

2006 CCRTS

The State of The Art and The State of The Practice

Title of Paper:

The Grand Challenges of Command and Control Policy

Authors: Jack Lenahan & Phil Charles

POC: Jack Lenahan Imagine-One Corporation

**Organization: Office of the Chief Engineer
Space and NAVAL Warfare Systems Command
Charleston, S.C.**

Address: P.O. Box 190022

N. Charleston, South Carolina: 29419

Phone: 843-218-6080

Email: John.Lenahan@Navy.mil

Abstract

We are interested in defining and investigating the grand challenges facing the command and control (C2) community in a network centric, transformational environment. The purpose of these investigations is to provide a rigorous basis for assessing the state of the art and the state of the practice of command and control in modern warfare. In 1900, David Hilbert¹ proposed a list of 23 outstanding problems in mathematics, a number of which have now been solved, some of which remain open but have guided mathematics analysis for the last 100 years. In a similar vein, it is the intent of this paper is to attempt to define the challenges facing modern defense organizations such that formal requirements and solutions to these problems may begin to evolve. Thus, once the grand challenges are defined and accepted, C2 art and practice may be analyzed and measured against these grand objectives on the basis of a continuum of progress. That continuum is suggested as containing the following elements: formal definitions of the grand issues; agreement of both the issues and their definition by the warfighting community; and formal metrics definitions for each issue such that progress is easily identified, measured, and recognized as progress.

Report Documentation Page

*Form Approved
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

| | | | | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------------|----------------------------|----------------------------------|---------------------------------|
| 1. REPORT DATE JUN 2006 | 2. REPORT TYPE | 3. DATES COVERED 00-00-2006 to 00-00-2006 | | | |
| 4. TITLE AND SUBTITLE The Grand Challenges of Command and Control Policy | | 5a. CONTRACT NUMBER | | | |
| | | 5b. GRANT NUMBER | | | |
| | | 5c. PROGRAM ELEMENT NUMBER | | | |
| 6. AUTHOR(S) | | 5d. PROJECT NUMBER | | | |
| | | 5e. TASK NUMBER | | | |
| | | 5f. WORK UNIT NUMBER | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Space and Naval Warfare Systems Command, PO Box 190022, North Charleston, SC, 29419 | | 8. PERFORMING ORGANIZATION REPORT NUMBER | | | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | 10. SPONSOR/MONITOR'S ACRONYM(S) | | | |
| | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | | | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited | | | | | |
| 13. SUPPLEMENTARY NOTES 2006 Command and Control Research and Technology Symposium | | | | | |
| 14. ABSTRACT | | | | | |
| 15. SUBJECT TERMS | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES 44 | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT unclassified | b. ABSTRACT unclassified | c. THIS PAGE unclassified | | | |

Introduction

At the 10th International Command and Control Research Technology Symposium, held in Washington last year, an astute member of the audience offered a wonderful suggestion. The audience member asked Dr. Alberts if it would be useful to address the tasks facing the Western Military Community as “Grand Challenges” in the manner which David Hilbert had described the great challenges facing mathematics over 100 years ago. In 1900, David Hilbert proposed a list of 23 outstanding problems in mathematics, a number of which have now been solved, some of which remain open but have guided mathematics analysis for the past 100 years. This author concurs with that conference attendee’s suggestion.

The U.S. Department of Defense (DoD) has embarked upon a journey which constitutes nothing less than a major restructuring of warfighting organization and strategy. That indeed is a “grand endeavor”. Thus, we are interested in defining and investigating the grand challenges facing the military community. Since the DoD has made a fundamental decision that this restructuring or transformation if you will, is to be centered around the concepts of Network Centric Warfare (NCW), it follows that many of the challenges will contain references to threads reflecting an NCW bias. The purpose of these investigations is to provide a rigorous basis for assessing the state of the art and the state of the practice of command and control. It is the intent of this paper to attempt to define the challenges facing C2 policy makers such that formal requirements and solutions to these problems may begin to evolve. Thus, once the grand challenges are defined and accepted, C2 art and practice may be analyzed and measured against these grand objectives on the basis of a continuum of progress. That continuum is suggested as containing the following elements: formal definitions of the most significant issues in Network Centric Warfare (NCW) and NCW C2; agreement of both the issues and their definition by the C2 community; formal metrics definitions for each issue such that progress is easily identified, measured, and recognized as progress.

In order to improve the process of grand challenge socialization and to encourage an accelerated response to these challenges, I am requesting that a prize fund be established for these grand challenges within the defense community. The prize for acceptable resolutions to each challenge, or group of related challenges, should be at least \$500,000.00. There should also be a restriction of a maximum of three awards to any single individual. Thus the maximum monetary reward should be restricted to \$1,500,000.00 per individual or organization.

Grand Challenge Selection Criteria

Grand, of course means impressive and ambitious in scale or scope. The proposed selection criteria² used for adopting a challenge as “Grand” are:

1. **Impact** – The resolution of a challenge will result in a major difference in terms of increased warfighter capability, increased situational awareness, better or more agile C2 organizational structures, increased C2 organizational capacity, and increased process influence in terms of “locking out” or dominating adversarial process options through the use of effects projection.

2. **Appropriateness** – The issue addresses the C2 community’s most urgent needs (this assuming that the C2 community knows what it’s pressing needs are)
3. **Depth** – The application of a solution to a given challenge is distributable across a broad swath of the spectrum of military operations.
4. **Feasibility** – Can the issue’s resolution be developed and deployed in a ten year time frame or less?
5. **New Knowledge** – New knowledge will probably need to be created to satisfy the grand issue.
6. **Indirect benefits** – The resolution of the issue can be utilized outside the U.S. military.
7. **Decomposability** - Issue easily decomposes into identifiable research goals³
8. **Collaborative** - The issue necessitates collaboration in more than one field or organization such that socialization and acceptance are enabled.
9. **Paradigm Shift** - The issue should contain a radical operational paradigm shift
10. **Innovative** - The issue will require new and innovative solutions not currently in existence versus a simple evolutionary advance in product or process (e.g., not the next revision of an operating system or database or yet another ontology, but innovative process and organizational solutions)
11. **Co-evolutionary** - One grand issue can co-evolve its solution with at least one other grand challenge
12. **Consistency** - The individual members of the set of challenges are conducive to co-evolution and not predatory in nature against another challenge, the challenges are not contradictory

The Grand Challenges

In evaluating the progress in the state of the art and practice of NCW C2, rather than “guess” at a “potential possible set of metricized improvements with respect to the issues impacting C2 over the last ‘x’ years”, I am proposing that the following challenges be formally defined, that the challenges must be agreed upon and accepted by the C2 community, that formal metrics for each challenge be defined, and that a formal process for launching and integrating the solutions to these challenges be defined, instrumented, and implemented, such that clear and easily identified milestones for each of the accepted challenges can be published and monitored. Then, at a future conference, the state of the art and practice as a before and after exercise can be properly measured and appreciated.

I have decomposed each of the grand challenges into “question sets” grouped by the following “dimensions”: Definitional Questions, Doctrinal Questions, Process Questions, Operational Questions, Metrics Questions, Leadership Questions, Assessment Questions, and Cost and Procurement Questions.

I. Formally and Succinctly Define Network Centric Warfare.

Suppose that Sun Tzu never wrote the “Art of War”. Suppose also that we are now tasked with compiling a document of 100 pages or less, which describes the major attributes of successful warfare and let us also assume that some version of Network Centric Warfare is the appropriate model. How might we approach such a task? What specifically is NCW? Is NCW a doctrine? How will we know when we have achieved NCW? Is NCW more of a “data sharing” enabler than a valid military strategy? Are we emphasizing technology over strategic thinking? Are we neglecting traditional strategy and visionary military planning because we believe that all possible military problems are solvable under an NCW umbrella? What constitutes a network centric warfare process as distinct from traditional military processes? Do our adversaries exploit NCW? Do we have a plan to counter any potential adversarial NCW advantages? Can a network centric force effectively combat a non-network centric force? Can a non-network centric force effectively combat a network centric force?

Definitional dimension questions

1. What specifically and succinctly is NCW?
2. Is NCW a new type of warfare quite distinct from Symmetric and Asymmetric? If so how?
3. What is the clear separation of the “network” segments of NCW theory versus the non network segments?
4. What is the scope of NCW theory? Will the entire federal enterprise be included in the domain of Network Centric Warfare theory or concepts?

Doctrinal dimension questions

1. Is Network Centric Warfare a Doctrine?
2. If yes, what is the specific doctrine for each branch of the services?
3. Is fight cheaper equal in importance to planning and fighting and winning all possible conflicts and missions?
4. Are we acquiescing to easier modes of military thinking since NCW is now considered dogma?
5. How do we know if NCW is an adequate response to Unrestricted and Proxy warfare?
6. Are other alternatives even being considered

Operational dimension questions

1. Is NCW a military vision? If yes what is it succinctly
2. Does NCW have a military strategy? If yes, what is it succinctly?
3. How can we assess and measure NCW’s success or failures against more traditional forms of warfare?
4. Are we emphasizing technology over strategic thinking?
5. Are we neglecting traditional strategy and visionary military planning because we believe that all possible military problems are solvable under an NCW umbrella?
6. What constitutes a network centric warfare process as distinct from traditional military processes?

7. Can we solve all possible military problems through the use of NCW concepts or evolving NCW concepts? If not, which specific military activities should maintain a traditional process approach?
8. Is there a simple theoretical comparison or contrast which can be clearly elucidated with respect to how NCW compares to traditional military approaches to Major Combat Operations (MCO), Operations Other Than War (OOTW), Unrestricted Warfare, Global War on Terrorism (GWOT), Symmetric Warfare, Asymmetric Warfare, Stability Operations, etc.?

Process dimension questions

1. Except for the ever present cost reductions rationale, why transform the DoD at all?
2. What process engineering methodology was used to identify that NCW was a proper new enterprise initiative needed for transformation?
3. What specific DoD requirements were not being satisfied that could only be satisfied by NCW?

Metrics dimension questions

1. How do we instrument NCW processes for simple measurements?
2. What are the metrics which will be used to validate Network Centric Warfare as compared to traditional military approaches for Stability Operations, OOTW, MCO, GWOT, Unrestricted, Symmetric and Asymmetric Warfare?
3. How do we measure the “success” of NCW in each of these areas?
4. How do you instrument NCW C2 processes vs. Standard C2 processes so that you know that an improvement threshold has been reached or crossed?

Leadership dimension questions

1. What are the leadership implications of NCW?
2. What becomes of the traditional chain of command?
3. Is connectivity from the president to the foxhole really a good thing?
4. Does NCW undermine the ability of future military leaders to make effective decisions?
5. Will new leaders make poorer decisions because of an extensive reliance upon automated tools and planning aides?
6. Who will develop the tactics, leadership models, and training for this new type of warfare?

Assessment dimension questions

1. What engineering rigor was used prior to the adoption of NCW as a strategy such that NCW became the transformation path of choice?
2. Why is the DoD being forced to transform if 9/11 was primarily an intelligence failure?

Cost & procurement dimension questions

1. What is the cost of implementing NCW?
2. What is the cost of not implementing NCW?
3. What is the cost in terms of lost or weaker leadership capability for Major Combat Operations if we spread the command leadership training requirements to include a much broader spectrum of non-traditional operations and activities?
4. What is the cost of concurrent legacy system maintenance and NCW transition?
5. Will NCW actually reduce system costs and enable the U.S. military to fight and win with a radically reduced force size?
6. Is “fight cheaper” and “outsource wherever possible” the primary directive being imposed upon the U.S. Military?

II. Composeable Alliance Hierarchies to Enable Unified C2 – Meta C2

One of the proposed benefits of network centric theory is the ability to use all the assets of the federal agencies, state agencies, and non-governmental organizations (NGO) more effectively. This applies equally to military operations and operations other than war (OOTW). If I may use the federal response efforts to hurricane Katrina as an example, although the response to hurricane Katrina was originally a civilian agency responsibility, the chaotic events that unfolded before the world forced president Bush to employ the military to provide a disciplined command and control environment. In reality, the DoD is now being asked to assist the entire federal enterprise in support of managing responses to catastrophic events and in the creation of virtual states and cities in response to major national incidents. The behavior of interagency resources during Katrina, exemplify the urgent need for unified command and control (UC2) between the military and non-military resources and processes. But what enables UC2? Should there be such a thing as a composeable National Command Authority (Note: I do not believe that the current attempt known as the National Command Capability or NCC is adequate), across all federal agencies?⁴ How do we create a formal accelerated framework for synthesizing dynamical alliance hierarchies⁵ which may contain complex jurisdictional, liability, legal, economic, and policing dimensions for all types and scales of military operations? When should New Orleans cede jurisdiction to the state of Louisiana, and when would New Orleans get back the jurisdiction that it ceded? When should Louisiana cede jurisdiction to the federal government and which agencies would assume legal and liability responsibilities? When would Louisiana get its jurisdiction back? Is there a serious risk of permanently erasing borders, forcing a cessation of the traditional American system of federal and state boundaries or our system of checks and balances? Will we concentrate too much power in the “Composeable National Command Authority”? Are we ceding state and local autonomy to an all powerful central authority just to enable unified C2? What type of inter-country or inter-governmental agency and NGO agreements must be in place or created prior to creating a” virtual organization” such that inter-governmental agencies may self organize to meet a new emergency? Can we scale or do we have the process capacity necessary to manage multiple city chemical, biological, radiological,

and nuclear (CBRN) attacks or multiple natural disasters, during concurrent active GWOT and MCOs? How can we assess such a capacity need?

In a traditional process, the tasks to be performed or process steps are assigned resources from an already existing pool, controlled by rules determined to be applicable to that particular activity. In a NCW composable process, none of this is true. The notion of process and organizational composable requires pre-determined rules and access to resources that currently exist under different processes or organizations. The task here is to construct a flexible and rapid mechanism for establishing immediate access to disparate organizations' process resources, then to achieve agreement on how a particular subset of those resources can be utilized, and in particular, who can command and control them. This is difficult to negotiate and establish since one of the major barriers to enabling Unified C2 amounts to jurisdictional cessation and reestablishment. Yet, in terms of surge capacity planning, these types of issues must be resolved or unified C2 will not happen on the scales necessary to manage multiple city CBRNs or multiple natural disasters, or all of the above during active GWOT or MCOs. Is there a methodology or process which could avoid years of lengthy negotiations when a rapid solution is required? Can we depend upon the negotiated outcome since many tsunami pledges and commitments have been unfulfilled? Would GWOT require different pre-C2 agreement models than MCO or OOTW?

Definitional dimension questions

1. What is a composable National Command and Alliance Authority hierarchy? Should the DoD be involved with such an activity?
2. What are the legal and jurisdictional definitions required to form such a pre-Unified C2 process or framework?

Doctrinal dimension questions

1. Should there be such a thing as a composable National Command Authority?
2. What are the interagency and inter-governmental boundaries and thresholds required for smooth jurisdictional cessation and restoration?
3. How are the cultural barriers to UC2 to be overcome? These phenomena are typical of governmental and non-governmental bureaucracies. How does one pre-stage the legal (statutory), regulatory, liability, international, and financial agreements necessary to rapidly create dynamic, adaptable, composable organizations as needed

Operational dimension questions

1. Who would negotiate these agreements, ambassadors, the State Department, DoD, or Home Land Defense, etc.?
2. How could such complex jurisdictional negotiations be accelerated?
3. How could complex liability agreements be accelerated?
4. How can an entire city or state be permanently relocated complete with legal, police, emergency, financial, economic and employment resources?
5. How can we synthesize dynamic alliances?

6. How do we design and operate such a framework on a continual basis so we can rapidly construct frameworks, such that Unified C2 planners can utilize hybrid assets in composing dynamic alignments of DoD, NGO, other U.S. government agencies, and agencies and departments of friendly foreign governments to address suddenly appearing requirements?

Process dimension questions

1. How do we create a formal accelerated process and framework for synthesizing dynamical alliance hierarchies which may contain complex jurisdictional, liability, legal, economic, and policing dimensions for all types and scales of military operations?
2. How do we design and implement the processes and policies required to permit the rapid pooling of diverse organizations and diverse organizational resources which will enable unified C2?
3. For OOTW, the New Orleans experience amounts to moving a city of one million people and creating a virtual city “on the fly”. The enormous issues posed by this recent event beckon for a well defined and more scalable process with the capacity to manage increasing security, communications infrastructure, social, and economic elements. To put this more simply, we must be able to create a “virtual state or city” on demand. This is another truly grand challenge.
4. Can we Take advantage or exploit multi-national corporate distribution assets such as Wal-Mart to supply Food, Gas – Funds – Food – Shelter
5. Scope & Scalability – from simple relief to running an entire city in Diasporas. How do we negotiate with “N” governments to pre-stage controls, policies, and local “rules of engagement” for NGOs (Red Crescent or Red Cross, etc.), the scope may be as large as moving a county, city, and state level populations and rebuilding large infrastructures. Should the DoD be in the business of creating “Virtual Governments” on the fly?
6. What are the rules for ceding jurisdiction, what are the rules for restoring local jurisdiction?
7. Do complex rules of engagement (process controls) some of which may conflict or directly contradict each other in a given process for a given task, create an environment in which self organization or emergent behavior are impossible? During Katrina, New Orleans, Louisiana, FEMA, Homeland Defense, and DoD all had different rule sets and thresholds which made seamless functioning of a Virtual Interagency Multi-national Organization (VIMO) difficult.

Metrics dimension questions

1. What process metrics would apply to this activity?
2. How would such metrics be instrumented?

Leadership dimension questions

1. How would cross agency leadership be identified and negotiated?

Assessment dimension questions

1. What assessment process or methodology can be used to predict the success of such arrangements?

Cost & procurement dimension questions

1. How much would creating such a framework cost?
2. How will assets be utilized and procured for a VIMO?

III. Unified Command and Control

Is it possible to integrate a team composed of diverse multiple resource types, operating under different models of command and control (control free, selective control, problem bounding, problem solving, interventionist, or cyclic) into cohesive military units? Will these organization members, trained under various C2 models work well together under a single (unified command and control) model? For the global war on terror (GWOT), can we answer Captain Digg's hypothetical question concerning how to construct a proper command and control model for a composite team comprised of Philippine army members, American army members, Doctors Without Borders (Les Medicines sans Frontieres) members, FBI members, Philippine Intelligence Members, etc. in combating a local insurgency? For operations other than war (OOTW), do we understand how to prepare, construct, and activate the unified command and control infrastructure, including the organizations and resources, which will be required for a potential massive relocation of American citizens from at least three major U.S. cities (potentially creating a virtual state) during and after a natural disaster or CBRN attack while the military is concurrently engaged in GWOT, other OOTWs and possibly MCOs?

Definitional dimension questions

1. What is the NCW definition of command, control, and a "policy"?
2. What is the definition of a Command and Control policy?
3. What is the definition of "Unified Command and Control"?
4. How is unified C2 different than NCW C2, JC2, or GC2?
5. Must unified command and control account for the following C2 types⁶ in its definition?
 - a. Control free - World War II - German
 - b. Selective control – Israeli
 - c. Problem Bounding – British Army
 - d. Problem Solving – American Army
 - e. Interventionist – Modern Soviet
 - f. Cyclic – Chinese Army

Doctrinal dimension questions

1. What is unified command and control doctrine in a pure military context?
2. In a mixed MCO, GWOT, and OOTW context?

Operational dimension questions

1. Do we understand how to prepare, construct, and activate the unified command and control infrastructure, including organizations and resources, which will be required for a potential massive relocation of American citizens from at least three major U.S. cities during and after a CBRN attack while the military is concurrently engaged in GWOT, other OOTW and possibly MCOs?
2. Will the proposed organizational and process attributes of self organization and emergence permit radically decentralized C2?



FIGURE 1: THE SPECTRUM OF UC2 OPERATIONS⁷

3. What are the operational impacts of the above spectral elements?
4. What are the leadership impacts of the above spectral elements?
5. How do we establish collaboration in a decentralized C2 environment?
6. What are operational types which truly outside the scope of traditional military organizations C2 or Unified C2?
7. How many unique or common Rules of Engagement sets are needed to optimize the above model?
8. What is the appropriate model of C2 for each of the above activities?

Process dimension questions

1. Do we understand how to prepare, construct, and activate the unified command and control infrastructure, including organizations and resources, which will be required for a potential massive relocation of American citizens from at least three major U.S. cities during and after a CBRN attack while the military is concurrently engaged in GWOT, other OOTW and possibly MCOs?
2. Will the proposed organizational and process attributes of self organization and emergence permit radically decentralized C2?
3. Can a single C2 model work across this spectrum?

Metrics dimension questions

1. What are the C2 metrics for each spectral element or type?
2. Are there common C2 metrics for all or subsets of the operations spectrum?

Leadership dimension questions

1. How does unity of command emerge?⁸ (by unity of command I mean the ability of a leader or commander to issue orders to individuals from a “mixed” or “composed” resource set and the associated expectation that the order will actually be executed regardless of the individuals original affiliation)
2. Are we training our officers to respond to such a catastrophe assuming DoD alone?
3. Are these other operations an unfair burden upon a trained warfighter?

Assessment dimension questions

1. How can this capability (Unified C2) be modeled, simulated, assessed, and measured?
2. What other agency resources can be assumed to be available for unified C2? How is this modeled and simulated?

Cost & procurement dimension questions

1. Create a cost model for each of the above spectral elements using a unified C2 model

IV. Develop an Emergence & Self Organization Theory for NCW C2

How critical is “emergence” and self organization” to the success of NCW? Can NCW work without emergence or self organization capabilities? How can emergent or self organizing C2 capability impacts be assessed? Do emergent capabilities support or conflict with self organizing capabilities? Can we predict what capabilities will emerge and when or will we be surprised? Can we predict when self organization is going to occur? How many different kinds of emergent capabilities can we expect to see in a given environment? What can trigger “an emergence”? What is the relationship between an emergent property or self organizing property and the properties or capabilities that it emerged from, are they supervenient and predictive or simply postdictive? What kinds of things can exhibit self organization – Organizations, Systems, Software Modules, Neural nets, Processes? What kinds of things can exhibit the property of emergent capabilities – Organizations, Systems, Software Modules, Neural nets, Processes? Can we assess whether or not our adversaries have developed emergent or self organizing Organizations, Systems, Software Modules, Neural nets, Processes?

Definitional dimension questions

1. What are the definitions of emergence and self organization?
2. What is the difference between emergence and self organization?

3. What is organizational emergence?
4. What is systems emergence?
5. What is the definition of process emergence?
6. Is self organization a capability?

Doctrinal dimension questions

1. Should the utilization of self organization become doctrine?
2. Should the utilization of emergent behavior become doctrine?

Operational dimension questions

1. How will command and control operate in such an environment?
2. How can a military planner rely upon so called emergent capabilities?
3. Will different UJTLS and NMTLS be required?

Process dimension questions

1. What do adaptable organizations look like?
2. Which process structures adapt?
3. What do self organizing organizations look like?
4. Can an organization emerge from another construct?
5. Can self organization be predicted and relied upon?
6. Can we predict the emergence of specific capabilities?
7. What are emergent capabilities in a given military or mission context?
8. Can we really rely upon the emergence of a particular capability?

Metrics dimension questions

1. How do you detect and measure self organization?
2. How do you detect and measure emergent capabilities?

Leadership dimension questions

1. What leadership training is needed to exploit self organization or emergence as capabilities?
2. Does self organization risk the integrity of unity of command?
3. Historical precedent implies failure if unity of command is ignored. What must the leader do to exploit self organization but retain unity of command?⁷

Assessment dimension questions

1. How do you assess improvements to warfighter capability due to self organization?
2. How do you assess improvements to warfighter capability due to emergent capabilities?

Cost & procurement dimension questions

1. How do you procure systems or agents which may exhibit self organization?

2. How do you procure systems or agents which may exhibit emergent capabilities?

V. Develop an Information Dynamics and Learning Theory for NCW C2

Identify the data, information, knowledge and information consumption dynamics of NCW. How will human and software agent actors “learn” to understand NCW process behaviors? Does the DoD need a “Grand Data Architecture” which can encompass all DoD data flows and aggregations, information flows and aggregations, and knowledge discovery, flow, and creation requirements? Or is a set of Interoperable Data Architectures better suited to support the needs of NCW? What are the characteristics of a “Grand Data Architecture” is such a thing even feasible, should it be required to support cognitive agents, fusion of complex data types, traditional data warehousing and mining, knowledge discovery and creation? Should we define a Dynamic Knowledge Model for Organizations and Individuals? Can we create an “information ecosystem”⁹ which can enable the “continual evolutionary appearance or emergence of Intelligent Agents and Swarm Intelligence, with increasing capabilities and emerging skills? Could the “information ecosystem itself” exhibit emergent capability behavior? Can swarms of planning agents collectively create a “military plan” by fusing their outputs or pheromones – their collective planning knowledge? What is architecture knowledge? Can architecture agents swarm and dynamically compose themselves in any domain? Can swarms exhibit emergent behavior patterns?

Definitional dimension questions

1. Define clearly and simply the distinctions between data, information, knowledge, and wisdom.
2. What is process data flow?
3. What is process information flow?
4. What is process knowledge flow?
5. What is process wisdom flow?
6. What is organizational data flow?
7. What is organizational information flow?
8. What is organizational knowledge flow?
9. What is organizational wisdom flow?
10. Define data architecture?
11. Define a “Grand Data Architecture” capable of supporting all DoD data flows and aggregations, information flows and aggregations, and knowledge discovery, flow, and creation requirements and data fusion, information fusion, and knowledge fusion
12. Define a Dynamic Knowledge Model for Organizations and Individuals?
13. Is there such a thing as a data swarm?
14. Is there such a thing as an information swarm?
15. Is there such a thing as a knowledge swarm?

16. Is there a capability of swarm intelligence that would permit a swarm to exhibit wisdom?
17. What is the difference between individual learning and organizational learning?
18. What is the difference between individual knowledge and organizational knowledge? (Tacit and Explicit models)¹⁰
19. What is the difference between a community of practice and a community of interest in terms of the Dr. Nonaka Takeuchi Spiral of socialization, externalization, combination, and internalization (SECI)?¹¹
20. Can organizational knowledge be treated as an inventory like commodity?¹²
21. When is knowledge needed, can knowledge be delivered at the right time to the right place?
22. When is organizational knowledge simply accumulated but never understood or utilized?
23. Is there a distinction between knowledge required by an edge organization vs. the edge warrior?
24. What is the precise relationship between knowledge and skills, how would it be measured?
25. Is there such a thing as just in time knowledge? Just in Time data? Just in time Information? What delineates each?
26. Is there such a thing as “knowledge chain management” for knowledge demand and supply?¹³

Doctrinal dimension questions

1. Should doctrine apply to DoD knowledge management?
2. Should doctrine apply to cognitive agent capabilities?
3. Who fires a weapon and who is responsible for the consequences?

Operational dimension questions

1. Should we be separating knowledge from its vital organizational contexts such that a “Google like search” only returns knowledge, but not the data or information used to derive or compile the knowledge?
2. Should an organization have a knowledge vision and strategy? What would it look like?

Process dimension questions

1. Should the new NCW organizations be required to provide an atmosphere that will lend itself to knowledge creation and exchange?
2. Is there such a thing as a knowledge creation process?
3. Knowledge swarm **Process** attributes, not the swarm attributes but the **process attributes**
 - A. Knowledge fusion and aggregation
 - B. Information dissemination and diffusion
 - C. Pheromone deposit complexity as a messaging technique

- D. Pheromone pattern recognition as a learning model
 - E. Avatar agents with knowledge interpretation and self tasking both at the knowledge agent level and at the platform control level (full agent based autonomous vehicle control)
 - F. Multi-dimensional pheromones to convey deeper knowledge needed for fusion algorithms
4. Can knowledge Swarms self organize?
 5. What is the probability that organization members will utilize knowledge peculiar to an organization or individual and to what granularity must the knowledge be collected from a universe of possible knowledge sets?
 6. How can we predict which knowledge will be useful to a particular organization (Community of Interest or Community of Practice) and actually used by the organization or its members? ¹⁴
 7. Is there a dynamic data ecosystem process set capable of supporting information and knowledge emergence, self organizing fusion agents, and planning agents capable of learning and self improvement?
 8. Can adaptive cognitive agents “learn” or acquire knowledge that is useful to an organization or individual?
 9. What will or should these agents be learning?
 10. Is such an activity measurable?
 11. Can such agents distinguish between appropriate knowledge and valid knowledge?
 12. Can adaptive cognitive or knowledge agents share, communicate; re-articulate what it learns to other agents and humans?
 13. Can such agents recommend “novel organizational constructs”?

Metrics dimension questions

1. Is there a clear and measurable relationship between an organization’s knowledge and its success?

VI. Minimum C2 Models and Minimum C2 Process Configurations

Can an elementary C2 problem be modeled in such a manner that a simple comparison between Network Centric C2 processes and Non-Network Centric C2 processes can be achieved? Given the following models or paradigms as a starting point: control free, selective control, problem bounding, problem solving, interventionist, or cyclic, what are the possible mixes of these models and possible alternatives to these models which can best support agility of command, reduced analysis times, and reduced decision times? Can we establish a baseline operational scenario assuming the problem solving model of C2, with a particular metrics set targeted (lethality, survivability, interoperability, etc.) and then simply change the C2 paradigm and re-run the model, such that the resulting metrics will reveal an optimal C2 construct? Can we predict the variations in the resulting metrics? There is a concept under review in NCW literature known as “surge”. What exactly is meant by “surge”? Is there a minimum organizational C2 construct which

facilities “surge”? What are the dimensions and boundaries of such a construct? What are the logistical and timing constraints of such an approach to military planning?

Definitional dimension questions

- a. Are there simple C2 process building blocks that can be used to scale a process as well as the force? Are there multiple building block types?
- b. Are there multiple organizational block types for strategic national, strategic theater, operations, and tactical levels of C2?¹⁵

Doctrinal dimension questions

1. Should doctrine apply to C2 scalability in a process capacity sense?
2. Should doctrine apply to minimum C2 units in an adversarial process influence sense?

Operational dimension questions

1. If the edge is defined as the operating forces, what does power to the edge really mean in terms of C2 organizational command and control in chain of command structures?
2. How do you define each key NCW process area in terms of minimum awareness impact, capacity impact, and influence impact?

Process dimension questions

1. How will dynamic joint, interagency, coalition and non governmental processes be constructed from the simple building blocks?
2. Is there a minimum C2 problem which can be so simply stated that “C2 building blocks” may emerge capable of being added together to support the C2 organization required for larger operations or increased C2 capacity?

Metrics dimension questions

1. Is there a clear and measurable relationship between an organization’s simplicity and its success?

VII. Develop an NCW Assessment, Metrics and Instrumentation Theory

Is it possible to develop a single integrated assessment process which can be applied to an active mix of the types of military operations described in figure 1? Can we develop a single integrated set of assessment metrics or must we continue to live with “stovepipe” assessment processes and their unique metrics? Can an assessment process be developed that provides more timely evaluations of “composed mission capability sets” and would such a process constitute a “just-in-time” assessment of the composed network centric capabilities? What are the boundaries of the assessment process in terms of procurement process influence? Should the assessment process be such that less than optimal assessment metrics prevent procurement? How are organizational constructs assessed? How are we to assess the operational impacts upon missions if our adversaries develop

and deploy the following disruptive technologies: Nano-technology devices, major cryptography breakthroughs, major computational and communications breakthroughs, etc.? How do we assess major or catastrophic events resulting in long term disruptions in the ability to supply the military with fuels? How do we assess the human-capability-interface requirements of force transformation? Given that network centric theory favors a “control free” C2 approach, what assessment model can be used to validate that the required organizational, knowledge, leadership, and analytical skills are present in a “Composed Force” to enable that “**Control-free** model. And in this same control free context, how is such a military process and organizational construct to be assessed such that the NCW concept of “surge requirements” or capacity management is properly evaluated?

Definitional dimension questions

1. What is the definition of the term assessment?
2. Define an NCW assessment process so that it is distinct from a more traditional system of systems assessment approach
3. What constitutes an NCW portfolio of capabilities?

Doctrinal dimension questions

1. Should Composeable Assessments become part of procurement strategy and doctrine?
2. Should a Service Oriented Architecture and Composeable Web Services be directed at the doctrine level to support DoD wide simulation and modeling capability sharing?

Operational dimension questions

1. How do we define NCW experimentation in a modeling and simulation sense that fits with minimal command and control structures?

Process dimension questions

1. Should we develop an NCW Assessment Process which is structurally unique from current assessment practices?
2. Is there a static assessment component dimension to NCW assessment?
3. Is there a dynamic assessment component dimension to NCW assessment?
4. Is there a interoperability assessment component dimension to NCW assessment?
5. Is there a campaign level assessment component dimension to NCW assessment?
6. Is there a mission level assessment component dimension to NCW assessment?
7. Is there a C2 process level assessment component dimension to NCW assessment?
8. How are hybrid legacy, component, and service oriented architectures to be assessed in a concurrent manner?

9. Should we assess traditional C2 models (Control free, selective control, problem bounding, problem solving, interventionist, and cyclic)¹⁵ against radically decentralized C2?
10. How will HSI (Human System Interfaces) and HCI (Human Capability Interfaces) be assessed in an NCW environment?

Metrics dimension questions

1. How will processes be instrumented (process step instrumentation mechanisms or monitors and reporting services) so as to measure awareness, capacity, and influence in hybrid architectural models?
2. How will processes be instrumented so as to predict successful option dominance and option lockout

Cost & procurement dimension questions

1. How will NCW implementation, testing, and assessment processes be procured?
2. Should we implement self service assessments as a procurement policy?

VIII. What is the Impact of Globalization upon NCW?

The continual outsourcing of critical systems development to firms with no loyalty to the US is a direct threat to our security. There must be boundaries established which make sense in terms of defending the key economic infrastructure segments from continual business architecture decomposition until the supply chain is so complex and delicate that terrorist interruption of that supply chain is made easier, not more difficult as it must be to retain defensible borders and economic bases¹⁶.

Definitional dimension questions

1. What is the definition of globalization?
2. What is the DoD official definition of outsourcing?

Doctrinal dimension questions

1. What is the DoD boundary for outsourcing capabilities which have been traditionally borne by the force membership? (Logistics for instance)
2. Do we have doctrine which counters one of the RAND¹⁷ studies major conclusions which is “With respect to national security, ongoing economic integration may make it harder to control the spread of weapons and technology beyond our borders and those of our allies?”

Operational dimension questions

1. What are the impacts of Globalism to military planning?
2. Can we manage a protracted war with an impromptu alliance formed by Global Religious Interests consisting of for example An Islamic

Turkey with access to NATO weapons and data, an Islamic Pakistan, and a nuclear Iran, etc.

3. Does globalization enable foreign countries to develop competing Network Centric Warfare (NCW) capabilities
4. What are the logistics impacts of supply chain fragility due to globalization?
5. Are DoD Network Centric Policies, Processes and Edge Organizations Sufficiently Adaptable to Adequately Respond to The Impact of Globalization?

Process dimension questions

1. What is the DoD outsourcing process for NCW?
2. Do we need composable policy frameworks, composable policy processes, and composable assessments and simulations, to provide the organizational dynamics required to support the process and policy adaptability needed in a Post-international, globalist environment

Metrics dimension questions

1. How will we measure DoD outsourcing success for NCW?
2. Is outsourcing another dimension which should become a mandatory component of modeling and simulation of NCW behavior?
3. What are the HSI metrics required for leadership in a globalized environment?

Leadership dimension questions

1. What leadership model is required to support outsourcing?
2. What leadership model changes are required to successfully exist in a globalized world?

Assessment dimension questions

1. How do we assess and simulate outsourcing in terms of procurement model impact?
2. How do we assess the HSI models required for leadership training in an expanding coalition environment?
3. How do we assess the composable policy frameworks which will be needed to successfully manage constantly changing business and global trends and infrastructures?

Cost & procurement dimension questions

1. How will we measure DoD outsourcing success for NCW? By cost?
2. Is outsourcing another dimension which should become a mandatory component of modeling and simulation of NCW behavior?

IX. Develop a Theory for Command and Control for Memetic Warfare

Memes are ideas that can be modeled and simulated. In a modern journalistic environment, dynamic information feedback from the theater can produce profound effects either for the better or for the worse on our troops and public support for military actions. Should the DoD “manage” idea content contained in theater news reports? The so called CNN effect¹⁸ – demands the development of more effective, creative, precise, and continuously assessed information models and dynamic strategies for the management of war theater news such that publicized data or information cannot be used against our forces by the enemy. In a previous paper that I authored on abstract C2 processes¹⁹, I suggested that memes be modeled as a process output type such that both adversarial meme processes and our counter anti-memetic activity could be modeled, simulated, and assessed. I am now adding to that suggestion that possible “benign” news reports be treated and simulated as a meme attack. Cognitive Effects Based Operations are meme based attacks specifically designed to impact an adversary’s process either by increasing various process latencies or by forcing a policy change. Examples of this would include the attempt to establish democracy in the Middle East and the use of leaflets in Operation Iraqi Freedom to instruct the opposing force of the consequence of using biological or chemical weapons on the invading American forces. Do we have the proper memetic dynamics models and processes needed to manage daily or hourly news events that may be detrimental to our global policies? Do we need significant cultural models and deep cultural understanding prior to undertaking propagandistic or memetic activities?

Definitional dimension questions

1. What are memes?
2. What are memes in the context of ideatic influences which may influence the behavior of a potential adversary in advance so that armed conflict can be avoided?
3. What is the definition of “psyops”?

Doctrinal dimension questions

1. Should memetic modeling and planning become U.S. doctrine?
2. What is the DoD doctrine concerning “Free Press Access” to battle information across the full spectrum of operations?
3. How should Al-Jazeera style news organizations be managed?

Operational dimension questions

1. How are memes defenses to be planned?
2. How are meme attacks to be planned?
3. Are memetic operations different for the different types of military operations?

Process dimension questions

1. What are memetic processes?
2. What are adversarial memetic processes?

Metrics dimension questions

1. How are memes measured?
2. How are memetic processes measured?
3. What is a successful meme attack?
4. Can we define if a CNN report contains harmful word content such that our forces are exposed to increased risk?

Leadership dimension questions

1. What leadership skills and training are required to successfully manage news and media relations?
2. What leadership skills are needed to manage a “meme team” responsible for creating favorable military process outcomes?

Assessment dimension questions

1. How are memetic processes to be defined and assessed?
2. How do we assess the so called “CNN effect” in terms of battle outcomes?

Cost & procurement dimension questions

1. What is the cost of not “managing” the news in terms of casualties?
2. What is the cost of procuring memetic services?

X. Application of Biological Models to C2 Paradigms

Does the application of a particular model from biology necessarily mean that an improvement in warfighting capability, C2 organization, systems design, small efficient processes, and organizational slenderness can necessarily be expected?

Are these natural and biological models a solution in search of a problem or are they appearing in response to CLEAR requirements of the force? Does swarming and pheromone theory really apply to NCW? What criteria should be used to assess and select a particular natural model for research as to its applicability for C2 Organizations and Warfighting?

Definitional dimension questions

1. What is the definition of a swarm?
2. What is definition of a pheromone?
3. What is definition of stygmergy?

Operational dimension questions

1. How would swarms work and in what operational context?
2. How would pheromones work and in what operational context?
3. How would stygmergy work and in what operational context?
4. What are the possible applications of cellular automata with respect to “cell formation” as a minimum c2 building block?

Process dimension questions

1. How would swarms work in a C2 process context?
2. Could swarms create and transmit useful process knowledge?
3. Can pheromones be used as a process mechanism for messaging?
4. How can we assess “dependability” or “reliability” of the application of biological concepts to warfighting?

Metrics dimension questions

1. How would the use of swarms be measured in terms of process or warfighter capability improvement success?
2. How would the use of pheromones be measured in terms of process or warfighter capability improvement success?

Assessment dimension questions

1. How would the use of swarms be assessed in terms of improving warfighter effectiveness?
2. How would the use of pheromones be assessed in terms of improving warfighter effectiveness?

XI. Technology Infusion Management for NCW Acquisition Processes

How do we move from a product based procurement model (boxology) to a services and capability delivery model of procurement? How do we radically improve the procurement process such that new technology is easily transferred to the warfighter? What if the “bad guys” get a new technology first - does the DoD need an assessment process which focuses on detection and countermeasure creation due to adversarial technological breakthroughs in weapons, sensors, and submarine warfare capabilities? Is acquisition broken? What is the impact of NCW upon the procurement process itself? Does NCW procurement require new and more sophisticated assessment, simulation techniques and tools? Can we restrict procurement to those services and capabilities which have been subjected to a rigorous engineering analysis, campaign level experimentation, and outcomes based effect assessment or simulation?

Definitional dimension questions

1. What is the definition of capability based procurement?

Doctrinal dimension questions

1. What are the Doctrinal implications of a capability based procurement policy?

Operational dimension questions

1. What are the implications for current procurement policy?
2. Is acquisition broken?
3. How will procurement work in a cross agency operation?
4. Can there be cross agency “cost sharing”?

Process dimension questions

1. What are the implications for the procurement process?
2. Can there be cross agency “cost sharing”?

Metrics dimension questions

1. What specific metrics can be used to measure that the DoD procurement process is actually improving?

Assessment dimension questions

1. How will capability based procurement actually be assessed?
2. How will cross agency procurement be assessed?

Cost & procurement dimension questions

1. Will capability based procurement actually reduce procurement time and costs?

XII. Define the Boundaries of Robotic Warfare and Cognitive AI

Currently, in the world of chess, only a small number of extremely competent grand masters can defeat the strongest machines such as Deep Junior. Applying this concept to military planning systems, it is possible that in ten to fifteen years, the planning ability of such devices will exceed human capabilities. Who or what will be allowed to fire a weapon of class “X” in a future conflict? Will human commanders ever cede control over class “X” weapons such as to construct the so called weapons grid? Will a human commander ever order a subordinate to follow the orders of artificially intelligent systems? If a software program orders the subordinate to fire and unintended damage or casualties result, the software was in error, so who goes to jail? Define the precise criteria necessary to determine good strategic and tactical cognitive AI Agent created plans as compared to human created alternatives. In terms of social dynamics, how will human warriors and planners adjust to a decreasing role in planning, tasking, and decision making? Is there a flow of C2 from the human to an intelligent AI agent? Is there a flow of command and control from an intelligent agent to a human? What rank would the agent maintain? Is it ethically acceptable to use in vivo neural networks? What metrics are required to measure human transformation into a hybrid cyber world? What is the interplay between human and machine intelligence? Many years ago, warfighters swore that they would never fire at an enemy they could not see, so will there be a similar objection to following orders or plans not humanly created? Will the fear of AI go the way of never firing until you see the enemy?

Definitional dimension questions

1. Define the precise criteria necessary to determine good strategic and tactical cognitive AI Agent created plans as compared to human created alternatives.

Doctrinal dimension questions

1. Who or what will be allowed to fire a weapon of class “X” in a future conflict?
2. What are the classes of decisions that the DoD will permit to be made by AI agents given that the human following a plan or decision generated by an artificially intelligent agent may be unaware of the alternatives dismissed or the reasoning tree used by the agent?
3. What is the fail safe mechanism for agent based plans which need dynamic adjustment?
4. Are there any boundaries that will not be traversed by intelligent agents in terms of planning, automated battle management aids, agent based platform and weapon scheduling and dispatching? Agent based deconfliction?
5. Will coalition partner’s planning agents be declared superior to our planning agents and U.S. forces be ordered to achieve an objective selected by an Italian, Japanese, or French autonomous planning agent complete with an assault plan?
6. Will human commanders ever cede control over class “X” weapons such as to construct the so called weapons grid?
7. In terms of social dynamics, how will human warriors and planners adjust to a decreasing role in planning, tasking, and decision making?
8. Is there a flow of C2 from the human to an AI agent? From the agent to the human? Will humans command agents and agents command humans at all ranks?

Operational dimension questions

1. Who or what will be allowed to fire a weapon of class “X” in a future conflict?
2. Will humans always make better plans?
3. Will a mid rank commander follow such a plan or orders?
4. How does composable National Command Authority co-exist with cognitive agents?
5. Will a lance corporal be willing to follow the orders of an intelligent agent with little or no human analysis in the process?

Process dimension questions

1. Is there a knowledge and decision disengagement flow of C2 from the human basis to an AI agent basis ?
2. Are such intelligent assistants needed to fill the gap created by a rapidly declining American educational system?
3. Can the procurement process benefit from the use of cognitive agents?

Metrics dimension questions

1. What metrics are required to measure human transformation into a hybrid cyber world?

2. How will we be able to have confidence in such agents not built in the U.S.? What are the appropriate assessment metrics for this class of AI? What about the software “Trust” required for agents which may have been developed by an outsource supplier?
3. How will leadership training be impacted by the use of such agents?
4. What planning system metrics and analysis criteria will exist to enable the human general or admiral to determine that an AI based military plan is superior or deficient to a human created plan?
5. What metrics will be used to evaluate mission planning agents?

Assessment dimension questions

1. What planning system assessment and analysis criteria will exist to enable the human general or admiral to determine that an AI based military plan is superior or deficient to a human created plan?
2. What assessment methodology will be used to evaluate mission planning agents?

Cost & procurement dimension questions

1. What are the implications for current procurement policy?
2. Can cognitive procurement agents be used to reduce human staffing needs?

Conclusions

The effort which will be required to succinctly define and communicate the exact nature of the military transformation which we are undertaking as a nation will be long term. The U.S. Department of Defense’s grand restructuring of warfighting organization and strategy requires that many concepts which are difficult to define need to be embellished and simplified for a wider and more general audience. This author believes that the effort to attack these challenges will pay enormous dividends in terms of a dynamic synergism between the challenges and their co-evolutionary development and application, resulting in radically superior warfighting capabilities.

Special Recognition

The authors would like to recognize and thank Dr. Ray Curts of COMMIT Inc. for his probing analysis and editorial contributions to this paper.

References

1. Hilbert, David, Mathematical Problems – Lecture delivered before the International Congress of Mathematicians at Paris in 1900, source : <http://babbage.clarku.edu/~djoyce/problems.html>
2. Fabio Salmanca-Buentello, Deepa L. Persad, Erin B. Court, Douglas K. Martin, Adballah S. Daar, Peter A. Singer, PLoS medicine Journal, Volume 2 Issue 5, May 2005 - Adapted from criteria used to evaluate medical nano technology projects in “Nanotechnology and the Developing World”

3. UKCRC Grand Challenges Working Party, May, 2002 - "Criteria for a Grand Challenge"
4. Pacetti, Don, Commander, USN retired, SPAWAR Charleston, Chief Engineer staff Naval historian, personal correspondence, November 2005
5. Bedau, M. A., McCaskill, J., Packard, N., & Rasmussen, S., Open Problems in Artificial Life,
6. Dr. David S. Alberts and Dr. Richard E. Hayes, "Command Arrangements for Peace Operations", national defense university, ndu Press Book, May 1995 , page 39.
7. C.A.Barrie, Admiral RAN, Chief of Force Defence, Canberra, 2002 "*The spectrum of operations*", from Force 2020 of the Australian Defence
8. Pacetti, Don, Commander, USN retired, SPAWAR Charleston, Chief Engineer staff Naval historian, personal correspondence, December 2005
9. Bill Inmon, "Information Ecosystem" – in *The Corporate Information Factory or the Corporate Knowledge Factory?* Joseph M. Firestone - Source - <http://www.dkms.com/papers/cifckf.pdf> - See W. H. Inmon, Claudia Imhoff, and Ryan Sousa, *Corporate Information Factory* (New York, NY: John Wiley & Sons, 1998), Pp. 2-3
10. Peter W. G. Morris, "Managing Project Management Knowledge for Organizational Effectiveness", University College London
11. Dr. Ikujiro Nonaka, "Organizational Knowledge Creation", from a summary of Dr. Nonaka's remarks written by Bill Spencer of NSA at the Knowledge Advantage Conference, November, 1997, page 3
12. MacKinnon, Douglas J., Dr. Raymond E. Levitt, and Dr. Mark E. Nissen *Knowledge as Inventory: Near-Optimizing Knowledge and Power Flows in Edge Organizations*, 10th ICCRTS, CCRP Press
13. MacKinnon, Douglas J., Dr. Raymond E. Levitt, and Dr. Mark E. Nissen *Knowledge as Inventory: Near-Optimizing Knowledge and Power Flows in Edge Organizations*, 10th ICCRTS, CCRP Press
14. Peter W. G. Morris, "Managing Project Management Knowledge for Organizational Effectiveness", University College London
15. Pacetti, Don, Commander, USN retired, SPAWAR Charleston, Chief Engineer staff Naval historian, personal correspondence, January 2006
16. Lenahan, Jack: "Are DoD Network Centric Policies, Processes and Edge Organizations Sufficiently Adaptable to Adequately Respond to The Impact of Globalization?" - 10th ICCRTS, "The Future of C2", June 2005.
17. Lorell, Mark, A, Lowell, Julia, et.al., RAND Project for the U.S. Air Force "Going Global – U.S. Government Policy and the Defense Aerospace Industry"
18. C.A.Barrie, Admiral RAN, Chief of Force Defence, Canberra, 2002 "The CNN Effect" from Force 2020 of the Australian Defence Ministry
19. Lenahan, Jack, CCRTS 20004 "An Abstract Process and Metrics Model for Evaluating Unified Command and Control A Scenario and Technology Agnostic Approach"

2006 Command and Control Research Technology Symposium

The State of The Art and The State of The Practice

**Title: The Grand Challenges of Command and Control
Policy**

Track: C2 Policy

Authors: Jack Lenahan & Phil Charles

POC: Jack Lenahan Imagine-One Corporation

**Organization: Office of the Chief Engineer
Space and NAVAL Warfare Systems Command
Charleston, S.C.**

Address: P.O. Box 190022

N. Charleston, South Carolina: 29419

Phone: 843-218-6080

Email: John.Lenahan@Navy.mil

Introduction

- We are interested in defining and investigating the grand challenges facing the C2 Community in a Network Centric Transformational Environment. The purpose of these investigations is to provide a rigorous basis for assessing the state of the art and the state of the practice of command and control. In 1900, David Hilbert proposed a list of 23 outstanding problems in mathematics, a number of which have now been solved, some of which remain open but have guided mathematics analysis for the past 100 years.
- In a similar vein, it is the intent of this paper is to attempt to define the challenges facing C2 policy makers such that formal requirements and solutions to these problems may begin to evolve.
- The U.S. Department of Defense (DoD) has embarked upon a journey which constitutes nothing less than a major restructuring of warfighting organization and strategy. That indeed is a “grand endeavor”. Grand of course means impressive and ambitious in scale or scope.
- We are proposing that a \$500,000.00 prize per challenge or group of challenges be funded and awarded for the successful resolution of each challenge or a set of the challenges. A maximum of \$1.5 Million per winner should be enforced.

Grand Challenge Selection Criteria

- The proposed selection criteria used for adopting a challenge as “Grand” are:
- **Impact** – The resolution of a challenge will result in a major difference in terms of increased warfighter capability, increased situational awareness, better or more agile C2 organizational structures, increased C2 organizational capacity, and increased process influence in terms of “locking out” or dominating adversarial process options through the use of effects projection.
- **Appropriateness** – The issue addresses the C2 community’s most urgent needs (This assumes that the C2 community knows what it’s pressing needs are)
- **Depth** – The application of a solution to a given challenge is distributable across a broad swath of the spectrum of military operations.
- **Feasibility** – can the issue’s resolution be developed and deployed in a ten year time frame or less?
- **New Knowledge** – New knowledge will probably need to be created to satisfy the grand issue.
- **Indirect benefits** – The resolution of the issue can be utilized outside the U.S. military.

Grand Challenge Selection Criteria (continued)

- **Decomposability** - Issue easily decomposes into identifiable research goals
- **Collaborative** - The issue necessitates collaboration in more than one field or organization such that socialization and acceptance are enabled.
- **Paradigm Shift** - The issue should contain a radical operational paradigm shift
- **Innovative** - The issue will require new and innovative solutions not currently in existence versus a simple evolutionary advance in product or process (e.g., not the next revision of an operating system or database or yet another ontology, but innovative process and organizational solutions)
- **Co-evolutionary** - One grand issue can co-evolve its solution with at least one other grand challenge
- **Consistency** - The individual members of the set of challenges are conducive to co-evolution and not predatory in nature against another challenge, the challenges are not contradictory

GC # 1 - Formally and Succinctly Define Network Centric Warfare

- Suppose that Sun Tzu never wrote the “Art of War”. Suppose also that we are now tasked with compiling a document of 100 pages or less, which describes the major attributes of successful warfare and let us also assume that some version of Network Centric Warfare is the appropriate model. How might we approach such a task?
- What specifically is NCW?
- Is NCW a doctrine?
- How will we know when we have achieved NCW?
- Is NCW more of a “data sharing” enabler than a valid military strategy?
- Are we emphasizing technology over strategic thinking?
- Are we neglecting traditional strategy and visionary military planning because we believe that all possible military problems are solvable under an NCW umbrella?
- What constitutes a network centric warfare process as distinct from traditional military processes?

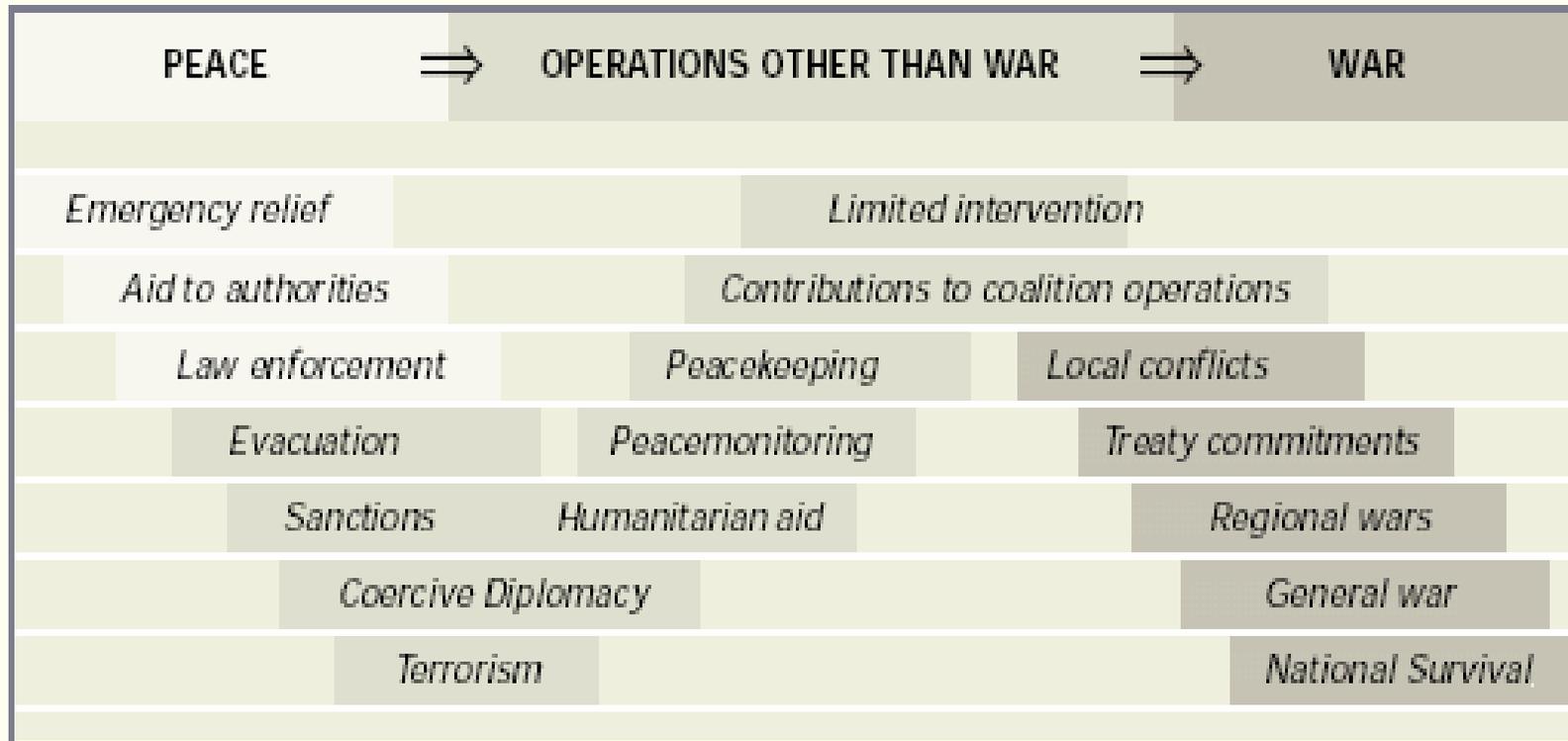
GC # 2 - Composeable Alliance Hierarchies to Enable Unified C2 – META C2

- The behavior of interagency resources during Katrina, exemplifies the urgent need for unified command and control.
- But what enables UC2?
- How do we create a formal accelerated framework for synthesizing dynamical alliance hierarchies which may contain complex jurisdictional, liability, legal, economic, and policing dimensions for all types and scales of military operations?
- Should there be such a thing as a composeable National Command Authority across all federal agencies? (Note: I do not believe that the current attempt known as the National Command Capability or NCC is adequate)
- What type of inter-country or inter-governmental agency and NGO agreements must be in place or created prior to creating a "virtual organization" such that inter-governmental agencies may self organize to meet a new emergency ?
- Can we scale or do we have the process capacity necessary to manage multiple city CBRN attacks or multiple natural disasters, during concurrent active GWOT and MCOs?.

GC # 3 - Unified Command and Control

- Do we understand how to prepare, construct, and activate the unified command and control infrastructure, including organizations and resources, which will be required for a potential massive relocation of American citizens from at least three major U.S. cities during (with the possible creation of a virtual state or city) and after a CBRN attack while the military is concurrently engaged in GWOT, other OOTW and possibly MCOs?
- What is the definition of a “policy”?
- What is the definition of a Command and Control (C2) policy?
- What is the definition of “Unified Command and Control”?
- What is unified command and control in a pure military context? In a mixed MCO, GWOT, and OOTW context?
- Will the proposed organizational and process attributes of self organization and emergence permit radically decentralized C2?
- What are the DOTMLPF implications of Unified C2?

GC # 3 – Spectrum of Operations – Will One C2 Model Work?



GC # 4 - Develop an Emergence & Self Organization Theory for NCW C2

- How critical is “emergence” and “self organization” to the success of NCW?
- How can emergent or self organizing C2 capabilities be assessed?
- Do emergent capabilities support or conflict with self organizing capabilities?
- Can we predict what capabilities will emerge and when or will we be surprised?
- What threshold crossing will actually trigger “an emergence”?
- Can we predict when self organization is going to occur?
- How many different kinds of emergent capabilities can we expect to see in a given environment?
- What is the relationship between an emergent property or self organizing property and the properties or capabilities that it emerged from, are they supervenient and predictive or simply postdictive?
- What kinds of things can exhibit self organization – Organizations, Systems, Software Modules, Neural nets, Processes?
- What kinds of things can exhibit emergent capabilities – Organizations, Systems, Software Modules, Neural nets, Processes?
- Will an information ecosystem enable agents to exhibit emergent capabilities?

GC # 5 - Develop an Information Dynamics and Learning Theory for NCW

- **Define clearly and simply the distinctions between data, information, knowledge, and wisdom.**
- **What is process data flow? - What is process information flow? - What is process knowledge flow? - What is process wisdom flow?**
- **What is organizational data flow? - What is organizational information flow? - What is organizational knowledge flow? - What is organizational wisdom flow?**
- **Identify the data, information, knowledge and information consumption dynamics of NCW.**
- **Does the DoD need a “Grand Data Architecture” which can encompass all DoD data flows and aggregations, information flows and aggregations, and knowledge discovery, flow, and creation requirements? Or is a set of Interoperable Data Architectures better suited to support the needs of NCW?**
- **What are the characteristics of a “Grand Data Architecture”, is such a thing even feasible, should it be required to support cognitive agents, fusion of complex data types, traditional data warehousing and mining, knowledge discovery and creation?**
- **Should we define a Dynamic Knowledge Model for Organizations and Individuals?**
- **How will human and software agent actors “learn” to understand NCW process behaviors?**
- **Can we create an “information ecosystem” which can enable the continual evolutionary appearance or emergence of Intelligent Agents and Swarm Intelligence, with increasing capabilities and emerging skills?**
- **Could the “information ecosystem itself” exhibit emergent capability behavior?**
- **Can swarms of planning agents collectively create a “military plan” by fusing their outputs or pheromones – their collective planning knowledge?**
- **What is architecture knowledge? Can architecture agents swarm and dynamically compose themselves in any domain?**
- **Can swarms exhibit emergent behavior patterns that will be useful to NCW?**

GC #6 - Minimum C2 Models and Minimum C2 Process Configurations

- Are there simple process building blocks that can be used to scale a process as well as the force?
- How will dynamic joint, interagency, coalition and non governmental processes be constructed from the simple building blocks?
- Are there multiple organizational block types for strategic national, strategic theater, operations, and tactical levels of C2?
- Is there a clear and measurable relationship between an organization's simplicity and its success?
- Is there a minimum C2 problem which can be so simply stated that "C2 building blocks" may emerge capable of being added together to support the C2 organization required for larger operations or increased C2 capacity?

GC #7 - Develop an NCW Assessment, Metrics and Instrumentation Theory

- **Is it possible to develop a single integrated assessment process which can be applied to an active mix of the types of military operations described in GC # 3 above ?**
- **Can we develop a single integrated set of assessment metrics or must we continue to live with “stovepipe” assessment processes and their unique metrics?**
- **Can an assessment process be developed that provides more timely evaluations of “composed mission capability sets” and would such a process constitute a “just-in-time“ assessment of the composed network centric capabilities?**
- **What are the boundaries of the assessment process in terms of procurement process influence? Should the assessment process be such that less than optimal assessment metrics prevent procurement?**
- **How are organizational constructs assessed?**
- **How do we assess traditional C2 models (Control free, selective control, problem bounding, problem solving, interventionist, and cyclic) against radically decentralized C2?**
- **How will HSI (Human System Interfaces) and HCI (Human Capability Interfaces) be assessed in an NCW environment?**

GC #8 - What is the impact of globalization upon NCW?

- **What is the DoD boundary for outsourcing capabilities which have been traditionally borne by the force membership? (Logistics for instance)**
- **Do we have doctrine which counters one of the RAND studies major conclusions which is “With respect to national security, ongoing economic integration may make it harder to control the spread of weapons and technology beyond our borders and those of our allies”?**
- **What are the impacts of Globalism to military planning?**
- **Can we manage a protracted war with an impromptu alliance formed by Global Religious Interests consisting of for example: An Islamic Turkey with access to NATO weapons and data, an Islamic Nuclear Pakistan, and a Nuclear Iran, etc.?**
- **Does globalization enable foreign countries to develop competing Network Centric Warfare (NCW) capabilities superior to our own?**
- **Are DoD Network Centric Policies, Processes and Edge Organizations Sufficiently Adaptable to Adequately Respond to The Impact of Globalization?**
- **How will we measure DoD outsourcing success for NCW?**
- **Is outsourcing another dimension which should become a mandatory component of modeling and simulation of NCW behavior?**
- **What are the HSI metrics required for leadership in a globalized environment?**

GC #9 - Develop a Theory for Command and Control for Memetic Warfare

- **Memes are ideas that can be modeled and simulated. Cognitive Effects Based Operations are meme based attacks specifically designed to impact an adversaries process either by increasing various process latencies or by forcing a policy change. Examples of this would include the attempt to establish democracy in the Middle East and the use of leaflets in Operation Iraqi Freedom to instruct the opposing force of the consequences of using biological or chemical weapons on the invading American forces.**
- **How should Al-Jazeera style news organizations be managed?**
- **Dynamic information feedback from the theater can produce profound effects either for the better or for the worse on our troops and public support for military actions. This so called “CNN effect” demands that a continuous strategy be devised for the management of war theater news such that publicized data or information cannot be used against our forces by the enemy.**
- **Do we have the proper memetic dynamics models and processes needed to manage daily or hourly news events that may be detrimental to our global policies? Do we need significant cultural models and deep cultural understanding prior to undertaking propagandistic or memetic activities?**
- **Should the DoD “manage the idea content” contained in theater news reports?**

GC #10 - Application of Biological Models to C2 Paradigms

- **Does the application of a particular model from biology necessarily mean that an improvement in warfighting capability, C2 organization, systems design, small efficient processes, and organizational slenderness can necessarily be expected?**
- **Are these natural and biological models a solution in search of a problem or are they appearing in response to CLEAR requirements of the force?**
- **Does swarming and pheromone theory really apply to NCW?**
- **What criteria should be used to select a particular natural model for research as to its applicability for C2 Organizations and Warfighting?**
- **How would swarms work in a C2 process context?**
- **Could swarms create and transmit useful process knowledge?**
- **Can pheromones be used as a process mechanism for messaging?**
- **How can we assess “dependability” or “reliability” of the application of biological concepts to warfighting?**

GC #11 - Technology Infusion Management for Unified C2 NCW Acquisition Processes

- **Is acquisition broken?**
- **What is the impact of NCW upon the procurement process itself?**
- **Can there be cross agency “cost sharing”?**
- **Does NCW procurement require new and more sophisticated assessment, simulation techniques and tools?**
- **Can we restrict procurement to those services and capabilities which have been subjected to a rigorous engineering analysis, campaign level experimentation, and an outcomes based effect assessment or simulation?**
- **How do we radically improve the procurement process such that new technology is easily transferred to the warfighter?**
- **What if the “bad guys” get a new technology first - does the DoD need an assessment process which focuses on detection and countermeasure creation due to adversarial technological breakthroughs in weapons, sensors, and submarine warfare capabilities?**

GC #12 - Define the Boundaries of Robotic Warfare and Cognitive AI

- **Who or what will be allowed to fire a weapon of class “X” in a future conflict?**
- **Who is responsible if a sailor, who is following the orders of an officer who is acting upon the direction of an “outsourced planning agent made in Russia”, causes civilian damage?**
- **Will human commanders ever cede control over class “X” weapons such as to construct the so called weapons grid?**
- **Define the precise criteria necessary to determine good strategic and tactical cognitive AI Agent created plans as compared to human created alternatives.**
- **In terms of social dynamics, how will human warriors and planners adjust to a decreasing role in planning, tasking, and decision making?**
- **Is there a flow of C2 from the human planner or commander to an AI agent?**
- **Is there a flow of C2 from the agent planner or commander to a human agent? What rank would the agent attain? Who would promote the agent?**
- **What metrics are required to measure human transformation into a hybrid cyber world?**
- **Are there any boundaries that will not be traversed by intelligent agents in terms of planning, automated battle management aids, agent based platform and weapon scheduling and dispatching? Agent based deconfliction?**

Conclusions

- The U.S. Department of Defense's restructuring of warfighting organization and strategy, requires that many concepts which are difficult to define, be simply stated for a wider and more general audience.
- Thus the effort which will be required to succinctly define and communicate the exact nature of the military transformation which we are undertaking as a nation will be long term.
- These challenges should pay enormous dividends in terms of a dynamic synergism between the challenges and their co-evolutionary development and application resulting in radically superior warfighting capabilities.