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# Cranfield - Situation Awareness Scale Users Manual

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## Introduction

Training to enhance situation awareness depends upon having satisfactory quantitative methods for measuring situation awareness. Until the development of the Cranfield-SAS, there was no direct subjective rating scale to measure the situation awareness of student (ab initio) civil pilots (see appendix 4 for an overview of the measurement guidelines for scale development). The development of the scale was part requirement for a Ph.D. at Cranfield University. The benefits of such a technique is that a pilot's progress in developing the skills necessary for situation awareness can be monitored. Instructors specifically can enhance the situation awareness of ab initio civil pilots in terms of:

- **Workload:** It has been proposed that situation awareness enables the pilot to know how to distribute his efforts. Since increased situation awareness should allow the pilot to accomplish the same goals at a lower level of effort, he or she could potentially maintain effective performance for a longer period of time, or conversely, maintain the same level of effort but accomplish more (i.e., with more spare capacity).
- **Decision making:** Situation awareness knowledge could significantly increase the frequency with which the pilot makes optimum decisions and decrease the time needed to reach these decisions. In addition, any decrease in workload resulting from increased situation awareness could also improve the chances of accurate decision making (Regal, Rogers and Boucek, 1988).
- **Design and Performance:** Design initiatives help pilots achieve situation awareness in complex environments by reducing demands on the pilots limited working memory and attentional capacities.
- **Training:** Traditional training programmes do not specifically address the issue of situation awareness. This rating scale could be used to promote changes in training and consequently enhance the situation awareness of students.

The "Cranfield-Situation Awareness Scale (SAS)" is based on pilot actions and knowledge that the aviation community considered important to maintaining situation awareness. In general situation awareness refers to pilots knowledge and understanding of the situation in relation to the requirements of the flight task. The "Cranfield -SAS" is a subjective assessment technique and was developed as either an observer-rating (i.e. by instructors) or as a self-rating (i.e. by student pilots) during different predefined flight tasks (see appendix 3 for overview of observer/self-ratings). It is intended that this technique should ultimately be used during flight, flight simulation, or in the debriefing session.

This users manual outlines how to use the Cranfield-SAS and has been distributed to instructors at flight schools (i.e. Great Britain and Canada) and to a major airline. The scale remains ownership of Cranfield University but may be photo-copied (or requests for additional copies) and used freely by both instructors and students (for self-evaluation). As the scale is still under evaluation, we would request that the registration form (presented on a green page in the last page of the manual) be returned to: Dr. C.D. Deighton at the Applied Psychology Unit, Cranfield University. A short questionnaire will then be sent to you to obtain your comments on the structure and content of the scale.

## **General description**

The Cranfield-SAS is a multi-dimensional rating procedure that provides an overall situation awareness score based on the addition of ratings on five subscales: Pilot Knowledge; Understanding and Anticipation of Future Events; Management of Stress, Effort and Commitment; Ability to Attend, Perceive, Assimilate and Assess Information and Overall Awareness. Each subscale is described below according to aspects designated in the Cranfield-SAS.

### **Pilot Knowledge**

This scale includes knowledge of flight procedures and goals, as well as that of aircraft systems (fuel and hydraulics) and aircraft performance. Also implicated is knowledge of the correct procedures for communicating with ATC and other members of the flight crew, along with that of safety standards and weather conditions. A further aspect is the evaluation of the situation in order to take appropriate action and application of course training to the flight situation.

### **Anticipation and Understanding of Future Events**

The second scale involves an understanding of the flight situation (i.e., mental picture) and the position of the aircraft, along with knowing what is happening at present and what might happen in the future. A further aspect is the accurate interpretation of these events.

### **Management of Stress, Effort and Commitment**

This scale entails coping with stress, along with managing workload and being motivated.

### **Capacity to Perceive, Attend, Assimilate and Assess Information**

The emphasis is on perception, which concerns the capacity to attend to information, to remember previous experiences, and 'perceive' the constraints of the flight task (i.e., time).

### **Overall Awareness**

This global scale entails "taking a look at the big picture" or being aware of every relevant aspect of the situation.

## **Implementation**

The Cranfield-SAS was designed for both in-flight/simulation and post-flight/simulation administration. Ratings may be obtained either during a task, after task segments, or following an entire task. Results from the usability study showed that the scales should be applicable to the following six stages of training:

- stage 1 general aircraft handling;
- stage 2 navigation;
- stage 3 instrument flying (basic);
- stage 4 instrument flying (airways);
- stage 5 night flying;
- stage 6 commercial pilot flight test.

The scale may be used by the instructor to evaluate a student (observer method). Alternatively the scale may be used by the student to evaluate their own standard of situation awareness. In both cases the content, structure and scoring procedure remains the same.

Two versions of the scale are provided: a long and short form. The long version of the scale is presented in appendix 1, while appendix 2 details the shortened version. The extended version may be used during the debriefing to provide diagnostic information about the students progress. To aid recall of the students performance, a shortened form has been developed for use in the operational environment (i.e. flight and simulation). Both versions of the scale require five ratings by the instructor.

## **Scoring of scale**

The requirement is to obtain numerical ratings for each subscale. The overall situation awareness score for each student is computed by adding all of the five sub-scales scores together, and entering the overall score into the total score box provided. A high score indicates a high level of situation awareness, while a low score indicates a lower level of situation awareness. On completion of the ratings, please provide any comments concerning the situation awareness of the student in the box provided.

Please consider your responses carefully and ensure that all of the scales have been completed. Thank you for your cooperation and participation in completing this technique.





**APPENDICES**



**Appendix 1 Long version of the Cranfield - SAS.****CRANFIELD - SITUATION AWARENESS SCALE (SAS)****INTRODUCTION**

The development of situation awareness is an essential part of the pilot's training and is recognised as crucial to safe flight. Situation awareness is a difficult concept to define precisely; however, the "Cranfield-SAS" is based on pilot actions and knowledge that the aviation community considered important to maintaining situation awareness. In general situation awareness refers to pilots knowledge and understanding of the situation in relation to the requirements of the flight task. A global approach (i.e., 'big picture' view) was taken to understand the underlying components of situation awareness. The "Cranfield -SAS" is a subjective assessment technique and was developed for instructors to use in evaluating the situation awareness of a student pilot during different predefined flight tasks. It is intended that this technique should ultimately be used during flight, flight simulation, or in the debriefing session with the student pilot. Furthermore, the assessment technique could be used to promote changes in training and consequently enhance students situation awareness.

**SCALE**

The technique contains five scales consisting of twenty two descriptions. Please read the instructions and carefully examine the descriptions accompanying each rating scale.

**PROCEDURE**

Fill in the personal details and flying experience of the student pilot undergoing examination. Following a specified flight task performed by the student pilot, you are asked to rate situation awareness according to twenty two descriptions. On a rating scale ranging from 1 (unacceptable) to 9 (excellent), insert the number that best reflects the pilot's situation awareness.

**PERSONAL DETAILS AND FLYING EXPERIENCE OF STUDENT PILOT**Date: Student: Instructor: Flight task details: Time: 

Current Flying Position of pilot: (for e.g., CPL, BCPL, ATPL course student)

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Flying Experience:

Total hours flown		Solo hours	
Hours flown within the last year		Dual hours	

## INSTRUCTIONS

During or after the flight, please rate the performance of the pilot on a scale from 1 (unacceptable) to 9 (excellent) according to the five scales. Insert the appropriate number in the rating box which accompanies each of the 22 descriptions. Please note that you can use any of the numbers ranging from 1 to 9. Please consider each scale individually.

1	2	3	4	5	6	7	8	9
Unaccept- -able		Poor		Acceptable		Good		Excellent

For Example

Q.1	How well does the pilot carry out the correct flight procedures?	7
-----	--	---

**Question:**      **Relating each description to the flight task, how well does the pilot:**

Scale 1: Pilot Knowledge		Insert rating here
		<b>Rating*</b>
Q. 1	carry out the correct flight procedures?	
Q.2	execute the goals of the flight task?	
Q.3	know the aircraft's systems, such as fuel and hydraulics?	
Q.4	know the aircraft's performance in regard to flight dynamics, weight, flaps, bank?	
Q.5	communicate and coordinate with Air Traffic Control and other members of the flight crew (if appropriate)?	
Q.6	apply course training, preparation work and preflight planning to carrying out the flight tasks?	
Q.7	avoid adverse risks, and comply to flight safety standards?	
Q.8	classify, evaluate the flight situation and take appropriate action?	
Q.9	know and is aware of weather issues, such as windshear, icing etc.?	

**Question:** Relating each description to the flight task, how well does the pilot:

**Scale 2: Understanding and Anticipation of Future Events**

Q.1	have an understanding of the flight situation which corresponds to the actual flight (i.e., mental picture)?	
Q.2	know and is aware of the position of the aircraft in relation to other aircraft, terrain, navigational aids, controlled airspace (i.e., spatial awareness)?	
Q.3	'think ahead of the aircraft' and anticipate what may happen?	
Q.4	accurately interpret incoming information?	
Q.5	know and is aware of the immediate situation as it is occurring (i.e., present state knowledge)?	

**Scale 3: Management of Stress, Effort and Commitment**

Q.1	cope with stress (i.e., is the pilot physically relaxed and mentally alert to the flight situation)?	
Q.2	manage his/her efforts and resources?	
Q.3	confidently and with commitment carry out the flight tasks?	

**Question:** Relating each description to the flight task, how well does the pilot:

**Scale 4: Ability to Attend, Perceive, Assimilate and Assess Information**

Q.1	remember and apply previous experience to the present situation?	<input type="checkbox"/>
Q.2	perceive information in the flight environment?	<input type="checkbox"/>
Q.3	assess the time constraints of the flight task, while noticing errors (i.e., estimated and actual time) that may develop?	<input type="checkbox"/>
Q.4	attend to information and divide his/her attention according to what the situation demands?	<input type="checkbox"/>

**Scale 5: Overall Awareness**

Q.1	how do you rate the pilot's overall awareness, taking into consideration all of the above descriptions?	<input type="checkbox"/>
-----	---	--------------------------

Total score = \_\_\_\_\_

**COMMENTS:**

## Appendix 2 Prototype for the shortened Cranfield-SAS.

### INSTRUCTIONS

During flight or simulation instruction, please rate the situation awareness of the pilot on a rating from 1 (unacceptable) to 9 (excellent) according to the five scales. Insert the appropriate number in the accompanying rating box. Please note that you can use any of the numbers ranging from 1 to 9. Please consider each scale individually.

1	2	3	4	5	6	7	8	9
Unaccept- -able		Poor		Acceptable		Good		Excellent

**Question:** Relating each description to the flight task, how well does the pilot:

TITLE	DESCRIPTIONS	RATING
KNOWLEDGE	have knowledge of goals, procedures, aircraft's systems and performance, cockpit resource management, course training, safe flying, decision making and weather issues.	
UNDERSTAND & ANTICIPATE FUTURE EVENTS	have an accurate understanding of their position, what is happening in the immediate situation, and anticipate what may happen in the future.	
MANAGEMENT	manage stress and effort, confidently and with commitment carry out the flight tasks.	
CAPACITY TO PERCEIVE, ATTEND, ASSIMILATE & ASSESS	Perceive, attend, integrate information with previous experiences and accurately assess the time constraints of the flight tasks?	
OVERALL AWARENESS	have an overall awareness of the situation, taking into consideration all of the above descriptions.	
<b>Comments:</b>		

Total score = \_\_\_\_\_





## **Appendix 3 overview of subjective/observer ratings.**

### **Subjective rating measures**

The Cranfield-SAS is a subjective measure of situation awareness. Subjective measures are extremely popular for various reasons: they are relatively inexpensive; nonintrusive; convenient; easy to analyze and have high face validity and user acceptance. In particular, subjective rating measures of situation awareness are by far the easiest to collect and so often have been favoured (Arbak, Schwartz, and Kuperman, 1987; Fracker and Davis, 1990; Selcon and Taylor, 1989; Venturino, Hamilton, and Dvorchak, 1989; Ward and Hassoun, 1990). The ease associated with obtaining subjective measures makes them very adaptable to operational environments, such as system design evaluation. Instrumentation requirements are minimal and the timing of data collection can be tailored to fit the particular operational situation. Operators and design engineers can readily accept that if pilots think that there is low situation awareness associated with the operation of a certain system, then design alternatives must be found.

Subjective measures are more direct than many of the other measures. Most importantly, they can be useful because involvement of underlying cognitive processes in the reported subjective experience provides a potential source of insight into their nature and structure. Subjective ratings take into account individual differences in ability, state and attitude. Differences that may be obscured in objective measures of performance. They are valuable because of, and not despite of their subjectivity.

Subjective situation awareness measures assume that individuals can judge and report accurately their feelings, thoughts and facts from experience. Ericsson and Simon (1980) both argue and show that participants are indeed capable of accurately reporting on their internal cognitive state. Further evidence comes from research conducted on workload (Gopher and Braune, 1984; Vidulich and Tsang, 1986; Vidulich and Wickens, 1984).

### **Observer-ratings**

Another type of subjective rating involves using independent, knowledgeable observers to rate the quality of a participant's situation awareness (i.e. instructors). For some data collection tasks, human observations may be robust and free from bias. An external observer's report can be interpreted as objective in contrast to the acknowledged subjectivity of self-report. It is common practice to use human expert ratings as objective data, but the subjective element is obvious.

Waag, Eddowes, Fuller, and Fuller (1975) reported a high degree of correlation between observer ratings and objective performance measures in standard flight manoeuvres. It was recommended that observer ratings be used as performance criteria in the development and validation of automated performance measures. Kelly et al. (1979) found correlations of 0.69 between the number of kills achieved by pilots in the simulator and their overall performance ratings by expert observers.

In Stiffler's (1987) study, situation awareness was measured in simulated combat by using experienced observers based upon flight employment of the briefed tactics and in-flight communications. Each pilot was asked to rate his own situation awareness during the mission debriefing. It was found that the correlation between the observers and the pilots was well above 0.9. Observer ratings have also been used extensively in assessing crew awareness (Stout, Carson, and Salas, 1991; Brannick, Prince, Prince and Salas, 1992).

The trained observer has more information than the pilot about what is happening, as a pilot might perceive that he/she is situationally aware when in fact not. Yet, the only information to which the observer has access concerning the pilot's perception of a situation is restricted to their actions and verbalizations. Nonetheless, knowledge of the relationship between situation awareness and the behaviour by which it is demonstrated can be a useful diagnostic tool in determining errors in situation awareness (stated misperceptions or lack of knowledge). As such, the use of outside observers to rate situation awareness may be very worthwhile.

## **Appendix 4 Scale measurement guidelines.**

### **Validity**

Validity of a scale refers to the ability of the scale to measure what it claims to measure. The validity of a situation awareness measure refers to the ability of the technique to quantitatively evaluate levels of situation awareness. As a minimum requirement, researchers have suggested that four types of validity should be considered: construct, content, predictive, and face validity.

The construct validity of a situation awareness assessment technique is the extent to which the technique measures the theoretical construct of situation awareness. As situation awareness is a hypothetical construct, it cannot be directly observed. Therefore, to achieve construct validity it must be shown that the measure reflects changes in what would be predicted for the construct of situation awareness. Construct validity of the Cranfield-SAS was established by conducting Principal Components Analysis, a statistical technique which identified the underlying components in a set of correlations. The name of each component was inferred by the researcher from the pattern shown by each component.

Content validity refers to the degree to which the items of a scale adequately sample the appropriate domain. Assessing content validity usually involves analysing the specific knowledge or behaviours relevant to situation awareness and rendering a judgment as to whether the sampled knowledge or behaviours are in fact representative. Content validity is specific to different mission domains. For example, a situation awareness metric having high content validity for a civil aviation mission will likely have low content validity for a strategic fast jet mission (Braby, 1989). The content validity of the Cranfield-SAS was assessed by eliciting expert ratings of the essential items that constituted situation awareness.

Predictive or criterion validity is an index of the degree to which the measure may be used in a predictive sense to determine levels of situation awareness. Predictive validity refers to the degree of correlation between the metric and some objective measure that could be used to evaluate the accuracy of a decision based upon the metric. For example, if the situation awareness metric is to be used to select one of several competing cockpit designs for a new aircraft, the criterion might be mission success. It is proposed that pilots with a high situation awareness rating will more than likely perform the designated flight tasks adequately.

Finally, face validity concerns the degree to which a scale appears to evaluators as relevant and acceptable. The face validity of a technique is important because if the evaluators consider the situation awareness technique as meaningless, then it is likely that motivation to use the technique will be low. Face validity of the Cranfield-SAS was investigated throughout two studies by eliciting pilot opinion regarding the usability and acceptability of the scale.

## **Reliability**

Reliability of a scale is often defined as the extent to which the scores on the scale are free from error. The reliability of a situation awareness measure is defined as the ability of the measure to yield similar results with repeated usage. Reliability is usually assessed by examining the consistency of scores given by a scale. Consistency measures of reliability fall into three kinds: test-retest, inter-rater and internal consistency. Test-retest methods require collecting the same measure from the same pilot under the same conditions at different times. Inter-rater reliability would measure the consistency of a situation awareness technique across different evaluators. The changes in the pattern of responses between individuals is taken as a measure of the stability of the technique. Internal consistency methods estimate reliability from the inter-correlations among all of the elements contributing to a measure. It is important to develop a test which is highly consistent; if one part of a test is measuring a variable, then other parts which are not consistent with that part cannot be measuring the same variable. The reliability of the Cranfield-SAS was conducted for each factor by employing Cronbach's coefficient alpha (Cronbach, 1951).

## **Sensitivity**

Sensitivity refers to the capability of a technique to discriminate significant variations in pilot situation awareness. Sensitivity is a function of scale construction. The Cranfield-SAS employs a Likert style 9 point rating scale. According to Taylor and Selcon (1991) "psychophysics indicates a limit on absolute identification by untrained subjects of between 5 and 9 stimuli, depending on the continuum" p.791. Therefore, the choice of a 9 point scale seems reasonable.

## **Diagnosticity**

Diagnosticity concerns the capability of a technique to discriminate causes of differences in situation awareness and to generate predictions. The level of diagnosticity required will depend on the goals of the situation awareness evaluation. For example, if the aim of the situation awareness evaluation is to determine whether a general situation awareness problem exists, then a technique with low diagnosticity may be implemented. Conversely, a technique with a high level of diagnosticity may be required for task design. The long version of the Cranfield-SAS may improve diagnostic power for a particular application and provide diagnostic information about components of situation awareness. Whereas the shorter version may be more applicable to the operational environment as it should minimize interference with the measured task.

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**REGISTRATION FORM**

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