# ARE YOU AWARE OF WHAT CATCHES YOUR ATTENTION?

**by Jean-Jacques Speyer**

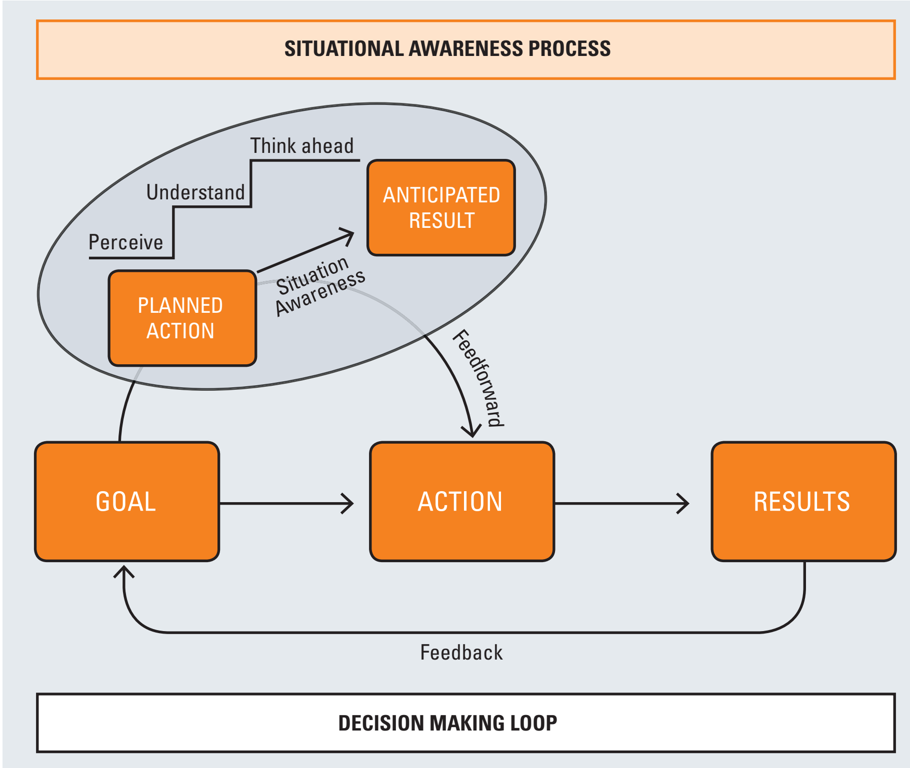
## 1. Situational Awareness, Attention, Vigilance, Alertness, Activity, Workload

The term **"Situational Awareness"** first appeared several decades ago. In aviation, as usual with Human Factors, there was some initial hesitation about what this new "buzzword" actually meant. But the more it survived, the more we kept throwing at it, replacing the word "situation" with terms like time, altitude, speed, position, terrain, energy, fuel, mode, system, automation, environmental, risk, fatigue or even emotional awareness...

The ergonomics of flight deck design continued to improve with the addition of monitoring devices, alerting systems and interfaces. It was, after all, a pragmatic and natural way to deal with "SA" in the never-abated quest to improve what we should be able to accurately perceive from what's actually going on. For the sake of good order I will review how this "construct" has finally become structured. A few definitions for a start, but eventually it all leads to an operational application.

When flying an aircraft, our "Situational Awareness" has to be continuously updated to stay ahead and project: Mica Endsley(1) keeps advising us to constantly anticipate what's next to refresh our "SA". With an **attitude** like the "unrest of a squirrel" we are permanently on the look-out for subtle changes, searching for clues of looming **threats**, ready to take dynamic decisions with options available to us. For instance, during the final approach phase this demands both a focused attention and an open attitude to be prepared for a missed approach, since we should be treating every landing as a rejected go-around. Let's reframe the whole notion of it.

**Attention** drives where we must concentrate our sustained focus. All the while keeping spare capacity to orient our distributed attentiveness to catch unexpected signals. As if we




were on our own personal autopilot, various "learned" automatic and subconscious information processes are at work in our brains ready to be passed on to our conscious diligence and warn us of any impending change and keep us alerted to its operational importance. The result is a compilation of many different perceptual and cognitive processes.

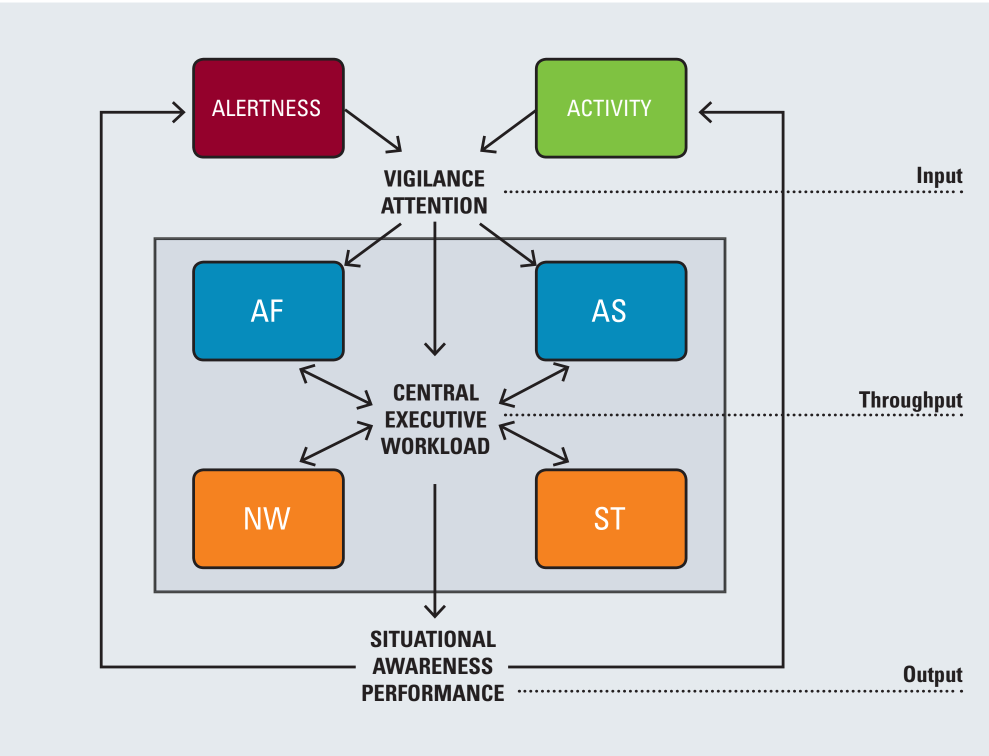
**Vigilance** governing this **"attentional filter"** is always at work (even to a certain extent when we are asleep). It is the capacity to subtly detect potentially unpredictable signals. A monitoring task is at risk of being negatively influenced if the subject's vigilance decreases. In this respect, signal detection ability depends both on the pilot's covert **alertness** and on their overt **activity**. And if neither overcomes sleepiness, this is liable to result in decreased **workload** through reduced ***effort***. In "Can ATM learn from the experience of pilot workload measurement" from Hindsight 21 I briefly reviewed workload as often related to the pilot's limited capacity to process information cognitively.

Alertness levels are influenced both by the environment and by the pilots' ***involvement***. But if sensory stimulations remain almost constant or very repetitive as with frequently recurring routines (or with highly automated processes not rigorously being attended to), this may well be related to feelings of ***monotony***. This could reduce a pilot's alertness and task activity.

## 2. Situational Awareness from a simple Neuroscience point of view

When on a final approach you usually have an expectation that you will make visual contact no later than at the minimum height specified for the procedure. Following Daniel Levitin's(2) train of thought, if everything is all right, this will free up some capacity for our ***"attentional filter (AF)"*** to deal with other issues. But in case the relevant "stabilised approach criteria" are no longer met, it becomes essential without delay to initiate a go-around. Being prepared for this absorbs more mental resources, which is the cost for ***"attentional switching (AS)"*** in situations that require a prompt response.

When there is no urgency for a decision or when we are not under any pressure, we could "so to speak remain on our own personal autopilot". We would be residing in loosely connected stream-of-consciousness thoughts that may degenerate to daydreaming. This ***"mind-wandering mode (MW)"*** is in sharp contrast to a mode dominant at the other extreme, the ***"stay-on task mode (ST)"*** under which we restrict ourselves to a strict focus-orientation.



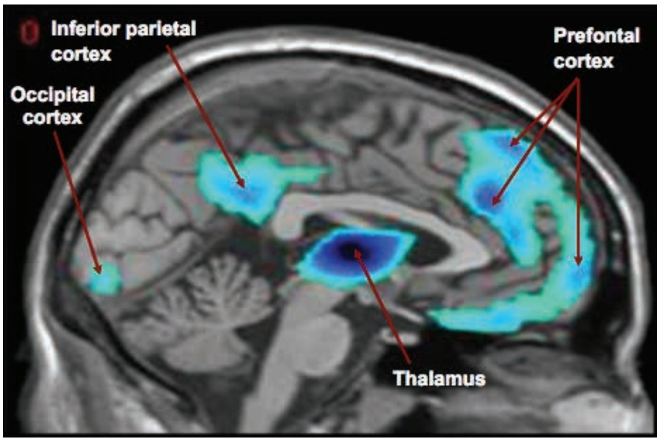

The ***"central executive (CE)"*** mode will kick in during more demanding tasks to direct supervisory attention to what we're doing and perhaps even help avoid tunnel vision.

At that stage, the ***"CE"*** will also be trading-off between immediate reward and future compensation, an ability that can be trained to some degree :

- to assess unknown & future situations under stress or time pressure,
- to project into the future to imagine future threats and risk precursors,
- to persistently resist the temptation to accept immediate gratification,

(in this case, *'immediate gratification' being: land to be relieved, to avert loss of face from a missed approach, be done with it rather than go around, to avoid starting a new approach all over again.*)

At this point let me bring in Kahneman's (3) "Thinking, System 1 and System 2", the two different ways for our brains to form thoughts and make resolutions, the former being "fast and furious", emotional,



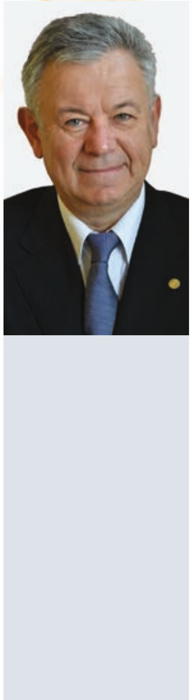

expedient and subconscious, the latter being "slow and composed", rational, effortful and conscious.

When neural activity reaches a certain threshold, we become aware of it and we would describe that as consciousness. Which is simply a mental construct for the sensations and perceptions that catch: our "CE", a system of limited capacity that can generally not attend to more than four of five items at the same time. Linked to short-term working memory, alternating tasks with one another under significant time pressure can indeed become quite an effort.

We also learn from neuroscience that parts of the brain can seemingly fall asleep or be in "disconnect" for a few moments or more without our realising it – think of "microsleeps" which might occur when driving along an empty motorway late at night! It would be far too simple to consider that we are either awake or asleep: some parts of our brain could be off-line, treading, recouping energy. As long as we are not calling on them this may go fully unnoticed.

All of this pertains to the five parts of our cognitive system **(AF, AS, MW, ST, CE)** any or all of which could be working only partially. Some part of our brain could be asleep, distracted or surprised by something else. This absent-mindedness could go as far as mental freeze, startle or incapacitation. This may happen when we are daydreaming and it may then take us a moment before shifting back to alertness. Just like after a napping episode because of some sleep inertia. Using brain imagery, Thomas et al (4) have visually shown that sleep loss is characterised by some brain deactivation:

- **prefrontal cortices** (the highlighted frontal brain section) which controls executive mental functions like situational awareness and problem-solving,
- **inferior temporal cortices** (the left-side highlighted region) which conceals high-order mental subtasks such as those involved in mathematical calculation and quantitative estimation,
- **the thalamus** (the central highlighted region) which harbours general alertness levels and attention.


## JEAN-JACQUES **SPEYER**

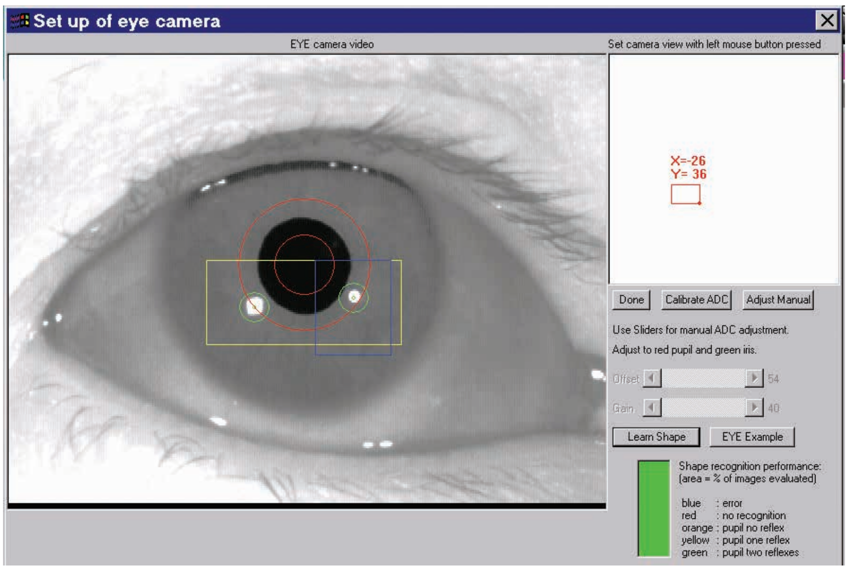
MS El & Mech Eng, VUB, Brussels, Belgium, MS Aero & Astro, MIT, USA, DU HF's & Ergonomics, Univ René Descartes, Paris, France. After an airline start as B707 Flight Engineer, JJ Speyer moved on to Flight Operations Engineering & Certification at Airbus from where he retired as Senior Director Airline Consulting, Fuel & Flight Efficiency at the end of 2009. He is currently Professor in Aircraft Specification & Certification at the Vrije Universiteit Brussel.


### 3. Stimulating Alertness using an existing Situational Awareness Procedure

**In Hindsight 22 on Safety Nets against Fatigue** I made reference to the EPAM system (standing for Electronic Pilot Activity and Alertness Monitoring) as the author of a paper (5) submitted for an academic qualification at the René Descartes University in Paris. Its concept was based both on the activity monitoring of manual pilot interactions with the aircraft interfaces and on individual pilot vigilance monitoring by means of cameras facing each crewmember position. The cameras were recording pilot eye movements (6), and were also experimentally correlated with individual EEG measurements "in situ".

This EPAM system produced visual and audio caution and warning alerts to inform a pilot of any persistent lack of activity or of alertness decrements. Significant alertness rebounds were measured when pilots responded by means of a tedious mental involvement & physical activity procedure that would refresh and re-invigorate their personal situational awareness. This is equivalent to the procedural review of flight & system parameters which is required after an absence from the flight deck during the cruise, or after handover from the another pilot (during the low vigilance typical of through-the-night flights), or after a period of in seat "Controlled Rest" (7) with the potential for sleep inertia following awakening.

Provided that pilots performed this situational awareness refreshment within a reasonably short timeframe(5) and sufficiently actively, the effect could result in a 'rebound' with increased alertness as evidenced from EPAM camera shots(6) correlated with EEG traces recorded in-flight(7). However, this effect was not seen if the re-activation procedure had been fragmented or carried out without a sufficiently focused involvement at too slow an activity pace. This finding corresponds with research from Kahneman and Beatty on pupil dilatation(6) (indicative of more alertness) verified to be increased with increasing task demand or difficulty(8).



## 4. Situational Awareness of ATC Controllers in future time-based operations

In order to cope with an expected threefold increase in aircraft movements over the next 25 years, the SESAR and NextGen concepts aim to change ATC from space-based to time-based operations and hence provide more flexibility for trajectory management. Meeting 3D waypoints at specific times calls for increased automation because the computations required exceed human calculation capabilities. HMI's are indispensable in the achievement of better strategic and tactical direction of waves of arriving and departing aircraft and include a variety of technologies e.g. CDA/CDD, point merge, timed arrivals, to name just a few.

Traditionally, air traffic controllers were providing tactical speed, route, altitude and vector instructions, based on a first-come-first served principle. With future ATM systems, controllers will have to integrate time as a fourth dimension in their mental picture so as to plan, prioritise and sequence flows, as well as to assure separation. Tactical control will become much more strategic with a larger planning horizon, with more anticipation and with more time constraints to be imposed upon pilots. Getting traffic to a waypoint on time becomes more burdensome for "SA" because much more "time-based-thinking" is required than controllers are presently used to whereas current ATC is being exerted in terms of "distance-based-thinking".

Technologically this has to be handled from two competing points of view. On the one hand, the new interfaces make it possible to reduce complexity and controller workload, freeing controllers so that they have more time to develop a general "meta" picture which is rather good for "SA". On the other hand, a reduction in "hands-on" involvement will detach them from continuous monitoring, which is likely to lead to vigilance decrements and even to deteriorating "SA" skills. Yet those are the very skills that are so necessary when system failures occur which may in extremis require a "back-to basics" solution. Human Factors issues must be properly addressed here, to specify and take into account appropriate "SA requirements" when designing complex ATM systems and associated operational procedures. An NLR (9) study details a set of ten essential SA requirements to enable time-based operations in ATM.

ATC controllers are now in a position similar to pilots. Their environment has become highly automated and meaningful mental monitoring is essential to ensure their cognition about what is going on with proper situational awareness procedures adapted to the coming generations of ATM.

What matters here is the bridge we build to **detect, assess, decide and act** in the art and science of our respective trades, be it Air Traffic Control or Flying Aircraft. It would sound trivial to conclude that to be aware we must be situationally aware. So let's go and re-read about the subject in OGHFA(10) which is online in SKYbrary. Playing "Catch 22" with it would certainly be a bridge too far…

Are you aware of what catches your attention? Situational Awareness!


## References

[1] Endsley, M. *Towards a theory of situational awareness in dynamic systems.* (1995) Human Factors, 37 (1), 32-64.

[2] Levitin, D.J. *The Organized Mind, Thinking Straight in the Age of Information Overload.* (2014) Pinguin Books.

[3] Kahneman D. *Thinking Fast and Slow*. (2011) Farrar, Straus and Giroux. New York

[4] Thomas M et al. *Positron Emission Tomography Study of Healthy Sleep-Deprived Adults, imaging decreased Metabolism in the Thalamus, Prefrontal Cortex and Inferior Parietal Cortex* (2000) Journal of Sleep Research. 9:335.

[5] Speyer J-J. *Spécification, Conception et Mise au Point d'un Système de Support pour le Maintien de l'Attention, de l'Activité et de la Vigilance en Vol*, (1998-1999) DU Bases Facteurs Humains pour la Conception de Systèmes Homme-Machine en Aéronautique, Université René Descartes, Paris, France,

[6] Denuit S, Caboor L. *Specification and Evaluation of a System to maintain Pilot Alertness in Flight*, (2002) Master's Thesis Mechanical Engineering- Aeronautics supervised by Speyer J-J, Vrije Universiteit Brussel, Belgium.

[7] Cabon P, Bourgeois-Bougrine S, Mollard R, Coblentz A, Speyer J-J. *Electronic pilot-activity monitor: a countermeasure against Fatigue on Long-Haul Flights*. (2003) Aviation Space Environmental Medicine 74:679–82.

[8] Kahneman D. *Attention and Effort*. (1973) Prentice Hall, Englewood Cliffs, New Jersey.

[9] E.A.P.B. Oprins , Zwaaf D., Eriksson D.J.F., van de Merwe G.K. Roe R. *Impact of future time-based operations on situation awareness of air traffic controllers*. NLR-TP-2009-236

[10] OGHFA : Operators Guide to Human Factors in Aviation, Flight Safety Foundation project, available in Human Performance section of SKYbrary