Situation Awareness and Situation Assessment: How Are They Related?

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The goals of human factors practitioners and industrial psychologists in situation awareness milieu are to assess individuals, teams, and organizations to measure current performance and predict future performance. The value in assessing situation awareness (SA) is that it impacts performance. Endsley (1995a) stated "SA provides the primary basis for subsequent decision making and performance in complex, dynamic systems." The purpose of this paper is not to discuss or propose another means of describing or measuring SA but instead to propose the role of situation assessment (SAS) in identifying the nature of SA, product and/or process, regardless of the definition or explanation of SA. It appears the research efforts bypassed the fundamental building blocks and rationale for describing a concept and instead developed measuring instruments and explanations of a complex phenomenon. Simply stated, SA and SAS are related by SAS providing the mechanism-of-action for the measurement of SA.

Situation awareness (SA) is passive when thought of as only a product. It doesn't imply action, making decisions, or doing anything—it just means taking in information and being aware of the variables impinging on the situation. On the other hand, situation assessment (SAS) when thought of as a process implies actions and decision making. This perception very quickly leads into a discussion of whether situation awareness is process or product or both. One of the problems with the theoretical construct of situation awareness is that it appears intuitive and requires only common sense to understand its implications so it must really exist. The opposite problem is that SA is obscure and difficult to define and measure so that even scientist practitioners do not agree. Situation awareness is definitely accepted in the scientific community as a concept or construct but other than that there is little agreement about how one goes about measuring it. There is some agreement by the scientist practitioners, although not totally, that SA is dynamic and it is both a product and a process. SA is the process of developing awareness of a situation and the product of awareness that is developed. SA should be viewed in terms of the process involved in its development and in the end product of what it comprises (Salmon, Stanton, Walker and Jenkins, 2009).

Because of the differences in approaches to measuring SA, the focus of this paper is to advance the study of SA by identifying measures that would predict SA regardless of its definition. The most often applied methodology for measuring situation awareness (SA) is the Situation Awareness Global Assessment Technique (SAGAT) model proposed by Endsley (1995b). She (1995b, page 36) defined situation awareness as "the perception of 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." A basic definition of situation awareness is that it refers to up-to-the-minute cognizance necessary to operate or maintain a system. However, situation awareness must be created based upon information obtained from many sources in the environment in conjunction with the person's schemata. The information in the environment does not enter into the person's consciousness without effort and when it does, it is processed by the person's filter. The quality and accuracy of situation awareness depends upon the ability of the person to adequately assess and process all the available information.

The interest is not in determining whether the individual was aware of the situation but it is more important to know if the person performed an accurate assessment of the situation in order to take appropriate action. By focusing on situation assessment, then we are able to provide interventions to individuals and teams to build relevant schema. Then in unfamiliar situations, the individuals or teams do not have to depend solely upon working memory to respond but instead are able to assess schema. Using this line of reasoning, training could be presented with realistic situations that would be stored in long-term memory to be recalled when similar situations are encountered.

The statement that the loss of situation awareness (SA) is the leading cause of human error in military aviation mishaps cited by Flach (1995 p. 151) appears to be circular reasoning: How does one know that SA was lost? …because the human responded inappropriately. Why did the human respond inappropriately? …because SA was lost. Patrick and Morgan (2010) stated that because too little attention was given to Flack's warning, "Situation Awareness: Proceed with Caution," there is little consensus and different theoretical and methodological approaches have been used to study SA.

Another approach to defining situation awareness is not needed. Salmon, Stanton, Walker and Jenkins (2009) conducted a review to identify and understand the different SA measures presented in the literature. They concluded that the SA literature is quite disparate and that many models exist but they present the construct quite differently (p. 32). Salmon, et al. (2009) believed that the perceptual cycle model of Smith and Hancock (1995) offers a complete description of how SA is achieved and maintained. Salmon, et al. (2009) indicate that the perceptual model of Adams, Tenney, & Pew (1995) was worth further study for the same reasons as the Smith and Hancock model. The models include the notion of a continuous cycle SA acquisition and maintenance including both the process and the product. They believed that the perceptual cycle model comes closest to most accurately describing the construct but has not received sufficient attention.

Salmon, et al. (2009) presented results of their review in Table 3.2, pages 52-55, "Summary of SA measurement techniques review." They identified 18 approaches. Other than with Situation Awareness Global Assessment Technique (SAGAT) from Endsley (1995a) and Situation Awareness Rating Technique (SART), Salmon, et al, 2009, p 56 concluded there was very limited validation evidence associated with the SA measurement techniques . A review of the literature could easily locate hundreds of articles and scores of books discussing various aspects of situation awareness for individuals and teams. It is as if situation awareness were examined from another perspective that the "truth" could be discovered. Certainly, there is a situation awareness construct but the construct would be most useful if it were able to predict behavior and job performance. Tenney, Adams, Pew, Huggins, and Rogers (1992) state that situation awareness contributes to good performance but is not synonymous with it. Vaitkunas-Kalita, Landry, and Yoo (2011) states "SA clearly appears to be an independent phenomenon that influences behavior."

The statement by Sarter and Woods (1991), "Situation awareness is based on the integration of knowledge resulting from recurrent situation assessments" is the impetus for proposing a model that supports the belief that SAS can be used to predict SA across dynamic settings. SA depends upon the ability of individuals to constantly update their conscious and mental resources. This paper will propose SAS constructs that provide the necessary information to maintain a current SA.

SITUATION ASSESSMENT

A methodology for measuring the predictors (elements) involved in the development of situation awareness is needed. Situation awareness is a hypothetical construct that cannot be measured directly. Fracker (1988, page 103) states that "Defining situation awareness determines what is to be measured but

does not suggest how it should be measured. For this latter purpose, a model of situation assessment is needed."

However, the processes of situation assessment that are used to develop situation awareness can be measured directly. Situation assessment is viewed as a process that refers to the various perceptual and cognitive activities involved in constructing, updating, and revising the state of awareness (Adams, Tenney & Pew, 1995). Sarter and Woods (1991) state that situation awareness is based on the integration of knowledge resulting from recurrent situation assessments. Endsley (1995 b, page 36) recognized the importance of SAS in referring to SAS as "the process of achieving, acquiring, or maintaining SA." Therefore, SAS affects SA as an unitary concept, neither simply a process or product solely but as integrated concept. The focus of this paper is not to link SAS to either process or product of SA but to link SAS to the concept of SA. The application of SAS will be to measure and predict SA which is constantly being updated. SAS will be able to able to measure SA without active interventions.

Situation assessment implies that the individual has responsibility for processing and understanding the forces acting within the situation and the consequences of action. Situation assessment is trainable and occurs prior to an event. The advantage of a situation assessment approach is that it does not depend solely on native intelligence but is trainable by building schemata.

Given that there is no universally agreed upon definition of SA, the direction that will be proposed in this paper is to examine the role of situation assessment (SAS) variables that will generalize to most of the approaches defining and describing situation awareness. The emphasis will be on SAS variables that are observable, measureable, and testable. We propose to identify the variables of SAS that will predict SA. Also, we propose to identify measurement tools that would be used to identify the SAS variables that affect SA. We are applying the beliefs as stated by others that SAS variables are essential to the development of SA. As long as SA is considered as unobservable phenomena and not directly measureable, research will continue. SA can be thought of as the full employment act for human factors professionals.

The research for the identification of SAS variables will apply a construct validation approach. A construct validation is appropriate because the SAS variables are measureable. The validated SAS variables can predict SA both as a process and as a product. The approach taken to validate the situation assessment variables will be modeled after the Campbell and Fiske (1959) approach. The SAS variables will be validated with the multitrait-multimethod approach to identify the variables that are related to the prediction of SA. Instead of developing another tool that attempts to measure SA directly, the SAS approach will discover the underlying constructs that are predictive of SA regardless of the changes in the environment and constructs that are possessed by individuals.

Context-free Situation Assessment Elements

To successfully develop a means to measure SA, the model of situation assessment should be context free. A context-free model means that SAS is independent of the environment in which SA is operating; therefore, SA is also context free. If it were not, then SA is dependent upon the specific conditions and an individual's level of SA could not generalize across the setting. Because SA is viewed as dynamic; each new event would require reassessing SA. Proposed elements of situation assessment are listed in Table 1. The first step in developing measurement instruments is to develop operational definitions for the variables. The process of developing operational definition as stated by Kerlinger (1973, p 31) is to assign meaning to a construct or variable by specifying the activities or "operations" necessary to measure it. Further explanation is that it gives meaning to a variable by explaining the actions to be taken by the investigator to measure the variable.

Smith and Hancock (1995) defined SA as externally directed consciousness because it is not until the externally directed task is made explicit that the observed behavior achieves the status reserved for SA. (Hauland, page 290). This interpretation assists in supporting a methodology for applying the development of behaviors for the purpose of measuring SAS. To develop the behaviors for the elements listed in Table 1, the critical incident methodology will be applied (Flanagan, 1954). In applying the critical incident methodology, subject matter experts will identify behaviors that represent effective levels of performance for each of the elements. In order to ensure that the behavioral statements are at the same level of effectiveness (a common metric), the behavioral statements will be scaled using the methodology proposed by Smith and Kendall (1963). The behavioral rating system for measuring assessment will be a matter of combining the ratings for each the elements and then summing across the elements.

The approach proposed is designed to be suitable for both individual and team situation assessment. By approaching SAS from an element level of measurement, interventions could be designed to provide training in the areas of weakness. It is not a reasonable process to wait until an individual or team fails to exhibit appropriate situation awareness before designing a training program. By taking a behavioral indicator approach to SAS, the individual or team SA potential can be identified based on the assessments developed for each element. Situation assessment is composed of these elements. The higher the score on the situation assessment elements will predict better SA. The method of scoring is very similar to the SAGAT system which arrives at a score for one of the three levels by adding the score based on the probes.

The advantage of approaching the measurement of SA from the SAS perspective is that an individual's SA aptitude can be determined prior to allocating job-related training resources. Not all individuals are equally capable of performing dynamic work or maintaining SA so the better process would be to identify individuals who are more likely to be successful prior to placing them in jobs.

Table 1. Hypothesized situation assessment elements (behavioral and cognitive).

Abstract reasoning	Ability to draw meaning from events and behaviors that appear unrelated to current endeavor
Attention	Cognizant of the activities in the environment
Automaticity	Ability to use past knowledge and experience with minimum expenditure of mental energy
Dynamics	Ability to adjust to new and novel situations
Encoding skill	Ability to interpret the influence of activities on the outcome —the skill of assigning meaning to events appearing abstract
Five-factor model of personality traits	Conceptualizes personality in terms of five basic dimensions: • Extraversion • Agreeableness • Conscientiousness • Neuroticism • Openness to experience

Mapping	Ability to fit new patterns of behavior within previously developed schema
Metacognition	Awareness or analysis of one's own learning or thinking processes
Motivation	Demonstration of sufficient engagement to ensure success
Multitasking	Ability to attend to multiple and competing activities
Pattern recognition	Ability to identify similar or dissimilar patterns of behavior
Perception	Details of the events are recognized and processed
Prediction	Ability to recognize the short- and long-term effects of actions or inactions
Psychophysiological variables	• EEG • EKG • Eye blink
Spatial ability	Ability to view stimuli in multiple dimensions

The selection of the situation assessment variables was based on applied psychology and as suggested by human factors literature. The listed elements are not an exhaustive list and it is reasonable that during the proposed study, subject matter experts will add or remove elements. Essentially the study of situation awareness is to predict performance such as being able to safely pilot an airplane or pilot a ship when there are multiple stimuli, competing demands, and interruptions. Some of the elements were selected for the purpose of identifying those that are amenable to training. Some elements are similar to personality traits in that they are enduring and not subject to change. The advantage of using the behavioral indicators as a means of measuring the elements is that some elements are not observable and can be measured only when they are represented as behaviors.

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REFERENCES

Adams, M. J., Tenney, Y. J., & Pew, R. W. (1995). Situation awareness and the cognitive management of complex systems. *Human Factors, 37*, 85-104. doi: 10.1518/001872095779049462

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminat validation by the multitrait-multimethod matrix. *Psychological Bulletin, 56*, 81-105.

Endsley, M.R. (1995a). Measurement of situation awareness in dynamic situations. *Human Factors, 37*, 65-84. doi: 10.1518/001872095779049499

Endsley, M. R. (1995b). Toward a theory of situation awareness in dynamic systems. *Human Factors, 37*, 32-64. doi: 10.1518/00187209577904953

Flach, J. M. (1995). Situation awareness: Proceed with caution. *Human Factors, 37*, 149-157. doi: 10.1518/001872095779049480

Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin, 51*, 327-358.

Fracker, M. L. (1988). A theory of situation assessment: Implications for measuring situation awareness. In *Proceedings of the Human Factors and Ergonomics Society 32nd Annual Meeting* (pp. 102-106). Santa Monica, CA: Human Factors and Ergonomics Society. doi: 10.1177/154193128803200222

Hauland, G. (2008). Measuring individual and team situation awareness during planning tasks in the training of en route air traffic control. *International Journal of Aviation Psychology, 18*, 290-304. doi: 10.1080/10508410802073333.

Kerlinger, F. N. (1973). Foundations of behavioral research (2nd ed.). New York, NY: Holt, Rinehart, and Winston, Inc.

Patrick, J., & Morgan, P. L. (2010). Approaches to understanding, analysing and developing situation awareness. *Theoretical Issues in Ergonomics Science, 11*, 41-57. doi: 10.1080/14639220903009946

Salmon, P. M., Stanton, N. A., Walker, G. H., Jenkins, G. P. (2009). *Distributed situation awareness: Theory, measurement and application to teamwork*. Burlington, VT: Ashgate Publishing Company.

Sarter, N. B., & Woods, D. D. (1991). Situation awareness: A critical but ill-defined phenomenon. *International Journal of Aviation Psychology, 1*, 45-57. doi: 10.1207s15327108ijap01001_4

Smith, P. C., & Kendall, L. M. (1963). Retranslation of expectations: an approach to the construction of unambiguous anchors for rating scales. *Journal of Applied Psychology, 47*, 149-155.

Smith, K. & Hancock, P. A. (1995). Situation awareness is adaptive, externally directed consciousness. Human Factors, 37, 137-148. doi: 10.1518/001872095779049444.

Tenney, Y. J., Adams, M. J., Pew, R. W., Huggins, A. W. F., & Rogers, W. H. (1992). *A principled approach to the measurement of situation awareness in commercial aviation* (NASA Contractor Report 4451). Langley, VA: NASA.

Vaitkunas-Kalita, S., Landry, S. J., & Yoo, H. –S. (2011). Coincidence between the scientific and folk uses of the term "situation(al)" awareness in aviation incident reports. *Journal of Cognitive Engineering and Decision Making, 5*, 378-400. doi: 10.1177/1555343411424694