

SHARED SITUATION AWARENESS BETWEEN HUMAN AND MACHINE

by Dr David Thompson

I recently hit a patch of ice whilst driving at night across the exposed roads of Salisbury Plain in Southern England. I had already received a low temperature warning on the dashboard, so I was aware that there could be ice, but as I came round a bend and changed elevation my car started to slide. It happened very quickly, although it felt like longer, the dashboard flashed the traction control warning sign and I felt the driving aids kick in as I tried to stabilise the vehicle.

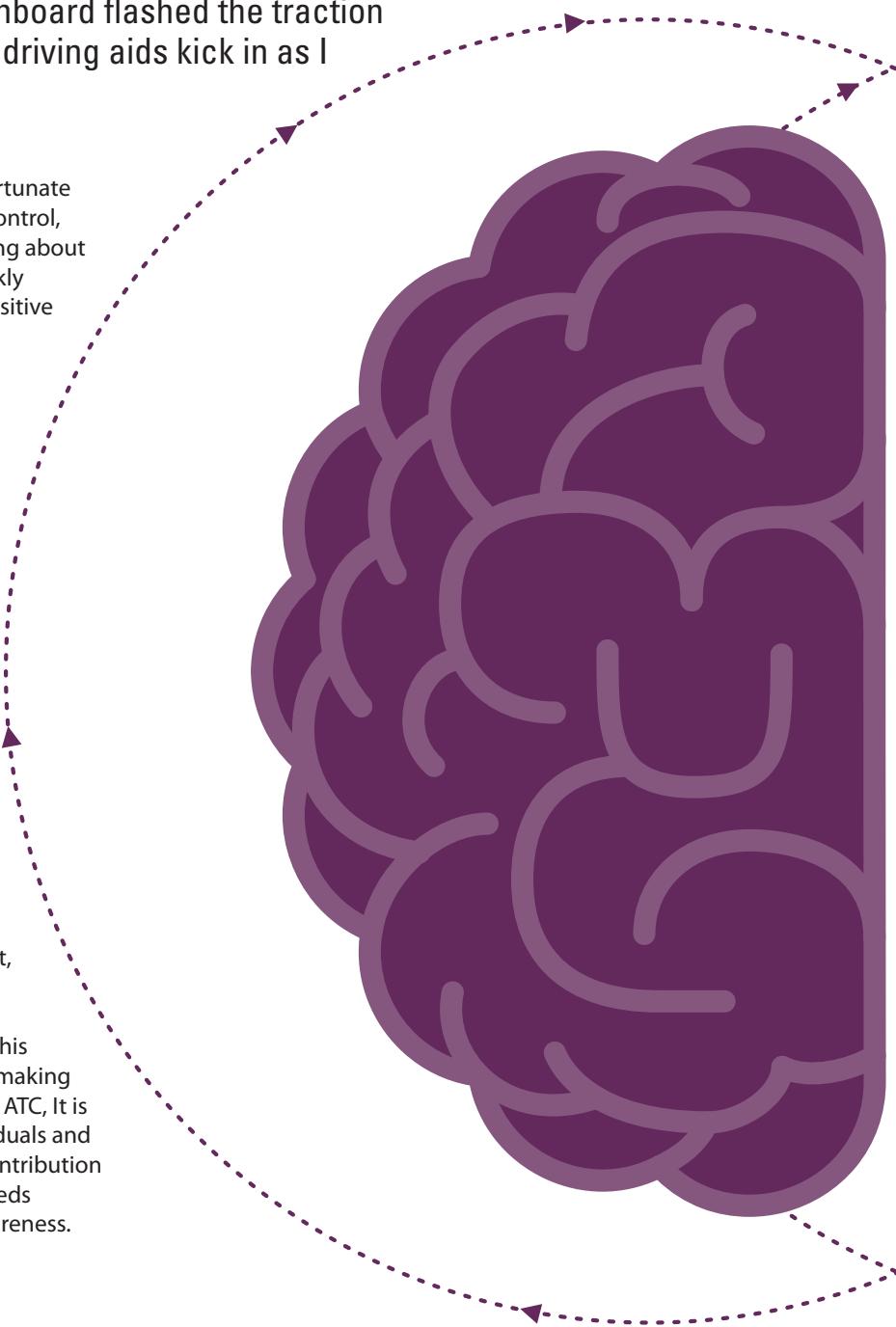
The driving aids worked really well, I was very fortunate no other vehicles were near to me; I recovered control, and got home safely. The incident left me thinking about how well the driving aids worked, and how quickly they recognised the loss of control and made positive correcting actions.

Electronic Support Tools in ATC

In the ATC domain, there are many ATCO support tools; and they are becoming ever more sophisticated. These tools help manage traffic flows and improve flight efficiency; they also spot safety issues and alert the ATCO to take preventative action when needed.

Whilst at NATS I helped with the validation and implementation of the interim Future Area Controller Tool Set (iFACTS) system into service in LACC. The iFACTS system features a number of support tools to assist the ATCO. Chief amongst these is Medium Term Conflict Detection (MTCD), which spots future conflicts up to 15 minutes ahead, enabling early resolution with minimal disruption.

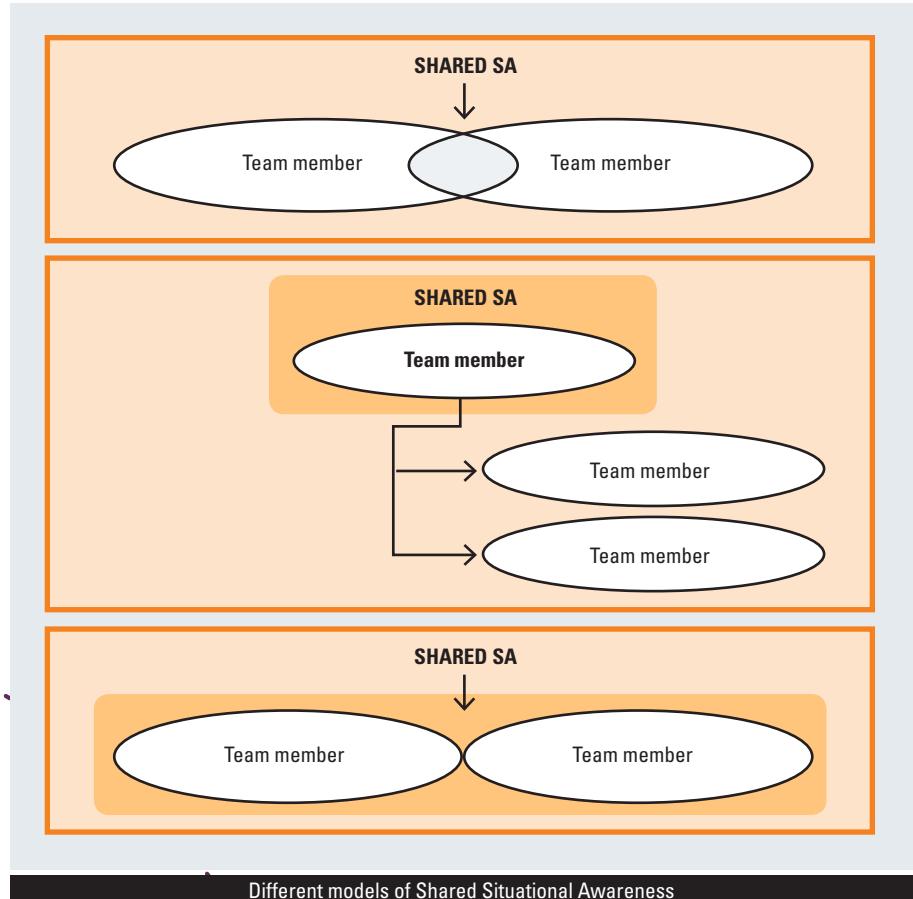
MTCD systems like iFACTS are designed to detect, and alert the controller to events that may have escaped their attention. These systems exhibit many aspects of situation awareness and share this 'picture' with the ATCO, to inform their decision-making and action. With all this sophisticated support in ATC, it is important we update our concept of how individuals and teams are supported, in order to consider the contribution that machines make explicitly. One area that needs updating is our concept of Shared Situation Awareness.



Background on Shared Situation Awareness

Situation Awareness concerns the awareness of the environment surrounding you and the complex dynamic events occurring within it. Mica Endsley defines Situation Awareness as the "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 status in the near future" [1].

Shared Situation Awareness (SA) theory goes on to suggest that even the most isolated of individuals will



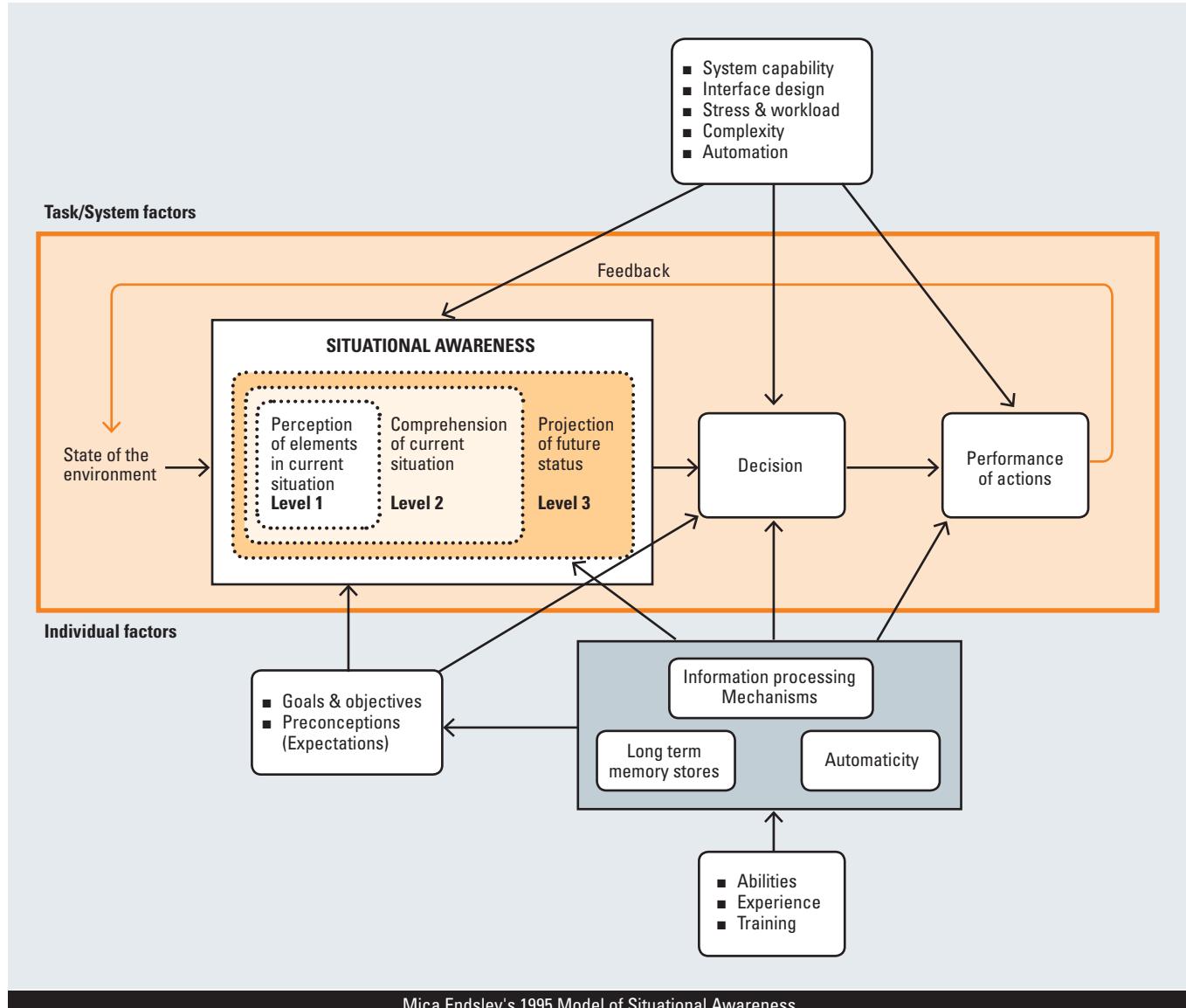
Different models of Shared Situational Awareness



have others supporting them, even if at great distance to them, and that the additional insight and awareness these others share to a situation helps to build a complete SA picture [2]. It is important to highlight that the focus is consistently between human team members and does not include machines as team members.

Shared SA is suited to complex and dynamic environments and scenarios such as medical trauma and surgery, aviation, and control centres for activities such as ATM. It can cover both the front line operators, but also the 'back office' service and support maintainers. Invariably it is focused on human team members, and does not include the contributions of machines.

There are a number of different definitions of Shared SA, which reflects different circumstances and where team structures and communications may vary [2]. So whether Shared SA represents the collective SA held by a team leader (e.g. a surgical team), or the shared knowledge and understanding between a tactical and planner ATCO team, or the common knowledge and understanding held by a counter terrorism squad; the common element is that SA is shared between individual humans.



Shared Situation Awareness in ATM

In ATM SA is shared between ATCOs, assistants, supervisors, pilots, system engineers, and many others. The breadth and depth of SA sharing is depending on team structure and closeness of the team. How about those decision support tools, where do they fit in, and how do they Share SA with the human team?

Let's take a closer look at Endsley's (1995) model of SA, and consider how MTCD is sharing SA in this context [1]. The process of SA is actually just one component of wider cognitive processes including perception, decision-making, and action.

It is important to highlight that SA is entirely an internal construct. In order to Share SA it must be communicated to other team members. This may be through formal methods such as written text, vocal communications, but also Non Verbal Communications such as finger pointing [3].

Systems such as MTCD, which shares SA with the ATCO, use visual and auditory display mechanisms to communicate salient items of interest. The presentation of these items may be subtle or very obvious, depending on the urgency and significance of the information. These shared communications are perceived by the ATCO, and added to their global SA, producing a Total SA picture.

Adding in autonomy

There are future ATM concepts that are exploring how to add to SA tools through the introduction of automated intervention mechanisms, for example automated speed adjustments from the ATM direct via data link to the cockpit Flight Management System. Such intervention could potentially bypass the attention of both the controller and the pilot. We must be careful when blending automation into the human-machine operating environment, as subtle differences between operational states can prove difficult to monitor in high workload and stressful scenarios [4].

On 6th July 2013, Asiana Flight 214 crashed into the sea wall just short of the runway threshold at San Francisco Airport¹. The accident occurred as the Boeing B777 was on a visual final approach under the manual control of a trainee Captain being supervised by an Instructor who was the aircraft commander responsible for the safety of the flight. One of the relief pilots was occupying a supernumerary seat in the flight deck.

During final approach, the crew's attention was concentrated on the vertical conformance of the aircraft to the glide slope whilst the speed reduced to dangerously low levels. The trainee Captain did not at first increase thrust to rectify this, erroneously believing the auto-throttle was set to an automatic intervention mode and therefore delegating situation awareness and action to the auto-throttle. On realising that the auto-throttle was not responding as anticipated, the trainee Captain eventually intervened by increasing thrust, but not until recovery was impossible. The Asiana crash shows how a flight crew (not just the pilot flying the aircraft) can completely lose SA and mismanage the aircraft flight path because they have not understood the way automated systems work or failed to monitor their status – and in this case also don't take any notice

of the view of the runway out of the window. Pilots have embraced automated systems to support their work, but sometimes have difficulty sharing SA with them. [5].

Future Considerations

We should recognise that the environment and traffic situation often presents us with uncertainty and we regularly expose operators to work in situations where the circumstances are less than ideal. Equipment may be faulty, systems may be unreliable and team members have human frailties. When in mixed modes of operation, particularly under stress and high workload, an operator without support tools may not have the full picture and be very reliant on the systems at work to help build their Total SA. Explicit recognition is needed of the fundamental reliance ATCOs have on Shared SA tools as they become ever more a part of the delivery of ATM service.

Distributed cognition is a concept that recognises and considers the contribution of non-human artefacts (e.g. equipment, control systems) in the completion of complex tasks [6]. If we return to our models of Shared SA, does Shared SA take place between human and machines, and should we be including MTCD as a team member?



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I consider that it does and it should. Therefore, it is important that we explicitly recognise the fundamental 'distributed cognition' contributions made by electronic support tools, both in terms of modelling, but also in terms of accountability [6]. Is it correct to attribute blame to the human in the system when the two, together, are responsible for task delivery? [5]

1- see http://www.skybrary.aero/index.php/B772,_San_Francisco,_CA,_USA,_2013

References

- [1] Endsley, M. R. (1995). Toward a theory of situation awareness. *Human Factors*, Vol. 37, Issue 1. 32-64
- [2] Prince, C., and Salas, E., Team Situation Awareness, Errors, and Crew Resource Management: Research Integration Guidance. In Endsley, M.R., (Ed). *Situation Awareness Analysis and Measurement* (2000). Pp 325 – 347, Chapter 15, Lawrence Erlbaum Associates, London. ISBN: 0-8058-2133-3
- [3] Endsley, M.R., Bolte, B. and Jones, D.G. (eds.), (2003). *Designing for Situation Awareness: An Approach to User-Centred Design*.
- [4] Autothrottle Design Highlighted In Asiana Crash. Boeing defends design philosophy for 777 autothrust mode (16/12/13). John Croft. *Aviation Week & Space Technology*.
- [5] Thompson D.J. (2015). Confusion in the cockpit: understanding human performance. *The Ergonomist*, September 2015.
- [6] Perry, M. (2003) "Distributed Cognition". In J.M. Carroll (Ed.) "HCI Models, Theories, and Frameworks: Toward an Interdisciplinary Science" (Morgan Kaufmann) 193-223.