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COALITION COMMAND AND CONTROL IN THE NETWORKED ERA

Accessing and Sharing: Facets of Addressing Information Overload

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ABSTRACT

Over the past decade, many have warned of the data/information overload challenges which need to be addressed as we introduce more advanced information technology within the military. The concept of net-centric warfare makes addressing the challenges critical. The USAF Air Force Research Laboratory's (AFRL) Commander's Predictive Environment (CPE) program office recognized that accessing and sharing information are critical facets of handling data/information overload but needed to identify explicit, specific areas to support program success. A workshop was held with researchers from AFRL Information (IF) and Human Effectiveness (HE) Directorates and domain experts to explore what 'accessing and sharing' means in relationship to battle-space prediction. A hierarchy was built identifying the attributes and the terms were grouped into three sub-categorizations and characteristics for each sub-categorization were listed. The result was presented to additional domain experts at a Warfighter Analysis Workshop for verification and input to the prioritization of CPE research. Comparing the results of the workshops concludes that while today's warfighters need simple solutions, the AFRL has identified potential areas of research that will provide better support in future years.

Introduction

(**Note:** The authors recognize that there are differences between data, information and knowledge especially with regard to the processing needs for each. However, the terms will be used interchangeably, especially since many documents researched to write this paper tend to use them interchangeably without definition.)

Joint Vision 2020 recognizes the importance of information and information superiority to support the strategic concepts of decisive force, power projection, overseas presence and strategic agility. Joint Publication 1-02 defines information superiority as the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same. JV2020 does emphasize that information superiority provides the joint force a competitive advantage only when it is effectively translated into superior knowledge and decisions. The United States Air Force (USAF) also recognizes that knowledge, or more generally information, management is critical. The USAF has an Information Management (IM) Cell within the Air Operations Center which employs the cycle shown in Figure 1 and as described in AFTTP 3-2.22 "Multi-service Tactics, Techniques, and Procedures for Joint Task Force Information Management." The Air Force Command and Control, Intelligence, Surveillance, and Reconnaissance Center Integration Directorate (AFC2ISRC/CX) completed a study and published "Joint Forces Air Component Commander (JFACC) Information Management (IM) Capability – 2010 Functional Decomposition Activities" in 2004 breaking down the activities which will need to be included to have an all-inclusive IM capability for the JFACC. Both documents identify processes which need to be addressed to provide the JFACC with the right information at the right time in the right way. However, these processes alone are not sufficient to ensure that goal is reached and does not guarantee information superiority. Rather, all physical, social, information and cognitive aspects of IM have to be addressed to get the full benefit from information and advanced information technology.

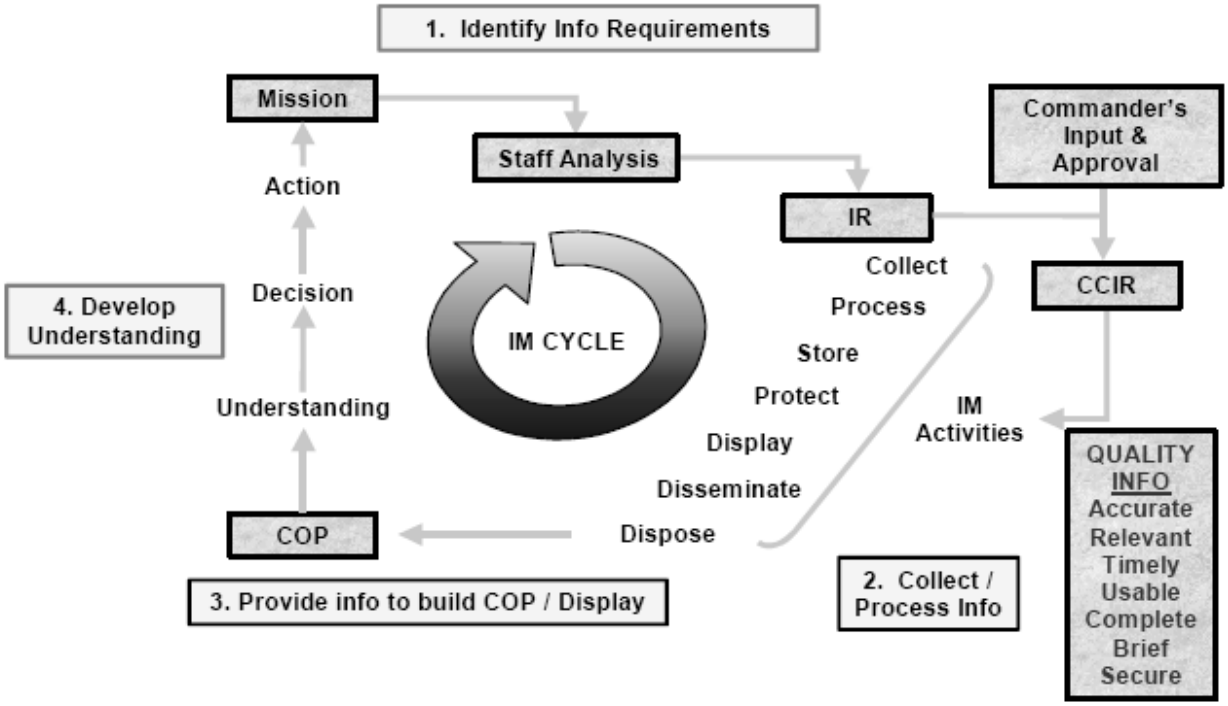
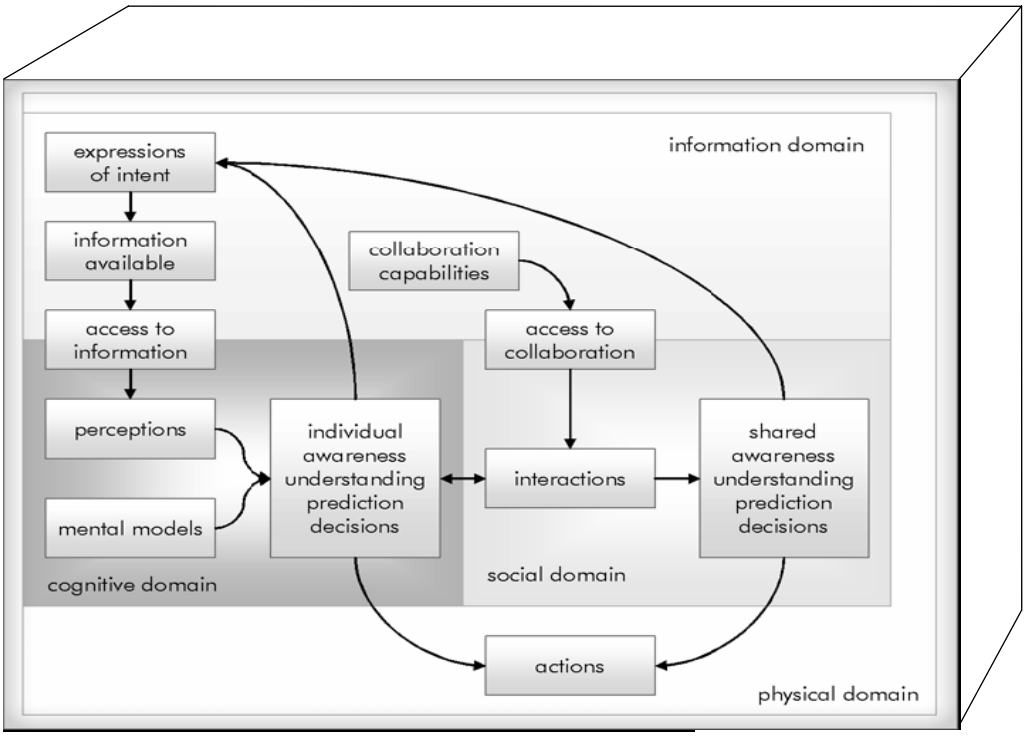


Figure 1. The USAF Information Management Cycle

In "War and Anti-War," (Toffler and Toffler, 1993), reference is made to Duane Andrews, who served as Assistant Secretary of Defense for Command, Control, Communications and

Intelligence (ASC(C3I)), stating that information is a strategic asset, "a powerful lever capable of altering high-level decisions by the opponent." Andrews spoke of "knowledge warfare" in which "each side will try to shape enemy actions by manipulating the flow of intelligence and information." Toffler and Toffler later make the observation that while the government talked about cyberwar, command and control warriors and the like, that there was no "formulation of a systematic, capstone concept of military "knowledge strategy." Alberts' (1996) "Unintended Consequences" was written to address concerns by the Chairman of the Joint Chiefs of Staff "regarding the unintended consequences of providing too much access to information." Patterson, Roth and Woods (1998) and Woods, et al (2001) did extensive studies on the vulnerabilities caused by data overload in the military intelligence analysis domain. These are just some of the myriad of references that could be listed which recognize the challenges of an information-based military.



Adapted from Leedom, 2004

Figure 2. Sensemaking Projected to the Future

Sensemaking (Leedom, 2004) involves a multidimensional process where cognitive, operational, organizational and doctrinal processes interrelate to support understanding within a complex and evolving battlespace. 'Prediction' or, as is more often used in the joint world, 'anticipation' can be considered to be that part of sensemaking that involves projecting the present into the future to explore potential states. Figure 2, which has a slight alteration from Alberts (2006), shows the added dimension of time. A more realistic depiction would involve a constantly moving timeline

with the future states constantly flowing to become the present while the present becomes the past and with feedback of present actions on possible futures to the sensemaking process. As can be imagined, the projection of any moment's understanding of a battlespace onto a constantly changing future introduces another order of complexity to information and its management. Yet, this is part of the challenge of the USAF Air Force Research Laboratory's (AFRL) Commander's Predictive Environment (CPE) program.

Commander's Predictive Environment

The goal of the joint AFRL Information (IF) and Human Effectiveness (HE) Directorates CPE program is to enhance the Joint Forces Commander (JFC), Joint Forces Air Component Commander (JFACC) and senior commanders' decision making process by supporting their ability to envision future battlespace options. The timeline of the program is transitionable capabilities by 2011. CPE will create technologies that support the JFC/JFACC and senior commanders' understanding of events and factors affecting adversaries, neutrals, and self over time so that action can be taken to shape the battlespace when possible. The program will include capabilities to focus intelligence processes toward understanding enemy intent, to overlay this understanding onto real time events, and to establish an envelope of likely future courses of action. CPE will enhance the commanders' understanding of the battlespace and allow them to proactively plan friendly operations in a more efficient and effective way. CPE will create an ongoing understanding of the operational environment so that the commander's decisions affect events in the battlespace instead of reacting to them.

The description above is very grand and very broad in vision, making program guidance more difficult. Therefore, the CPE Program Management Office decided to focus the scope into a manageable program by engaging Air Operations Center experts, from both the research as well as the operational community, upfront in requirements identification and concept development. The first in a series of workshops was held in October 2005 to begin this effort. The group of researchers and experts first defined what all CPE *could* entail based on the vision given above. Three capability areas were defined at the first workshop as 1) Understand the Battlespace, 2) Evaluate Courses of Action, and 3) Access and Share Battlespace Information (ASBI). These capability areas were further defined as:

- Understand the Battlespace

Understand the basic information and the interactions among political, military, economic, social, information, and infrastructure (PMESII) impacts on self (and allies), adversaries, or neutrals, in the time epochs of past, present and the future.

- Evaluate Courses of Action (COAs)

Understand how our COAs alter plausible futures to achieve the commander's intent. Our COAs are expressed in terms of Diplomatic, Informational, Military, and Economic (DIME) actions that may be taken.

- Access and Share Battlespace Information

This function can best be described in terms of four objectives that center around the sender, the recipient, and the media used to gather, store, process, display, and disseminate CPE-related information and includes the below objectives:

Objective 1: Identify and access critical information relevant to pending decisions. This includes identifying and accessing relevant data for context-dependent critical information relevant to pending decisions. CPE should provide the capability to perform filtered searches that be accessed according to criticality of information (e.g., routine, critical). CPE should provide the data that can reveal critical nodes and vulnerabilities that may be used in effects-based operations. This information will allow commanders and staff to present possible actions and anticipated consequences to others that need the information and to integrate the information with other relevant systems.

Objective 2: Perceive data with multiple sensory modes
This objective recognizes that "visualizing" the battlespace by itself is too limiting. CPE should allow users to perceive cognitive bias-free data using multiple sensory modes and varying degrees of resolution as required for communication. It addresses alternative information processing functions, varying cognitive levels, styles, or function, and considers framing and other well-defined cognitive biases.

Objective 3: Allow data sharing to be tailored to the style of communicator and recipients.
This objective recognizes that when it comes to sharing and communicating information, one size doesn't fit all. Decision environments that force the user to operate the way the environment dictates rather than being adaptable to the preferences of the user may be destined to failure. This incorporates the notion that within CPE, communication (and decision making) aids should be "personalized" and tailorable to allow different users to operate in the environment in different ways.

Objective 4: Communicate and share high quality, understandable, and credible information
This objective means that CPE must provide the user with the ability to communicate and share high quality, credible information in a usable, timely, understandable, useful, and defensible way. Dissemination of information may be available either through information push or pull capabilities. CPE needs the capability to play forward or back the operational situation, to visualize, compare and contrast multiple future states and implications, and to share assessments and rationale with peers, superiors, and subordinates. It must display the current battlespace situation, communicate selected options and commanders' intent, and facilitate collaboration with other decision makers.

While there is much to be written about all three areas of CPE, the rest of this paper will focus on the last capability area, that of Accessing and Sharing Battlespace Information (ASBI).

Accessing and Sharing Battlespace Information

AFRL Workshop

While all three of the sub-group areas define CPE in general, ASBI is the very critical underpinning to the CPE program which is germane to network-centric warfare. In addition, ASBI is a research area that brings together some of the strengths of both information technology and human effectiveness, and warrants multi-disciplinary collaboration between researchers from the AFRL Information (IF) and Human Effectiveness (HE) Directorates. Researchers from these directorates with a few domain experts defined the requirements for developing an ASBI data/information environment within a military organization for prediction. During a brainstorming session, various aspects of what each researcher believed ASBI should entail were identified. These attributes were grouped into three sub-categorizations and characteristics for each sub-categorization are shown in Table 1.

Table 1. ASBI Sub-characteristics and Attributes

3.0 Access and Share	**3.1 Access data/info/models from external sources**	3.1.1 Provide flexible interfaces with sources (e.g., natural language)
		3.1.2 Provide smart queries (user characteristics)
		3.1.3 Add semantic understanding (categorization, ontologies)
		3.1.4 Qualify data
		3.1.5 Provide contextual framing
		3.1.6 Add temporal frame
		3.1.7 Receive sensor information
		3.1.8 Add prioritization to queries of (requirements for) models/ information /data (including statements about timeliness needs)
		3.1.9 Enable intelligent subscription
		3.1.10 Discover relevant models
	3.2 Access/share data/info/models with internal processes and users	3.2.1 Format for use (normalize, ontology)
		3.2.2 Synthesize data/information (differences in uncertainty references, latencies, approaches to measurement error)
		3.2.3 Manage context
		3.2.4 Manage quantity wrt cognitive overload
		3.2.5 Manage and orchestrate workflow; provide visibility into workflow
		3.2.6 Manage data aggregation and associated security issues
		3.2.7 Facilitate collaboration
	3.3 Expose and share products	3.3.1 Tailor products (what and how) to recipients' needs (e.g., color-blind user, time horizons)
		3.3.2 Provide explanation of results and associated pedigree
		3.3.3 Control access/security
		3.3.4 Enable intelligent collaboration
		3.3.5 Display meta information, contextual information, uncertainty along with product
		3.3.6 Display abstract concepts (e.g., social unrest)
		3.3.7 Maintain usage history
		3.3.8 Push updates and similar products; obtain feedback (Provide predictive usage)
		3.3.9 Conduct limited advertising

As can be seen by Table 1, the list is not all-inclusive of concepts and issues which could be considered part of ASBI. The group focused on aspects that they felt applied to CPE specifically. They also excluded areas, such as multi-level security, that were already being addressed or which might be interesting but could not be justified as a strong research focus for

the CPE program. What became very obvious in discussions during the development of the hierarchy was the difference in the way the information technology researchers defined this area, as opposed to the way the human-effectiveness researchers defined the area. The result was an appreciation of the need to address the physical and cognitive levels of ASBI while being aware of the social and information domains. In addition, the *interdependencies* required between the domains to sufficiently address ASBI surfaced.

Warfighter Analysis Workshop (WAW)

Once the various aspects of ASBI with respect to CPE were defined, the results were presented at a Warfighter Analysis Workshop (WAW) to get the warfighters' input on what would be relevant, high-priority areas for CPE to focus on. The WAW was attended by warfighter representatives including personnel from the 505th Training Wing, Project Checkmate, and the 12th Air Operations Center (AOC). The CPE program in general was briefed to give the participants background. Then each sub-area was explored. For ASBI, the key themes from the WAW were that inadequate understanding of the battlespace was a priority and that CPE must provide an immediate understanding of the battlespace in context. In addition, they stressed that any technology being implemented in the AOC must enhance and integrate with, not inhibit, AOC operations. They indicated that the greatest potential for gain from the CPE program is supporting their ability to access and share information. The warfighters wanted a way of measuring and communicating the 'big picture' to decision makers including political, military, economic, social, information and infrastructure effects of diplomatic, information, military and economic actions. Finally, the group emphasized that any capability developed must tie in with our expected planning and operational partners including other services, coalition partners and other government agencies.

There was discussion of the need within an AOC for a strong, competent Information Manager, someone who can bridge the gap between structuring, sharing and filing the data, knowing what the data says, and who needs it. In theory, there is such a person, indeed a whole IM cell as mentioned in the beginning of this paper, but in reality, there are evidently a myriad of challenges that still need to be addressed. The authors find this statement intriguing as it shows that, despite all the technology fielded in the AOC to support information handling, the smooth and effective flow of information is dependent upon one role in particular. That person, or that group of people, would require deep and intimate knowledge of the whole AOC's needs and requirements to appropriately bridge the gap.

The general results concerning ASBI input to CPE were:

- Must accept & process data from many sources.
- Capability for advanced searches and queries
- Subscriber-based push and pull for access to data from all intelligence (INT) sources
    - Particularly human intelligence (HUMINT) and open-source intelligence (OSINT)
    - Ability to choose between raw data and analyzed data
    - Graphical linkages of intelligence reports for a focused area over a short period of time

- Management of data, information, and finished intelligence
  - Multi-source, multi-INT, multi-format
  - Multiple levels of security
  - Automated cataloguing for easy access
  - Automated input of data for tools
  - Allows us to "play well with others"
- Use common standards for data exchange
- Must be done with minimal loss
  - Single "query" access to distributed heterogeneous data – Make query easy
- Tailorable to user preferences
- Traceability to source data
- Continuous update to ensure persistence in data / information
  - Ability to capture text, text chat, voice, and other communications
  - Alternative ways of presenting quantitative information to decision makers
  - The ability to produce automated briefings

A final take-away from the WAW is that all of the sub-categories of the three high level categories were informally rated by the warfighters by answering the questions "How well do we do today?" and "Where do we need to do better?" For the first question, the ASBI sub-categories were all rated in the bottom 25% indicating that they felt the AOC did not do well in this area at the current time. For the second question, the ASBI sub-categories were rated in the top 25% meaning this is an area they feel needs improved. Both of these results gave the impression from this group of warfighters that CPE can find areas for investment in the program that would substantially improve the performance in the AOC with respect to ASBI.

Discussion

As the workshops and sessions were held with the purpose of identifying where CPE should focus, the results of the AFRL workshops needed to be compared with the results of the WAW. While there was not a tight coupling between the two on ASBI, Table 2 below lists the related responses.

The gaps and mismatches between the products of the AFRL workshops (dominated by technologists and researchers), and those from the WAW (dominated by those fighting in today's environment and with today's tools) are interesting as they indicate a different perception to what CPE could provide. The WAW participants generally were imagining a typical environment where data would be delivered and the warfighter does the manipulation. In fact, one warfighter made a comment to the effect, "Just give me the data and I'll be able to do my job." The results from the researchers included concepts that involve potential tools being used to discover relevant models, help manage cognitive workload, provide explanations, and display abstract concepts. This obviously highlights a dilemma in the DOD research environment where the focus has been changed to support today's warfighter and yet without forward thinking solutions, tomorrow's warfighter will be buried under tomorrow's problems. We at AFRL expect the future capabilities proposed by the AFRL CPE Workshops to be more effective answers to the ASBI problems over the long-term in addressing the challenges that the warfighter currently has,

although we acknowledge the warfighter today would be pleased with some of the simpler functions being addressed, such as automated input of data.

Table 2. Comparison of WAW and AFRL Workshop Results

WAW Results	AFRL Workshop Results
Must accept & process data from many sources	Receive sensor information
Capability for advanced searches/queries Single query access	Provide smart queries Add prioritization to queries
Subscriber-based push and pull for access Continuous update to ensure persistence	Enable intelligent subscription Push updates and similar products Conduct limited advertising
Management of data	Format for use Synthesize data information Manage data aggregation and associated security issues Display meta information Manage context Control/access security Maintain usage history
Traceability to source	Provide semantic understanding Qualify data Provide contextual framing Add temporal frame
Tailorable to user preferences	Provide flexible interfaces Tailor products

Conclusion

Over the past decade or so, many have warned of the data/information overload challenges which need to be addressed because of implementing advanced information technology within the military and the problem still exists. Today's warfighter is indeed having the foretold challenges. An overall result of both the AFRL workshops and the WAW was a strong message that basic knowledge management steps to handle data/information overload in the AOC still need to be taken to enable warfighters in a net-centric environment, where more information is expected to be pushed to the edge, to reach that goal. All physical, social, information and cognitive aspects of IM have to be addressed to get the full benefit from advanced information technology. CPE has an opportunity to drill into the specific problems within the AOC and understand the challenges of IM as it is a critical underpinning to the program's success as well as the successful employment of an AOC as a weapon system for 2011 and beyond. The goal of the CPE program is to enhance the JFC, JFACC, and senior commanders' decision making process by supporting their ability to envision future battlespace options and at AFRL, we

believe that addressing the ASBI challenges with forward thinking solutions will support that goal.

DISCLAIMER

The views expressed in this paper are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense or the U. S. Government.

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