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

Presenter
Buck Buchanan
APL C2 Initiative Director
thomas.buchanan@jhuapl.edu
(443) 778-3865

APL Contributors
Steve Forsythe
Jim Hillman
Bob Leonhard
John Nolen

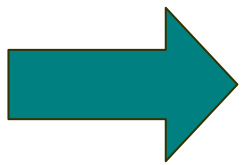
APL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

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" …

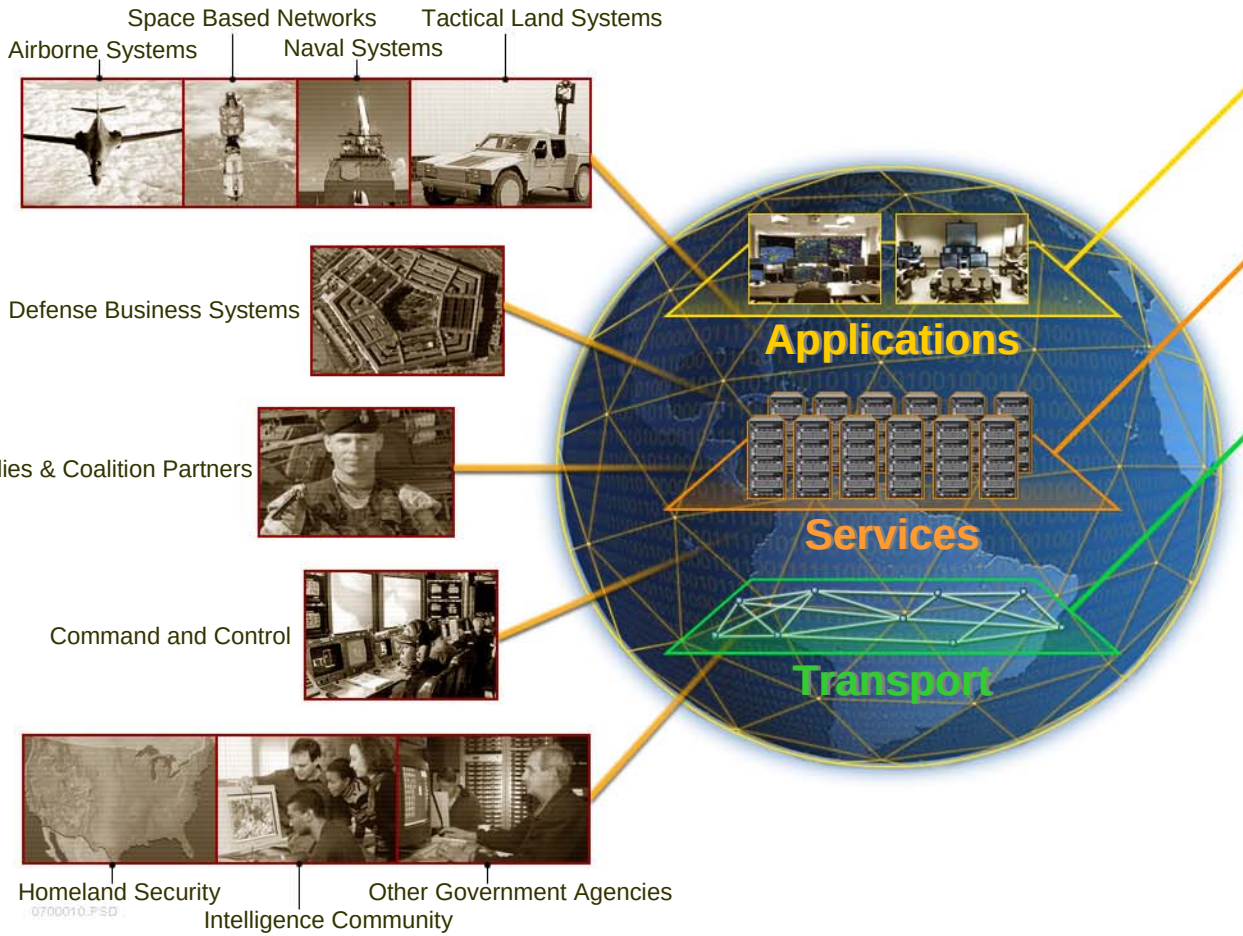
… Transforming to the "To Be"

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

Net-Centricity Underlies the C2 Vision

A universal network for collaboration that provides …



- **Loosely coupled applications**
- **Highly adaptive and flexible**

- **Defined data strategy**
- **XML driven by DoD directives**
- **SOA enterprise environment**

- **IP based with high QoS**
- **High- availability multimedia communications**

Transformation Satellite (TSAT)

Joint Tactical Radio System (JTRS)

Global Information Grid - Bandwidth Expansion (GIG-BE)

Warfighter Information Network-Tactical (WIN-T)

Mobile User Objective System (MUOS)

Net-Centric Enterprise Services (NCES)

System-of-Systems Common Operating Environment (SOSCOE)

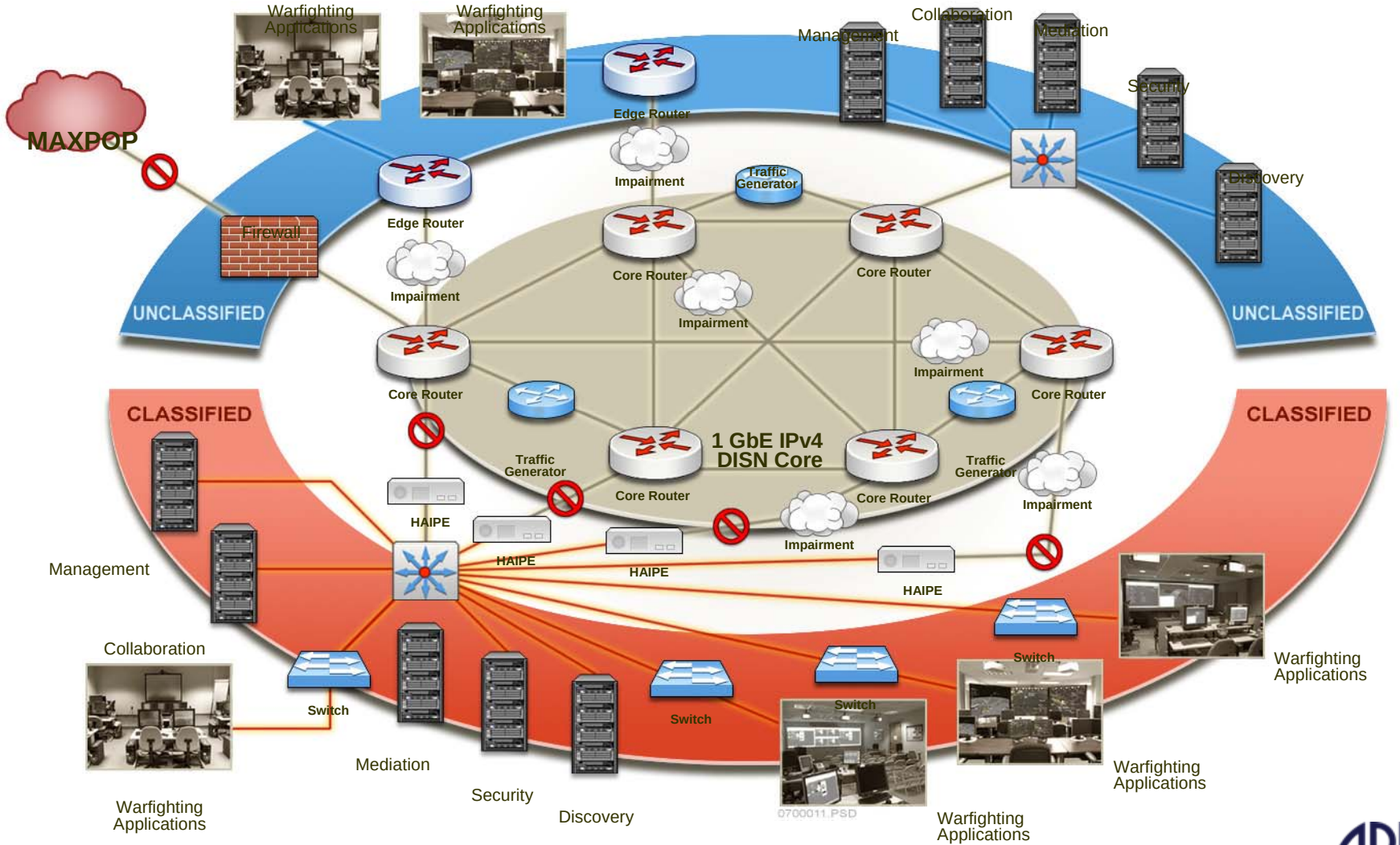
… requisite performance, interoperability, and information assurance

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



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…

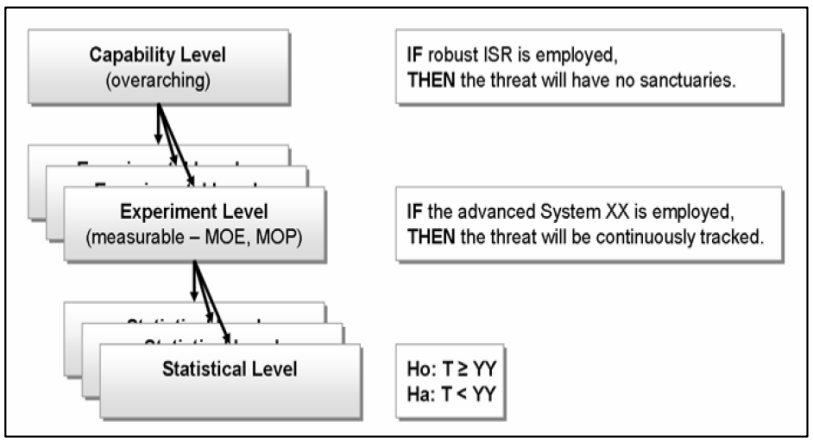
…and the foundation of experimentation is a system of well thought-out hypotheses. Without hypotheses, experiments are nothing more than tech demos.

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.

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***



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

Example of an Enabling Concept for Experimentation

- **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**

27 Participants Assigned to Three Groups

USAF
USN/USMC
MITRE
USJFCOM
JHU/APL

JOINT STAFF
NORTHROP GRUMMAN
BOEING

Group #1 - Look at problems associated with vertical / horizontal C2
Group #2 - Look at a constrained environment (current funded programs / capabilities)
Group #3 - Look outside the box

Top Six Hypotheses of 25

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

Group 1 – Vertical / Horizontal C2
Group 2 – Constrained Environment
Group 3 – Out of the Box

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 what 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**

C2 HYWAL Summary / Conclusions

- Conference objectives were intended to be bold
  - Collaboration needed between C2 theorists, technologists, and practitioners to influence evaluation of advanced C2 concepts and enabling technologies
  - 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, experimental hypotheses, experimental venues, and metrics
  - Kass method successfully demonstrated for C2 hypotheses development
- Also a challenge bridging the so-called “air gap” between theoretical and testable
  - Two basic testing / experimentation approaches recommended
    - Narrowly define experiment into testable metrics
      - Drawback: scoping experiments to what 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

Summary / Conclusions *(Cont'd)*

- **Military transformation of C2 requires a mix of quantitative and qualitative analysis to identify key capabilities**
  - **Hypotheses testing 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**

The Challenge

"A hiatus exists between the inventor who knows what they could invent, if they only knew what was wanted, and the soldier who knew, or ought to know, what they want and would ask for it if they only knew how much science could do for them. You have never really bridged that gap yet."

Sir Winston Churchill, *The Great War, Vol. IV*

JOHNS HOPKINS
UNIVERSITY

Applied Physics Laboratory

Conventional Warfare v. Unconventional Warfare

Conventional Warfare

- Conventional forces
- Defined combatants
- Linear battlefield
- Terrain objectives

Unconventional Warfare

- Irregular forces
- Undefined combatants
- Non-linear battlefield
- Non-terrain objectives

Examples:

- Desert Storm, 1991
- Iraqi Freedom, 2003
- …but each had unconventional components

Examples:

- Enduring Freedom, 2001
- Iraqi Insurgency, 2003-5
- …but each had conventional components

Desert Storm → OIF → Panama 89 → Kosovo 99 → OEF → Iraqi Insurgency → Global War On Terror

Conventional ← → **Unconventional**

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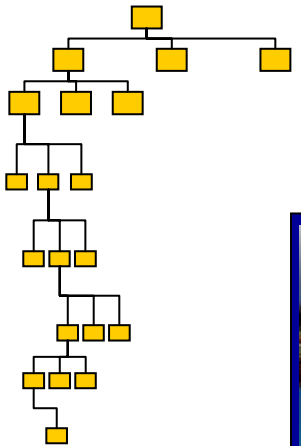
Hierarchy v. Anarchy

Hierarchical relationships

- Senior
- Subordinate
- Supporting
- Supported

"Anarchical" relationships

- Coalitions
- Cooperation across organizations
- Liaison with central or local officials
- Ties with national or local religious or tribal organizations
- …



Panama 89 | Desert Storm | OIF | OEF | Iraqi Insurgency | Kosovo 99 | Global War On Terror

Hierarchy — Anarchy

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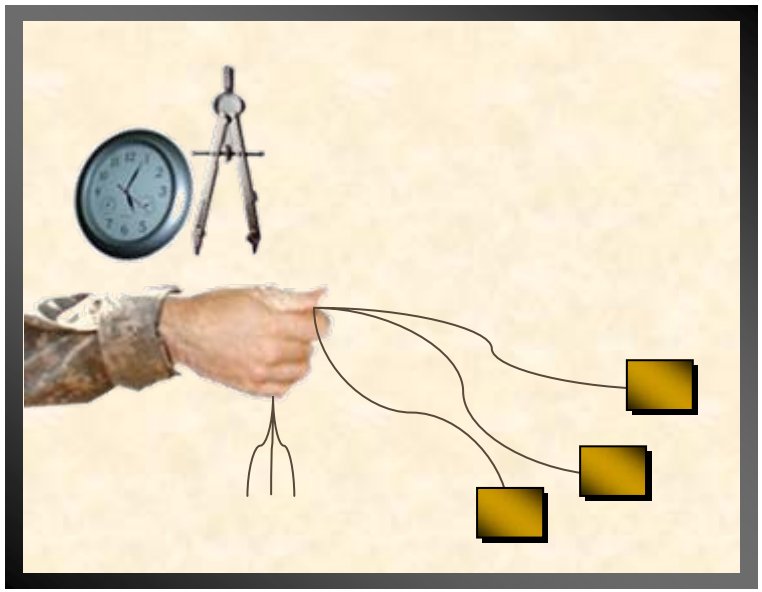
Centralized Control v. Decentralized Control

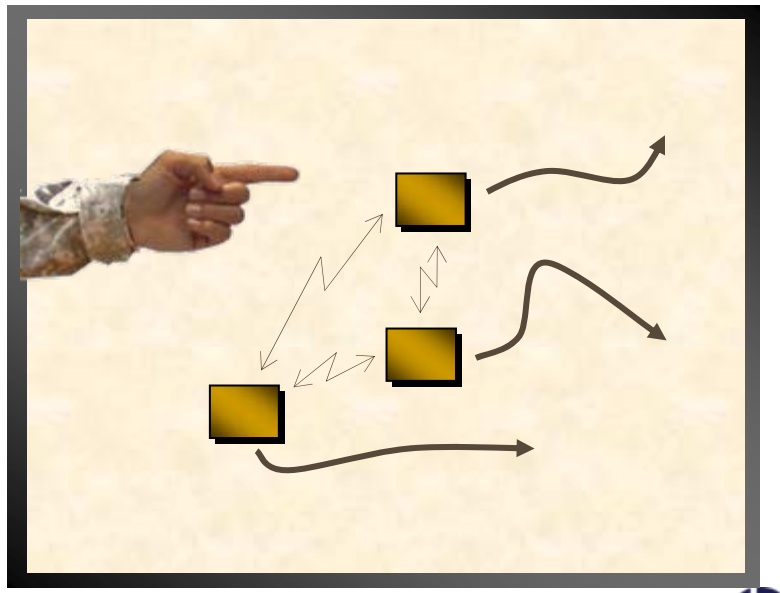
Centralized control

- TPFFD execution
- Air Tasking Orders
- Air Defense Zones
- Bandwidth allocation
- Rules of Engagement
- …



Decentralized control

- Commander's intent
- Mission orders
- Areas of Operation
- Self-defense
- Subordinate initiative
- …



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Concentration of Forces v. Dispersion of Forces

Concentration of forces

- Focus combat power
- Seize key objectives
- Take decisive action

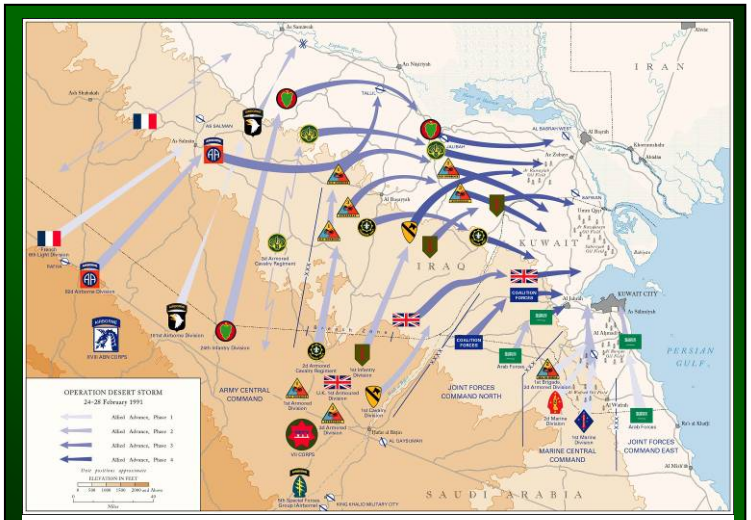
e.g., Airland Battle

Examples:

- Main attack, Desert Storm
- Faluja, Spring 2005

Dispersion of forces

- Control more area
- Reduce target profile
- Hide intent



e.g., Distributed Operations

Examples:

- Afghanistan, 2001
- Iraqi Insurgency

Knowledge v. Ignorance: Decision Makers Must Act with Imperfect Information

Knowledge

- **Drawn from credible information about**
  - **Friendly forces**
  - **Enemy forces**
  - **Terrain & weather**
- **Acquired from many sources**

Examples from OIF:

- **Friendly strength**
- **Enemy weapons**
- **Enemy tactics**
- **Terrain analysis**
- **Weather forecasts**

Ignorance

- **Unacquired information**
- **Incorrect information**
- **Misinformation**

Examples from OIF:

- **Hussein's location**
- **Absence of WMD**
- **Persistence of Baath militias and irregulars**
- **Delays caused by sand storms**

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Planning and Execution: Decision Makers Must Be Both Reactive and Proactive

Proactive

- Used against an easily anticipated enemy
- Normally requires information superiority
- The preferred way to fight in the American military—but not always possible

Reactive

- Used against an enemy that defies templating
- A sound approach when information is scarce
- Often the precursor to or successor to proactive measures

DECIDE - DETECT - DELIVER

DETECT - DECIDE - DELIVER

A dynamic Command Concept must not default to one or the other…but facilitate <u>both</u>

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Hypotheses and Ratings (1 of 5)

Group #	Averages in Quartiles Across Matrix (highest is best)	Pri	STD
1	H1. - If the quality of synchronized data meets necessary attributes to support decision authority, then flexibility exists where decisions can be made	3.20	1.15
1	H2. - If the quality of synchronized data meets necessary attributes to support decision authority, then decision quality (timeliness, accuracy, assuredness) will be improved.	3.40	1.06
1	H3. - 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 effects.	3.90	1.06
1	H4. - If the same actionable data is available across the command structure, then each command can simultaneously operate across the spectrum of supported and supporting with all other command nodes.	3.50	1.02
1	H5. - If you add situationally invoked security policies (bend to rules), then you can significantly increase the mission effectiveness of coalition operations.	3.30	1.34

Hypotheses and Ratings (2 of 5)

Group #	Averages in Quartiles Across Matrix (highest is best)	Pri	STD
1	H6. - If provided a collaborative environment tailorable to decision-makers, the quality of decision will be increased.	3.90	0.85
1	H7. - If we create the ubiquitous network where everyone has access, then as situational stress increases, the individual will fall back on hierarchal trust relationships.	2.70	1.34
1	H8. - If there is access to the ubiquitous network which could lead to information/ sensory overload, then there is an impact on how decision-makers collaborate.	3.20	1.09
2	H9.- If a standards based security capability is implemented in network management tool suites, then we can detect, in real time, intrusions into the Terrestrial GiG sub-networks [NIPR and SIPR] as measured by frequency and type of attack.	2.40	0.89
2	H10. - If the characteristics of existing networks are understood, then joint standard procedures could be developed to define how to manage and integrate the networks.	2.90	1.25

Hypotheses and Ratings (3 of 5)

Group #	Averages in Quartiles Across Matrix (highest is best)	Pri	STD
2	H11. - If a joint knowledge management capability (process and technology) is established, then military decisions would be more agile and effective.	2.90	1.14
2	H12. - If the knowledge shared with disadvantaged users is limited by technology, then decisions will be impaired.	3.00	0.95
2	H13. - If a joint collaboration capability is established that can exchange and manage knowledge, then joint military operations will be more effective.	3.70	1.01
3	H14. - 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	3.90	1.15
3	H15. - If we understand the enemy and the environment, then we will be able to turn the enemy against himself.	3.80	1.31

Hypotheses and Ratings (4 of 5)

Group #	Averages in Quartiles Across Matrix (highest is best)	Pri	STD
3	H16. - In some cases, if we turn the enemy against itself, we will achieve our objectives more quickly and efficiently than if we use our own resources alone to defeat the enemy.	3.20	1.29
3	H17. - If we had the capability to know when to delay killing an enemy asset, then we could learn more about the overall enemy activities and achieve our objectives more efficiently.	3.00	1.00
3	H18. - If we use cyberspace options, then our response time can be reduced.	3.40	1.06
3	H19. - If we can influence the opponents through cyberspace, then we can effect operations anywhere in the world.	3.80	1.07
3	H20. - f we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment.	4.00	1.00

Hypotheses and Ratings (5 of 5)

Group #	Averages in Quartiles Across Matrix (highest is best)	Pri	STD
3	H21. - If we use "shadow commanders" (some of which are machines) to create a market of C2 decisions, then better COAs will be developed and selected.	3.30	0.96
3	H22. - If we use "shadow commanders" to create a market of C2 decisions, then those personnel who consistently perform well will be easily identified.	3.00	1.00
3	H23. - If procedures are altered to allow improved feedback, then learning will be improved.	3.40	1.17
3	H24. - If we can use rewards and incentives effectively, we will be able to influence the behavior of groups (NGO's, partners, local population) that we don't "control".	3.30	1.17
3	H25. - If we used market-based (dispersed) planning function, then we could rapidly plan and replan.	2.80	1.02

Capability Hypothesis (H14)

Capability Hypothesis : ***If we improve our sensing / understanding of non-physical domains, then we will create new action options for ourselves, better understand how to eliminate enemy options, and better predict outcomes of our actions***

- **Experimental Hypothesis: If cell phones are provided to locals in a theater of operations (or surrogate), and in a non-government forum provide infrastructure to support local needs (e.g. free water), then local sources of operationally useful information will be improved**

- **Measures: Target audience's adoption of technology (e.g., .local eyes cell phone) to generate operationally useful information, number of non-kinetic/nontraditional options, change in number of significant actions (measure of affect), measures of trust relationships (e.g. build a trust data base on individuals over time for transfer as units transfer)**

- **Discussion: This is a two part hypothesis:**
  - **Improvement in ability to sense non-physical domains**
  - **Understanding non-physical domains**

Both enables feedback on how well our understanding corresponds to *reality and allow us to adjust as needed*

Capability Hypothesis (H3)

Capability Hypothesis : ***If the same actionable data is available to entire command structure, then there is improvement in horizontal / vertical coordination that enables decision makers to operate inside the enemy's decision cycle resulting in achieving desired effects***

- **Experimental Hypothesis: If a Command Center has a user defined operational picture (UDOP) capability, then coordination and decision cycle will be improved**

- **Measures: Cognition measures, process speed, increased collaboration, improved decision quality (e.g., Air Tasking Order quality)**

- **Discussion: Much discussion about trying to define "actionable data". Definition settled on is actionable data is timely, correct, relevant, trustworthy, and consumable that aids in making a good decision and execution. Problem with this hypothesis is all detailed relevant data needed at lowest levels could not be consumable or relevant at higher level. However, reverse may be true. What is relevant to your commander may always be relevant to you (e.g. commander's intent is relevant to everyone).**

Capability Hypothesis (H6)

Capability Hypothesis : ***If provided a collaborative environment tailorable to decision-makers, the quality of decision will be increased***

- **Experimental Hypothesis: If given two network structures, one strictly hierarchical and the other tailorable by the decision maker(s), then the tailorable network will outperform the hierarchical one in solving complex problems**

- **Measures: Cognition measures, process speed, increased collaboration, improved decision quality (e.g., ATO quality)**

- **Discussion: Information needed to solve the decision problem and discoverable throughout nodes of the network. Competition venue could be used to compare performance and information exchange**

Group 1 - Problems Associated with Vertical / Horizontal C2

- **Conceptual Idea: The quality of data throughout the chain of command needs to be synchronized with the level of decision making authority**

- **Hypotheses:**
  - **If the quality of synchronized data meets necessary attributes to support decision authority, then flexibility exists where decisions can be made**
  - **If the quality of synchronized data meets necessary attributes to support decision authority, then decision quality (timeliness, accuracy, assuredness) will be improved.**

Group 1 - Problems Associated with Vertical / Horizontal C2

- **Conceptual Idea: Unimpeded access to actionable (relevant, valid, timely) data enables horizontal and vertical collaboration throughout a C2 environment, improving decision-making.**

- **Hypotheses:**
  - **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 effects.**
  - **If the same actionable data is available across the command structure, then each command can simultaneously operate across the spectrum of supported and supporting with all other command nodes.**

Group 1 - Problems Associated with Vertical / Horizontal C2

- **Conceptual Idea: Adding situationally dependent flexibility to existing security policies enhances C2 decision-making with coalition operations.**

- **Hypotheses:**
  - **If you add situationally invoked security policies (bend to rules), then you can significantly increase the mission effectiveness of coalition operations.**

Group 1 - Problems Associated with Vertical / Horizontal C2

- **Conceptual Idea: A collaborative environment tailorable to the decision-maker will increase mission success.**

- **Hypotheses:**
  - **If provided a collaborative environment tailorable to decision-makers, the quality of decision will be increased.**
  - **If we create the ubiquitous network where everyone has access, then as situational stress increases, the individual will fall back on hierarchal trust relationships.**
  - **If there is access to the ubiquitous network which could lead to information/ sensory overload, then there is an impact on how decision-makers collaborate.**

Group 2 - Constrained Environment
Candidate Enabling Concepts

Collaboration
Coordination

Common needs that broadly apply across the joint, combined, coalition, NGO and GO community of users in a Joint Theater of Operations:

- **Knowledge Management**
- **Information Transport**
- **Information Assurance**
- **Network Management**
- **Enterprise Services**

Issue Set:

- **Common framework**
- **COCOM's willingness to share data**

Group 2 - Constrained Environment
Network Management

- **Enabling Concept: Network management enables information sharing for command and control.**
  - **Responding to network attacks**
  - **Providing dynamic routing to accommodate loading constraints**

✓ **If a standards based security capability is implemented in network management tool suites, then we can detect, in real time, intrusions into the Terrestrial GiG sub-networks [NIPR and SIPR] as measured by frequency and type of attack.**

Types of Attack:

- **Denial of Service**
- **Data Theft**
- **Spoofing (Source System Spoofing)**
- **Unauthorized alterations of data**

Scenario: Red Team attacks a network that is realistically loaded using a variety of attack mode:

- **Spamming with large data files**
- **Other**

Group 2 - Constrained Environment
Network Management

- **Enabling Concept: Future Network management schemes should enable GiG information sharing among advantaged (thick pipe) and disadvantaged (thin pipe) users.**
- ✓ **If the characteristics of existing networks are understood, then joint standard procedures could be developed to define how to manage and integrate the networks.**

Current global information grid is a combination of disparate sub-networks in the airborne, space, terrestrial and maritime domains

Group 2 - Constrained Environment
Knowledge Management

- **Enabling Concept: Access to relevant, actionable information coupled with knowledge management enables decisive action (at all levels).**

✓**If a joint knowledge management capability (process and technology) is established, then military decisions would be more agile and effective.**

✓**If the knowledge shared with disadvantaged users is limited by technology, then decisions will be impaired.**

✓**If a joint collaboration capability is established that can exchange and manage knowledge, then joint military operations will be more effective.**

Group 2 - Constrained Environment
Concept to Hypothesis

- **Enabling Concept: Network management capability that protects the exercise of command and control by enables command and control by:**
  - **Allowing for advantaged (thick pipe) and disadvantaged (thin pipe) users**
  - **Responding to network attacks**
  - **Providing dynamic routing to accommodate loading constraints**

✓ **If a standards based security capability is implemented in network management tool suites, then we can detect, in real time, intrusions into the Terrestrial GiG sub-networks [NIPR and SIPR] as measured by frequency and type of attack.**

Types of Attack:
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Scenario: Red Team attacks a network that is realistically loaded using a variety of attack mode:
- **Spamming with large data files**
- **Other**

Group 2 - Constrained Environment
Definitions

- "Knowledge management (KM), which is the systematic processes by which knowledge needed for an organization to succeed is created, captured, shared, and leveraged."
- The Joint Forces Command (JFCOM) Pamphlet 5 cites the draft JP 6-0, and establishes an unofficial DoD definition as

  "Knowledge management is the handling, directing, governing, or controlling of natural knowledge processes (acquire/validate, produce, transfer/integrate knowledge) within an organization in order to achieve the goals and objectives of the organization."
- Knowledge:
- The body of truths or facts accumulated in the course of time.
- The sum of what is known:

Group 3 – Out of the Box

- Chaos Theory
- Self-Synchronization
- Complex Adaptable Systems
- Trade between exploration and integrating
- Releasing control

- Situational Awareness
- Planning
- Decision
- Execution

Group 3 – Out of the Box
Laundry List of New Concepts

- Turn the enemy organism against itself
- Use the enemy system to learn about the situation
- More profound non-physical sensing
- Use cyberspace as a way of manipulating, impacting, controlling the enemy
- Support faster learning and distribution of learning (to support adaptability of our forces)
  - Related ideas…
  - Shadow commanders accessing, manipulating and 'deciding' on the same information base, creates a market-style competition of ideas/advice
  - Shadow 'automated' commanders doing the same thing.

Group 3 – Out of the Box
New Sensing Paradigms

- **New Concept:**
  - **Determining what the enemy is doing and why requires new sensing paradigms.**
- **Capability Hypothesis:**
  - **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**
- **Experimental Hypothesis: can this be done quickly enough to enable well-established C2 cycles.**
- **Statistical Hypothesis:**

This new sensing capacity needs to be complemented with new info mgmt capabilities.

Group 3 – Out of the Box
Turn the enemy organism against itself

- New Concept: Use the enemies key assets against itself. (e.g., sensors, culture)
- Capability Hypothesis:
  - If we understand the enemy and the environment, then we will be able to turn the enemy against himself.
  - In some cases, if we turn the enemy against itself, we will achieve our objectives more quickly and efficiently than if we use our own resources alone to defeat the enemy.
  - If we had the capability to know when to delay killing an enemy asset, then we could learn more about the overall enemy activities and achieve our objectives more efficiently.
- Measures: Seizures (due to tips), Fratricide, distrust, fewer of our resource needed, reduced tempo

Group 3 – Out of the Box
Use Cyberspace to Impact the Physical Battlespace

- New Concept: Cyberspace has global reach, rapid response, and offers new, creative methods of shaping the battlespace.
- Capability Hypothesis: If we use cyberspace options, then our response time can be reduced.
- If we can influence the opponents through cyberspace, then we can effect operations anywhere in the world.
- Experimental Hypothesis:
- Statistical Hypothesis:

Group 3 – Out of the Box
Learning/feedback in a complex environment

- New Concept: In a complex continuously evolving battlespace agility and learning may be more relevant than planning and execution
- Capability Hypothesis:
  - If we improve our ability to share learned success (and failures), then we will be more adaptable to a rapidly changing environment.
  - If we use "shadow commanders" (some of which are machines) to create a market of C2 decisions, then better COAs will be developed and selected.
  - If we use "shadow commanders" to create a market of C2 decisions, then those personnel who consistently perform well will be easily identified.
  - If procedures are altered to allow improved feedback, then learning will be improved.
- Experimental Hypothesis:
  - A C2 system with better support for learning and then distributing the learning across the force will improve force effectiveness.
  - If we use blogs to allow troops in the field to share successes and failures, then operations will rapidly take advantage of successes and failures.

Group 3 – Out of the Box
Rewards and Incentives

- New Concept: Influencing the behavior of people I don't control requires rewards and incentives.
- Capability Hypothesis:
  - If we can use rewards and incentives effectively, we will be able to influence the behavior of groups (NGO's, partners, local population) that we don't "control".
  - If we used market-based (dispersed) planning function, then we could rapidly plan and replan.
- Experimental Hypothesis:
- Statistical Hypothesis:

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**

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, exercises, and T&E are required to develop viable net-centric C2 foundations**

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.*