Beyond situational awareness: A skill set analysis for situational control

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Abstract

**Background**: Situational awareness has been conceptually defined as an awareness of past events to contextualise an understanding of what is happening at present and future implications. Lacking or inadequate situation awareness has been identified as one of the primary factors in accidents attributed to human error. While pilots intuitively understand the concept of situational awareness, very little attention has been paid to the actual skill sets which are necessary to develop and maintain this mental model. Furthermore, situational awareness does not guarantee freedom from undesired aircraft states. This is only achieved through situational control, which requires further skill sets which have not been previously identified in this paradigm.

**Methods**: An analysis of the cognitive and social skills required for developing and maintaining four dimensional schemas in a situational awareness context is conducted by reviewing the literature. Using this analysis the transition from mental schema to situational control is then examined from a further skill set perspective.

**Results**: Accurate situational awareness requires at least eight individual skills, which combined, make up a minimum skill set. Once situational awareness is achieved, further key skills are required for situational control. A model of situational control is established.

**Conclusions**: A comprehensive skill set of social and cognitive skills is required to develop awareness of the current situation and likely future developments. Further skills are then required to ensure control of the situation in order to maintain the desired flight path and state. Focused training in these specific skills in future could enhance aviation safety at a personal and team level.

**Background**

Considerable research (eg Endsley, 1999, 2006; Flin, O’Connor and Crichton, 2008; Hartman & Secrist, 1991; Harwood, Barnett, and Wickens, 1988; Regal, Rogers & Boucek, 1988; Sarter & Woods, 1991) has quantified situational awareness (SA) conceptually as a mental schema where past events and existing cues are used to comprehend what is happening in the environment at present and promoting a clear understanding of what is likely to happen therefore as a result. In the aviation environment Pilots and others are further required to maintain this mental model on a continuous basis, at both a personal level and at a team level, in a very complex, information rich and dynamic environment.

Breakdowns in SA have been cited regularly in aviation incident and accident reports as a principal causal factor and while most Pilots intuitively understand the term Situational Awareness, it appears that little consideration has been given in most aviation training curricula to actually training Pilots in how to develop, better manage and enhance their SA. While the overall construct of SA is conceptually understood quite widely, the individual groups of skills which comprise the overall skill set of situational awareness is at best poorly defined and largely unconsidered.

Furthermore, an understanding of what is happening and what may happen as a result in the future does not guarantee any future control over that situation. Rather, control of the situation both now and in the future is achieved, often by positive intervention, through further skill-sets which are superimposed on the SA skill-set. Further examination of these skill-sets and the establishing of a model for ‘situational control’ will be explored further.

**Methods**

An analysis of the research has shown that SA is largely a set of cognitive and social skills which, when maintained individually at an appropriately high level, allow an accurate mental model of past events, the existing situation, and what is likely to happen as a result of this unfolding situation. While team SA relies in the first place on accurate individual SA, it is
largely the result of effective communication, context, expectation and routines. While shared mental models are critical in maintaining group SA, any breakdown in individual SA through underperformance of one or more individual SA skills can in turn detract from overall team SA. Having individuals performing all of the skill-sets which contribute to overall SA to a high standard, is likely, given effective communication and knowledge levels, to allow a high level of group SA to develop and be maintained throughout.

Eight individual skills are identified which contribute to SA. These include communicating effectively; planning; learning and knowledge retrieval; temporal awareness; vigilance, workload assignment and management; reviewing and modifying and inquiry. These are further discussed:

Effective communication is a critical process in both single pilot and multi-crew environments for development of an individual’s SA and also for developing shared mental models with fellow crew members and/or other agents (Endsley & Garland, 2000). To be effective, the right words, tones, volume, pitch and body language must be used so that the receiver shares the same meaning as the sender.

Planning is a fundamental part of staying “ahead of the aircraft”. It is not just thinking ahead but actually thinking about specific flight path control (ie. where the aircraft should be in space and time. e.g. at what height, at what speed, in what configuration). Planning takes considerable cognitive effort at times and requires the potential inertia of complacency to be overcome.

While knowledge is not generally considered as a skill, per se, the acts of effective storage of information (learning) and recall of that information at the right time are skills (Anders Ericsson, Chase & Falloon, 1980). Techniques such as effective coding and chunking of new information can enhance both learning and effective recall.

Temporal awareness is simply having a good awareness of time passage (Grosjean & Terrier, 1999), including quantifying how long it takes to do things, how much time is available, and closely monitoring current progress against a mental timeline. Anecdotally, it would appear that some individuals are naturally temporally aware, whereas others need to actually recognise that this is a specific skill which can be improved.

Vigilance is a skill associated with a certain required discipline in its application. In automated aircraft in particular, there is evidence that vigilance or the discipline to maintain vigilance is often ineffectively applied (Warm, Dember & Hancock, 1996). Continually scanning instruments and systems effectively has largely become superseded by automated alerting systems which will produce messages or warnings when something requires further attention. This brings about a form of “passive – monitoring” which provides little foresight of unfolding developments, and useful trend-type information which may provide clues to unfolding and progressive changes in the situation. Regular scans and self-discipline are critical skills in this process.

Workload Assignment and Management is a multi-faceted skill. Workload management involves an implicit understanding of what tasks are required and when they are needed during normal operations. This way, peaks of high workload can be smoothed out by doing some things in advance or assigning specific tasks to other people (including those on the ground). High workload is a principal reason for errors such as slips, lapses and omissions occurring, so careful delegation is an important enabling skill. Well constructed Standard Operating Procedures (SOP’s) should contribute to this process; however, in the dynamic world of aviation there are times when SOP’s may be cumbersome, particularly during non-normal or unexpected events. This often brings about the omission of, or deviance from, SOPs in an attempt to “optimise” during high workload or high stress situations. Management of workload under stress is a critical skill that requires a clear understanding of and continual reassessment of priorities. Possibly in the process of “load shedding” under stress, incident and accident data clearly shows that flight-path control is often neglected under these circumstances.

Review/Modify is the skill of continually monitoring progress and adjusting plans to suit ever-changing circumstances. It is a continual process of checking and updating actual and projected flightpath in “four dimensional” space and adapting the plan as necessary during the dynamics of flight.
Inquiry is the skill of “healthy suspicion”, i.e. not automatically accepting critical information at face value. It involves appropriate questioning at an individual level as to whether things are going to plan, whether the aircraft is where it should be, whether all of the information needed is available and correct, and in questioning others until ambiguous situations are resolved (CAA, 2006). Appropriate communication skills are essential for effective inquiry in order to maintain a healthy team climate.

All of these discreet skill sets working in concert are necessary for an individual to become and remain situationally aware. Once situationally aware then, threats and errors are better able to be managed in order that they do not become consequential and develop into an undesired aircraft state. Aircraft systems can be better managed in an appropriate and timely manner and all decisions are appropriately considerate of safety.

**Results**

If a pilot is situationally aware, there is a much stronger chance that impending threats and internal human errors will be avoided, caught, mitigated or managed. undesired aircraft states often come about through poor management of these challenges and complexities and can, in some cases, result in catastrophe. Situational awareness further allows more effective naturalistic and analytical decisions. An astute mental model of the existing and developing situation allows accurate problem definition, effective option generation, appropriate risk assessment, and effective selection of the best decision choices. Additionally, SA allows appropriate management of the aircraft systems in both normal and non-normal situations in a manner which enhances safety and efficiency.

These three additional skill-sets, effective threat and error management, making decisions considerate of risk and managing the aircraft’s systems, engender an additional level beyond SA. It allows the situational to be controlled and it is this situational control which is the key to maintaining optimal and safe flight path management. A model of situational control is illustrated below to demonstrate the inter-relationship of these skill-sets and flight path management.

**Conclusions**

While conceptually pilots are generally familiar with the notion of situational awareness, SA does not in itself guarantee effective flight path management. SA is comprised of a set of skills, which individually and collectively contribute to or detract from SA and may or may not exist equally at an individual and team level.
Accurate and effective flight path management requires not only SA but effective management of other skill-sets also. By being situationally aware pilots can then manage effectively the threats and errors which abound, make well informed decisions that are considerate of risk, and can manage the aircraft’s systems in both normal and non-normal modes very effectively. These constitute the elements which then allow pilots to exercise situational control and in turn actively manage the flight path in a safe, efficient and appropriate manner.

A model for situational control has been developed which demonstrates the inter-relationship and criticality of these individual skill-sets as a pre-cursor to effective flight path management and further attention in training organisations to skill-set development will enhance future situational awareness, situational control and in turn, flight path management.

References


