

SITUATION AWARENESS ANOTHER NAKED EMPEROR



'On 11 April 2012, an aircraft commanded by a Training Captain who was also in charge of Air Operations for the airline was supervising a trainee Captain on a night passenger flight. The aircraft failed to establish on the Lyons ILS and, in IMC, descended sufficiently to activate both MSAW and EGPWS 'PULL UP' activations which prompted recovery. The investigation concluded that application of both normal and emergency procedures had been inadequate and had led to highly degraded situational awareness for both pilots'.

This is just one of many hundreds of incident investigation outcomes which attribute the failings to the crew, team or other unwitting individual. Like many factors which are associated with humans who lose or have degraded or incomplete situation awareness or SA, the reason is reasonably simple to diagnose, however without understanding why this has happened, those in aviation will never improve the appropriate mitigations. The problem lies in the term itself, since it is the product of more complex cognitive systems not merely a concept or in this and other incident and accident cases, a human construct.

First coming into popular use in the 1980's, when Mica Endsley and others discussed the phenomena, it was generally agreed that it was the information from immediate verbal and visual sources and to some extent knowledge from long-term memory that aligned to build situation awareness. This awareness then forms the basis on which correct decisions can be formulated and actions taken. Several definitions of this phenomena can be found and can be summarised as 'the extraction of information from the environment which is then integrated with operational knowledge and mental models, to create a mental picture of the situation which can be used to confirm and predict present and future events'. Defining situation awareness in this way indicates three levels of cognitive involvement regarding; firstly the perception of the situation, secondly, the comprehension of the situation and finally the projection of the present reality into the future.

However to be able to really understand what creates the structures and processes underlying this cognitive representation, one has to look to research within neurophysiological and neuropsychology. The research by Kosslyn (1980) and Farah (1985) concluded there were shared cognitive neurological structures for both the mental model accessed from long term memory and the mental picture

as created and accessed within short term memory. Later research also documented that the production of images and their consequent use to enhance situation awareness occurred in a multi-modular fashion; that is the production and use of these images from their mental model is sequentially organised. There is also robust evidence from Farah (1985), Marks (1986) and Isaac (1990) that this production occurs in at least three stages. Firstly the images are created or compiled in the right occipital lobe, secondly these images are verified from elements of long-term memory in the frontal occipital region, and in the third stage they are used in the planning of sequential tasks which are generated in the left temporo-parietal area. This research also demonstrated that as a mental image is created from the mental model the consequent cortical activity can be mapped using an enhanced electroencephalographic (EEG) techniques (Isaac, 1990).

From this past experimental evidence, a three level system for the use of imagery to enhance situation awareness is suggested:



- **Level 1 - the perception** of the situation
- **Level 2 - the comprehension** of the situation
- **Level 3 - projection** of the situation into the future

This approach is identified as an important functional concept in the aviation environment, particularly when considering the creation of a traffic scenario which is then predicted in time and space for further consideration. This research evidence also indicates that the use of the term situation awareness is wholly inadequate if we are to continue to attribute incidents to a loss or degraded SA. We need to appreciate the individual cognitive elements which make up this 'ability' before we can make any judgements concerning the failure of SA in individuals. But how do we evaluate these cognitive elements?

Early experimental protocols and some recent research have attempted to evaluate and assess an individual's SA. However whilst some attempt to capture the elements mentioned above, few really investigate the cognitive elements which are attributable to SA. Some of these are mentioned below and lastly a more comprehensive approach is explained which has successfully been used with operational controllers in New Zealand and EUROCONTROL (Brétigny).

Early situation awareness assessment techniques:

A number of measures of situation awareness have been developed over the last few years. Each has its advantages and disadvantages and can be summarised into three approaches:

1. Query techniques in which the subjects are asked directly about their perception of certain aspects of the situation.

2. Rating techniques in which either the subjects themselves or observers of the subjects are asked to rate SA along a number of dimensions, typically presented in a series of scales.

3. Performance based techniques in which the level of SA is inferred from the level of performance.

Assessing the three cognitive levels of SA:

The studies conducted in New Zealand and EUROCONTROL (Brétigny) considered the creating, verification and dynamic control of the 'mental picture' and the salience of the use of mental models in the production of the controllers' 'traffic picture' and, by implication, their situation awareness. It was also intended to take the developments in human information processing and detail which aspects of information processing were most relevant to the maintenance of the controller's picture.

The development of the measures for this research had elements of all the above examples and reflected the demands of short term memory which include:

- queries of relational information
- evaluation of individual ability in the use of their mental model and mental picture
- adaptation to the specificity of the ATC task

This first method was known as the Situation Awareness Strategy Questionnaire (SASQ). The Situation Awareness Strategy Questionnaire (SASQ) was developed to elicit and record the kinds of strategies used by air traffic controllers in their working environment. The particular section of the questionnaire used in this research concerned a 'screen failure' and the initial and subsequent actions and strategies taken by the controllers. The questionnaire also tried to establish the cognitive processes which were adopted by controllers and their use of visual, written or spoken recall of flight details together with their individual recovery strategies.

The second method used was known as the Situation Awareness Strategy Intervention (SASI) and included the following:

- queries of relational information
- queries in an operationally valid setting
- simulation which is not interrupted
- response time indicators
- adaptation to the characteristics of the task

The Situation Awareness Strategy Intervention (SASI) technique was developed after the results of the first experiments using the SASQ. This method consisted of scripts used in simulation which would elicit the search, retrieval and planning routines of the controllers. These intervention queries and activities were as follows:

evaluated the self reported ability to retain the mental model and traffic picture and the quality of the situation awareness during the failure of the system. This research was conducted with four independent groups over four consecutive years and found robust and repeatable results.

Intervention	Timing of Situation ⁵	Query/Action
1. Pseudo pilot ⁶	20 seconds after original instruction with 8 aircraft on frequency	TBR 366, say again heading?
2. Pseudo pilot	On first contact and in direct conflict with aircraft at FL 240	FLD 224, request climb to FL 240 due to weather?
3. Pseudo pilot	In response to an aircraft just identified requiring route clearance, the heading is made incorrectly (aircraft turns left)	CAC turn right heading 090 maintain flight level 330
4. Pseudo pilot	Introduces an unannounced flight at the far SE boarder of the sector	Aircraft label flashed for acceptance
5. Pseudo pilot	In response to a question from aircraft call sign PNK	PNK, request position of the next 'weigh points' to DELTA?
6. Observing subject matter expert	At a pre-defined moment and at the discretion of the expert	The expert covers a part of the radar screen and asks for any conflict or conflicting aircraft and if so their heading, altitude etc.

Table 1 - The SASI intervention queries and activities

The main advantage of these methods was that the researchers and subject matter experts could not only evaluate a controller's moment to moment awareness and their ability to continue controlling 'safely' with reduced system support, but also used valid queries relating to an operationally valid setting, but which did not interrupt the simulation activity. Finally the questionnaire

Human performance in this complex and integrated system is limited by two main factors, the functionality of the machinery and the functional capacity of the human. With the introduction of more automated systems in air traffic control and the flight-deck there will be a consequent effect on the operator's skills. Many of these changes will affect the skills and attributes which are inherent in the

1- All references to aircraft and positions was customised to the simulation chosen

2- Pseudo pilots are those personnel who work 'behind' the simulation as the pilots of the aircraft being controlled

creation and maintenance of SA, for instance:


- many of the spoken messages between controllers and between pilots and controllers will be replaced by transmitted data which will appear, if at all, automatically in visual form.
- a change in workload and work rate will have a consequent change in the creation of the operators 'picture'.
- the increasing introduction of systems which are more automated will change the creation of the mental model and its cognitive strength.

Situation awareness is sensitive to the demands of the short-term memory system. Research has shown that the iconic memory system (memories concerned with either pictorial or image representations) seems to be able to retain at least some information about visual images over a short period in the form or code similar to the original information. It also appears that the information is susceptible to disturbance by other visual stimulation (Isaac, 1990). This is a crucial factor when considering the visual information displayed and monitored by air traffic controllers and pilots in highly automated environments. In the context of these studies, the type of information, and the relatively short time periods normally associated with a dynamic air traffic control situation, suggest that immediate problems encountered

by a controller will be due to the limitations of short-term memory, rather than information retrieval from long-term memory (Isaac, 1990).

And finally:

'On 28 July 2010, the crew of an aircraft lost contact with the runway at Islamabad during a visual circling approach and continued in IMC outside the protected area and flew into terrain after repeatedly ignoring EGPWS Terrain Alerts and PULL UP Warnings. The investigation concluded that the Captain had pre-planned a non-standard circuit which had been continued into IMC and had then failed to maintain situational awareness, control the aircraft through correct FMU inputs or respond to multiple EGPWS Warnings. The inexperienced First Officer appeared unwilling to take control in the absence of corrective action by the Captain'.

It has been recognised that SA is an essential pre-requisite for the safe operation of any complex dynamic system but unless we assign the relevant cognitive 'failures' to the individuals caught up in incidents and accidents we will never clearly articulate what went wrong nor how we can mitigate future events. 



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