OUR EVOLVING DEFINITION OF KNOWLEDGE: IMPLICATIONS FOR C2ISR SYSTEM PERFORMANCE ASSESSMENT

Paper #241
10th International Command and Control Research and Technology Symposium
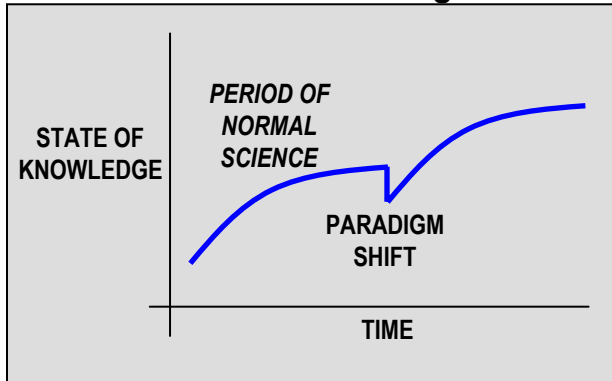*Ritz-Carlton Hotel, McLean, VA*
13-16 June, 2005

DENNIS K. LEEDOM, Ph.D.
Evidence Based Research, Inc.
1595 Spring Hill Road, Suite 250
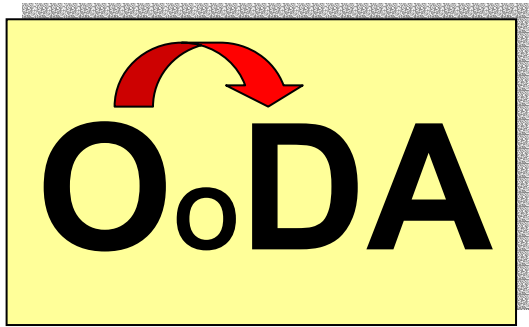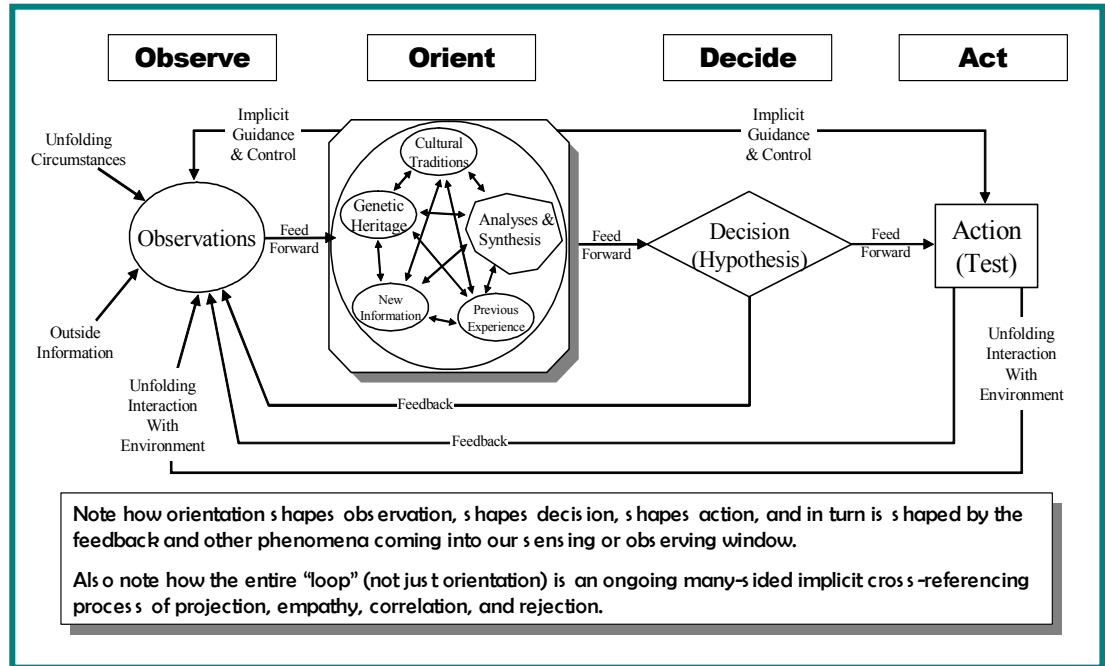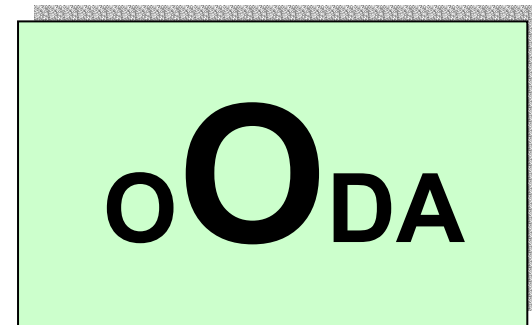*Vienna, VA 22182*
dkl-texas@cox-internet.com

John Boyd's OODA Loop Model

Thomas Kuhn's "Paradigm Shift"

STATE OF KNOWLEDGE

PERIOD OF NORMAL SCIENCE

PARADIGM SHIFT

TIME

Observe	Orient	Decide	Act

Note how orientation shapes observation, shapes decision, shapes action, and in turn is shaped by the feedback and other phenomena coming into our sensing or observing window.

Also note how the entire "loop" (not just orientation) is an ongoing many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection.

"Current C2ISR Models"

PARADIGM SHIFT

"Future C2ISR Models"

Mao Tse-Tung

Ho Chi Minh

FSLN / Sandinista

Intifada / PLO

Unique elements of 4th-generation warfare…

- Strategic goal: *Defeat our political will* to engage in a region

- Strategy: Pursue *political, economic, and social actions*, engaging in limited military operations only when it furthers strategic interests *(create impression of intractable struggle)*

Hammes, T.X. (2004). 4th-generation warfare. *Armed Forces Journal*, November 2004

Implications for design of C2ISR functionality…

- Adversary is coalition of convergent interests, rather than single nation state
  → *Identify and disrupt critical linkages that hold coalition together*

- Adversary coalition consists of several tiers: leaders, supporters, civilian interests
  → *Employ different approach to disrupting or manipulating each tier*

- Multiple, overlapping networks exists across political, social, economic, religious, humanitarian, and military dimensions
  → *Understand the role, structure, and processes of each type of network*

- Strategic objectives are accomplished through direct C^2, economic/social disruption, intimidation of specific individuals/groups, and exploitation of emergent situations
  → *Identify and influence fitness conditions, rather than severing commo links*

Wicked problem environment…

- Problem space is ill-structured
- No "right" solution, only "good enough"
- Problem-solving ends only when you run out of resources
- Unique/novel set of conditions and factors
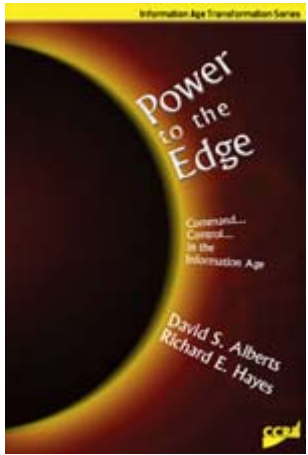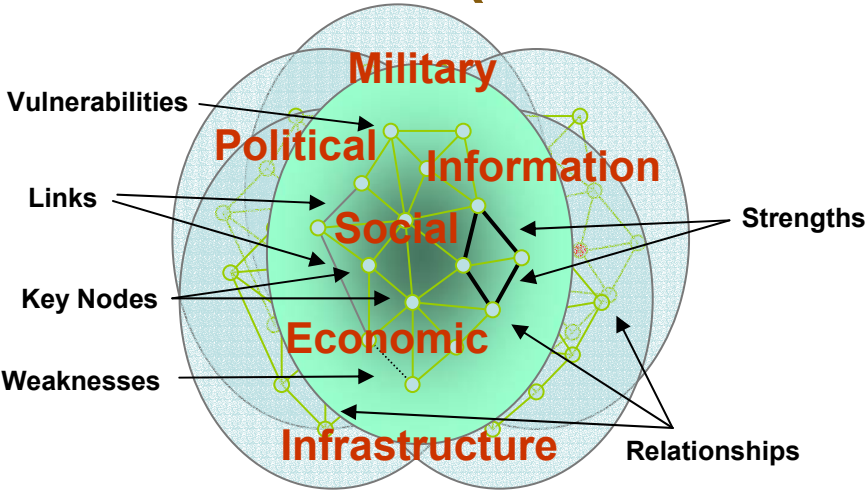- No second opportunities to do it again
- No obvious alternative solution

Sensemaking driven by action…

- Clarify/prioritize goals and constraints
- Characterize battlespace relative to these goals/constraints
- Identify key dimensions and variables predictive of cause/effect relationships
- Identify key obstacles to success
- Build solution paths to overcome obstacles

Effects-Based Operations

Vulnerabilities
Links
Key Nodes
Weaknesses

Military
Political
Information
Social
Economic
Infrastructure

Strengths
Relationships

Diplomatic
Economic
Military
Information
Legal
Humanitarian

Power to the Edge
Command... Control... in the Information Age
David S. Alberts
Richard E. Hayes
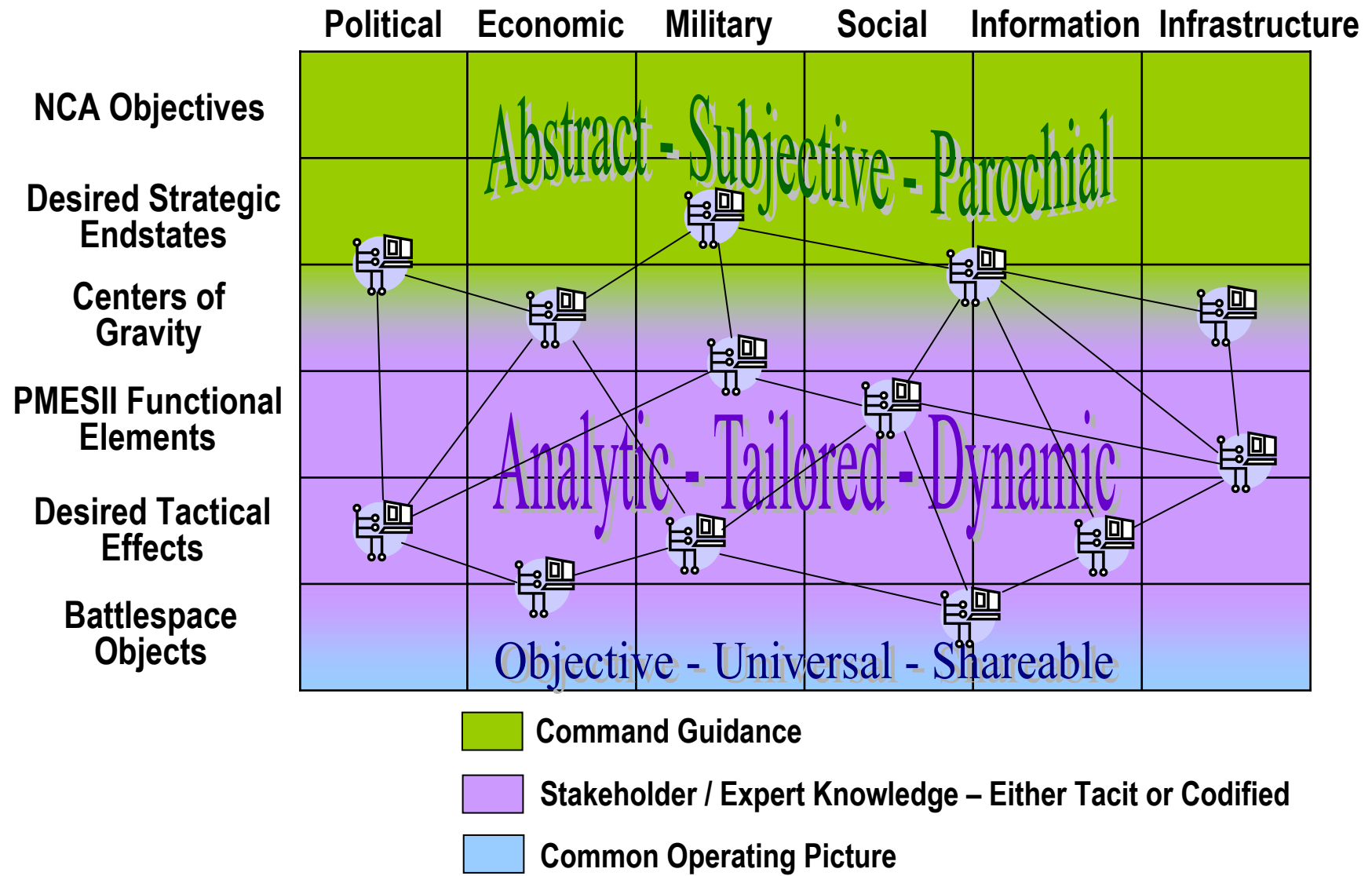
"*as bandwidth becomes ever less costly and more widely available, we will be able to not only allow people to process information as they see fit but also allow multiple individuals and organizations to have direct and simultaneous access to information and to each other. We will also be able to support richer interactions between and among individuals.*"

A matrix diagram with columns: Political, Economic, Military, Social, Information, Infrastructure.

Rows (top to bottom): NCA Objectives, Desired Strategic Endstates, Centers of Gravity, PMESII Functional Elements, Desired Tactical Effects, Battlespace Objects.

Overlaid text in the matrix:
- Abstract - Subjective - Parochial
- Analytic - Tailored - Dynamic
- Objective - Universal - Shareable

Legend:
- Command Guidance
- Stakeholder / Expert Knowledge – Either Tacit or Codified
- Common Operating Picture

"…it would sure be nice if we had some clear idea what it was we were trying to do first."

Admiral Mike Boorda

Old Analytic Paradigm

New Analytic Paradigm

OBSERVE — ORIENT — DECIDE — ACT

DIPLOMATIC
LEGAL
INFORMATION
HUMANITARIAN
ECONOMIC
MILITARY

PMESII
PROBLEM SPACE

FOCUSED, ACTIONABLE
KNOWLEDGE
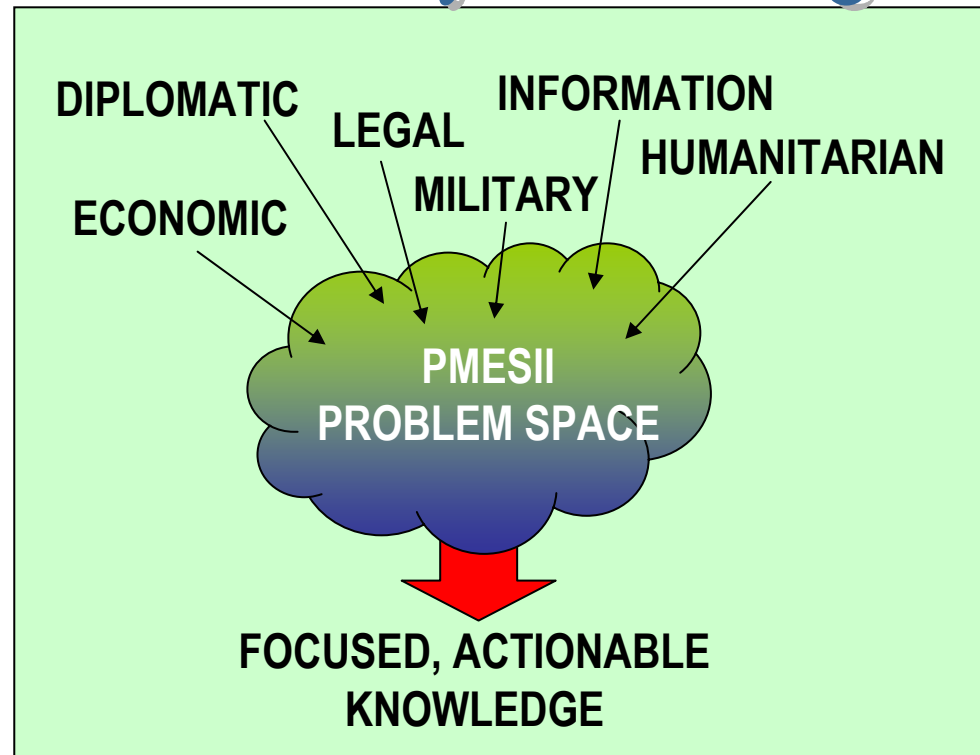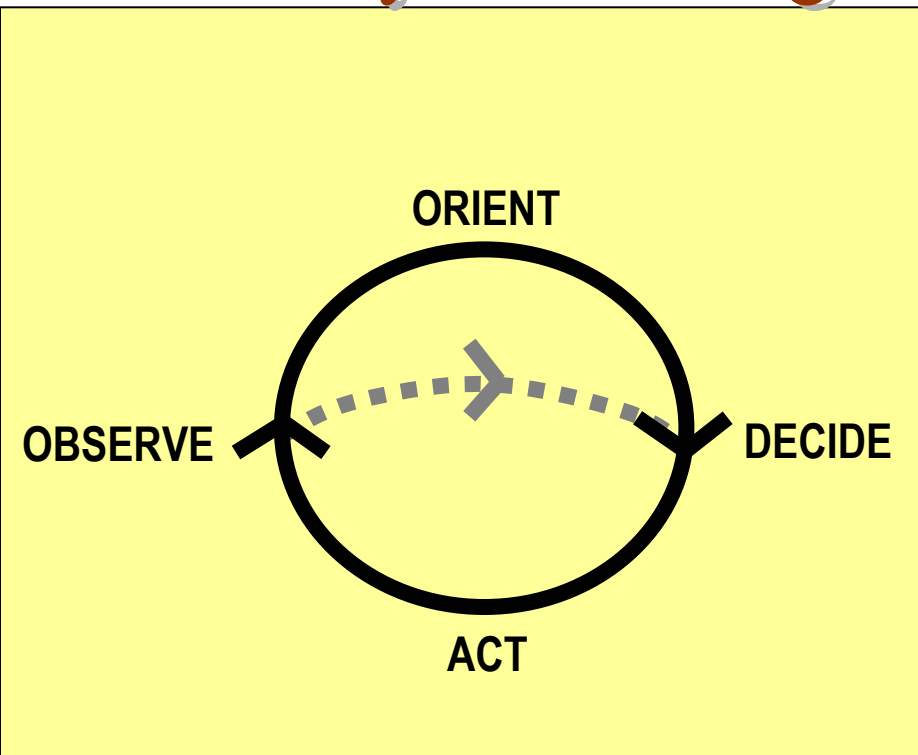
RATIONALISM
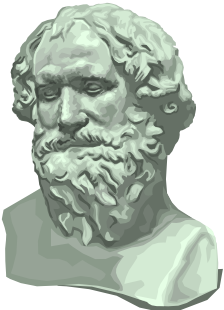
- Knowledge is derived primarily from logical reasoning without benefit of empirical observation
- This school of philosophy has strongly influenced the language of mathematics and artificial intelligence
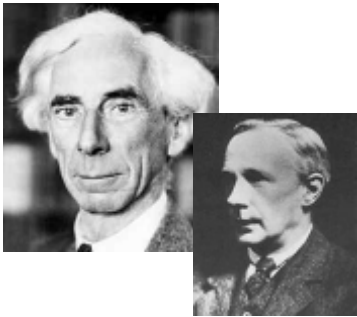
Euclid, Socrates, Plato…

EMPIRICISM

- Knowledge is derived primarily from empirical observation and induction wherein general ideas emerge from specific facts
- "Cause and effect" associations are mentally imposed on the natural world to organize and explain experiences

*Bacon, Hobbes, Locke, Berkeley, Hume…*

ANALYTIC PHILOSOPHY

Russell, Moore…

- Knowledge is developed through acquisition and definition
  - A small portion is acquired empirically through the senses
  - A greater portion is developed through description that depends upon language and grammar
- An extreme form of this philosophy, logical positivism, argues that only those things which can be logically proved true or false are worthy of scientific study
- A further philosophical development, logical atomism, argues that language can be broken down in primitive concepts
- This philosophy is strongly reflected in artificial intelligence and modern definitions of intelligence fusion
- The general school of analytic philosophy is reflected in the "scientific method"
  - Knowledge is built upon the accumulation of facts and definitions
  - These facts and descriptions are universal in nature, independent of context
  - Knowledge is logically built or unfolded through the processes of induction and decomposition

ASSOCIATIONISM
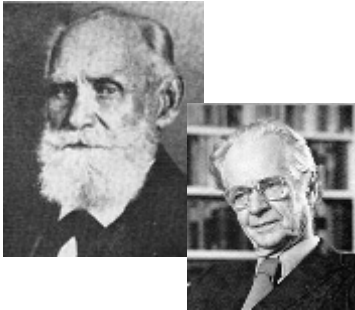
*Pavlov, Skinner,
Thorndike, Watson…*

- Knowledge focuses on the relationships among phenomena and is primarily developed through the scientific method
- This school of philosophy gave rise to interest in S-R pairs and the linkage of understanding with action
- A later reflection of this philosophy is seen in naturalistic decision making with its emphasis on the RPD model

STRUCTURALISM

*Wundt, Titchener,
Brentano, Stumpf…*

- Knowledge can be structured as a set of universal primitives organized within a systematic framework, much like the periodic table of elements in chemistry
- Physics deals with knowledge that is *independent* of the knower, whereas psychology deals with knowledge that is *dependent* upon the knower

PRINCIPLE OF FALSIFIABILITY
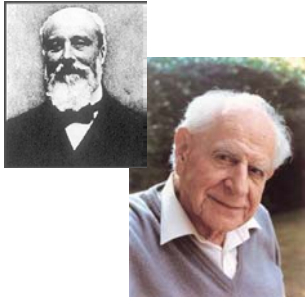
- Any empirical evidence can be made compatible with a given theory by the addition of *ad hoc* hypotheses
- A theory is not scientific if it does not admit consideration of the possibility that it might be false

Duhem, Popper…

CONFIRMATION HOLISM

- Scientific theories are confirmed or disconfirmed as a whole
- Entire theoretical frameworks are subject to revision, as reflected in the phenomena of paradigm shifts
- The creation of knowledge is framed by a set of beliefs that are socially developed and evolve over time

Quine, Kuhn…

LINGUISTIC DETERMINISM

Sapir, Whorf

- Language and grammar are systematically related to how one uniquely conceptualizes the world
- Language and jargon variations will influence how different communities perceive a problem or situation

PERSONAL CONSTRUCTS

Kelly

- Each individual acts as a scientist, continually framing their experience in terms of personal models and hypotheses
- Core constructs, constituting deeply held values and principles, are unlikely to change in the face of contradictory information
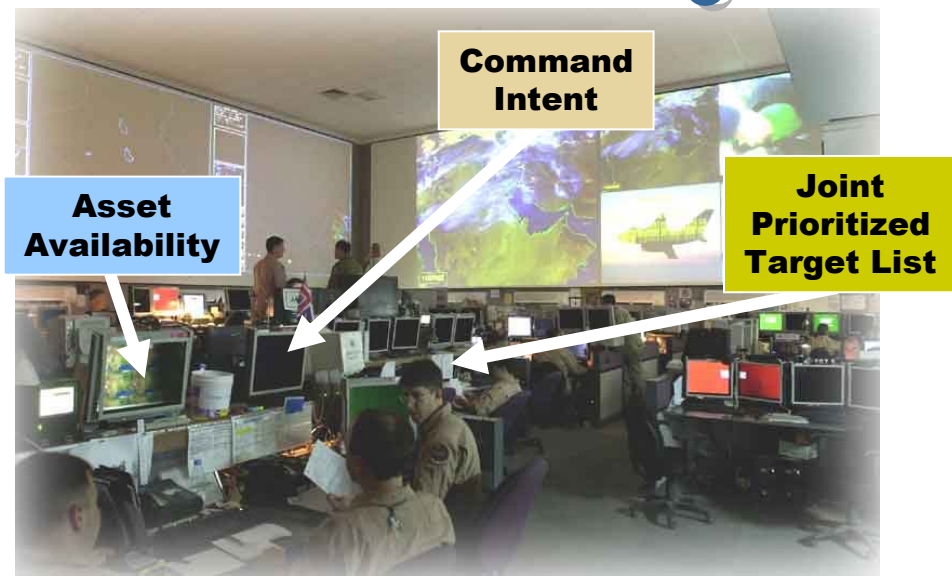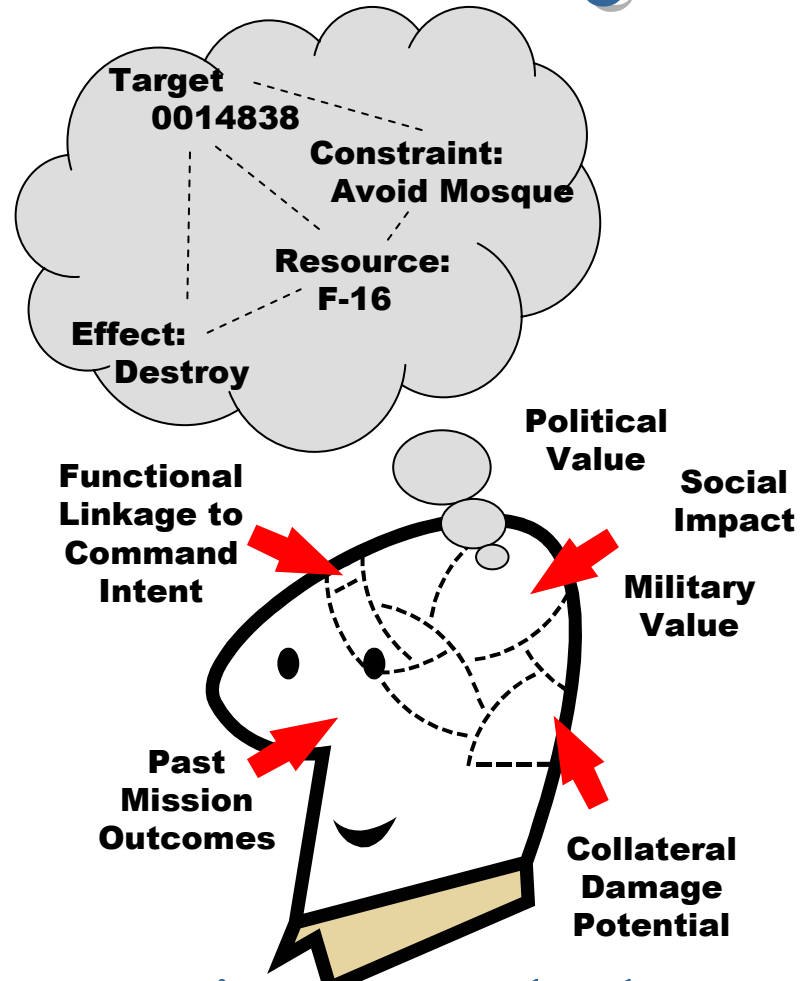
TACIT KNOWLEDGE

Polanyi

- There exist two complimentary, but mutually exclusive, dimensions of knowledge: tacit knowledge and focal knowledge
  - Focal knowledge is that knowledge dynamically held about the immediate problem, object, or phenomena in one's focus of attention
  - Tacit knowledge provides the background context that serves to frame and sharpen that which is in focus

Focal Knowledge

Target 0014838

Constraint: Avoid Mosque

Resource: F-16

Effect: Destroy

Shared Knowledge

Command Intent

Joint Prioritized Target List

Asset Availability

Political Value

Functional Linkage to Command Intent

Social Impact

Military Value

Past Mission Outcomes

Collateral Damage Potential

Tacit Knowledge

WORLD 2
Individual Thoughts and Perspectives

WORLD 1
Physical Objects and Forces
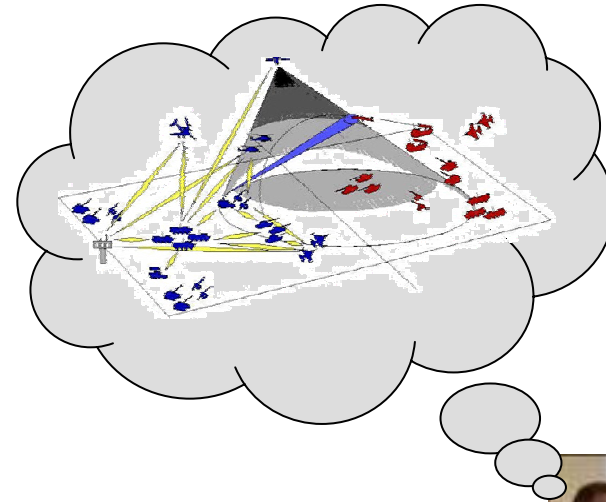
WORLD 3
Collectively Shared Understandings

Nonaka, Takeuchi

- It is nearly impossible to find a publication on organizational knowledge or knowledge management that does not use the term "tacit knowledge"
- Knowledge is best defined as justified true belief

Davenport, Prusak

- Tacit knowledge a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information
- In organizations, it can be found in organizational routines, processes, practices, and norms

Weick, Choo

- Patterns or connections to past experience can be found in the form of ideology, 3rd-order controls, paradigms, theories of action, tradition, and stories
- Cultural knowledge consists of those beliefs an organization holds to be true based on experience, observation, and reflection on self and the environment

CONSTRUCTED MENTAL MODEL OF SITUATION

FRAGMENTARY MENTAL MODELS

AVAILABLE DATA (CUES)
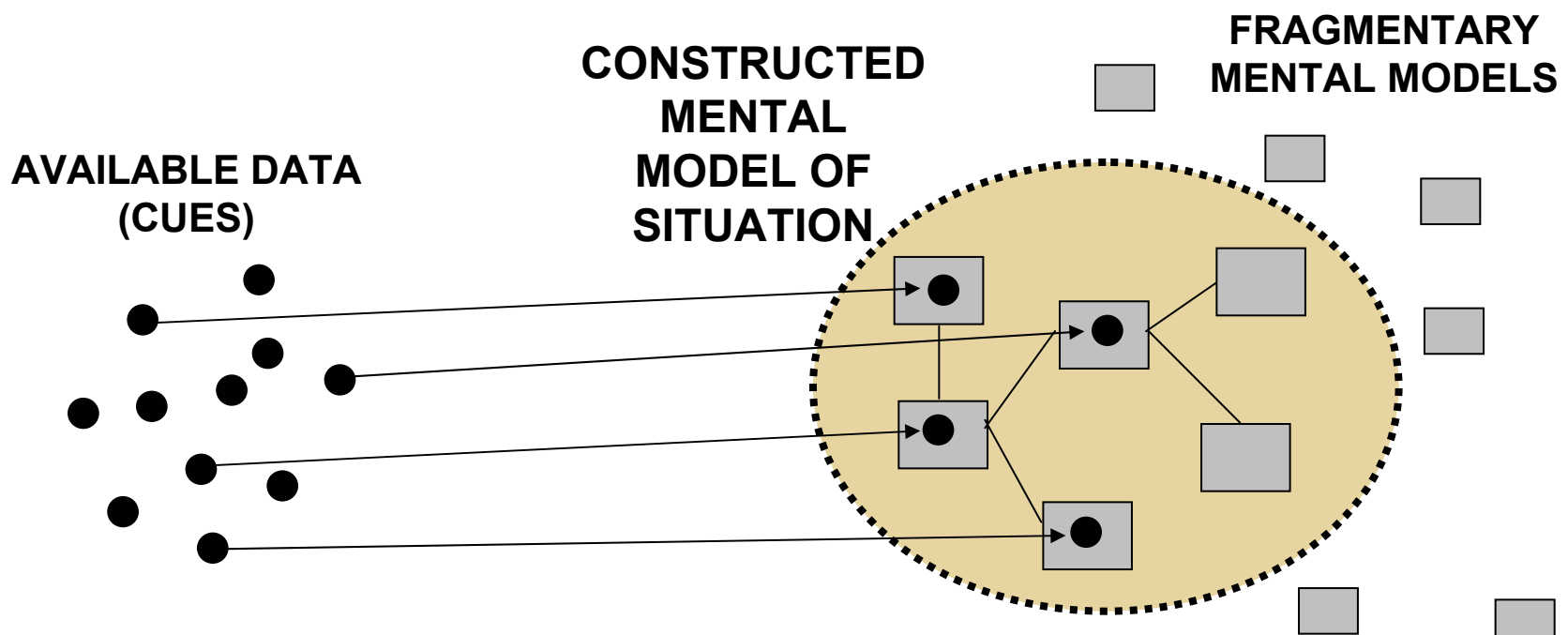
SENSEMAKING FUNCTIONS:

Frame Elaboration
Frame Questioning
Frame Preservation
Frame Comparison
Frame Seeking
Reframing

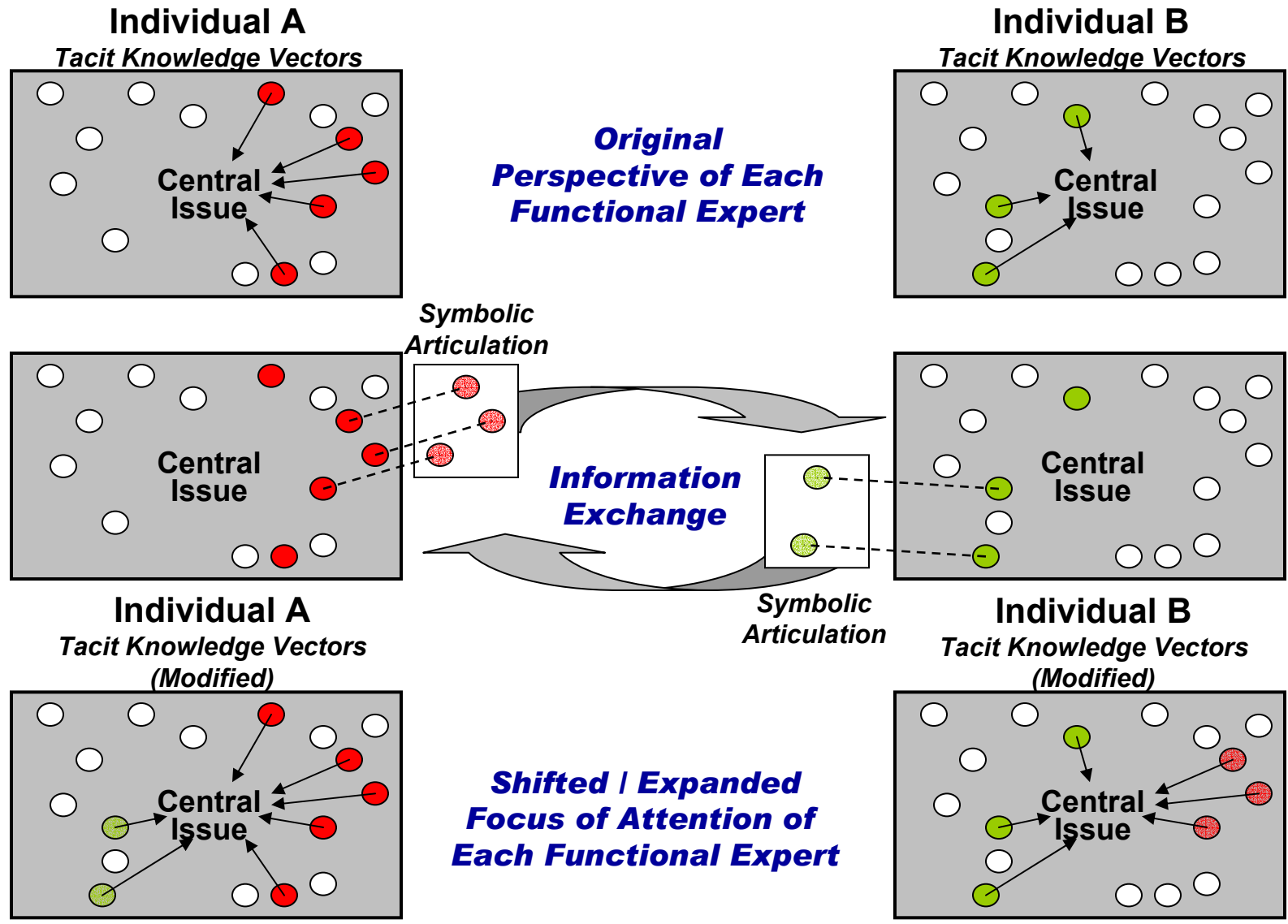Sieck, W.R.; Klein, G.; Peluso, D.A.; Smith, J.L. & Harris-Thompson, D. (2004). *FOCUS: A Model of Sensemaking* (Final Technical Report, Contract 1435-01-01-CT-31161, US Army Research Institute). Fairborn, OH: Klein Associates, Inc.

FOCAL PROBLEM OR ACTION
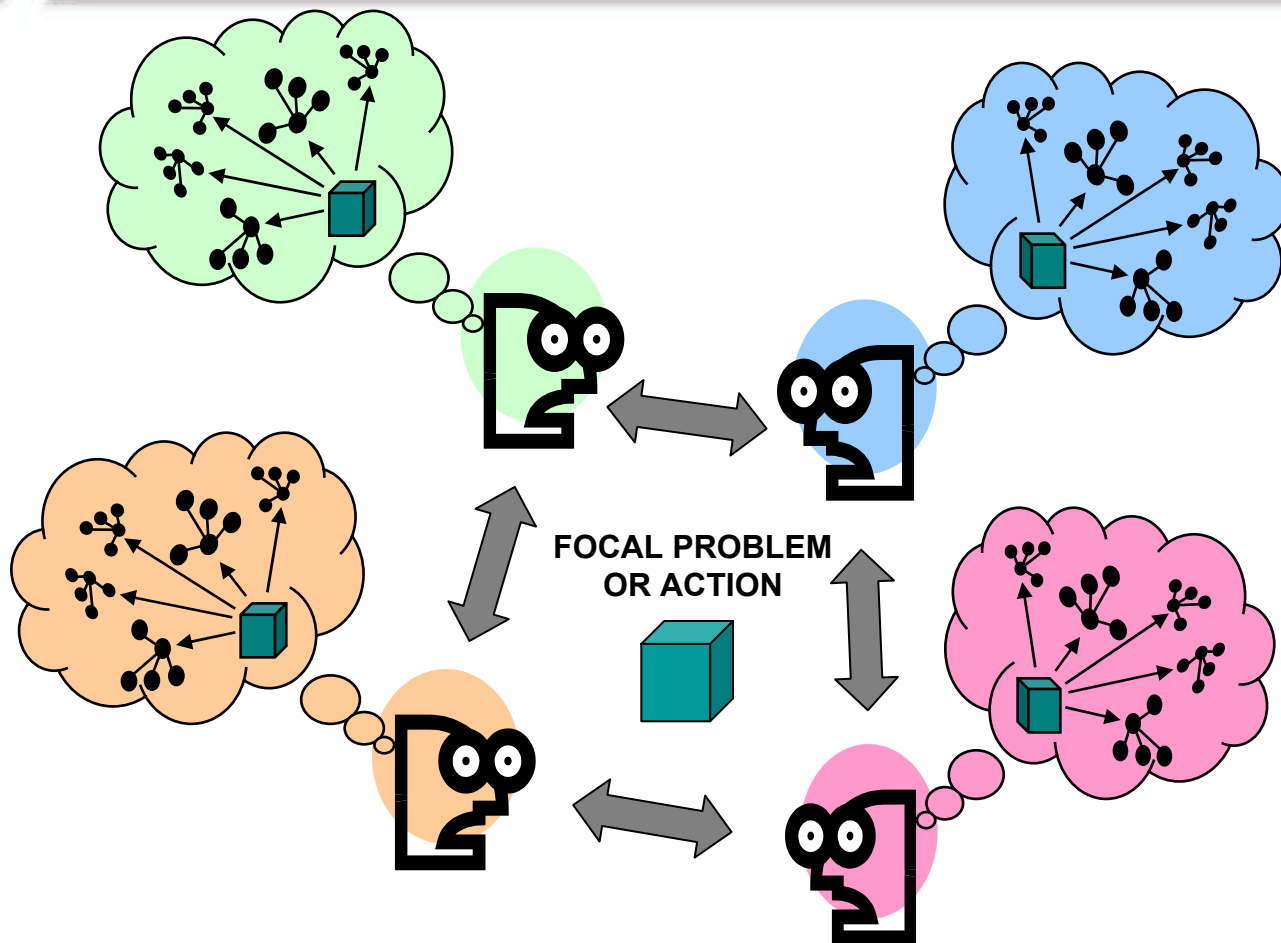
Tsoukas, H. (2002). *Do We Really Understand Tacit Knowledge?* Presented to Knowledge Economy and Society Seminar, LSE Department of Information Systems, 14 June, 2002.

Individual A
Tacit Knowledge Vectors

Individual B
Tacit Knowledge Vectors

Central Issue

Central Issue

Original Perspective of Each Functional Expert

Symbolic Articulation

Central Issue

Information Exchange

Central Issue

Symbolic Articulation

Individual A
Tacit Knowledge Vectors (Modified)

Individual B
Tacit Knowledge Vectors (Modified)

Central Issue

Central Issue

Shifted / Expanded Focus of Attention of Each Functional Expert

Inter-Agency Group

What do I want to achieve, and when?

Coordination

COMMANDER

Frames	Data
• Strategic / operational goals and constraints • Desired endstates and centers of gravity • Concept of operation	• Political/cultural input from external contacts

Probing Actions

Operational Battlespace

Commitment & Focus

FOCAL KNOWLEDGE

Incremental, iterative decision process

Dynamic, analytic framework of actionable knowledge that serves to identify and enable the next series of decision points

Elaboration & Validation

Feedback

STAFF

Frames	Data
• Tactical causal models that define / articulate nodes and effects • Metrics for assessing progress	• Sensor data, HUMINT, SPOTREPs • Open source intelligence • Effects assessments

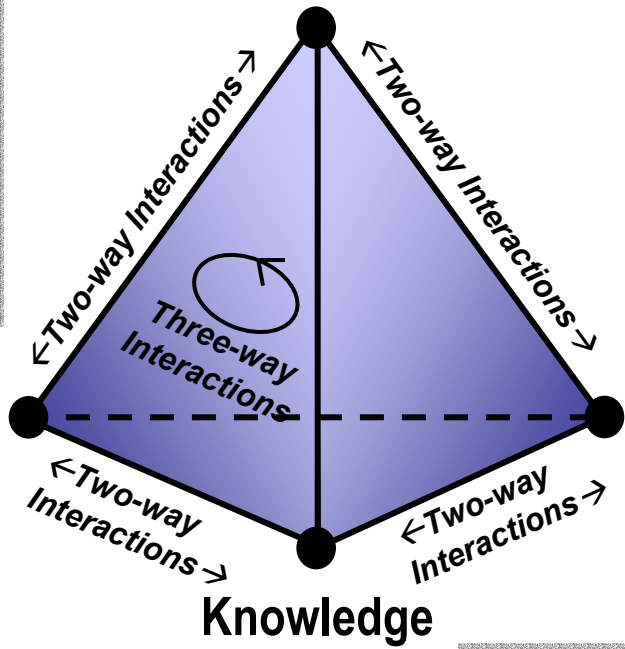*What is the current and projected situation?*

Knowledge Worker Characteristics

•*Recruitment / Education*
•*Leadership*
•*Joint / Service Training*
•*Operational Experience*
•*Personnel Management*

•*National Security Challenges*
•*Mission Goals / Objectives*
•*Joint / Service Doctrine*
•*Tactics / Techniques / Procedures*
•*PMESII Battlespace Variables*
•*Diplomatic / Information / Military / Economic Response Options*
•*Battlespace Sensors / Info Sources*
•*Information Systems / Work Aids*
•*Information Network Connectivity*

Problem-Task Structure

←*Two-way Interactions*→

←*Two-way Interactions*→

Three-way Interactions

←*Two-way Interactions*→

←*Two-way Interactions*→

Social-Organizational Context

•*Interagency / Coalition Stakeholders*
•*Authority / Command Structures*
•*Organization Boundaries / Interfaces*
•*Staff Planning / Execution Rhythms*
•*Patterns of Collaboration*

Knowledge Products

•*Planning Estimates / IPB*
•*Mission Analysis*
•*Prioritized Effects List*
•*Effects Tasking Order*
•*Joint Target List*

Coherence of Problem-Task Structure

- Info sources, sensemaking support tools, and networks contribute to framing problem space
- Organizational structure and staff procedures define appropriate patterns of collaboration
- Theories of action, mental models, and metrics adequate for articulating political, military, economic, social, information, and infrastructure dimensions of battlespace
- Work flow patterns enable effective contribution of stakeholders across units, agencies, organizations
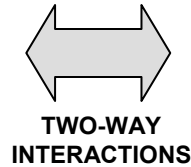
Adequacy of Knowledge Workers

- Leaders demonstrate critical thinking skills regarding each dimension of battlespace
- Staff training and personnel assignments are responsive to 4th generation warfare environment
- Organizational knowledge maps enable rapid and comprehensive involvement of the right expertise
- Staff leaders provide effective monitoring and adjustment of collaboration to insure appropriate participation and quality of knowledge products

TWO-WAY INTERACTIONS

TWO-WAY INTERACTIONS

TWO-WAY INTERACTIONS
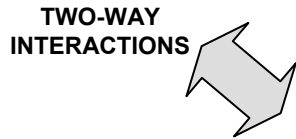
Maturity of Social-Organizational Networks

- Joint training develops cross-boundary awareness of staff capabilities and perspectives
- Personnel rotation policies allow construction and maintenance of mature social networks
- Authority and command structures facilitate bottom-up staff initiative and organizational agility
- Staff planning and execution rhythms enable self-synchronization while maintaining cohesion of the sensemaking process
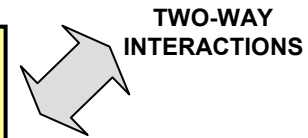
C^2 Process Issues

## Quality of Actionable Knowledge

- Addresses political, military, economic, social, information, and infrastructure dimensions
- Links centers of gravity, functional elements, and battlespace nodes to command intent
- Is properly vetted for rules-of-engagement and other operational constraints

C^2 Product Issues

Individual Sensemaking

- Frames identify key elements of understanding of current operational situation
- Frames provide feasible path of action to achieve objectives and meet constraints
- Frames have been adequately validated by available data and information
- Alternative interpretations of available data and information have been considered
- Major areas of uncertainty are accommodated through risk-planning and/or collection of additional data and information
- Data/frame structures are kept current with the evolving operational situation
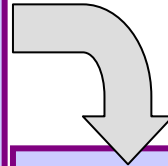
Collaboration Process

- Availability and participation of expertise are effectively monitored and adjusted to insure quality of knowledge product
- Tacit understandings are effectively articulated in explicit, symbolic form for other participants
- Information exchanges effectively transfer attentional cues among participants
- Technological, cognitive, social, and organizational obstacles to participation and exchange are diagnosed and resolved
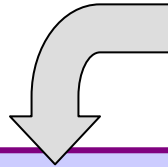
Shared Sensemaking

- Key elements of various stakeholder viewpoints are identified and gaps/inconsistencies identified
- Participants reach consensus regarding central issues along each dimension of battlespace
- Participants are able to reconstruct understanding of operational situation from other viewpoints
- A common frame of understanding is reached that accommodates perspective of each stakeholder
- Common frame of understanding provides consistent path of action for synchronizing effects and outcomes
- Participants understand each area of risk/uncertainty and its potential impact across different actions/effects

QUESTIONS

DENNIS K. LEEDOM, Ph.D.
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