Results of The Johns Hopkins University Applied Physics Laboratory's C2 Hypotheses Exercise

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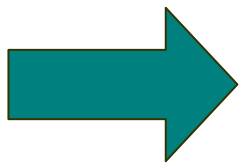
The Command and Control Challenge

- Inconsistent situational understanding within and between different command levels
- Limited ability to rapidly identify necessary participants across command levels for planning, action, and response
- Difficult to collaborate in an efficient manner to do dynamic planning
- Hard to receive rapid feedback to assess and adapt to emerging conditions and shorten timelines (e.g., time-sensitive targeting)
- Constrained ability to command in a dynamic environment

Sources: 9/11 Report, Operation Anaconda Report, FCS Requirements, USAF C2 FNA, JFCOM OIF Lessons Learned

Closing the Gaps



Moving from the "As Is" …

… Transforming to the "To Be"

C2 Operational Vision

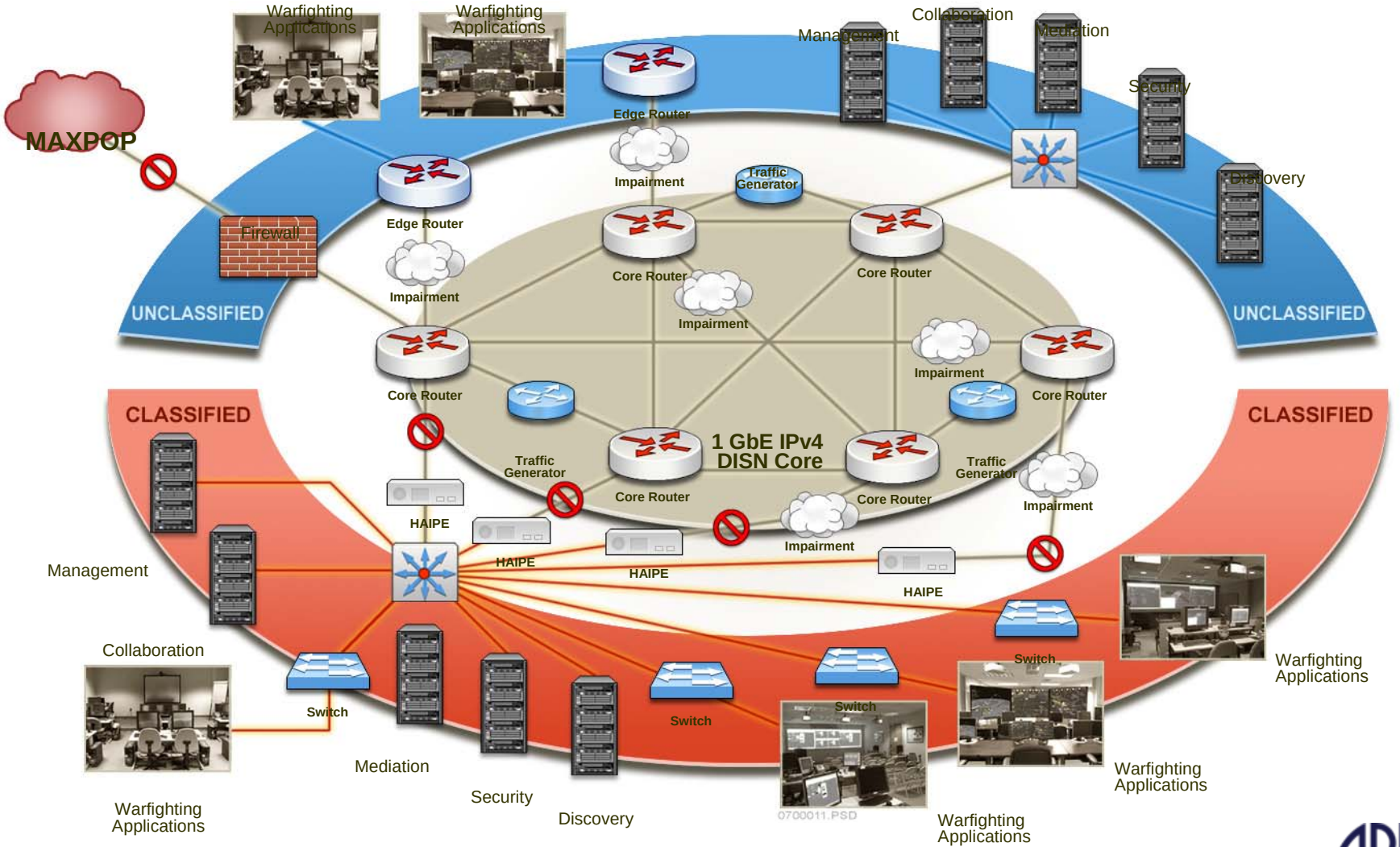
- A shared understanding of the battlespace including real-time coordinated interfaces between commands at all echelons
- Distributed/collaborative decision making across echelons, services, agencies, and coalitions
- Self-synchronizing forces enabling a command structure adaptive to the warrior/responders needs
- Decision making based on predictive and measured assessments of desired effects

One View Of Net-Centricity

“Reading current literature about net-centric warfare is like reading a math book with all theorems and no proofs.”

Anonymous

APL GIG Test Bed:
Technology Integration, Experimentation, and T&E



Some Lessons We Are Learning

- **Net-centricity represents a significant paradigm shift for warfighters and system developers**
  - **Changing the culture is as important as (and as hard as) developing required technical capabilities**
  - **Effectiveness needs to be demonstrated**
- **Quantification is essential to understanding C2 system performance**
  - **Metrics are needed at every level to establish the effectiveness of C2 concepts, technologies, and operational approaches**
- **Hands-on experimentation is critical**
  - **Exploratory development, test beds and ranges, exercises, and T&E are required to develop viable net-centric C2 foundations**

APL's C2 Operational Concept

Salient Features

- **Acknowledges complexity and diversity of conflicts/crises – the interaction of opposing considerations within unique operational environments**
  - **Conventional and Unconventional Warfare**
  - **Hierarchy and Anarchy**
  - **Knowledge and Uncertainty**
  - **Centralized and Decentralized Control**
  - **Concentration and Distribution of Combat Power**
  - **Proactive and Reactive Decision Making**

C2 is influenced by the operational environment and will vary over time and levels of war

APL's C2 Operational Concept (Cont'd)

Salient Features

- **Contemplates full spectrum of military activities**
  - **Presence, peacekeeping, and armed conflict**
  - **Coalition and interagency operations**
  - **Homeland defense**
- **Focuses on conceptual flexibility – the expectation that any operational environment is dynamic and that future C2 must also be dynamic**
- **Assumes future C2 must integrate emerging operating concepts with emerging technologies in four key areas:**
  - **Advanced Situational Awareness/Understanding**
  - **Decision Making**
  - **Planning**
  - **Execution**

Why a C2 Hypotheses WALEX (C2 HYWAL)?

???

ANALYSIS & EXPERIMENTATION

HYPOTHESES

Concept!

Solution!

The Problem:

Many agencies routinely offer technology demonstrations…

…but few ever progress to developing effective concepts and systematic solutions.

The Solution:

Concepts are assessed through viable analysis and experimentation…

…and the foundation of experimentation is a system of well thought-out hypotheses. Without hypotheses, experiments are nothing more than tech demos.

C2 HYWAL Objectives

- **Provide a forum for C2 Concept and Doctrine Stakeholders to influence evaluation of advanced C2 concepts and enabling technologies.**
- **Identify 3 – 5 high payoff, high risk Network Enabled Command and Control implementing concepts.**
- **Develop 2 operational hypothesis for each of the implementing concepts.**
- **Suggest an experiment focus and evaluation metrics for each operational hypothesis.**

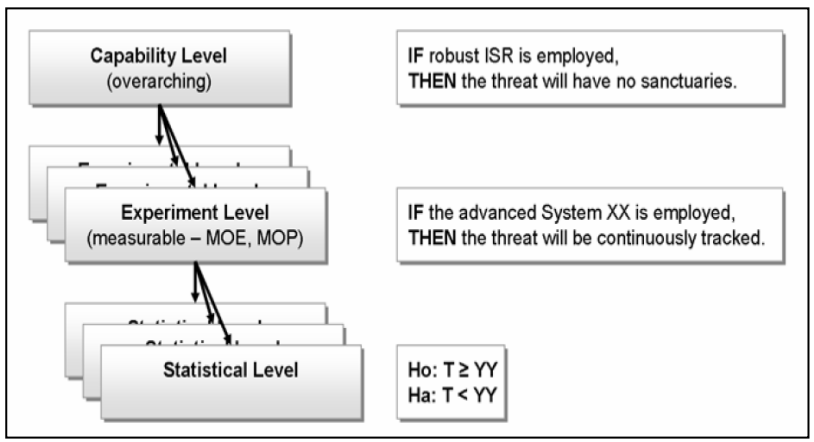
27 Total Participants

USAF
USN/USMC
MITRE
USJFCOM
JHU/APL

JOINT STAFF
NORTHROP GRUMMAN
BOEING

Kass Model - Hypotheses

It is useful to consider three different levels of ***warfighting experiment hypotheses***. At the most abstract level the if-then aspects are described in terms of capabilities and operational effects. These capability hypotheses, however, are not useful to experimenters who require hypotheses with implementable treatments and observable effects. The high-level "capabilities hypothesis" needs to be translated into one or more "experimental level" hypotheses. This is accomplished by translating the high-level capability into *enabling* systems that can be surrogated or modeled in an experiment.



--Richard A. Kaas
The Logic of Warfighting Experiments
CCRP, 2006

Kass Methodology

- **Begin with a restated *conceptual idea* derived from current literature**
- **Develop example *capability level hypotheses***
- **Develop example *experimental level hypotheses* *(these can be field experiments, tabletop experiments, or wargames)***
- **Develop example *statistical level hypotheses***

More on what we mean in a minute

Example of an Enabling Concept for Experimentation (1)

- **Conceptual Idea: "Shared situational awareness increases mission effectiveness."**
- **An operational setting:**
  - **SOF Team infiltrated by SSN to an Objective area**
  - **SOF team has direct control of a UAV and receives sensor data by direct downlink.**
  - **After SOF team is disembarked from SSN enemy forces are redeployed and target is moved**
  - **UAV Imagery confirms enemy / target movements**
  - **SOF team uses UAV data to avoid enemy forces and engage target.**
- **Desired operational outcome:**
  - **Ingress, target destruction and egress are successful**
  - **Overall mission is successful**

Back to the Kass Model Using Example

- **Conceptual Idea: "Shared situational awareness increases mission effectiveness."**
- **Capability Hypothesis: If UAV data is available to share, then military units will maneuver and fight more effectively.**
- **Experimental Hypothesis: If UAV data is available to a SOF team then the likelihood of detection will decrease and mission accomplishment will increase**
- **Statistical Hypothesis (one example): If the measured detection rate of blue forces with UAV data is less than the measured detection rate without predator data by a factor of two sigma or more, than the presence of predator data significantly reduced the probability of SOF team detection**

Example of an Enabling Concept for Experimentation (2)

CONCEPT: Shared situation awareness leads to increased self-synchronization and dramatic increases in mission effectiveness.

CAPABILITY HYPOTHESIS: If all members of a joint interagency task force have shared situation awareness, then reaction and decision times are greatly reduced.

EXPERIMENTAL HYPOTHESIS: If the commander employs liaison teams equipped with system X, then crisis response teams will react faster to emergencies.

STATISTICAL HYPOTHESIS: If system X equipped liaison teams are fielded with PVOs, then intelligence tips from PVOs will increase.

SCENARIO: US/Coalition interagency task force conducts humanitarian relief following severe outbreak of cholera in major urban area. Low-level insurgency threatens peaceful recovery. World community interested; many NGOs/PVOs committed to relief efforts.

COMMANDER, US FORCES has several options for C2 organization, including the capability to provide liaisons and equipment to share situation awareness among all joint, interagency, and coalition partners, in addition to selected NGOs/ PVOs.

WARGAME tests various options and their outcomes through the use of an event list that presents insurgent attacks, interaction with host nation government and groups, and disaster relief requirements.

This scenario explores the C2 Concept dynamics of *hierarchy and anarchy*, and *centralized and decentralized C2.*

C2 HYWAL Group Tasking

- Group #1 - Look at problems associated with vertical / horizontal C2
- Group #2 - Look at a constrained environment
- Group #3 - Look outside the box
  - Identify 3 – 5 high payoff, high risk Network Enabled Command and Control implementing concepts.
  - Identify 2 operational hypothesis for each of the implementing concepts.
  - Suggest an experimental design and evaluation metrics for each operational hypothesis.

Top Six Hypotheses

H#	Averages in Quartiles Across Matrix (highest is best)	Priority
20	If we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment. (Group 3)	4.00
14	If we improve our sensing and understanding of non-physical domains, Then we will create new action options for ourselves, better understand how to eliminate the enemy's options, and better predict the outcome of our actions (Group 3)	3.90
3	If the same actionable data is available to the entire command structure, then there is improvement in horizontal and vertical coordination that enables decision-makers to operate inside the enemy's decision cycle resulting in achieving desired effect (Group 1)	3.90
6	If provided a collaborative environment tailorable to decision-makers, the quality of decision will be increased. (Group 1)	3.90
15	If we understand the enemy and the environment, then we will be able to turn the enemy against himself. (Group 3)	3.80
19	If we can influence the opponents through cyberspace, then we can effect operations anywhere in the world. (Group 3)	3.80

Applying Kass Model to our Highest Priority Capability Hypothesis

Capability Hypothesis : ***If we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment***

- **Experimental Hypothesis #1: Given a blog platoon leaders read to gain latest insight into Techniques, Tactics, and Procedures (TTPs) appropriate for his/her situation, if blog had monitor/editor, then feedback loop will be improved and platoon leaders would implement improved TTPs**

- **Measures: Ratio of good to bad data in blog, probability of implementing bad TTP rather than an improvement because of blog**

- **Discussion:**
  - **Blogs currently provide a feedback loop to allow platoon leaders (and others) to exchange information about did/didn't work**
    - **Clearly a tradeoff between validating and vetting ideas and suggestions versus a free flow of information**
  - **Experiment would attempt to measure effect of providing a monitor/editor to improve blog information content**

Applying Kass Model to our Highest Priority Capability Hypothesis (Cont'd)

Capability Hypothesis : ***If we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment***

- **Experimental Hypothesis #2: For platoon leaders in the field utilizing a blog for TTP updates, if a blog rates the effectiveness of posts, then the feedback loop will be improved and platoon performance improved**

- **Measures: Ratio of good/bad data, platoon performance parameters / metrics**

- **Discussion: Similar to experimental hypothesis #1, but it attempts to quantify value of allowing bloggers to identify important and useful information (as well as identify bad or wrong information)**

Applying Kass Model to our Highest Priority Capability Hypothesis (Cont'd)

Capability Hypothesis : ***If we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment***

- **Experimental Hypothesis #3:** **If separate repositories of Lessons Learned are automatically combined into a single, integrated, rated data repository and made available to exercise participants, then effectiveness of the forces will be improved**

- **Measures:** **Percentage of duplicates, percentage of contradictory lessons, utilization of lessons learned, number of events where lessons learned were not applied**

- **Discussion:** **Similar to experimental hypothesis #1 and #2, but attempts to measure value of integrating current "blessed" repositories of lessons learned and thereby maximize their usefulness**

Summary / Conclusions

- Conference objectives were intended to be bold
  - Engender collaboration between C2 theorists, technologists, and practitioners to influence evaluation of advanced C2 concepts and enabling technologies
  - Rich exchange of views and collaboration
  - Results serve as a basis for future C2 research and collaboration
- Central premise was a set of C2 hypotheses could be derived and serve as basis of future C2 testing and experimentation
- Challenging to link operational hypotheses developed experimental hypotheses, experimental venues, and metrics
    - More time / effort needed for this task than was available
- The Kass method was successfully demonstrated for C2 hypotheses development

Summary / Conclusions *(cont'd)*

- Noted challenge bridging so-called "air gap" between theoretical and testable
  - Two basic testing / experimentation approaches recommended
    - Narrowly define experiment into testable metrics
      - Drawback: scoping experiments to that which can be tested, the hard-to-measure virtues of shared awareness, self-synchronization, and collaboration (particularly across a large C2 enterprise) may be lost
    - Measure innovations in terms of adoption
      - If users see value, measured or otherwise, they will adopt innovations
- Military transformation of C2 probably requires a mix of quantitative and qualitative analysis to identify key capabilities
  - Testing hypotheses such as these could lead to more informed decisions regarding C2 solutions, balancing capabilities with resources, and identifying key areas for innovation
- Now looking at possible venues to carry on the initial progress made at this conference

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