Situation Awareness: A continuing journey.

"Hell's damnation, Mister, are you deaf, dumb and blind? Look astern, man, look astern! The wind will come out of the south-west any minute now" (W. Jones, 1999, p. 218)

"Our crew were mostly real sailormen, who had learned the lessons of bitter experience. Yet all knew that our mishaps were due to the Mate's lack of intelligent anticipation of the change in the wind." (W. Jones, 1999, p. 220)

The above excerpt from W. Jones (1999) book "The Cape Horn Breed" gives an insight into the fact that even in the early 1900's there was a knowledge that Situation Awareness (SA) was needed to successfully carry out a task, it just hadn't been given a title yet.

In this article I hope to take us on a SA journey that will discuss this controversial subject and what it means for marine pilotage.

Situation Awareness in Maritime Pilotage

In maritime pilotage, SA refers to the pilot's ability to recognise and comprehend the state of the ship's systems, the state of the marine environment, the relative positions and behaviours of other vessels and hazards (Walker, Stanton et al., 2008) as well as predicting how these components will interact or change in the near future (Shebilske, Goettl et al., 2000) . It is essential for the marines pilot to "observe, integrate and remember" (Sarter & Woods, 1991, p. 47) and then use all of this information to correctly position the ship into the future.

In other words the marine pilot is continually scanning and taking in the information flow from all around him and using that to understand what is going on to enable him to place the ship in a safe space. The potential for conflicts in this information flow can be represented by reference to situations where the pilot in the course of managing the navigation, guidance, and control of the ship, is also simultaneously receiving information presented by the ship systems. The pilot then interprets that information to help in identifying the cause of the conflict and then chooses an appropriate response. (Adams, Tenney et al., 1995)

The real test of SA though, is when emergency situations arise and it is here that the currency of a marine pilot's SA in regards to his view of the state of the ship, its systems and environment are critical to his ability to make decisions, revise plans and manage the ship (Adams, Tenney, et al., 1995). It follows then that one of the "principal benefit of achieving SA is that the operator (marine pilot) is better prepared to deal with upcoming events" (Adams, Tenney, et al., 1995, p. 91) and is thus able to stay ahead of the game (M. Endsley, Farley, Jones, Midkiff, & Hansman, 1998). Situation Awareness is therefore critical in helping to achieve safe pilotage outcomes and the importance of SA cannot be understated.

A Brief History of Situation Awareness

As a concept SA was first identified in aviation circles during World War One when it was realised that one of the best ways to avoid being shot down was to become aware of the enemy before they became aware of you. Methods were then devised to accomplish this. (Stanton, Chambers et al., 2001)

The idea of SA was then put on the back burner until the late 1980's when "SA related research began to emerge within the aviation and air traffic control domains (M. R. Endsley, 1993) when it was realised that system design was outstripping human capacity to deal with some of the information flow from these designs. This in turn led to calls for development of better SA amongst the system users. "This trend reflects on one hand, the growing extent to which automation does more, and the human operator often does (acts) less in many complex systems but is still responsible for understanding the state of such systems in case things go wrong and human intervention is required." (Sheridan & Parasuraman, 2006; C. Wickens, 2008, p. 397)

Leading on from aviation the SA construct has been extended across to other areas such as the military, sport and automobiles. The maritime field has seen limited SA work done which is hard to fathom as ships lend themselves perfectly to the concept of SA. Modern ships bridges are becoming highly automated man-machine systems and the concept of SA is as needed in this operational setting as it is in any other complex system where there is a requirement to operate and control a complicated system in a dynamic environment (Motz, MacKinnon et al., 2008).

Schager (2008, p. 117) makes the point that “the SA concept is commonly used in the military, in aviation and in maritime accident reports. The concept seems however, not to be a part of most mariners’ standard vocabulary”.

Situation Awareness and Accidents

The maritime industry has a particular combination of demands such as “fatigue, stress, work pressure, communications, environmental factors …” (Hetherington, Flin et al., 2006, p. 402) which could be termed as potential error inducing hazards. Most of the world’s maritime authorities have found that human error is a dominant factor in a great number of maritime accidents (Grech, Horberry et al., 2002).

A number of these human errors can be described as being caused by SA problems and the application of SA is required in the safety critical areas where management of complex systems such as those existing in the maritime, aviation and automobile fields (Schager, 2008).

For all this, it is apparent that there is still little discussion on SA problems being a causal part of the accident. It is often inferred such as being caused by the pilot becoming disorientated in the fog (Australian Transport Safety Bureau, 1998, p. 17), or by the fact that the “communication on the bridge during the pilotage was minimal, did not encourage ‘challenge and response’ and also resulted in the bridge team not developing a ‘shared mental model” (Australian Transport Safety Bureau, 2007, p. 44) or there was inadequate monitoring causing “an inattentive ‘state of the bridge’ at a critical phase of the passage” (Australian Transport Safety Bureau, 2007, p. 44). The grounding of the Bunga Teratai Satu was caused when the Mate “allowed himself to become distracted … from the navigation of the ship” due to a telephone call

(Australian Transport Safety Bureau, 2001, p. 36) but there is no real acknowledgement that a loss of SA has occurred and at what level.

On occasions investigation reports do come out and state that a loss of SA was part of the reason for an accident as in the report on the investigation of the collision between Skagern and Samskip Courier in the Humber Estuary 7 June 2006 points out that one of the causes of the collision was the loss of situational awareness by one of the pilot's. This loss of SA was caused by his inability to change radio channel's in the dark (Marine Accident Investigation Branch, 2007, p. 61) and also the in report into the grounding of the Peacock in the Great Barrier Reef in 1995 where one of the conclusions was that the Pilot lost situational awareness due to the probability that he fell asleep (Australian Transport Safety Bureau, 1997, p. 31). These types of statements, however, are few and far between and as such make it necessary for the researcher to use their own judgement as to the causes of the loss of SA.

Part of the above problem is due to what Grech (2005, p. 62) points out is the overuse of the term the "loss of situation awareness was a leading cause of human error in accidents". This has led to circular reasoning (Flach, 1995) arguments which goes as follows: there was a loss of SA and an accident occurred, how do we know there was a loss of SA, because there was an accident. This in turn has led to a diminishing of the concept of SA.

The ATSB's view is that SA is a term that is sometimes understood by various groups (Human Factors people, trainers, operational member's) who can then use it in slightly different forms due to the breadth of meaning (expanding upward on the simple spatial awareness). The ATSB therefore have decided to be more specific and hence less sophisticated, particularly in using terminology that may put readers off when describing the factors in play in an incident (and also the investigation analysis). This avoids getting tangled over terms that may be difficult to understand.

Definitions of Situation Awareness

Situation Awareness is a complex field, which is not helped by the lack of a "universally accepted definition" (Stanton, Salmon et al., 2005, p. 213) and "it is important to realise that, much like other constructs (attention, workload, stress, risk, etc), SA has no absolute or correct definition" (ESSAI, 2000, p. 36). The Latin quote "Quot Homines, Tot Sententiae" which means there are as many opinions as there are people (Goettl, 1997) sums up nicely the discussion on the definition of SA as well as the measurement of and its status as a psychological construct.

Two of the most commonly used definition of SA are:

1. SA is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and their projection of their status into the near future. (M. Endsley, 1988b)

2. SA is "externally directed consciousness" with SA being "the invariant in the agent-environment system that generates the momentary knowledge and

> behaviour required to attain the goals specified by an arbiter of performance in the environment. (Smith & Hancock, 1995)

The definition given by Endsley (1988b) is geared around an information processing framework, whilst Smith and Hancock (1995) take a more holistic view and though the definitions may appear to be divergent in their views as to what actually constitutes SA "there is general agreement amongst the many definitions that SA refers to an individuals dynamic awareness of the external situation" (Salmon, Stanton et al., 2009, p. 8). The main point of difference lies in the reference to SA as either the process of gaining awareness, the product of awareness (Endsley) or as a combination of both (Smith and Hancock).

Models of Situation Awareness and the Theories that Lies Behind Them

The theories that lie behind SA are still subject to great debate and Stanton et al (2010, p. 29) point out that there is still much theorising on whether situation awareness "is a phenomenon best described by psychology, engineering or system ergonomics".

The psychology approach identifies SA as existing in the minds of the people in the system, the engineering approach puts SA out in the world linked by artefacts and objects that people use and the system approach has SA functioning in a distributed cognition way that uses the interaction of people and their artefacts in the world (Stanton, Salmon, et al., 2010).

The theories for SA discussed in this article are taken from the psychological perspective which are strongly bound up with the definitions that have given rise to the concept and thus like the definitions a universally accepted model is yet to be found (Stanton, Chambers, et al., 2001).

The various models can be broadly classified into:

1. Individual Processes: where the SA construct is considered from an individual's perspective,
2. Distributed Processes: where SA is considered from a systems perspective, the argument being that SA is distributed not only with the individual but also across aspects that make up the total system. (Stanton, Salmon, et al., 2005)

Again this article deals with SA models that deal with individual processes.

The main point of contention between the theoretical perspectives lies in whether SA refers to the processes employed in achieving and maintaining it or by the end product of SA, derived as a result of these processes.

Two of the main theoretical approaches each view SA in different ways. Endsley's (1995) Three Level model is based on an information processing approach that establishes a model composed of three levels of SA that describe SA as a product of the knowledge related outcomes of the three levels, separate from the processes used to achieve it (Woods & Sarter, 2010) whereas the Perceptual Cycle model proposed by Smith and Hancock (1995) presents SA as an active interaction between humans and their environment and they go onto suggest that it is the context of the interactions that defines SA both in terms of the cognitive processes used to engineer it and the continual updating of the product of SA (Stanton, Salmon, et al., 2005).

A Few Thoughts until Next Time

It is probably becoming apparent by now that what actually constitutes situation awareness remains for the time being an elusive concept. It has always been with us to help us survive in not only good times but bad as well and it has grown over the years to a concept that is now considered on three fronts, the psychological, the engineering and the systems approach, which all in their own way contribute to the argument about what is situation awareness. It is like the universe in a way, in that it is ever expanding and there will probably never be a finite end to the debate.

At the moment there is no distinct definition, model or measurement method that is available for use, there is much debate on what parts of cognitive activity are actually used in forming and maintaining SA. New methods such as Distributed Situation Awareness that views SA as system orientated instead of individually orientated (Salmon, Stanton, et al., 2009) continue to evolve and they again change the landscape and make the goalposts move further away. The process versus product debate also hinders the theoretical development of SA as the three-level model and activity approach "emphasise product (i.e. the resultant state of SA in the mind of the operator) whereas the perceptual cycle emphasises process (i.e. the acts of acquiring SA by the human operator)" (Stanton, Chambers, et al., 2001, p. 203).

The development of SA as a stand alone construct therefore, still has a long way to go and currently research to improve SA focuses on two main strategies, which are either designing system interfaces, which encourage better sampling of the environment, which in turn reduces the cognitive workload or the provision of training in SA at the individual and team levels. (Stanton, Chambers, et al., 2001) This is an ongoing process.

In regards to the use of the SA models, the maritime industry seems to have gravitated towards using Endsley's Three Level Model probably because it is easy to use and understand. One of the problems with these models is that they have been designed for individual processes and there has been some difficulty converting them for use in team and shared environments.

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