Macro cognition in Complex Team Problem Solving

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Develop the ability to make sense of and use information (e.g. converting data to knowledge) within the cognitive domain.

Improve Decision making – enhanced situational awareness through collaborative engagement and remote monitoring to compress the Observe-Orient-Decide-Act loop

………… Adm James R Hogg, Director CNOSSG

2006 Quadrennial Defense Review (QDR)

…. a substantial 15 percent increase in U.S. Special Operations Forces (SOF)

"SOF will increase their capacity to perform more demanding and specialized tasks, especially long-duration, indirect and clandestine operations in politically sensitive environments and denied areas,"

"SOF will have the capacity to operate in dozens of countries simultaneously" and will deploy for longer periods to build relationships with "foreign military and security forces"
# Military Requirements / Drivers

## Naval S&T Focus Area

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<th>Focus Area</th>
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<td>Maritime Domain Awareness</td>
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<td>Information, Analysis and Communication</td>
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<td>Asymmetric &amp; Irregular Warfare</td>
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<td>Distributed Operations</td>
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<td>Assure Access and Hold at Risk</td>
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## Operational Concepts & Missions

- Distributed Operations
- Asymmetric Warfare
- Operational Environments
- Information, Analysis and Communication
- Survivability and Self-Defense
- Naval Warrior Performance and Protection
- Platform Mobility
- Fleet/Force Sustainment
- Affordability, Maintainability, and Reliability
- Power & Energy

## Combat Force of the Future

- Distributed Operations
- Asymmetric Warfare
- Knowledge Interoperability
- Small, Quick-Response Teams

## Warfighting & Support Functions

- Strong requirement in CNOs SSG XXVI “Cyberspace and Maritime Operations in 2030”
Capabilities Required

- Rapid Team Analysis of Large-Volume, Uncertain Data
- Knowledge Interoperability in Coalition Ops
- Measures of Team Situational Awareness
- Accelerated Team Synchronization
- Improved Heterogeneous Team Performance
- Develop Team Collaboration Performance Metrics
- Superior Speed of Command and Course of Action Selection
- Cultural/Language/Experience-Free Representation and Transfer of Meaning
- Computational Models of Subjective Reasoning/Course of Action Selection
Program Objective

Understand the cognitive processes underlying team decision making in order to aid and improve team performance in quick-reaction, NDM-type problem solving.
Office of Naval Research
Collaboration and Knowledge Interoperability (CKI) Program

MODEL OF TEAM COLLABORATION
Focus on Macro-Cognition

**Problem Area Characteristics**

**Collaborative Situation Parameters:**
- time pressure
- information/knowledge uncertainty
- dynamic information
- large amount of knowledge (cognitive overload)
- human-agent interface complexity

**Team Types**
- asynchronous
- distributed
- culturally diverse
- heterogeneous knowledge
- unique roles
- command structure (hierarchical vs. flat)
- rotating team members

**Operational Tasks**
- team decision making, COA selection
- develop shared understanding
- intelligence analysis (team data processing)

**Collaboration Stages & Cognitive Processes**

- **Knowledge Construction**
  - Meta-Cognitive:
    - individual conversion of data to knowledge
  - Macro-Cognitive:
    - individual mental model development
    - knowledge interoperability development
    - iterative information collection and analysis
    - team shared understanding development
    - develop, rationalize, & visualize solution alternatives
    - convergence of individual mental models to team mental model
    - individual task, team and domain knowledge development
    - individual visualization and representation of meaning

- **Collaborative Team Problem Solving**
  - Meta-Cognitive:
    - team integration of individual knowledge for common understanding
  - Macro-Cognitive:
    - knowledge interoperability development
    - iterative information collection and analysis
    - team shared understanding development
    - develop, rationalize, & visualize solution alternatives
    - convergence of individual mental models to team mental model
    - individual task, team and domain knowledge development

- **Team Consensus**
  - Meta-Cognitive:
    - team agreement on a common solution
  - Macro-Cognitive:
    - team negotiation of solution alternatives
    - team pattern recognition
    - team shared understanding development
    - convergence of individual mental models
    - critical thinking
    - sharing hidden knowledge
    - individual knowledge development

- **Outcome Evaluation and Revision**
  - Meta-Cognitive:
    - solution adjustment to fit goals and exit criteria
  - Macro-Cognitive:
    - compare problem solution against goals
    - team shared understanding development
    - convergence of individual mental models of solution
    - analyze, revise output

**Mechanisms for achieving Meta and MacroCognitive Processes (applies to all stages)**

**Verbal communications:** representing and discussing individual information, discussing team generated information, questioning, agreeing / disagreeing, negotiating perspectives, discussing possible solutions, providing rationale.

**Non-Verbal communications:** facial expressions, voice clues (vocal paralanguage), hand gestures, body movements (kinetics) touch (haptics), personal space, drawing, text messages, augmented video, affordances (cognition in objects).
**Objective:** Present a taxonomy of team collaboration stages and associated macrocognitive processes and sub-processes. The taxonomy will serve as a starting point toward achieving a better understanding of the cognitive aspects of team collaboration.

**Impact:** Understanding team macrocognition will produce more effective team collaboration tools resulting in more timely and accurate mission decisions from C2 down to individual warfighter. Tools will also improve intelligence analysis and mission planning.
# Team Collaboration Taxonomy

## Collaboration Stages and Macrocognitive Processes

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<th>Major Macrocognitive Processes</th>
<th>Knowledge Construction</th>
<th>Team Problem Solving</th>
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**Developing Shared Problem Conceptualization**

- Visualization and Representation of Meaning

**Building Common Ground**

**Knowledge Sharing and Transfer**

**Team Shared Understanding**
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Illustration of Dynamic Interaction of Macro-cognitive Processes across Collaboration Stages

Macro-Cognitive Processes:

1. Individual mental model construction
2. Individual task knowledge development
3. Individual visualization & representation of meaning
4. Knowledge interoperability
5. Iterative information collection & analysis
6. Team shared understanding
7. Develop, rationalize & visualize solution alternatives
8. Convergence – Individual to team mental model
9. Team agreement on a common solution
10. Team negotiation
11. Team pattern recognition

Task: Knowledge Construction

Task: Outcome, Evaluation and Revision

Task: Team Problem Solving

Task: Team Consensus
**Summary**

- **Multidisciplinary Research in Macrocognition poses Terminology Challenges**
  - Terminology will often be domain specific
  - Multiple meanings of terms will likely exist
  - Multidisciplinary contributions add complexity to functional relationships
  - Granularity of the processes must be defined (nesting of processes)
  - A new Ontology may be needed

- **Future Research Issues**
  - Macrocognition is an understudied construct within team cognition
  - Macrocognition is a key factor in team performance in ad-hoc, problem solving teams
  - Macrocognition consists of several macrocognitive processes consistently present in collaborative team activity
QUESTIONS ?