A SENSEMAKING VISUALIZATION TOOL WITH MILITARY DOCTRINAL ELEMENTS

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Presentation Outline

1. Introduction
2. Military doctrinal elements: Cognition and visualization
3. The theory for display design and visualization
4. The sensemaking visualization model
5. Model validation
6. Results and Summary
7. Research extensions
INTRODUCTION

What is sensemaking?

1. What is relevance in what they see?
2. Are they seeing the same thing?
3. Do they have the same interpretation in context?
4. How does the situation understanding enable action?
Sensemaking Challenge

To create a systematic, widespread and persistent Cognitive Edge for the warfighter
Sensemaking: An End-to-End Approach

Adapted from "Understanding Information Age Warfare" (CCRP, 2001)
Search is the mind’s eye,
But sensemaking is the mind’s muscle.

Collection without sense-making, both automated and human, is both wasteful and falsely reassuring.

Robert David Steele, CEO of OSS.Net, March 25, 2006
It would sure be nice if we had some clear idea what it was we were trying to do first.
What is sensemaking?

DERIVING MEANING FROM FRAGMENTARY CUES—(DARPA’S Information Awareness Project)

COLLECTING “DOTS” and BRIDGING MEANING TO HUGE VOLUME OF DATA---INQ-Tel (Arlington-based company).

A SYSTEM OF ACTIONS, SYMBOLS AND PROCESSES THAT ENABLES AN ORGANIZATION TO TRANSFORM INFORMATION INTO VALUED KNOWLEDGE WHICH INTURN INCREASES ITS LONG-RUN ADAPTIVE CAPACITY – (Schandt, 1997; pp. 8)
According to Franks, battle command means seeing what is now, visualizing the future state or what needs to be done to accomplish the mission and then knowing how to get your organization from one state to the other at least cost against a given enemy on a given piece of terrain. The primary components of battle command that depend directly on the commander’s intuition are decision making, visualizing, concept formulation and battlefield awareness--selecting the critical time and place to act, and knowing how and when to make adjustments during the fight.

Using judgment acquired from experience, training, study, and creative thinking, commanders visualize the situation and make decisions. In unclear situations, informed intuition may help commanders make effective decisions by bridging gaps in information. Through the art of command, commanders apply their values, attributes, skills, and actions to lead and motivate their soldiers and units… (FM 3.0)
Military Doctrinal Elements

The sheer volume of information can camouflage the critical information we need. We’re still working on our ability to glean through this information and find the necessary information nuggets that will aid in decision making (MG. Kamiya, 2007)
Military Doctrinal Elements

Reality of the Battle Field
Mission/Enemy/Terrain +weather/Troops/Time available/Civil (METT-TC)

Decision Situation assessment
Sensemaking

Situation
Understanding
Awareness

Decision

Identify/Analyze/Examine/Evaluate/Explore

Visualize/Describe/Explain/Predict/Control

Optimized COA & Running estimates

Anticipate Influence Affect

CDR Decision Making Points

DIME PMESII

After-fact Report/Review

Decision Superiority Assessment Meter (DESAM)

Human: Adaptive, insightful Collaborative, leadership Decision quality

Information: Relevancy, timeliness, Availability, reliability Trust, quality, etc.

Technology: Resiliency, robust, Reliable, adaptable Adaptive,
The End State and the Nature and Design of the Operation

- Operation Environment
- Enemy

The Problem

- Operational Environment
- Enemy

Describe

Time, Space, Resources, Purpose, and Action

- Decisive Operations
- Shaping Operations
- Sustaining Operations

Direct

Warfighting Functions

- Movement and Maneuver
- Intelligence
- Fires
- Sustainment
- Command and Control
- Protection

Understand

The Problem

- Doctrine
- Principles of war
- Operational themes
- Experience and judgment

Visualize

The End State and the Nature and Design of the Operation

- Offense
- Defense
- Stability
- Civil Support

Direct

Warfighting Functions

- Movement and Maneuver
- Intelligence
- Fires
- Sustainment
- Command and Control
- Protection

Describe

Time, Space, Resources, Purpose, and Action

- Decisive Operations
- Shaping Operations
- Sustaining Operations

Assess

- Initial commander's intent
- Planning guidance
- Commander's critical information requirements
- Essential elements of friendly information

Continuous Learning

Running estimates

Elements of operational design

BATTLE COMMAND
The **Art** and **Science** of Battle Command

**Understand**

**COP**

- Time, Space, Resources, Purpose & Action
- Decisive Ops
- Shaping Ops
- Sustaining Ops

**Visualize**

- Principles of War, Tenets, Experience
- Factors of the Situation (METTC)

**Describe**

- Elements of Operational Design
  - End State & conditions
  - Center of Gravity
  - Decisive Points
  - Lines of Operation
  - Culminating Point
  - Operational Reach & Approach
  - Simultaneous & Sequential Ops
  - Linear & Nonlinear Ops
  - Tempo

**Direct**

- Warfighting Functions
  - Mvmt & Manvr
  - Intelligence
  - Fires
  - Sustainment
  - Cmd & Control
  - Protection

- Plans & Orders
- Preparation
- Execution

**Assess**

- Staff Running Estimates
- Input from other Commanders

**Effects**

**COP**

- End State & conditions
- Center of Gravity
- Decisive Points
- Lines of Operation
- Culminating Point
- Operational Reach & Approach
- Simultaneous & Sequential Ops
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**LandWarNet** provides the full spectrum of connectivity – from the deployed Soldier to Home Station Operations Centers, National/Strategic Intel Centers and Logistic Support & Sustainment locations – encompassing Joint, Interagency, and Multinational capabilities.

In short, we need to develop an integrated approach for the understanding (framing) and visualizing, describing, directing, assessing, and reframing of unified operations.
THE THEORY FOR DISPLAY DESIGN & VISUALIZATION

1. Human cognitive processes
2. Display theories
3. Visualization modalities & techniques
4. Decision performance
Mission, commander intents, doctrines, focus, effects, intuition/tacit knowledge, insights, hindsight, foresights

Commanders describe operations in terms suited to experience and mission

Card, et al. (1999):
1. Increase cognitive resources
2. Reducing search
3. Enhance pattern recognition
4. Easy perceptual monitoring
5. Seeing the features of on-going events
6. Provide a manipulable medium

High level SA that the mind cannot perceive, organized knowledge, map actionable knowledge to goals, causal linkages, understand risks, provide running estimates, etc.

Mental model trigger

Display

Deliberate process, Mnemonic devices, enable first-level SA. Provide sampled data elements

Understand Situation

Envision the Problem space With critical features

Visualize

Sensemaking

Sense, Perceive, Monitor

Info fusion and exploitation

Organized knowledge

Focal knowledge sharing

Critical thinking

A TETRAHEDAL MODEL LINKING VISUALIZATION, COGNITION, DISPLAY, AND SU
Cognition and Visualization in Situational Understanding: An Abstraction Model

- Situation Understanding
  - Characterization of the adversary; Envisioning; Mapping actionable knowledge to effect

- Cognitive Enablers and Filters
  - Perspective taking & assumptions
  - Frame hypotheses
  - Sensemaking

- Visualization
  - Cognizing decision elements, cues, clues, signs, symbols, and signals & enabling neural activities

- Perception
  - Environmentally embodied; Perception of first-level cues, followed by the instantiation of recognition-primed activities;

- Information Display Rendering
  - Information portrayal; Display of tangible information elements of the situation to support cued cognition; Affordances
How Visualization Enables the Commander’s Cognitive Process

Sensemaking Processing Stages

- Situation understanding
  - Meaning processing & implications for actions
- Knowledge discovery
  - Mental model, meaning and interpreting, situation recognition
  - The “aha” experience, patterns, link analysis, signals, correlation, etc.
  - Spatial knowledge, environmental constraints, system dynamics
- Situation Awareness
  - Spatial information collection, organization, filtering, etc.
  - Cues/Clues
  - Case-based situation framing
  - Experience, intuition, retrospection

Display and Visualization Components for Situation Awareness
THE SENSEMAKING VISUALIZATION MODEL

Building The Visualization Ontology

Sensemaking Process

Individual Analyst

Group Arguments, Discussions/Narratives

Data Mining Algorithms

Information Fusion

Situation Story

Meaning-> Interpretation-> Understanding-> Action

Doctrinal Thinking

Visualize, Detect, Decide

Our Current S3 (version 1.0) for Collaborative Sensemaking and information fusion capability
Case-1
Captain XX just receive intelligence reports on possible attacks on critical infrastructure including kidnapping key political and religious leaders. Prepare a sensemaking and inform the commander on the available courses of action to respond.

Case-2
General Haltrack is informed that a group of terrorists has been arrested in node K south of the adversary network. Intel showed that they have spread to other cells in the network, but are not identifiable.

Use a sensemaking model to analyze the situation. Include information on the terrorists cell—who they are, sponsors, their strategies, how the evolve, their motives, etc. Work with all intelligent organizations.
6 Experienced military officers: 4 LTC, 2 Majors; 5 males, 1 female. 2 from ROTC; 2 from BCBL; 1 reserved component; 1 retired. 116 man years of service.

Minimal Constructed Scenarios Developed from Cynefin Problem Typologies:

- MCS1: Knowable
- MCS2: Complex
- MCS3: Chaos

SM = Sensemaking perception
SA: Situation awareness perception
SU: Situation understanding perception
PRELIMINARY VALIDATION RESULTS: Sensemaking perception score (1-7: 1= absolutely not useful ; 7 = absolutely very useful)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Min score</th>
<th>Average</th>
<th>Max score</th>
<th>Standard deviation</th>
<th>% variance contribution (factor loading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allows for concept mapping</td>
<td>2.6</td>
<td>3.2</td>
<td>5.1</td>
<td>1.5</td>
<td>0.12</td>
</tr>
<tr>
<td>Contextual reasoning for ideas sharing</td>
<td>1.1</td>
<td>2.8</td>
<td>4.7</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Interpretation of situation</td>
<td>2.4</td>
<td>4.3</td>
<td>6.5</td>
<td>1.3</td>
<td>0.32</td>
</tr>
<tr>
<td>Retrospective information search</td>
<td>2.0</td>
<td>4.5</td>
<td>6.8</td>
<td>0.67</td>
<td>0.26</td>
</tr>
<tr>
<td>Predictive analysis</td>
<td>1.9</td>
<td>3.1</td>
<td>4.3</td>
<td>0.96</td>
<td>0.2</td>
</tr>
</tbody>
</table>
## Preliminary Validation Results: Situation Awareness Perception Score (1-7: 1-absolutely not useful; 7 = absolutely very useful)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Min score</th>
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<th>Max score</th>
<th>Standard deviation</th>
<th>% Variance Contribution (Factor Loading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common operating picture</td>
<td>4.2</td>
<td>6.6</td>
<td>7.0</td>
<td>0.6</td>
<td>0.27</td>
</tr>
<tr>
<td>See area of interest</td>
<td>3.3</td>
<td>4.8</td>
<td>6.5</td>
<td>0.91</td>
<td>0.16</td>
</tr>
<tr>
<td>See information changes over time</td>
<td>2.0</td>
<td>3.5</td>
<td>5.8</td>
<td>1.2</td>
<td>0.07</td>
</tr>
<tr>
<td>Team information sharing and dialog</td>
<td>4.6</td>
<td>6.8</td>
<td>7.0</td>
<td>0.2</td>
<td>0.38</td>
</tr>
<tr>
<td>Team situation awareness</td>
<td>3.1</td>
<td>3.9</td>
<td>5.4</td>
<td>1.3</td>
<td>0.12</td>
</tr>
</tbody>
</table>
PRELIMINARY VALIDATION RESULTS: Situation Understanding perception score (1-7: 1-absolutely not useful; 7 = absolutely very useful)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Min score</th>
<th>Average</th>
<th>Max score</th>
<th>Standard deviation</th>
<th>% variance contribution (factor loading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain situation</td>
<td>1.5</td>
<td>3.2</td>
<td>4.9</td>
<td>1.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Describe situation</td>
<td>2.0</td>
<td>3.4</td>
<td>4.7</td>
<td>1.3</td>
<td>0.22</td>
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<tr>
<td>Visualize courses of action</td>
<td>4.8</td>
<td>6.1</td>
<td>7.0</td>
<td>0.08</td>
<td>0.48</td>
</tr>
</tbody>
</table>
Summary and Results

The results show the followings:

(a) the perception rating of S3 with respect to the cognitive measures was highly significant, $F(2, 37) = 2.4 < 5.8$ computed value;

(b) the problem scenarios were highly significant, $F(2, 37) = 2.4 < 3.23$;

(c) there was noticeable interaction effect between the cognitive measures and the problem types, $F(4, 37) = 2.09 < 11.3$
NORTH CAROLINA A&T STATE UNIVERSITY
Research Extension to SASO Planning