A Process Model of Situated Cognition in Military Command and Control

Collaboration and Knowledge Management Workshop
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## A Process Model of Situated Cognition in Military Command and Control

### Collaboration and Knowledge Management (CKM) Workshop, 11-13 Jan 2005, San Diego, CA
Agenda

- Situation Awareness versus Situated Cognition
- A Process Model of Situated Cognition
- The *USS Stark*: A Case Study (Individual)
- Team versus Shared Situation Awareness
- The *USS Stark*: A Case Study (Distributed)
- Measurement Methods and Metrics
"The perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and their status in the near future." (Endsley, 1988)

"A common, relevant picture of the battlefield scaled to specific levels of interests and special needs." (TRADOC Pamphlet 525-5)

"The product of applying analysis and judgment to the common operational picture..." (FM 3-0 (Operations))

Ideal SA; Achievable SA; Actual SA (Pew, 2000)

"Where am I? Where’s my buddy? Where’s the enemy?" (An Army Officer)

“That’s my SA (pointing to his FBCB2 screen).” (An Enlisted Soldier)
# Methods for Measuring SA

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<th>Subjective</th>
<th>Objective</th>
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<td>Retrospective</td>
</tr>
<tr>
<td>Direct</td>
<td>Indirect</td>
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<tr>
<td>Obtrusive</td>
<td>Unobtrusive</td>
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- **SART**: Situational Awareness Rating Technique
- **SA-SWORD**: Situation Awareness-Subjective Workload Dominance
- **SARS**: Situation Awareness Rating Scale
- **MARS**: Mission Awareness Rating
- **SAGAT**: Situational Awareness Global Assessment Technique
- **SALIENT**: SA Linked Instances Adapted to Novel Tasks
- **SABARS**: Situation Awareness Behaviorally Anchored Rating Scale

These methods tend to measure:

- **states**, not processes
- **humans**, not systems
An Alternative to Situation Awareness

What is needed is a model and a methodology that:

- focuses on *processes* rather than states
- includes both *human and machine* ‘components’ of a system
- is oriented on assessing *human-system performance*
- tracks the *evolution* of activities and cognition
Situated Cognition

- Borrowed from the learning and linguistics literature
- Includes mental activities *embedded in an evolving context*
- Includes *human and machine agents*
- Involves *collaborative activities*
- **Goal-directed**
A Process Model of Situated Cognition

1. All data in the environment

2. Data detected by technological systems

3. Data available on local C2 system

4. Data perceived by decision maker

5. Comprehension of decision maker

6. Projection of decision maker

Lenses consist of local situation, OPORD, doctrine, experience

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Misshaped lenses will skew a decision maker’s perceptions, comprehensions, and projections.
Feedback Loops in the Model

All Data in the World

Data Detected By Sensors

Data on Local C2 System

Perception

Comprehension

Projection

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Feedback Loops in the Model

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Case Study: *USS STARK*

On the evening of May 17, 1987, the *USS Stark* was patrolling international waters in the Persian Gulf off the coast of Bahrain and Saudi Arabia. At 2109 that evening, the *USS Stark* was struck by the first of two Exocet AM-39 anti-ship cruise missiles, fired from an Iraqi F-1 Mirage fighter.
Oval 1: Ground Truth
Oval 1: Ground Truth

Stark is 12nm west of Iraqi exclusion zone.
Oval 1: Ground Truth

AWACS is aloft.
Oval 1: Ground Truth

Other USN vessels are in the area.
Oval 1: Ground Truth

Iraqi F-1 Mirage flying toward the *USS Stark*.
Oval 2: Sensor Coverage

*USS Stark* is 12 nm from Iraqi exclusion zone.
AWACS is aloft.
Other USN vessels in the area.
*Unknown aircraft appears on radar.*
Oval 3: Workstation Display

*USS Stark* is 12 nm from Iraqi exclusion zone.
AWACS is aloft.
Other USN vessels in the area.
**Unknown aircraft appears on radar.**

Audible alarms on SLQ-32 turned off
Oval 4: Perception

Aircraft on detected on radar.
Aircraft tagged as friendly.

Content of Lenses:
US had sided with Iraqis.
Brindel was on final cruise.
XO & TAO missed intel briefings.
Iraqis had been flying farther south w/o incident.
Aircraft is no threat to USS Stark.

Final turn of F-1 is picked up by sensors on AWACS and Stark but is not detected by CIC crew, leading to incorrect perceptions, comprehensions, and projections.
Aircraft will turn away from *USS Stark*.

The crew comprehend the ship has been hit but they do not know the source of the attack. Hence, their projections are of little use to them.
Team Situation Awareness

The degree to which all team members possess the SA required for their jobs.
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The degree to which all team members possess the SA required for their jobs.
Shared Situation Awareness

The degree to which team members possess the same SA.

No Shared Situation Awareness
Shared Situation Awareness

The degree to which team members possess the same SA.

Team Goal
1955 hrs:
- AWACS acquires unk a/c
- AWACS evaluates as "friendly strike/support aircraft"
- STARK by CIC on LASALLE
- LASALLE switches SPS-49 to 200 nm mode
- Data sent to all ships via N-3DS
- STARK CIC detects track
- STARK CIC confirms track with AWACS
- STARK CIC personnel determine track is not a threat
- STARK switches SPS-49 from 200 nm mode to 80 nm mode
- Track appears on SPS-49 radar
Process Tracing

- Maps out how the incident unfolded
- Focuses on how a given outcome came about
- Externalizes internal processes
- Uses data from multiple sources
- Describes the sequence of information flow and knowledge activation

(After Woods, 1993)
Metrics for Situated Cognition

Technological side of model:
• Playback of ground truth using various sources (e.g., database queries, screen captures)

Human side of model:
• Individual characteristics of sensemakers
  Experience and training (including proficiency with computers and technology)
  Personality, Intellect
  Index of Learning Styles

• Behavioral Analysis (direct observation, voice and A/V Recordings)
  Noldus System for Behavioral Capture and Analysis

• Physiological measures of participants (Head and Eye movements, heart rate variability, EEGs)

• Geographical Recall and Analysis of Data in the Environment (GRADE)

• Cued Retrospective Interviews
## Evaluating Data Sources

<table>
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<td>Audio/Video</td>
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<tr>
<td>GRADE</td>
<td>4, 5, 6</td>
<td>SART</td>
<td>4, 5, 6</td>
</tr>
<tr>
<td>Retro Interviews</td>
<td>4, 5, 6</td>
<td>Wrist Monitors</td>
<td>4</td>
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</tbody>
</table>
GRADE  
(Geographical Recall and Analysis of Data in the Environment)

• Not a memory test. A way to gauge where the officer is focused at that moment.
• Facilitates comparison between Oval 3 (what is displayed on local workstation) and Oval 4 (what is perceived by the decision maker).
• On cue participants turn away from the screen.
• “As quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.”
• Flip an acetate overlay
• “Tell me what the battlespace will look like 30 minutes from now.”
• Number and timing of GRADE events based on scenario.
INSTRUCTIONS
1. Fill in your SART ratings below. (Refer to descriptions on the inside cover of this binder if necessary.)
2. **On the paper map**, as quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.
3. Flip the acetate overlay.
4. **On the acetate overlay**, sketch what the battlespace will look like 30 minutes from now.

Demand (1 to 7) 2  
Supply (1 to 7) 6  
Understanding (1 to 7) 2
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Demand (1 to 7) 5 Supply (1 to 7) 6 Understanding (1 to 7) 5
G R A D E
(Adapted for Trident Warrior ’04)
Experimental Design

USS TARAWA

USS JPJONES

USS Pearl Harbor

TAO
ESG
PHIBRON

1 2 3

A
B
C

1 2 3

A
B
C

1 2 3

A
B
C

4 Data Pauses within each Segment (1/2/3) of each Scenario (A/B/C)
Results

*Chart I* – progression of GRADE scores from Scenarios A to B

*Chart II* – variation in GRADE scores among different watch stations (TAO/ESG/PHIBRON)
Sample Heart Rate Variability

Running up and down stairs

7 min. low workload

7 min. high workload

7 min. high workload
Subjective Workload Assessment Graph (Cognitive) (SWAG–C)

![Graph showing workload percentage over time.](Image)

- Highest Workload
- Just About Right
- Lowest Workload

Workload (Percentage of Maximum)

Time (in Minutes)
The case of the *USS Stark* illustrates the *utility of the process model* of situated cognition as a descriptive and explanatory tool for both individual and collaborative activities.

The model *combines both human and machine* system components.

By employing multiple methods of data collection, *the evolution of an event can be traced* as data and information flow through the machine and human components of the system.

The model *facilitates determining when and how activities go awry*.

Knowledge of how and when errors occur is *critical to the design of new C2 systems* and the re-design of existing systems.
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