decision Synchronization *(but need to account for system dynamics)*

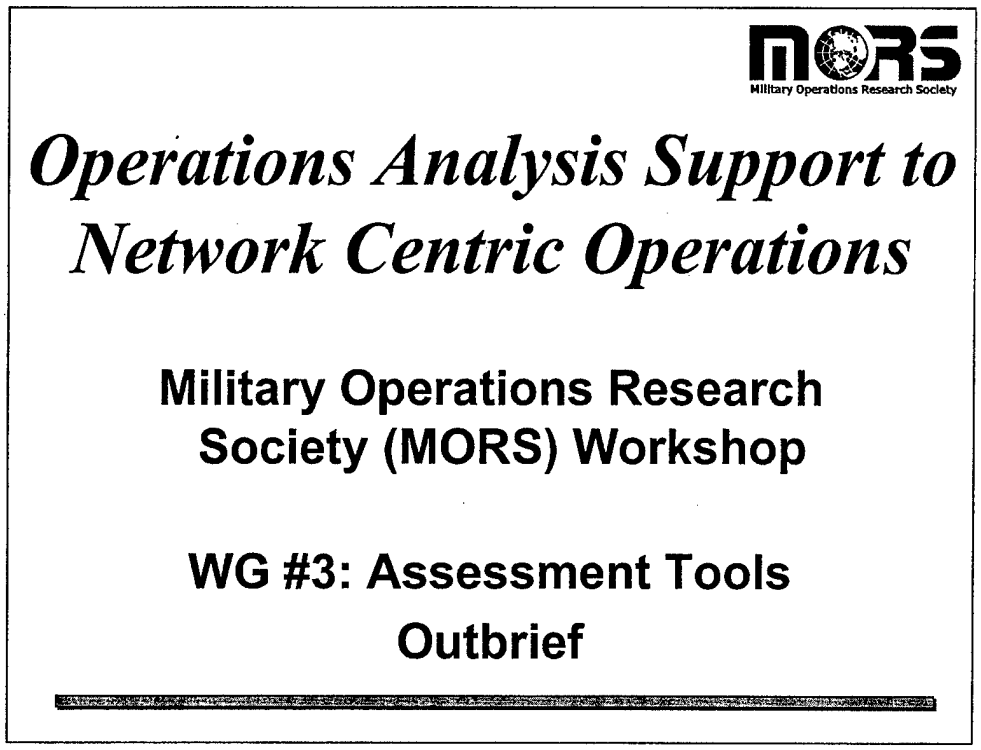
Not modeling self-synchronization (dynamics of decision to action synchronization)

Agent-based models are beginning to develop this capability

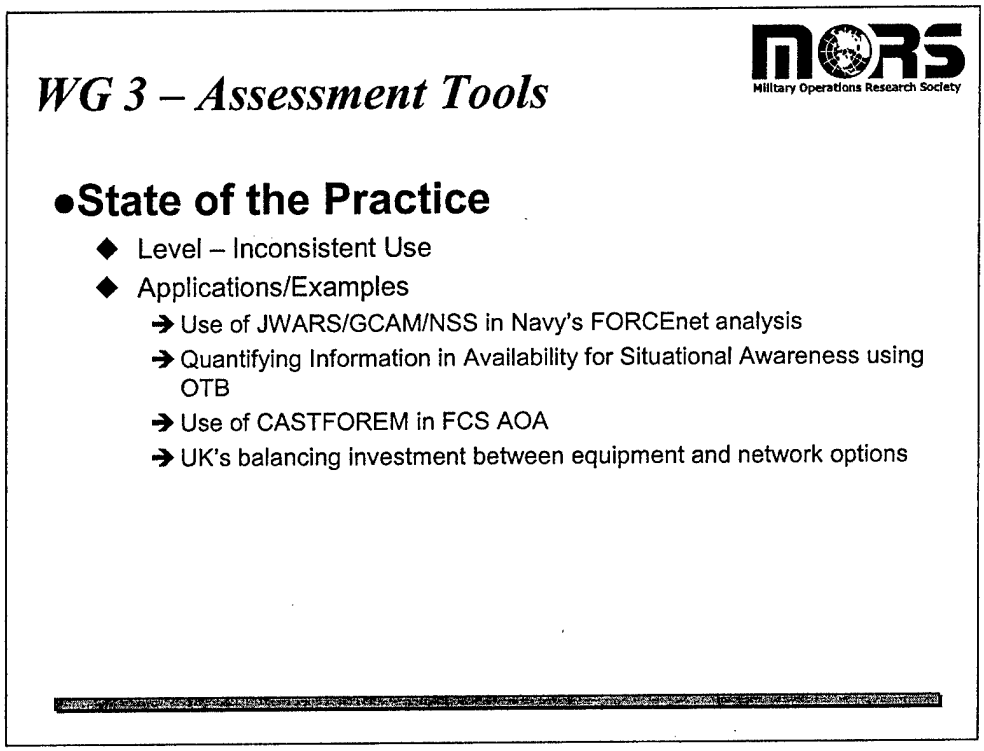
Local vs. Central Control is an issue in agent-based models (increased degrees of freedom) with significant results.

Commercial examples of cognitive modeling (large discount stores, grocery stores, etc.)


Building the Framework on the Tenets of NCO
Information Sources
Value Added Services
Force
C2
Effectors
Quality of Organic Information
Quality of Networking
Degree of Networking
Net Readiness of Nodes
These in turn dramatically increase mission effectiveness
Quality of Individual Sensemaking
Individual Awareness
Individual Understanding
Individual Decisions
Quality of Inter-actions
Degree of Shared Sensemaking
Shared Awareness
Shared Understanding
Collaborative Decisions
Degree of Decision Synchronization
C2 Agility
Degree of Actions/ Entities Synchronized
Force Agility
Degree of Effectiveness



This group included 24 members, including representatives from 5 different countries (US, UK, The Netherlands, Denmark and Israel):



Much of the discussion was focused on the state of the practice of assessment tools for NCO. Most of the presentations during the second day were on models and simulations. It was the groups conclusion that in the context of NCO, the tools were used infrequently. During the second day of the workshop, the working group listened to presentations on some current NCO tools in use. It was the conclusion of the group that the tools were used infrequently and can be attributed to single service development, portrayal etc. Also, the tools are designed for a specific purpose, and with NCO being a transformational concept, the tool set needs to be developed in order to be sure we are assessing NCO correctly.

The working group listened to four presentations on the second day of the workshop. During the first working session, we participated in the JWARS joint session in the auditorium with Working Groups 1 and 2. During the second session, Dr. Ben Taylor and Lynda Sharp presented the "UK High-level Campaign models and NEC related Studies." Doug Mackey then presented on CASTFOREM followed by LTC Stephen Riese's presentation on "Quantifying Information Availability for Situation Awareness" during the third working session. The final session of the day was used to discuss these presentations and discuss questions pertaining the charge to the working group.

Some important discussions took place on the final day of the workshop. We were picking away at the problem of identifying the state of the practice of assessment tools for NCO. Initially some discussion accepted that the physical modeling was pretty good, though it is incapable of illustrating effects, as illustrated in EBO (on a smaller scale). The simulations can show the loss of a power grid or damage on a railway, but it cannot illustrate how these losses really effect the accomplishment of the overall goals of the operation.

WG 3 – Assessment Tools

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- **State of the Practice (by domains)**

Domain	Assessment	Comment
Physical	GREEN	• Many models exist for the physical domain (movement, attrition, *etc.*) at all levels of aggregation and fidelity.
Information	YELLOW	• Concentrates on how to deliver information superiority. • Sensor and communications modelling are adequate if not modelled as widely as physical domain. • Combat models exist at all levels from campaign to mission that can demonstrate the sensitivity of attrition-based combat to improved information availability.
Cognitive	ORANGE	• Link between information and decisions is non trivial and that information superiority does not imply decision superiority. • Models that replicate human decision making (beyond rule bases) do exist, but are not widely embedded in combat simulations • Extensive work required to calibrate their behaviour to real human decision makers • Requires collection of new kinds of data from experimentation and real operations.
Social	RED	• Flexible networks of collaborating individuals work remains mostly within the research environment. • Some work exists on emergent properties of groups in adaptive agent based models (e.g. Project Albert). • The military OA analysts need to engage/include social scientists and both individual and group psychologists.

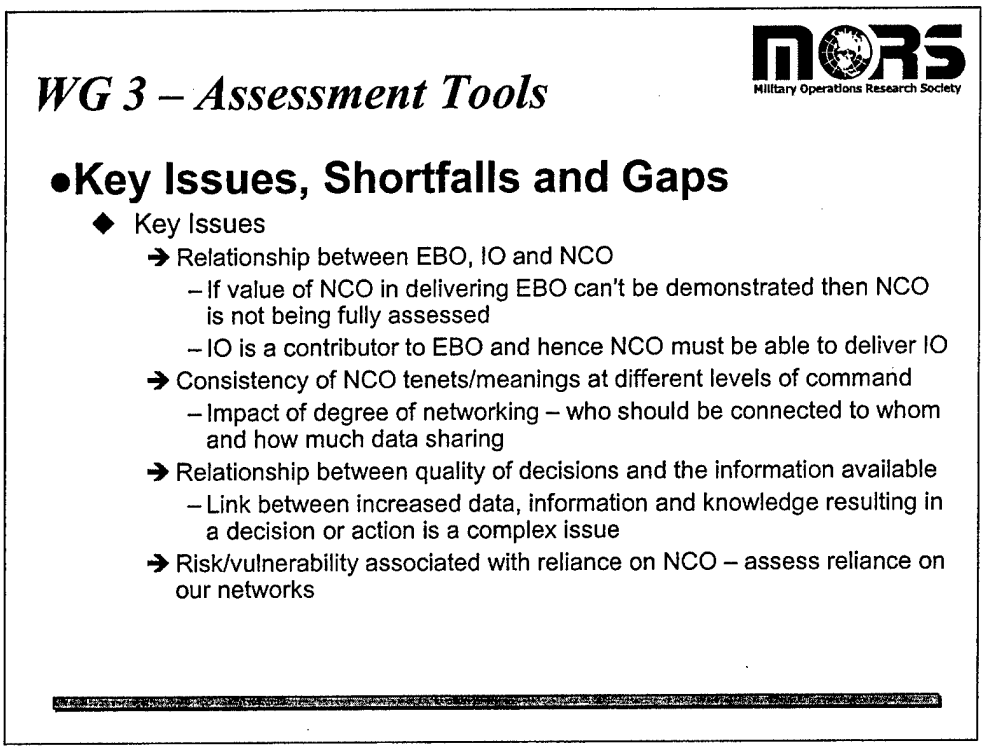
The working group assessed the "State of the Art" in relation to each of the four domains associated with Network Centric Warfare. The results of the discussion are outlined as follows:

Physical Domain: Traditional combat models encompass the physical domain; movement, attrition, logistics, etc are understood and captured in the existing toolset. This is not a priority area for attention. Many models exist for the physical domain at all levels of aggregation and fidelity.

Information Domain: Modelling here concentrates on how to deliver information superiority. Sensor modelling and communications modelling are adequate if not modelled as widely as physical domain. Combat models exist at all levels from campaign to mission that can demonstrate the sensitivity of attritional combat to improved information availability.

Cognitive Domain: Research has shown (Riese et al and others) that the link between information and decisions is non trivial and that information superiority does not imply decision superiority. Models that replicate human decision making (other than rule bases – which can be shown not to represent the human thought process) do exist, but are not widely embedded in combat simulations. Where such models do exist extensive work will be required to calibrate their behaviour to real human decision makers. This will require the collection of new kinds of data from experimentation and real operations.

Social Domain: The way in which flexible networks of collaborating individuals work (and how they can be stopped from working) is an area that remains mostly within the research environment. Some work exists to understand the emergent properties of groups in adaptive agent based models (e.g. Project Albert). The military OA analysts need to engage with a broader range of SMEs, including social scientists and both individual and group psychologists.



Some issues and shortfalls that were identified by the working group are summarized below. It should be noted that it is difficult to differentiate between possible shortfalls or reservations with the concept of NCO rather than the tools available to assess NCO.

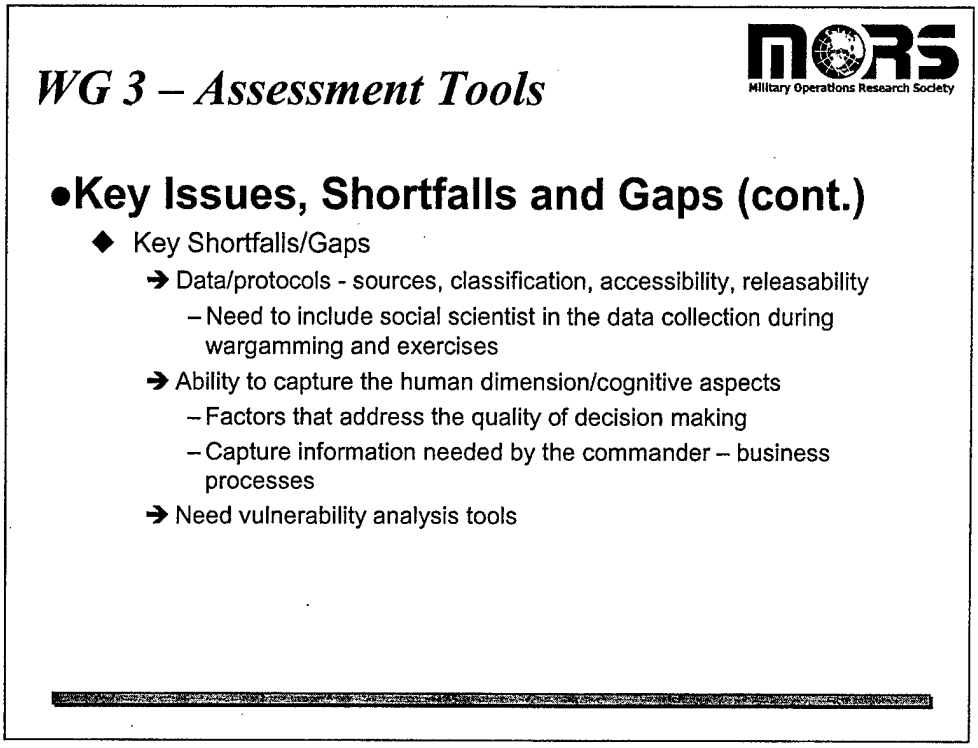
Relationship between concepts:

- Effects Based Operations is a philosophy of conflict designed to defeat an enemy's ability and/or willingness to fight by a broader set of means than the physical destruction of combat power
- Network Centric Operations is a way in which military forces will conduct operations to deliver EBO
- Digitisation is the introduction of the technology required to enable NCO
- The consequence of the above is that the tools required to assess NCO are a subset of those required to assess EBO. If the value of NCO in delivering EBO cannot be demonstrated then NCO is not being fully assessed.
- Effects Based Operations deliver success by attacking an enemy in ways beyond the attritional. Tools to assess EBO, and hence NCO, must address a wider set of outputs than attrition and hence traditional combat modellers are unlikely to have understanding of the issues required to model EBO or NCO properly. INSIGHT: Model/Tool development projects must include access to relevant expertise in social and cognitive domains.

NCO means different things to different people at different levels of command. It is centered around "what can NCO do for me" and the answer being a wide variety of issues, makes it difficult to assess the effects of NCO throughout a force. Issues such as "how much networking" is necessary were discussed though no conclusion was brought to fruition. The sergeant on the field may not need as much networking as the command centers.

Discussions led to the revelation that there are few tools to examine the relationship between the quality of the decisions and the amount of data that is available to the decision maker. Stephen Riese's presentation highlighted the fact that some commanders, even though they have high situation awareness, count on intuition rather than available data. The issues relating to the data, information, and knowledge and the results is not captured with the current tool set.

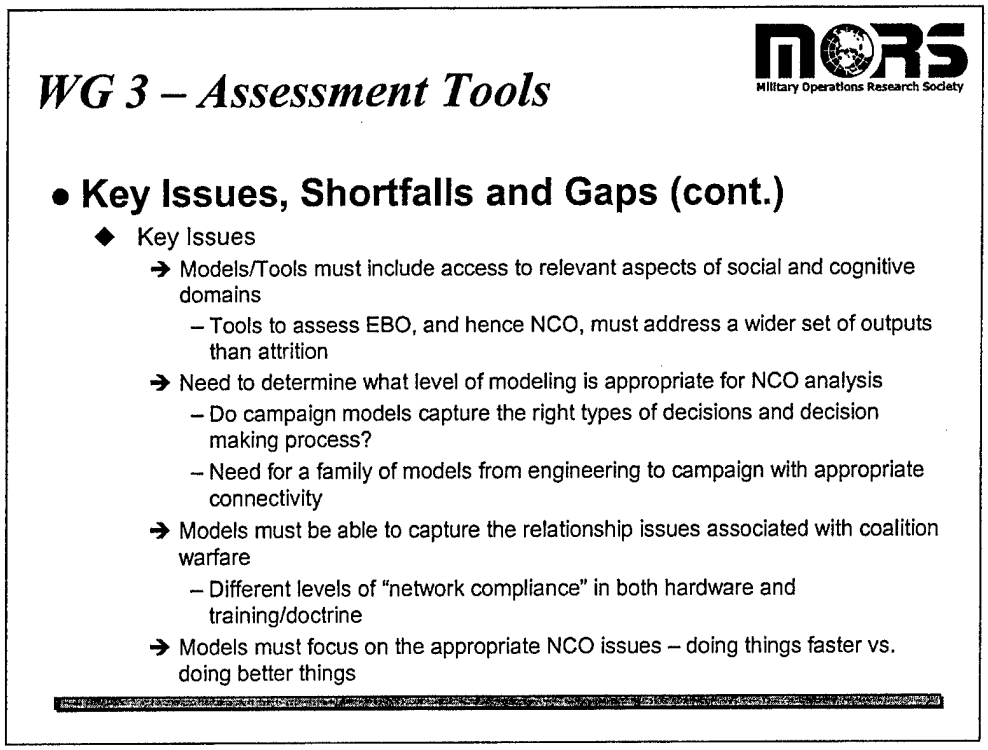
Transforming a force to Network Centric Operations raises serious concerns about the forces reliance on the network. Tools need to be developed to assess the vulnerabilities related to this reliance on the network. Again, this can be an assessment or concern about the theory of NCO rather than the tools used to assess NCO concepts and operations.



A huge shortfall in tool creation and application is data availability. Data for creating and populating models is difficult to acquire. The sources, classification, accessibility, and releaseability issues hinder the productiveness of the tools. Also, results that are classified are not as beneficial to the community than those which are easily distributed. This is crucial to get community buy in, and to test the theory of NCO rigorously prior to commitment to transform the force.

Data need to be gathered and collected by social scientists among others. NCO is Human Centric, and those who study humans need to assist in gathering the data because they may recognize behaviors and characteristics that engineers and analysts may not recognize.

The human dimensions of NCO currently are not captured and explored. Some issues that were addressed earlier in the brief included what information is necessary to improve decision making and assessing how much information is needed by the commander to make a good decision. These questions essentially highlight the business processes that are involved.



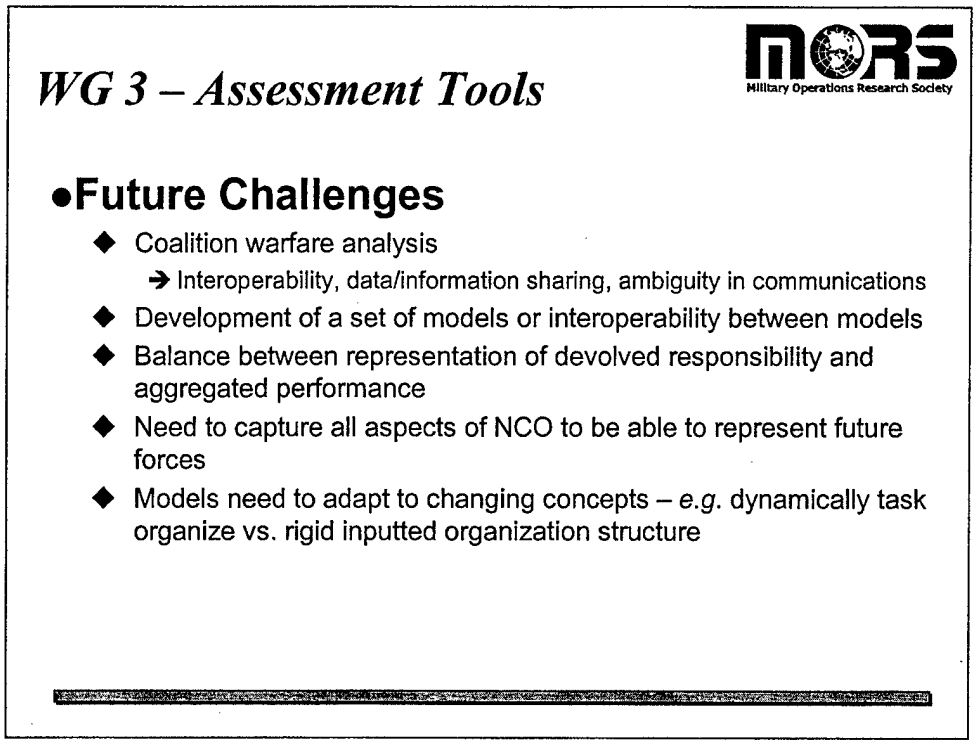
(Continued from Previous page.)

Addressing the Human issues is necessary to conduct proper assessment of NCO therefore assessments and development MUST include professions such as social scientists in order to assess the concepts fully. The term Network Centric Operations is sometimes misleading. At a closer look, it is really Human Centric and Network Enabled.

The toolset must be able to address the high-level 'so-what' questions at the campaign and national force structure level. Therefore tools are required that can work at this level. Since we have little or no NCO data with which to calibrate high-level models the tool set must include lower level models.

If coalition operations are to be undertaken in the future then (at least) campaign level models must be able to capture the issues of the relationship with allied forces having different levels of 'network compliance' in both their hardware and training/doctrine.

The models need to focus on the correct aspects of NCO. What makes a network centric force better than a platform centric force? How are the people able to innovate and devise new ways of doing things?



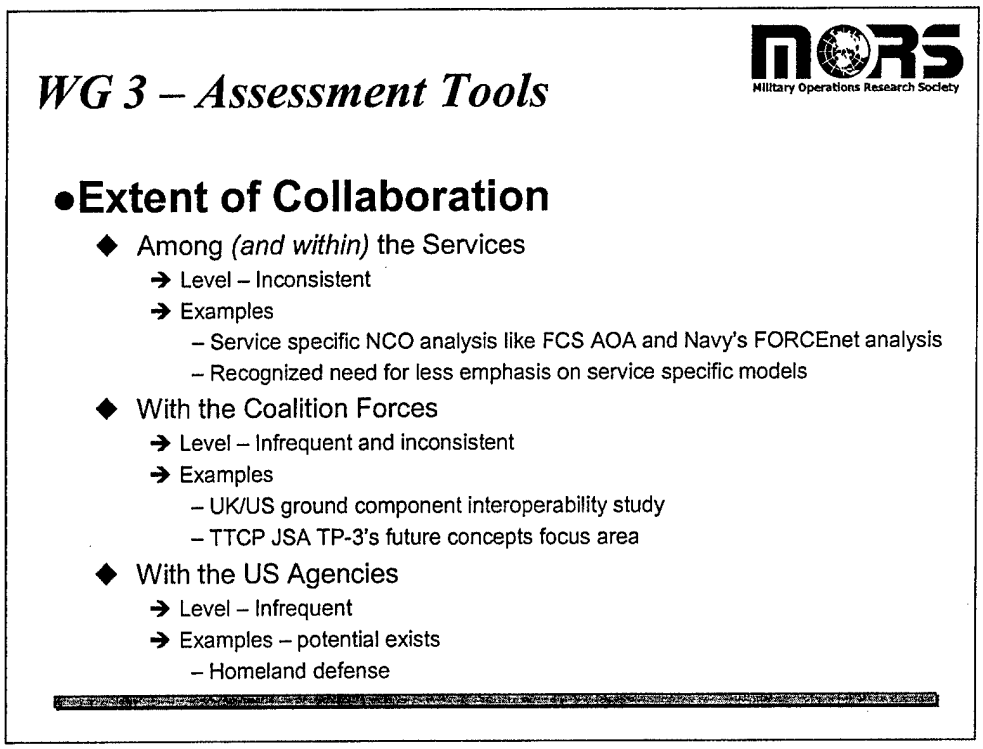
Coalition warfare analysis is lacking in today's assessment tools. In the US, analysis of joint operations is making some headway, but most operations in the future will be composed of coalition forces. Throughout recent history, the ability to share information in a coalition environment has been difficult though necessary. Other issues that need to be addressed in the coalition environment are the language barrier and systems interoperability.

In order to represent NCO accurately, a new set of models or a new way of interfacing between them needs to be created. The amount of granularity necessary to represent the lower level effects and the scaling to represent the operational/ strategic outcomes require a set of tools that are interoperable. After all why would NCO be a new way of thinking if we already have models to represent it?

NCO assessment tools will require detailed performance of the lower levels of command (as illustrated in *Power to the Edge*). This devolved responsibility needs to be paralleled with an aggregate level model to highlight the greater force performance due to pushing the new capability of the lower level units.

In order to represent NCO accurately and conduct accurate NCO analysis, all aspects of NCO need to be represented. This means networking not only two battalions but all actors involved in the operation including reachback capabilities. This is the essence of NCO, and the capabilities cannot be explored if they are not represented. In essence, the tools need to be able to represent the future forces.

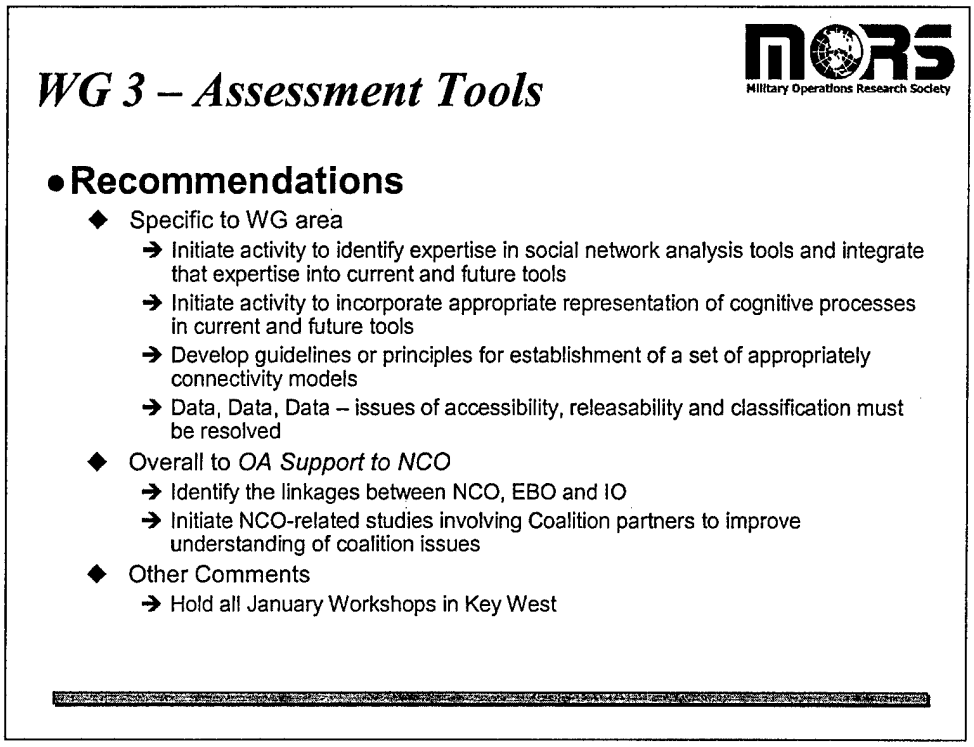
Essentially, the tools that need to be developed need to be able to adapt to changing and emerging concepts. This is necessary for assessment of new ways of doing things vs. the old way of doing things.



The levels of collaboration among and within the services is inconsistent. Currently the NCO analysis that is being conducted is service specific, though it is recognized that to be taken seriously joint assessment is needed.

Collaboration with the coalition forces is infrequent and inconsistent. The workgroup could not identify many examples of coalition collaboration. Though the UK/US ground component interoperability study and the TTCP JSA TP-3's future concepts group came to mind.

With US agencies, collaboration was infrequent though potential was seen to interact with the Department of Homeland Security. Representatives from this area were not present and the group felt it was inappropriate to make assumptions.



The working group formulated a set of recommendations.

In order to address the issue of assessing the cognitive areas of NCO, social scientists and their tools need to be included into the assessment. The views of the social scientists and the engineers are different and therefore data collection, tool application, assessment tools etc. will need to keep these different views in mind.

The current tool set does not capture the relevant cognitive aspects associated with NCO. This is partially due to the limited knowledge (or over abundance of opposing views) of cognitive functions. Therefore the appropriate representation of cognitive processes in current and future tools needs to be pursued.

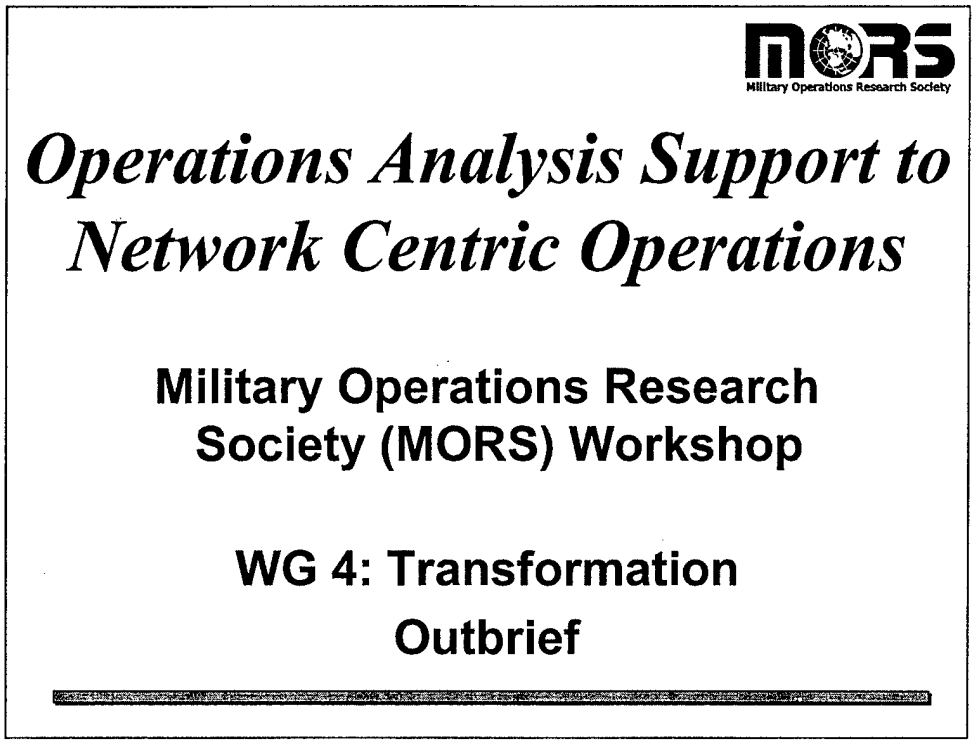
The modeling associated with NCO needs guidelines. These guidelines will help create models that can be interconnected and compatible so all the aspects of NCO can be represented.

Data is a huge issue. Continuing issues with data accessibility, releasability and classification need to be resolved. Also, in NCO, we need to be sure that we are collecting the right data necessary to conduct proper assessment. Industrial age data collection may not be the proper method for collecting data in the information age.

Overall Recommendations:

The linkages between and among the emerging concepts of NCO, EBO and IO should be identified (an attempt was made earlier in this brief)

In the future, coalitions will be commonplace. Therefore it is imperative that coalition studies of NCO be initiated. As it stands, coalition partners are working toward network centric concepts, though a greater understanding of research and NCO related activities is necessary.



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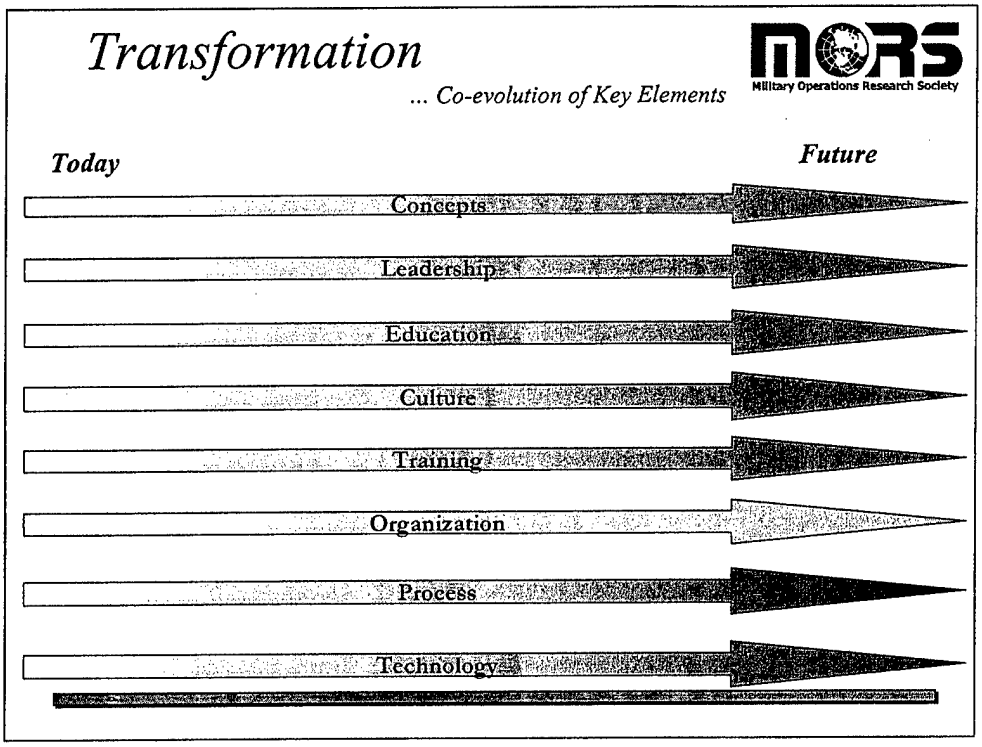
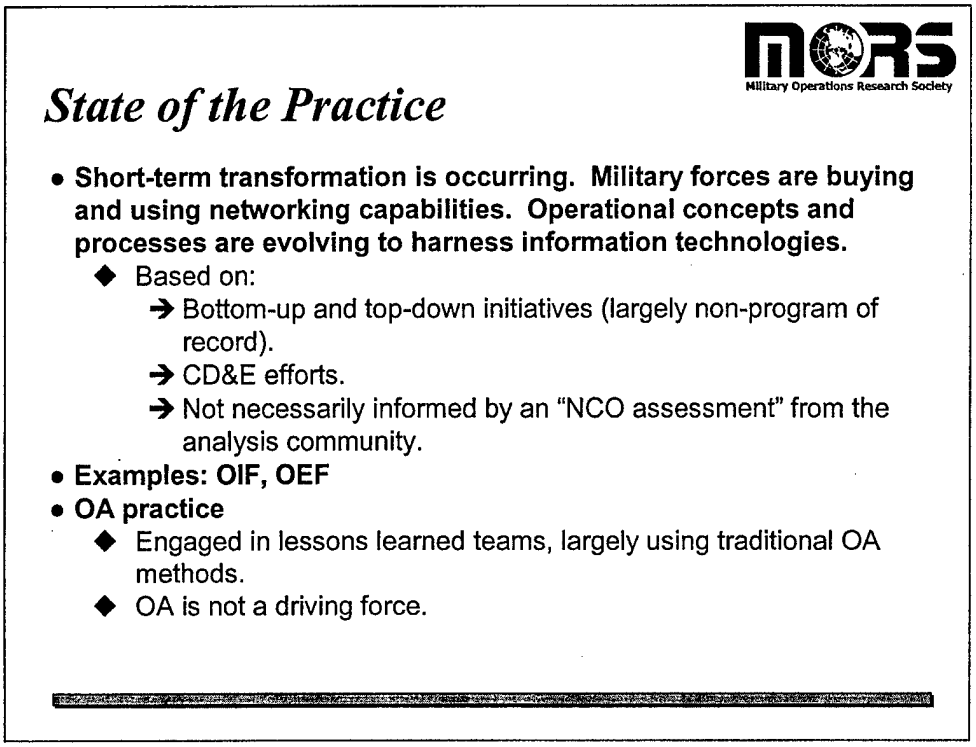
- Jerry Levesque
- Douglas Hales (Canada)
- George Cran (United Kingdom)
- Donald Chappell
- MAJ Richard Ast (US Army)
- Dan Haller
- William Price
- Bob Manke (Synthesis Group)



Transformation is clearly about moving from an industrial age force to an information age force - we had no dissent on that point.

WG 4 took the view that transformation will only happen when these 8 "key elements" co-evolve to take full advantage of information age technologies, capabilities and opportunities. The key task for the Force Transformation group is to understand how we can apply OA techniques across the 8 "key elements" and balance the transformation process.



The operations analysis community is marginally engaged in current short-term transformation efforts. Short term transformation is occurring through operational units buying or using information technology systems and through the prototyping efforts of the Concept, development and Experimentation (CD&E) program.

- Analysts are engaged in the "lessons learned" teams deployed to OEF and OIF and this is encouraging.
- Analysts are not involved early enough in the CD&E process. Frequently, the analyst is not called upon until a concept is ready to enter the experimentation phase of development.
- We don't really have a template for assessing NCO impacts — this is evolving and analysts need help. Feeding back the lessons of recent operations into the design of standing collection plans and analysis techniques for future operations would create an environment of continuous learning.

State of the Practice

- **Long-term transformation initiatives ongoing. Top level guidance is on the street (NMS, DPG, TPG) but it is somewhat confusing and contradictory.**
  - Translation into an innovative transformation program is problematic.
- **Examples**
  - Service Efforts (FORCEnet, FCS) are not yet linked.
  - The current programming and budgeting system does not foster transformation.
- **Not informed by "NCO assessment" from analysis community**
  - No template/guidance for NCO assessment
  - We are still early in the process, there is pressing need/great opportunity for community to get involved
  - Challenge is to integrate across the eight "key elements"
    - → Not all of the tools are "OA" tools

There is a plethora of (sometimes conflicting) guidance governing US DoD transformation efforts. Some of this guidance is informed by analysis (efforts of ODS NII/CCRP come to mind) but additional analysis will be critical.

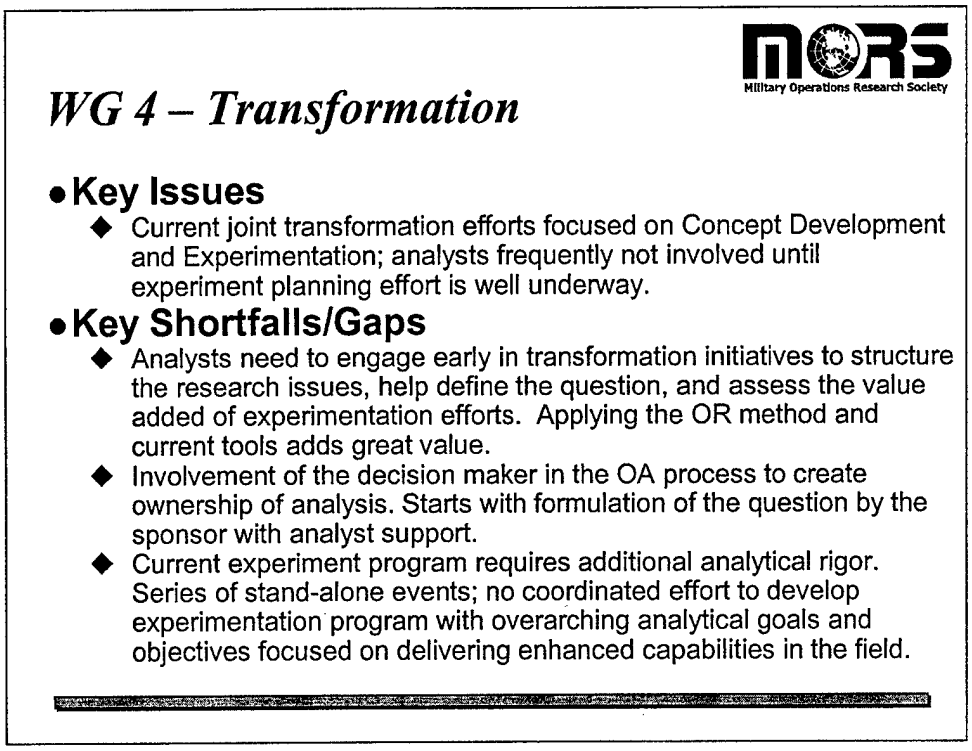
Conflicting guidance makes it tough to develop an innovative, effective transformation program. The transformation of how the US DoD does business is ongoing and will provide the foundation and governance for realizing NCO. This will be a precursor to any significant long-term deliberate force transformation being achieved.

Service efforts are not linked. While they are not being conducted in isolation, greater collaboration is required.

The current budgeting feedback system (JROC, DOTMLPF) does not foster transformation. Some will argue that this system is actively hostile to the notion of trading off platform-centric programs for network-centric programs.

Again, the analysis community has not been proactively engaged in the transformation process. We do have some analytically-derived principles (primarily from the CCRP body of work), but we need to actively translate these principles into sound analysis practice.

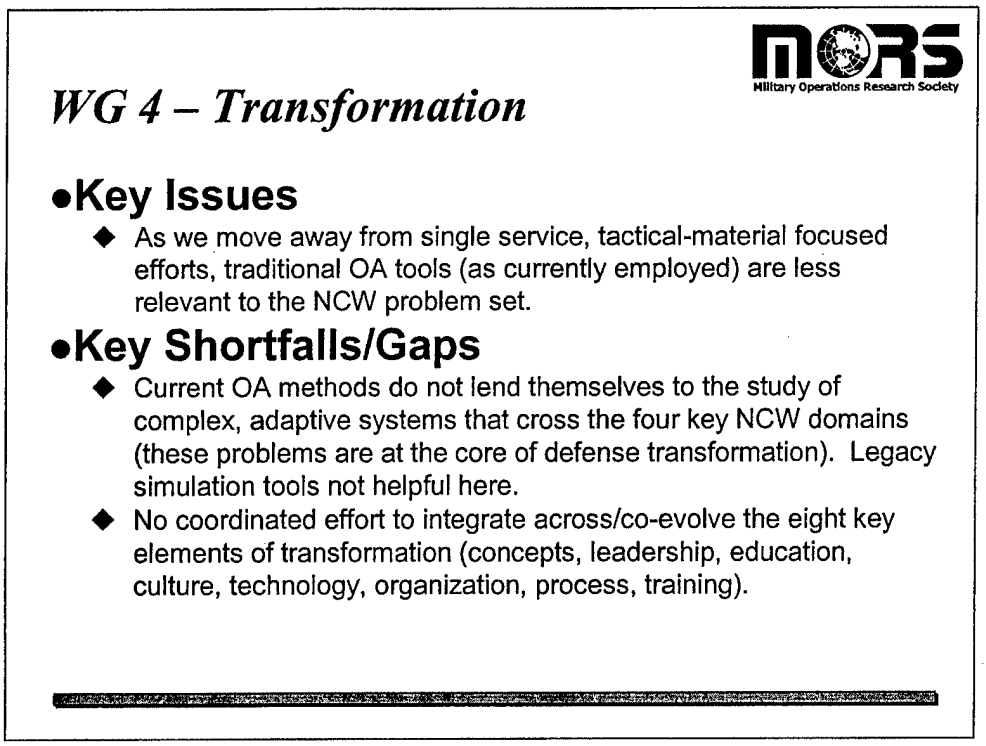
How do we integrate across 8 disparate elements? This requires us to fundamentally examine how we are currently conducting analysis. The sense of our group is that the analysis community is a bit on the sidelines in the current debate (rhetorical argument has much more influence than analysis).



A specific example of the analyst being on the sideline is in the joint experimentation community where the analyst is not brought in until relatively late in the experiment design phase. This often can lead to an experiment design that does not support the questions of interest.

This type of behavior is symptomatic of the broader problem of project sponsors not being engaged with the analysis community in some circumstances. The result can be a lack of ownership of the results of the analysis performed in support of the study.

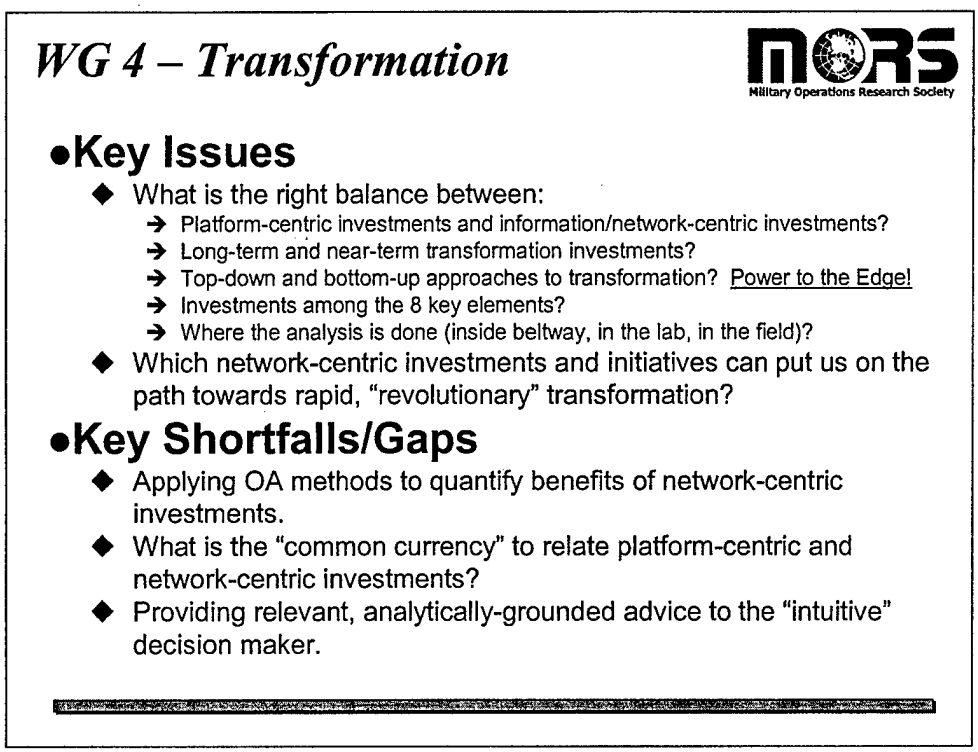
The next step to integrating analysts into Concept Development and Experimentation (CD&E) is the design of experiment campaigns. The analyst can assist in the design of objectives, data collection and analysis techniques that assist in the analysis of individual events as well as longitudinal analysis between events.



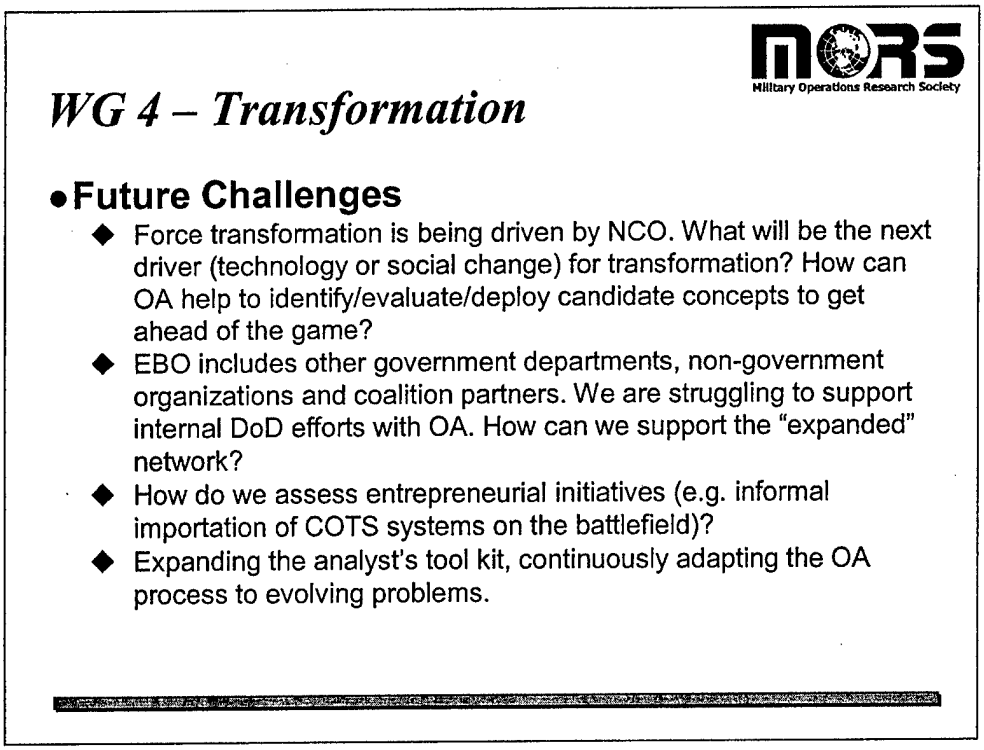
As the analytical focus of NCW moves from a tactical level to an operational and strategic level, the nature of the system components and interactions under investigation becomes more complex because of the increased focus on interactions between humans instead of technology. In general there is a shift from quantitative objective measurements to qualitative subjective measurements. Traditional OA tools do not support the upper end of the spectrum well.

The representation of complex adaptive systems across the four domains of NCO and the eight elements of transformation can be supported by the softer system techniques. Techniques that support strategic planning have utility in structuring thoughts and ideas that can create a degree of accountability and traceability in these types of systems.

OA should look to other disciplines that have developed techniques for dealing with the complexity of systems centered around the human.



Trade-off studies between material solutions has traditionally been a rich area for OA techniques. With the need to trade-off between platforms, networks and information a set of common metrics are difficult to develop as a basis for comparison. Currently studies can provide at best an indicative assessment of risk associated with each option but not definitive options for decision makes. Thus there is still a large component of "intuition" in the investment decisions being made.

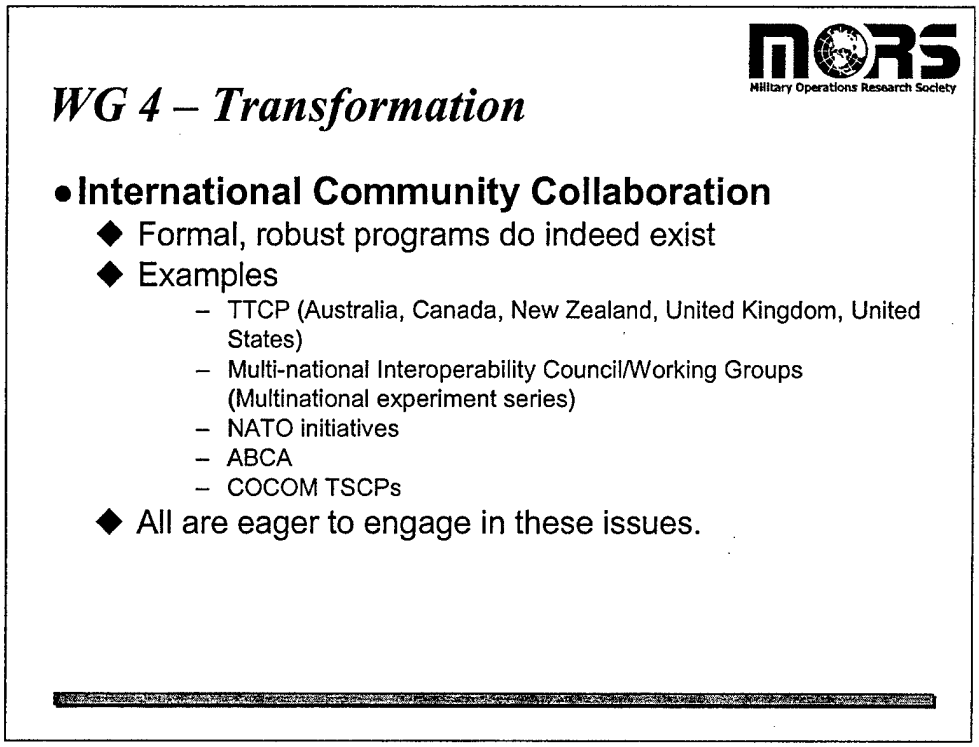


What is the next transformational capability or technology on the horizon? Analysts can and should be engaged in this effort, and clearly must look beyond the bounds of defense industries for promising opportunities. By taking a broad look at the 8 "key elements" of transformation (and beyond) we may uncover areas for further investigation. This is not a one player game - we must also think about areas that potential adversaries can exploit and work them in to our future scenarios and operating concepts.

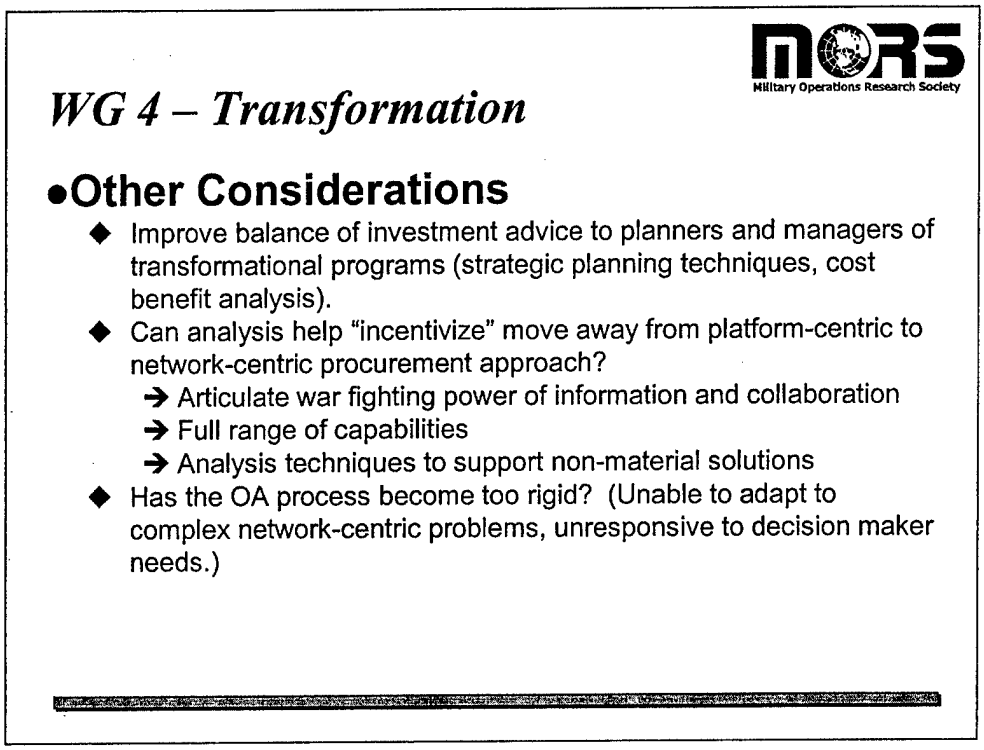
NCO most certainly is about fostering collaboration and networking to a wide degree. We must expand our network of analysts to include interagency, coalition and non-governmental partners.

Use of PDAs on the battlefield is an example of bottom-up approaches that have been attempted by tactical and operational forces. These typically are not officially sanctioned. Some may have great value, some may have minimal impact, some may be downright dangerous. Analysts need to engage in the effort to assess these "bottom-up" initiatives.

In a complex, network centric world the analysis challenges will continue to evolve. We should not adopt a mindset of getting the tools and processes "right" - we need an ethos of continuously examining our tools and processes to make them better.



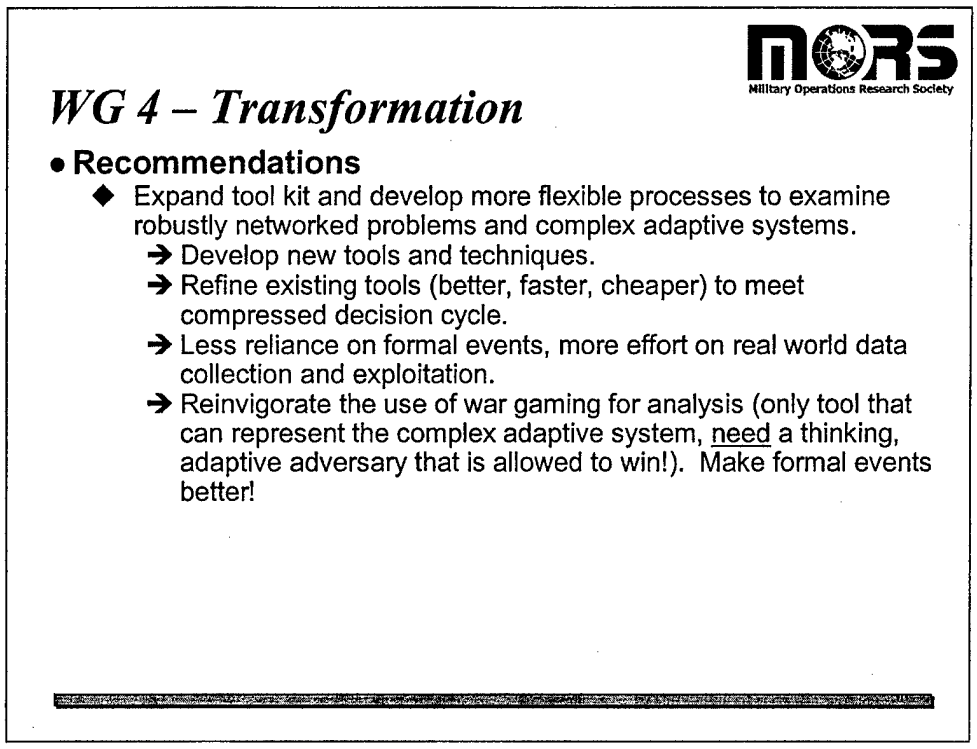
A spectrum of change of military forces in the international community exists from status quo to modernization through transformation of forces. Nations are at different points in the spectrum with respect to NCO but they are committed to moving away from the status quo end of the spectrum. The participation to various multinational forums is evidence of the commitment.



How should we direct our transformational efforts; how do you decide how to allocate your experimentation resources? Operations analysts can and should apply decision analysis techniques and other methods to help illuminate these questions. Studies and research are also key here.

How do you explain the war fighting value of network centric approaches to the military services? Until you do, service leadership will be understandably reluctant to cancel platform-centric programs in favor of network-centric forces. The analysis community must continue to develop methods to articulate the war fighting value of information technologies and robustly networked, collaborative teaming.

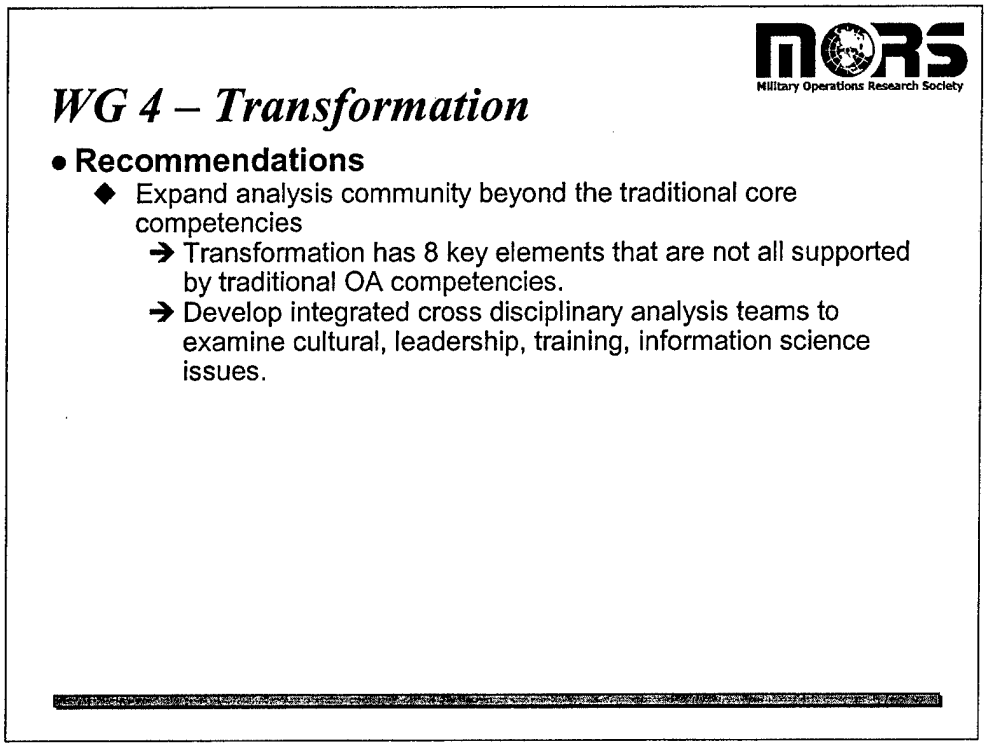
Why was it necessary to have a workshop dedicated to OA support for Network Centric Operations? We have been presented with a problem that was not easily understood using traditional OA methods and we needed to bring the community together to discuss the state of the art and ways to adopt OA practices to this challenging set of problems. OA, of course, is fundamentally a flexible, multidimensional approach to problem solving.



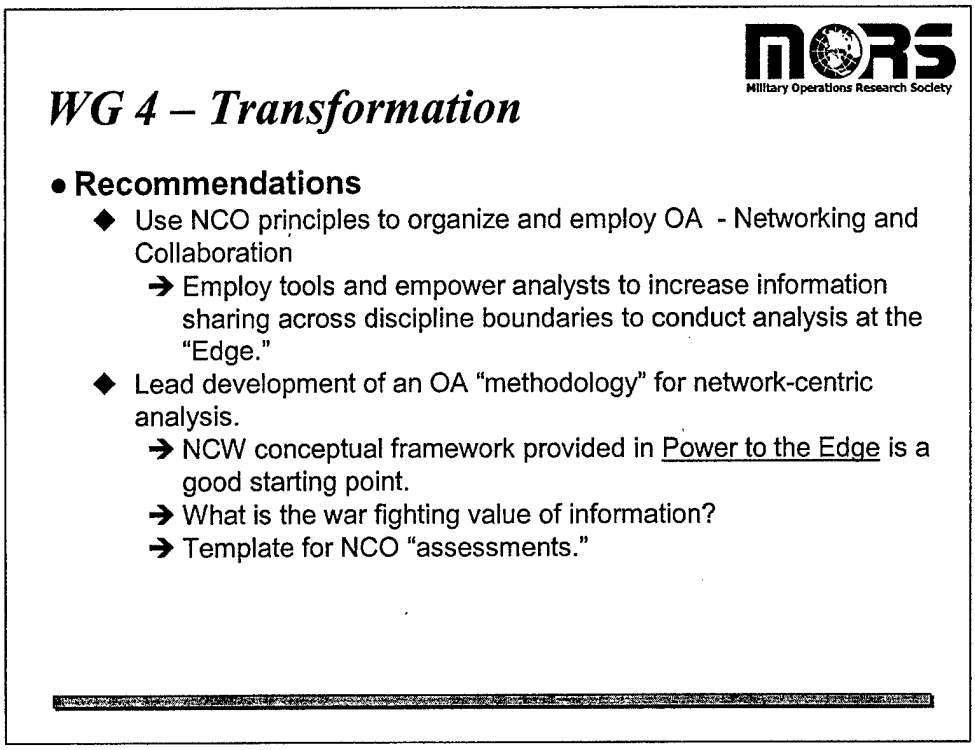
The state of the art in OA practice is a collection of methods that are used either as a stand alone application or combined to examine multiple aspects of the problem. Bringing in techniques from disciplines outside OA and the analyst's tool kit can become extensive. However the frameworks for integrating these tools and their results are an area for development of the OA community through meta-analysis i.e. analysis of the OA process. The guiding principles for the application of the "cross-disciplinary tool kit" is that it must be able to provide timely results with an economy of effort. This is particularly important when dealing with real world situations to meet compressed decision cycles.

A technique that offers potential to act as a framework for integrating analysis techniques is a war gaming construct. The key elements of a war game are a realistic representation of the environment, credible friendly capabilities and a thinking and adaptive adversary. The practice of war gaming should be reinvigorated and the development of techniques to represent and measure the impact of NCO initiatives need to be developed.

A MORS Symposium working group or composite group dedicated to NCO is needed. NCO is much more than C4ISR and Information Operations (IO). This new working group/composite group could be charged to examine the OA toolkit and processes in order to better focus on the NCO problem.



We have identified 8 elements that are key to completing the transformation to a network centric force (concepts, leadership, education, culture, technology, organization, process, training) and there are undoubtedly more. We need to expand the analysis community beyond the traditional competencies and include disciplines with expertise in the 8 (or more) key elements. OA began as/remains a multidisciplinary approach to problem solving. We must continue to utilize cross-disciplinary analysis teams to address complex NCO issues. As we begin to make headway on NCO analysis techniques we must share new problem solving approaches and bring additional disciplines into the OA "mainstream."



NCO principles need to be employed by analysts to reach out across organizational and geographic boundaries to the skills required for a particular application. Analysts should be supported by synchronous and asynchronous collaboration to build analysis concepts, conduct live and virtual experiments and share results.

Many of the technologies made available to industry and to the collaborative war fighter could be easily extended to the analysis community.

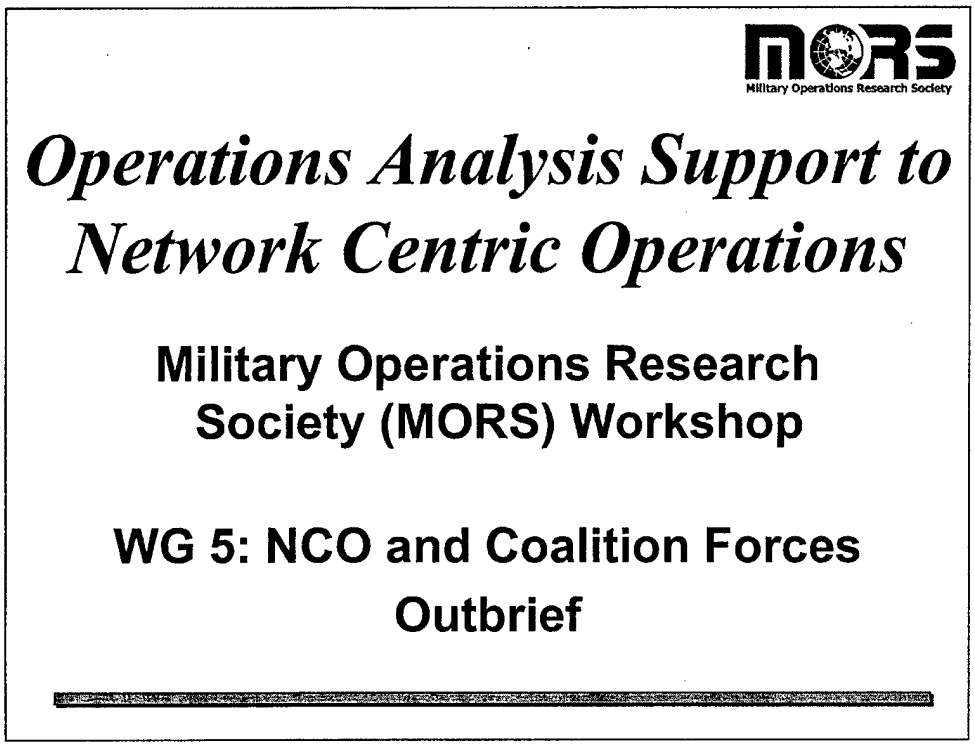
An online "community of practice" website would go a long way to furthering this effort.

Power to the Edge provides a wonderful starting point - the "conceptual framework" development chapter is invaluable. The next step is to develop an "analytical framework" to guide analysts working in the NCO domain.

We still have some fundamental questions to address. What is the war fighting value of information? Is there a candidate list of metrics for conduction NCO analysis? What are the fundamental characteristics of the NCO problem? MORS is in a good position to foster the development of an OA methodology for NCO. Again, a MORS Symposium working group or composite group on NCO would be most helpful.

WG 4 – Transformation

- **Presentations given in WG 4**
  - "Strategic Planning and Force Transformation", Duncan Tailby, Defense Science and Technology Organization, Australia
  - "Joint Prototype Testing", Joe Drelling, Joint Forces Command J9/MYMIC LLC



On 27-29 January 2004 WG5 met as part of the MORS Workshop on Operational Analysis (OA) Support to Network Centric Operations (NCO). There were 15 participants in the working group from the US, UK, Canada, Australia and Sweden. Eleven papers were presented during the working group sessions. There were three major objectives of the working group: (1) To review and discuss papers that addressed current practice in the areas of tools, studies and experimentation/live events. (2) To discuss each individual country's state of practice of OA in support of NCO, to identify good and bad points and to identify future directions. (3) To assess 'collaborative' efforts' among coalition partners to determine shortcomings and to recommend ways to improve collaborative OA efforts. Most participants of the working group were experts and practitioners in the field of OA support to NCO in their respective countries.

WG 5 – "NCO and Coalition Forces"

- **Papers**
  - "Insights from UK Data Link and Situational Awareness Studies" (UK)
  - "NetCentric Operations in the Canadian Context" (CA)
  - "Network Analysis from a Swedish OR Perspective" (SW)
  - "Network Centric Operations and the Joint Interagency Coordination Group Workshop Results" (US)
  - "Analysis of Carrier Task Force Network Centric Warfare Architectures for Network Centric Defense" (US)
  - "An Analytic Approach to Network Centric Warfare Metrics and their Relationships: From Connectivity to Operational Tempo" (AU)
  - "A Functional Survey of Netted Warfare Analysis Methods and Selected Applications to Coalition Maritime Tactical Situations" (US)
  - "Dutch and German Forces Employment of Network-Centric Capabilities During Peace Keeping Operations" (US)
  - "ACIDC Developments From Operation Iraqi Freedom Lessons Identified" (UK)
  - "Analysis From Multi-National Limited Objective Experiment 2" (US)
  - "Analysis Plan for Multi-National Experiment 3" (US)

Eleven papers were presented during the working group sessions. The general order in which they were presented was: (1) Country study overviews; (2) Tools; and, (3) Experiments and live events. Papers also included a focus on ground force NCO, maritime NCO and Air Force NCO. The papers were important in providing a basis for discussion to determine the state of OA support to NCO in each country. They were also important in order to understand innovative methods and applications in the participating countries. Two papers were presented on recently completed case studies of international NCO in a NATO exercise from a few years ago and the use of "Blue Force tracking" of ground forces by the UK and US in Operation Iraqi Freedom.

WG 5 – "NCO and Coalition Forces"

MORS Military Operations Research Society

United Kingdom

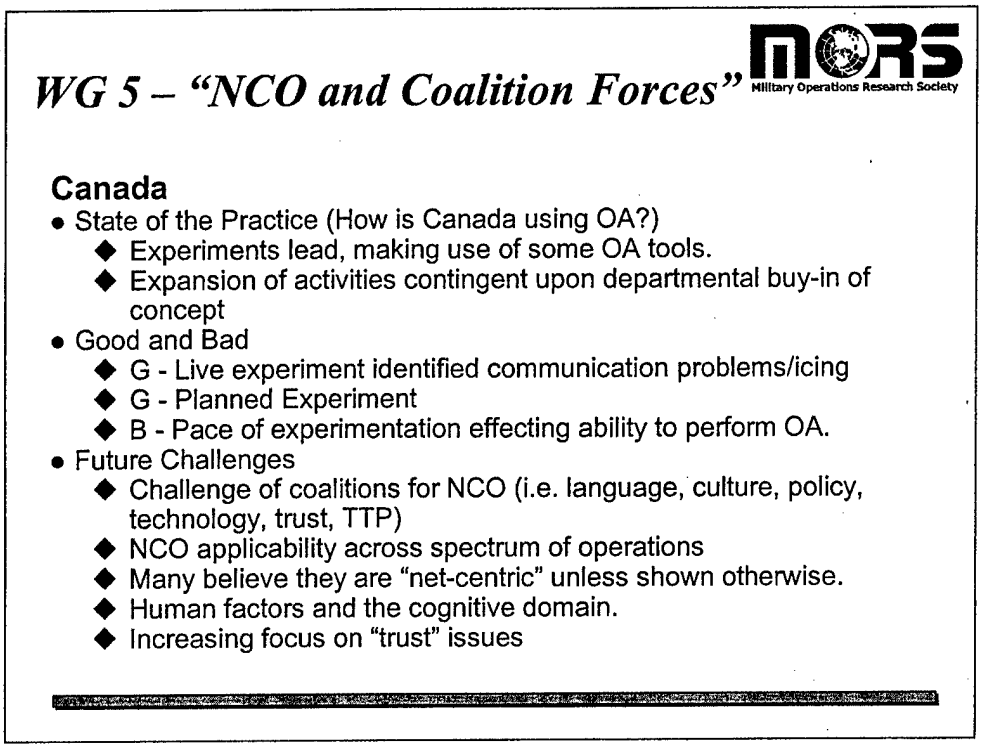
- State of the Practice (How is the United Kingdom using OA?)
  - Broad toolset
  - Use of soft OA
  - OA tools selected based upon re-use and broad application
  - Picture models
- Good and Bad
  - G - Situational Awareness analysis
  - B - Linkages between lower and higher level models
  - B - Impact of not representing non-Integrated Communications Information System in modeling (too many stove-pipes)
- Future Challenges
  - Moving into the cognitive and the information quality domains (not just timeliness/comms)
  - Modeling "adaptive behavior"
  - High level investment decisions (NCO vs weapons balance)

The UK believes that a networked force will allow improved situational awareness, agility and synchronization. Although a range of Concepts has been developed for NEC (covering areas such as the development of a Joint Operational Picture, collaborative planning, mission organized force elements, effects based planning and enhanced tempo) the main focus of NEC investment is currently in the arena of experimentation. The experimentation takes various forms, through environments and organizations such as NITEworks, CBMARTD, ACIDC, JUEP.

The OA community has a wide breadth of tools available to undertake analysis in support of NEC activities. These cover the spectrum from discrete event simulation, classical OA tools, sampling and surveys through to multi dimensional criteria analysis, picture models and soft systems methodologies.

The UK is confident with the tools for assessing issues such as picture quality and timeline comparisons at the tactical level, and are moving towards analysis of some of the cognitive issues associated with situational awareness. There are however still significant gaps in the assessment of the quality of information products at the higher level. There are also limitations in aggregating information and knowledge factors between low level models and high level models and hence difficulties in the calibration of tools at the Campaign level. Currently analysis often fails to represent the baseline case, (for example not accounting for the many stove-piped stand-alone systems that currently contain the data used by decision makers) and the resultant limitations in showing the true worth of integrated solutions.

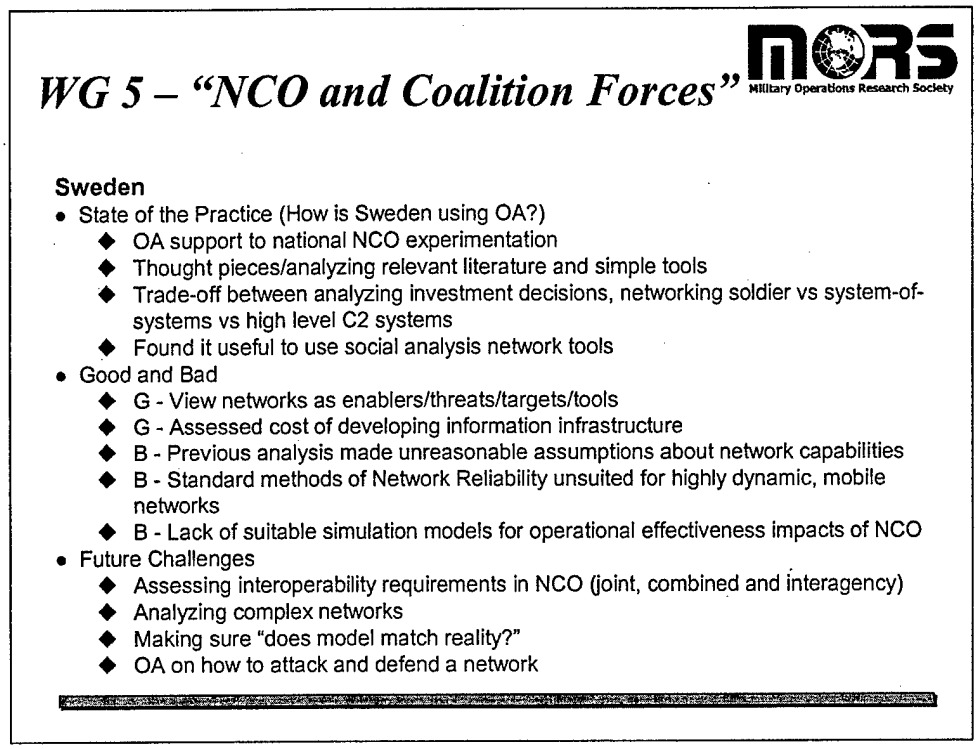
The future challenges are to increase the availability of tools and metrics for addressing issues such as quantification of information quality and to develop tools within the cognitive domain to handle adaptive behaviour and/or emergent properties. A key problem which must be addressed is how to deal with Balance of Investment issues above the immediate NEC level, where nations have to trade networked enabled capabilities at the expense of platforms or other hardware.



While there have been some NCO-related initiatives within Canada, such as the development of an Integrated ISR Architecture, currently there is no national decision regarding the adoption of NCO. A high-level departmental symposium scheduled for Fall 2004 is expected to resolve this and, hopefully, result in the development of a roadmap for the way ahead. Meanwhile, a series of UAV experiments at the Canadian Forces Experimentation Centre, using some OA tools, are working towards proving the NCO case.

The use of planned experiments in examining the merits of NCO has proven useful. For instance, difficulties with communications, TTP and UAV icing were discovered through experimentation which may not have been discovered otherwise. However, the pace of experimentation has provided challenges for the completion of OA before resources are committed to the next in the series of UAV experiments.

Future challenges remain for Canada in the area of NCO. For instance, in view of Canada's participation in international coalitions, questions remain about the impact of such considerations as language, culture, policy differences, technology and TTP. Also, the role of human factors and the cognitive domain for NCO need to be explored. For instance, how is trust transferred across an NCO environment between coalition partners? Moreover, questions exist about the use of NCO across the full spectrum of violence (i.e. during low intensity conflict, peace support operations, etc.). Importantly, especially in view of Canada's participation in coalition warfare, the issue of how trust is transmitted across an NCO environment between coalition partners needs to be explored.



The current main NCO-related OA effort at the Swedish Defence Research Agency (FOI) is our support to the Swedish Network-based Defence experimentation program, where FOI is tasked to evaluate the ongoing system demonstrator program.

FOI also supports the long-term planning process within the Swedish Armed Forces Headquarters, providing analysis in support of the Long-term Parliamentary Defence Decision 2004. FOI was tasked with developing and providing coarse cost estimates of alternative network structures, coupled to different future force structures. The main emphasis has been on the network components necessary to ensure a joint networking capability. Early in that work we pointed to the basic balance of investment between networking soldiers, platforms and C2 systems, respectively.

Given limited resources and a general lack of large, suitable simulation models, we are forced to focus more on soft OA methods, literature studies and simple models.

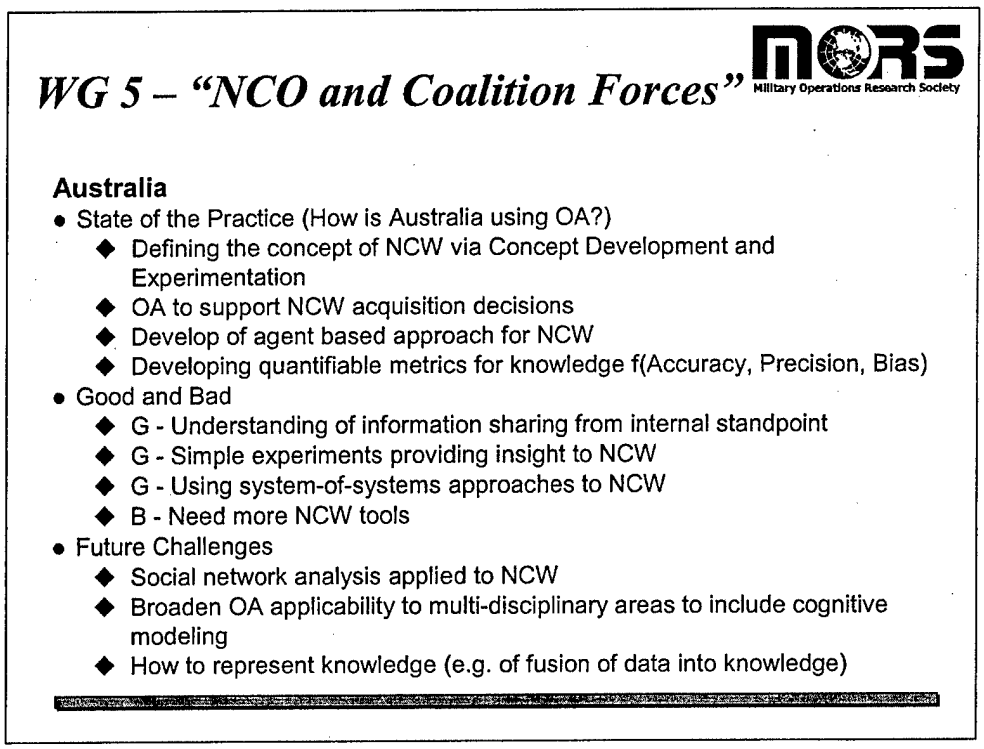
We take a broad view of the role of networks in the field of Defence Analysis, which can be outlined in the following four aspects: 1) Networks as enablers; 2) Networks as Threats; 3) Networks as targets; and, 4) Networks as tools.

The first, networks as *enablers*, is of course the main aspect, and encapsulates all our current efforts to leverage the power of networks in developing new military capabilities and concepts of operation.

The second aspect covers the idea that various criminal and terrorist groups are effectively *early adopters* of networking. If you believe this, a better understanding of network forms of organization and related concepts of operation is required not only to transform our armed forces, but also to understand the character of future conflicts in general.

The third aspect raises the obvious fact that in network-centric operations, your networks will be prime targets for enemy attack. More broadly, it recognizes that *all* our values at risk in future conflicts are increasingly networks *per se*; civilian infrastructure is largely an interconnected set of co-dependent networks. The proper way to identify, evaluate and then mitigate these new vulnerabilities is however far from obvious.

The fourth aspect ties it all together and starts with the simple question: Do we as OR analysts have the proper tools and the necessary understanding to deal with all other aspects of network centric operations in the future? Project Metanet is a multi-year competence-building activity to incorporate recent findings from such diverse areas as complexity studies, bioinformatics, and Social Network Analysis, into our work at the Swedish Defence Research Agency.

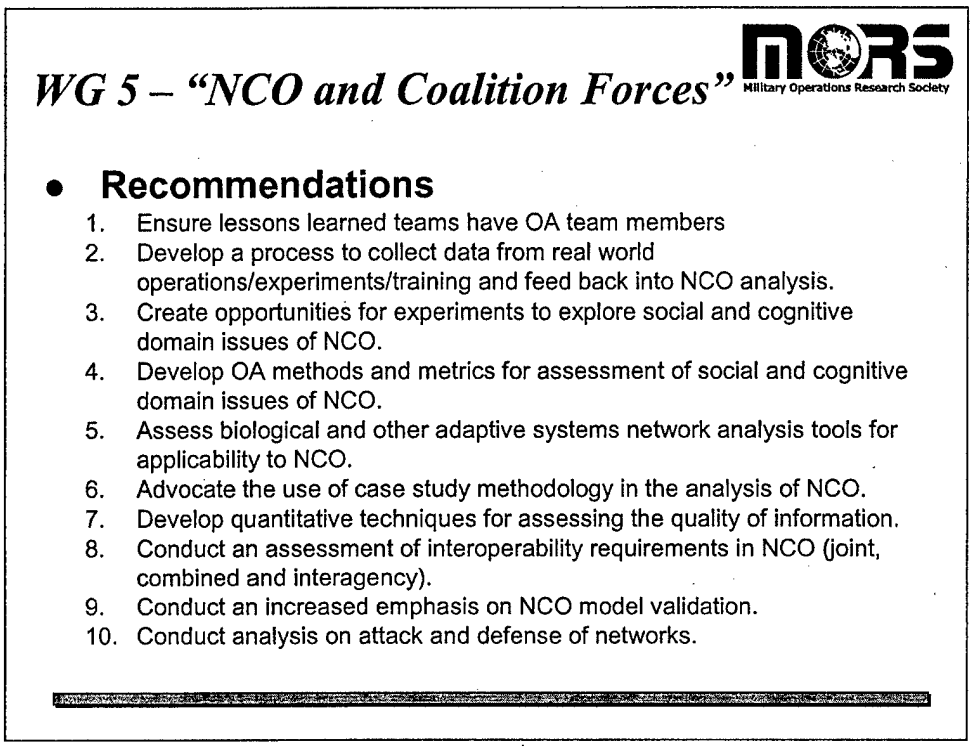


Network Centric Warfare (NCW) is recognised as a key element in maximising the Australian Defence Force (ADF) military effectiveness both the Chief of Defence Forces vision for the ADF, *Force 2020* and *Future Warfighting Concepts*, documents. The latter document describes NCW as: "Network-centricity will help us to link national, ADF and coalition sensors, engagement systems and decision makers into an effective and responsive whole. At its core, NCW seeks to provide the future force with the ability to generate tempo, precision and combat power through shared situational awareness, clear procedure and the information connectivity needed to synchronize our actions to meet the commander's intent."

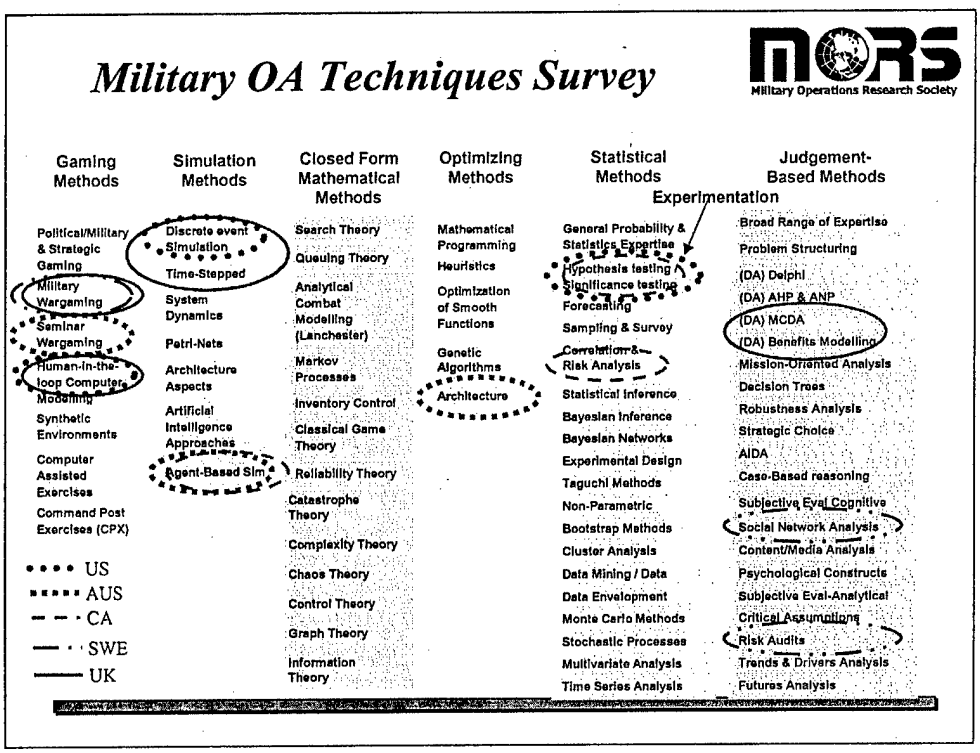
To better understand and assess the benefits and vulnerabilities of networked operations, and to provide timely advice to our senior decision makers on balance of investment (e.g. NCW versus weapons), we need to carry out Operations Analysis (OA) using a range of tools. In Australia, we are defining the concept of NCW via concept development and experimentation. We have found that small scale experiments in the form of seminar wargames and matrix games to be particularly useful for gaining insights into NCW. We are also developing agent-based techniques for modeling NCW. The value of quantifiable metrics for knowledge assessment is also recognized.

Our current advantage is in our comparatively good understanding of information exchange, skills in conducting small-scale experiments and using systems of systems approach to analyze NCW. On the other hand, we note that many more tools have yet to be developed to assess the benefits of NCW.

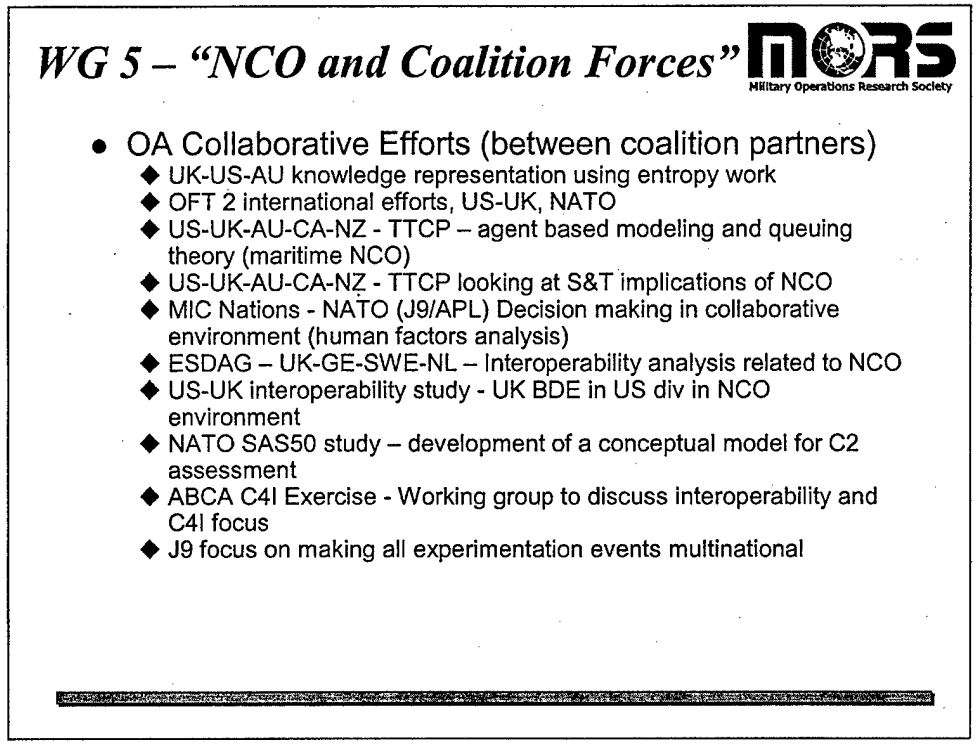
Some of the challenges include the inclusion of social network analysis techniques in our NCW analysis and the need to broaden OA capability to multi-disciplinary areas, including social and cognitive modeling. A proper representation of knowledge, e.g. via fusion of data into knowledge, remains elusive.



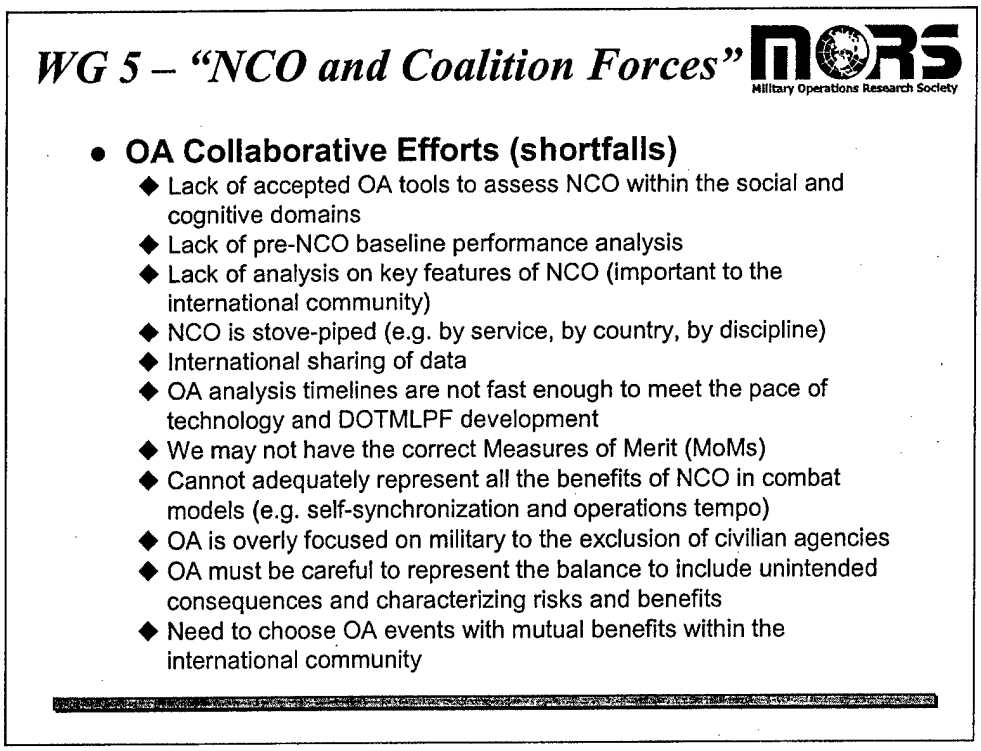
The recommendations were derived primarily from the 'Future challenges' identified by each individual country and agreed to by the entire group as applicable to all coalition countries. The recommendations included how to provide OA support in experiments or real world events (recommendations #1-#3). There was the recognition among coalition country representatives, as in most of the other previous working groups, that there were shortcoming in doing OA in the social and cognitive domains when following the NCO Conceptual Framework (#4). Sweden suggested that biological and adaptive system network tools could be very beneficial when trying to understand how to build or understand robust networks (#5). During the out brief the Army Sponsor independently made this same recommendation. As a result of the perceived benefit of the two international case studies presented during the sessions it was recommended that this approach be adapted as a viable technique for doing OA for NCO (#6). But it was suggested that it was necessary to have the same analytic rigor and objectivity applied to the case study methodology as with other analytic techniques. During the sessions there was general agreement that current OA tools are adequate to assess network speed of service and latency. However, it was pointed out that OA tools are not adequate to assess the impact of various levels of the quality of information (#7). It was agreed, from a coalition point of view, that a major purpose of analysis is to assess interoperability between coalition partners. A major shortcoming is that there has never been an assessment of the requirements for interoperability between various coalition partners which would lead to operational architectures and system architectures (#8). Coalition countries agreed that it is critical when developing all NCO models that we should never lose sight of the stringent requirement that all NCO models be subject to rigorous assessments to insure that models match reality (#9). Finally given the view that all coalition forces will be heavily reliant on networks in any future military operation it is important that significant analysis be undertaken to determine the impact of network attacks and to develop means to protect networks (#10).



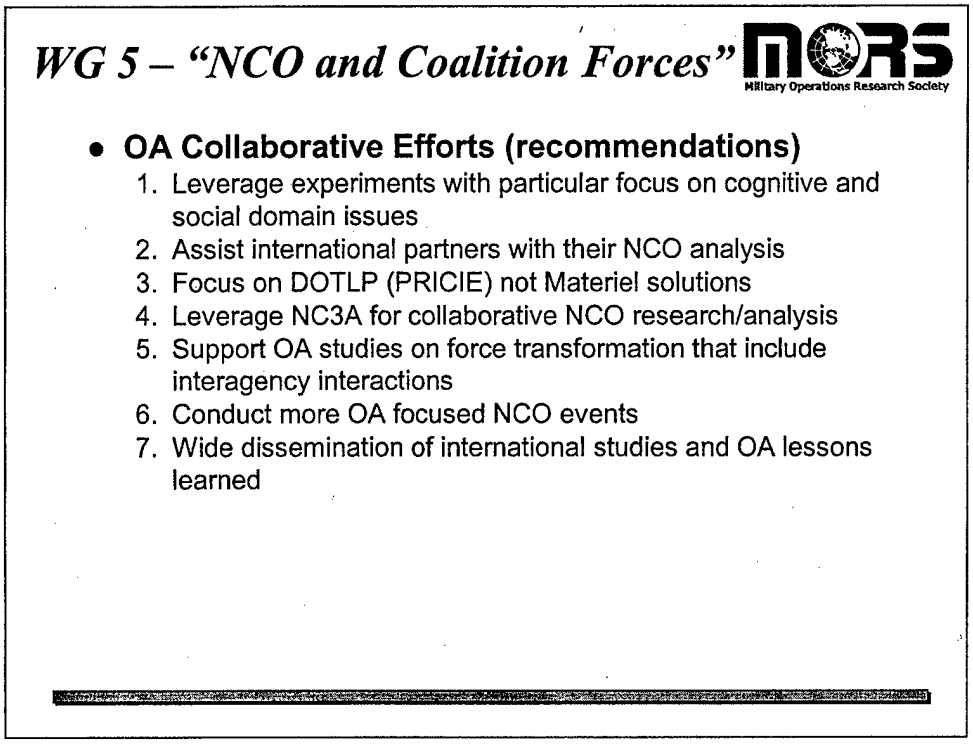
A quick survey was undertaken during the working group session to identify the techniques coalition country representatives felt were most applicable to NCO. Each country was given three "votes" that they could apportion among the various tools. The guidance was that they should identify the tools or techniques that were most relevant and useful now and in the immediate future for OA support to NCO. It is interesting that there was not overlap by any three countries for a particular technique but there was double overlap for the techniques of military war gaming, human-in-the-loop computer modeling, discrete event simulation (normally large force effectiveness models that are where networks are overlaid on platform centric models), agent based simulation (countries are staring to use simulations such as the 'Mana' simulation), and experimentation. Representatives felt that experiments should be focused and include clear hypothesis that can be confirmed or denied. They should not be demonstrations without rigorous experimental design and there should be analysis plans for data collection.



The third major objective of the working group was to assess the state of coalition 'collaborative' OA analyses in support of NCO. This began by identifying all known recent or planned analytical events. Many of the activities are modest events between coalition partners (entropy work, agent based modeling, S&T assessment, an assessment of decision making in collaborative environments, development of a conceptual model, and working groups to discuss interoperability). The two 'Office of Force Transformation' (OFT) case studies are also modest level efforts primarily being done by the US to assess coalition interoperability. The only larger efforts are the US-UK interoperability study and the US Joint Forces Command (JFCOM J9) experiments that include significant multinational participation and interoperability assessments. The conclusion is that there is still a need for significant collaborative analytical events between coalition partners.



Shortfalls were identified based on the recent OA collaborative efforts. Coalition country representatives identified shortcomings based on their understanding and participation in recent collaborative efforts.

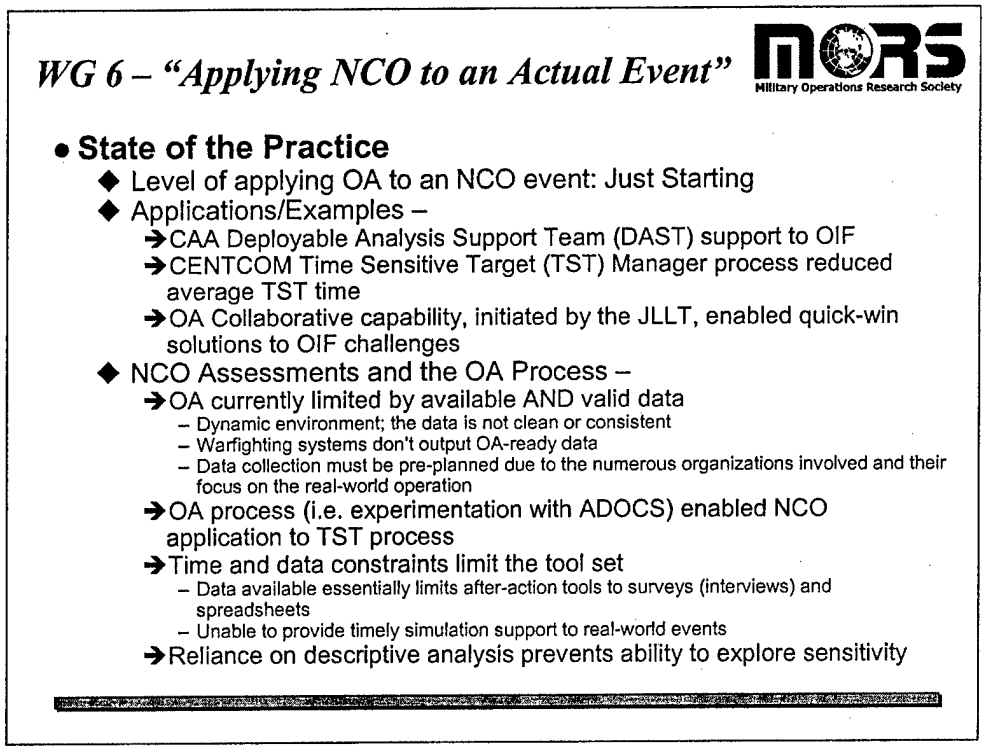


There were seven recommendations to improve 'collaborative' OA in support of NCO between coalition partners. The working group determined that it was important to focus on cognitive and social issues when doing collaborative OA assessments (recommendation #1). The working group determined that when conducting collaborative analysis there is a requirement to represent key networked entities. However, there were cases where 'disadvantaged' participants may not be represented if there is not assistance. A recommendation is to provide assistance to insure that key disadvantaged players are part of important analysis (#2 and #5). There have been some analytical events (e.g. J6 Sensor to Shooter US-UK study, US-UK FSCS/Tracer study) that have resulted in recommendations for investments by coalition partners. There is evidence that there is a reluctance to provide necessary resources to support 'materiel' investment recommendations. Therefore a recommendation is that countries focus on non-materiel alternatives in their analysis first (doctrine, organization, training, logistics, personnel -- #3). A concern was that NATO has a relatively large analytical organization, NC3A, that did not participate in this workshop. Given the emphasis in OA support to NCO by a number of NATO countries it was recommended that NC3A take an active role to sponsor collaborative analysis in this area (#4). At the conclusion of the workshop all participants agreed that this workshop and working group proved very useful. There was strong agreement that there should be more international OA events. Also, there was strong agreement that all countries should do much better at sharing studies, lessons learned and data.

Operations Analysis Support to Network Centric Operations

Military Operations Research Society (MORS) Workshop

WG 6: Applying NCO to an Actual Event Outbrief

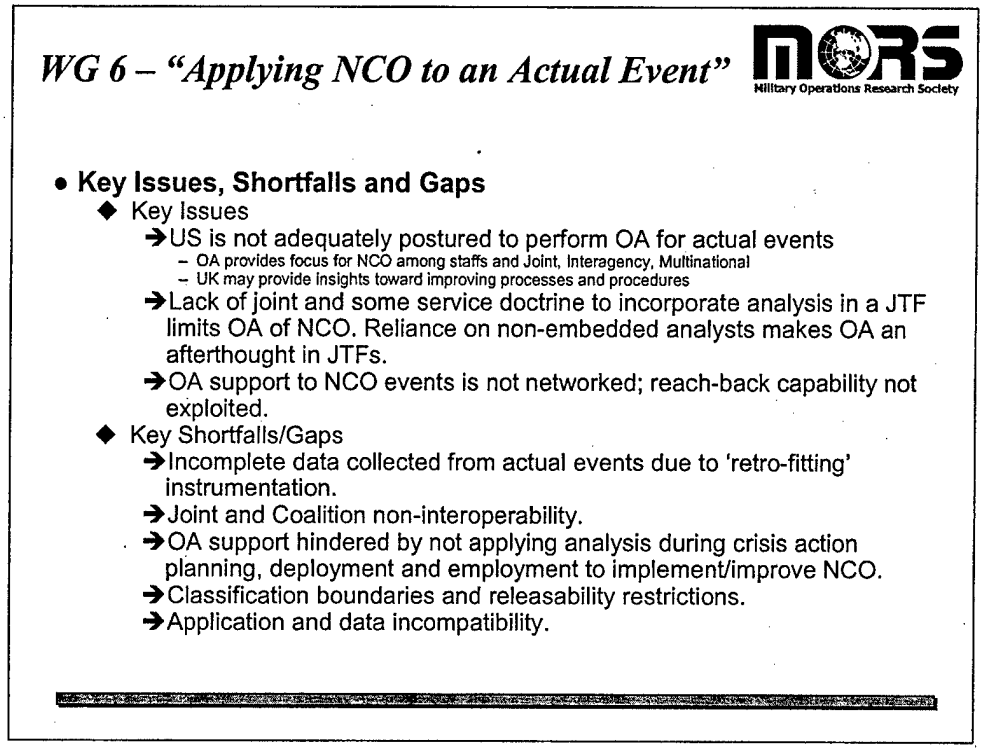


Examples:

- CAA embedded an analyst in the CFLCC C5 during OIF and currently have one deployed to CJTF-7
- CENTCOM TST Manager was a collaborative link between the disparate organizations in the TST-approval process
- JLLT analysis, enabled by a robust collaborative capability, provided "quick-win" (rapid turn-around) support to CENTCOM and the component commands during OIF

NCO Assessments and the OA Process:

- Deployed CAA analysts discovered that data and info was not being collected or stored.
- Available data was often only in "text" format and lacked discipline in its collection

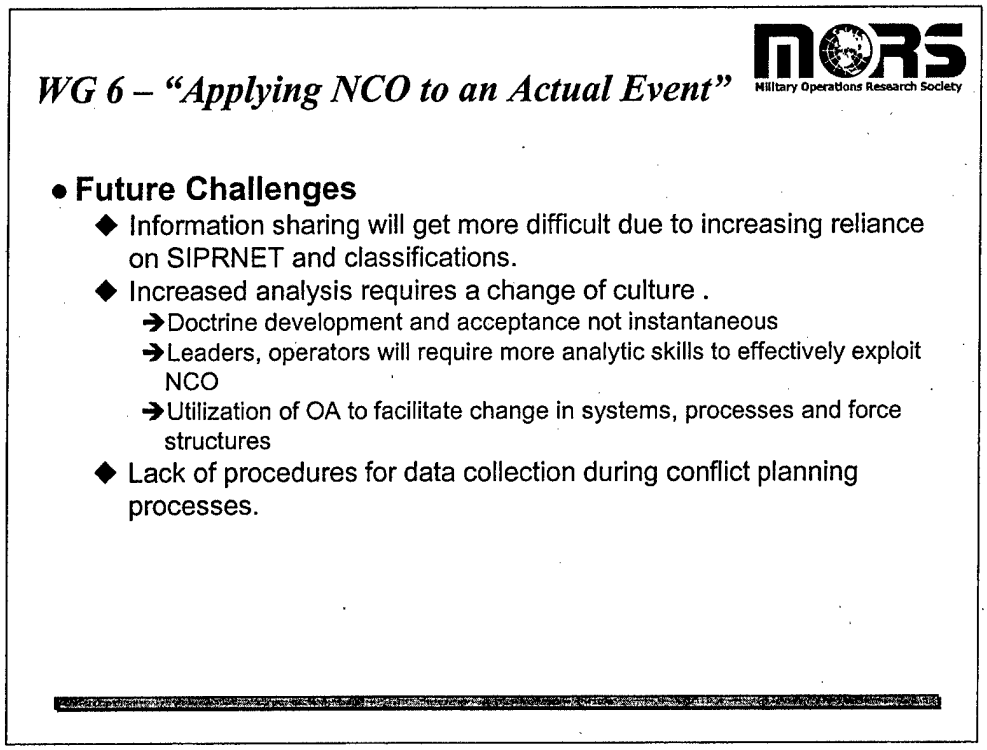


Key Issues:

- CAA had to overcome inertia to get its analysts accepted into the combatant command. Typical staff officer and leaders are unfamiliar with the tools and capabilities brought by a trained analyst.
- UK analysts were well-embedded into deployed UK forces and have a history of being embedded in deployed forces. That model for employment of analysts could be a start for the US program.
- Deployed OA assets were not aware of each other's efforts. Teams went into theater, often on short notice, and did not have time to contact other agencies prior to deployment to become familiar with and coordinate efforts. Lack of collaboration between teams (except in selected cases) prevented sharing techniques and data.

Key Shortfalls/Gaps:

- Warfighting systems not designed to capture OA data. When data is desired, the instrumentation to capture it had to be developed and implemented "on the fly."
- Warfighting systems are often non-interoperable, so data being collected would not be in any kind of standard format.
  - Example: Falconview (USAF) and C2PC (USA) cannot interact without extensive modification
- Lack of OA during crisis action planning, deployment and employment is an overall OA shortfall (not just for NCO).
- Classification and releasability problems are also not just NCO-related.

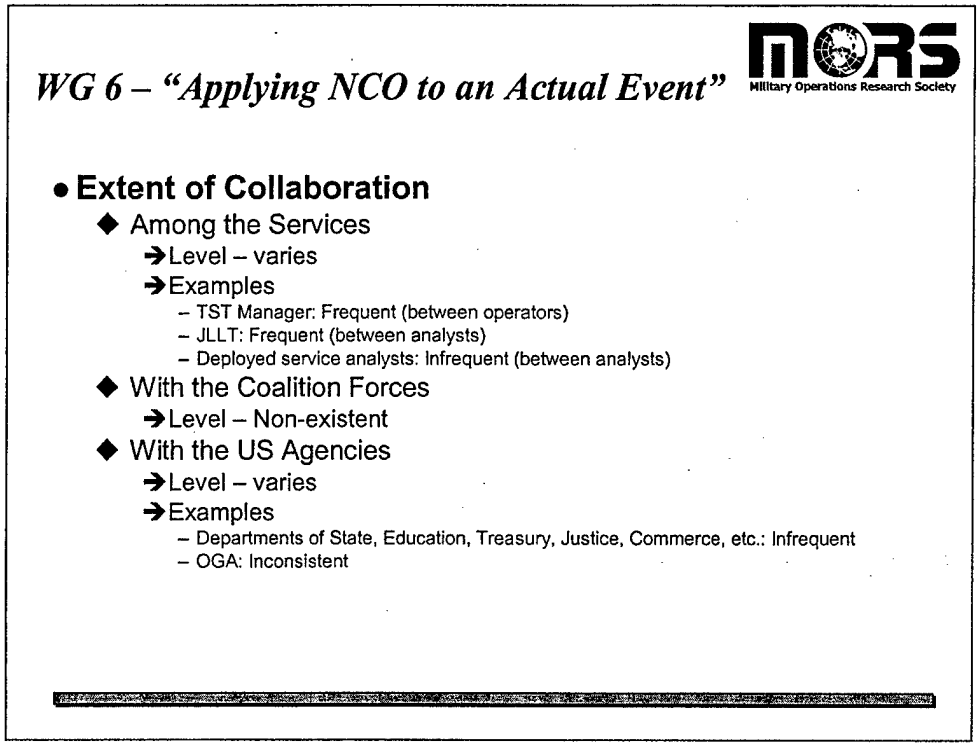


If we don't do anything, the info sharing problem will actually get worse because the planning, execution and analysis processes are conducted increasingly on the SIPRNET. This has the effect of excluding our coalition partners.

Overclassification of planning, deployment and execution and sustainment products exacerbates the information sharing problem. This adds work to the declassification work that the staff Foreign Disclosure Officers must do prior to transferring products to coalition information sharing systems like CENTRIX.

The warfighting culture needs to be changed to accept more analysis. This will require changes in doctrine and training and experience of leaders.

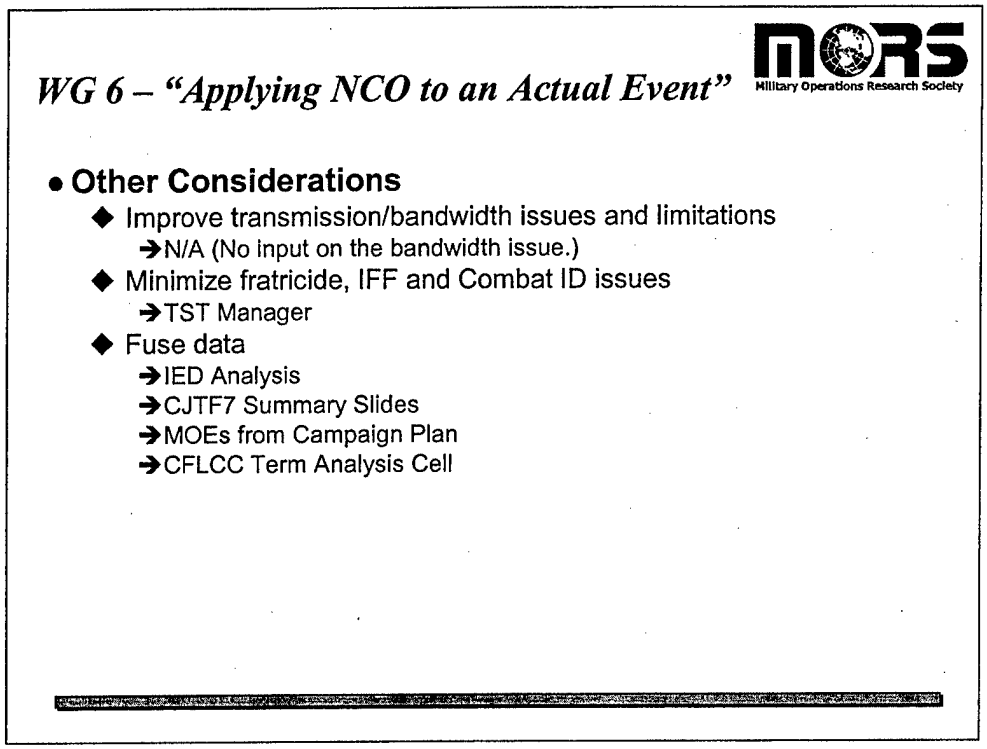
As analysts do more collection and analysis in the field, the procedures for data collection will mature, but emphasis on collecting data should start in the planning phase.



Collaboration between services is varied and has two dimensions: between operators and between analysts. The TST manager is an example of continuous collaboration between operators. Collaboration between analysts was good with the Joint Lessons Learned Team (JLLT) because they were located at all Combatant and Component Headquarters so contact was physical. Collaboration between service teams at disparate sites was very infrequent.

No collaboration appears to have been done in OIF between US and coalition analysts. Most seemed unaware of the others' existence.

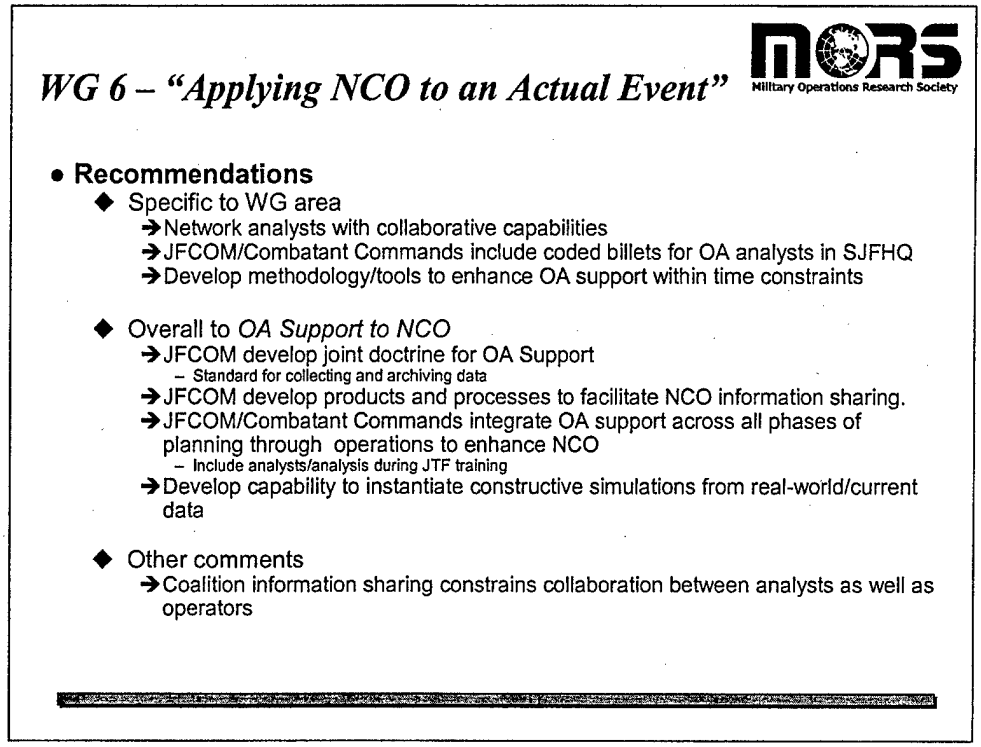
There was some collaboration with OGA analysts, but very little collaboration between anyone, much less analysts, in DOS, DoEd, DoCommerce, etc. OIF Phase IV planning involved almost every major agency in the US government and none of them had sufficient collaborative capabilities and expertise to contribute effectively and in a timely manner.



The TST manager was a good example of a NCO-enabling system that contributed to minimizing fratricide. No other systems could be identified in the discussion.

There were many examples of data fusion some from Combat Operations (Term Analysis) and the rest from the post Combat phase.

- Term brought together analysts from many disciplines to map the oil distribution system (for instance).
- IED analysis did the same but to find solutions to the Improvised Explosive Devices (IED) causing problems for coalition forces.
- CJTF7 tried to provide multiple looks at on-going operations in order to help the commander gauge progress.



- Specific recommendations include:
  - Networking analysts so that they can exchange techniques and data
  - Code billets in the SJFHQ for OA analysts so that, when they plug into a JTF, analysts focused on performing the OA function will be available.
  - Develop rapid turn-around models and other analytic tools to assist deployed analysts.
- Overall Recommendations:
  - There needs to be doctrine as well as tools and processes in order to get OA support into the field to assist from planning through post hostilities.
  - A simulation that can take the data from the Common Operating Picture and "run forward" to provide analysis of alternative course of action could have great utility for analysts to assist the commander.
- The US has to come to grips with the coalition information sharing issues to assist operations and the analysis of operations.

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Backup Slides

WG 6 – "Applying NCO to an Actual Event"

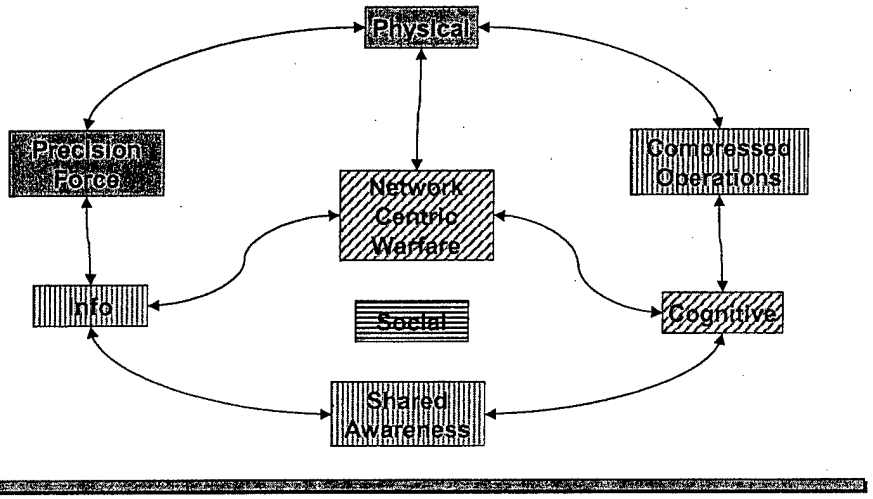
Military Operations Research Society

- **Presentations**
  - *"Joint Lessons Learned: Network Centric Warfare Observations in Operation IRAQI FREEDOM,"* by Maj Michele Cook, Joint Lessons Learned Team, USJFCOM
  - *"Providing Analytical Support to SWA Phase-IV Ops with Representation in Theater (PASSPORT),"* by CPT Allison Stewart, Center for Army Analysis

WG 6 – "Applying NCO to an Actual Event"

MORS Military Operations Research Society

Applying the OA Process to the NCW Key Domains



WG 6 – "Applying NCO to an Actual Event"

Military Operations Research Society

- **Current State of Health of the OA Process**
  - Problem Structuring: Yellow
  - Measures of Merit: Orange
  - Human Factors/Organization: Red
    - ➔No social sciences aspect of OA training
  - Scenarios: Orange
  - Data: Red
    - ➔No data on performance of networks
  - Tools: Orange
  - Risk and Uncertainty: Orange
  - Report: Yellow

Operations Analysis Support to Network Centric Operations

Military Operations Research Society (MORS) Workshop

Synthesis Committee Report

Synthesis Committee Team

Military Operations Research Society

WG 1	Measures of Merit	Mike Bauman, FS Jeff Kline	USA USN
WG 2	Methods and Process	Greg Parnell, FS	USMA
WG 3	Assessment Tools	Dave Garvey	Consulting
WG 4	Force Trans. Process	Bob Manke	USN
WG 5	NCO and Coalition Forces	Gene Visco, FS	Consulting
WG 6	Applying NCO	Bill Kemple	NPS
Floaters		Chris Herstrom Jerry Kotchka, FS	Industry Industry

Synthesis Team

The Synthesis Team was created to develop a holistic view of the deliberations of all of the Working Groups participating in the Workshop. Consistent with that goal, a team was selected that included representation from the Services, industry, consulting and academia. Selected members of the Synthesis Team actively participated in each of the Working Groups (see the Viewgraph for the specific assignments). The Synthesis Team convened periodically during the course of the Workshop to discuss and compare the evolving findings and recommendations of each Working Group. Drawing on those deliberations, the Synthesis Team developed some broad observations about the nature of the problem and formulated a set of cross-cutting findings and recommendations. These products are presented and discussed in this presentation.

TOR Overall Objectives

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- **To provide assessment to revitalize the state of analytical practice. "State of Health"**
- **To provide a roadmap to revitalize the state of analytical practice. "Findings"**
- **To recommend priorities of any initiatives identified (in the roadmap). "Recommendations"**
- **Areas to consider**

◆ Metrics	WG1
◆ Analytical processes/methodologies	WG2
◆ Modeling and Simulation	WG3
◆ NCO and Force Transformation Process	WG4
◆ NCO assessment collaboration	WG5
◆ Quick turn analyses of NCO enables an event	WG6

The Synthesis committee organized their output to answer the overall objectives of the Terms of Reference (TOR).

Broad Observations

- **Participation of senior service analytical leaders and experienced analysts from all service and joint commands in MORS Workshops significantly enhance interactions, findings and recommendations.**
- **Network Centric Operations are inherently joint, which suggests a need for a "joint" business model that enables services to conduct operations analysis in support of "born joint" NCO concepts.**
- **The networking of operations analysis centers and analysts to support NCO needs to be addressed in order to enhance deployment, experiments and assessments.**
- **For NCO analyses, a set of measures of merit (MOMs), not a single MOM needs to be addressed.**

As a result of the Synthesis Team discussion of on going activity, some broad observations were generated and presented to the workshop.

First, there exists a need to include senior service analytical leaders and experienced analysts in MORS workshops to enhance interactions, findings, recommendations and to mentor more junior participants.

Second, a joint business model is needed that enables services and joint commands to conduct operations analysis in support of emerging NCO concepts. This will facilitate the initiation of OA activity early in the planning process.

Networking of operations analysis centers and operation analysts along with adequate reach back should provide a significant improvement in support of decision makers. However, an environment of trust is needed among analysts and between the analyst and decision maker.

The final broad observation is that NCO analysis will not be addressed by a single MOM but by a set of MOMs.

Major Issues

- **Measures of Merit**
  - Measuring NCO "effectiveness" may require generation of non-traditional MOEs to evaluate cognitive and social domains. However, traditional warfighting MOEs could still be applicable as we use NCO to do the same missions differently.
- **Processes and Methodologies**
  - Since the framework emphasizes "Quality of Individual Sensemaking" and "Quality of Shared Sensemaking" as the major processes in the cognitive domain, the lack of processes and methodologies for OA using sensemaking and cognitive modeling make the NCO framework high risk.

A major consideration is to initiate the development of NCO MOMs as new NCO concepts and experiments are developed.

The NCO framework presented at the plenary session was evaluated after considerable discussion. A major issue was the gap between sensemaking and decision making, along with a lack of knowledge as to the "state of the analysis" for sensemaking and cognitive modeling.

Major Issues (Continued)

- **Assessment Tools**
  - The current tools need improvement. The "data domain" (both real blue and red data – current and projected) is still too stovepiped.
- **Force Transformation Process**
  - Current joint efforts focused on Concept Development and Experimentation (CD&E); analysts frequently not involved until well after problem definition.
  - For trade off studies between platform-centric versus network-centric, the OA techniques for quantifying network-centric investment are lacking.

Each working group assessed that the data domain remains an area for significant improvement. The need for "standard, approved" data for friendly, unfriendly and neutral forces – both current and projected – would be a significant improvement. Assessment tools were judged to need improvement. The OA tools for the physical domain are more adequate then the information, cognitive or social domains.

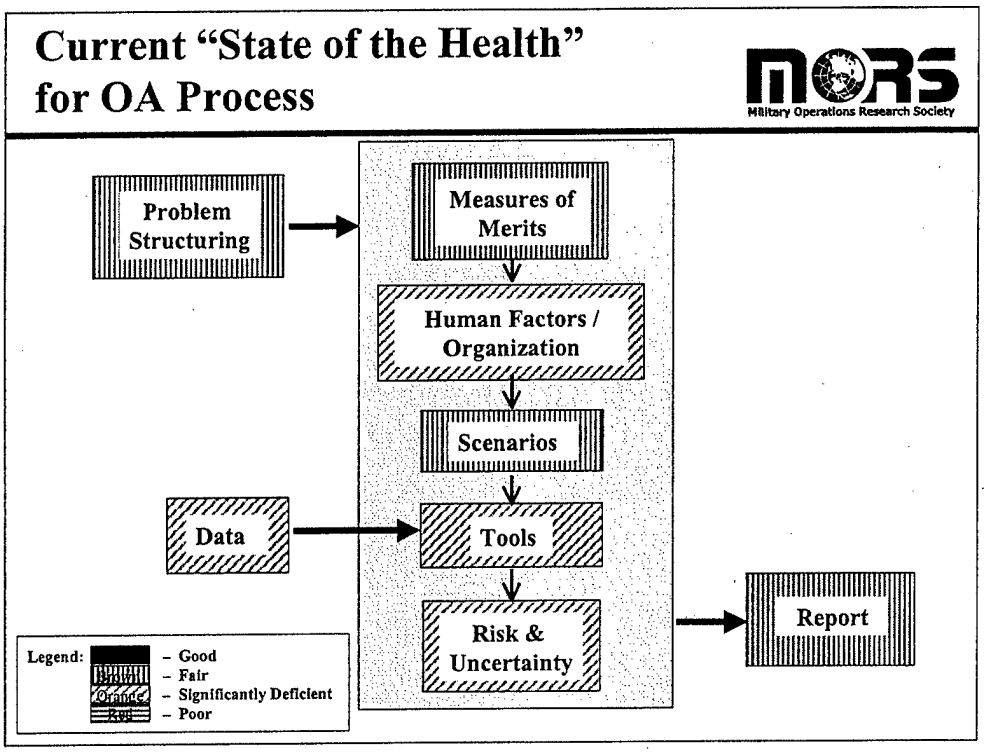
As for the Force Transformation Process, it is clear that operations analysis, even the senior operations analysts, are not involved early in the process. The analyst's experience, critical thinking, understanding of available models and measures of merit can be a valuable resource.

In addition, the OA community knows they must help decision makers address the issue: how much is a "pound of networking or horizontal integration" worth, similar to the old challenge associated with the worth of a "pound of C4I."

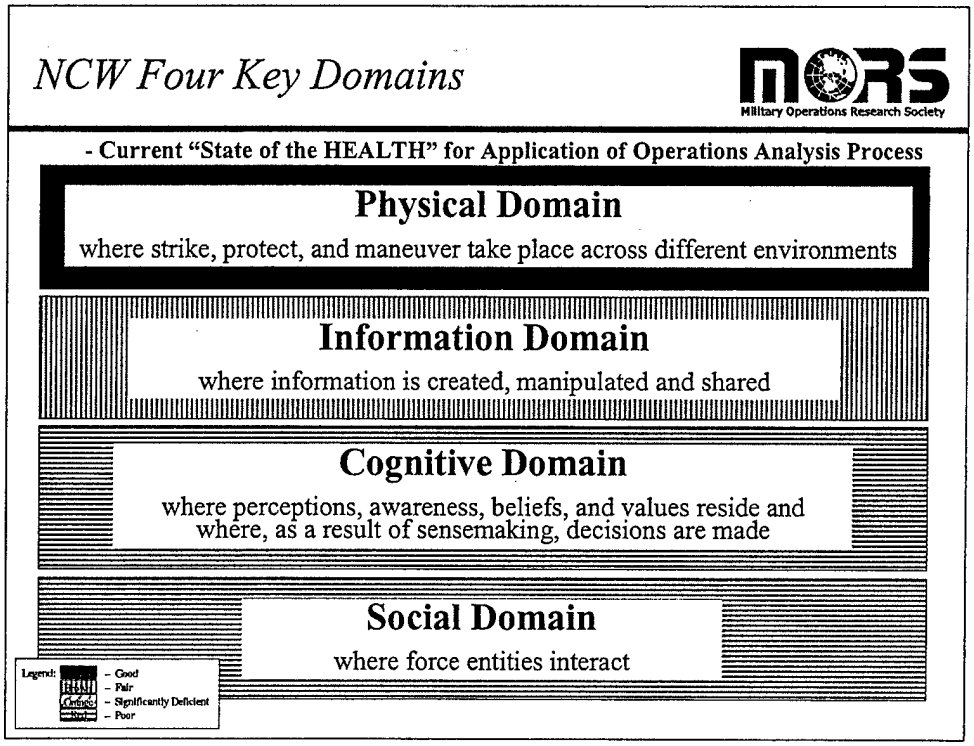
Major Issues (Continued)

- **NCO and Coalition Forces**
  - Collaboration among coalition nations remains insufficient.
- **Applying NCO to Actual Events**
  - Need to ***consistently deploy*** and ***network*** analysts with operational forces.
  - Information sharing will get more difficult due to increasing reliance on SIPRNET and similar activities and will constrain collaboration among analysts as well as operators.

Although there was significant involvement and sharing of allied countries' OA capability to support NCO, it was judged that collaboration among coalition nations remains insufficient due to multi-level security, OA resources, and other factors. Similar constraints (e.g. security) will impact information sharing among analysts. The deployment and netting of operations analysts with sufficient reachback capabilities is a major issue that must be addressed as NCO concepts and tactics are developed.



Over five years ago at the MORS Mini-Symposium and Workshop on "Analyzing C4ISR for 2010," a template for the NATO Code of Best Practice for Assessing Command and Control was developed and evaluated. This template was used to evaluate the OA process for NCO. The associated view graph documents the evaluation. There seems to be an overall decrease in the adequacy of the process due mainly to a feeling that NCO may be more difficult then C4ISR.



Each working group was asked to assess the "state of the health" of the NCW Conceptual Framework that was discussed at the plenary session. The overall qualitative assessment is documented in the associated chart. The physical domain is assessed to be in much better "health" from the application of the OA process than the other three domains.

Measures of Merit

- **Findings:**
  - MOMs must both enable the analyst and inform the client; these may be starkly different for NCOA. MOMs for NCOA are a work-in-progress.
  - Survivability-related MOM are increasingly relevant to military operations and remain so for NCOA as well, at all levels (MOP, MOE).
  - A combination of MOMs is necessary for OA of networked "cause-and-effect" relationships.
- **Recommendations:**
  - Use findings of this workshop to develop a TOR to structure a follow-on MORS event (e.g., mini-Symposium) in order to expose a larger body of analysts to NCOA practice to date (challenges, initiatives, successes, failures).

The findings and recommendations from the Measures of Merit Working Group focused on the assessment that the MOMs for NCO, especially for understanding a networked "cause and effect" relationship, are a work-in-progress. However, previous MOMs for the physical domains for warfighting missions are well understood and remain relevant. A recommendation of the MOMs working group as well as others was to conduct a future MORS session to share results of NCO related OA.

Processes and Methodologies

- **Findings:**
  - The NCO framework emphasizes "Quality of Individual Sensemaking" and the "Quality of Group Sensemaking" versus decision making.
  - Many in the NCO community assume that cognitive modeling is **the** solution to modeling sensemaking (as opposed to one of the potential solutions).
  - The lack of processes and methodologies for OA using sensemaking and cognitive modeling make the NCO framework high risk.
- **Recommendations:**
  - Continue research on sense making and cognitive modeling
  - Consider revising the NCO framework to focus on "Quality of Individual Decision Making" (to enable decision superiority).
  - Allow sense making and cognitive modeling to compete with other modeling techniques in the implementation of NCO modeling.

The findings of the Process and Methodologies Work Group focused on the NCW conceptual framework and the gap between sensemaking and decision making. It was also suggested that the relationship between cognitive modeling and sensemaking modeling needs to be addressed. Research in this area was recommended, along with a need for the framework to focus on the "Quality of Individual Decision Making."

Assessment Tools

- **Findings:**
  - The tools exist, but the data domain (both real blue and red data) is still too stovepiped.
  - The methods to change information to knowledge seem to exist within the models, but are not well understood.
  - Netting assessment tools is necessary but not sufficient; we must learn to "do better things," not "do things better."
  - The networked force must be treated as a holistic entity not as a sum of discrete elements.
- **Recommendations:**
  - Ensure assessment tools are used at the "relevant" scale of operations.
  - Adequately define the problem before selecting the assessment tool.

The findings of the Assessment Tools Working Group was along three dimensions: 1) "better" data; 2) improvement in NCO assessment tools; 3) and, the netting of assessment tools in order to achieve synergy in the application of a tool set.

A major recommendation of the team was to adequately define the problem and MOMs so the "relevant" scale of operations is understood before selecting the assessment tool.

Force Transformation Process

- **Findings:**
  - The further we move away from the transformation efforts that are focused on single service, tactics, material and entities, the fewer OA tools are available to the analyst for cognitive and social assessments.
- **Recommendations:**
  - Use NCO principles to organize and employ OA capabilities to enable force transformation.
  - Expand the traditional core competencies by using interdisciplinary analysis teams.

To effect Force Transformation it was concluded that the further we move away from assessing transformations that are focused on single service, tactics and material, ("old" missions, etc.) the fewer OA tools are available to the analyst for information, cognitive and social domain related assessments. A major recommendation was to organize or network and deploy OA capabilities in order to enable force transformation assessment activities.

NCO and Coalition Forces

Military Operations Research Society

- **Findings:**
  - OA analysis timelines are not fast enough to meet the pace of technology and DOTMLPF development.
  - OA is overly focused on the military to the exclusion of civilian agencies.
  - Need to consider a new level of embedded analysis (OA in-theater w/data mining and assessment tools) to provide real time feedback on NCO effectiveness.
- **Recommendations:**
  - Improve the rigor of analysis of case studies and experiments (hypothesis testing, analysis plans, collection and dissemination).

The NCO and Coalition Forces Working Group found that the OA timelines are not fast enough to keep pace with technology and other developments. The experience of the UK's embedded OAs needs to be assessed and maybe followed. However, the inclusion of civilian agencies also must be addressed.

Based on coalition forces experience, it was recommended that OA be made more proactive and rigorous (hypothesis testing, analysis plans, etc.) by involving OAs as the problems for the case studies and experiments are defined.

Applying NCO to Actual Events

- **Findings:**
  - Lack of joint and some service doctrine to incorporate analysis in a JTF limits OA support of NCO.
  - Reliance on non-embedded analysts makes OA an afterthought in JTFs.
  - OA currently limited by available and valid data.
    - → Dynamic environment; the data is not clean or consistent
    - → Warfighting systems don't output OA-ready data
    - → Data collection must be pre-planned due to the numerous organizations involved and their focus on the real-world operation
  - Time and data constraints limit the tool set.
- **Recommendations:**
  - Develop products and processes to facilitate NCO information sharing in order to network analysts with collaborative capabilities.
  - Develop methodology/tools to enhance OA support within time constraints of the actual event.
  - Develop joint doctrine to plan and use OA support for NCO.

When assessing applications of OA to NCO actual events, it was found that, because policies and doctrine to incorporate analysis is lacking, along with the non-use of embedded analysts, OA becomes an afterthought. If these findings and the data domain is improved then the assessment of actual NCO events will be improved. Recommendations focused on developing doctrine, plans and processes to network OAs and include them early.

"Actionable" Recommendations

- **Establish a "business model" that enables services to conduct operations analysis in support of "born joint" NCO concepts and that is underpinned by a set of approved tools and data.**
- **Provide the capability to capture and share results and data of experiments, training, analysis and experience. One way to do this is to Create center(s) of excellence within services and JFCOM for NCO assessments.**
- **Enable (thru agreements, business practices) the networking of analysts working NCO and provide reach back for tools, data and previous studies.**
- **Conduct a follow on MORS mini-symposium to share NCO analysis and experimentation results.**

An effort to synthesize the findings and recommendations into a short list of "actionable" recommendations was attempted for the first time. This list is in the associated chart. They focus on creation of processes to conduct joint OA for NCO, to link analysis centers of excellence and net deployed OAs with adequate reachback. In addition, the support of a follow on MORS session was recommended.

Summary

- **Good News**
  - OA process developed in the Industrial Age has applicability to Network Centric Operations (NCO) in the Information Age.
  - We are beginning to understand the practices that should be followed to perform credible NCO analyses.
    - → From attrition based to effects based
  - We know there are NCO considerations that continue to present challenges (i.e., social domain, ...).
- **Bad News**
  - Currently, we do not do a satisfactory job in documenting, sharing and learning from NCO analyses performed.

The Synthesis Team discerned that news on OA support to NCO ran the gamut from good to bad to worse to better.

The good news is that the OA process developed in the Industrial Age has applicability to Network Centric Operations (NCO) in the Information Age. We are starting to understand the practices that should be followed to perform credible NCO analyses. In addition, we know there are NCO considerations that remain challenges.

The bad news is that we do not do a satisfactory job in documenting, sharing and learning from NCO analyses performed.

Summary (Continued)

- **Worse News**
  - With the arrival of terrorism, other asymmetric threats, rogue nations, and homeland defense, the NCO assessment problem and Force Transformation, are substantially more difficult and more urgent.
- **Better News**
  - If the recommendations of this workshop are implemented, they will provide a basis for the Operations Analysis Process/Community to address the most critical analytical challenges to support NCO and Force Transformation.

The worse news is, that with the arrival of terrorism, other asymmetric threats, rogue nations, and homeland defense, the NCO assessment problem and Force Transformation are substantially more difficult and more urgent.

Although these are daunting challenges, there is some better news that is implicit in this workshop itself. If the recommendations of this workshop are implemented successfully, they will provide a basis for the Operations Analysis process and community to address the most critical analytical challenges to support NCO and Force Transformation.

MORS Special Meeting Acronyms

MORS Workshop:
Operations Analysis Support to Network Centric Operations

ABCA	American, British, Canadian, Australian Armies Standardization Program
ACIDC	**WG 5 (United Kingdom)**
ADF	Australian Defence Force
ADOC	Air Defense Operations Center
AFSAA	Air Force Studies and Analyses Agency
AoA	Analysis of Alternatives
AU	Australia
BAH	Booz Allen Hamilton
C2	Command and Control
C2P2	**Army (WG 6) Command and Control Protection????**
C3	Command, Control and Communications
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CA	Canada
CAA	Center for Army Analysis
CBA	Capabilities Based Acquisition
CBMARTD	**WG 5 (United Kingdom)**
CCRP	Command and Control Research Program
CD&E	Concept Development and Experimentation
CENTCOM	United States Central Command
CENTRIX	Combined Enterprise Regional Information Exchange System
CFLCC	Coalition Forces Land Component Command
CJTF-7	Combined Joint Task Force (NATO)
CNO	Chief of Naval Operations
COBP	Code of Best Practices
COCOM TSCPs	Combatant Command Technical Control Systems Programs
CONOPS	Concept of Operations
COTS	Commercial Off The Shelf
DAST	Deployable Analysis Support Team
DoD	Department of Defense
DOS	Department of State
DOTMLPF	Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities
DPG	Defense Planning Guidance
EBO	Effects Based Operations
EBR	Evidence Based Research
FCS	Future Combat System
FOI	Swedish Defense Research Agency
FS	Fellow of the Society (MORS)
HPTs	High Priority Targets
HUMINT	Human Intelligence

IA	Information Assurance
IED	Improvised Explosive Devices
IER	Information Exchange Requirement
IO	Information Operations
ISR	Intelligence, Surveillance, Reconnaissance
IT	Information Technology
JEFX	Joint Expeditionary Force Experimentation
JFCOM	US Joint Forces Command
JLLT	Joint Lessons Learned Team
JMEM	Joint Munitions Effectiveness Manual
JNTC	Joint National Training Capability
JROC	Joint Requirements Oversight Council
JTF	Joint Task Force
JUEP	**WG 5 (United Kingdom)**
JWARS	Joint Warfare System
MDMP	Military Decision Making Process
MoD	Ministry of Defense
MOEs	Measures of Effectiveness
MOMs	Measures of Merit
MOOs	Measures of Objectives or Measures of Outcomes
MOPs	Measures of Performance
MORS	Military Operations Research Society
MORSS	Military Operations Research Society Symposium
NATO	North Atlantic Treaty Organization
NC	Network Centric
NC3A	NATO C3 Agency
NCO	Network Centric Operations
NCOA	Network Centric Operations Analysis
NCOW	Network Centric Operations and Warfare
NCW	Network Centric Warfare
NEC	Network Enabled Capability
NGO	Non Governmental Organization
NII	Networks Intelligence and Information
NMS	National Military Strategy
NPS	Naval Postgraduate School
OA	Operations Analysis
OEF	Operation Enduring Freedom
OFT	Office of Force Transformation
OIF	Operation Iraqi Freedom
OOTW	Operations Other Than War
OPTEMPO	Operations Tempo
ORD	Operational Requirements Document
ORSA	Operations Research Society of America
OSD	Office of the Secretary of Defense
PK	Probability of Kill
SEAS	System Engineering Analysis Simulation

SIAP	Single Integrated Air Picture
SJFHQ	Standing Joint Force Headquarters Core Element
SoS	Systems of Systems
SW	Sweden
TOR	MORS Term of Reference
TPG	Technology Planning Guide
TRAC	TRADOC Analysis Center
TRADOC	Training and Doctrine Command
TST	Time Sensitive Target
TTCP	Test Training Certification Plan
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
USA	United States Army
USA/US	United States of America
USAF	United States Air Force
USMA	United States Military Academy
USMC	United States Marine Corps
USN	United States Navy
WIN-T	Warfighter Information Network – Tactical

MORS Special Meeting Terms of Reference

MORS Workshop:
Operations Analysis Support to Network Centric Operations

1. Background –

As Network Centric Operations (NCO) are being developed, assessment needs vs. capability gaps are being discussed and options considered by the US Armed Forces. In these early stages, an assessment of Operations Analysis to support Network Centric Operations needs to be conducted.

For instance, functional requirements and metrics need to be developed. Some MOEs and MOPs have been developed for some mission areas, but not for the higher level command and control functions. Also, what are the analytic processes to assess Network Centric Operations for PPBS and joint experimentation? What methodologies will enable quantification, insight and understanding on NCO Concepts of Operations? What Modeling & Simulation is available to support assessments of NCO Concepts and what are the campaign model limitations?

Additionally, our growing Operational and Systems Architectures need to be leveraged as we understand bandwidth requirements. How can NCO be applied in the Force Transformation Process? How will it shape force structure and the concepts of operations? What are the inter-relationships between information and weapons systems?

Furthermore, are there interoperability issues among the Joint, Allied and Coalition Forces? How are Allied & Coalition Forces using operations analysis to support NCO? What are their lessons learned? How do we stay in step with the Coalition Forces? What do we do for those Coalition Forces that will not / cannot participate in the network? What about with US Agencies, such as Homeland Security, Justice, etc.?

Finally, how can effects-based operations be applied to NCO? How effective are our Information Warfare operations? When is it more effective to achieve non-lethal vs. lethal effects? How do we determine how effective Information Warfare is? What are the co-evolving landscapes in C4ISR? Are there better data practices? How do cognitive and behavioral factors influence command and control?

This Workshop will research and examine the above questions, using the applicable NCO-related findings of the recently completed MORS Special Meetings on Effects-Based Operations, Information Operations, C4ISR, Data Practices, Cognitive and Behavioral Factors Influencing Command and Control, and Decision Support.

2. Goals and Objectives –

Many organizations are interested and involved in employing and analyzing Network Centric Operations. The analytic community needs to support the military services with assessments as Network Centric Operations is being developed. The community should play a leadership role in creating/refining these needed metrics, processes, methodologies, models and simulations. The community should share efforts, successes and failures in the key capabilities.

The goal of this meeting is to provide an opportunity to bring a multi-disciplined team of analysts, operators and engineers from those organizations together to share their work, develop a common view of the state of practice, expose members of the broader analytic community to their needs, identify shortfalls and potential solutions.

There are several overarching issues each working group will consider. They are:

- What is the state of the practice? Identifying key issues and shortfalls –
  - What is the guidance for best principles and practices relating to NCO assessments?
  - What area(s) do we need to understand better than the current knowledge levels?
  - What area(s) do we need to prioritize higher to understand sooner?
  - What are the operational data concerns (i.e., observables, validation, etc.)?
  - What are the operations analysis competency development and knowledge sharing concerns?
  - What are the cultural issues?
- What is/should be the context and relationships between the Operations Analysis community and the stakeholder (those organizations working with NCO) needs?
- What are the examples of how OA has been applied to support NCO?
  - What are the future challenges?
  - How do NCO assessments fit in the overall OA process?
    - Define the problem
    - Determine the appropriate Measures of Merit
    - Select a scenario set
    - Determine the representative operational situations/CONOPS
    - Determine the models
    - Conduct the analysis
    - Evaluate/communicate results
    - Assess/feedback

- Do the results of recently completed MORS Workshops apply to NCO? If so, how?

  - *Analyzing Effects-Based Operations*
  - *Operations Research Methods for Information Operations*
  - *Advancing C4ISR Assessment*
  - *Improving Defense Analysis through Better Data Practices*
  - *How Cognitive and Behavioral Factors Influence Command and Control*
  - *Decision Aids/Support to Joint Operations Planning*

- How will the other U. S. Agencies (i.e., HLS, Justice, etc.) collaborate in an NCO environment? Has any OA been conducted to incorporate the Agencies with the Service's NCO environments?
- Other considerations (primarily for WGs 4, 5 & 6). What analyses has been completed providing recommendations:

  - To improve known transmission and bandwidth issues and limitations?
  - To minimize fratricide, IFF, Combat ID issues?
  - To fuse data?

The overall objectives of this special meeting on *Operations Analysis Support to Network Centric Operations* will be to provide an assessment and a roadmap to revitalize the state of the analytical practice and to recommend priorities for any initiatives identified. Some specific objectives for the Working Groups include recommending:

- Functional requirements and metrics that need to be developed / refined
- Analytical processes and methodologies to optimize and evaluate NCO
- Modeling and simulation to support NCO assessments
- How NCO assessments can be applied in the Force Transformation Process
- NCO assessments collaboration among the Joint, Allied and Coalition Forces
- How quick turnaround analyses of NCO enables an event

3. Approach –

a. 1st Day – Mini-Symposium – The meeting will commence with a mini-symposium format that will include operational based discussions as well as progress to date. The purpose of this portion is to bring all participants up to speed on the state of the practice and frame the analytical challenges and issues for the working groups.

(1) **Keynote Presentation** *(~ 1 hour presentation with 15 minutes for Q&A)* – From a high, Joint-level perspective:

(a) Define and provide a brief background on Network Centric Operations
(b) Identify the overriding challenges the analytical community needs to address
(c) Provide an overview of the progress to date using operations analysis to support NCO, including any problems and paradoxes

(2) **Service Presentations** *(total – 1 ½ hours with ~ 15 minutes for each Service and ~ 15 minutes available for questions)* –

(a) Presentations – *(each Service and 1 Coalition Country; ~ 15 minutes each)*

- Provide an overview of the challenges and progress to date using operations analysis to support NCO (with examples)
- Highlight context, issues, what is needed from the analytical community
- Identify some of the broad analytical and difficult questions

(b) Q&A – After all presentations, the remaining time (~ 15 minutes) will be for questions

(3) **Framework Presentations** *(~ 1 ½ hours)* –

(a) An Overview of NCO Differences (~ 45 minutes) – Comparing and contrasting the NCO differences:

- Among the US Services
- With the US Agencies (i.e., HLS, Justice, etc.)
- With the Coalition Forces
- Highlighting OA examples, where appropriate

(b) What is Network Centric Operations? (~ 20 minutes)

- After the attendees have listened to the Keynote, Service and NCO Differences presentations, this is a brief to focus the Working Group discussions

(c) What is the Operations Analysis Process? (~ 30 minutes)

- This is another brief to focus the Working Group discussions
- A review of the OA process to see how OA "fits" in the six Working Groups

(4) **Guidance Presentations** *(~ 1 ½ hours)* –

(a) Workshop Introduction Brief – by the Special Meeting Co-Chairs (~ 20 minutes)

- Discuss the Working Group objectives
- Highlight the overarching analytical issues
- Provide a schedule overview for the Workshop
- Introduce the Working Groups and their Chairs, Co-Chairs & Advisors

(b) Technical Chair Comments and Guidance (~ 10 minutes)
(c) Reports on previously completed related MORS Workshops (listed above), highlighting any relationships to NCO (~ 50 minutes ➔ ~ 10 minutes each)

(d) Synthesis Group Overview – by Synthesis Group Chair *(~10 minutes)*

- Discuss the role of the Synthesis Group
- Highlight what input is desired from the attendees
- Introduce the Synthesis Group

b. 2nd & 3rd Day – Workshop – The Mini-Symposium will be followed by a two-day workshop where participants will meet in working groups to further examine specific topics, including discussing the overarching issues of the Workshop. Working groups will prepare a report on their activities to present to other workshop participants at the last session of the workshop. To focus the discussion in each of the working groups, a select group of people will be requested to prepare and present papers. The workshop attendees will be organized into six working groups plus a synthesis group. The working group structure is detailed below.

(1) WG 1: *Measures of Merit* – Using the OSD project on NCW Framework and Dr. Albert's "Maturity Matrix" to measure progress of the network as a foundation, this working group will examine the functional requirements and metrics being developed for Network Centric Operations. Some potential discussion points include:

(a) What are the issues from previous work on NCO metrics? Are any of these issues not defined? If so, which ones?
(b) What is the status of not only the network MOPs, but also the transformation MOEs? Network MOPs may not capture the synergy associated with being able to network.
(c) The Army's Future Combat System and the Navy's FORCEnet have metrics.

- Are they consistent?
- Are they inclusive?
- Are they adequate?

(d) What about the Key Performance Parameters (KPPs)? What should they be?
(e) Can the previously proposed NCO measures be "audited" to determine where the gaps are?
(f) Can "traditional" metrics make a contribution to evaluating NCO? If so, how? If not, why not?
(g) What is the frame of reference for examining the relationship among NCO, Rapid Decisive Operations (RDO) and Effects Based Operations (EBO) metrics? Define the common areas. By doing so, this may enhance the ability to use the previous work on metrics for RDO and EBO that applies to NCO.
(h) How do you determine and link metrics across the physical, information, cognitive and social domains? What are the metrics in each domain?
(i) What are observable and measurable metrics vs. intangible metrics?
(j) How are the new metric hierarchies linked to combat power and outcomes?

(2) WG 2: *Processes and Methodologies* – This working group will examine analytical processes and methodologies to optimize and evaluate Network Centric Operations. Some potential discussion points include:

(a) Analysis process changes needed in order to assess NCO in light of the forces of transformation, e.g., EBO, capabilities-based acquisition, spiral development, increasing JFCOM role and "joint" task force capabilities perspective, and increasing involvement with NGOs, international entities, and OOTW.

- What processes changes are needed to better reflect the importance of joint experimentation (assessing concepts) and the potentially decreasing need for traditional mission analysis, and to involve stakeholders more?
- What are the emerging implications for the methodologies and tools that support these processes, e.g., emerging need for mini-wargames to supplant or supplement campaign level models?
- Given the analytical community's current capability in assessing NCO, what process changes could be implemented in the interim and what needs to take a longer-term perspective, e.g., process improvement road map?

(b) The methodologies to enable quantification, insight and understanding of NCO CONOPS and information age paradigms.

(3) WG 3: *Assessment Tools* – This working group will examine and recommend the modeling and simulation to support assessments, i.e., POM to system engineering to experimentation of NCO Concepts, including the role of wargames, field experiments and exercises. Some potential discussion points include:

(a) The campaign model limitations

- Currently assume "perfect knowledge / ISR"
- Recommended solution (FORCEnet, CEC, etc.) goals are to deliver "near-perfect environment" … shows no delta in performance

(b) Representation of C2, human, organizational behaviors and interactions

- Trust in netted environment
- History of "mistakes"

(c) The representative hierarchy of models

(4) WG 4: *Force Transformation Process* – This working group will examine how using OA in support of Network Centric Operations can be applied in the "Force Transformation Process". Some potential discussion points include:

- NCO assessments shaping force structure and the concepts of operations
- Operational and system architectures required

- NCO doctrine towards transformation
- Inter-relationships between information and weapons systems

(5) WG 5: *NCO and Coalition Forces* – This working group will examine applying OA to Network Centric Operations and interoperability among the Joint, Allied and Coalition Forces. Some potential discussion points include:

- In addition to the Joint Forces, how are other (i.e., Allied & Coalition) Forces using operations analysis to support NCO?
- What are their lessons learned?
- What collaboration assessments have been accomplished among the Joint and Coalition Forces?
- How do the Joint Forces stay in step with the Allied & Coalition Forces? Training, exercises, policy? Information sharing?
- How do the Joint Forces maintain the relationship with those Coalition Forces that are not / can not get on the network?

(6) WG 6: *Applying NCO to an Actual Event* – This working group will examine how applying OA to Network Centric Operations enables time critical events. Some potential discussion points include:

- What is a collaborative target?
- In what length of time is "critical"?
- How can quick-turnaround analyses support the event?
- What type(s) of analysis(es) is(are) recommended?
- The different ways the Air Force used OA and lessons learned in recent events to reduce the time from 4 hours to 45 minutes (with a goal of 2-3 minutes)

(7) Synthesis – The synthesis group will bring together the work of the six working groups and develop overall assessment/recommendations from the analysis community for the individual service operations analysts to consider.

4. Agenda – (tentative)

Day/Time	**Activity**
Monday, 26 January 2004	
1700	Working Group Chair and Co-Chair Warm-Up Session
Tuesday, 27 January 2004	
0700	Registration and Continental Breakfast
0800	MORS President's Welcome
0805	Welcome by Host
0810	Proponent Welcome

0820	Workshop Overview
0845	Keynote Presentation
1000	Break
1030	Service Presentations
1200	Lunch in Working Group Rooms – WG Introductions
1315	Framework Presentations
1500	Break
1530	Guidance Presentations
1700-1830	Mixer

Wednesday, 28 January 2004

0715	Continental Breakfast
0800	Working Group Session #1
0945	Break
1015	Working Group Session #2
1200	Lunch in Working Group Rooms
1300	Working Group Session #3
1445	Break
1515	Working Group Session #4
1700	WG Chair, Co-Chair and Synthesis Group Daily Wash Up

Thursday, 29 January 2004

0715	Continental Breakfast
0800	Working Group Session #5
0945	Break
1015	Working Group Session #6
1200	Lunch in Working Group Rooms
1330	Working Group Outbriefs: WG 1, 2, 3 & 4
1500	Break
1530	Working Group Outbriefs: WG 5, 6 & Synthesis
1630	Workshop Wrap-Up
1700	Adjourn Workshop

Friday, 30 January 2004

0800	Working Group Chairs complete Working Group Annotated Briefings
1200	Adjourn Workshop (for Chairs)

The tentative utilization for the working group sessions will be:

(1) Day 1 Working Group Lunch – Kickoff: Introduction, agenda, issues & goals; and Provide context to orient WG participants for discussion and debate
(2) Working Group Session # 1 – Technical Papers Session #1
(3) Working Group Session # 2 – Technical Papers Session #2
(4) Day 2 Working Group Lunch – As required (Consider: Speaker to address frontier issues on WG topic)
(5) Working Group Session # 3 – Frame WG response & collect issues (brainstorming)
(6) Working Group Session # 4 – Characterize OA Support and assess gaps / shortfalls
(7) Working Group Session # 5 – Recommend strategies and roadmaps
(8) Working Group Session # 6 – Refine ideas, arguments, capture WG debate, etc.
(9) Day 3 Working Group Lunch – Complete presentation for WG Outbrief

5. Attendees –

a. Attendance will be by invitation only. Attendees will include invited experts from OSD, all Services, the Joint Staff, University Affiliated Research Centers, Federally Funded Research and Development Centers, operational commanders, DoD contractors and others, including representatives from our Allied / Coalition Analytical Communities . Workshop chairs will control membership of their sessions in conjunction with the Organizing Committee. Attendance will be limited to 200 people.
b. Working Groups (WGs) will be led by a Chair, one to three Co-Chairs and an Advisor. This leadership group will be comprised of all MORSians or a combination of MORSians and Subject Matter Experts (SMEs). The responsibilities of this team include:

(1) Chair –

(a) Dynamic individual that is a SME in the WG topic
(b) Solicits analysts and operators in the field to participate in the WG
(c) Guides the WG during the Workshop
(d) Challenged to provide the "substance" of the special meeting WG
(e) Develops the WG's final product

(2) Co-Chair – Individual interested in WG topic; assist Chair as Chair requests
(3) Advisor – Individual that is a SME in the operational side of the WG topic; assists Chair in WG membership, provides perspective during Workshop, and assists Chair as requested

c. Another key group of individuals during the Workshop is the Synthesis Group. This group will provide representation to each of the WGs and assist the Workshop Chairs consolidate the working group results and develop overall assessment/recommendations from the analysis community for the individual service operations analysts to consider.

6. Products –

Several products will be generated from the workshop:

- An Executive Summary in the form of a text document and a scripted briefing for the MORS Sponsors addressing the workshop objectives, findings, conclusions and recommendations will be offered within 30 days.
- A proceedings document containing summaries of all sessions and annotated copies of appropriate briefing slides and presentations.
- An article summarizing the meeting and its findings will be produced and submitted to *PHALANX* in time for the next deadline after the meeting.
- A general session presentation will be made at the 72nd MORSS.

7. Milestone Table – See the *OA Support to Network Centric Operations Plan of Actions & Milestones*

8. Proponents –

Director, Assessment Division (N81), Office of the Chief of Naval Operations

9. Planning and Organizing Committee –

General Co-Chairs:	Dennis Baer, Northrop Grumman IT Kirk Michealson, Lockheed Martin ISS/AC-T
Technical Co-Chairs:	Dr. Richard Hayes, Evidence Based Research, Inc. Dr. David Alberts, OSD(NII)
Synthesis Chair: Group:	Dr. Jerry Kotchka, FS, Lockheed Martin ISS/AC-T CAPT Jeff Kline, NPS Michael Bauman, FS, TRAC Ft. Leavenworth David Garvey, Alidade Incorporated Dr. Stuart Starr, FS, The MITRE Corporation Dr. Russ Richards, JFCOM (MITRE) Dr. Greg Parnell, FS, USMA Prof Bill Kemple, NPS Bob Manke, Naval Undersea Warfare Center
Site Coordinator:	Booz Allen Hamilton
Administrative Coordinators:	Brian Engler, Executive Vice-President, MORS Natalie Kelly, Vice-President for Admin, MORS
MORS Bulldog:	Dean Free, Anteon

Working Group Chairs:

WG1 – *Measures of Merit*:

Chair – Jim Jacobs, Northrop Grumman IT
Co-Chair – Corinne Wallshein, AFSAA
Advisor – Dr. Kimberly Holloman, Evidence Based Research, Inc.

WG 2 – *Processes & Methodologies*:

Chair – Dr. Daniel Maxwell, Evidence Based Research, Inc.
Co-Chair – Ralph Klingbeil, Naval Undersea Warfare Center
Co-Chair – Jeffrey Vick, Boeing Military Studies & Analysis
Advisor – Graham Mathieson, UK Defence Science & Tech Lab

WG 3 – *Assessment Tools*:

Chair – Steven Beres, Evidence Based Research, Inc.
Co-Chair – Dr. Mark Youngren, The MITRE Corporation
Co-Chair – Ben Taylor, UK Defence Science & Tech Lab
Co-Chair – TJ Ferrell, Boeing Military Studies & Analyses
Advisor – LtCol Gregory McIntyre, JWARS, OSD(PA&E)

WG 4 – *Force Transformation Process*:

Chair – Bob Gregg, Whitney, Bradley & Brown, Inc.
Co-Chair – Duncan Tailby, JFCOM – Analysis Division
Advisor – Dr. John Hanley, IDA

WG 5 – *NCO & Coalition Forces*:

Chair – COL Pat Vye, ODUSA(OR)
Co-Chair – Ray Christian, Naval Undersea Warfare Center
Co-Chair – Joe Quartararo, JFCOM – Analysis Division
Co-Chair – Alan Cowdale, UK Defence Science & Tech Lab
Advisor – Walt Perry, RAND

WG 6 – *Applying NCO to Actual Events*:

Chair – MAJ Sean Deller, JFCOM, J9, Lessons Learned
Co-Chair – MAJ Greg Petrick, Hanscom AFB, Analysis Division
Advisor – COL Steven Mains, JFCOM, J9, Lessons Learned

Sponsor/Service Reps:

Air Force:	Roy Reiss, Air Force Studies & Analyses Agency
Army:	COL Hoa Generazio, ODUSA(OR)
Navy:	Mr. Greg Melcher, N81
Marine Corps:	Dr. George Akst, MCCDC Studies & Analysis
Joint Staff:	COL Wilmer Sweetser, JS (J8)
OSD:	Mr. Jim Bexfield, FS, OSD(PA&E)

MORS Workshop Briefs:

Analyzing EBO – Dr. Richard Hayes & Sue Iwanski
OR Methods for IO – Dr. Dick Deckro
Advancing C4ISR – Dr. Stuart Starr, Charles Taylor and Cy Staniec
Better Data Practices – Tom Allen
Influence C&C – Priscilla Glasow
Decision Support – Pat McKenna

10. Administrative –

Name – *Operations Analysis Support to Network Centric Operations*
Dates – 27-29 January 2004
Location – Booz Allen Hamilton, McLean, VA
Fees –

Mini-Symposium Only:	US Federal Government $115 and $230 for all others
Entire Workshop:	US Federal Government $225 and $450 for all others

Attendance – 200 people, by invitation
Classification – Unclassified

MORS Special Meeting Planning Committee

MORS Workshop:
Operations Analysis Support to Network Centric Operations

1. Core Group –

General Co-Chairs:	Dennis Baer, Northrop Grumman IT Kirk Michealson, Lockheed Martin ISS/AC-T
Technical Co-Chairs:	Dr. Richard Hayes, Evidence Based Research, Inc. Dr. David Alberts, OSD(NII)
Synthesis Chair:	Dr. Jerry Kotchka, FS, Lockheed Martin ISS/AC-T
Group:	CAPT Jeff Kline, NPS Michael Bauman, FS, TRAC Ft. Leavenworth David Garvey, Alidade Incorporated Dr. Stuart Starr, FS, The MITRE Corporation Dr. Russ Richards, JFCOM (MITRE) Dr. Greg Parnell, FS, USMA Prof Bill Kemple, NPS Bob Manke, Naval Undersea Warfare Center
Site Coordinator:	Booz Allen Hamilton
Administrative Coordinators:	Brian Engler, Executive Vice-President, MORS Natalie Kelly, Vice-President for Admin, MORS
MORS Bulldog:	Dean Free, Anteon

2. Working Groups –

   a. WG1 – *Measures of Merit*:

      Chair – Jim Jacobs, Northrop Grumman IT
      Co-Chair – Corinne Wallshein, AFSAA
      Advisor – Dr. Kimberly Holloman, Evidence Based Research, Inc.

   b. WG 2 – *Processes & Methodologies*:

      Chair – Dr. Daniel Maxwell, Evidence Based Research, Inc.
      Co-Chair – Ralph Klingbeil, Naval Undersea Warfare Center
      Co-Chair – Jeffrey Vick, Boeing Military Studies & Analysis
      Advisor – Graham Mathieson, UK Defence Science & Tech Lab

c. WG 3 – *Assessment Tools*:

Chair – Steven Beres, Evidence Based Research, Inc.
Co-Chair – Dr. Mark Youngren, The MITRE Corporation
Co-Chair – Ben Taylor, UK Defence Science & Tech Lab
Co-Chair – TJ Ferrell, Boeing Military Studies & Analyses
Advisor – LtCol Gregory McIntyre, JWARS, OSD(PA&E)

d. WG 4 – *Force Transformation Process*:

Chair – Bob Gregg, Whitney, Bradley & Brown, Inc.
Co-Chair – Duncan Tailby, JFCOM – Analysis Division
Advisor – Dr. John Hanley, IDA

e. WG 5 – *NCO & Coalition Forces*:

Chair – COL Pat Vye, ODUSA(OR)
Co-Chair – Ray Christian, Naval Undersea Warfare Center
Co-Chair – Joe Quartararo, JFCOM – Analysis Division
Co-Chair – Alan Cowdale, UK Defence Science & Tech Lab
Advisor – Walt Perry, RAND

f. WG 6 – *Applying NCO to Actual Events*:

Chair – MAJ Sean Deller, JFCOM, J9, Lessons Learned
Co-Chair – MAJ Greg Petrick, Hanscom AFB, Analysis Division
Advisor – COL Steven Mains, JFCOM, J9, Lessons Learned

3. Other Members –

a. Previous MORS Workshops –

Analyzing EBO – Dr. Richard Hayes, EBR, Inc.
Ms. Sue Iwanski, Northrop Grumman IT

OR Methods for IO – Dr. Richard Deckro, AFIT
LtCol Greg McIntyre, AFSAA

b. At-Large Members –

Jeff Manickas, Naval Undersea Warfare Command
George Cran, UK Defence Science & Tech Lab
Danielle Martin, EBR, Inc.

c. MORS Leadership –

Dr. Steven Pilnick, MORS VP(MO)
Mr. William Dunn, MORS Special Meetings Chair

MORS Special Meeting Presentations

MORS Workshop:
Operations Analysis Support to Network Centric Operations

1. Tuesday, January 27th, Mini-Symposium –

   a. Keynote Presentation –

      (1) *Transforming Defense* – VADM Arthur Cebrowski, USN, Retired

   b. Service Presentations –

      (1) *Operations Analysis Support to Network Centric Operations: A Joint View* – COL Steven Mains, Joint Forces Command, J-9, Lessons Learned
      (2) *Operations Analysis Support to Network Centric Operations: An Army Perspective* – Mr. Michael Bauman, Director, TRADOC Analysis Center, Fort Leavenworth, KS
      (3) *Analysis for Network Centric Warfare in the Navy* – Dr. Michael Bell, Senior Analyst, FORCEnet Requirements Branch, Office of the CNO (N61F)
      (4) *Operations Analysis Support to Network Centric Operations: UK Overview* – Dr. George Cran, Defence Science and Technology Laboratory (DSTL) Network Enabled Capability (NEC) Programme Leader, United Kingdom's Ministry of Defence

   c. Framework Presentations –

      (1) *C^2 in the Information Age: The Last Mile of Transformation* – Developed by Dr. David Alberts, Director, Research and Strategic Planning, OASD (NII); presented by Dr. Richard Hayes, President, Evidence Based Research, Inc.
      (2) *Network Centric Operations: Differences in Perspective* – Dr. Richard Hayes, President, Evidence Based Research, Inc.

   d. Guidance Presentations –

      (1) *Operations Analysis Process* – Dr. Jerry Kotchka, Senior Operations Analyst, Lockheed Martin Advanced Concepts
      (2) *Summary of the MORS Workshop: "Analyzing Effects-Based Operations"* – Dr. Richard Hayes, President, Evidence Based Research, Inc. and Ms. Sue Iwanski, Senior Operations Analyst, Northrop Grumman Information Technology
      (3) *Summary of the MORS Workshop: "Operations Research Methods for Information Operations – A Battlespace of the 21st Century"* – Developed by Dr. Richard Deckro, Professor, Operations Research Department, Air Force Institute of Technology; presented by LtCol Greg McIntyre, Deputy Director, Analyses Foundations, Air Force Studies and Analysis

(4) *Working Group Guidance* – Mr. Kirk Michealson, Senior Operations Analyst, Lockheed Martin Advanced Concepts
(5) *Technical Chair Guidance* – Dr. David Alberts, Director, Research and Strategic Planning, OASD (NII) and Dr. Richard Hayes, President, Evidence Based Research, Inc.
(6) *Synthesis Group Guidance* – Dr. Jerry Kotchka, Senior Operations Analyst, Lockheed Martin Advanced Concepts

2. Wednesday, January 28th, Workshop Joint Session – (Working Groups 1, 2, 3 & 6)

a. *Using JWARS for Analysis* – LtCol Greg McIntyre, Deputy Director, Analyses Foundations, AFSAA/SAA and Mr. Donald Bates, Director, JWARS Office, OSD(PA&E)

3. Wednesday-Thursday, January 28th-29th, Working Group Presentations –

a. Working Group 1, *Measures of Merit* –

(1) *Using JWARS for Analysis* – LtCol Greg McIntyre, Deputy Director, Analyses Foundations, AFSAA/SAA and Mr. Donald Bates, Director, JWARS Office, OSD(PA&E)
(2) *NCO Conceptual Framework,* Dr. Daniel T. Maxwell, Evidence Based Research, Inc.
(3) *IERs, the Pk's of Network Modeling*, Mr. Peter M. Kerekanich, TRAC
(4) *WIN-T Analysis of Alternatives, Emerging Results*, Mr. Steve Herndon, TRAC
(5) *NC Measures of Merit from a Queueing Theory Perspective*, Dr. Ralph S. Klingbeil, NUWCDIVNPT
(6) *Quantifying Information Availability for Situational Awareness*, LCOL Stephen R. Riese, TRAC

b. Working Group 2, *Processes and Methodologies* –

(1) *Using JWARS for Analysis* – LtCol Greg McIntyre, Deputy Director, Analyses Foundations, AFSAA/SAA and Mr. Donald Bates, Director, JWARS Office, OSD(PA&E)
(2) *NCO Conceptual Framework,* Dr. Daniel T. Maxwell, Evidence Based Research, Inc.
(3) *Full Spectrum Analysis*, Graham Mathieson, Defense Science and Technology Laboratory, UK MoD
(4) *Sweden's Roadmap to Network-Based Defence Transformation*, Dr. Anne Worm, Swedish Defence Research Agency

c. Working Group 3, *Assessment Tools* –

(1) *Using JWARS for Analysis* – LtCol Greg McIntyre, Deputy Director, Analyses Foundations, AFSAA/SAA and Mr. Donald Bates, Director, JWARS Office, OSD(PA&E)

(2) UK High-level Campaign models and NEC related Studies, Dr. Ben Taylor and Lynda Sharp, Defense Science and Technology Laboratory, UK MoD
(3) *CASTFOREM*, Doug Mackey, TRAC-WSMR
(4) *Quantifying Information Availability for Situational Awareness*, LCOL Stephen R. Riese, TRAC

d. Working Group 4, *NCO and Force Transformation* –

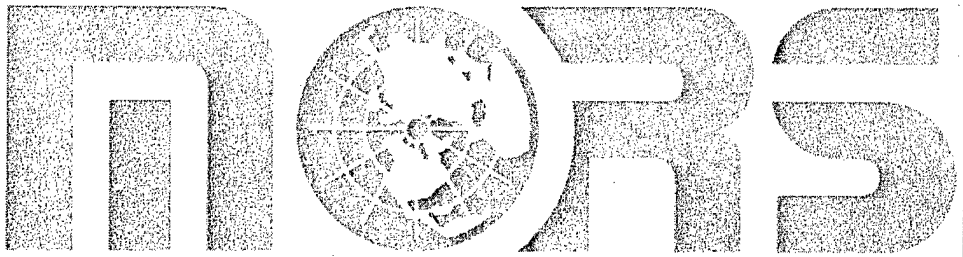
(1) *Strategic Planning and Force Transformation*, Duncan Tailby, Defense Science and Technology Organization, Australia
(2) *Joint Prototype Testing*, Joe Drelling, Joint Forces Command J9/MYMIC LLC

e. Working Group 5, *NCO and Coalition Forces* –

(1) *Insights from UK Data Link and Situational Awareness Studies* (UK)
(2) *NetCentric Operations in the Canadian Context* (CA)
(3) *Network Analysis from a Swedish OR Perspective* (SW)
(4) *Network Centric Operations and the Joint Interagency Coordination Group Workshop Results* (US)
(5) *Analysis of Carrier Task Force Network Centric Warfare Architectures for Network Centric Defense* (US)
(6) *An Analytic Approach to Network Centric Warfare Metrics and their Relationships: From Connectivity to Operational Tempo* (AU)
(7) *A Functional Survey of Netted Warfare Analysis Methods and Selected Applications to Coalition Maritime Tactical Situations* (US)
(8) *Dutch and German Forces Employment of Network-Centric Capabilities During Peace Keeping Operations* (US)
(9) *ACIDC Developments From Operation Iraqi Freedom Lessons Identified* (UK)
(10) *Analysis From Multi-National Limited Objective Experiment 2* (US)
(11) *Analysis Plan for Multi-National Experiment 3* (US)

f. Working Group 6, *Appling OA Support to an Actual NCO Event* –

(1) *Using JWARS for Analysis* – LtCol Greg McIntyre, Deputy Director, Analyses Foundations, AFSAA/SAA and Mr. Donald Bates, Director, JWARS Office, OSD(PA&E)
(2) *Joint Lessons Learned: Network Centric Warfare Observations in Operation IRAQI FREEDOM*, by Maj Michele Cook, Joint Lessons Learned Team, USJFCOM
(3) *Providing Analytical Support to SWA Phase-IV Ops with Representation in Theater (PASSPORT)*, by CPT Allison Stewart, Center for Army Analysis



Military Operations Research Society

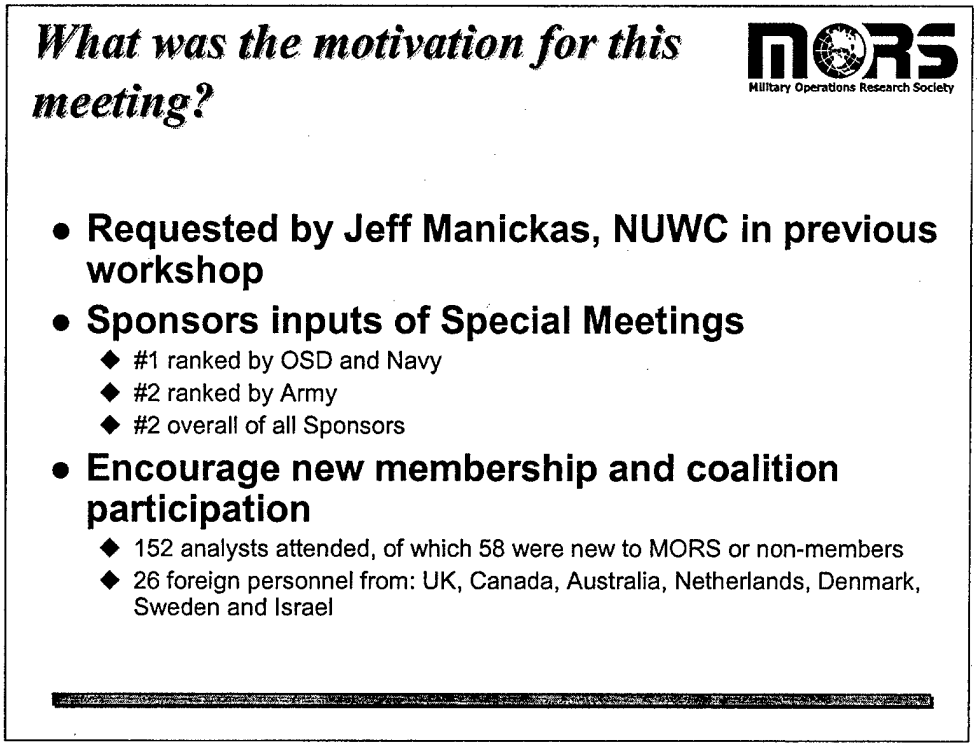
Operations Analysis Support to Network Centric Operations (NCO)

Sponsors Briefing

27 February 2004

Agenda

- What was the motivation for this meeting?
- How it was organized?
- What we found out?
- Where do we go from here?



Jeff Manickas recommended at the New Analysis Techniques Tutorial Workshop at JHU/APL in November 2002.

152 analysts and decision makers participated!! Of these, 94 were existing or former members and 58 were new to MORS or non-members. Included in the latter number were 26 foreign personnel from: UK, Canada, Australia, Netherlands, Denmark, Sweden and Israel.

How it was organized?
Schedule

- **1st Day - Mini-symposium**
  - Keynote Address – VADM Cebrowski, USN, (Ret.)
  - Service and Coalition Presentations
  - Framework Presentations
  - Guidance Presentations
- **2nd and 3rd day – Workshop**
  - WG 1: Measures of Merit
  - WG 2: Processes and Methodologies
  - WG 3: Assessment Tools
  - WG 4: NCO and the Force Transformation Process
  - WG 5: NCO and Coalition Forces
  - WG 6: Applying NCO to an Actual Event
  - Synthesis Group

Core Leadership

Co-Chairs: Dennis Baer, Northrop Grumman IT and Kirk Michealson, Lockheed Martin - ISS/AC-T

Technical Chairs: Dr. Richard Hayes, Evidence Based Research, Inc. and Dr. David Alberts, OSD(NII)

WG 1 Chair: Jim Jacobs, Northrop Grumman IT

WG 2 Chair: Dr. Daniel Maxwell, Evidence Based Research, Inc.

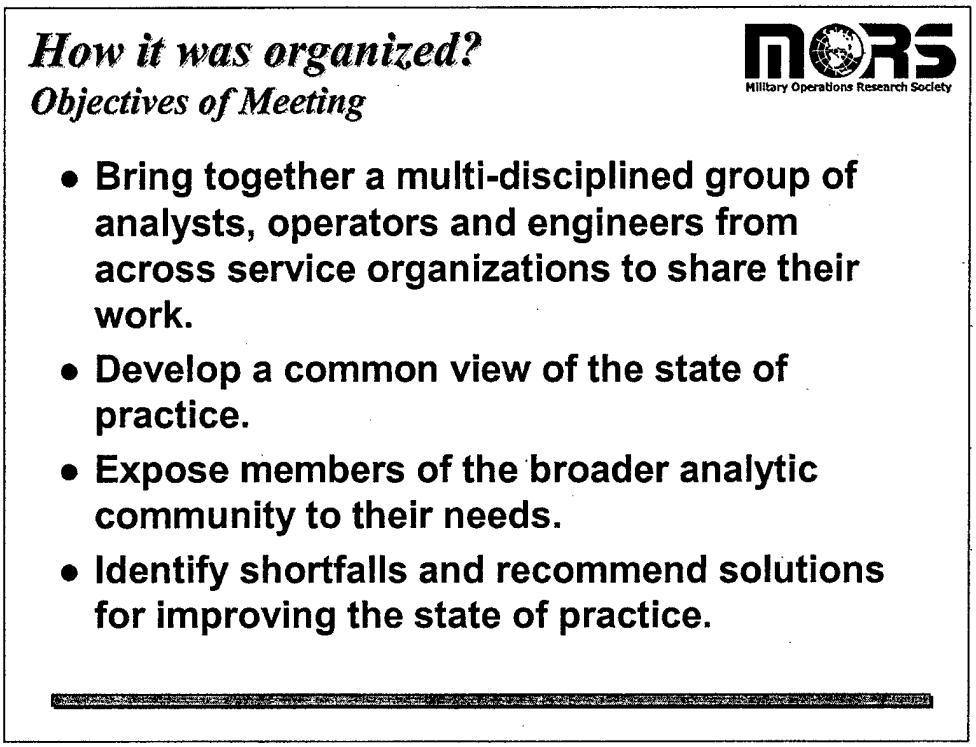
WG 3 Chair: Steven Beres, Evidence Based Research, Inc.

WG 4 Chair: Bob Gregg, Whitney, Bradley & Brown, Inc.

WG 5 Chair: COL Pat Vye, ODUSA(OR)

WG 6 Chair: Maj Sean Deller, JFCOM (Lessons Learned)

Synthesis Group Chair: Dr. Jerry Kotchka, FS, Lockheed Martin - ISS/AC-T

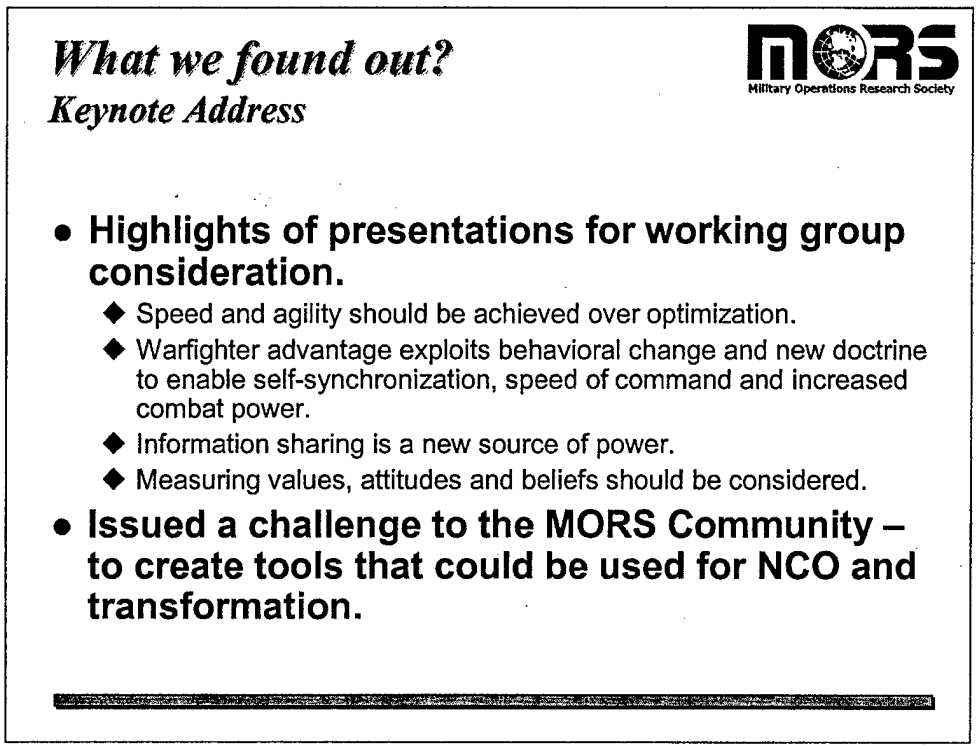


As Network Centric Operations (NCO) are being developed, the analytic community is being called upon to support the military services with assessments of needs and capability gaps to support decisions concerning options under consideration by the US Armed Forces and its coalition partners. Many organizations are interested and involved in employing and analyzing Network Centric Operations. With the emergence of "Information Age" warfare, the Operations Analysis (OA) community recognizes it must play a leadership role in creating and refining needed metrics, processes, methodologies, models and simulations. The community acknowledges an urgent need to share its efforts, successes and failures in developing the key capabilities required for analytically rigorous assessments of NCO. On 27-29 January 2004, MORS held a workshop on *Operations Analysis Support to Network Centric Operations* at the Booz Allen Hamilton Conference Center in McLean, VA. The goal of the meeting was to bring together a multi-disciplined group of analysts, operators and engineers from across service organizations to share their work, develop a common view of the state of practice, expose members of the broader analytic community to their needs, identify shortfalls and recommend solutions for improving the state of practice.

What we found out?
Broad Observations

- **More Senior analytical leaders and experienced analysts in MORS workshops.**
- **Joint business models**
- **Networking of analysts**
- **NCO addresses a set of Measure of Merits (MOMs), not by a single MOM**

A few broad observations of the workshop were noted. First, there exists a need to include senior service analytical leaders and experienced analysts in MORS workshops to enhance interactions, findings, recommendations and to mentor more junior participants. Second, a joint business model is needed that enables services and joint commands to conduct operations analysis in support of emerging NCO concepts. This will facilitate the initiation of OA activity early in the planning process. Third, networking of operations analysis centers and operation analysts along with adequate reach backreach-back should provide a significant improvement in support of decision makers. However, an environment of trust is needed among analysts and between the analyst and decision maker. Finally, that NCO analysis will not be addressed by a single Measure of Merit (MOM) but by a set of MOMs.



VADM Arthur Cebrowki, Director – Force Transformation, provided the keynote address. Some of the highlights from his presentation the participants could consider for their working group discussions included: 1) speed and agility should be achieved over optimization; 2) the warfighter advantage exploits behavioral change and new doctrine to enable self-synchronization, speed of command and increased combat power; 3) information sharing is a new source of power; and, 4) measuring values, attitudes and beliefs should be considered. During his presentation, he also issued a challenge to the MORS Community—to create tools that could be used for NCO and transformation.

What we found out?

Service and Coalition Presentations

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- **COL Steven Mains (JFCOM, J9, Deputy Director, Lessons Learned Group) provided the Joint Staff perception.**
  - Data is found – Information is made.
  - Collection does not equal knowledge. A huge "frame rate" could be counterproductive.
  - Networks do not produce knowledge. They pass data between people that can turn it into information and information between people that can turn it into knowledge.
  - Knowledge is the key to Network-Centric Operations.

What we found out?

Service and Coalition Presentations (con't)

Military Operations Research Society

- **Mr. Michael Bauman, FS, Director, TRADOC Analysis Center, presented the Army point of view highlighting the analysis completed for the Future Combat System.**
  - The FCS program and focused Army investments in new modeling have advanced the Army's ability to model and analyze network-enabled operations (aka NCO).
  - The military OA community still faces challenges though
    - → Complexity of NCO scenarios, overwhelming data and ambiguous cause-and-effects.
    - → Metrics useful to analysts and decision makers that also resonate with warfighters.
  - The "business model" to enable OA of joint operations, to include NCO, is still an exploratory work-in-progress.
    - → A means to generate data for joint system concepts is evolving.
    - → A mechanism to achieve authoritative representation of future joint concepts is much less mature.

What we found out?

Service and Coalition Presentations (con't)

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- **Dr. Michael Bell, Senior Analyst, FORCEnet Requirements, N61, followed with the Navy's status with their NCO system, FORCEnet. Some highlights included:**
  - ◆Demonstrated FORCEnet's value of analytical framework:.
    - →Connects FORCEnet capabilities and NCW Framework
    - →Capabilities under revision
    - →Quantitative measures partially successful and improvements proposed
  - ◆Improved representation of how knowledge is achieved in C4ISR campaign analysis.

What we found out?

Service and Coalition Presentations (con't)

Military Operations Research Society

- **Dr. George Cran, UK MoD Network Enabled Capability (NEC) Programme Leader, presented the United Kingdom view. Dr. Cran highlighted the operations analysis issues for NEC**
  - Bringing together future military thinking with future technological capabilities across the spectrum of operations and levels of command.
  - Thinking out of the box – doing better things.
  - Bringing all Lines of Development into the analysis, especially people issues.
  - Bringing practicalities to the vision: drawing operational lessons learned and experimentation into the analysis.
  - Enhancing the tool-set to reflect NEC with greater fidelity.
  - Conducting Balance of Investment studies between 'hard' systems and information systems.

What we found out?
Framework Presentations

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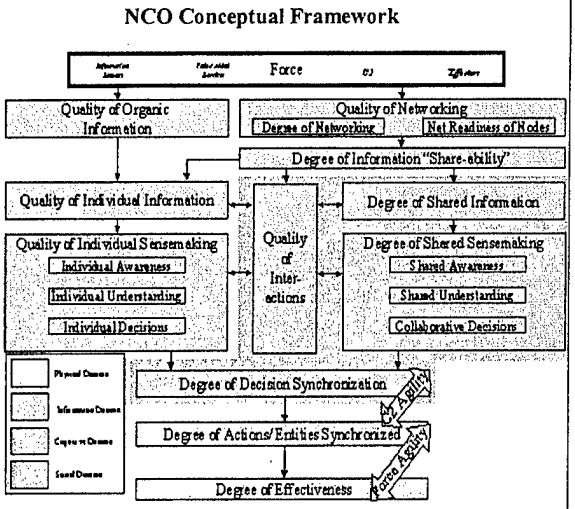
- **The Technical Co- Chairs, Dr. David Alberts and Dr. Richard Hayes, provided two framework discussions:**
  - "C2 in the Information Age: The Last Mile of Transformation"
  - "Network Centric Operations: Differences in Perspective"



The first, titled "C2 in the Information Age: The Last Mile of Transformation," was intended to provide a common definition of Network Centric Operations for the working groups. Some of the discussion points included the value of the NCO Framework, the prerequisites for transformation, power to the edge, making it happen – becoming an "edge" organization, and the OSD(NII) initiatives for building, populating and protecting the network. The second, titled "Network Centric Operations: Differences in Perspective," was offered to present the Network Centric differences among the United States, United Kingdom, Sweden, Australia and NATO.

What we found out?
Framework Presentations (con't)

Military Operations Research Society

- **As one of the Technical Co-Chairs for the Analyzing Effects-Based Operations Workshop, Ms. Sue Iwanski passed on the following take-away thoughts:**
  - The term "Indicators of Success" was used for EBO since it expands beyond traditional Measures. NCO may also require non-traditional Measures.
  - Fundamental Sciences were considered to be useful for EBO.
  - The EBO tool chest was envisioned to include easily manipulated, specialized modeling and simulation tools, computational social science tools, data mining, colored Petri nets, neural networks, and specialized tools developed in particular application areas.
  - Networks are targets in EBO. Information exchange is vital to NCO.
- **As the Chair for the Operations Research Methods for Information Operations Workshop, Dr. Richard Deckro prepared a list of points to consider for the participants:**
  - Build MOE's and Battle Damage Assessments for NCO
  - Extend into EBO MOEs for NCO use
  - What should a NCO "JMEMS" look like?
  - Does the NCO framework help?
  - What do Commanders need to use NCO as a "primary arrow" in their quiver?
  - Leadership understanding
  - Tools
  - Intel
  - What are the human element needs?

What we found out?

Guidance Presentations

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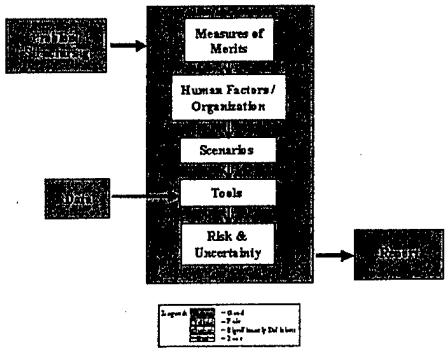
- **The working groups were asked, if possible, to provide assessments to revitalize the state of analytical practice, i.e., their "State of Health" in two areas: the Operations Analysis Process and the Network Centric Warfare four key domains.**

Operations Analysis Process



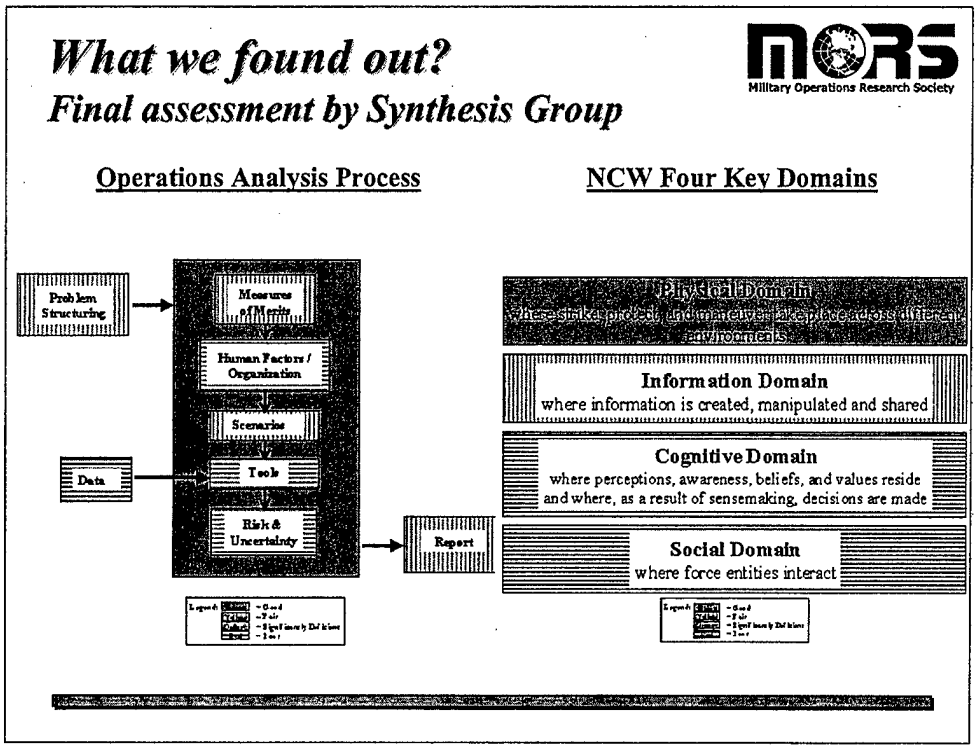
NCW Four Key Domains

Physical Domain
where strike, protect, and maneuver take place across different environments

Information Domain
where information is created, manipulated and shared

Cognitive Domain
where perceptions, awareness, beliefs, and values reside and where, as a result of sensemaking, decisions are made

Social Domain
where force entities interact



Network Centric Warfare Operations can be represented using four key domains (physical, information, cognitive and social), the state of health for OA, in relation to these domains, was estimated as deficient or poor. Even at the physical level of modeling and analysis, it appears that the Operations Analysis community continues to focus on the warfare (combat) portion of NCO and not on the larger set of military missions (e.g., OOTW) – as evidenced by the scarcity of methods for these situations. In general, applying OA across the four domains was considered fair or poor: physical – fair, information – fair, cognitive – poor, and social – poor. Overall, the OA community seems to be uncomfortable with expanding their analysis into the cognitive and social levels. Scientific approaches of the past that addressed the physical domain well apparently do not represent the other domains well, and are usually limited in focus to key physical interactions associated with combat and combat support operations. Methods from other disciplines, such as the medical medicine, genetics, sociology, psychology, political science, and cultural anthropology fields, should be considered as potential sources of knowledge that could inform the OA process and community.

What we found out?
WG 1: Measures of Merit

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- **The findings focused on the assessment that the MOMs for NCO, especially for understanding a networked "cause and effect" relationship, are a work-in-progress. However, previous MOMs for the physical domains for warfighting missions are well understood and remain relevant.**
  - MOMs must both enable the analyst and inform the client; these may be starkly different for Network Centric Operations Analysis (NCOA). MOMs for NCOA are a work-in-progress.
  - Survivability-related MOMs are increasingly relevant to military operations and remain so for NCOA as well (at all levels, i.e., MOPs, MOEs).
  - A combination of MOMs is necessary for OA of networked "cause-and-effect" relationships.

What we found out?

WG 2: Processes and Methodologies

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- **The findings focused on the NCW conceptual framework and the gap between sense-making and decision making. It was also suggested that the relationship between cognitive modeling and sense-making modeling needs to be addressed.**
  - The NCO framework emphasizes "Quality of Individual Sense-making" and the "Quality of Group Sense-making" versus decision making.
  - Many in the NCO community assert that cognitive modeling is an essential part of the solution to modeling sense-making.
  - The lack of processes and methodologies for OA using sense-making and cognitive modeling make the NCO framework a challenge to operationalize.

What we found out?

WG 3: Assessment Tools

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- **The findings were along three dimensions: 1) "better" data; 2) improvement in NCO assessment tools; 3) and, the netting of assessment tools in order to achieve synergy in the application of a tool set.**
  - Some tools exist, but the data domain (both real blue and red data) is still too stove-piped.
  - The methods to change information to knowledge seem to exist within the models, but are not well understood.
  - Netting assessment tools is necessary but not sufficient; we must learn to "do better things," not "do things better."
  - The networked force must be treated as a holistic entity not as a sum of discrete elements.

What we found out?

WG 4: NCO and the Force Transformation Process

- **To effect Force Transformation it was concluded that the further we move away from assessing transformations that are focused on a single Service, tactics and material ("old" missions, etc.), the less OA tools are available to the analyst for information, cognitive and social domain related assessments.**

What we found out?
WG 5: NCO and Coalition Forces

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- **It was discussed that the OA timelines are not fast enough to keep pace with technology and other developments. The experience of the UK's embedded OAs needs to be assessed and possibly followed. However, the inclusion of civilian agencies, such as the Department of Homeland Security, must also be addressed.**
  - OA analysis timelines are not fast enough to meet the pace of technology and DOTMLPF development.
  - OA is overly focused on military to the exclusion of civilian agencies.
  - Need to consider new level of embedded analysis (OA in-theater with data mining and assessment tools) to provide real time feedback on NCO effectiveness.

What we found out?

WG 6: Applying NCO to an Actual Event

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- **It was found that because policies and doctrine to incorporate analysis is lacking, along with the minimal use of embedded analysts, that OA becomes an afterthought. If these findings and the data domain are improved, then the assessment of actual NCO events will be improved.**
  - Lack of joint and some Service doctrine to incorporate analysis in a JTF limits OA support of NCO.
  - Reliance on non-embedded analysts makes OA an afterthought in JTFs.
  - OA currently limited by available and valid data.
  - Time and data constraints limit the tool set.

What we found out?
Extent of Collaboration

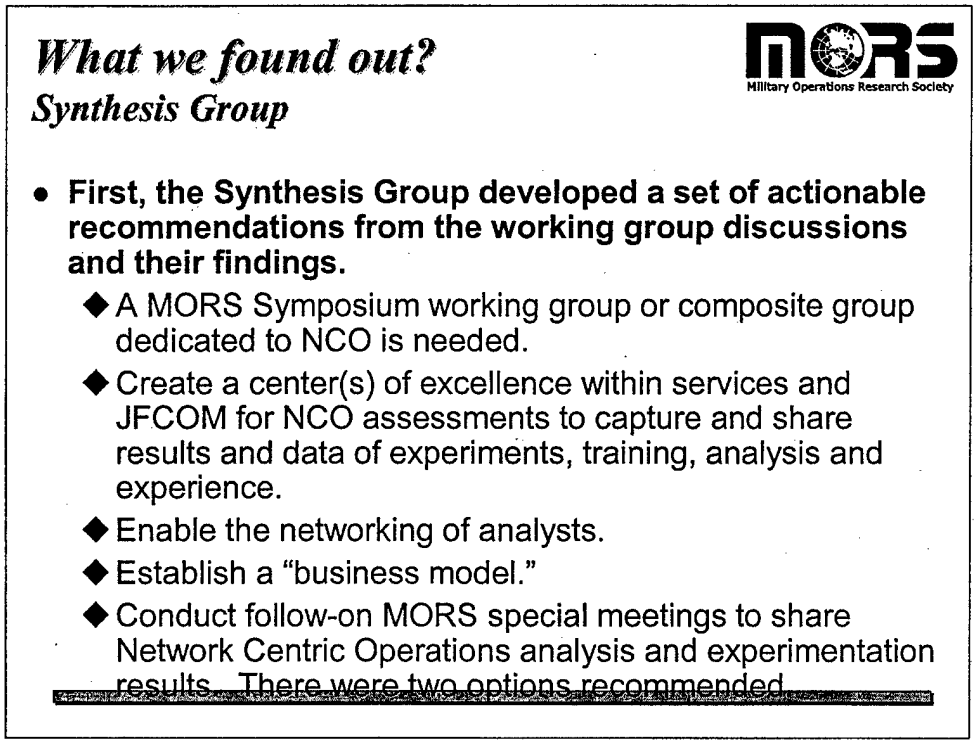
- **Among the Services**
  - Two dimensions: Between operators and between analysts
  - Inconsistent and very infrequent
- **With the US Agencies**
  - Difficult to asses
  - Examples unknown
- **With the Coalition Forces**
  - Infrequent and inconsistent
  - Most collaboration is on a bilateral basis

As with the State of the Practice, each of the working groups were asked to provide a self-assessment of the level of collaboration among the Services, Coalition Forces and US Agencies where operations analysis has been applied to NCO.

The level of collaboration among (and within) the Services was assessed as inconsistent. Collaboration between services is varied and has two dimensions: between operators and between analysts. Collaboration between analysts was good with the Joint Lessons Learned Team because they were located at all Combatant and Component Headquarters – so contact was physical. Collaboration between Service teams at disparate sites was very infrequent. Most were completely unaware of the others' existence.

The collaboration with the US Agencies was difficult to assess because the majority of the attendees did not know examples. Working Group 6 discussed that the *OIF* Phase IV planning involved almost every major agency in the US government; however, none of them had the collaborative capabilities and expertise to contribute effectively and in a timely manner.

For the Coalition Forces, collaboration was considered infrequent and inconsistent. A spectrum of change of military forces in the international community exists from status quo to modernization through transformation of forces. Nations are at different points in the spectrum with respect to NCO but they are committed to moving away from the status quo end of the spectrum. The participation to various multinational forums is evidence of the commitment. It was noted that most collaboration with Coalition forces is on a bilateral basis. Many of the activities are modest events between coalition partners (entropy work, agent based modeling, S&T assessment, an assessment of decision making in collaborative environments, development of a conceptual model, and working groups to discuss interoperability). The conclusion is that there is still a need for significant collaborative analytical events between Coalition partners.



First, the Synthesis Group developed a set of *actionable* recommendations from the working group discussions and their findings.

- A MORS Symposium working group or composite group dedicated to NCO is needed. NCO is much more than C4ISR and Information Operations. This new working group/composite group could be charged to examine the OA toolkit and processes in order to better focus on the NCO problem. At the 72nd MORSS, propose the CG B Chair discuss this issue with the leadership from Working Groups 5-10, providing recommendations to the MORS Working Group/Composite Group Committee Chair and the Vice President (Meeting Operations).
- Create a center(s) of excellence within services and JFCOM for NCO assessments to capture and share results and data of experiments, training, analysis and experience.
- Enable (thru agreements, business practices) the networking of analysts working NCO and provide reach-back for tools, data, and previous studies.
- Establish a "business model" that enables services to conduct operations analysis in support of "born joint" NCO concepts that is underpinned by a set of approved tools and data.
- Conduct follow-on MORS special meetings to share Network Centric Operations analysis and experimentation results. There were two options recommended:

A 2-day or 3-day Mini-Symposium to educate the community in the area of NCO analyses. Training and education was seen to be critically important to transformation overall, and specifically, to the operations analysis practice in support of NCO.

A 3-day Workshop to discuss the issues more fully. It was suggested to provide foundation presentations during the morning of the 1st day and outbriefs during the afternoon of the 3rd day—this would leave two full days for discussion and further debate. During this workshop the working groups felt they only "scratched" the surface in their discussions.

What we found out?

Synthesis Group Summary

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- OA process developed in the Industrial Age has applicability to Network Centric Operations (NCO) in the Information Age.
- We do not do a satisfactory job in documenting, sharing and learning from NCO analyses performed.
- With the arrival of terrorism, other asymmetric threats, rogue nations, and homeland defense, NCO is an opportunity for transformation.

What we found out?
Future Challenges

- **Metrics developed for social and cognitive domains.**
- **Tools developed or adapted to changing and emerging concepts.**
- **Anticipating next transformational capability or technology on the horizon.**
- **Coalition warfare analysis is lacking in today's assessment tools.**
- **The warfighting culture needs to be changed to accept more analysis, i.e., emphasis on collecting data should start in the planning phase.**

The working group attendees were asked to assess their future expected challenges.

The primary challenge for measures of merit is to keep up with the rapidly changing scope of NCO. Agility is a desirable feature (for which measures are needed) in NCO. The metrics set should be agile as well. Not only do we need more and better measures for NCO, we need to rigorously address the issue of sufficiency. How much is enough? The answer may differ from one situation to the next. Development of standards for NCO analysis, including metrics, faces the challenge of incorporating the terminology and practices of the social sciences in order to establish measures in the social and cognitive domains.

In order to accurately represent NCO, a new set of models or a new way of interoperating between them needs to be created. Today's models cannot represent NCO. In order to accurately represent NCO and conduct accurate NCO analysis, all aspects of NCO need to be represented. This means networking not only two battalions but also all actors involved in the operation including reach-back capabilities. This is the essence of NCO, and the capabilities cannot be explored if they are not represented. Essentially, the tools that need to be developed need to be able to adapt to changing and emerging concepts. In a complex, network centric world the analysis challenges will continue to evolve. We should not adopt a mindset of getting the tools and processes "right"—we need an ethos of continuously examining our tools and processes to make them better.

Notes Continued from previous page (E-25).

What is the next transformational capability or technology on the horizon? Analysts can and should be engaged in this effort, and clearly must look beyond the bounds of defense industries for promising opportunities. By taking a broad look at the 8 "key elements" of transformation (and beyond) we may uncover areas for further investigation. This is not a one-player game—we must also think about areas that potential adversaries can exploit and work them in to our future scenarios and operating concepts. Palm pilots on the battlefield are an example of bottom-up approaches that have been attempted by tactical and operational forces. These typically are not officially sanctioned. Some may have great value, some may have minimal impact, and some may be downright dangerous. Analysts need to engage in the effort to assess these "bottom-up" initiatives.

Coalition warfare analysis is lacking in today's assessment tools. In the United States, Joint is making some headway, but most operations in the future will compose Coalition forces. Throughout recent history, the ability to share information in a Coalition environment is a great difficulty though necessary. Other issues that need to be addressed in the Coalition environment are linguistic issues, and the systems interoperability. NCO most certainly is about fostering collaboration and networking to a wide degree. We must expand our network of analysts in include interagency, Coalition, and non-governmental partners.

On the battlefield, if we don't do anything the information-sharing problem will actually get worse because the planning, execution and analysis processes are conducted increasingly on the SIPRNET. This has the effect of excluding our Coalition partners. Over-classification of planning, deployment, and execution and sustainment products exacerbates the information-sharing problem. This adds work to the declassification work that the staff Foreign Disclosure Officers must do prior to transferring products to coalition info sharing systems like CENTRIX.

The warfighting culture needs to be changed to accept more analysis. This will require changes in doctrine and training and experience of leaders. As analysts do more collection and analysis in the field, the procedures for data collection will mature, but emphasis on collecting data should start in the planning phase.

Discussion

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- **Where we go from here?**
  - ◆ DoD Analysis Community
  - ◆ MORS Community

Where we go from here?
DoD Analysis Community

- **Synthesis Group**
  - Center of Excellence
  - Networking of Analysts
  - Establish a Business Model
- **Future Challenges**
  - Metrics
  - Tools
  - Technology Assessment
  - Coalition Warfare Analysis
  - Integrating Analysis Into Warfighting

Where we go from here?
MORS Community

Military Operations Research Society

- **Synthesis Group**
- **Future Challenges**
- **Composite Group for NCO**
- **Follow-on Meeting**

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MORS Workshop: Decision Aids/Support to Joint Operations Planning

Pat McKenna, USSTRATCOM, McKennaP@stratcom.mil

At the request of United States Strategic Command (USSTRATCOM), MORS conducted a Workshop on Decision Aids/Support to Joint Operations Planning at Offutt AFB, NE, 18-20 November 2003. The Air Force Studies and Analyses Agency (AFSAA), as a MORS Sponsor, was a proponent of the meeting. Eighty-two (82) people representing all the services, the Combatant Commands, OSD, the Joint Staff, and other agencies attended the conference. Two of the attendees were from the United Kingdom (UK), offering a valuable perspective on the topic. Forty of the participants were attending their first MORS event. **Pat McKenna** and Dr **Roy Rice**, FS, were co-chairs of the Workshop.

The focus of this workshop was on Military Planning, Joint Operation Planning (Crisis and Deliberate), Joint Operation Planning and Execution System (JOPES) functions of Strategy Determination and Course of Action Development. The intended audience was analysts and operational planners at all levels of military organizations. Our goals and objectives were to identify analytic approaches that might be used to enhance the JOPES planning functions of Strategy Determination and Course of Action Development.

Specific Objectives:

- Examine techniques of eliciting information from decision makers and displaying information back to decision makers.
- Examine the implications of time on the level of detailed analysis possible and how tools/techniques can address time/detail scaling issues.
- Examine tools/techniques/theories that could be applied to the JOPES functions of Strategy Determination and Course of Action Development.

Background on JOPES

As discussed in Joint Pub 5-0, *Doctrine for Planning Joint*

(See **DECISION,** *p. 36)*

MORS Workshop: Operations Analysis Support to Network Centric Operations

Kirk Michealson, Lockheed Martin Advanced Concepts, kirk.a.michealson@lmco.com
Dennis Baer, Northrop Grumman IT, dennis.baer@ngc.com

Background

As Network Centric Operations (NCO) are being developed, the analytic community is being called upon to support the military services with assessments of needs and capability gaps to support decisions concerning options under consideration by the US Armed Forces and its coalition partners. Many organizations are interested and involved in employing and analyzing Network Centric Operations. With the emergence of "Information Age" warfare, the Operations Analysis (OA) community recognizes it must play a leadership role in creating and refining needed metrics, processes, methodologies, models and simulations. The community also acknowledges an urgent need to share its efforts, successes and failures in developing the key capabilities required for analytically rigorous assessments of NCO.

On 27-29 January 2004, MORS held a workshop on *Operations Analysis Support to Network Centric Operations* at the Booz Allen Hamilton Conference Center in McLean, VA. The goal of the meeting was to bring together a multi-disciplined group of analysts, operators and engineers from across service organizations to share their work; develop a common view of the state of practice; expose members of the broader analytic community to their needs; identify shortfalls and recommend solutions for improving the state of practice. 152 analysts and decision makers participated. Of these, 94 were current or former members and 58 were new to MORS. Among the participants were 26 foreign personnel from the UK, Canada, Australia, Netherlands, Denmark, Sweden and Israel.

Workshop Description

Mini-Symposium Overview (1st Day) –

The mini-symposium on the first day featured presentations to bring us up to speed on the state of the practice of operations

(See NCO, p. 30)

Appendix F

analysis support to NCO. After the welcome and introductions by the MORS President (LTC **Willie McFadden**, USA), Host (Mr **Steve Starner**, BAH) and General Co-Chairs (Mr **Dennis Baer**, Northrop Grumman IT and Mr **Kirk Michealson**, Lockheed Martin Advanced Concepts), VADM **Arthur Cebrowski**, USN (Ret.), Director, Office of Force Transformation provided the keynote address on "Transforming Defense and Implementing Network Centric Warfare."

Next the Services were invited to provide, from their perspective, an overview of the challenges and progress to date using operations analysis to support NCO, including highlighting context, issues and what is needed from the analytical community, and identifying some of the broad analytical and difficult questions they have observed. The Service presentations were provided by COL **Steven Mains** (Joint Forces Command, J9, Lessons Learned Group); Mr **Michael Bauman**, FS (Director TRADOC Analysis Center, Fort Leavenworth, KS); Dr **Michael Bell** (Senior Analyst, FORCEnet Requirements Branch, Office of the CNO); and, Dr **George Cran** (NEC Programme Leader, Defence Science and Technology Laboratory, UK Ministry of Defence).

Dr **Richard Hayes**, President of Evidence Based Research, Inc. and Workshop Technical Co-Chair, provided two framework presentations. The first offered a foundation of Network Centric Operations in a brief titled "C2 in the Information Age: The Last Mile of Transformation," while the second discussed the conceptual differences between the United States and Coalition Countries with respect to NCO and Transformation.

The final sessions of the day were presentations that offered guidance for the remaining two days of the workshop. Dr **Jerry Kotchka**, FS (Lockheed Martin Advanced Concepts) provided a review of the operations analysis process; Ms **Sue Iwanksi** (Northrop Grumman IT) followed with an overview of the MORS *Analyzing Effects-Based Operations* Workshop; and, LtCol **Greg McIntyre** (Air Force Studies and Analyses Agency) offered an overview of the MORS *Operations Research Methods for Information Operations* Workshop.

Workshop Overview (2nd & 3rd Days) –

The mini-symposium was followed by a two-day workshop. The participants met in six working groups: (1) *Measures of Merit;* (2) *Processes and Methodologies;* (3) *Assessment Tools;* (4) *NCO and Force Transformation;* (5) *NCO and Coalition Forces;* and, (6) *Applying NCO to Actual Events.* A *Synthesis Group* was formed to examine insights across all six working groups and to help bring together a consistent set of workshop findings.

NCO Definition

A common definition of Network Centric Operations was developed by the Technical Co-Chairs (Dr **David Alberts**, OSD (NII), and Dr Richard Hayes). Network Centric Operations involves the development and employment of mission capability packages that are the embodiment of the tenets of Network Centric Warfare (NCW) in operations across the full mission spectrum. These tenets state that a robustly networked force improves information sharing and collaboration, which enhances the quality of information, the quality of awareness, and improves shared situational awareness. This results in enhanced collaboration and enables self-synchronization, improving sustainability and increasing the speed of command, all of which ultimately result in dramatically increased mission effectiveness.

The principles of Effects Based Operations (EBO) go hand-in-hand with NCO because warfare, particularly effective warfare, has always been effects-based. **Sun Tzu, Genghis Khan**, **Napoleon**, **Eisenhower** and **Schwarzkopf** all would be familiar with the principles that (1) warfare should include all the instruments of national power and that (2) each instrument should be applied in a way that maximizes its desirable impact, minimizes undesirable ones, and complements actions taken in other arenas. These basic principles, which define the essence of EBO, occur in a context that makes them particularly relevant today. First, we have the means to gather, integrate, and apply more data, information, and knowledge than analysts and policy makers in earlier eras — we are in the Information Age. The tenets of NCW address these means and postulate how they can increase mission effectiveness. The seven tenets of NCW are:

1. Robustly networked force
2. Information sharing
3. Collaboration
4. Quality of information
5. Shared situational awareness
6. Self-synchronization
7. Sustainability and speed of command

Second, we live in a world that is more tightly coupled than ever before, creating opportunities and challenges for direct and indirect, desirable and undesirable effects.

NCO encompasses Networked Enabled Capability (UK, Australia), Networked-Based Defense (Sweden), and concepts from other nations also based upon operationalizing the tenets of Network Centric Warfare.

Goals and Objectives

Many organizations are attempting to analyze, understand, and employ Network Centric Operations. The analytic community needs to support the military services, joint community, and other stakeholders with assessments as NCO is being developed. The community should play a leadership role in creating and refining the metrics, processes, methodologies, models and simulations necessary to understand this emerging area. The community should share efforts, successes and failures in the key capabilities. As a first step, the goal of the meeting was to provide an opportunity to bring a multi-disciplined team of analysts, operators and engineers from those organizations together to share their work, develop a common view of the state of practice, expose members of the broader analytic community to their needs, identify shortfalls and potential solutions.

The overall objectives of the workshop were to provide an assessment and a roadmap to revitalize the state of the analytical practice as it relates to NCO, and to recommend priorities for any initiatives identified. In other words, to assess:

- "State of Health" – Provide an assessment of the state of analytical practice related to NCO.
- "Findings" – Provide a roadmap to revitalize that state.
- "Recommendations" – Recommend priorities for any initiatives identified in the roadmap.

Some specific objectives for the Working Groups were as follows:

- *WG 1: Measures of Merit.* A great deal of work has gone into developing a conceptual framework for Network Centric Warfare. An extensive body of literature exists and robust discussion continues. Measures of merit have been addressed often in this context. Several approaches have been proposed for measuring the effectiveness of Network Centric Operations. Much of the discussion has focused on measures of performance for the network that enables NCO. One reason for this inclination is that, relative to other areas of NCO theory, data is readily available. However, NCW is not simply a new communications system with embedded decision support. Therefore, it is important to examine the impact of NCW technologies and practices across the physical, information, cognitive and social domains. To devise metrics for these other aspects of NCO, several approaches were considered for the workshop. The Network Centric Operations Conceptual Framework (Figure 1) was the starting place. Discussions on cognitive and social aspects also were reviewed to ensure that the appropriate measures and metrics were considered.
- *WG 2: Processes and Methodologies.* There were three objectives: (1) use the NCO Conceptual Framework to assess operations analysis ability to evaluate NCO enabling capabilities, (2) identify areas of weakness in both the NCO Conceptual Framework and the OA Process, and (3) recommend near and longer term actions that will improve the operations analysis community to support NCO related research, analyses, and implementation.
- *WG 3: Assessment Tools.* The objective of this working group was to assess various models across the four Network Centric Warfare domains. Models are a set of algorithms and data, with supporting infrastructure that manages output, random number generation, etc. For each major algorithm that models an important aspect of NCO, whether contained in the existing tools or those under development, the modeling process was examined to determine if it is mature, developing, immature or unknown. The working group also discussed if research is needed to increase understanding of how specific NCO aspects can be assessed or new algorithms developed. For data, an insight gained from a model is the combination of the data and the model's transformations of input data into output. Given all of the existing and proposed tools that may be used for NCO, the state of the data required to make these tools "study ready" was assessed.

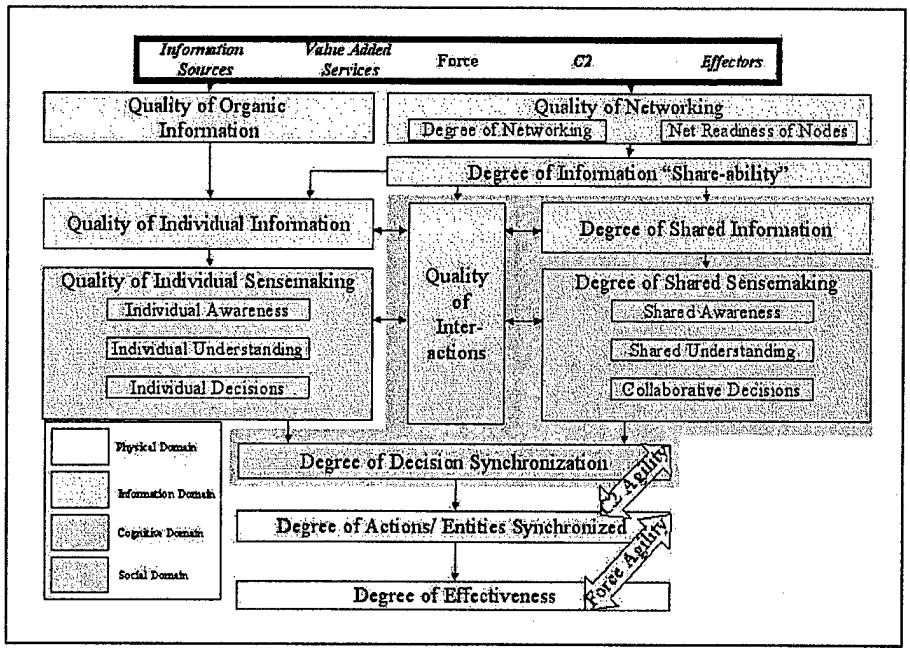

Figure 1: NCO Conceptual Framework

- *WG 4: NCO and the Force Transformation Process.* Working Group 4 examined how operations research methods can be applied to NCO in the context of the Force Transformation Process. Transformation will only happen when eight "key elements" coevolve to take full advantage of information age technologies, capabilities and opportunities. These eight key elements are: (1) concepts; (2) leadership; (3) education; (4) culture; (5) training; (6) organization; (7) process; and, (8) technology. The principal task for the Force Transformation group was to understand how OA techniques can be applied across the eight "key elements" of transformation and balance the transformation process.
- *WG 5: NCO and Coalition Forces.* There were three major objectives of this working group: (1) to review and discuss papers that address current practice in the areas of tools, studies, and experimentation or live events; (2) to discuss each individual country's state of practice of OA in support of NCO, to identify good and bad points and to identify future directions; and, (3) to assess collaborative efforts among coalition partners to determine shortcomings and to recommend ways to improve collaborative OA efforts. Papers were presented in three areas: (1) country study overviews; (2) tools; and, (3) experiments and live events.
- *WG 6: Applying NCO to an Actual Event.* This working group examined the application of Network Centric Operations in support of recent operations in Afghanistan and Iraq. The working group reviewed the data for Operations Desert Storm and Iraqi Freedom to look for the limiting factors, the tools and techniques, and the different ways that operations analysis can help take information and enable events.

State of the Practice

The working groups were asked, if possible, to provide their "State of Health" in two contexts: the Operations Analysis Process (Figure 2) and the Network Cen-

(See NCO, p. 32)

(continued from p. 31)

tric Warfare four key domains (Figure 3). Additionally, the seven tenets of NCO in relation to the framework were evaluated by the *Processes and Methodologies* Working Group and the eight key elements of transformation were considered by the *Force Transformation* Working Group.

Within the OA Process, the measures were evaluated as frequently being used, but inconsistent in their application. In addition, the immaturity of an "NCO OA Process" was considered consistent with the state of the understanding of NCO, and, in the context of NCO, the tools were used infrequently. Current measures, tools and practices are understandably grounded in what we know and the decision process we support, but applying operations analysis in the area of Network Centric Operations is in its infancy. The US Army's Future Combat System and the Navy's FORCEnet activities are initial efforts.

In applying operations analysis to NCO events, discussions highlighted the perceptions that: the OA process is currently limited by available and valid data, the real-world operation is a dynamic environment and the data is not clean or consistent, warfighting systems do not output analytically-ready data, and data collection must be pre-planned due to the numerous organizations involved and their focus on the real-world operation.

The state of health for OA, in relation to the NCO four key domains shown in Figure 3, was estimated as deficient or poor. Even at the physical level of modeling and analysis, the Operations Analysis community continues to focus on the warfare (combat) portion of NCO and not on the larger set of military missions (e.g., OOTW) – as observed in the scarcity of methods for these situations. In general, applying OA across the four domains was considered fair or poor: physical – fair; information – fair; cognitive – poor; and, social – poor. Overall, the OA community seems to be uncomfortable with expanding its analysis into the cognitive and social levels. Scientific approaches of the past that addressed the physical domain well apparently do not represent the other domains as well, and usually are limited in focus to key physical interactions associated with combat and combat support operations. Methods from other disciplines, such as medicine, genetics, sociology, psychology, political science and cultural anthropology fields, should be considered as potential sources of knowledge that could inform the OA process and community.

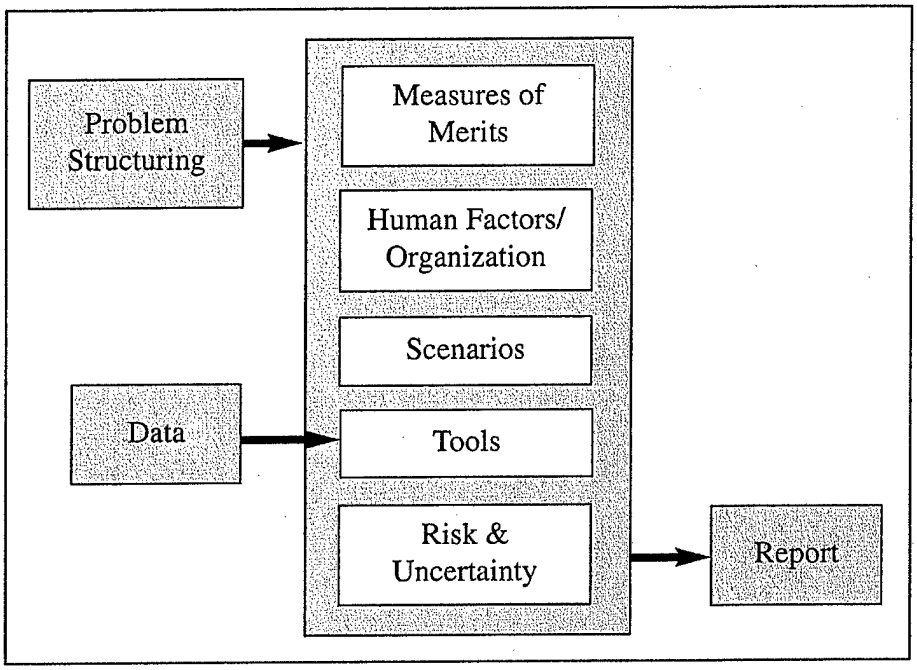

Figure 2: Operations Analysis Process

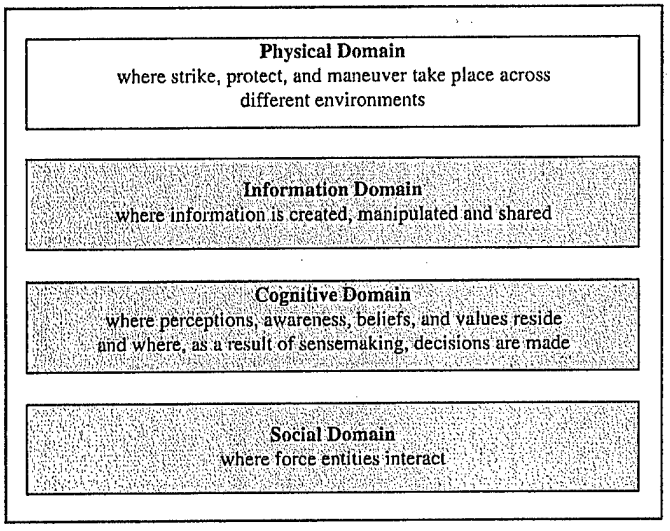

Figure 3: New Four Key Domains

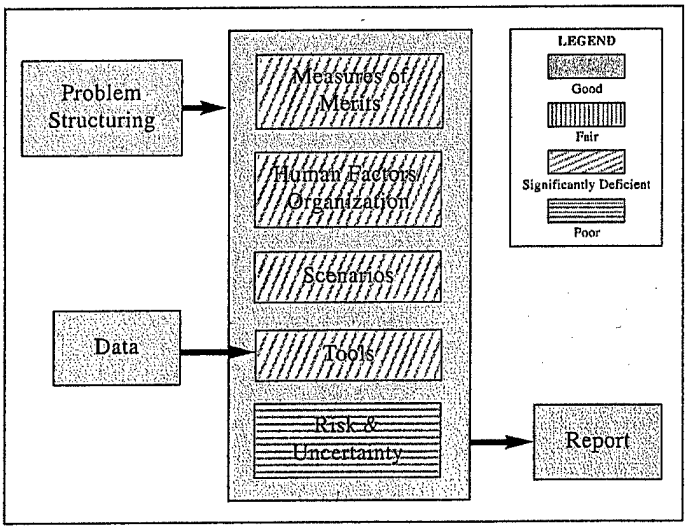

Figure 4: Overall Assessment of Applying OA to NCO

Over five years ago at the MORS Mini-Symposium and Workshop on "Analyzing C4ISR for 2010," a template for the NATO Code of Best Practice for Assessing Command and Control was developed and evaluated. This template was used to evaluate the OA process for NCO and the Synthesis Group's overall assessment in having examined assessments from all six working groups is contained in Figure 4. There seems to be an overall decrease in the adequacy of the process, due mainly to a feeling that NCO as a whole may be more difficult to evaluate then C4ISR alone.

With inputs from each of the working groups, the Synthesis Group's overall qualitative assessment across the NCW four key domains is provided in Figure 5. The physical domain is assessed to be in better "health" from the application of the OA process than the other three domains.

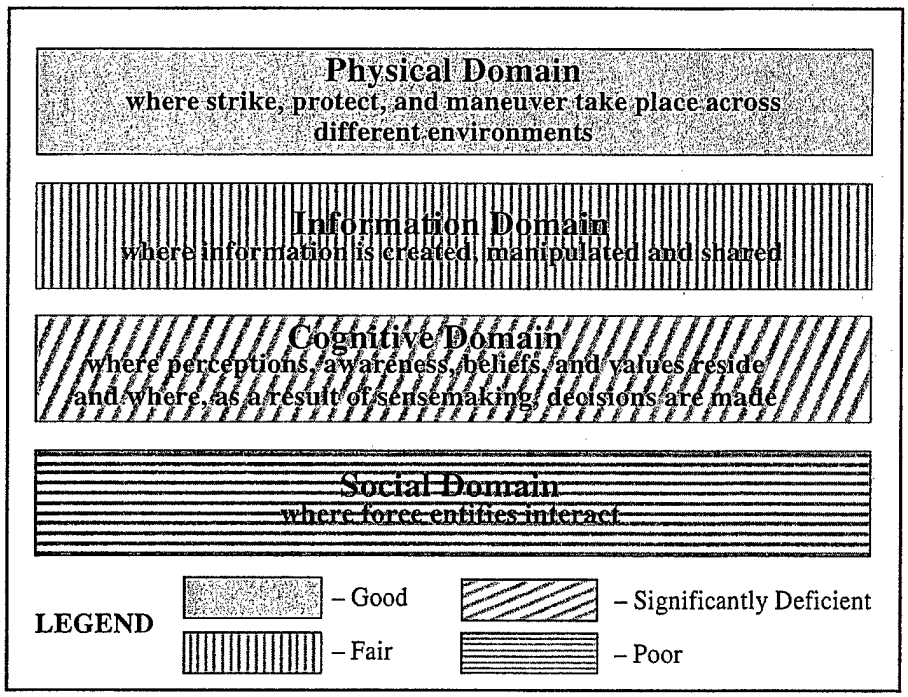

Figure 5: Qualitative Assessment Across NCW Four Key Domains

Synthesis Group Findings

After participation among the working groups and detailed discussions in their meetings, the Synthesis Group submitted their findings.

Working Group 1: ***Measures of Merit (MoMs)*** – The findings focused on the assessment that the MoMs for NCO, especially for understanding a networked "cause and effect" relationship, are a work-in-progress. However, previous MoMs for the physical domains for warfighting missions are well understood and remain relevant.

- MoMs must both enable the analyst and inform the client; these may be starkly different for Network Centric Operations Analysis (NCOA) than for traditional OA. MoMs for NCOA are a work-in-progress.
- Survivability-related MoMs are increasingly relevant to military operations and remain so for NCOA as well (at all levels, i.e., MOPs, MOEs).
- A combination of MoMs is necessary for OA of networked "cause-and-effect" relationships.

Working Group 2: ***Processes and Methodologies*** – The findings focused on the NCW conceptual framework and the gap between sense-making and decision making. It also was suggested that the relationship between cognitive modeling and sense-making modeling needs to be addressed.

- The NCO framework emphasizes "Quality of Individual Sense-making" and the "Quality of Group Sense-making" versus decision making.
- Many in the NCO community assert that cognitive modeling is an essential part of the solution to modeling sense-making.
- The lack of processes and methodologies for OA using sense-making and cognitive modeling make the NCO framework a challenge to operationalize.

Working Group 3: ***Assessment Tools*** – The findings were along three dimensions: "better" data, improvement in NCO assessment tools, and the networking of assessment tools to achieve synergy in the application of a tool set.

- Some tools exist, but the data domain (both real blue and red data) is still too stove-piped.
- The methods to change information to knowledge seem to exist within the models, but are not well understood.
- Networking assessment tools is necessary but not sufficient; we must learn to "do better things," not "do things better."
- The networked force must be treated as a holistic entity not as a sum of discrete elements.

Working Group 4: ***NCO and Force Transformation*** – To effect Force Transformation it was concluded that the further we move away from assessing transformations that are focused on a single Service, tactics, and material ("old" missions, etc.), the fewer OA tools are available to the analyst for information, cognitive and social domain related assessments.

Working Group 5: ***NCO and Coalition Forces*** – It was discussed that the OA timelines are not fast enough to keep pace with technology and other developments. The experience of the UK's embedded OAs needs to be assessed and their example, maybe, followed. However, the inclusion of civilian agencies also must be addressed.

- OA analysis timelines are not fast enough to meet the pace of technology and DOTMLPF development.
- OA is overly focused on military to the exclusion of civilian agencies.

(See NCO, p. 34)

(continued from p. 33)

- Need to consider new level of embedded analysis (OA in-theater with data mining and assessment tools) to provide real time feedback on NCO effectiveness.

Working Group 6: *Applying OA to Actual NCO Events* – It was found, because policies and doctrine to incorporate analysis is lacking along with the non-use of embedded analysis, that OA becomes an afterthought. If these findings and the data domain are improved, then the assessment of actual NCO events will be improved.

- Lack of joint and some Service doctrine to incorporate analysis in a JTF limits OA support of NCO.
- Reliance on non-embedded analysts makes OA an afterthought in JTFs.
- OA currently limited by available and valid data
- Time and data constraints limit the tool set

Extent of Collaboration

As with the State of the Practice, each of the working groups were asked to provide a self-assessment of the level of collaboration among the Services, Coalition Forces and US Agencies where operations analysis has been applied to NCO.

The level of collaboration among (and *within*) the Services was assessed as inconsistent. Collaboration between services is varied and has two dimensions: between operators and between analysts. Collaboration between analysts was good with the Joint Lessons Learned Team because they were located at all Combatant and Component Headquarters – so contact was physical. Collaboration between Service teams at disparate sites was very infrequent. Most were completely unaware of the others' existence.

The collaboration with US Agencies was difficult to assess because the majority of the attendees did not know of examples. Working Group 6 discussed that the OIF Phase IV planning involved almost every major agency in the US government; however, none of these agencies had the collaborative capabilities and expertise to contribute effectively and in a timely manner.

For the Coalition Forces, participants considered collaboration to be infrequent and inconsistent. A spectrum of change of military forces in the international community exists from status quo to modernization through transformation of forces. Nations are at different points in the spectrum with respect to NCO, but all are committed to moving away from the status quo end of the spectrum. The participation in various multinational forums is evidence of the commitment. It was noted that most collaboration with Coalition forces is on a bilateral basis. Many of the activities are modest events between coalition partners (e.g. entropy work, agent based modeling, S&T assessment, an assessment of decision making in collaborative environments, development of a conceptual model, and working groups to discuss interoperability). The conclusion is that there is still a need for significant collaborative analytical events between Coalition partners.

Recommendations

First, the Synthesis Group developed a set of *actionable* recommendations from the working group discussions and their findings.

- A MORS Symposium working group or composite group dedicated to NCO is needed. NCO is much more than C4ISR and Information Operations. This new working group or composite group could be charged to examine the OA toolkit and processes to better focus on the NCO problem. At the 72nd MORSS it is proposed that the CG B Chair discuss this issue with the leadership from Working Groups 5-10, providing recommendations to the MORS Working Group/Composite Group Committee Chair and the Vice President (Meeting Operations). *[Ed Note: This proposal will be addressed during the 72nd MORSS]*
- Create center(s) of excellence within services and JFCOM for NCO assessments to capture and share results and data of experiments, training, analysis and experience.
- Enable (e.g. thru agreements, business practices) the networking of analysts working NCO and provide reach-back for tools, data and previous studies.
- Establish a "business model" that enables services to conduct operations analysis in support of "born joint" NCO concepts and that is underpinned by a set of approved tools and data.
- Conduct follow-on MORS special meetings to share NCO analysis and experimentation results. There were two options recommended:
  - A 2-day or 3-day Mini-Symposium to educate the community in the area of NCO analyses. Training and education was seen to be critically important to Transformation overall, and specifically, to the operations analysis practice in support of NCO.
  - A second 3-day Workshop to discuss the issues more fully. It was suggested to provide foundation presentations during the morning of the 1st day and outbriefs during the afternoon of the 3rd day – this would leave two full days for discussion and further debate. During this initial workshop, the working groups felt they only scratched the surface in their discussions.

Synthesis Group Summary

The Synthesis Group summarized their findings thus:

The good news is that the OA process developed in the Industrial Age has continued applicability to Network Centric Operations (NCO) in the Information Age. We are only beginning to understand the practices that should be followed to perform credible NCO analyses. In addition, we know there are NCO considerations that remain challenges. The bad news is that we do not do a satisfactory job in documenting, sharing, and learning from NCO analyses performed.

The worse news is that, with the arrival of terrorism, other asymmetric threats, rogue nations, and increased concern for homeland defense, the challenges of effectively assessing NCO and efficiently accomplishing the goal of Force Transformation are complex and urgent. Although these are daunting challenges, there is some better news that is implicit in this workshop itself. If the recommendations of this workshop are implemented successfully, they will provide a basis for improving the operations analysis process and empowering the OA community to address the most critical analytical challenges to support NCO and Force Transformation. ✪