Concept Development and Experimentation

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Agenda

- Why perform concept development?
- Where do ideas originate?
- Concept development and experimentation
- What is an experiment? Why experiment?
- Challenges for effective experimentation
- Illustrative conceptual models
- Experimentation is not a panacea
- Campaigns of experimentation
- Illustrative experimentation
- Conclusions

Why Perform Concept Development?

- **Fundamental changes in the threats to national security**
  - **From fixed to variable threats**
  - **From episodic to continuous conflicts**
- **Fundamental changes in the missions**
  - **From warfighting to national security**
  - **Increasing need for international peace operations**
  - **Requirement for agile capabilities**

Why Perform Concept Development? (2)

- **Enormous changes in information technologies**
  - **Capacity to share information**
  - **Capacity for collaboration**
- **Massive expansion of relevant partners**
  - **Not only multinational, but also interagency**
  - **Not only governmental, but international organizations (IO), non-governmental organizations (NGO), private industry, and local authorities**
- **From secure within our borders to global linkages**
  - **NATO out-of-area missions**
  - **Economic, social, and political arenas**

Threat vs. Military Role

Adversary	Military Force	Policing & Monitoring	Supporting Civilian Missions
Nation States	Iraq	Bosnia	State Sponsored Counterfeiting and Smuggling
Sub-National Actors	Kosovo	Somalia	Rwanda
Organizations	Afghanistan	WMD Technology Transfers	Homeland Security
Individuals & Networks	Maritime Interception of Immigrants	Drug Interdiction	Illegal Monetary Transfers
Systemic Challenges	Quarantine to Control Ebola Outbreak	Illegal Fishing/ Pollution Control	Earthquake, Tsunami and Hurricane Responses

The Tenets of Network Centric Warfare

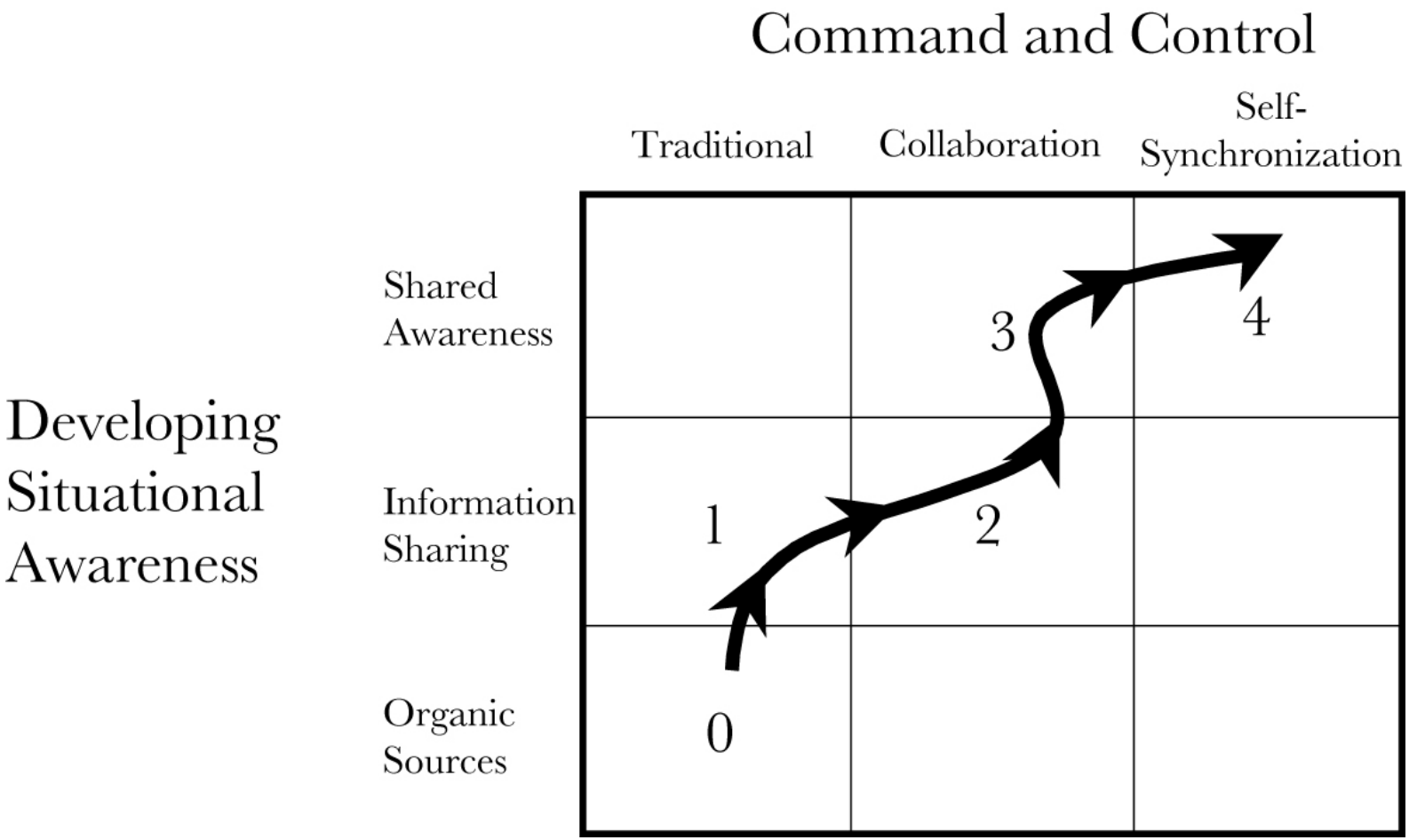
1. A **robustly networked force** improves **information sharing**

2. **Information sharing** and **collaboration** enhance the quality of information and **shared situational awareness**

3. **Shared situational awareness** enables **self-synchronization**

4. These, in turn, dramatically increase **effectiveness and efficiency**

Network Centric Operations Maturity Model



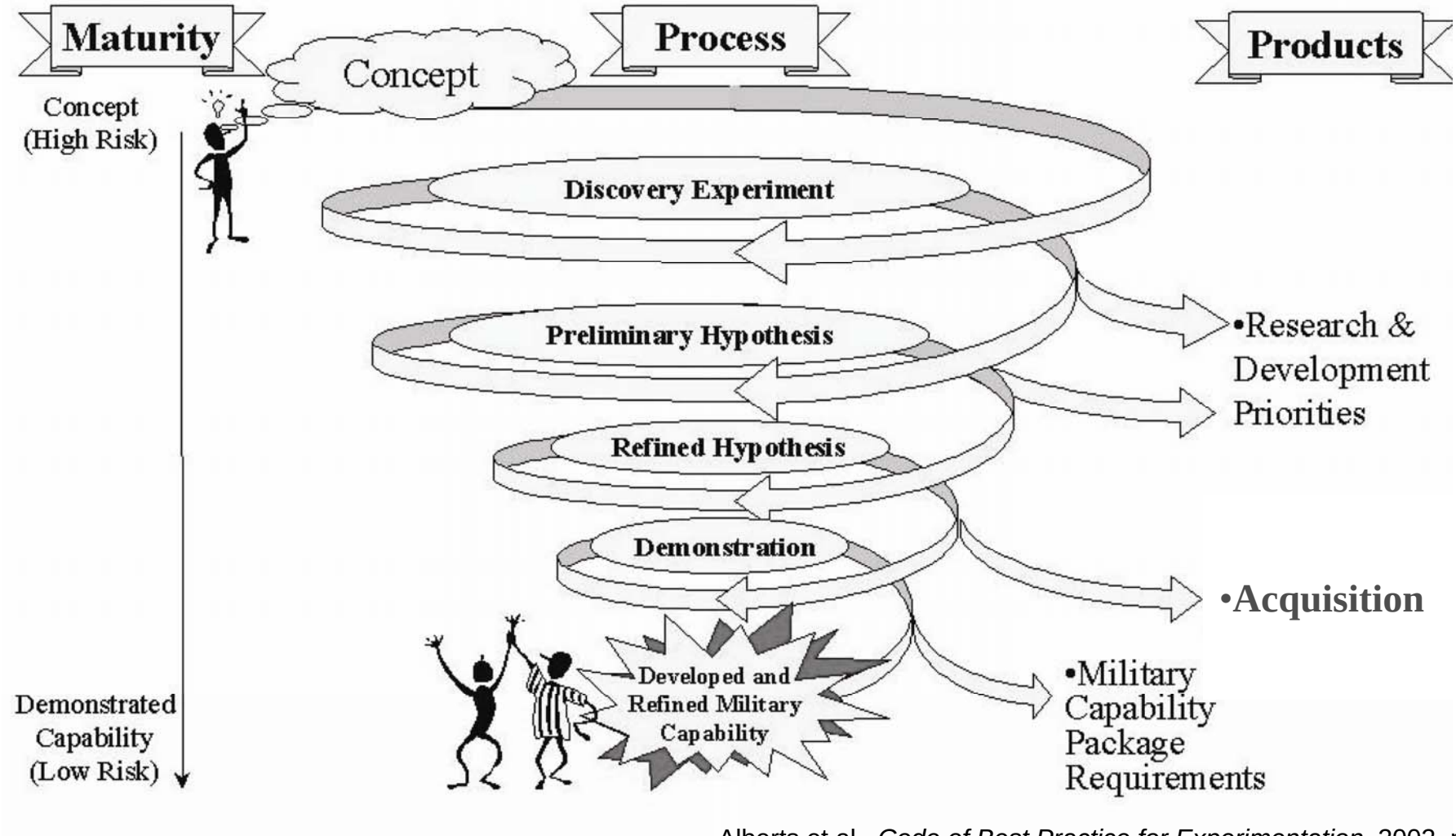
Alberts & Hayes, *Power to the Edge*, 2003. p109.

Concept Development: Where Do Ideas Come From?

- **The Force and its partners**
  - **Field Commands**
  - **Elements of the force**
  - **Interagency groups**
- **Lessons learned from operations and exercises**
- **Deliberate concept development activities**
- **Research and development communities**
- **Improved theory and policy**
- **Technology developers**
- **By analogy from other fields**

New Concepts May Come From Anywhere!

Concept Development and Experimentation: From Theory to Practice



Alberts et al., *Code of Best Practice for Experimentation*, 2002. p26.

What is an Experiment?

- From the Latin, *experiri,* which means “to try”
  - Knowledge founded upon observation or experience – empirical
  - Requires establishing some level of control
  - Requires manipulation of one or more factors
  - Seeks to identify cause and effect
- Three Types of experiments
  - *Discovery* experiments: to determine the impact of something previously untried (explore the unknown)
  - *Hypothesis testing*: to explore alternative cause and effect relationships (refine knowledge)
  - *Demonstration*: to show established relationships (educate)
- Experiments may involve: Humans only, machines only, humans and machines interacting

Why Experiment?

- **Stakes are very high: national interests, lives and treasure**
- **National security institutions are, therefore, correctly conservative – slow to change**
- **Experimentation provides a means to:**
  - **Mitigate risk**
  - **Identify innovations that are useful and matter**
  - **Learn conditions under which innovations work**
  - **Provide empirical evidence to inform policy and budgetary dialogues**

Challenges for Effective Experimentation

- **Identify the correct research question and mission capability package**
  - **Relevant to improved mission accomplishment**
  - **Focused enough for meaningful progress**
- **Prepare for success**
  - **Involve stakeholders**
  - **Build a multidisciplinary team**
  - **Include domain expertise, experimentation design expertise, and technical support**
  - **Plan for peer review throughout the process**

Challenges for Effective Experimentation (2)

- **Conduct rich literature search on prior work**
- **Develop a conceptual model: an executable one, if possible**
  - **Objective functions (dependent variables)**
  - **Controllable independent variables**
  - **Uncontrollable independent variables**
  - **Relevant relationships**

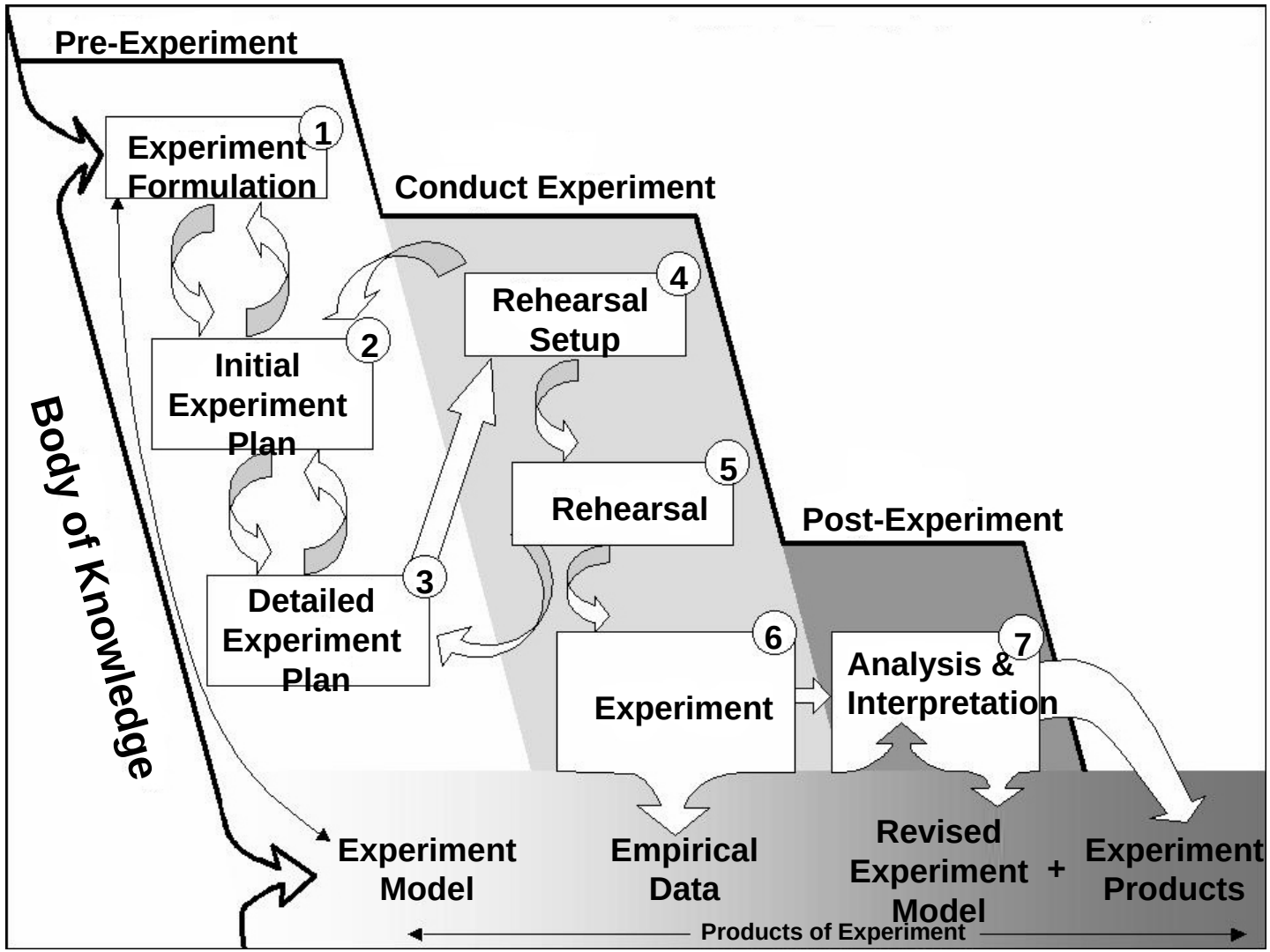
Challenges for Effective Experimentation (3)

- **Create meaningful measures of merit**
  - **Measures of performance (MOP)**
  - **Measures of force effectiveness (MOE)**
  - **Measures of policy effectiveness (MOPE)**
- **Design a robust experiment**
  - **Sample the important space**
  - **Find an adequate facility and technical support**
  - **Locate appropriate subjects**
  - **Develop robust data collection and data analysis plans – at the same time**

Challenges for Effective Experimentation (4)

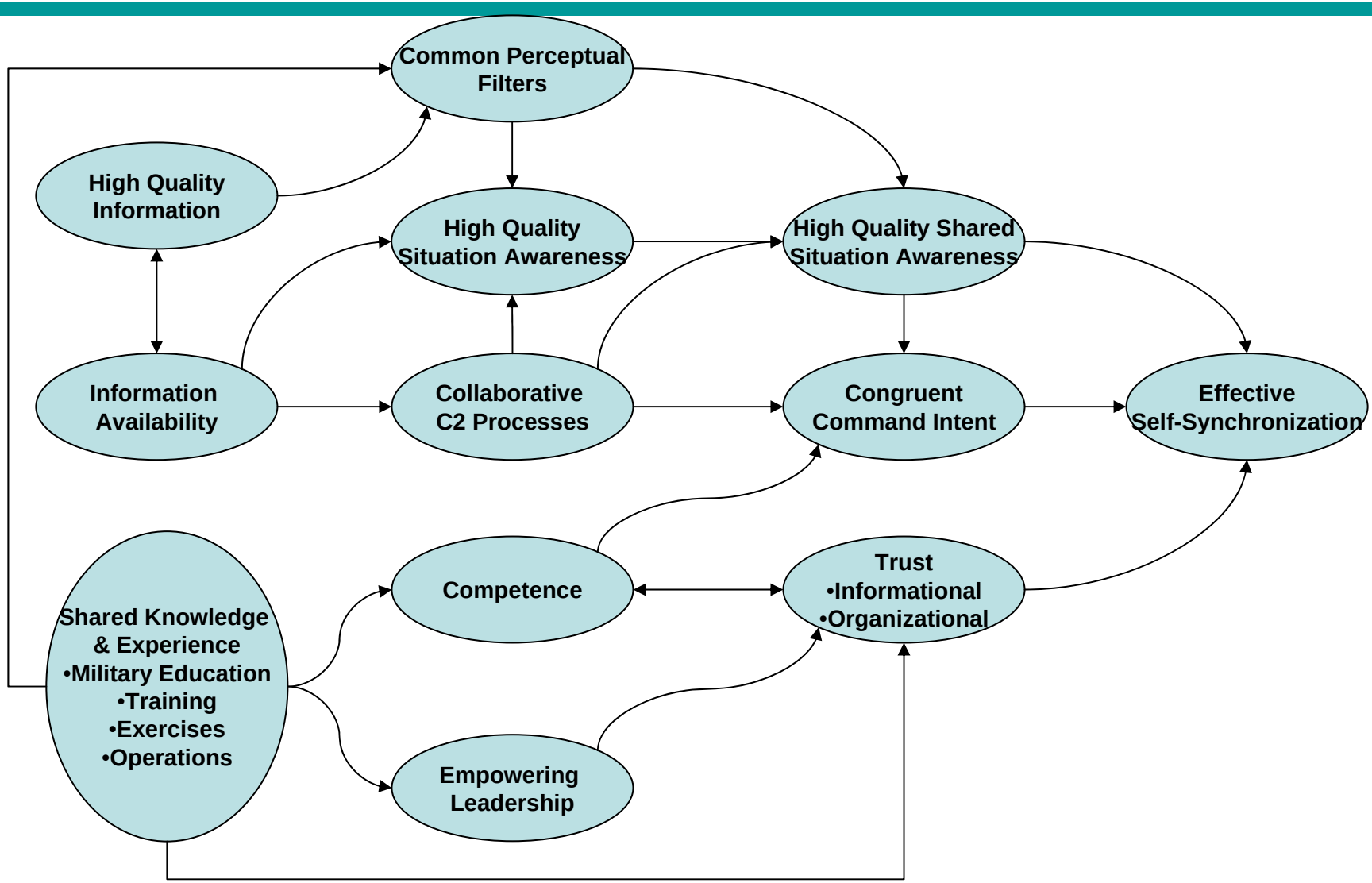
- **Conduct an end-to-end rehearsal**
- **Execute the experiment as you designed it**
- **Conduct effective analyses: immediate and in-depth**
- **Revise the conceptual model**
- **Disseminate reports broadly**
- **Archive and make available data and experimentation artifacts**
- **Create a community of interest that cuts across operators, researchers and decision makers**

Steps in an Individual Experiment



Alberts et al., *Code of Best Practice for Experimentation*, 2002. p62.

Illustrative Conceptual Model Self-Synchronization



Alberts et al., *Code of Best Practice for Experimentation*, 2002. p135.

Experimentation is Not a Panacea

- **Experimentation is one tool in the tool kit**
- **Experimentation is appropriate when:**
  - **A valid, reliable, and credible environment is available**
  - **The important part of the problem space can be identified**
  - **The number of variables to be studied is modest**
  - **The time and resources are available for quality experimentation**
- **Experimentation is properly employed as one part of a larger effort**
- **Campaigns of experimentation, including supporting events (seminars, war games, modeling activities, peer review sessions, etc.) are superior to isolated experiments**

Why Conduct Campaigns of Experimentation?

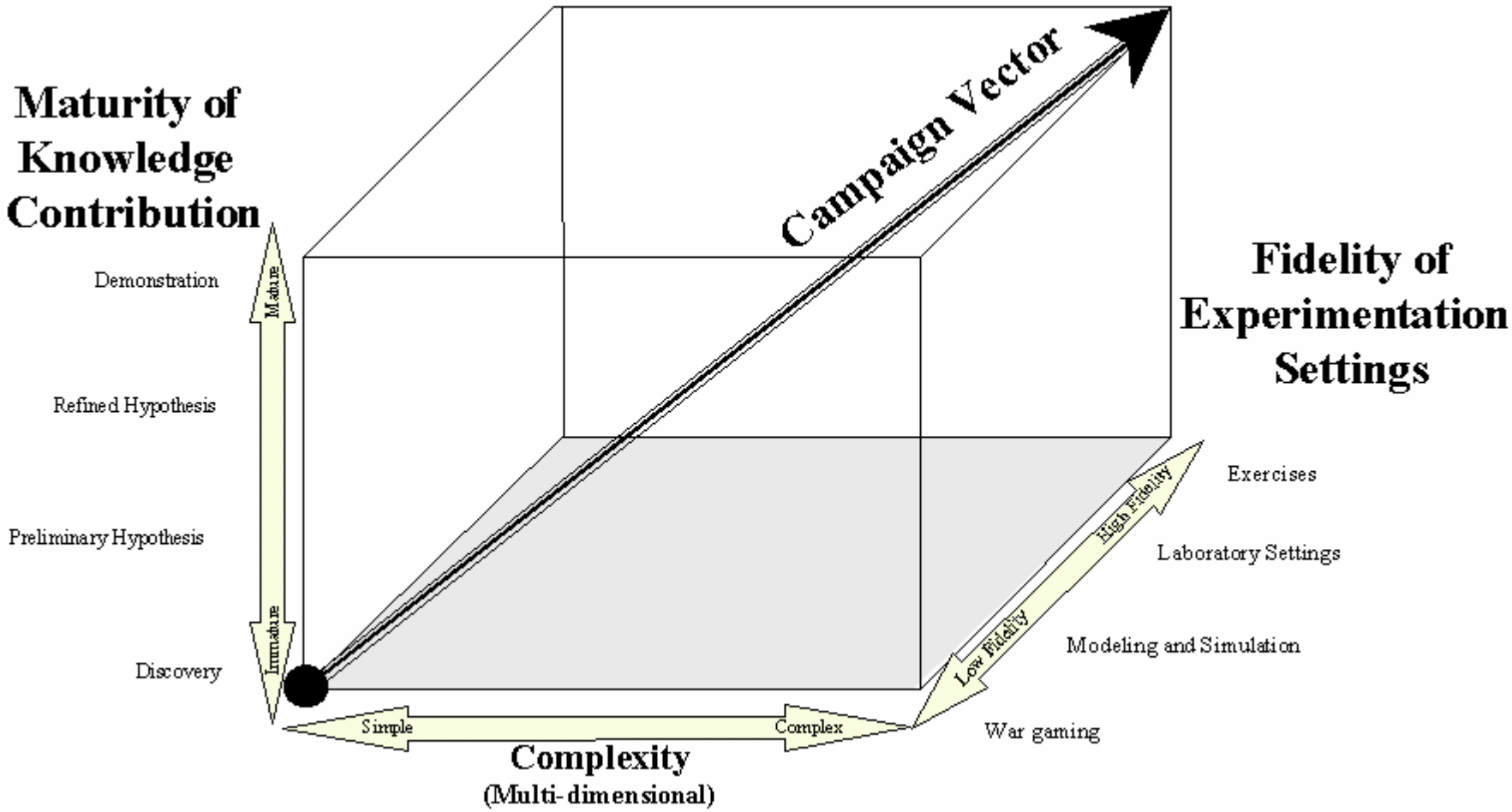
- **Individual experiments lack the breadth and depth necessary to support intelligent innovation**
  - **To achieve adequate control for validity, individual experiments focus on manipulating a few variables while seeking to control many others**
  - **The set of controls and assumptions used in a single experiment must be explored in others in order to ensure that the knowledge gain is valid**
  - **Replication of results is essential in order to avoid undetected problems arising from errors in design, measurement, or biases**

Why Conduct Campaigns of Experimentation? (2)

- **Campaigns of experimentation benefit the community by:**
  - **Focusing attention on specific innovations (MCPs) and exploring their potential or impacts**
  - **Accelerating progress toward specific objectives (e.g., polio vaccine)**
  - **Reducing risks associated with innovations, and**
  - **Improving the efficiencies of some practice or process**
- **Campaigns of experimentation balance the needs for variety and replication**

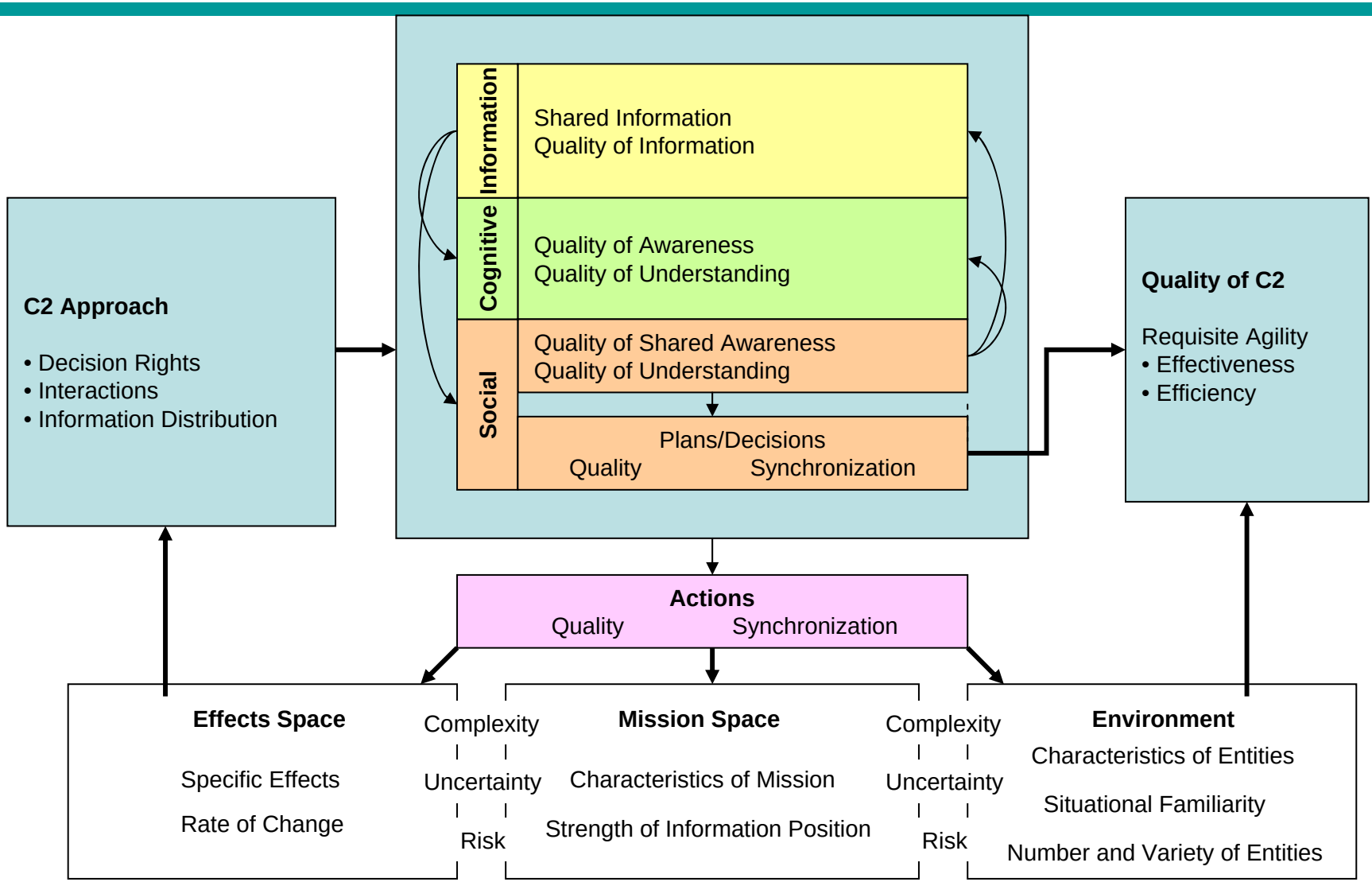
Campaigns of Experimentation are intended to improve actionable knowledge

The Experimentation Campaign Space



Alberts et al., *COBP for Experimentation.* (Washington: CCRP, 2002), 49.

Conceptual Model for Network-Enabled Meta-Campaign of Experiments



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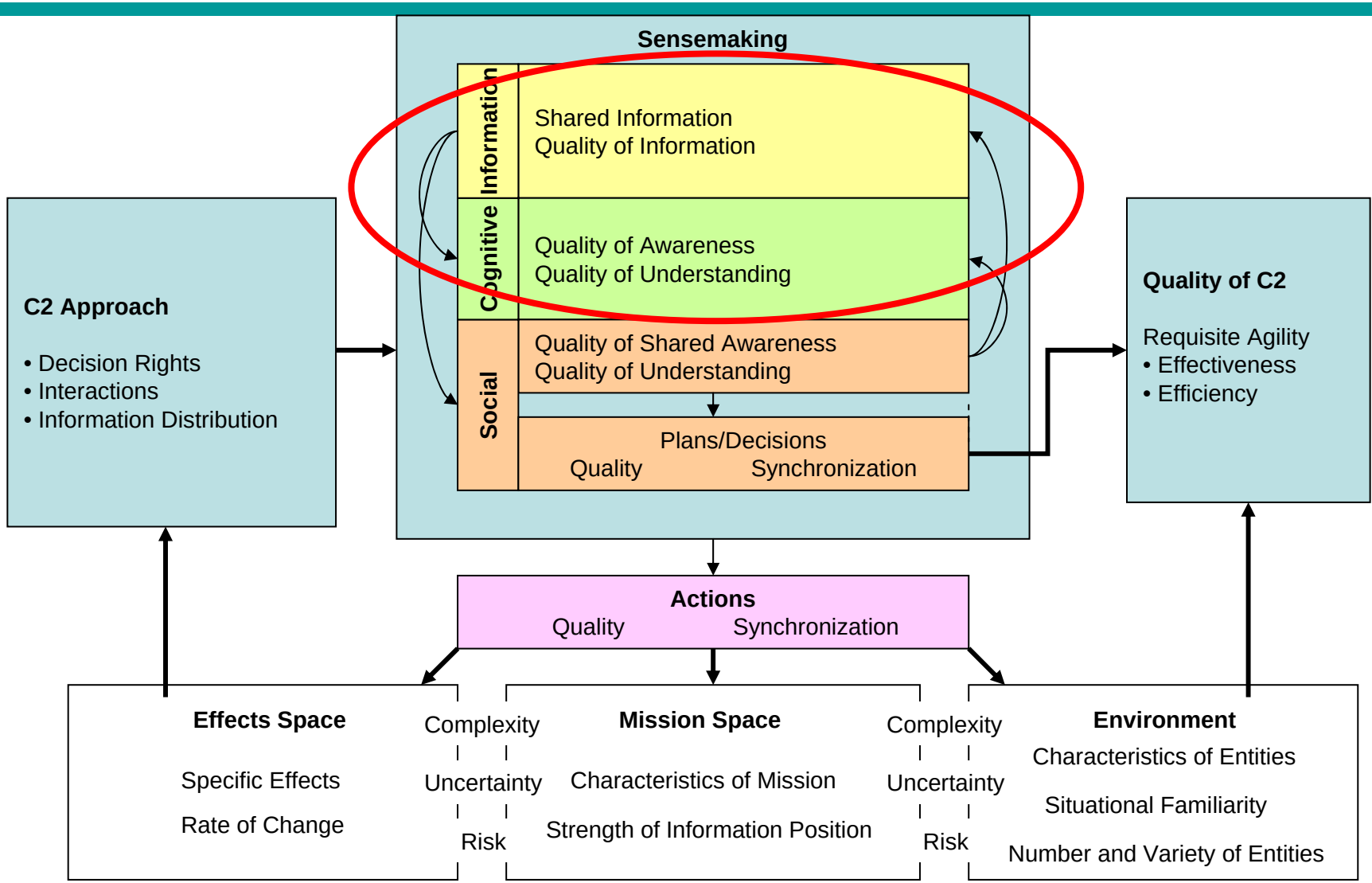


ELICIT: A New CCRP Campaign

- **Experimental laboratory for investigating collaboration, information-sharing, and trust (ELICIT)**
- **Information sharing focus**
- **Controls for:**
  - **Organizational structure**
  - **Information distribution mechanism**
  - **Communication between players**
- **Variety of experimental subjects**
  - **Several Boston area universities**
  - **Naval Postgraduate School**
  - **UK, Singapore, Canada, and Germany**
  - **Others under discussion**
- **Produces a detailed transaction log**
  - **Assembling as a database**
  - **Multiple teams developing analytical approaches**

Anatomy of a Success: CPOF (1)

- **Originated as a Defense Advanced Research Project Agency (DARPA) Project**
  - **Senior retired military support**
  - **Improved visualization technologies**
  - **Greater bandwidth becoming available**
- **First DARPA experimentation program**
  - **Broad multidisciplinary team**
  - **US Army and USMC as potential transition targets**
  - **Team and knowledge building activities**
  - **Several limited objective experiments**
  - **Research phase culminated in a series of war games**
  - **Many of the initial technologies discarded**
- **Transition a mixed bag**
  - **USMC declined**
  - **US Army accepted**
  - **Deployed to Iraq with First Cavalry Division**

Anatomy of a Success: CPOF (2)

- **Field Experience**
  - **Initially division headquarters**
  - **Expanded over time to brigades and some battalions**
  - **DARPA technical support for revision in the field**
  - **Data collected and sent to DARPA repository (reality instrumented)**
  - **Users debriefed during and after field experience**
  - **DARPA still processing data**
- **Current Status**
  - **US Army considering service wide adoption**
  - **US JFCOM considering adoption in joint arena**
  - **Returned to experimentation phase**

Integrated Battle Command (IBC): On-Going Campaign

- **Enabling tool for the whole of government approach:**
  US DARPA and US Joint Forces Command
- **Phase 1 (Proof of Concept) Completed**
  - **Federated models support improved decision making and planning**
  - **From actions to effects**
  - **Potential exists to shrink planning teams**
  - **Change in process and perspectives (unexpected result)**

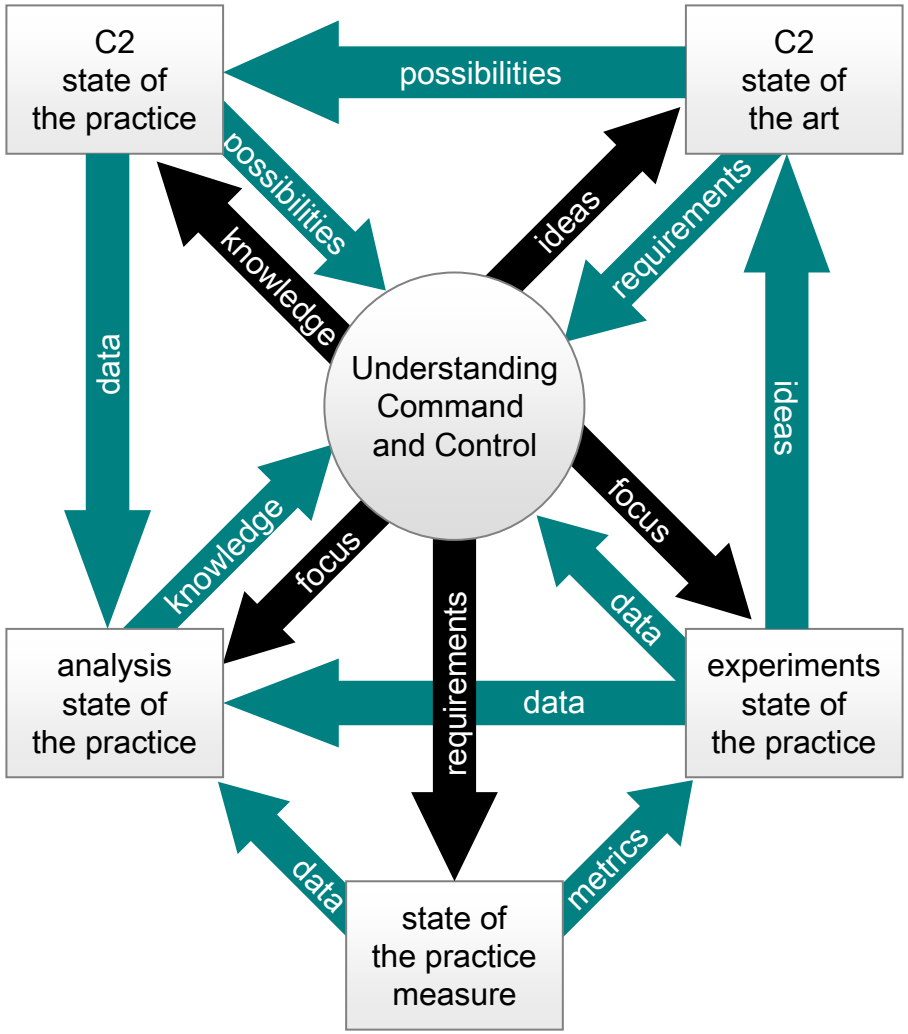
Integrated Battle Command (IBC): On-Going Campaign (2)

- **Phase 2: Capability Development**
  - **Limited Objective Experiment (LOE) 1: Visualization and Human Machine Interfaces**
  - **LOE 2: From desired effects to potential sets of actions**
  - **Introducing mini-experiments**
  - **Incorporating new models**
    - **Theory of conflict**
    - **Planning tools**
  - **Tracking informal organization and process**
  - **LOE 3 and Capstone: Compare current planning organizations and processes to IBC supported alternatives**

Integrated Battle Command (IBC): On-Going Campaign (3)

- **Assessments**
  - **JFCOM: Qualitative improvements – SME desirability**
  - **DARPA: Quantitative improvements (resources, time, options and effects considered)**

Synergies of Multi-Pronged Efforts



Alberts & Hayes, *Understanding Command and Control*, 2006. p195.

Two Persistent, Pernicious Problems

- **Focus on Innovation by purchasing objects**
  - **Not all nations or partners are resource rich**
  - **Objects, including IT systems, are enablers**
  - **Many important improvements can be accomplished by changes in policies and processes**
    - **Information sharing**
    - **Collaboration**
- **Lack of broadly accessible Knowledge Base for experimentation**
  - **Sharing concepts, data, metrics, etc. reduces costs**
  - **Needed to answer the key questions**
    - **What experiments have been done?**
    - **What experiments are underway or planned?**
    - **Which key concepts and ideas are being ignored?**

Broad Guidance for Successful Campaigns of Experimentation

- **Assume that the planning and execution of individual experiments follow the known best practices.**
- **Create the conditions necessary for success:**
  - **Build a strong, multidisciplinary team, and**
  - **Create an explicit conceptual model.**
- **Conduct a sound campaign:**
  - **Plan for, execute, and pay attention to peer review,**
  - **Maintain the Conceptual Model over time,**
  - **Create a database, including "metadata" tags,**
  - **Capture and document experimentation artifacts (scenarios, measurement tools, surveys, etc.)**

Broad Guidance for Successful Campaigns of Experimentation (2)

  - **Conduct analyses beyond the individual experiments (model-experiment-model, cross-cutting analyses within the campaign, comparative analyses with studies outside the campaign)**
- **Create a foundation for the future:**
  - **Widespread distribution of results, across the relevant Communities of Interest (COI)**
  - **Making data available to other researchers, and**
  - **Preserving experimentation artifacts and making them available to others in the relevant COIs**

Conclusions (1)

- **Weaknesses in current experimentation tend to cluster around failures to:**
  - **Build the necessary multi-disciplinary team needed**
  - **Conduct an adequate literature search so the effort is properly focused**
  - **Select topics that have both short and long term value**
  - **Define and maintain the conceptual model properly**
  - **Develop appropriate metrics – valid, reliable, and credible**
  - **Invest adequately on pre- and post-experiment activities**
  - **Make the results (data, artifacts, and findings) available across the community**

Conclusions (2)

- **Campaigns of Experimentation, including supporting events (seminars, war games, modeling activities, peer reviews) and analyses are essential**
  - **A series of Limited Objective Experiments is wise**
  - **Capstone events are best used as demonstrations**
  - **US DARPA is initiating a program of "mini-experiments"**
- **Experimentation is not an end in itself**
- **Innovation is not an end in itself**
- **The goal is Mission Capability Packages that matter!**

Publications

www.dodccrp.org

- *Command Arrangements for Peace Operations* (Alberts & Hayes, 1995)
- *Understanding Information Age Warfare* (Alberts et al, 2001)
- *The Code of Best Practice for Experimentation* (Alberts et al., 2002)
- *NATO Code of Best Practice for C2 Assessment* (SAS026, 2002)
- *Power to the Edge* (Alberts & Hayes, 2003)
- *The Code of Best Practice for Campaigns of Experimentation* (Alberts & Hayes, 2005)
- *Understanding Command and Control* (Alberts & Hayes, 2006)
- *Complexity, Networking, and Effects-Based Approaches to Operations* (Smith, 2006)
- *The Logic of Warfighting Experiments* (Kass, 2006)
- *Guide for Understanding and Implementing Defense Experimentation (GUIDEx)* (TTCP, 2006)
- *Planning: Complex Endeavors* (Alberts & Hayes, 2007)