



INSTITUTE FOR DEFENSE ANALYSES

## **Introduction to Measuring Situational Awareness in Mission-Based Testing Scenarios**

John Haman, Project Leader

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OED Draft Final  
October 2023

Public release approved. Distribution is  
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IDA Document 3000630

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#### About This Publication

This work was conducted by the Institute for Defense Analyses (IDA) under contract HQ0034-19-D-0001, for the Office of the Director, Operational Test and Evaluation. The views, opinions, and findings should not be construed as representing the official position of either the Department of Defense or the sponsoring organization.

#### Acknowledgments

The IDA Technical Review Committee was chaired by Dr. V. Bram Lillard and consisted of Dr. Breeana Anderson, Dr. Jonathan Bell, Dr. Jason Gonzales, and Mr. Bruce Simpson from the Operational Evaluation Division, and Dr. Janna Mantua from the Science and Technology Division.

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## **Introduction to Measuring Situational Awareness in Mission-Based Testing Scenarios**

John Haman, Project Leader

Elizabeth A. Green

# Executive Summary

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This briefing provides an introduction and training material to aid system evaluators in implementing best practices for measuring situational awareness (SA). We view informational engagement and training across the test and evaluation community to be an essential element of progressing the practice of measuring SA in operational testing (OT).

At the 2023 DATAWorks conference, IDA presented a briefing that aimed to promote a scientific understanding of what SA is (and is not) and encouraged discussion amongst practitioners tackling the challenge of measuring SA. Following the DATAWorks presentation, AEC requested that IDA, as an extension of our analytical support to DOT&E, provide a brown bag lunch briefing to encourage discussion and present methodological best practices for this important topic.

This briefing was developed to promote a scientific understanding of what SA is (and is not). We briefly

introduce Endsley's model of SA, review the tradeoffs involved in some existing measures of SA, and discuss a selection of potential improvements for SA measures during realistic testing scenarios (i.e., operationally realistic testing events, not necessarily exclusive to OT). This briefing also includes a discussion of common misconceptions about SA measurement and practical guidance for practitioners deciding on whether or not, and how, to measure user SA for a particular system. The contents of this briefing are similar to our DATAWorks presentation, but have been edited to make them more practice-oriented for this practitioner audience.

## Background

Situational awareness is an important component of human-systems integration. SA plays a key role in decision making and human performance: higher operator SA is associated with increased operator performance and decreased operator errors.<sup>1,2</sup> In general, SA can be thought

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<sup>1</sup> Endsley, Mica R. "A survey of situation awareness requirements in air-to-air combat fighters." *The International Journal of Aviation Psychology* 3, no. 2 (1993): 157–168.

<sup>2</sup> Endsley, Mica R., and Esin O. Kiris. "The out-of-the-loop performance problem and level of control in automation." *Human factors* 37, no. 2 (1995): 381–394.

of as an individual's "perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."<sup>3</sup>

While situational awareness is a common suitability parameter for systems under test, there is no standardized method or metric for quantifying SA in OT. This leads to varied and suboptimal treatments of SA across programs and test events. Current measures of SA are exclusively subjective and paint an inadequate picture.

Future advances in system connectedness and mission complexity may exacerbate the difficulty associated with assessing situational awareness. Technological improvements are likely to necessitate increases in the complexity of the warfighters' mission, including changes to team structures (e.g., integrating human teams with human-machine teams), command and control (C2) processes (e.g., expanding C2 frameworks toward joint all-domain C2), and battlespaces (e.g., overcoming integration challenges for multi-domain operations). Operational complexity in turn increases the complexity of operators' informational needs and may make maintaining high SA harder. In such situations, well-developed SA measurement in OT will be more important and more difficult.

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<sup>3</sup> Endsley, Mica R. "Design and evaluation for situation awareness enhancement." In *Proceedings of the Human Factors Society annual*

*meeting*, vol. 32, no. 2, pp. 97–101. Los Angeles, CA: Sage Publications, 1988.



# **Introduction to Measuring Situational Awareness in Mission-Based Testing Scenarios**

Elizabeth A. Green

October 4, 2023

**Institute for Defense Analyses**  
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Nice to meet you!



### **Elizabeth A. Green, Ph.D.**

- Research Staff Member at the Institute for Defense Analyses (IDA) in the Operational Evaluation Division (OED).
- Provides Test Science support to DOT&E's Land and Expeditionary Warfare Programs.
- Background: Cognitive Neuroscience – Metacognition – Learning & Performance

## BLUF

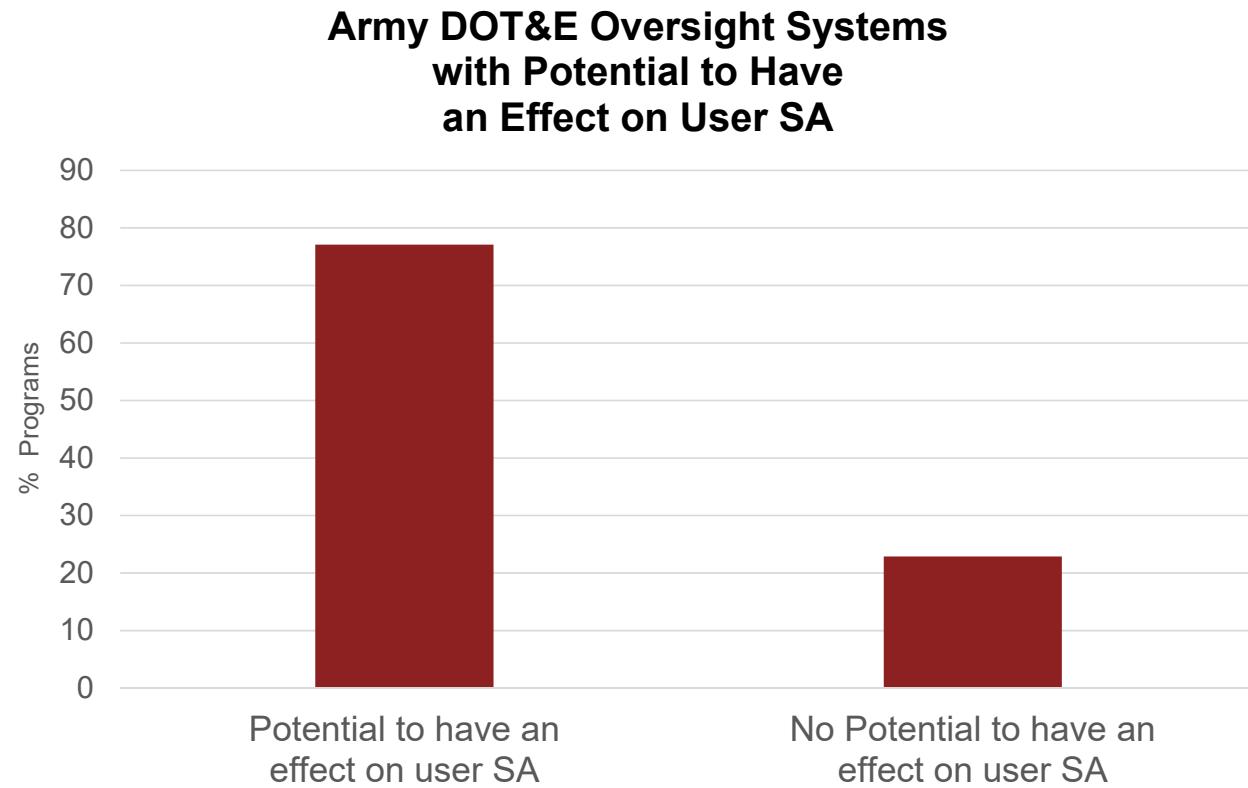
- Evaluations can benefit from SA measurement being included in early testing (CT, DT, IT). There's no need to wait for the OT!
- SA measurement method choice should be made considering:
  - Is the system designed to affect or enhance user SA?
  - The operational context: Who is the user? Are there multiple users? How do users employ the system? Are there multiple use cases (e.g., at different echelons)?
- SA can (and often should) be objectively measured to capture information about system contribution to mission accomplishment.
- Additional resourcing may need to be allotted for SA measurement.

# Situational Awareness is one of *many* human-systems integration concepts relevant to testing.

Concept	Measures
<b>Training</b>	OATS
<b>System usability</b>	SUS, UMUX-LITE
<b>Operator workload</b>	ARWES/CSS, NASA-TLX
<b>Operator trust [of system]</b>	TOAST
<b>Operator situational awareness</b>	<i>[no standard within OT]</i>

ARWES – Air Force Flight Test Center Revised Workload Estimate Scale; CSS – Crew Status Survey; NASA-TLX – National Aeronautics and Space Administration Talk Load Index; OATS – Operational Assessment of Training Scale; OT – Operational Testing; SUS – System Usability Scale; TOAST – Trust of Automated Systems Test; UMUX – Usability Metric for User Experience

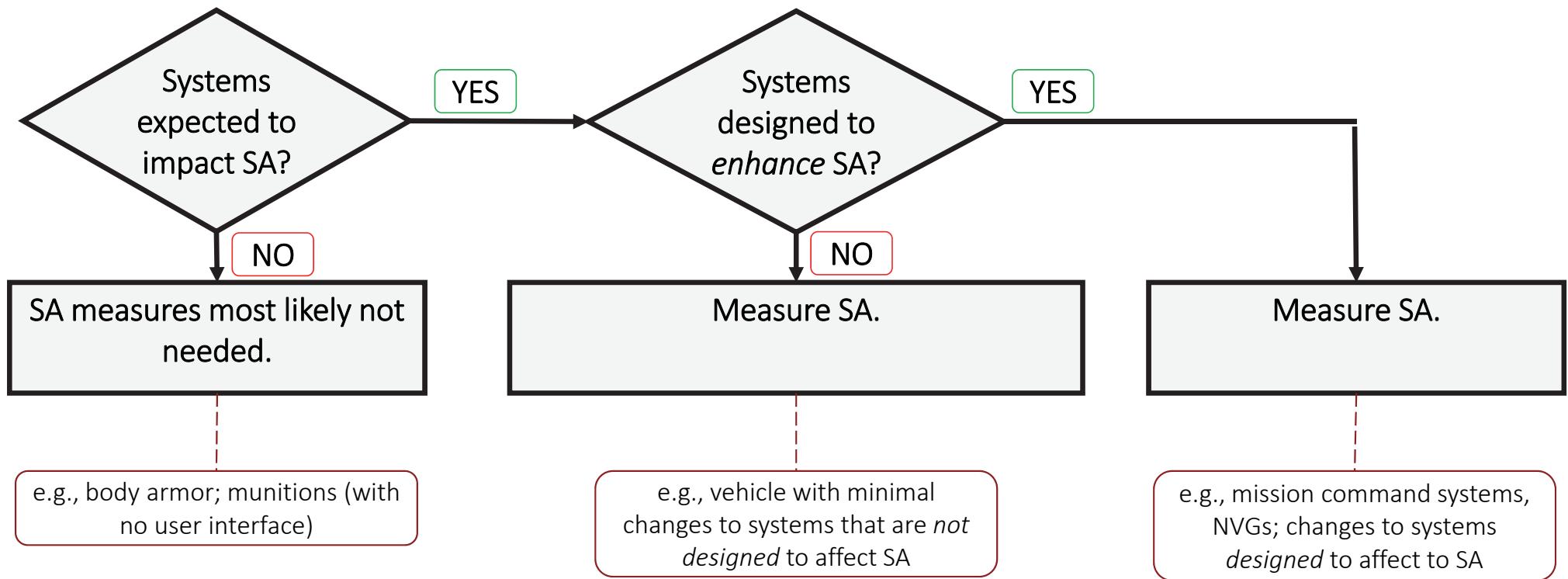
## How relevant is all of this “SA stuff” to Army systems?



Counts based on IDA's evaluation of the Army programs currently on the DOT&E oversight list.

SA – Situational Awareness

# The information in this briefing should help you think about whether and how to measure SA.



## Three reoccurring misperceptions about SA measurement

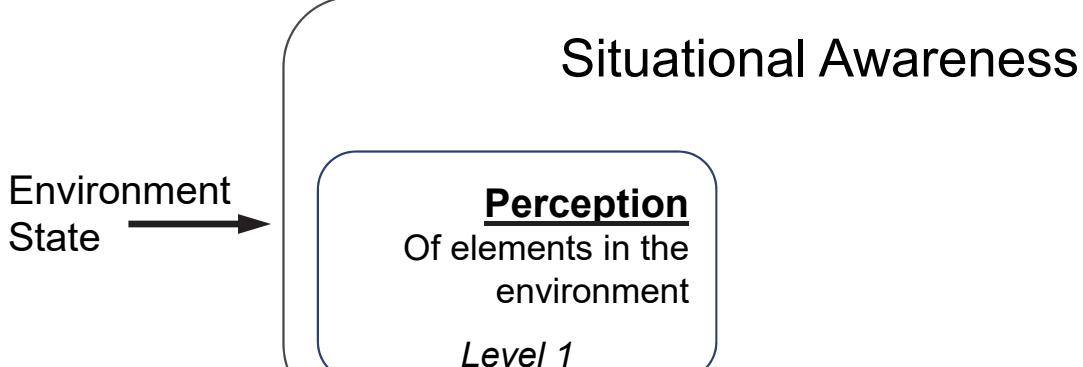


**Increased technology doesn't increase situational awareness.**

- 1) We shouldn't measure SA
  - SA is beyond the scope of our test.
  - "We are not testing operators."
- 2) We should but can't measure SA
  - "SA is really important, but impossible to measure."
- 3) We can and already do measure SA
  - We should measure SA for every system.
  - We can collect a complete characterization of SA using surveys.

# **WHAT IS “SITUATIONAL AWARENESS”?**

# Modeling situational awareness at the user, task, and system level



(Endsley, 1999)



User Decision: Where are all friendly units currently located?

System Contribution:  
*...could impact how soldiers perceive this information.*

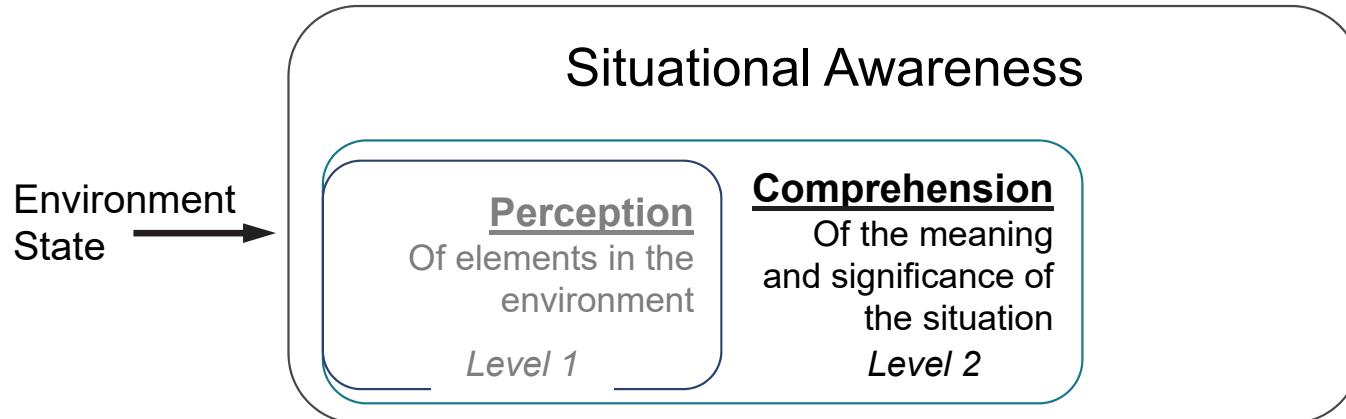
SA – Situational Awareness



User Decision: Are we taking fire?

System Contribution:  
*...might impact soldiers' ability to perceive this information.*

# Modeling situational awareness at the user, task, and system level



(Endsley, 1999)



Brigade –  
Mission Command System

User Decision: Which friendly units are outside of their maneuver boundaries?  
System Contribution:  
*...could impact how soldiers comprehend displayed information.*

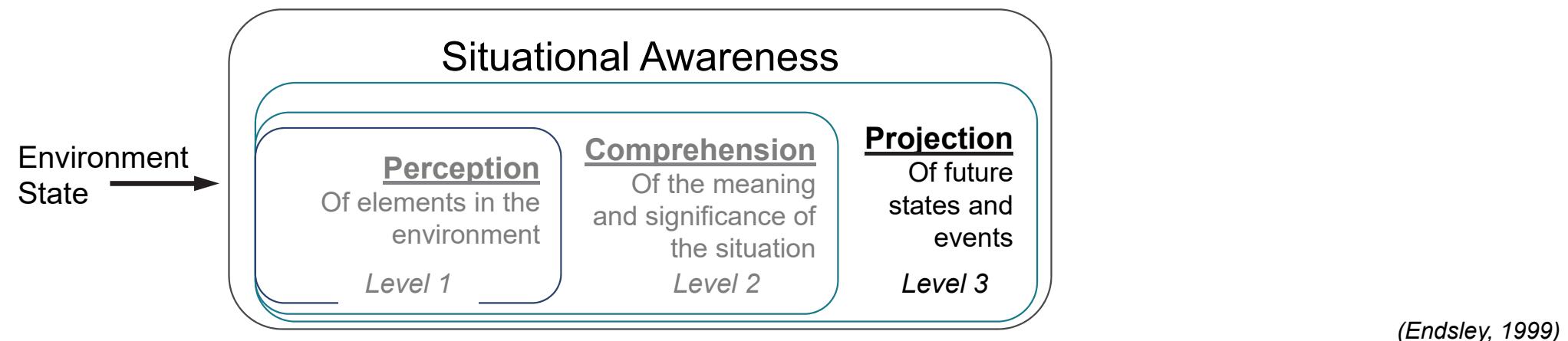


Infantry Squad –  
Night Vision Device

User Decision: Which enemy element presents the highest-level threat?  
System Contribution:  
*...might impact soldiers' ability to interpret available information.*

SA – Situational Awareness

# Modeling situational awareness at the user, task, and system level



(Endsley, 1999)



Brigade –  
Mission Command System

User Decision: What additional assets are needed to carry out the mission?

System Contribution:  
*...could impact how soldiers use their understanding of the situation to make this decision.*

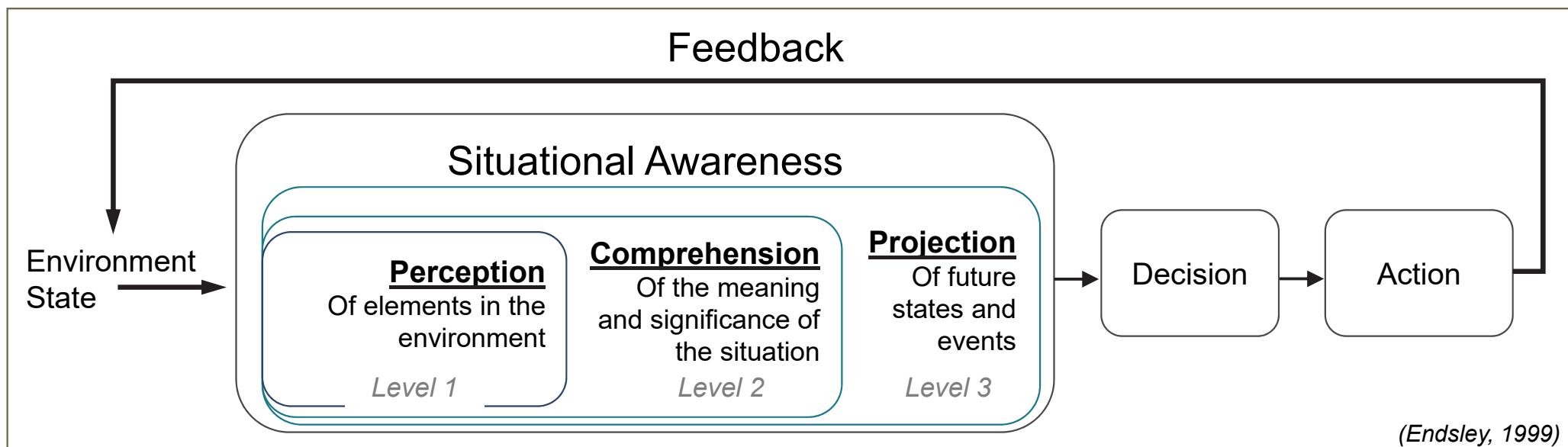


Infantry Squad –  
Night Vision Device

User Decision: What do you expect the enemy to do in the next 5 minutes?

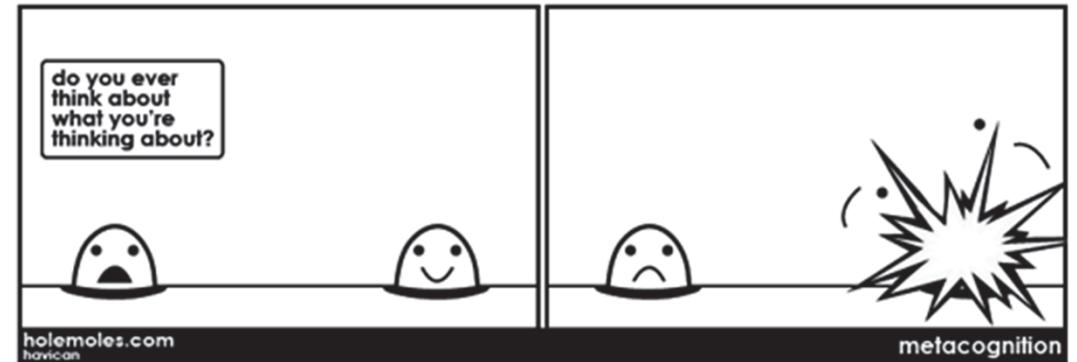
System Contribution:  
*...might impact soldiers' ability to project future enemy actions.*

**Modeling SA at the user, task, and system level provides valuable information about how and why soldiers make decisions and take actions.**



<b><u>Some Related Factors:</u></b>	User Perception <ul style="list-style-type: none"><li>• Workload</li><li>• Usability</li></ul>	System Design <ul style="list-style-type: none"><li>• Automation</li><li>• Interfaces</li></ul>	User Background <ul style="list-style-type: none"><li>• Goals</li><li>• Experience</li><li>• Training</li><li>• Ability</li></ul>
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SA – Situational Awareness



## HOW IS SITUATIONAL AWARENESS MEASURED?

# Misleading SA “measures” we have seen at test

## ✗ Custom Surveys:

- Global SA Self-Reports
  - “[The system] would improve my situational awareness.”
    - Scale: 7-point; Strongly Disagree to Strongly Agree
- Topic SA Self-Reports
  - “Rate your SA for flight hazards/mission progress/route information.”
    - Scale: 7-point; Very Low to Very High



## ✗ Generic Surveys:

- Situation Awareness Rating Technique (SART)
  - 10 items; 3 Subscales: attentional demand, attentional supply, and understanding
    - Does not necessarily measure SA! (Endsley, Sollenberger, & Stein, 2000)

## ✗ Inference from Mission Performance

- “The mission was successfully completed, so SA must have been good.”

# A portfolio of *indirect indicators* may show whether a system significantly degrades SA

## Performance Measures

Task Success / Failure



Reaction Time

## Physiological Measures



Portable EEG



### Pros

Objective data source

Inobtrusive

Can be collected in real time

### Pros

Objective data source

Sound really cool

### Cons

*Indirect* measure of SA.

Dependent on data collection (instrumentation, data collectors)

Limited to observable behaviors

Success/Failure can be subjective. Should be clearly defined.

### Cons

*Indirect* measure of SA.

Limited research on relationship between measures and SA

Equipment is expensive & not usable in some test environments

Obtrusive

Data are very difficult to analyze

Some physio data will likely be PHI

## A portfolio of *indirect indicators* may show whether a system significantly degrades SA

Situation-Specific Validated Surveys

e.g., Situation Awareness Behaviorally Anchored Rating Scale (SABARS)

- Item development based on Goal Directed Task Analysis (GDTA) or similarly detailed task analysis.
  - o GDTA defines goals, information requirements, and to-be-made decisions specific to *system, task, & user*
- User performance of behaviors consistent with acquiring and disseminating SA rated by SMEs or O/Cs
- Analysis is specific to data collection for a particular event: *factor analysis & hypothesis testing*



More information on development and implementation:  
Strater et al., *Measures of platoon leader situation awareness in virtual decision-making exercises*.

# **Direct measures of SA: The best, most informative assessment method**

Objective, Query-Based Measures

e.g., Situation Awareness Global Assessment Technique (SAGAT)

- Query development based on Goal Directed Task Analysis (GDTA) or similarly detailed task analysis.
  - o Queries can either:
    - Solicit real-time *knowledge* information from users
    - Involve data collection of objective & measurable variables
    - May need to include follow-up AAR with BLUFOR & OPFOR to “fill in the blanks.”
- Data collection either in simulated environment or during real world activities.

AAR – After Action Review; BLUFOR – Blue (friendly) Forces; OPFOR – Opposing Forces

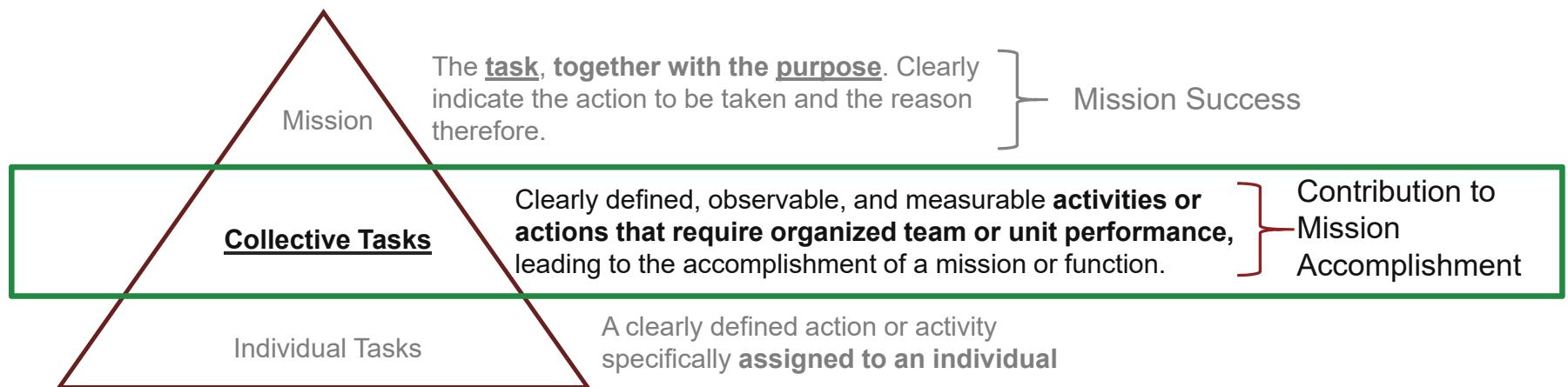


Participant completing a SAGAT mission task (Salmon et al., 2007)

More information on development and implementation:  
Strater et al., *Measures of platoon leader situation awareness in virtual decision-making exercises*.

## Example: Develop a query-based excursion/demonstration of SA

- First, conduct a detailed task analysis for relevant user(s) and task(s)



### Notional Examples:

- Troop transport vehicle: Embed measures in gunnery lanes (DT or IT)
- Mission command system: Embed measures in Plan, Prepare, Execute, Assess phases (DT, IT, or OT)

### Considerations

- Scenarios should cover relevant tasks
- Each scenario should have queries at SA level
- Queries should have a scorable/correct answer
- May need to conduct multiple runs to cover missions & mission-relevant factors

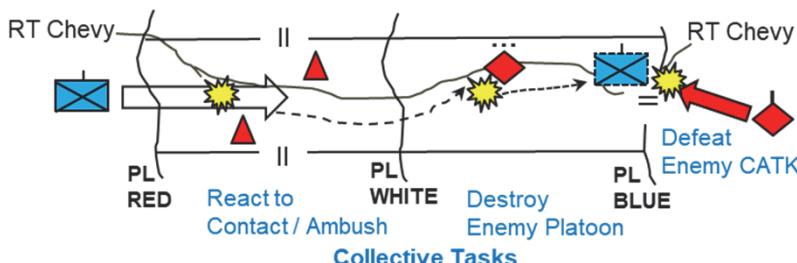
DT – Developmental Test; IT – Integrated Test; OT – Operational Test; SA – Situational Awareness

# Example: Develop a query-based excursion/demonstration of SA

- Next, identify appropriate queries for implementation during your test event.

## Mission Order:

Conduct MTC from PL RED to PL BLUE and destroy enemy forces in zone in order to prevent the disruption of attack by follow-on friendly forces along Route Chevy.



	SA for...	Sample of SA Decisions & Metrics
Level 1: Perception	Threat Forces	<ul style="list-style-type: none"> <li>• How many threat forces are present? (# of threat forces detected / missed; As part of OPORD: report all threat forces)</li> <li>• Where is the enemy firing from? (# of correct ID of Enemy Location logged)</li> </ul>
	Friendly Forces	<ul style="list-style-type: none"> <li>• Where am I? (Report; Vehicle Position Accuracy, COP or Report)</li> <li>• Where are other friendly forces? (Accuracy of Friendly forces locations, COP or Report)</li> </ul>
Level 2: Comprehension	Threat Forces	<ul style="list-style-type: none"> <li>• Can I engage the threat? (# of engagements with accurate estimate of distance to target)</li> <li>• Which target is highest priority? (# of engagements where most dangerous target engaged first)</li> </ul>
	Friendly Forces	<ul style="list-style-type: none"> <li>• Is enemy fire threat to me/how effective is enemy fire? (Digital/Voice reports of friendly casualties; Requests for support; Reports)</li> <li>• Which friendly forces are exposed to enemy fire? (Request or Report)</li> </ul>
Level 3: Projection	Threat Forces	<ul style="list-style-type: none"> <li>• What do you expect the enemy to do in next 3 minutes? (Report &amp; comparison to enemy decision; Request selection from list)</li> </ul>
	Friendly Forces	<ul style="list-style-type: none"> <li>• Are friendly forces in line of fire? (# of engagements with Fratricide; Request or Report)</li> <li>• How long will it take to get to next position? (Request or Report)</li> </ul>

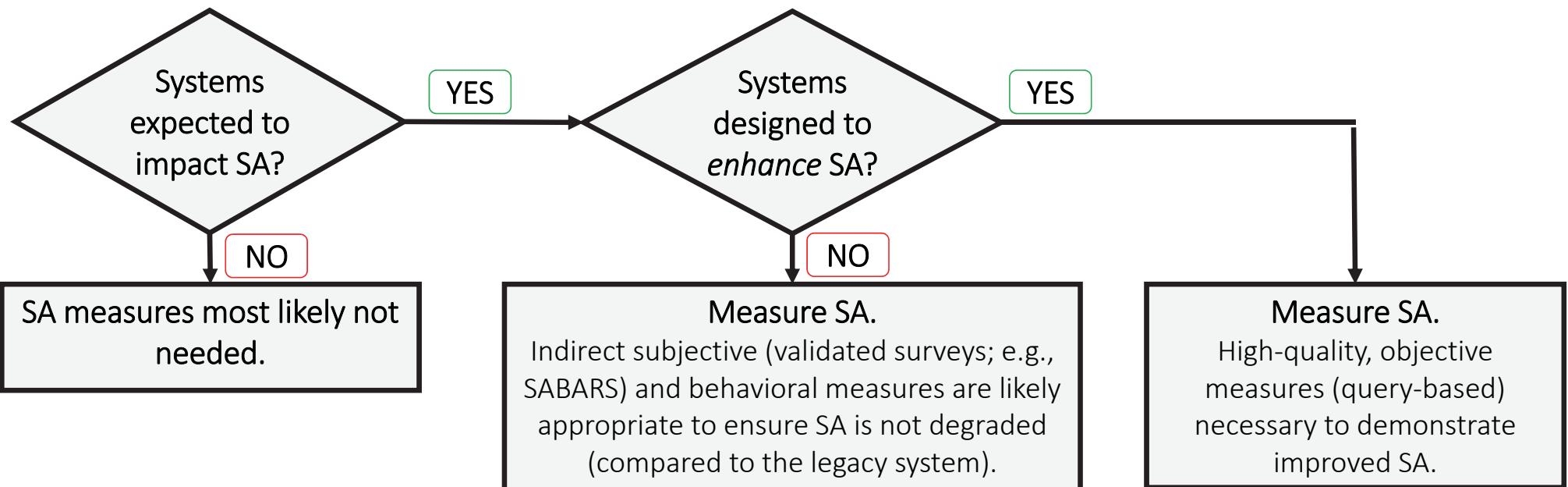
CATK – Counterattack; COP – Common Operating Picture; ID – Identification; MTC – Movement To Contact; OPORD – Operations Order; PL – Phase Line; RT – Route; SA – Situational Awareness

# **How SHOULD You IMPLEMENT This INFORMATION?**

## Step 1: Define users, respective task & purpose, and expected system contribution

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## Step 2: Consider whether and how to measure SA for this SUT, user group, and mission



## Step 3: ????

SA – Situational Awareness; SABARS – Situation Awareness Behaviorally Anchored Rating Scale; SUT – System Under Test

## **Step 3: Select specific measures and resource for your test event(s)**

- Considerations based on selected SA assessment measure
  - Performance & SAGAT-like measures: Resourcing for additional civilian or military data collectors
  - SABARS & Query-based measures:
    - Resourcing time and manpower for GDTA & SA measure development
    - Resourcing manpower for SME & O/C raters
- Considerations based on system
  - Updated version of an existing system – include comparative condition
  - New system replacing an old system (same function) – include comparative condition
  - Entirely new capability – this system is now the comparison condition!

## Takeaways

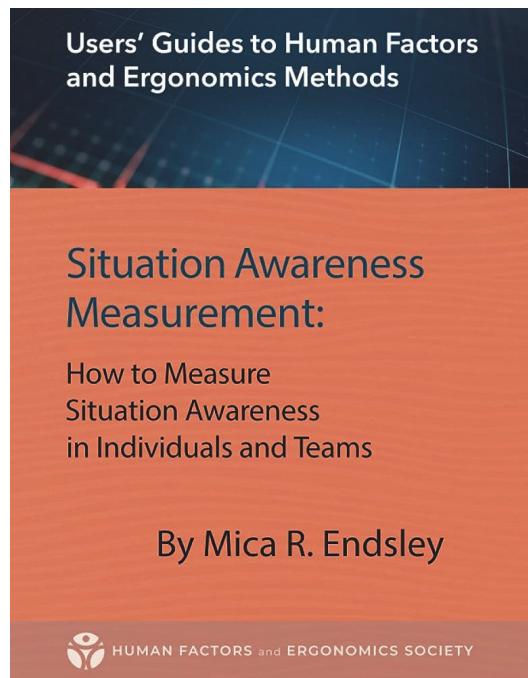
- Humans are not always aware of the state of their SA.
- There's no need to wait for the OT! Evaluations can benefit from SA measurement being included in early testing (CT, DT, IT).
- There is no “checklist” for a SA measurement. SA measurement method choice should be made considering:
  - Is the system designed to affect or enhance user SA?
  - The operational context: Who is the user? Are there multiple users? How do users employ the system? Are there multiple use cases (e.g., at different echelons)?
- SA can (and often should) be objectively measured to capture information about system contribution to mission accomplishment.
- Additional resourcing may need to be allotted for SA measurement.

# Any Questions?



- Clarifications on Substantive Material
- Comments or Concerns

# Select Recommended Resources



Informational resource about SA measurement (including military examples)



U.S. Army Research Institute  
for the Behavioral and Social Sciences

Research Report 1770

## Measures of Platoon Leader Situation Awareness in Virtual Decision-Making Exercises

Laura D. Strater and Mica R. Endsley  
SA Technologies

Robert J. Pleban  
U.S. Army Research Institute

Michael D. Matthews  
U.S. Military Academy

20010524 051

April 2001

Approved for public release; distribution is unlimited.



U.S. Army Research Institute  
for the Behavioral and Social Sciences

Research Report 1753

## Modeling and Measuring Situation Awareness in the Infantry Operational Environment

Mica R. Endsley  
SA Technologies

Leonard D. Holder and Bruce C. Leibrecht  
TRW Inc.

Daniel J. Garland  
SA Technologies

Richard L. Wampler  
TRW Inc.

Michael D. Matthews  
U.S. Army Research Institute

January 2000

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DATA QUALITY INSPECTED &

Army-specific research reports. Descriptive information on measure development & comparison of measures.

## Additional References & Resources

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**REPORT DOCUMENTATION PAGE**

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