

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

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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?

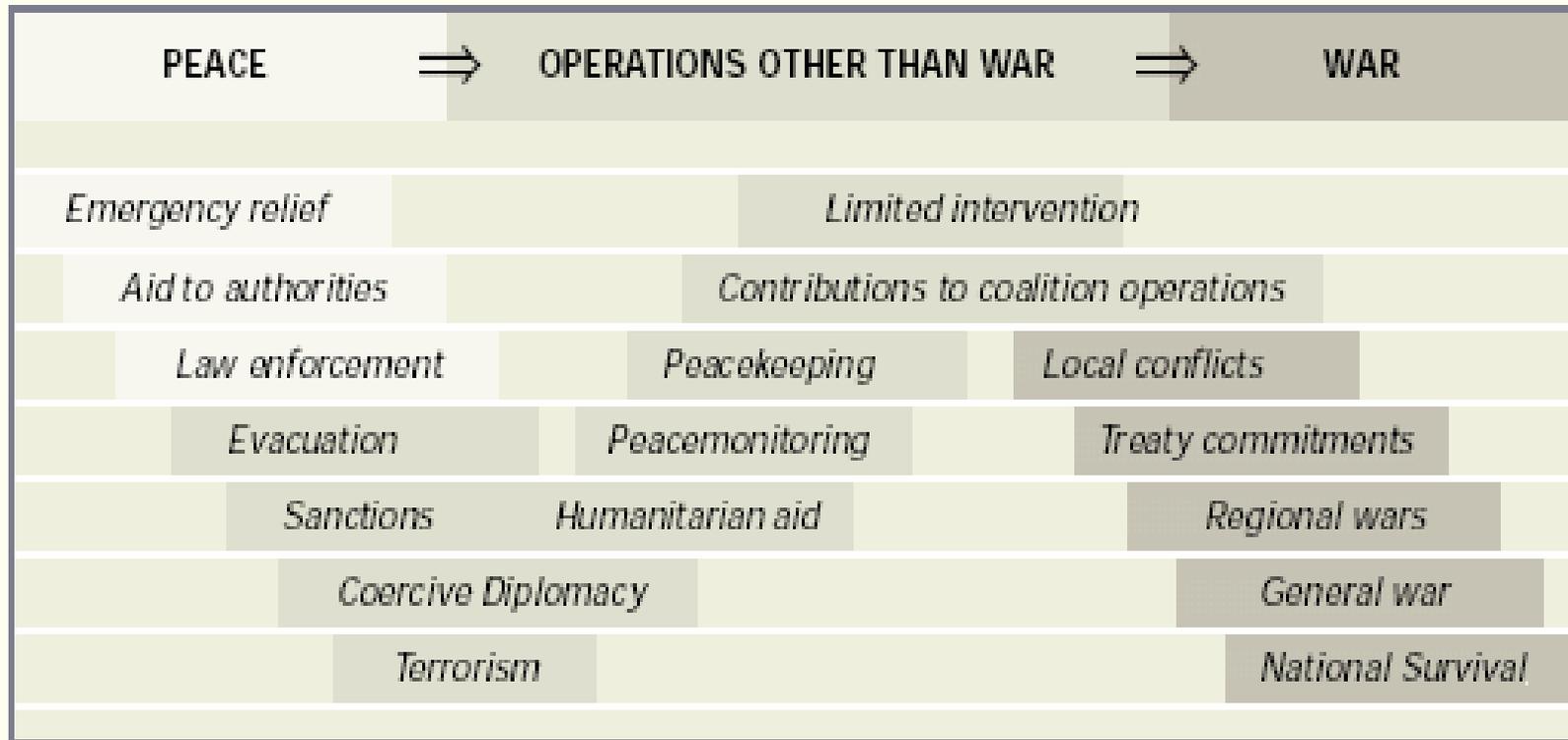
GC # 2 - Composeable Alliance Hierarchies to Enable Unified C2 – META C2

- 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.