11th ICCRTS

COALITION COMMAND AND CONTROL IN THE NETWORKED ERA

Cover sheet for paper I-071

Awareness – does the acronym "SA" still have practical value?

Cognitive Domain Issues, C2 Analysis, Network-Centric Metrics

Geoffrey Hone*, Lynne Martin[#], Robert Ayres*
Geoffrey N Hone (POC)
Department of Information Systems,
*Cranfield University at the Defence Academy of the United Kingdom
[#]SJSUF at NASA Ames Research Center, California

Cranfield University, Shrivenham, Swindon SN6 8LA, UK

+44 (0) 1793 785687

g.n.hone@cranfield.ac.uk (POC)
(lmartin@mail.arc.nasa.gov; r.ayres@cranfield.ac.uk)

Awareness – does the acronym "SA" still have any value?

Geoffrey Hone (POC)
Dept of Information Systems
Cranfield University at the Defence Academy of the UK
g.n.hone@cranfield.ac.uk

Lynne Martin
SJSUF at
NASA Ames Research Center
California
lmartin@mail.arc.nasa.gov

Robert Ayres
Dept of Information Systems
Cranfield University at the Defence Academy of the UK
r.ayres@cranfield.ac.uk

Abstract

This paper argues that the use of the acronym SA to refer to both Situational and Situation Awareness, has blurred any distinction between the terms, and devalued the acronym for any application to awareness. The terms "Situational Awareness" and "Situation Awareness" refer to similar (and indeed related) constructs, but, from its application to sport in the 1970s, SA as "Situational Awareness" has always had an implicit immediacy that is absent from SA as "Situation Awareness". The term SA is now irrevocably linked to the work of Endsley, (and her definition remains probably the most useful) yet there has been dissatisfaction with the Endsley model for over a decade. It is argued that, with a model of awareness that offers the potential for discrimination without confusion (the 3-Questions or 3-Q model – derived from the Endsley definition, but not from her model), a better appreciation of awareness in military and civilian environments will be obtained, and the confusion over SA removed. Further to an exposition of this model, approaches to the assessment of awareness will be discussed.

Introduction

It has previously been argued that the acronym SA has been misused in such a way as to eliminate its value (Hone, 2003; Hone, Macleod and Smith, 2005). This has generated confusion between the term SA (referring to Situational Awareness) used in the sport psychology of the 1970s, and the term SA (referring to Situation Awareness) as modelled by Mica Endsley from the late 1980s onward (e.g., Endsley, 1988a). The tiny difference between Situational and Situation is critical. Each usage of SA relates to a person's awareness of their environment, and potential changes to it. The original sport psychology usage was by practitioners (initially coaches, and then the early sport psychologists) who all knew exactly what SA meant. SA was always related to the "here and now" in an environment that could change in a single second. Theoretical work in this area was focused on stimulus-response theory (Dickenson, 1976), perceptual cues (e.g. Abernethy and Russell, 1984), and attentional style (Chandler, 1986, based on Niedeffer, 1976). As used by Endsley, SA involves slower processes, in sequence (Endsley's Level 1, Level 2, Level 3), and removes the immediacy. In terms of modern, fluid, manoeverist combat, particularly at squad and platoon level, this latter approach seems less than appropriate.

Mavor, Kidd and Prince (1995) argued that the Endsley concept of SA needed revision, suggesting subdivision into Local and Global variants of awareness, the latter further removing immediacy. There have been several other approaches to SA (some merely being minor adjustments to the Endsley model): a discussion of some of these can be found in Kirlik and Strauss (2003) / Strauss and Kirlik (2003). The Three Questions (3-Q) model proposed by Hone (2003), using a restatement of Endsley's definition of SA, retained the now ambiguous acronym, but was more in line with the original sport psychology usage. Modifications to this model are discussed later.

This paper will first consider the Endsley model, both in terms of its contribution to awareness theory, and its inherent problems. It will then discuss an alternative approach (the 3-Q model) that is intended both to obviate some of the contradictions present in the Endsley approach, and to accommodate the original sport psychology concept of Situational Awareness. Finally, it will question whether awareness can be measured or – as a potentially viable alternative – assessed.

The Endsley Model

Whilst the Endsley model, and its related methodology (the Situation Awareness Global Assessment Technique, or SAGAT; Endsley, 1988b), have both been questioned (e.g. Feary, 1997; Miller and Shattuck, 2005), her 1988 definition of SA remains the most appropriate, and indeed the most valuable for military Awareness research purposes and for many civilian applications.

> ***Situation Awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their state in the future.***
>
> ***Endsley, 1988***

Some commentators have reduced this definition to the three words "Perception, Comprehension, Projection" but this does seem to retain the problems inherent in the original Endsley model. The first of these problems is that the definition is cast in such a way that it is not obvious how the definition may be operationalised. This does not prevent any reasoning about the topic, but makes it difficult to test that reasoning, and must render any formal measurement impossible.

Next, in her model, Endsley proposed three levels of awareness, corresponding to the three phrases in her definition. The problem here is that a critical assessment of Endsley's three "levels" will show that they are more properly components of that state that can be termed awareness.

The first phrase in Endsley's definition:

"*…a persons's perception of elements in the environment within a volume of time and space …*"

requires **BOTH** that one (or more) perceptual processes have taken place, **AND** that one (or more) cognitive processes have taken place. The cognitive process(es) must – in either a military or civilian environment – include an element of comprehension. If this requirement is

not fulfilled, Endsley's "Level 1 SA" would only amount to the unprocessed total of all perceptual input, and that in turn carries the assumption that perceptual input is discrete.

Comprehension – as the appreciation, or evaluation, of some or all of the perceptual input – is referred to as "Level 2 SA", but must surely have started immediately after the perceptual input commenced for there to have been cognitive awareness, and understanding of the situation. In the real world, perceptual inputs are both discrete and continuous, and those inputs are processed in a continuous manner. The presumed state that has been termed "Level 1 SA" cannot therefore exist in isolation, and is only a viable construct if considered as part of an ongoing process.

The parts of Endsley's definition cannot, therefore, be simply considered as separate levels. Level 2 can only be an extension of Level 1 (the continued processing of a data stream), while Level 3 is really a matter of intermittent or continuous product from a perceptual-cognitive process, then being further processed by "What-If" reasoning (itself a cognitive process). Thus, Levels 1 and 2 cannot really be distinguished, but Level 3 may perhaps be separated from them – depending on the need for further action. This may reflect differences between psychology teaching in Europe (Perception as part of Cognition) and the USA (Perception and Sensation as a stand-alone topic - separate from Cognition), but remains a serious theoretical flaw.

The reduction of Endsley's definition proposed by Hone (Hone, 2003; Hone *et al*, 2005) as part of the 3-Q Model, becomes:

WHO IS WHERE?
(reduced from "…*a persons's perception of elements in the environment within a volume of time and space* …")
WHAT ARE THEY DOING?
(reduced from "… *the comprehension of their meaning* …")
WHAT WILL THEY DO?
(reduced from "*...the projection of their status in the near future*")

These 3 questions now provide a base that can be related to (*inter alia*) virtually all combat activity, to such civilian tasks as air traffic control and pilot skills (air or maritime), and to many sports. In this reduction it is assumed that the "Who" in "WHO IS WHERE?" also includes inanimate objects and environment features – such as could be encompassed by "WHAT" – but the "What" is deliberately omitted to avoid confusion with the second question. It must be noted here that the 3 Questions relate to a single individual viewpoint – as was implicit in the original Endsley definition. It will be seen, in the next section, that such a reduction to 3 questions does potentially permit those questions – and hence the 3-Q Model - to be more readily operationalised.

The 3-Q Model

This model starts by assuming that Awareness is a variable state, but that the state can only be attained by satisfactory (either partly or wholly) answers to the three questions. In this model, the three questions (and indeed the phrases from Endsley's definition from which they were derived) are considered to be components of awareness. Thus, it can be considered as a 3-Stage model, where each stage requires some data (as answers to each of the three questions),

but where the answers may come from pools of data subject to different forms of processing; and where the data can be considered as comprising both discrete items and a continuous flow. It could also be considered as a 3-Component model.

The 3-Q model was originally represented by overlapping circles (resembling a Venn diagram). As shown below (Figure 1), it refers to "SA", capturing the essence of Situational Awareness as in its original usage by Sport Psychologists. Here data input, processing, and reasoning all overlap, and the fusion of answers to all three questions leads to the percept termed SA, irrespective of the completeness of any (or all) of the answers.

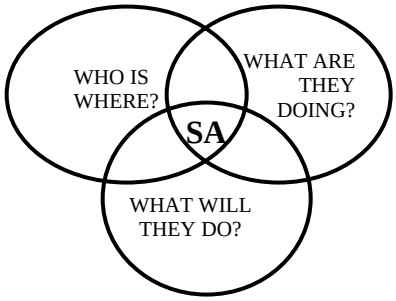

Figure 1: Basic 3-Q SA Model

This model can be applied to ground combat events at Squad, Section or Platoon level, to most forms of football, to basketball, to motor racing, to air traffic control and airfield ground movement, and to much of disaster management; in short to any activity where the situation is in constant flux, and where all data, evaluations and assessments (answers to the Three Questions) are of a transitory nature. It has since been considered that to avoid any further confusion over the meaning of SA, the product of the merged (or fused) answers should really be termed Transitory Awareness (TA).

The original 3-Q model differentiates between such factors as time availability (which Strater and Endsley (2005) regard as a task factor, but which must be considered as a critical determinant of awareness demands), span of command (rather than the commander's rank), and the geographical area of interest. This is achieved by separating the circles of the (pseudo-Venn) diagram by an increasing amount. The arrows linking each circle indicate that there is now a slower process – which could be related to several theories of human memory and information processing; and this in turn allows that the percept of "awareness" would similarly increase or expand to encompass both local and thence global events. This produced a 3-Stage model of Awareness with the stages (perhaps better described as types) of Transitory Awareness (TA), Local Awareness (LA), and Global Awareness (GA) as in Figure 2 below. The term "Types" will be used here from now on.

If each type of awareness (TA, LA, GA) is regarded as a model, then this approach is also compatible with the Battlefield Situation Assessment Framework of Cohen, Adelman, Tolcott, Bresnick and Marvin (1993), and hence with the Freeman and Cohen (1995)

approach to the training of cognitive skills with regard to Battlefield Situation Assessment. In particular, LA and GA are highly relevant to the Freeman and Cohen (1995) approach, which also emphasises the importance of available time.

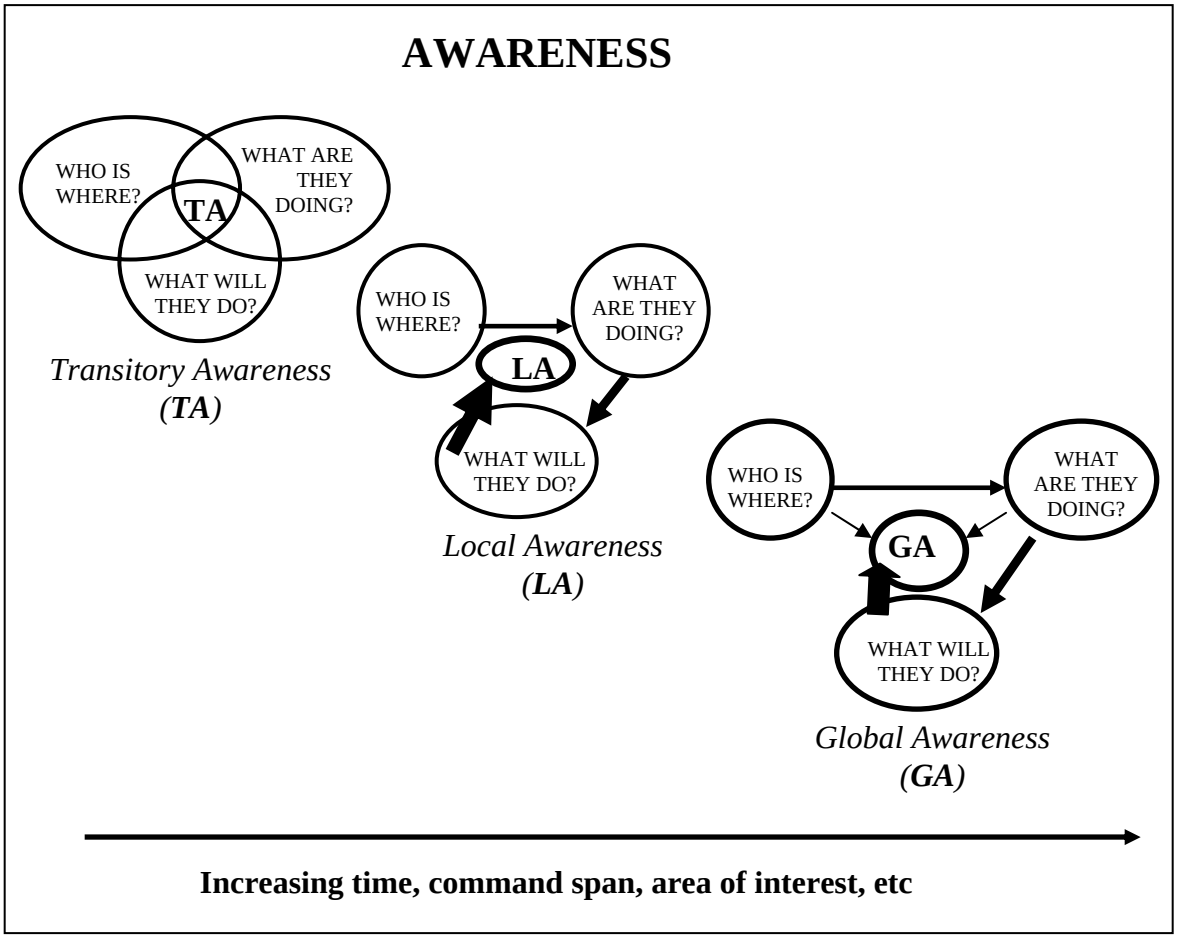

Figure 2: Three types of awareness

Thus, the Transitory (or TA) type maps on to the old SA of Sport Psychology, while the Local (LA) and Global (GA) types reflect the proposals of Mavor *et al* (1995). Local Awareness, as such, bears a close relationship to the Endsley model. No attempt has been made to quantify the difference between three types; rather, the true situational factors (whether of combat, or other activity) will indicate the relevant type or types. Indeed, it is proposed that with this model, an individual could possess awareness of any type (or indeed of all types at once), and it is here that there is the greatest divergence from the Endsley model. As example: a weapon squad leader in a fire-fight may have good TA, low LA, and minimal GA, while his Platoon Commander could be physically only a few feet away with TA, LA, and GA all rated as good. Each will be concerned with the "Who" of Question 1, but also with the "what" in the sense that an enemy tank will be regarded as an entity, and the crew inside will be part of that entity. The LA of Carrier Flight Deck personnel will be directly related to safety in terms of

obstructions, while that of the approaching pilot will be related to weather, and ship and aircraft movement – but ship and aircraft movement will form part of TA (for all parties) as well. For each, Question 1 relates to both animate and inanimate objects (including the potentially moveable). Similarly, the driver and navigator in a competition rally crew, or an airfield approach controller and the pilot of an aircraft on final approach will have a common interest, and will both be concerned with the same high-level task, but will be attending to different data inputs and will have different degrees of TA, LA and GA. A similar approach to awareness has been proposed by Andre, Foyle and Hooey (2005), in relation to the ground movement of aircraft. While the three stages (or types of awareness) proposed by Andre, *et al*, are given different names (Local Guidance, Route Awareness, and Global Awareness) as is appropriate to their specific application, there is a substantial agreement between this approach and the 3-Q Model. In essence, there is no single point that is TA (or LA, or GA), but each type represents a continuum, and any of the three continua may overlap to some degree (as shown in Figure 3).

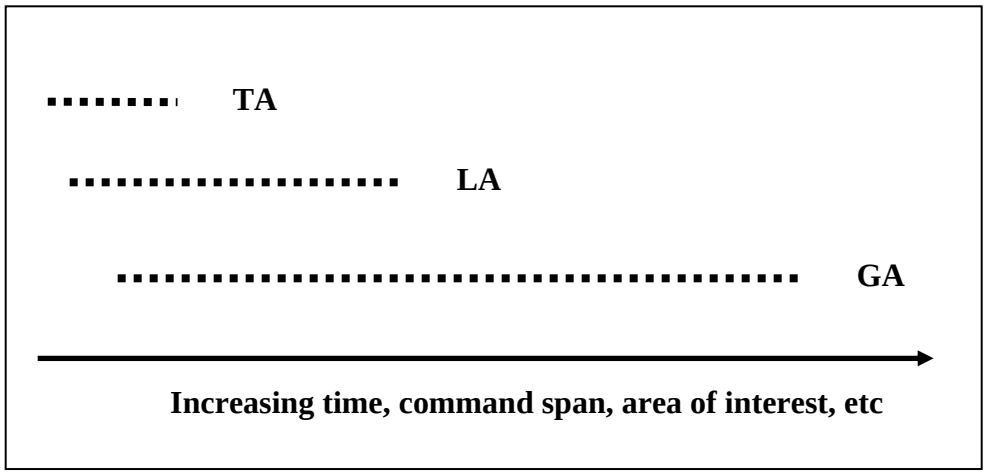

Figure 3: Potential overlap of the three Awareness Types

This approach was used by Hone, Macleod and Smith (1995), to provide one axis (3 levels) of a 3-D matrix for assessing scenarios as fit for purpose. The two other axes were the type of conflict (4 levels) and the level of command (3 levels). Giving 36 cells to the matrix, this was held to give adequate discrimination, without needing excessive detail.

Measurement or Assessment

One key question must be that of whether awareness – in any form – can be measured, or whether it can only be assessed. Here one should note Endsley's own comment that when subjective measures of SA are assessed, the tendency is for them to measure the participants' confidence in their situation awareness rather than their actual situation awareness (Endsley, 1994). Jeannot, Kelly and Thompson (2003) criticised SAGAT heavily, and proposed their own instrument (SASHA), the last question in SASHA indicates that they were also aware of this problem, and sought to deal with it by a separate question. Of equal importance must be whether intervention in a task, in any way, will affect participant performance. Finally, one must consider both the task itself and the type of awareness under study.

- Task and type of awareness

Awareness, at each of the three levels discussed earlier must consist of a fusion of data. Some of the data will be used at more than one level, and those data may be of different relevance for different types of awareness. Some years ago, it was convention to refer to "strong" or "weak" fusion of (visual) depth information. However, information that was highly relevant in a static scene, could be reduced in import when some elements in the scene were moving (Smith and Davies, 1989; Hone, 1994). If this is related to Transitory and Local Awareness, it can be argued that data that are of immediate importance in transitory awareness may lose their importance as a contributor to local awareness. Having said this, the rate at which the environment changes will affect any variation in importance – a principle covered in the ecological approach to perspective (Gibson, 1966). A pilot in a ground attack role will expect to experience a far greater change to his TA than a commercial pilot nearing the end of her landing approach, while the LA situation may be somewhat similar for each pilot. For commercial pilots, flying as part of a 2-person crew, each pilot will have a different LA, even though many features of that LA will probably be identical in nature: the Pilot-in-Command will (for example) have inputs from the controls which are not available to the co-pilot. Any measure of awareness must be sensitive to the rate of change of cues in the environment and the key items of information.

As awareness progresses from Transitory to Local and Global, any rate of change will be slowed and accordingly an interruption may not be so critical. The approach of Miller and Shattuck (2005) of temporarily blanking a simulator display, and asking the individual to draw a quick sketch of the relevant features of that display – which can subsequently be compared with a screenshot taken at the moment of blanking – has the great merit of actually collecting data on one specific individual's view of events. In a naval scenario, it identified which surface vessels formed part of the individual's awareness, and hence what proportion of the total display was included in that awareness. Consideration of the time factor suggests that this approach is best concerned with LA, although it could also be argued that TA at sea will cover a greater time span and geographical area when compared to the TA of an individual engaged in activities as diverse as ground combat, or motor racing, or shipping movements in a busy civilian port. The Miller and Shattuck method can be applied both at random intervals, and on the occurrence of critical events, and this must go a long way to overcoming those objections raised by Feary, McCrobie, Alkin, Sherry, Polson, Palmer, and McQuinn (1998) which led to them modifying the SAGAT approach.

- Interruptability

Since awareness is an ongoing melding of dynamic information, it is considered that any attempt to interfere with the essential task (an interruption) in order to obtain some measure of "awareness" has the potential to be unsuccessful, particularly with regard to Transitory Awareness, and this can best be demonstrated in a relevant simulator.

The general objections to SAGAT (Endsley, 1988b) already mentioned, essentially represent two views:

a) any interruption of the task will itself alter the feature being measured
b) randomising the data collection points may miss the critical data, while collecting data at critical moments in the task has the potential to render the data collection invalid.

These points would suggest that research techniques that randomly interrupt the participant are more useful for investigating local or global awareness, where time criticality is not at a second-by-second level. From this, the possibility must be considered that the difficulties in measuring SA have arisen from the use of the (Endsley) SA construct; which, since it cannot be operationalised, is not readily amenable to measurement.

One obvious alternative, to any interruption of the task, must be the observer assessment of the awareness of the individual performing that task. Here, awareness has to be inferred through relating actions to the cognition behind them, and therefore back to the awareness that would prompt such actions. Theorising that communication between cockpit crew could be a measure of SA, Orasanu (1995a,) found that higher performing crews made more SA related communications than crews with a lower performance. She argued that the exhibited knowledge of the aircraft and crew status was an indication of the individual's SA and a contributor to team SA. On this basis, an instrument that focuses on flight crew behaviour, while they are performing the tasks required during a given flight, should capture any observable indications of SA (e.g., verbal communications, nonverbal communications, and task-critical behaviours). It should be noted that, in this section, SA refers to the Endsley view of awareness – it would be interesting to separate the communications of cockpit crew into TA-related and GA-related comments, and perform the same assessment.

By focusing on how a team operates in its natural environment, it may well be possible to use communication as one measure of awareness. Assuming that both actions and utterances by flight crews are performed with the overall goal or mission in mind, it can be inferred that some observable behaviours may reflect the level of awareness of a crew member (Orasanu, 1995b). In further support of the notion that observable behaviours may reflect the level of SA of a (flight crew) crew member, Villeda (2001) showed that expert observers can assess the awareness of an individual (in simulated flight) when an appropriate checklist/questionnaire has been designed.

In the early 1990s, several researchers worked on the premise that SA was made up of cognitive components, and that it was possible to measure SA by analyzing the resulting cognitive behaviours (e.g., Orasanu, 1990; Stout, Carson, & Salas, 1991; Fowlkes, Lane, Salas, Franz, and Oser, 1994). Behavioural analysis of crews has the merit of being non-intrusive, specific actions or verbalizations being used as criteria for performance. The problem with this is that it is impossible to know what an individual is thinking during the task, or to know what the person using a weapon system is seeing through the sighting sub-system. As a specific military example, tank gunners and their commanders are taught to consider the next target while engaging the current one – and this must surely require a measure of TA (and also - simultaneously - of LA).

Another approach would be to build a simulation in which the individual is exposed to events or entities that should lead to a reaction. The strength of that reaction may be a measure of awareness. This was discussed by Sutton and Edelman (2005) in relation to a simulation developed from a computer game – particularly relevant to Transitory Awareness – but could also be applied to (say) simulations under ModSAF or JANUS software, as a way of measuring Local or Global Awareness. A similar view was offered by Pritchett, Hansman and Johnson (1996), proposing that one could make measurements at the point of what they

termed Knowledge Based SA (Endsley's Level 2), or wait until the knowledge had been processed into decisions (Endsley's Level 3) and make performance-based measurements. If, of course, the view that Levels 1, 2, and 3 are discrete is invalid (as suggested earlier) then the Pritchett *et al* approach may potentially also be invalid – though this comment would not apply where Level 3 could be distinguished from merged (or continuous) Levels 1 and 2. Of the techniques noted above, the majority are focussed on assessment; the approach of Sutton and Edelman (2005) being the only technique holding that awareness can be measured. However, if Orasanu's (1995a, b,) method was applied with sufficient rigor, it could be argued that a measure (or at least a correlate) of awareness could be obtained. For both the reaction time and team interaction methods, awareness is measured through its relationship with other criteria (i.e., reaction time and crew interaction).

It seems logical, then, to arrange for observers to be able to make external assessments – using a simple checklist – in such a way that they can make their assessments both at random, and when a critical part of the task is presented. This is simple to arrange on a laptop computer such that the checklist is presented at random, but can also be called up by the observer at any point in the task performance with a suitable indication that the checklist had so been called for.

Kirlik and Strauss (in press) have tested a more direct method for measuring awareness, based on a systems approach. They have constructed their measurement method based on the lens model of Brunswik (1956). For this, the circumstances of the event to be measured have to be defined in advance, with the system operator's tasks, and information required, having to be scoped out in terms of criteria, judgements and cues respectively. Strauss and Kirlik (in press) applied this technique to a submarine stealth exercise simulation, and were able to measure variance in awareness as participants used two different displays. The application of this technique to other domains is, we believe, readily apparent.

To relate the problem of measurement versus assessment to Network Centric Operations (NEC), consider the example offered by Quilty (2004), who compared the older form of combat to the set-piece, pre-determined plays of American Football, and NEC to the fluid and dynamic action of soccer (Association Football). It would not, surely, be practicable to interrupt either sport in the middle of the action to conduct any form of measurement; but while American Football could, perhaps, have some form of measurement taken at the end of each play, the transitory nature of soccer – and hence of NEC – would suggest that awareness during a transitory activity may probably only be assessed if the activity is to continue.

As an example, consider a simulation (in a networked tactical training system) with a troop/platoon (UK/US usage) of tanks advancing across rolling terrain. In the course of that advance, a house becomes visible in such a way that part of the house remains hidden. This represents a visual data input to the troop commander (and indeed the commander of each tank) that the ground is sufficiently uneven as to hide an enemy tank from the opposing force, a view that would be reinforced by the continual changes as the tanks advanced. The commanders' behaviour at that point would provide information as to their awareness (TA or LA depending on the environment) and it is at that point that an observer would wish to capture the available awareness data – whether or not data had been collected on a random basis only moments before. If there is an enemy tank, and it engages our hypothetical troop,

then the observer may wish to collect further data. All data collection checklists from that run could be compared in chronological order with a recording of all data from the simulation.

It is the norm with military training simulations to record each complete run in order to conduct an After Action Review, or post-mortem. The ability to determine the awareness of (say) a troop commander at different stages in a simulator exercise would be of particular value to the trainers. Matching the situation, task and cues available at that point with the Commander's actions (or orders) would provide information as to the Commander's awareness (TA or LA depending on the environment) and it is at that point that an observer would wish to capture the available awareness data, independent of being cued to collect data at a randomised interval. The key to this approach is in designing the exercise scenario to provide features that will enable Awareness to be observed and assessed, and in the provision of a suitable software/platform combination to facilitate the observations. We are already considering the specific form that such software might require in order to run on a generic laptop computer.

Conclusion

This paper started by questioning the merits (if any) of retaining the acronym SA. It has been shown that the term is used for two similar - but distinct – constructs relating to the concept of awareness; and that "awareness" is sufficiently broad in compass as to require at least three related constructs (or types of awareness). It has also been argued that the three types of awareness proposed (TA, LA and GA) are such that they do not directly transfer from one application to another. TA for a racing driver may vary over milliseconds, for an infantryman over seconds, but for the pilot of a ship entering harbour only over minutes. The three types of awareness (TA, LA, GA) do, however, seem to have a fairly universal applicability. Similarly, the components of each type require fundamentally similar data inputs, but the processing of that data will depend on the viewpoint of the individual.

Several approaches to the assessment and/or measurement of awareness have been referred to, and it would seem clear that while the types of awareness can be transferred between applications, any attempt to produce a single generic measure of awareness is unlikely to be successful. Those studies which have produced instruments for the assessment of awareness, have generally tended to use external observers. In all, this leads to the conclusion that there is more merit in the assessment of the awareness of individuals (or perhaps very small teams), than there is in attempting measurements that will be highly restricted in scope, and may prove to be invalid.

Similarly, it is concluded that there is no good reason to retain the acronym SA in reference to any type of awareness. This raises the question of the specific Sport Psychology usage of SA. It may be appropriate to return exclusive use of the acronym to them. Alternatively, it may be more appropriate to suggest that the TA, LA, GA of the 3-Q Model of Awareness offers sufficient advantages to sport psychology as to justify its adoption in that field.

References

Abernethy, B. and Russell, D.G.; (1984). Advance cue utilisation by skilled cricket batsmen. **Australian Journal of Science and Medicine in Sport, 16(2), pp. 2-10.**

Andre, A. D., Foyle, D.C. and Hooey, B.L.; (2005). Situation Awareness in an Augmented Reality Cockpit: Design, Viewpoints and Cognitive Glue. **Proceedings of HCI International 2005.** Las Vegas, NV. Published on CD Rom.

Brunswik, E.; (1956). **Perception and the Representative Design of Psychological Experiments**. Berkeley, CA: University of California Press.

Chandler, J.D.; (1983). **Pistol Coaching**. Droitwich, Worcs: Peterson Publishing Co. Ltd.

Cohen, M.S., Adelman, L., Tolcott, M. ., Bresnick, T A., and Marvin, F.; (1993). **A cognitive framework for battlefield commanders' situation assessment**. Arlington, VA: Cognitive Technologies Inc.

Dickenson, J.; (1976). **Behavioural analysis of sport**. London: Lepus Books.

Endsley, M.R.; (1988a). Design and evaluation for situation awareness enhancement. **Proceedings of the 32nd Annual Meeting of the Human Factors Society, 97-101.**

Endsley, M.R.; (1988b). Situation awareness global assessment technique (SAGAT). **Proceedings of the National Aerospace and Electronics Conference (NAECON).**

Endsley, M.R.; (1994). Situational awareness in dynamic human decision making: measurement. In R.D. Gilson, D.J. Garland and J.M. Koonce (Eds) **Situational Awareness in Complex Systems** (pp79-97). Daytona Beach, FL: Embry Riddle Aeronautical University Press.

Feary, M.; (1997). **Control-Based vs. Guidance-Based Training for Automated Vertical Guidance.** Unpublished Masters Thesis, San Jose, CA. San Jose State University.

Feary, M., McCrobie, D., Alkin, M., Sherry, L., Polson, P., Palmer, E. and McQuinn, N.; (1998). **Aiding Vertical Guidance Understanding. NASA Technical Memorandum NASA/TM-1998-112217.** Linthicum Heights, MD: NASA Center for Aerospace Information.

Fowlkes, J.E., Lane, N.E., Salas, E., Franz, T. and Oser, R.; (1994). Improving the measurement of team performance: The TARGETs methodology. **Military Psychology, 6 (1),** 47-61. Lawrence Erlbaum Associates, Inc.

Freeman, J.T. and Cohen, M.S.; (1995). **Methods for Training Cognitive Skills in Battlefield Situation Assessment, Technical Report 95-2**. Fort Leavenworth, Kansas: US Army Research Institute.

Gibson, J. J.; (1966). **The Ecological Approach to Visual Perception**. Boston MA. Houghton Mifflin.

Hone, G. N.; (1994). **Brightness and contrast as cues to depth in the simulator display: cue combination and conflict resolution**. Unpublished PhD Thesis, Surrey University.

Hone, G. N.; (2003). **The Myth of SA**. Presented at the Symposium: NEC - The Human Dimension. Shrivenham: The Defence Academy of the UK, Nov 2003.

Hone, G. N., Macleod, I.S. and Smith, S.J.; (2005). Awareness and Scenario-Based Requirements. **Proceedings of the Human Systems Integration Symposium 2005,** Washington, DC. American Society of Naval Engineers. Published on CD-ROM

Jeannot, E., Kelly, C. and Thompson, D.; (2003). **The Development of Situation Awareness Measures in ATM Systems.** Brussels, Eurocontrol.

Kirlik, A. and Strauss, R.; (2003). **A Systems Perspective on Situation Awareness I: Conceptual Framework, Modelling, and Quantitative Measurement. Technical Report AHFD-03-12/NTSC-03-2**. Savoy, Il. Institute of Aviation, University of Illinois at Urbana-Champaign. (And to be published in I J Industrial Ergonomics).

Mavor, A.S., Kidd, J.S. and Prince, C.S.; (1995). **Tactical Display for Soldiers**. National Academy Press, Washington DC.

Miller, N. L. and Shattuck, L. G.; (1995). Presentation at the ASNE/USNavy workshop on Human-System Integration Tools. Arlington, VA.

Orasanu, J.; (1990). **Shared mental models and crew performance** Cognitive Science Library Tech. Rep. #46. Princeton, N.J.: Princeton University.

Niedeffer, R. M.; (1976). Test of Attentional and Inter-personal Style**. J. Personality and Social Psychology, 34.**

Orasanu, J.; (1995a). Evaluating team situation awareness through communication. In D. J. Garland & M. R. Endsley, (Eds.), **Experimental analysis and measurement of situation awareness,** (pp . 283-288). Daytona Beach, FL: Embry-Riddle Aeronautical University Press.

Orasanu, J.; (1995b). Situation awareness: Its role in flight crew decision making. In R. S. Jensen & L. A. Rakovan (Eds.), **Proceedings of the Eighth International Symposium on Aviation Psychology, 2**, 734-739. Columbus, OH: Ohio State University.

Pritchett, A. R., Hansman, R.J. and Johnson, E.N.; (1996). Use of testable responses for performance-based measurement of situation awareness. In D. J. Garland and M. R. Endsley (Eds.), **Proceedings of an International Conference: Experimental Analysis and Measurement of Situation Awareness** (pp. 289-293). Daytona Beach, FL: Embry -Riddle Aeronautical University Press.

Quilty, J.; (2004). **The Transition toward Network-Centric Operations** Presented at the 2nd International Workshop on Global Security, Berlin, Germany. Downloaded from the Internet on 27-Jan-2006.

Smith, M. W. and Davies, I. R. L.; (1989). **Fidelity in Simulation**. Final report to the Army Personnel Research Establishment (ref. 2064/99) Guildford: Surrey University.

Stout, R. J., Carson, R., and Salas, E.; (1991). **Can team process behaviors enhance performance?** Paper presented at the Annual meeting of the American Psychological Association, New Orleans, LA.

Strater, L. D. and Endsley, M. R.; (2005). Designing to Enhance SA in the CIC. **Proceedings of the Human Systems Integration Symposium 2005,** Washington, DC. American Society of Naval Engineers. Published on CD-ROM.

Strauss, R. and Kirlik, A.; (2003). **A Systems Perspective on Situation Awareness II: Experimental Evaluation of a Modelling and Measurement Technique. Technical Report AHFD-03-13/NTSC-03-3.** Savoy, Il. Institute of Aviation, University of Illinois at Urbana-Champaign. (And to be published in I J Industrial Ergonomics)

Sutton, J.J., and Edelmann, V.; (2005). Leader and Team Adaptability in Multinational Coalitions (LTAMC): An International Research Project. **Proceedings of the 10th ICCRTS**. Washington, DC: CCRP.

Villeda, E. B.; (2001). **Identifying and Evaluating Situation Awareness Behaviours in Simulation Training Scenarios**. Master's Thesis, Embry-Riddle Aeronautical University.