HindSight 23

The ability or opportunity to understand and judge an event or experience after it has occured

EUROCONTROL

SITUATIONAL AWARENESS?!

SA AND NATHAN POLOSKI'S INJUSTICE
by Professor Sidney Dekker

SITUATIONAL AWARENESS VERSUS TIME IN POSITION
by Dr Michaela Schwarz and Fuat Rusitovic

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by Captain Wolfgang Starke

Summer 2016

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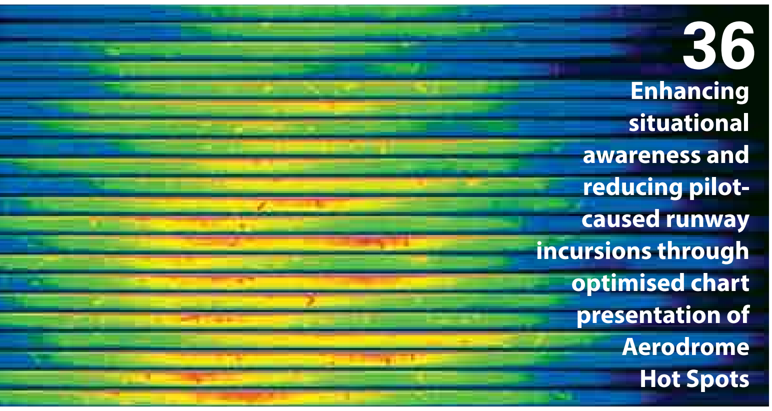

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EDITORIAL TEAM

Dear Readers,

Ascribing the cause of an accident or incident to 'a loss of situational awareness' is rather like a saying that someone died from 'a heart attack'. This provides some information but opens up a whole series of questions. Why did the heart attack happen? Poor diet, smoking, heart disease or was it a more immediate factor such as an electric shock? In the same way, why was there a loss of situational awareness?

The articles in this issue provide a fascinating insight into what situational awareness is and how we can all improve our understanding of "what is going on around us". They look at the subject from the point of view of both controllers and pilots and they look at how the concept has developed and changed over time.

In the past, pilots had few sources of information so, as Captain Johan Glantz describes so succinctly in his article, "In a DC9 knowing 'what's going on around you' often meant 'Where are we?'." Now we have so much information available to us, we now need to be able to filter this so that we can focus on the things that really matter. This is also true for air traffic controllers, who now have much more information on the screen than was the case in my day. For air traffic controllers, of course, establishing and maintaining a good mental picture of what is happening – not just now but also in the future – is absolutely vital. It is at the heart of their role.

At the same time, we also have to understand the tools that are helping us fly/control the aircraft and the tools that are supplying us with the information. So we have to know if the Weather Radar is set up correctly to show CBs, or whether the control screen is providing all the information we need. If you do not understand the tool, then you cannot rely on it.

And as we move forward to managing 4D trajectories operated by aircraft with precision navigation in free route airspace with full air-ground data connectivity, we need to think about the human at the heart of this. Does he or she have the information required to prove good situational awareness? Is he or she able to maintain this situational awareness? Because if there is a problem beyond the programming of the system, then that is when the human will be suddenly required to make critical decisions.

As we develop and implement new systems, we need to think about how the pilots and controllers will interact with the systems and about whether they are getting the right information at the right time, whether it is through a handover from the previous controller or via a sign by the side of a taxiway. There are some very interesting and thought-provoking articles in this edition and I would like to thank all the authors for their hard work and their insights.

The Director General

FRANK **BRENNER**

has worked in Air Traffic Management for his entire career. He has been Director General of EUROCONTROL since 1 January 2013.

Since taking up his functions at EUROCONTROL, he has initiated the development of a Vision and Strategy, including the development of Centralised Services as part of the SESAR deployment concentrating on how to support controllers with new technology which increases safety.

Before joining EUROCONTROL, Frank Brenner was General Manager Operations for FABEC, Vice Chairman of EUROCONTROL's Performance Review Commission and a member of the Performance Review Body. Trained as an air traffic controller, he has held a number of posts at DFS including Head of ATM Operations, Director of Operations at the Business Unit for Aeronautical Data Management and Director of DFS's Control Centre Business Unit. operational posts.

OUT OF SIGHT, OUT OF MIND

In the previous edition of HindSight I told you about transponder failure.
Six months later,
I still want to talk about it.

Having a flight in controlled airspace without a correctly functioning transponder is one of the most serious situations for Air Traffic Controllers. The source for this danger is the simple fact that controllers will be unable to see the actual position of an aircraft, whilst they would still be responsible for keeping it apart from other traffic.

Or, in other words, having an aircraft 'out of sight' for exactly those that need to know where these aircraft are. Unsurprisingly, this situation is one of the Top 5 safety priorities for the European ATM Network Manager.

A flight without a correctly functioning transponder can be the single point of failure to the entire mid-air collision protection system in aviation. A flight without a correctly functioning transponder means no surveillance for ATC using only secondary radar, no STCA and no ACAS. Peeling off your protection layer after layer is like peeling off an onion – sooner rather than later it makes you cry!

'But what's the problem?' some people ask. Surely it's the controller's job to keep their 'situational awareness' and detect promptly if an aircraft track suddenly disappears from their screen.

Some even go further in their assumptions. They consider that each failure of a transponder will be duly identified and properly managed by the Air Traffic Controller. Is this really possible? Such fundamental assumptions underpin various serious arguments for acceptable levels of aviation safety. But are they realistic?

You may recall the mid-air collision that happened almost 10 years ago over the Amazon, Brazil. The transponder of one of the aircraft involved stopped transmitting the Mode C altitude which rendered ACAS useless. This single fact removed many of the protection layers. This fact was not perceived by the pilots who were focused on solving issues relative to the performance of the aircraft. The investigation report also identified that "The ATCO 1 of sector 7 did not notice the information alerts relative to the loss of the mode C and did not take the prescribed corrective actions". So nobody identified it! How serious is an argument for safety which only relies on pilots or controllers identifying transponder failure?

Is this just a single case? It is not. Each year I see an incident or two involving a flight without a correctly functioning transponder in the sample of most serious incidents in Europe. Some are failures of the transponder, some are Mode C interruptions and some are controlled airspace incursions by an aircraft without an operational transponder. Almost all of them result in serious incidents with few if any barriers left other than Providence. What's telling is that in many of these cases, the inoperative transponder was not identified by the controller.

Detecting when an aircraft drops off your screen may have been a reasonable assumption years ago. Then, the number of aircraft in the ACC sectors was not as high as it is today and controllers were just taking care of safety without so many pressures for efficiency, environment…

At that time, what was on your screen was also in your head. If an aircraft suddenly disappeared, even if you were not looking directly at it, it was rapidly discovered by comparing the 'picture' in your head with what you were seeing on the screen. A favourite 'exercise' of the instructors during recurrent training in the simulator at the time was to sneak behind the screen, turn it off and ask you to recreate the situation picture. Try doing that with the current levels of traffic!

The fact of the matter is that, today, the assumption that a transponder failure will be identified on time by the controller is no longer valid unless there are reliable tools to provide you an alert. By this I mean tools that provide active alerting and are not just a record in a table or a list that is hidden from your regular scan.

Today, transponder failure, without a system support for detection, can be confidently described by the old phrase "out of sight, out of mind".

Enjoy reading HindSight!

Tzvetomir Blajev
Editor in Chief of Hindsight

SA AND NATHAN POLOSKI'S INJUSTICE

By Professor Sidney Dekker

In September 2014, two F/A-18C Hornet Jets collided over the Western Pacific after taking off from the San Diego-based aircraft carrier USS Carl Vinson. Search crews were able to find one of the pilots, who received medical attention onboard the aircraft carrier. The other pilot was never found: the search for him was called off the next day and he was presumed dead the day after that. Neither were the two Hornets ever found: they had sunk in waters kilometres deep.

The Navy launched its investigation into the collision and came with its conclusion half a year later. Vice Admiral Mike Shoemaker, himself an F/A-18 pilot, said that the dead pilot should have exercised more of what his military calls "situational awareness, or S.A." In this case, it would have meant not relying only on cockpit instruments but looking outside "to spot a looming catastrophe." Because "situational awareness, or the lack thereof, can prevent or cause mishaps."

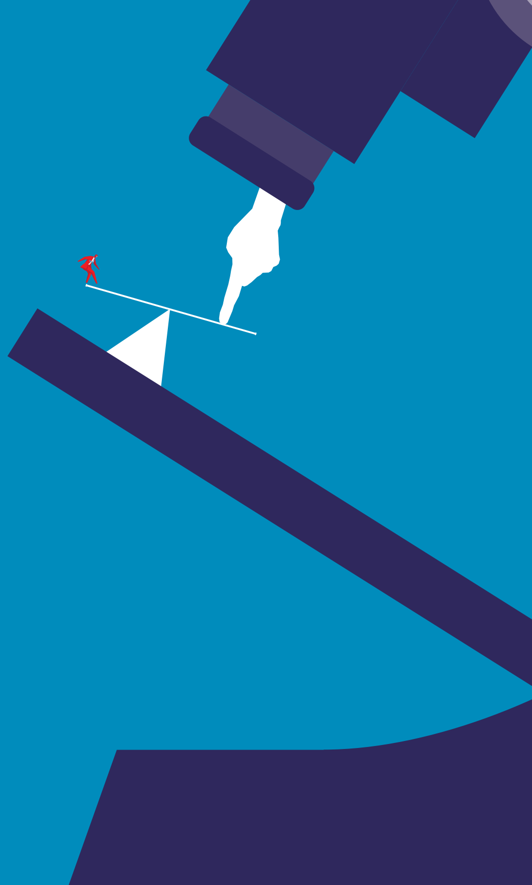
I have often invoked one of my early mentors, Aviation Medical Specialist and NASA human factors expert Dr. Charlie Billings. At the first scientific meeting on 'situation awareness' ever, convened in Florida in the 1990's , he got up and said: "Situation Awareness is a construct! And constructs can't cause anything!" And human factors researcher John Flach famously warned in 1995 against the circularity of constructs like it:

Why did he lose situation awareness?
Because he was complacent.
How do you know he was complacent?
Because he lost situation awareness.

I have since written many times, in many places, about the awful use of "situation awareness" (and particularly "the loss of situation awareness") in investigations, scientific articles and discussions among practitioners and researchers alike. I have clearly not been very successful. "Loss of situation awareness" is a favourite cause, in liberal use with the American National Transportation Board and other investigation bodies. And it gets worse. I learned recently of a Canadian criminal court case against an operator who, in the words of the prosecution (the Crown in this case), had "lost situation awareness" and had therefore been criminally negligent in causing an accident that killed two people. In another case, the coroner who investigated a friendly fire incident that killed three British soldiers in Afghanistan in 2007, rendered the verdict that the crew of an American fighter jet had lost "situational awareness" and were looking at the wrong village when they dropped the bomb.

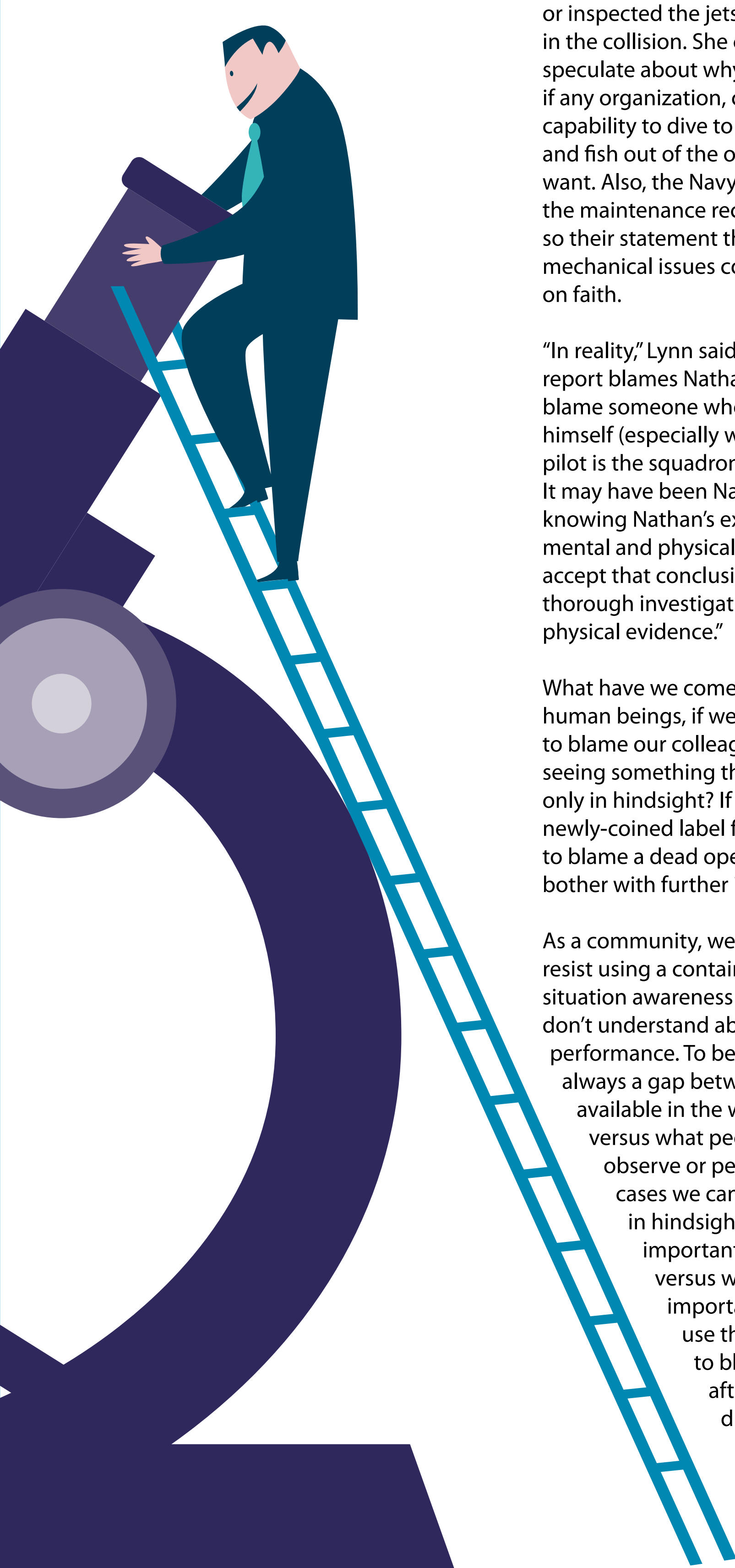
But what does all that mean? A "loss of situation awareness" explains nothing. It is a judgment: it is merely the difference between what we know now, versus what the pilot knew then. Now that we know the outcome, it is also what we believe the pilot should have known. But he didn't because he was complacent. Perhaps that kind of conclusion makes us feel better, sleep better.
We have found the bad apple. We have found the cause. Perhaps it fulfils a political purpose, because no further difficult questions about system vulnerabilities need to be asked.

But is it ethical? Is it smart? Is this what we pride ourselves on being – an industry that has long led the march of understanding human factors in safety? I was sufficiently inspired by the news of the investigation into this Navy crash, that I published a blog on



safetydifferently.com about it. Not long after I had done so, I received an email from Lynn. I didn't know Lynn, and she didn't know me, but she'd read the blog and decided to write me.

The pilot who was never found and presumed dead had a name. They always do, by the way (though we sometimes forget that in the technical parlance of post-accident discussions and reports). His name was Nathan. Lieutenant Nathan Poloski. Lynn was his aunt. Lynn, herself a retired trial lawyer, told me she was very upset when she read the investigation about Nathan's accident. She felt the conclusion was premature at best, given that the Navy never retrieved or inspected the jets involved in the collision. She could only speculate about why, but the Navy, if any organization, certainly has the capability to dive to those depths and fish out of the ocean what they want. Also, the Navy never released the maintenance records of either jet, so their statement that there were no mechanical issues could only be taken on faith.



"In reality," Lynn said to me, "the Navy report blames Nathan. It's easy to blame someone who can't defend himself (especially when the other pilot is the squadron commander). It may have been Nathan's fault, but knowing Nathan's extraordinary mental and physical abilities, I can't accept that conclusion without a thorough investigation – including all physical evidence."

What have we come to, as fellow human beings, if we use a construct to blame our colleagues for not seeing something that is obvious only in hindsight? If we rely on a newly-coined label for 'human error' to blame a dead operator and not bother with further investigation?

As a community, we should resist using a container term like situation awareness for things we don't understand about human performance. To be sure, there is always a gap between what is available in the world to look at, versus what people actually observe or perceive. In many cases we can point out only in hindsight what was important to observe, versus what was not so important. We shouldn't use that gap as an way to blame someone after the fact. They didn't have the benefit of hindsight. And in Nathan's case, he doesn't even have the opportunity to defend himself.

Instead, we should use the gap between what was available to an operator versus what was observed by that operator as a call for deeper investigation. It's not the conclusion or end to the investigation. It is the beginning! To understand why there is a gap, you will have to understand people's goals at the time – the various things they were trying to achieve and that helped direct their attention. Remember that they didn't start work that day to go kill themselves, or kill or hurt someone else. They came to work to do a good job. So make sure you understand why it made sense for them to look where they did, rather than blaming them for not seeing what you only now can say was important. That's too cheap, too easy. It's judgmental. It's not an explanation. And it's not human factors.

Make the actual effort to reconstruct why people looked where they looked; why it made sense to them at the time to direct their attention there – given their knowledge and their multiple goals. You will probably find very quickly that you don't need the term 'situation awareness' for that explanation at all. For many decades in human factors, we did perfectly fine without it, and you should be just fine, too. Nathan Poloski, for one, would probably appreciate it. S

PROFESSOR SIDNEY **DEKKER**

is Professor and Director of the Key Centre for Ethics, Law, Justice and Governance at Griffith University, Brisbane, Australia. Author of best-selling books on human factors and safety, he has had experience as an airline pilot on the Boeing 737.

THE CHANGING CONTEXT OF SITUATIONAL AWARENESS

by Captain Ed Pooley

My time in aviation has included a great deal of direct self interest in the subject of Situational Awareness because – like all pilots – I was "there at the time". The number of passengers and fellow crew members accompanying me made no difference whatsoever to my interest in the subject because this situational awareness was always a personal as well as a professional priority – and for once there was complete harmony between these two spheres of life. So what I am about to offer on the context of this matter is couched essentially in those terms.

That doesn't necessarily mean controllers of air traffic and controllers of UAVs should stop reading now but you should be prepared to evaluate my remarks against your own degree of such harmony. And one caveat - what follows considers the issues from a singular perspective. As airline pilots, we are fortunate to operate most aircraft whilst working in teams of at least two equivalently-trained individuals, although I don't believe that invalidates a transfer of most of my observations to other front-line working environments.

My first observation is that the context in which situational awareness is achieved is continuously evolving. At least theoretically, the direction of evolution is for the better. We have increasing aids to enhance our situational awareness - in my case the traffic displays provided by TCAS II and the terrain mapping provided by an EGPWS database used with the accuracy of a GNSS position are the two outstanding examples which come to mind. Viewed from the perspective of situational awareness, however, these two cases are rather different. Before TCAS II arrived, unless I could see other traffic, I had only the mental map limited to aircraft working the same radio frequency which was both comparatively vague and often incomplete. Before EGPWS and GNSS position accuracy, I made sure (a) I was absolutely clear what the disposition of terrain along a route was both pre flight and in flight and (b) because knowledge of one's position unless in VMC was to varying degrees less accurate, I allowed for significant margins between me and trouble! Afterwards, the preparation and monitoring became less rigorous and the acceptable margins less generous. In both these cases, the possibility of complacency was not, for me at least, a risk since it would not be allowed to diminish the overwhelming priority of maintaining active self awareness of position relative to terrain and traffic. And in both cases, to keep me in one piece, it was often necessary to continuously maintain a far greater level of alertness because reliance on what was then a much lower level of automatic provision of information, alerts and warnings was not an option.

So my next observation is that as we continue to rapidly and inevitably accelerate into the age of automation, we should not forget that the primary driver for this is often efficiency rather than safety itself and that the latter has only been dramatically enhanced through making the aircraft 'pilot-proof' as far as possible through automation which is almost all-encompassing and extremely reliable. However, despite the fact that this scheme seems to work most of the time for most people, some of the accidents and serious incidents out there have been primarily founded on an obvious absence of situational awareness.

Let me acquaint you with a few out of many examples which show cases where the situational awareness barrier against the risk of (or actual occurrence of) loss of control, mid air collision and CFIT respectively failed to function:

- On 27 February 2012, the crew of an Airbus A330 en route at night and crossing the East African coast northbound at FL360 encountered sudden violent turbulence as they flew into a convective cell they had not seen on their weather radar[1]. They briefly lost control of their aircraft in both pitch and roll as it climbed 2000 feet, but flight envelope protection was activated and they eventually regained control and continued the flight. The Investigation concluded that they had not seen the rapidly developing cell because they had not been using their weather radar properly.

1- see more at:
http://www.skybrary.aero/index.php/A332,_en-route,_near_Dar_es_Salaam_Tanzania,_2012


IN CASE OF
EMERGENCY
BREAK THE GLASS

- On 2 September 2013, a Boeing 737 crew delayed their go around at Delhi despite it becoming obvious that they were not going to get a landing clearance because an A320 was taking off from the same runway. Despite VMC prevailing and both aircraft being on the same frequency, the 737 was then flown straight ahead on go around so that it began to catch up with the unsighted A320 also climbing, but at a faster, rate below. The 737 crew then received a TCAS RA to DESCEND which they were very slow to respond to. As the A320 crew responded to their coordinated TCAS CLIMB RA, the 737 RA strengthened to INCREASE DESCENT. At the very last minute, the 737 crew spotted the A320 about to climb through their level and made a rapid 30° bank as they passed within 90 metres of each other at 1600 feet agl[2]. You might well ask what the role of ATC was in all this but that makes no difference to the fact that situational awareness would have enabled the 737 crew to foresee and fully mitigate the risk of collision in a situation where the aircraft were only just sufficiently clear of the terrain for TCAS II to generate RAs.

- On 15 March 2012, a Norwegian Air Force Hercules was on a positioning transport flight over northern Sweden when it descended into uncontrolled airspace below MSA and entered IMC. Shortly after levelling at FL070, it flew into the side of a 6608 foot high mountain which destroyed the aircraft and killed everybody on board[3]. The Investigation attributed the accident primarily to the crew and noted that they had selected an EGPWS mode of operation which had no terrain database at the latitude they were flying.

All three of the aircraft in the examples quoted above were relatively new designs which in many ways enhance overall crew awareness, but do so passively. So my final observation is that I am not sure whether we have fully understood the challenge which the 'age of information' we now live in has created for the maintenance of proactive situational awareness as well as informed reactive situational awareness. Or whether we are getting so good at detecting problems automatically that we will soon be able to outsource 'proactive' situational awareness to computers. A good example is the increasing prevalence of the Visual Situation Display (VSD). Pilots no longer have to actively deduce whether they are descending towards their destination, the VSD shows them the situation and saves them the trouble. But what does this do for the maintenance of an active mind during a typical flight in which relative boredom often increasingly characterises most of it apart from the take off and the non-automatic landing? And does it matter? Unless the 'machine' can also deal with the problem detected, I suggest that it probably does matter. A reduction in 'before-the-event' situational awareness due to reliance on passive acquisition of information rather than active is likely to increase the time it takes to revert to an active reality on the rare occasions when something abnormal or otherwise unexpected does occur. There is a good chance that we are watching the decline of active situational awareness and if we then rely solely on 'reactive' situational awareness then we have arguably removed a significant barrier to an unwanted outcome. And that is before the case where, on a particular day, the automated aeroplane is not quite 100% – the MEL has allowed despatch without that VSD which you are now so accustomed to relying on for situational awareness – that you need to revert to the application of mental agility. But will this be easy, or even possible, unless more training time is allocated to both the 'old-fashioned' and now 'back up' ways of actively maintaining routine situational awareness as well as the new ways?

So we need to ask how best do we persuade the pilots of today and those who are concerned with their professional competence that proactive self-generated rather than simply received routine situational awareness is still important - and train them accordingly.

We also need to persuade system designers that one of their primary objectives in an automated flight deck is not only to deliver an environment which is 'pilot-proof' but one which, to the extent possible, also effectively supports proactive as well as reactive situational awareness.

CAPTAIN ED **POOLEY**

is an Air Operations Safety Adviser with over 30 years experience as an airline pilot including significant periods as a Check/Training Captain and as an Accident/ Incident Investigator. He was Head of Safety Oversight for a large short haul airline operation for over 10 years where his team was responsible for independent monitoring of all aspects of operational safety.

2- see more at: http://www.skybrary.aero/index.php/A320/B738,_vicinity_Delhi_India,_2013
3- see more at: http://www.skybrary.aero/index.php/C30J,_en-route,_northern_Sweden_2012

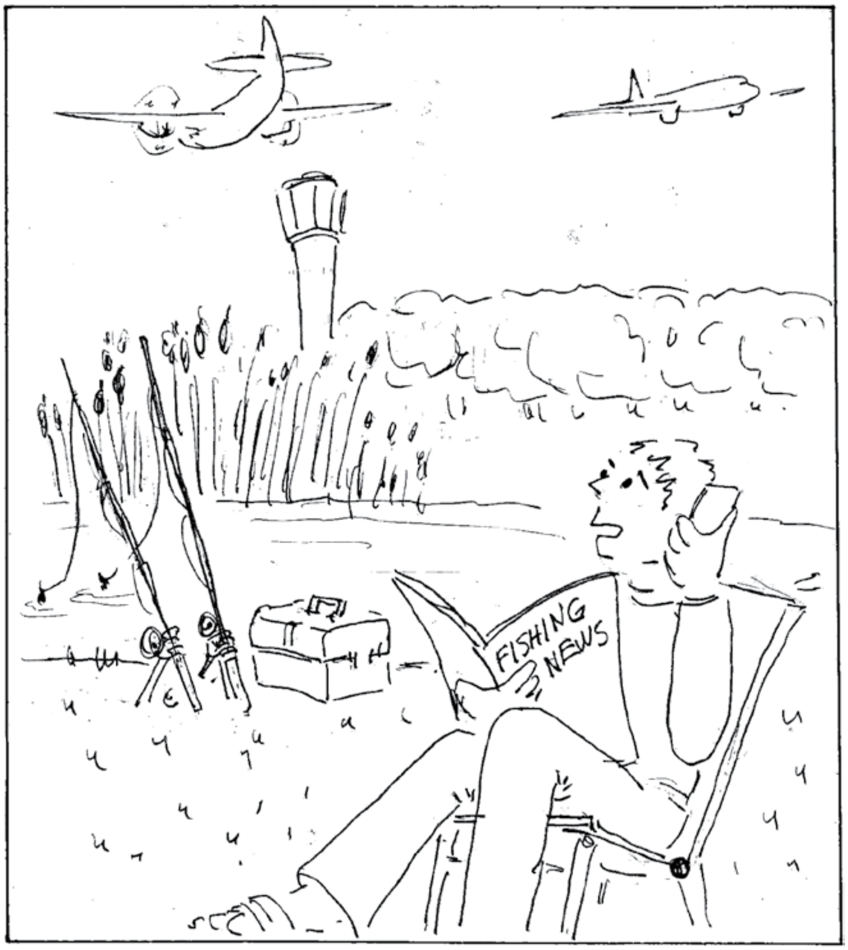
THE BLUE PRAM by Bengt Collin

At Arrival Service

The woman was standing in front of the desk. She was dressed in a casual way, blue jeans, green t-shirt and a dark green jacket. She had a grey suitcase. She was holding a small baby, probably around six months old, in her arms. "I just arrived from Anywhere Airport, my pram hasn't arrived. It's a blue pram, a very nice looking pram if I may say so. Do you know where it is?" "Roy, could you please check for this lady's pram, it's missing. Please start with the luggage hall behind the public area, look for a blue pram, it must be somewhere in there. It just arrived from Anywhere Airport."

The woman continued: "First that scary flight, then this"; she was upset. "I was looking out of the aircraft window, we just descended below cloud when I saw the ground just below us", she closed her eyes and stayed silent for a second. "The Captain said something about an aircraft on the runway, I never saw the runway". She paused again, continued with a puzzled voice; "after ten more minutes we landed". "Isn't that strange"?

"Well, it depends on how you look on things, doesn't it" he replied. "You probably don't have the full picture".



Yeah Boss, I'm just reading the briefing and I've started to follow the traffic. Let me grab my gear and I'll be in position in 10 minutes

BENGT **COLLIN**

formerly worked at EUROCONTROL HQ as a Senior Expert involved in operational ATC safety activities. Bengt has a long background as Tower and Approach controller at Stockholm-Arlanda Airport, Sweden

Roy slowly walked away, leaving them on their own. The sound from Roy's shoes sliding over the terminal floor was apparent, he never lifted his feet properly. Why can't Roy walk like other normal people, he thought?

On the Flight Deck BRM299

It was Susan's first flight after a ten days well deserved vacation. She had accumulated thousands of hours of flying experience as a first officer, but only a few on this aircraft type; she felt well prepared though. They were heading north descending through flight level 120 for an approach to runway 18 Left. To her left, was Bob, the Airline's main instructor and examiner. Bob was also in charge of flight operations for the Airline, a true legend, very experienced indeed. She liked the idea of becoming a Captain like Bob!

In the Approach Centre

He arrived just on time for the start of his shift. All the computers for individual briefing were available, obviously everybody else had already arrived for the evening shift. This was his fifth day in a row at work, to save time he immediately pressed the check-in button on the HMI and entered the centre. He passed the supervisor desk, "Hi, I made it just on time didn't I". "Anything unclear, you know about the Minimum Safe..", he interrupted the supervisor, "I understand everything"; he decided it was time for a cup of coffee, after all everybody just started working. "OK", the supervisor replied while continuing reading the document in front of her.

In the Somewhere Tower

"We need to change the runway again, this rules are really annoying", Dagmar said to Mo, the tower supervisor who just re-entered the tower. Two months earlier the new environmental rules on landing and departure directions were introduced. Regardless of the wind the controllers were only allowed to use the same runway configuration for a maximum of two hours, stupid. "Mo, can you please assist me in coordinating a change to runway 36 left"? Dagmar co-ordinated with the approach controller herself, at the same time turning away from her working position; time for a healthy orange juice and a glass of water "Grey dull weather this evening Dagmar. But it's dark, you wouldn't have seen the sun anyway", he said in a positive way while coordinating with the supervisor in the centre. He finally sat down in a comfortable armchair and began reading a copy of HindSight Magazine.

In the Approach Centre

He sat down in his working position. Quite busy but he liked that. Eight inbound aircraft expected the next twenty minutes to Somewhere Airport plus one to the smaller Whenever Airport. A few departures expected too. The tower controller from Somewhere Airport called, asking for a change of the runway direction. "OK, no problem we can change immediately if you like. BRM299 will be the first one to runway 36 left.

On the Flight Deck BRM299

Susan, as 'Pilot Not Flying', checked the latest weather on the ATIS. OK visibility, still runway 18 left for landing. Should be a relaxed and uneventful approach. It was her birthday, she knew her partner was preparing a special meal for them, warm herring with blue berry pudding. Yum, yum! She was interrupted in by the approach controller calling on the frequency. "BRM229, turn left heading two four five, new runway for landing 36 left". "OK, it will save us at least 10 minutes, I like to get home as soon as possible", the Captain commented after they replied to the controller. Soon after beginning radar vectoring, with the aircraft auto pilot engaged, the controller asked them if the 30 nm remaining was sufficient. He realised they were too high, but with his experience it should be no problem. They started the briefing for the new runway.

In the Somewhere Tower

"Mo, the visibility is getting worse, we need to prepare for runway 36 right instead and initiate CAT III". Annoying since they just changed runway some five minutes ago; Dagmar called the approach controller.

In the Approach Centre

"BRM299 prepare now for runway 36 right frequency 111.6 due weather conditions" Another aircraft called causing a blocked transmission. He replied the other aircraft. The first aircraft BRM299 was really fast, the label on his HMI indicated 240 knots. It was really getting busy, he should have called for a Final Director to assist him but now he didn't have time.

On the Flight Deck BRM299

"ILS selected", the First Officer advised. "Select flaps one", the Captain instructed . "Traffic is starting to build up" the First Officer replied. "That was for us" the Captain commented after a call on the frequency. OK sorry, Susan replied to the call "Heading 260, cleared for approach runway 36 left, BRM299.

At the Approach Centre

"ABC123 fly heading two nine five". "Heading two nine five ABC123". "BRM299 turn right heading two eight five, vectoring for ILS runway 36 right". He noticed BRM descending rapidly but since it was still a bit high he decided to delay the inbound turn as long as possible.

On the Flight Deck BRM299

"Heading two eight five, runway 36 right BRM299" Susan replied. "Runway 36 right??? I need to program the FMGS for runway 36 right" Bob said. "Can you please take over controls for a while Susan?" Bob started programming, something went wrong the first time he tried, but he was successful the second. He thought of requesting a new approach, but changed his mind considering all the inbound aircraft behind them. He took over again as Pilot Flying and activated the APP mode. "Capture" happened almost immediately whilst passing the localizer at an angle of ninety degrees. The auto pilot introduced a bank right with some sideslip to capture the localizer beam.

At the Approach Centre

He was just about to turn BRM299 inbound when another pilot called. Well, they managed to turn inbound anyway, he observed the inbound turn on his HMI.

In the Tower

"Mo, please come and look at my approach HMI. BRM299 is indicating 260 knots abeam twelve miles final". "Must be a new record, we need to urgently extend the runway by a few kilometres to allow necessary distance for landing". Dagmar regretted her words immediately, luckily they were not recorded anywhere. Mo didn't reply - he was snoring.

On the Flight Deck BRM299

"SPEED, SPEED", Susan saw the Flap 1 limit of 230 knots (indicated) was going to be exceeded and tried to alert the Captain. "TERRAIN AHEAD, TERRAIN AHEAD", the warning from the on board system was synthetic, clear and impossible to misunderstand.

At the Approach Centre

His Minimum Safe Altitude Warning system activated. Since the sound of the alert due to a planned software update was out of service (notified in the computer based controller briefing), he did not immediately notice. After turning away from his HMI for a few seconds, discussing with a colleague how to best fry herring, he turned back. An alert, why was there no sound? Trying to understand the situation, waiting a few seconds, he acted. "BRM299 maintain altitude, you are too low, you are below the glide". No reply from flight deck. "BRM check your altitude immediately, you are too low".

At Arrival service

"Here it is, blue as you asked for." Roy looked happy and satisfied. "But Roy, that's a blue suitcase, not a blue pram." "Well, it depends how you look on things, doesn't it?"

CASE STUDY COMMENT 1
DRAGAN MILANOVSKI

A few opportunities to alter the unfortunate chain of events that led to this incident were missed, both in the air and on the ground. Sometimes we get so engaged by the situation and so focussed on the desired positive outcome that we cannot see anything else beyond that. It is against human nature to "zoom out" a bit while executing complex, but also routine tasks that usually end up being uneventful...

That is why we need training that will enable recognition of situations that require switching to the slow thinking mode where the bigger picture is more apparent and where, as with hindsight, it becomes so obvious something else needs to be done.

At first this looks to be contradictory to what we are trying to achieve with training. Well at least in the traditional sense where the main objective is to develop knowledge and skills that enable controllers and pilots to perform repetitive and complex tasks as routines. This is necessary in order to handle the complexity of the job without suffering from mental overload. Controllers and pilots must be able to perform while their brains "operate on autopilot". This case study shows that although this is necessary it is also not enough.

Let's look at the actions of the approach controller. Other participants in this incident can also be looked at in a similar way. The questions would be very similar, if not the same:

- All of us have been in situations when it is so tempting to feel you are on top of things and go for a cup of coffee. Doing more or less the same briefing several days in a row certainly feels like an unnecessary waste of time. So what makes you avoid the "I understand everything" situation and force yourself into another briefing and more importantly into a short "what does it mean for me" reflection?
- Controllers can ask for assistance when necessary and they all know how to do it. However, what makes you ask for assistance in time, before it becomes too busy?
- Changing the runway in use is a routine task, controllers know perfectly well how to perform it and have a very good appreciation of what it means to those crews that are first to be affected by the change. So what makes you consider and actively offer alternatives for the first few aircraft in the sequence? This is especially true for the situations where a second change is necessary relatively soon after the first. Why do you dedicate more attention to these aircraft and why do you make sure the crews are well informed about the situation?
- Deteriorating weather certainly needs to be taken into account at a certain stage. What makes you start building-in larger safety buffers into your control actions due to complex weather?

I am sure you can come up with a lot of similar questions yourself that eventually lead to the same answer: You can do all this because besides the required knowledge and skills you also have the appropriate attitude that enables you to perform (use your knowledge and skills) in a competent manner i.e. to engage the slow thinking mode when the situation requires it. A blue suitcase or a blue pram – it certainly depends on how you look at things, doesn't it?

A RECOMMENDATION
Addressing the right attitudes in training, in an integrated manner while developing knowledge and skills, is essential. This is even more relevant for refresher training as we often take it for granted that attitudes are built in.

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is an ATC training expert at the EUROCONTROL Institute of Air Navigation Services in Luxembourg. Most of his operational experience comes from Skopje ACC where he worked for a number of years in different operational posts.

CASE STUDY COMMENT 2
SHOTA JANASHIA

Briefings before you take over the shift can be a boring routine for aviation personnel...

From my own experience (shame on me) I can tell that longer you are in the aviation industry, the less attention you usually pay to it. I mean, come on, we are aviation professionals (Pilots, ATCOs, Technicians etc.), we are trained to perform under any conditions, we can figure out ourselves what is going on. Just let me sit in that chair and I will deliver a performance you will not forget soon. New restrictions, regulations, software malfunctions, weather forecast – piece of cake, I will figure it out in a few seconds! Easy!

Well sometimes that few seconds are the difference between operations that are "relaxed and uneventful" and incidents.

Let's take a look at our case, specifically at the Approach Centre controller. He "made it just in time" for the evening shift. "Just in time" to take over the duty without a proper briefing. I am not surprised that briefings annoy controllers (let's be honest they never are entertaining), but over the time you learn how to select important data out of the excessive information provided during a briefing. Of course you have to receive a proper briefing to be able to do so. And who is responsible for a proper briefing? Certainly it is our duty to be professionals enough not to take over the shift without having proper situational awareness. Then there are Shift supervisors. Normally it is written in supervisor's job description that they should provide a briefing to their controllers. In our case the supervisor was going to ask the controller if he knew about the software updates, but she was interrupted by the controller's "I understand everything". After the answer to an unfinished question the supervisor just continues reading the document in front of her. That is not how you ensure that a controller in your shift gets a proper briefing.

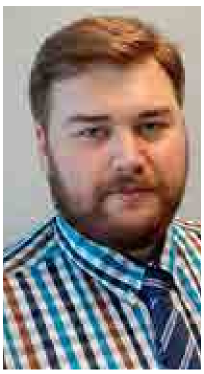
Now back to controller. I believe that he honestly thought he understood everything. After all it was "his fifth day in a row at work". He simply assumed that this shift would not be any different to the last four. And assumption is often a mother of all screw-ups. The Approach Centre controller's HMI might have been functioning in a same manner during the previous four shifts, but that does not mean that it would continue like that forever. And it did not. The controller should have been pre-warned about the change, because one of the notifications included in the computer based controller briefing was about the planned software update which would involve the sound of the Safe Altitude Warning not being available because of it.

In the aviation industry things change all the time and all the changes are important. Personnel impacted by a change should be notified about it as soon as possible. Having information about even seemingly unimportant alterations is a way to save time in day-to-day operations. And sometimes saved time means saved life.

Our case is a good example of how important a few seconds can be both for pilots and for a controller. It took the controller a few second to understand why the Minimum Safe Altitude Warning signal had activated but without sound. By the time he acted, the aircraft was already below the glide path. If controller had received a proper briefing, he would not have been puzzled by a silent alert and would have been able to give timely advice to the aircraft about its low altitude.

A RECOMMENDATION
The ANSP should ensure that all of controllers receive a proper briefing prior taking over the shift. The Time needed for a briefing should be included in shifts, so that controllers would only be able to check-in at their positions after receiving a full briefing.

SHOTA
JANASHIA



is currently employed as a safety officer in "Sakaeronavigatsia" Ltd, the Georgian ANSP. He is a licensed air traffic controller and OJTI with 10 years experience in different operational posts.

CASE STUDY COMMENT 3
CAPT. WOLFGANG STARKE

"Haste makes waste", and with those three words we might end the comment already as the rushed approach was certainly not contributing to safety in air transportation. But is there maybe a little bit more one can learn from this case study?

The guy in the arrival hall told the lady, with her missing pram, that it depends on how you look on things. We probably don't have the whole picture. So let's try to look at the incident that has taken place at Somewhere airport from a different angle. Let's not just blame the flight crew for a rushed approach but rather ask how these incidents can happen over and over again despite all the high quality training operational staff gets.

Setting the scene

Chapter 1, the crew complement

A first officer with quite a bit of flying experience but being totally new on this particular aircraft type. Sitting next to her is a very senior and well-respected instructor and examiner. His young first officer admires him, likely she will accept everything he does as correct and that it is done for a certain reason, even if she don't fully understand (but does not query neither). Such a complement was a contributing factor to the fatal crash at Tenerife some 30 years ago.

In this story the Captain is likely to be eager for cost savings as he is responsible person for flight operations. The first Officer is not in a hurry but it is her birthday and her partner is expected to prepare a descent dinner. She has by far no objections getting home early.

Chapter 2, the air traffic control staff

The controller came in late for his shift, rushing through his briefing. In fact, the controller did not do any briefing, he just confirmed check-in. The supervisor knew the Controller well and maybe therefore did not insist confirming the controller was aware of the minimum safe altitude alert sound inhibit. As he was on his fifth consecutive shift he missed to reassure everything is unchanged. A little bit complacent but normally not a major problem.

Chapter 3, the rules

Nowadays rules occasionally do not follow the principle of "safety first" but are rather attributed to environmental issues, economic pressure or political decisions. When looking at the different rules and restrictions as isolated rules, none of them seem to be an issue.

The chain of events

For some local reason an arriving aircraft was changed from Runway 18 left to Runway 36 left. That change reduces available track miles into the airport significantly. Normally a flight crew would ask for additional track miles or delay vectors but given the high amount of traffic this time the flight crew decides to rush their descent.

A decision that was taken by the captain but not being queried by his first officer.

Almost immediately after changing the runways ATC needed to change the runways again due to the prevailing weather conditions in combination with the environmental rules. Without the environmental rules in place there would likely have been no runway change.

Also procedures at the Approach Centre was getting a little rushed. If well prepared the controller would have expected this and there would probably have been an assisting director ready at hand.

The change from runway 36 left to 36 right probably added the amount of workload that was required to overload the two pilots. Busting their intercept coming ways too low and fast into a dangerous situation. The situation was even more dangerous as the controller skipped his briefing and therefore was not aware of a degradation of his safety nets, delaying his actions to warn the crew.

WOLFGANG **STARKE**

is a Bombardier Dash8-Q400 check captain and type-rating instructor with the Air Berlin group. He chairs the Air Traffic Management and Aerodromes Working Group of European Cockpit Association (ECA) and serves on committees for the Vereinigung Cockpit (German Air Line Pilots' Association) and for IFALPA (International Federation of Air Line Pilots' Associations). He is an IFALPA representative member of ICAO's Surveillance Panel.

The conclusion

If you look at all the things that happened, nothing seems out of the ordinary when assessed as isolated events. It is just the combination that makes the sum of all the little things that becomes a very dangerous and potentially fatal situation.

Of course, in hindsight one is wondering why people do not state "unable" more early. But sitting at the operational staff working position in that situation is somewhat different. Of course the airline demands the pilots to fly safe all the time. Same time pilots are asked whether they can possibly hurry just a little bit as the connection time for their passengers at the destination is rather short and the airline does not want to produce hundreds of minutes of delay.

ATC of course has safety as their highest goal but same time trying to offer short and economic routes. An air traffic controller does not normally instruct a short approach or less track miles but usually offers a shorter approach. Something an airline pilots in a hurry is likely to accept.

In the end we all occasionally accept a small deviation from standard operating procedures and well-accepted best way of practices. Be it the controller skipping his briefing on the fifth consecutive shift as he is a little late anyway or the pilot rushing approach and briefings favor of saving some minutes of flight time.

We all do not hesitate to do so, as this one little non-standard is just a little, little one. As it is such a little one it will not degrade safety of the flight.

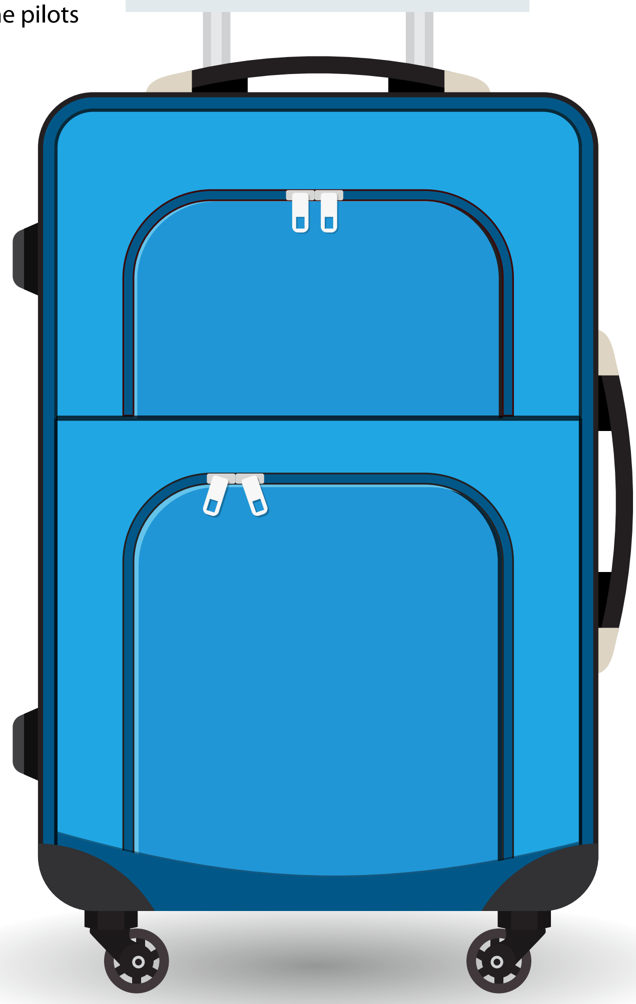
What we all need to remember is the following; if you drink one large beer or three small ones does not make any difference, you will in either case not be allowed to drive your car afterwards.

In aviation the same is true. One major non-standard is not better nor worse than doing a couple of small non-standards. Eventually one will be out of the normal procedures and patterns and risk of incident or accident is increased.

At the first moment you are not able to cope with a given workload by using normal procedures and best ways of practise is the moment when you definitely need to state "UNABLE".

Sometimes it does not depend on how you look at things, sometimes you need to be rigid. There is for sure a difference between a blue pram and a blue trolley, the latter one would not help the young mother with her little child, regardless how you look at things!

A RECOMMENDATION
Changes can occur unexpectedly even within a run of consecutive duties. Always check for any unexpected changes and brief yourself thoroughly before every shift! S



SITUATIONAL AWARENESS **VERSUS TIME IN POSITION**

by Michaela Schwarz and Fuat Rusitovic

It has been widely accepted that Situation Awareness (SA) is important for effective decision-making and performance in Air Traffic Control (Endsley, 2006). HindSight asked Michaela Schwarz and Fuat Rusitovic to explain how SA is managed and ensured at Austro Control, Vienna.

What does Situation Awareness mean to you?

Fuat: Imagine sitting in front of a screen and suddenly one of your fellow controllers calls out "The Austrian is requesting 360!" What? Which of the 20 airborne Austrian Airlines flights is he/she referring to? Was this message for me?
Those are questions that would normally rise, if my situational awareness is compromised as an ATCO. However in the majority of the cases it is not and I instantly know that this message was for me and which aircraft was concerned. How come?

Michaela: In the basic ATCO training we teach that Situation Awareness consists of three elements (Endsley, 1988):

1. the perception of the elements in the environment (aircraft targets) within a volume of time and space,
2. the comprehension of their meaning; and
3. the projection of their status in the near future.

But how does it work in practice?

Fuat: When I start working in position, I receive a handover from the previous controller. He/she will give me a short briefing about the current traffic picture, things to do in the next few minutes, ongoing conflicts, unusual circumstances, adverse weather situations and so on. Basically I receive a part of his/her mental picture in order to build my own mental picture as quickly as possible and I don't have to start from scratch finding my way into the traffic situation When I am about to be released from position, I share my mental picture with the new controller coming in, so she can get started more easily.

Michaela: From a scientific perspective (Dominguez et al., 1994, p.7) an ATCO *'continuously extracts information from the environment (i.e. the radar screen/ aircraft label etc.), integrates that information to create a mental picture of the current situation and uses that picture in directing further perception and anticipating future events.'* (compare Figure 1)

So how long does it take to get the whole mental picture?

Fuat: To be honest, I don't know. It could be 2 minutes; it could be 7, 10 or as long as 15 minutes depending on the quality of the handover, the sector complexity and the time it takes to adjust my personal settings. There are so many bits and pieces in this puzzle that nobody could tell. And that puzzle changes all the time. Traffic load, traffic complexity, adverse weather, who is my sector partner, who works on the adjacent sectors, what other conversations are going on in the room (SUP instructions, private talks etc.).

So when I come back from my break I already take a look around to see

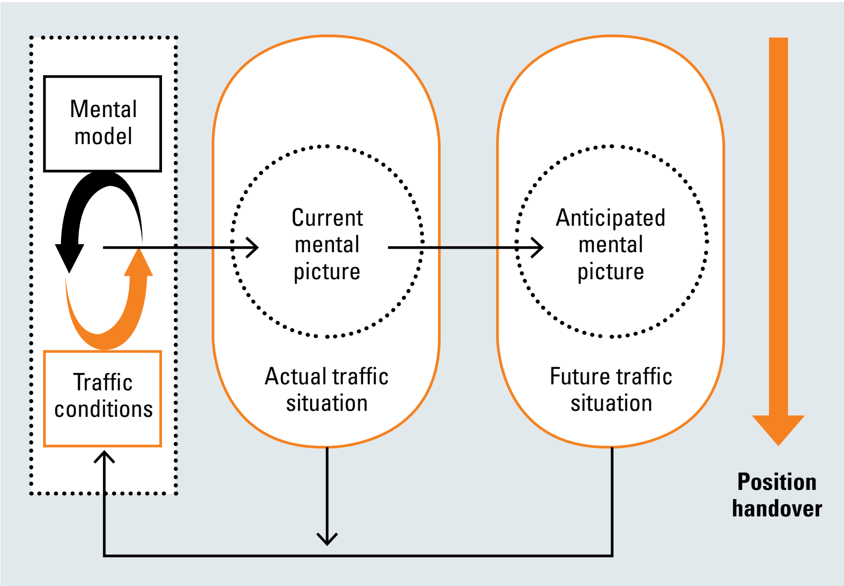


Figure 1 - Individual Situation Awareness Loop (Adapted from Kallus et al., 1998, p.9)

who is working on the other sectors. I receive another handover and setup my screen/ adjust my personal settings. I check the traffic in my sector and in the adjacent sectors. Are there departures from nearby airports? Will they get their requested flight level? Any inbounds to local or nearby airports that I will have to handle in the next 10 minutes?

> "Maintaining Situational Awareness is the fun part of ATC!"

Once you have the picture how do you keep it?

Fuat: The process of maintaining situation awareness is one of the parts that make my job so tough and exhausting. But it's also the fun part of it as it is challenging and rewarding. There is no better thing than feeling that you are absolutely aware of the situation and being able to predict actions that will happen in the next couple of minutes. We (ATCOs) consider it absolutely normal, that most of the times when an adjacent sector calls you, you already know what the other sector is going to say. Or you hear that an aircraft in the previous sector is requesting a direct routing and you coordinate that routing just before the previous sector calls. But it's a hard way to get there and requires a lot of training.

> "Keeping the situation awareness is like working on an assembly line"

Keeping the situational awareness as an ATCO is like working on an assembly line with information on it that moves at a very high speed. You have to take a quick look at every single piece of information and decide quickly if you need to further process that information or not.

Michaela: This process includes integrating information from various sources (compare Figure 2):

- aircraft label (e.g. speed, level, heading) on the main screen
- radar screen
- support screen (weather, CARD, flight plan/ lists)
- pilots
- CPDLC/ datalink?
- Verbal communication/ coordination within/between sectors
- Supervisor/sector chief
- Charts/ manuals? Any other?

Fuat: Furthermore you even have to decide early if you might need that information in the future. If you mistakenly discard relevant information or use the wrong/ outdated information, your situational awareness is compromised. Sometimes you may not recognize straight away that you missed out on a piece of information which is part of the big picture, such as turbulence reports from traffic at FL360 in the adjacent sector, because there is no traffic at that level in your area of responsibility. You only recognize that you missed it at the moment an aircraft is requesting the very same level. If you detect your mistake early, it might be insignificant, if you end up detecting the mistake late or not at all, your work can get difficult. You never know.

How do you train for Situation Awareness?

Fuat: Trainee controllers tend to focus on their own sector in the beginning, while neglecting what is going on around them in other sectors. With time they are trained to listen to what's going on in their immediate environment and observe actions of other controllers to complete their own traffic picture. "What if scenarios" help trainees to switch their attention between their own sector and other sectors. Moreover they learn to think ahead and project their own actions and actions of pilots and other controllers in the near future to anticipate certain actions.

So what is the hardest part for you?

Fuat: The hardest part is building that mental picture. Building up situational awareness takes time. No handover procedure in this world is capable of ensuring a complete transfer of the mental picture from one controller to

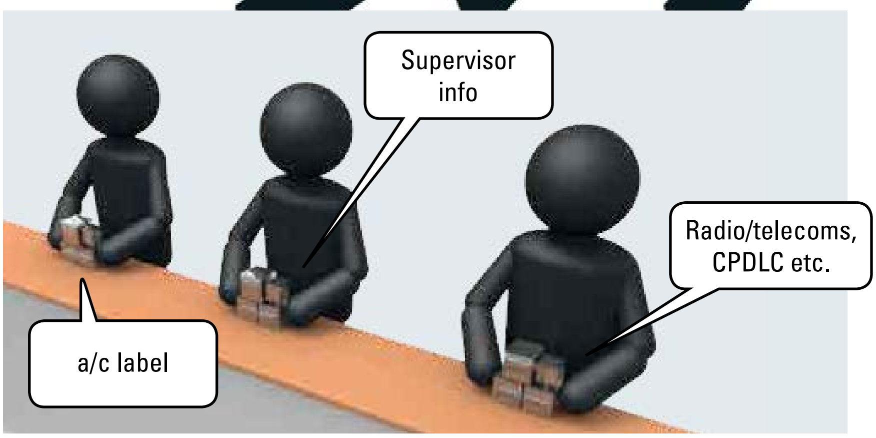


Figure 2 - Integration of information sources

another. You can highlight certain things, but you can't transfer the big picture with all of its details. That's probably the reason why statistically a majority of occurrences happens within 5-10 minutes after a position handover.

Michaela: From a HF perspective the hardest part is preventing human errors related to situation awareness on the assembly line. We follow a proactive approach and address Situation Awareness already at the design stage of new or changed operational equipment and procedures. The tricky part however is the interactive nature of SA subcomponents. When implementing new controller support tools or procedures that were initially designed to enhance SA, they may on a second look reduce SA on another unexpected and unmeasured factor (Wickens, 1995).

So what's the ultimate solution?

Michaela: The impact of changes to equipment, tools and procedures on SA can be measured through subjective and objective means. A complete review can be found in Endsley (1996). And in practice Fuat?

Fuat: Maintaining situational awareness is fun, but there is a good reason why the time in position is limited as an ATCO. Over time your brain gets mentally fatigued and information processing slows down. Even at off-peak times you have to keep the assembly line - let's call it quality management for information - working at a very high level. What are the adjacent sectors talking about, how will their traffic situation affect yours? Is an aircraft reporting adverse weather conditions in an adjacent sector? Just to make sure that the next call out of "Austrian is requesting 360!" does not come in unexpected.

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works as an ATCO and on-job-training instructor at the ACC Vienna. He is involved in the planning and development of pre-on-job simulator training and the coordination of the Team Resource Management program at Austro Control.

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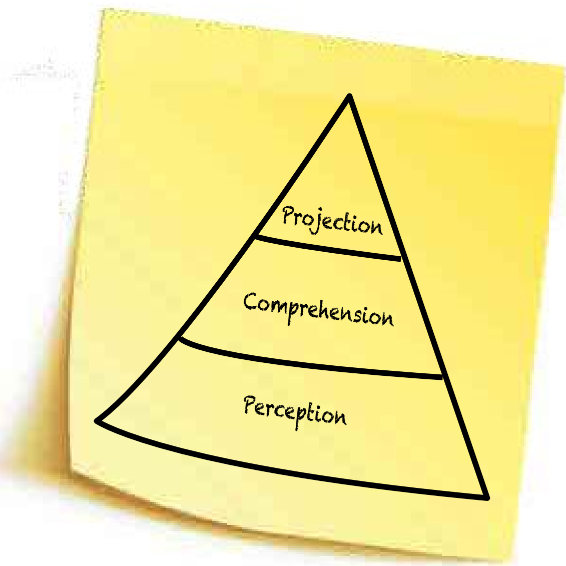
HOW MUCH ARE WE AWARE OF SITUATIONS?

by Florence-Marie Jégoux

"Passengers ending up in Rodez instead of Rhodes!" "In Italy, tourists found themselves more than 400 miles off track when, instead of entering Capri in their car GPS, they typed in Carpi, which is in the North of Italy!"

Who has never got lost while looking for a specific place? When I learned to fly, I was told that "there are only two kinds of private pilots: those who got lost, and… those who will!" And I think that it is the same for an ATCO: getting lost in a traffic situation in which there is something wrong, something they no longer understand.

The basis of Situational Awareness is the Endsley model (Figure 1).



PERCEPTION: the continuous extraction of environmental information

Some problems can occur in this phase: if we get too much data at a time, we get overloaded. We focus on just part of the information (tunnel vision) and miss the part that matters…

In the program at our last HF training workshop, we not only focused on visual and auditory illusions but also on the "blind spot". When trying to provide a definition for "blind spot", we came up with several different meanings:

- **The medical blind spot:** part of the retina that does not get any information, which leads the brain to « reconstruct a reality » based on surrounding available data. We performed a test to demonstrate it to controllers during the workshop. All of them were amazed to realise that we do not really "see" reality, instead our brain recreates what we think is real…
- **The driving blind spot,** which depends on the vehicle you use. Now panoramic wing mirrors us help a lot in our cars but certainly not that much when driving a mechanical digger… or during push back operations from specific stands for instance.
- **The flying blind spot:** put a descending low-wing aircraft above a high-wing aircraft flying level and you'll get the picture…
- **The radar blind spot:** in some areas, radars do not provide information: controllers usually know that in some specific areas, they lose radio and radar contact if pilots fly too low.
- **The personality blind spot:** blind spot even exists within ourselves, as in the Johari Window Model: other people might know things about ourselves that we don't.
- **The cultural blind spot:** we only become aware of the characteristics of our national culture when we go abroad, or in the control centre or team culture we may only see its characteristics when we change workplaces or teams.

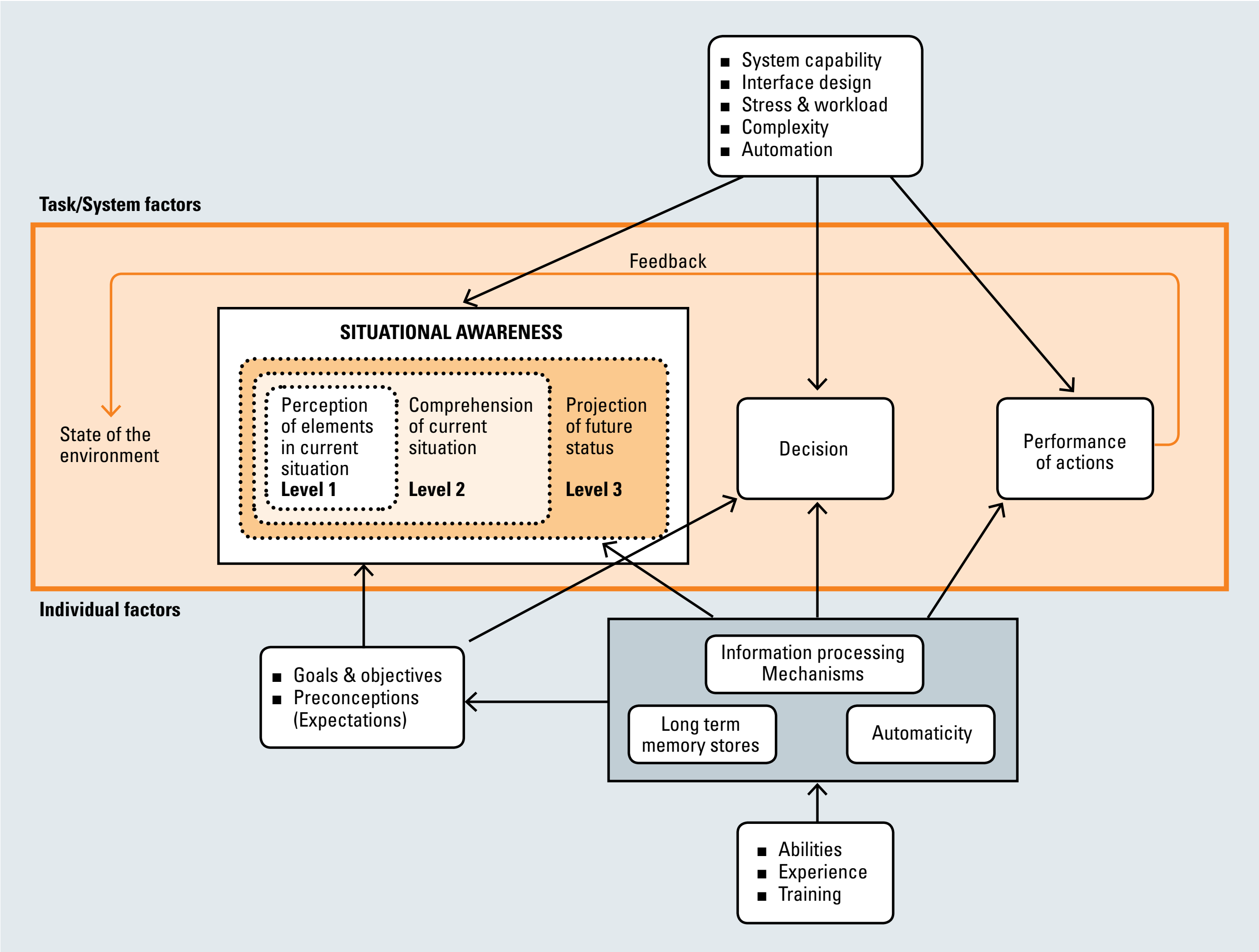


Figure 1 - the Endsley model

And the general meaning we found is "non-perception zone": meaning that in some situations, we do not perceive information is relevant or we do not even perceive it is there.

So, what can we do about it, knowing that in some situations we won't get the whole picture? Well, in systemic studies, it is interesting to get the opinion of a consultant or a coach to resolve problems: the outside view sometimes helps to reveal what we cannot see from the inside. It's the same in ATC: a team member can give additional information or raise a doubt which may help to realise that we've missed something.

We shouldn't be scared all the time by the fact of imperfect or partial perception but being aware of it can lead us to adapt, i.e. to change plans, to build in more margins, or to realise more quickly that we are on the wrong path, when comprehension is not that easy…

COMPREHENSION: integration of information with previous knowledge to form a coherent mental picture

What is interesting in HF is that we learn things we had no idea it existed before, although we use them on a daily basis… I didn't know that we could have different views of a situation, although I already had a glimpse of that, for example when friends or colleagues convinced me about their opinion. They put forward their arguments, we reasoned together and I sometimes had to admit that their arguments were much more valid and more interesting than mine. In such cases, I accepted their opinion and abandoned mine.

As you surely know, we are often quite reluctant to do that…

In a SA course I discovered that one person may also have many SA's. We weigh the pros and cons and we select the one that we prefer based on our experience and our trials and errors. So there is a very valid question: is our brain democratic? With time pressure and workload as a context, we may make up our mind according to the loudest voice, and get drawn into bias.
This could be the "recency effect", in which we tend to choose the most recent idea we got or the primacy effect, in which we even stop searching for the meaning at the first possibility we find, disregarding pertinent clues or meaningful data. Of course, this all happens within seconds or less: in air traffic control, during busy traffic sequences we certainly do not have time for years of academic research…

Instead, we tend to stick to the comprehension of a world in which we find ourselves right whilst projecting our best role in the play…

PROJECTION: use of the mental picture in directing further perception and anticipating future events

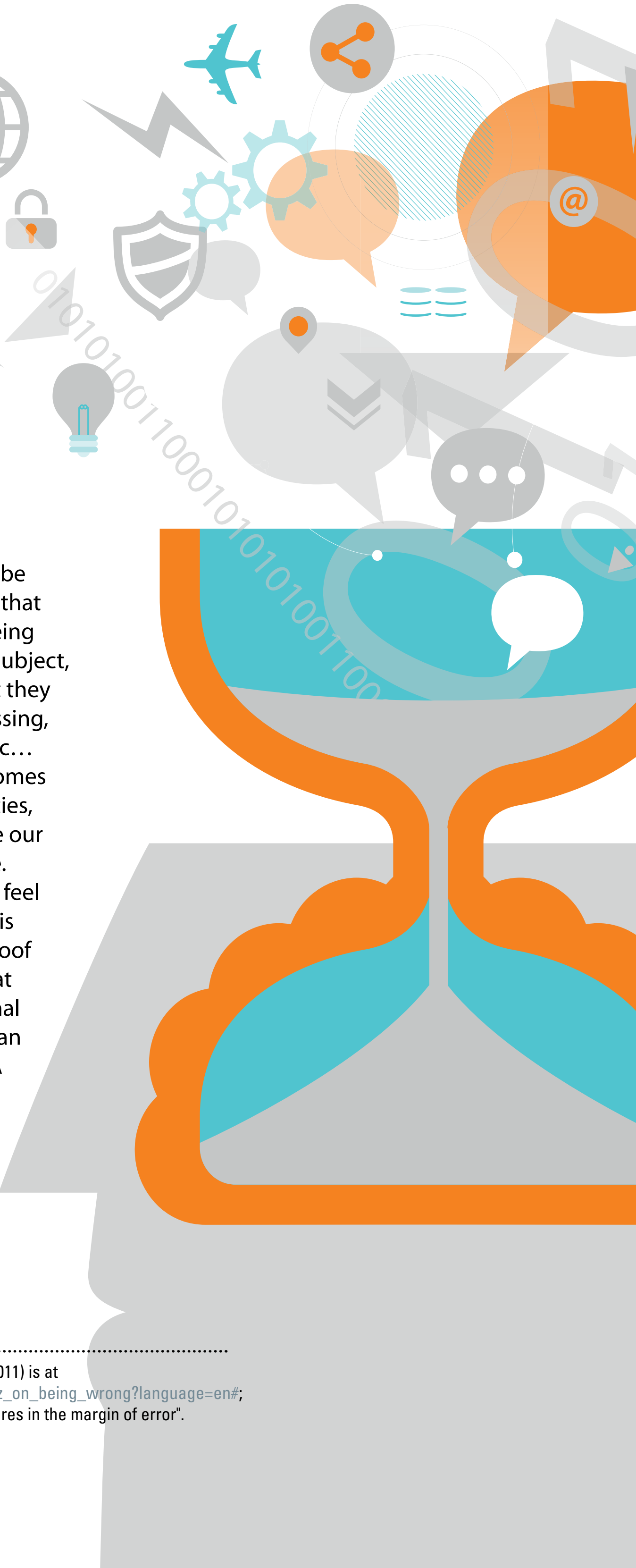
We usually imagine scenarios about the traffic, for example: "If he continues at this speed, he will end up catching up the aircraft ahead". It is like writing a theatre piece while figuring out what all the characters will do if they play the role we write for them. This part is crucial for decision-making and for supervising after acting. "If he's catching up the previous plane, I'd better ask him to reduce at 180kt when he passes overhead NEMOT". The script for acting and monitoring is then triggered. We gain many resources when we act and monitor automatically. It saves energy for what's left in the shift, which cannot be known for sure.

This automatic monitoring can get alarms when the parameters are not usual. It allows us to take them into account during the feedback loop.For instance, when airline companies started to use the "cost index" and asked pilots to fly accordingly, we got some very unusual speeds to deal with. As we were not aware of that policy, we were not looking for those parameters and made a projection which turned out to be wrong.

And we tend to prefer situational awareness where we are right. As Kathryn Schulz put it in her TED conference presentation or in her book[1] "How does it feel, to be wrong?" Just before we realise that we are wrong… "It feels like being right!" Basically, whatever the subject, none of us wants to admit that they are wrong. It can feel embarrassing, devastating, dreadful or horrific… Who likes that?? But when it comes to our professional competencies, it may be even trickier because our professional identity is at stake. We want to be competent and feel competent and so a part of us is ready to ignore any adverse proof just to confirm to ourselves that we are a competent professional controller, if not the best. We can disregard evidence that our SA is not good just to prove to ourselves that we are right, avoid negative feelings and save the energy which would be needed to change all our plans. How does it feel, to be unaware of the situation?

Yes, it feels like being aware…

Our inner movie theatre likes to play a very beautiful movie where planes land safely, performance is at its maximum and everything is all right. And luckily for us, unlike the illustrations above, 99,99% of the time, it's the right movie!



1- Kathryn Schultz's TED presentation (2011) is at http://www.ted.com/talks/kathryn_schulz_on_being_wrong?language=en#; her book is called "Being wrong, adventures in the margin of error".

Risk management

The question was "How much are we aware of the situations?" But another interesting one would be "How much can we be?"

We receive hundreds thousands of pieces of information every second from our environment and from our own body via our senses.

In the perception part of the SA, our brain has to filter them and pick out the most important ones, the ones that will be relevant to comprehension. If this selection does not work properly or if there are too much relevant data, we would end up with tons of data overloading our brain. This is typically what happens on a beautiful sunny day with VFR traffic all over the coast looking like bees around a honey pot. If you control low level coastal airspace, you will know what I mean: after working your shift, you don't even remember where you live or what colour your car is… We cannot use that mode for too long. We have to get some cognitive rest to "reset" it.

The imperative to "be aware" is not enough to counter a brain function that was not designed for controlling such a complex system without errors and thereby being right 100% of the time. Our brain does not function perfectly. It operates in a probabilistic way, which means that it does not seek to be exhaustive or perfect. It needs to make sense of the information it gets, be approximately right in most situations and quick enough to make timely decisions. So we can be aware up to the limits of our brain. And our brain is lazy or thrifty, depending on how we perceive it.

But its great advantage is that it is adaptive and creative: it can find solutions in unprecedented situations. This automatically happens in ATC, more than often. Have you ever experienced the creativity of VFR pilots? After more than 30 years in air traffic control, one of my colleagues told me that many times every year she carries on spotting new "procedures" and is amazed by this discovery: "I've never seen that one before!!"

Controllers who realise that they cannot be aware of everything may anticipate, set barriers, dispel doubts, take more margins and find other creative and adaptive ways to mitigate the risk. The system as a whole also has a strong role to play - managers, ATSEP, system designers and all the ancillary services are meant to support ATC and share risk management on an integrated basis.

However, the 99,99% times when we are right trigger another risk: that of becoming overconfident and losing sight of the 0.01% of remaining risk: "Oh, no, it never happens! No worries"… And this is why taking the experience of others into account is so important. It can help us avoid making the same mistakes, allow us to take advantage of their best practices and save time and energy so that we do not reinvent the wheel every day.

An airline pilot told us that his 12500 flying hours are just 2.5 days of his company flying experience … We tried to gather such data for ATCOs, but we found that it would be far too complicated. Anyway, it gave us food for thought. We surely cannot pretend to have a complete SA when a whole career includes only 2.5 days of company's experience…

Whatever our intelligence or experience, we will always make mistakes, we will always overlook important data one day. Zero-risk is a bias, not a possibility. Our responsibility is to build a system in which risk does not result in harmful consequences. This is why we work in teams and rely on others just as they rely on us - we help our colleagues and they help us. Team work makes it easier to combine all our SA's, getting more detection of our blind spots.

This is also why we use feedback and communicate lessons learned from experience. Our inner GPS sets the good target 99,99% of the time and the very few times we say or hear a wrong heading, our inner error detector is efficient enough to immediately correct it and put us back on one of the right tracks. Our professional experience, which is a kind of 'tracks library', is then enriched by our trials and errors as well as other's experience. S

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became an air traffic controller in 2004 working in the ANSP of Western France for the French Civil Aviation Authority (DGAC). For the last 6 years, she has been working as a Human Factors coordinator and specialist for their training department. She also works for the French HF National Group and is trained in systems theory. She was a private pilot for 10 years.

SITUATION AWARENESS **ANOTHER NAKED EMPEROR**

'On 11 April 2012, an aircraft commanded by a Training Captain who was also in charge of Air Operations for the airline was supervising a trainee Captain on a night passenger flight. The aircraft failed to establish on the Lyons ILS and, in IMC, descended sufficiently to activate both MSAW and EGPWS 'PULL UP' activations which prompted recovery. The investigation concluded that application of both normal and emergency procedures had been inadequate and had led to highly degraded situational awareness for both pilots'.

This is just one of many hundreds of incident investigation outcomes which attribute the failings to the crew, team or other unwitting individual. Like many factors which are associated with humans who lose or have degraded or incomplete situation awareness or SA, the reason is reasonably simple to diagnose, however without understanding why this has happened, those in aviation will never improve the appropriate mitigations. The problem lies in the term itself, since it is the product of more complex cognitive systems not merely a concept or in this and other incident and accident cases, a human construct.

First coming into popular use in the 1980's, when Mica Endsley and others discussed the phenomena, it was generally agreed that it was the information from immediate verbal and visual sources and to some extent knowledge from long-term memory that aligned to build situation awareness. This awareness then forms the basis on which correct decisions can be formulated and actions taken. Several definitions of this phenomena can be found and can be summarised as 'the extraction of information from the environment which is then integrated with operational knowledge and mental models, to create a mental picture of the situation which can be used to confirm and predict present and future events'. Defining situation awareness in this way indicates three levels of cognitive involvement regarding; firstly the perception of the situation, secondly, the comprehension of the situation and finally the projection of the present reality into the future.

However to be able to really understand what creates the structures and processes underlying this cognitive representation, one has to look to research within neurophysiological and neuropsychology. The research by Kosslyn (1980) and Farah (1985) concluded there were shared cognitive neurological structures for both the mental model accessed from long term memory and the mental picture as created and accessed within short term memory. Later research also documented that the production of images and their consequent use to enhance situation awareness occurred in a multi-modular fashion; that is the production and use of these images from their mental model is sequentially organised. There is also robust evidence from Farah (1985), Marks (1986) and Isaac (1990) that this production occurs in at least three stages. Firstly the images are created or compiled in the right occipital lobe, secondly these images are verified from elements of long-term memory in the frontal occipital region, and in the third stage they are used in the planning of sequential tasks which are generated in the left temporo-parietal area. This research also demonstrated that as a mental image is created from the mental model the consequent cortical activity can be mapped using an enhanced electroencephalographic (EEG) techniques (Isaac, 1990).

From this past experimental evidence, a three level system for the use of imagery to enhance situation awareness is suggested:

- **Level 1 - the perception** of the situation
- **Level 2 - the comprehension** of the situation
- **Level 3 - projection** of the situation into the future

This approach is identified as an important functional concept in the aviation environment, particularly when considering the creation of a traffic scenario which is then predicted in time and space for further consideration. This research evidence also indicates that the use of the term situation awareness is wholly inadequate if we are to continue to attribute incidents to a loss or degraded SA. We need to appreciate the individual cognitive elements which make up this 'ability' before we can make any judgements concerning the failure of SA in individuals. But how do we evaluate these cognitive elements?

Early experimental protocols and some recent research have attempted to evaluate and assess an individual's SA. However whilst some attempt to capture the elements mentioned above, few really investigate the cognitive elements which are attributable to SA. Some of these are mentioned below and lastly a more comprehensive approach is explained which has successfully been used with operational controllers in New Zealand and EUROCONTROL (Brétigny).

Early situation awareness assessment techniques:

A number of measures of situation awareness have been developed over the last few years. Each has its advantages and disadvantages and can summarised into three approaches:

1. Query techniques in which the subjects are asked directly about their perception of certain aspects of the situation.

2. Rating techniques in which either the subjects themselves or observers of the subjects are asked to rate SA along a number of dimensions, typically presented in a series of scales.

3. Performance based techniques in which the level of SA is inferred from the level of performance.

Assessing the three cognitive levels of SA:

The studies conducted in New Zealand and EUROCONTROL (Brétigny) considered the creating, verification and dynamic control of the 'mental picture' and the salience of the use of mental models in the production of the controllers' 'traffic picture' and, by implication, their situation awareness. It was also intended to take the developments in human information processing and detail which aspects of information processing were most relevant to the maintenance of the controller's picture.

The development of the measures for this research had elements of all the above examples and reflected the demands of short term memory which include:

- queries of relational information
- evaluation of individual ability in the use of their mental model and mental picture
- adaptation to the specificity of the ATC task

This first method was known as the Situation Awareness Strategy Questionnaire (SASQ).The Situation Awareness Strategy Questionnaire (SASQ) was developed to elicit and record the kinds of strategies used by air traffic controllers in their working environment. The particular section of the questionnaire used in this research concerned a 'screen failure' and the initial and subsequent actions and strategies taken by the controllers. The questionnaire also tried to establish the cognitive processes which were adopted by controllers and their use of visual, written or spoken recall of flight details together with their individual recovery strategies.
The second method used was known as the Situation Awareness Strategy Intervention (SASI) and included the following:

- queries of relational information
- queries in an operationally valid setting
- simulation which is not interrupted
- response time indicators
- adaptation to the characteristics of the task

The Situation Awareness Strategy Intervention (SASI) technique was developed after the results of the first experiments using the SASQ. This method consisted of scripts used in simulation which would elicit the search, retrieval and planning routines of the controllers. These intervention queries and activities were as follows:

evaluated the self reported ability to retain the mental model and traffic picture and the quality of the situation awareness during the failure of the system. This research was conducted with four independent groups over four consecutive years and found robust and repeatable results.

Intervention	Timing of Situation[5]	Query/Action
1. Pseudo pilot[6]	20 seconds after original instruction with 8 aircraft on frequency	TBR 366, say again heading?
2. Pseudo pilot	On first contact and in direct conflict with aircraft at FL 240	FLD 224, request climb to FL 240 due to weather?
3. Pseudo pilot	In response to an aircraft just identified requiring route clearance, the heading is made incorrectly (aircraft turns left)	CAC turn right heading 090 maintain flight level 330
4. Pseudo pilot	Introduces an unannounced flight at the far SE boarder of the sector	Aircraft label flashed for acceptance
5. Pseudo pilot	In response to a question from aircraft call sign PNK	PNK, request position of the next 'weigh points' to DELTA?
6. Observing subject matter expert	At a pre-defined moment and at the discretion of the expert	The expert covers a part of the radar screen and asks for any conflict or conflicting aircraft and if so their heading, altitude etc.

Table 1 - The SASI intervention queries and activities

The main advantage of these methods was that the researchers and subject matter experts could not only evaluate a controller's moment to moment awareness and their ability to continue controlling 'safely' with reduced system support, but also used valid queries relating to an operationally valid setting, but which did not interrupt the simulation activity. Finally the questionnaire

Human performance in this complex and integrated system is limited by two main factors, the functionality of the machinery and the functional capacity of the human. With the introduction of more automated systems in air traffic control and the flight-deck there will be a consequent effect on the operator's skills. Many of these changes will affect the skills and attributes which are inherent in the

1- All references to aircraft and positions was customised to the simulation chosen
2- Pseudo pilots are those personnel who work 'behind' the simulation as the pilots of the aircraft being controlled

creation and maintenance of SA, for instance:

- many of the spoken messages between controllers and between pilots and controllers will be replaced by transmitted data which will appear, if at all, automatically in visual form.
- a change in workload and work rate will have a consequent change in the creation of the operators 'picture'.
- the increasing introduction of systems which are more automated will change the creation of the mental model and its cognitive strength.

Situation awareness is sensitive to the demands of the short-term memory system. Research has shown that the iconic memory system (memories concerned with either pictorial or image representations) seems to be able to retain at least some information about visual images over a short period in the form or code similar to the original information. It also appears that the information is susceptible to disturbance by other visual stimulation (Isaac, 1990). This is a crucial factor when considering the visual information displayed and monitored by air traffic controllers and pilots in highly automated environments. In the context of these studies, the type of information, and the relatively short time periods normally associated with a dynamic air traffic control situation, suggest that immediate problems encountered by a controller will be due to the limitations of short-term memory, rather than information retrieval from long-term memory (Isaac, 1990).

And finally:

'On 28 July 2010, the crew of an aircraft lost contact with the runway at Islamabad during a visual circling approach and continued in IMC outside the protected area and flew into terrain after repeatedly ignoring EGPWS Terrain Alerts and PULL UP Warnings. The investigation concluded that the Captain had pre-planned a non-standard circuit which had been continued into IMC and had then failed to maintain situational awareness, control the aircraft through correct FMU inputs or respond to multiple EGPWS Warnings. The inexperienced First Officer appeared unwilling to take control in the absence of corrective action by the Captain'.

It has been recognised that SA is an essential pre-requisite for the safe operation of any complex dynamic system but unless we assign the relevant cognitive 'failures' to the individuals caught up in incidents and accidents we will never clearly articulate what went wrong nor how we can mitigate future events.

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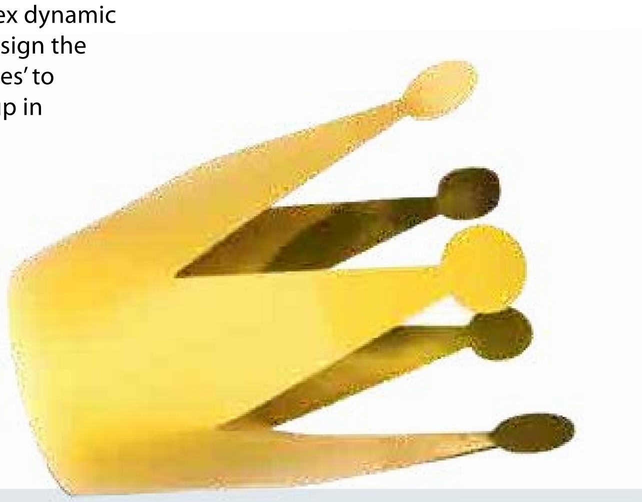
leads the Human Performance development work in the pilot/ controller interface in NATS, UK. She gained her PhD in Cognitive Neuropsychology at Otago University in New Zealand. Her previous work has been in the development of incident investigation tools and techniques in European ATM, the introduction of TRM into the ATC environment and the introduction of Day to Day Safety Surveys techniques into NATS. She has written several book chapters, academic papers and the book Air Traffic Control: the human performance factors.



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ORANGE IS THE NEW BLACK… ENHANCED AIRFIELD SIGNAGE TO IMPROVE SITUATIONAL AWARENESS IN THE VICINITY OF AERODROME CONSTRUCTION WORKS

by Gaël Le Bris, David Siewert and Robert Berlucchi

Over the years, the aviation community has regularly faced accidents and incidents associated with infrastructure and procedures modified during airport construction works. Some of these safety events could have been prevented by better visual alerting. Paris-CDG and the FAA Airport Construction Advisory Council (ACAC) worked with the user community and evaluated in the field innovative signage to enhance situational awareness.

Airside construction works are always sensitive activities since they involve constraining the aviation operations and often create temporary new hazards. Accident and incident data show that standards alone are not sufficient[1]. Specific measures must be carefully developed through a comprehensive safety risk management process involving pilots and air traffic controllers. The risk assessment should incorporate lessons learned from past experience and include such experiences at other airports. The readers of HindSight may be familiar with these issues since they have been previously discussed in this magazine[2],[3].

The key challenge for operational safety during construction works is situational awareness. Past occurrences demonstrate that the usual means of communication with the pilot community are not always sufficient. For instance, publishing an AIP Supplement even on an AIRAC cycle[4] is not the guarantee that this information will reach the flight deck. In 2008 an aircraft took off from a temporarily shortened runway at Paris-Charles de Gaulle (CDG), without being aware of the reduction. The aircraft performance was calculated by the pilots using the full runway length, despite reference to the reduction in a current AIP Supplement and verbal reminders from the controller[5]. Also, painting comprehensive and required markings when a runway threshold is temporarily relocated is not enough either. In 2009 at Chicago O'Hare, an aircraft undershoot a temporary displaced threshold (DTHR) despite the presence of the correct markings. After this incident and a field visit with pilots, these markings were reinforced beyond the standards so as to enhance their conspicuity[6]. Such events are not isolated and similar ones continue to occur all around the world.

1- Safety of the runway operations with a temporary displaced threshold during construction works, Gaël Le Bris, TRB/TRIS, 15 November 2013, http://docs.trb.org/prp/14-3126.pdf
2- Mind the gap… Keeping aircraft operations safe during runway construction works, Gaël Le Bris, Hindsight n°19, Summer 2014, pp. 58-61, http://www.skybrary.aero/bookshelf/books/2796.pdf
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4- http://www.skybrary.aero/index.php/Aeronautical_Information_Publications_(AIPs)
5- http://www.skybrary.aero/index.php/B738,_Paris_CDG_France,_2008
6- What's on Your Runway? (Expanded Version), Lessons Learned During Runway 28 Threshold Relocation – Chicago O'Hare International Airport (ORD) in 2009, Wayne Rosenkrans, AeroSafety World, July 2012: http://flightsafety.org/aerosafety-world-magazine/july-2012/construction-council

Innovating together to improve safety

The best solutions for aviation safety issues involving human decisions are always the simplest ones. With this in mind, airports on each side of the Atlantic Ocean worked simultaneously on similar ways of preventing accidents by increasing pilot awareness during taxiing. At Chicago O'Hare in 2009 and at Paris-CDG between 2011 and 2014, yellow signs with special messages were introduced. However, in Singapore in 2009, two aircraft took off without taking into account a reduction in runway length despite a lighted sign advising of the SHORTENED RUNWAY[7]. This showed that a distinctive variation of standard signage should be considered for temporary and safety-critical information.

In 2012, Paris-CDG and the ACAC met together and shared their experience and researches on airfield signage. They agreed to continue their common efforts in order to maximise their contribution to the improvement of the airfield safety during construction works.

Designing a new signage for construction sites

Specifying a new signage system means identifying specific messages and then selecting an appropriate graphical presentation (colours, lettering size, etc.). Different designs and colours were considered and a set of slightly but visibly different variants of the usual standard was selected for further investigation.

We usually think about two colours when it comes to construction works and safety: yellow and orange. Since yellow is already used in airfield signage for communication of regular information such as direction signs and markings, the ACAC came up with the idea of using an orange background as it was already used for temporary roadway signage in the United States.

We verified that orange was one of the two approved colors for construction signs in the Convention of Vienna on Road Traffic[8]. Also, it is the standard in many other countries including Canada, Brazil, New Zealand and Ireland. For the lettering, two different colors were considered and evaluated in the field: black and white.

For the text, the ACAC designed and evaluated variants built around three different signs: CONSTRUCTION AHEAD, CONSTRUCTION ON RAMP and RWY 8L TAKEOFF RUN AVAILABLE 10,000 FT (or any other runway designation and length). Paris-CDG performed parallel and complementary research focused on the development of specific messages for each one of the major hazards that could require increased situational awareness during taxi and takeoff.

7- http://www.skybrary.aero/index.php/A343,_Changi_Singapore,_2007
8- Convention of Vienna on Road Traffic, section G §I.4, version of 28 February 2012

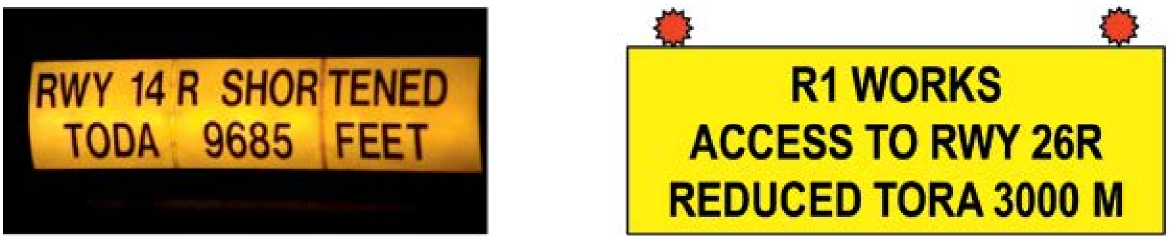

Figure 1 - Reduced TORA signs at Chicago O'Hare (2009) and Paris-CDG (2012)

Figure 2 - Roadway construction signs in different countries

These messages must be short, simple and straight-to-the-point.

The following is a list of the proposed messages:

- CONSTRUCTION AHEAD for situations where the risks are not precisely located and identifiable. For instance, this sign should be used when there is an increased risk of vehicle/pedestrian incursion from a construction site on operational taxiways. When the end of the section under construction is not clear, an END CONSTRUCTION sign should be added;

- MAX SPAN 65 m (or any other wingspan) is a text that has been used for years at Paris-CDG with very good results when the maximum allowable wingspan is reduced. This is a good, simple message;

- DEAD END is a message used for advising the crews that a taxiway temporarily terminates in a dead end. Previous messages included FROM X TO Y ONLY, with X and Y the names of the closest and farthest accessible stands. However, taxiway incursions occurred since this information did not specifically point out the problem as a dead end, it just implied that certain stands were not accessible;

- REDUCED 08L TAKEOFF RUN AVAILABLE 3000 m (or other runway length) is obviously the most important development in this project. It prevents the most critical accident possible for a departing aircraft -the collision at high speed with constructions.

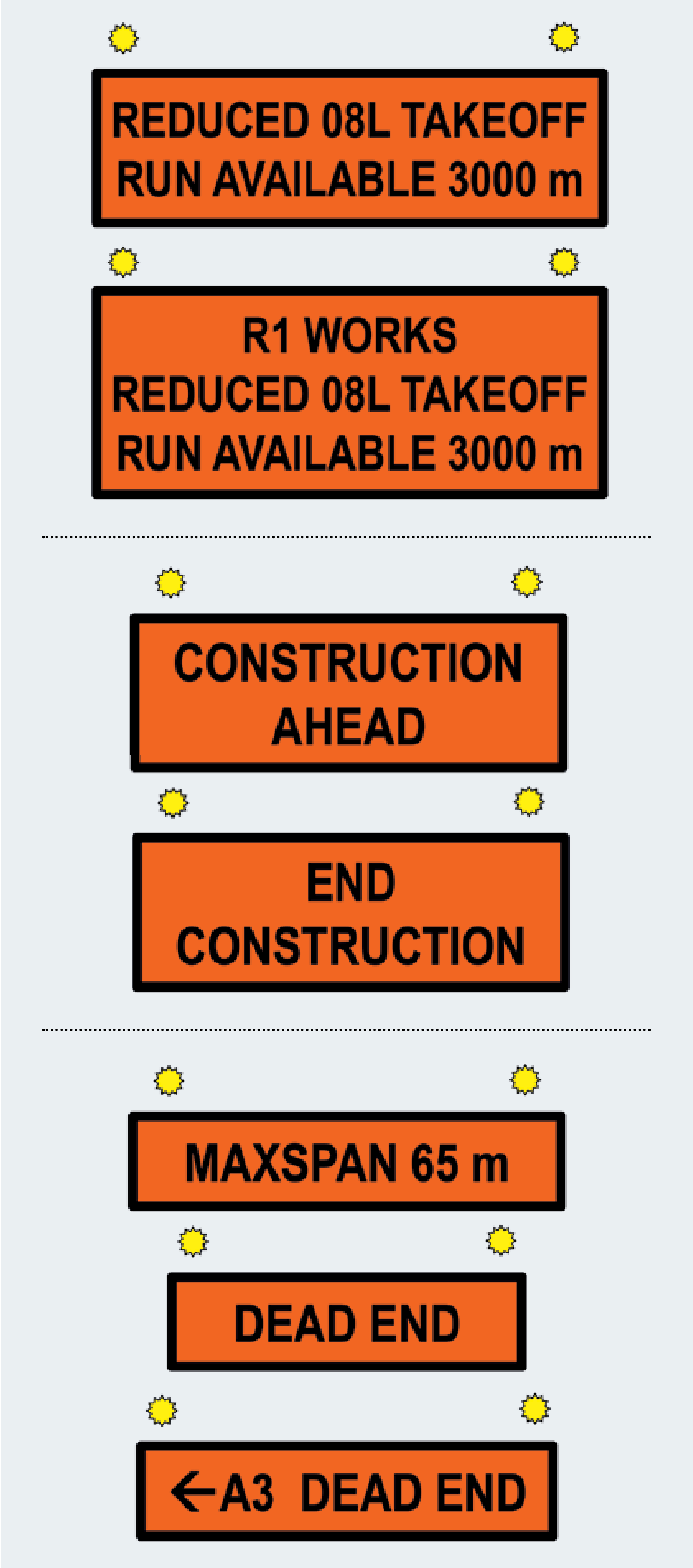

Figure 3 - Tempory information signs

The importance of field evaluation

The design process was performed by workgroups involving all the stakeholders in airside operations - pilots, air traffic controllers, towing service providers, airside drivers, etc. It was reviewed and validated by Local Runway Safety Teams (LRST)[9] also known as Runway Safety Teams (RSAT). However, whilst this approach to design can sound fine, it has little value if it is not trialed successfully in operation.

To validate the final sign prototypes, comprehensive field evaluations were conducted at a number of airports in 2013 and 2014 - Chicago O'Hare (ORD); Portland International (PDX); Theodore Francis Green (PVD); Long Island MacArthur (ISP); Orlando Sanford (SFB) and New York JFK.

Paris-CDG benefited from the FAA's trials and based on feedback from them, CDG designed a three-phase evaluation. Trials were conducted during actual taxiway construction works using operational ground routings. A questionnaire was prepared and sent to the airfield drivers and to pilots with the support and collaboration of their airlines - Air France, EasyJet, FedEx, SAS and Singapore Airlines. After passing orange signage, participants were invited to complete the questionnaire on paper or online.

The trial took place in three phases with each one taking account of the feedback from the previous one Phase 1 involved an orange background with a 300 mm-high lettering CONSTRUCTION AHEAD. Since the participants complained about the size of the letters and the conspicuity of the white lettering against the orange background, Phase 2 replaced the white lettering by a 400 mm-high black lettering and the same message. Phase 3 evaluated the marking variant with the text DEAD END.

The results of the evaluations

Overall, vehicle operators and pilots overwhelmingly agreed that the messages, character heights and colours of the black and orange signs were comprehensible, conspicuous and an effective way of providing alerts about construction activity.

At the six U.S. airports, 87% of 131 respondents (98 vehicle operators and 33 pilots), 'strongly agreed' or 'agreed' that the CONSTRUCTION AHEAD sign was conspicuous and 88% 'agreed' or 'strongly agreed' that the sign was readable from a sufficient distance. At Paris-CDG, 80% of the combined 116 respondents to Phases 1 and 2 (including 100% of the 17 respondents to Phase 2) understood the meaning of CONSTRUCTION AHEAD.

When evaluating the CONSTRUCTION ON RAMP sign, 92% of the combined total of 51 respondents in the U.S. campaign 'agreed' or 'strongly agreed' that the sign was conspicuous,88% 'agreed' or 'strongly agreed' that the sign was comprehensible at a sufficient distance and 94% 'strongly agreed' or 'agreed' that the sign adequately alerted them to temporary construction activity.

A total of 27 pilots and vehicle operators in the U.S. evaluated TORA signs providing available takeoff run information. Overall, 92% of them 'agreed' or 'strongly agreed' that these signs were conspicuous, 81% 'agreed' or 'strongly agreed' that the signs were comprehensible at a sufficient distance and 89% 'agreed' or 'strongly agreed' that the signs adequately alerted them to temporary construction activity.

At the six U.S. airports, 89% of the combined respondents 'agreed' or 'strongly agreed' that the CONSTRUCTION AHEAD sign provided an adequate alert of temporary construction activity. At CDG, 72% of the 110 respondents (including 100% of the respondents to Phase 2) agreed that the sign improved their situational awareness in the vicinity of construction.

9- http://www.skybrary.aero/index.php/Local_Runway_Safety_Teams_%28LRST%29

Figure 4 -Orange construction signs evaluated in the United States

Figure 5 - Orange construction signs evaluated at Paris-CDG

The final concept and operational deployment

At Paris-CDG, the set of orange signs was adopted as a best practice to be included in the safety risk assessments (SRA) of the airfield construction works. Each situation requiring enhanced visual information now has a specific orange sign, with variants adapting the concept to the local airside geometry including the alternative of a ground-marked version when there is no space for a vertical sign.

The ICAO (Annex 14) and the EASA CS ADR-DSN standards for the minimum height of the lettering is 30 cm for usual information signs. However, the feedback from the field trials clearly indicated that 40 cm high lettering is a minimum for all the aviation signs not just for runway signs.

The first operational deployment occurred in September 2015 with the CONSTRUCTION AHEAD sign. The goal was to increase the situation awareness on a modified ground routing where a possible confusion between a taxiway (non-runway entry) and a Rapid Exit Taxiway (RET) had been identified.

Following the publication of the final report of the U.S. study[10], the FAA has updated its standards. Advisory Circular 150/5370-2 Operational Safety on Airports During Construction has been modified to include safety orange construction signage as a visual aid to alert pilots and vehicle operators of existing airport construction. It is recommended that signs displaying CONSTRUCTION ON RAMP and CONSTRUCTION AHEAD are placed at locations leading to ramps and other areas with construction activity. When a runway is temporarily shortened due to construction, it is recommended that signs indicating the reduced takeoff run available (TORA) are placed at runway entrances.

Additionally, it is recommended that the overall size of the signs should be 76 cm (30 inches) high by 213 cm (84 inches) wide with the near side of the sign be placed perpendicular to and approximately 11 m (36 ft) from the taxiway pavement edge.

Both pilots and vehicle operators considered that either text TORA or the expanded text TAKEOFF RUN AVAILABLE acceptable for use on TORA signage. However, it was recommended that additional education be conducted to increase understanding of the TORA acronym to ensure pilots have adequate situational awareness in the case the runway is shortened.

Sharing best practice

This research project, "from the field to the field", developed a practical answer to a real and recurrent aviation safety issue. Of course, this is not a unique or magical solution, it must be used in association with other means of risk mitigation in order to help with the layered approach on which Reason's "cheese slices" for avoiding an accident are based[11].

Our efforts in collection, sharing and improvement of best practice go beyond the temporary information signage itself. In 2015, Paris-CDG and the ACAC participated in a webinar recorded by the Transportation Research Board (TRB) to sharing these practices with the community[12]. Also, the ACAC has, since 2011, maintained an inventory of best practices and lessons learned[13], while a coalition of airports within the Infrastructures Workgroup of Alfa-ACI[14] is preparing guides on how to conduct safe aerodrome works. These materials now include the orange signage among the recommended tools to ensuring safe airport operations during construction work. S

10- Development and Evaluation of Safety Orange Airport Construction Signage, Robert Bassey, October 2015, http://www.tc.faa.gov/its/worldpac/techrpt/tc15-52.pdf
11- http://www.skybrary.aero/index.php/James_Reason_HF_Model
12- TRB Straight to Recording for All: Safety of Runway Operations during Construction Works, http://www.trb.org/Main/Blurbs/173568.aspx
13- Runway-Taxiway Construction Best Practices & Lessons Learned, Revision H, 7 April 2014, http://www.faa.gov/airports/runway_safety/runway_construction/media/Rwy_Const_Lsn_Lrnd_Bst_Prc.pdf
14- The Alfa-ACI is the association of the French-speaking airports members of the Airports Council International (ACI).

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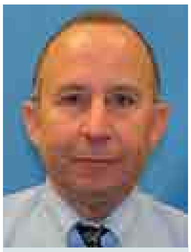

ROBERT **BERLUCCHI**

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IMPROVING SITUATIONAL AWARENESS THROUGH BETTER SOPS

by Captain Ed Pooley

I hope you will not disagree that effective SA is closely linked to the effectiveness of the SOPs that link us – directly or via an intervening system – to the reality upon which our operational decisions must be founded. They represent a significant part of the prevailing context for good SA.

On that basis, it is useful to reflect on how these SOPs are adopted. Some are mandated - or strongly encouraged – by the Safety Regulation Agency under which your activities are conducted. Many others are those advocated by the manufacturers of the systems you will be using which are almost always followed. Finally there are those adopted at an organisation level because the management believes they represent a beneficial addition to the previous two. Such practices have in the past often been added, removed or ignored at the personal whim of a senior manager in an organisation without much effort being made to assess the extent to which this action might affect safety improvement. For airlines, the extent of this third element has been dramatically reduced by the advent of aircraft manufacturer FCOMs and FCTMs. Few would dispute that these have been an extremely beneficial consequence of the advent of a wider definition of product liability than simply the airworthiness of the aircraft. But despite the reduction in the role of organisation management in respect of SOP decision making, the need for those airlines at the 'cutting edge' to demonstrate best practices which go beyond the main body of SOPs is still really important – especially in terms of maximising the SA of a two crew flight deck team. In all parts of the aviation sector, history shows us that the best practices of today often inspire the regulatory mandates of tomorrow - to put it more bluntly, safety regulation rarely leads and often follows!

With the foregoing in mind, I am going to look at a best practice SOP which, in my opinion and that of airlines which use it, greatly improves SA during an approach to land but which has not been widely adopted. In fact it is an idea which has been consistently ignored and in some cases even expressly dismissed without evaluation both at the organisational level and by many bodies with a responsibility for or a professed interest in safety. Of course the spread of good ideas is always subject to the "not invented here" or (for regulatory inspectors) the "we didn't do that in my airline" excuse, but in the example I will now describe, I'm sure there must be more to non-adoption than that.

My example is an alternative SOP for flying an approach – any approach whether flown in IMC or not. Most will appreciate that the usual procedure is that throughout an approach, one pilot controls the aircraft and is designated as 'Pilot Flying (PF) whilst the other – the Pilot Monitoring (PM) or Pilot not Flying (PNF) supports this task by carrying out ancillary duties and, crucially, monitoring the actions of the PF and their consequences for the aircraft flight path. Only in exceptional circumstances would a role reversal occur and then only in the interests of maintaining (or recovering to) a safe flight path when the PF has failed to do this. It is such an unfamiliar situation – particularly so if the one making an ad hoc take over is not the aircraft commander – that accidents often follow because take over does not occur. However, of wider significance is the fact that the success of this almost universal model is based on an assumption that monitoring of the PF by the PM is effective. In fact there is a lot of evidence out there to suggest that either the act of monitoring itself or the act of communicating its findings to the PF frequently fails.

So now let's consider an alternative way to fly an approach which is based on a **planned** role reversal. Now that very low visibility landings are routine, there are variations in the detail but in simple terms, the approach is flown by one pilot who hands over to their colleague for landing but keeps control if the approach is rejected

in favour of a go around before a decision to continue to a landing has been made. A changeover to the landing pilot does not necessarily occur at or even approaching the prescribed minimum altitude for the approach but it may do. Under this system, either pilot is able (subject to the aircraft commander's decision and applicable approach minima or company limits) to land the aircraft. This method has generally been referred to as a 'Monitored Approach' but sometimes goes by other names too.

At a stroke, this method completely changes the dynamics of monitoring during the approach. The pilot who is expecting to take over for the landing tends to be very attentive to the flight path management of the other pilot because he is going to 'inherit' the result. The pilot who is flying the approach is aware that unless the expected role reversal is called by the other pilot, they will need to fly a go around without messing it up. Both influences contribute additively to an increased likelihood that any approach will be well flown. One airline which gave me direct experience of this method has been using it for over 40 years and, as a leader in the use of 'Operational Flight Data Monitoring' (OFDM) they have been able to validate the beneficial effect on operating standards - and on mitigating the risk of approach and landing accidents. They are not entirely alone - another major European carrier of more recent origin also makes use of the approach role reversal method and it has been successfully adopted by some much smaller airlines too.

Of course, there is much more to it than this simple summary communicates, but there are places where you can find out more about it[1]. The point of using it as an example here was to illustrate my contention that 'choice' SOPs can critically enhance SA. Any procedure which has demonstrably stood the test of time should not be ignored in the quest for SA which is as near to reality as we can get. How else can you expect that the decisions – big and small – which all front line operators repeatedly take will be the best ones? I conclude that when thinking about how to enhance SA, don't forget the potential effect of changes to SOPs.

Finally, those of you who are not pilots of multi crew aircraft and therefore don't work in a team where an anticipated role reversal takes place with a fully shared SA which has been built up over a significant time, is there a wider message? I think there probably is since the shared SA necessary for pilot role change depends on both pilots having acquired the same (accurately recognised) SA before the change. This achievement is then 'validated' in the minutes following the changeover. There is perhaps a parallel with the shared SA needed between controllers handing over a position. Whilst this is a one-for-one change in which the departing controller can, unlike the pilot relinquishing the PF role, 'switch off' once the changeover is complete, their departure cannot safely occur until SA has been briefed, SA has been understood and that understanding of SA has been validated. I suspect that some handovers do not include the third 'validation' of (assumed) SA stage. Of course, the off-going controller will be understandably keen to 'get it over with' and the on-coming controller may well not feel they need to be watched for a few minutes. But unless the position is very quiet, it might be an idea to 'extend' the SOP for a changeover slightly in this way. An equality between real and perceived SA is, after all a vital pre-requisite for safety and this may enhance the chances of it after a change of controller. The same might be said for the handover of any safety critical position. S

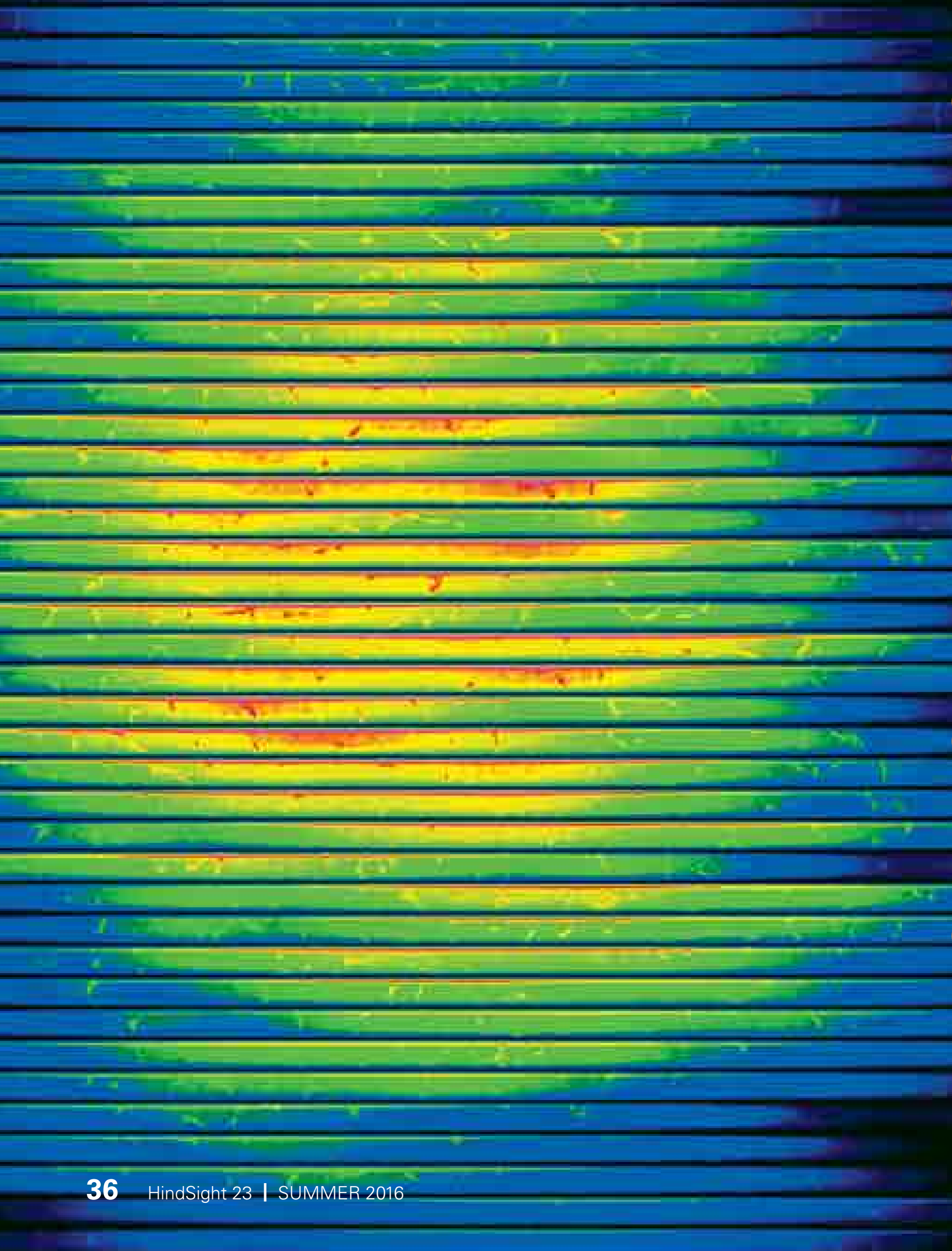
1- For example, start with http://www.skybrary.aero/index.php/Monitored_Approach which has links to sources with much more information on the subject.

CAPTAIN ED **POOLEY**

is an Air Operations Safety Adviser with over 30 years experience as an airline pilot including significant periods as a Check/Training Captain and as an Accident/Incident Investigator. He was Head of Safety Oversight for a large short haul airline operation for over 10 years where his team was responsible for independent monitoring of all aspects of operational safety.

EFFECTIVE PRESENTATION OF AERODROME HOT SPOTS CAN ENHANCE SITUATIONAL AWARENESS AND REDUCE RUNWAY INCURSIONS

Recently the EUROCONTROL Safety Improvement Sub-Group (SISG), under whose auspices this magazine is produced, commissioned a study aimed at understanding how AIP Runway Hot Spot information is transposed to commercially-produced aerodrome charts and to promote any good practices that are found to help improve Situational Awareness. Specifically the group wanted answers to five questions:



1. What is the level of uptake by Airport Operators in providing Hot Spot information?
2. How effective is the information that is supplied?
3. How is the information supplied by the Airport Operators transposed to commercial aeronautical charts that are on the Flight Deck?
4. Is the information provided to flight crews consistent with that published in the AIP?
5. What industry best practice can be shared to enhance Situational Awareness?

Before we answer those questions, let's be clear about what we are talking about. What is an Aerodrome Hot Spot?

ICAO Doc 9870 defines a Hot Spot as:
A location on an aerodrome movement area with a history or potential risk of collision or runway incursion, and where heightened attention by pilots/drivers is necessary.

ICAO Annex 4 lays down the criteria used to establish a hot spot on a chart and the symbols to be used.

ICAO PANS-ATM Doc 4444 states that many aerodromes have hazardous locations on taxiways and/or runways where incidents have occurred. Such positions are commonly referred to as "hot spots".

The formal definition of hotspots can alert pilots and drivers to movement area design issues which cannot be readily mitigated by signage or lighting or where poor visibility may contribute to **reduced Situational Awareness** in relation to active runways. It can also alert to potentially critical points where the visual control room (VCR) or other surveillance systems are less effective usual.

Right, now we've got the legal bit out of the way, let us get back to the questions that were posed.

❶ What is the level of uptake by Airport Operators in providing Hot Spot information?

The SISG study collected a sample of AIP aerodrome diagrams for 64 European airports, generally 3 per state. In addition a selection of AIP aerodrome diagrams from Australia, China and USA were reviewed as comparison at a global level.

It was found that almost 25% of airport diagrams had no Hot Spot information at all. Whether these airports genuinely had no Hot Spots to report or had not carried out the work is not known. However, this group included three European capital city airports with multi-runway operations.

❷ How effective is the information that is supplied?

A review of the of airports that did have Hot Spot information on their AIP charts concluded that less than 40% were judged to be effective. Effectiveness, in this case, being a combination of presentational clarity and usefulness of the information. 45% of airport AIP charts were judged to be of no or low effectiveness. In some cases a symbol showing a Hot Spot is shown on the Airport Diagram but there is no additional explanatory information to help with pilot understanding/awareness of why the Hot Spot is there and what actions they can take to mitigate the associated risk. In other cases the accompanying text simply states a generic message such as "Do not cross the holding point without an ATC clearance."

So clearly whilst the majority of airport operators have made a start, there is a lot more that we can do to make the effort worthwhile i.e. the end game being to improve Situational Awareness , which in turn should reduce the frequency of Runway Incursions.

❸ How is the information supplied by the Airport Operators transposed to commercial aeronautical charts that are on the Flight Deck?

Here's a legal bit again. European Commission Regulation 73/2010 lays down the requirements on the quality of aeronautical data and information for the single European sky, in terms of accuracy, resolution, integrity and timeliness. In terms of scope, the aeronautical data/information process chain extends from original data sources (e.g. surveyors, procedure designers, aerodrome operators, etc.), through AIS to the end user. Concerning aerodrome operators, it applies for those aerodromes for which IFR or Special-VFR procedures have been published in national AIPs, as such procedures demand higher safety awareness.

The European AIS database (EAD) enables aeronautical information providers to enter and maintain their data in the repository and enables data users to retrieve and download AIS data and AIP charts in a digital format. Source providers also supply information to commercial organisations for transposition to flight crew information, both on paper and electronically. Information is supplied by a global network of 246 worldwide providers. A total of around 420,000 source pages are notified for amendment per annum. That is 35,000 for each monthly AIRAC cycle.

The accepted source page is entered into an Electronic Source Library and examined by analysts to identify the changes made and then passed to the appropriate downstream production group. This generates a staggering 270,000 database change transactions every monthly cycle.

Before publication each changed data file, be it paper, electronic or text is subject to two sequential peer reviews. Should significant discrepancies be found, notification is made by periodic NAV data/chart alerts before the next cycle.

MIKE **EDWARDS**

was until recently Head of Safety Investigation at NATS (the UK Air Navigation Service Provider). He held this role for 7 years and prior to that he was Head of Investigation at London ACC. He had been an ATCO at Edinburgh and Heathrow before becoming the manager of all student controllers and then a Supervisor at London Terminal Control. He holds a PPL with Group B rating.

❹ Is the information provided to flight crews consistent with that published in the AIP?

The quick answer is YES. In the vast majority of cases the information shown on the AIP diagram is copied exactly by commercial suppliers. All of the information available from the AIP on 43 of 47 examples examined was the same. In three out of the remaining four examples, the commercial product had more information or more accurate information. In only one case was a part of the available AIP information not transposed onto the commercial product. Thus, in all but one occasion the commercially produced product reproduced or improved on the AIP information.

❺ What industry best practice can be shared to enhance Situational Awareness

ICAO recommends the local generation of AIP charts to show runway hotspots, which, once issued, must be kept up to date and revised as necessary. All identified hot spots should be examined for short or long term opportunities for mitigation of or removal of the hazard identified. These actions include:

- awareness campaigns;
- enhanced visual aids (signs, markings and lights);
- use of alternative routings;
- changes to the movement area infrastructure, such as construction of new taxiways, and decommissioning of taxiways;
- closed-circuit television (CCTV) for critical VCR sight line deficiencies

The EUROCONTROL study found five examples of suggested best practice that singularly or in combinations may improve the visibility and quality of Hot Spot information and thus enhance Situational Awareness.

- *Each Hot Spot depicted by a clear bright red circle and joined to a red label box e.g. HS1*
- *Large, eye-catching textual information elaborating the action required of pilots in and around the Hot Spot. This should be on the main aerodrome diagram or on the obverse page if clarity is best served.*
- *The use of additional graphical boxes depicting the Hot Spots in greater detail. These additional boxes should be physically linked by lines or arrows to the Hot spot on the main diagram, if possible.*
- *Where the aerodrome diagram would otherwise be too cluttered to present Hot Spots effectively, the use of specific Hot Spot pages can be effective.*
- *The use of a colour-coded format which assists the depiction of runways, Hot Spot areas and normal taxiways can be very effective in enhancing the Situational Awareness of the flight crew.*

EXAMPLES OF CURRENT INDUSTRY BEST PRACTICE

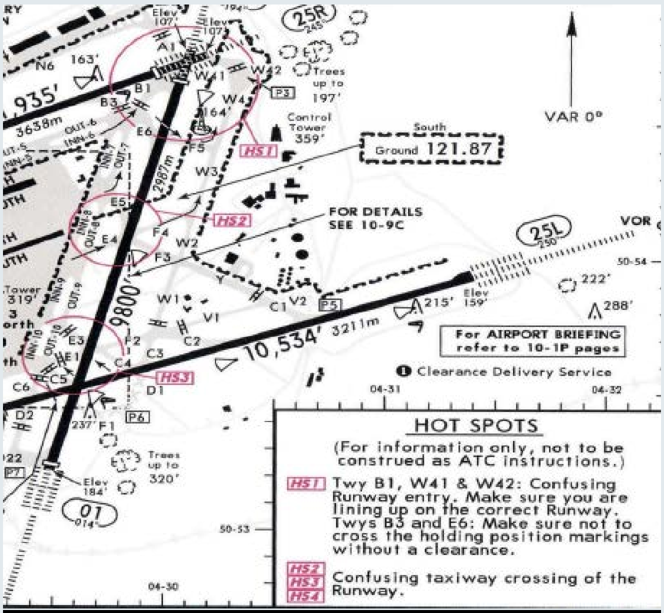


Figure 1

Figure 1 illustrates each Hot Spot depicted by a clear bright red circle and joined to a red label box e.g. HS1, HS2, HS3. It also has an example of large tabulated textual information elaborating the action required of pilots in and around the Hot Spot:

Figure 2

Figure 2 illustrates the use of additional graphical boxes depicting the Hot Spots in greater detail. These additional boxes should be physically linked by lines or arrows to the Hot spot on the main diagram, if possible.

Figure 3 illustrates where the aerodrome diagram could otherwise be too cluttered to present Hot Spots effectively, the use of specific Hot Spot pages can be effective. This figure shows a good use of this method. It allows an expanded view of the holding points. It also makes use of colour, in this case black for runway, grey for taxiway but both overlaid in red for Hot Spot area, and green for grass.

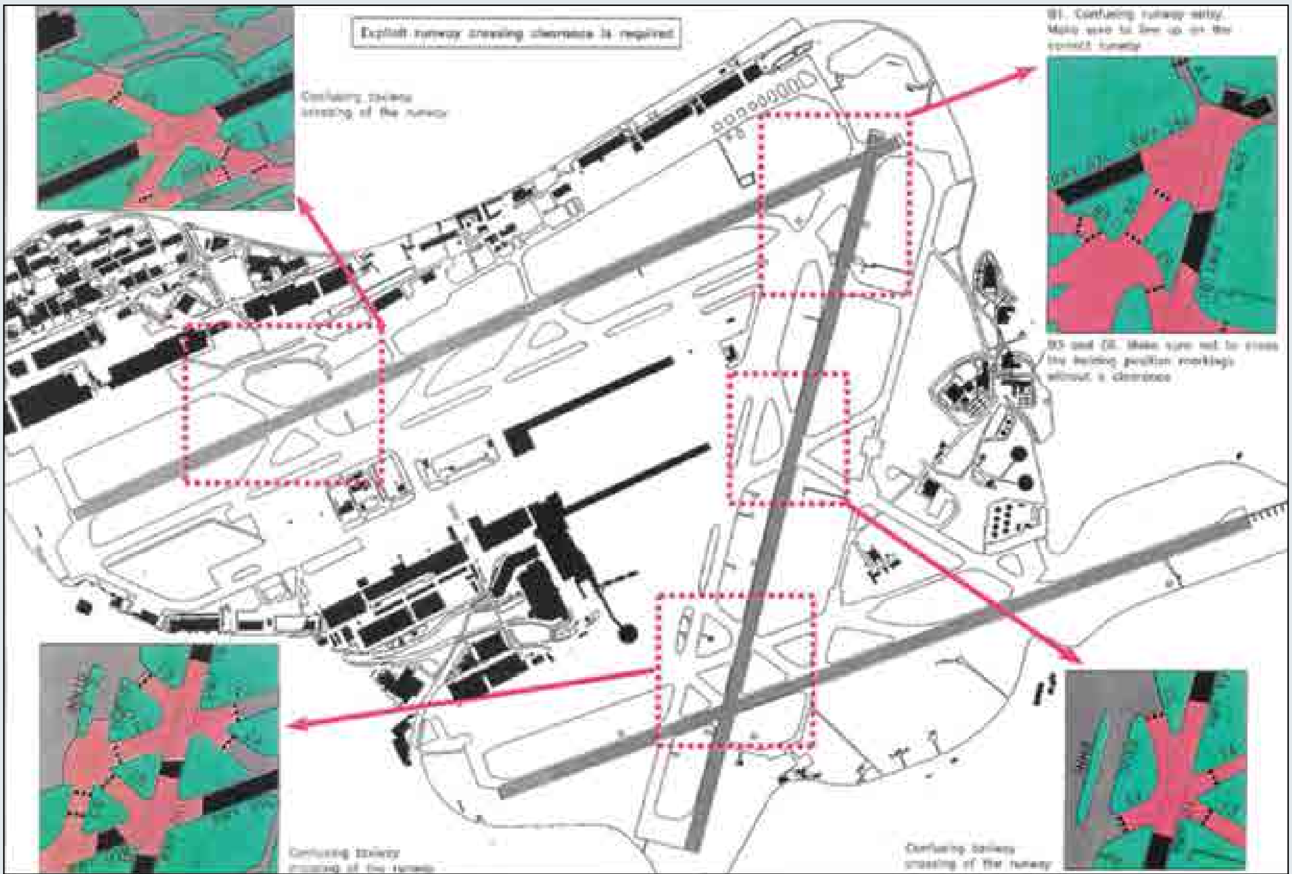
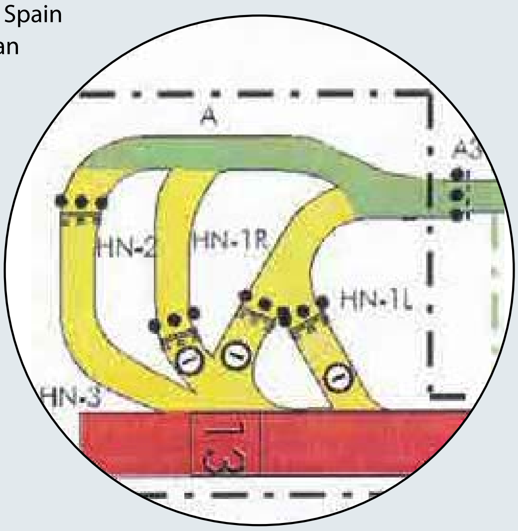


Figure 3

This figure illustrates the use of a colour-coded format which can assist in the depiction of runways, Hot Spot areas and normal taxiways.

The use of this colour set is standard practice in Portugal and Spain and, if presented well, can be a very effective way to enhance Situational Awareness.

Taxiway
Caution Area
Runway



So what can you do to help?

Check out the Aerodrome Diagram in the AIP for your local airport. Does it show Hot Spots? If so, are they useful? Do they use any of the five best practices illustrated?

If the answers to these questions are not all positive, then seek out the airport Local Runway Safety Team (if there isn't one, find the Airport Director), invite them the look at this article and volunteer your services in whatever way that you feel able. The message is simple:

Effective Depiction of Hot Spots = Enhanced Situational Awareness = Fewer Runway Incursions = Less Risk of something nasty happening (possibly to you).

WHAT YOU SEE ON A TCAS TRAFFIC DISPLAY IS NOT ALWAYS WHAT YOU WILL GET

by Stanislaw Drozdowski and Captain Max Butter

Ever since Wilbur Wright said to his brother Orville "let's build another one", the possibility of a collision between two aircraft has been a reality...

In the early days of aviation the separation between aircraft was solely achieved by visual means (see-and-avoid). The pilot looked outside in order to detect any hazards (principally other aircraft) and if a threat was detected, they would then undertake an avoidance manoeuvre. Today, pilots still scan the airspace around their aircraft not only when wholly responsible for their own separation but also when separation is provided by air traffic control and see-and-avoid is still applied successfully on countless occasions every day. Admittedly, at the speeds flown by commercial jets the chances of a successful avoidance manoeuvre as a result of visual acquisition can be quite low.

With the introduction of TCAS in the early 1990s, pilots of aircraft equipped with it were given an additional tool which helps them to visually acquire other aircraft. Each TCAS installation comes with a traffic display which depicts the approximate position of nearby aircraft, relative to one's own aircraft. It indicates the relative horizontal position of other aircraft in the vicinity as well as their relative vertical position if they are equipped with altitude reporting transponders (Mode C or Mode S).

the position of other aircraft can be off by as much as 30°, however, usually the error is not more than 5°. Due to surveillance errors the target symbol on the display may jump.

Pilots can select various ranges of the traffic display and also TCAS surveillance range may be automatically reduced to 5 NM in high density airspace. With a small maximum range selected, pilots may be more likely to see aircraft in their vicinity which do not also appear on their TCAS traffic display. Even if aircraft are detected by TCAS, they may not be displayed, since some installations limit the number of displayed targets or provide relative altitude filtering.

The primary purpose of the traffic display is to aid a flight crew in the visual acquisition and maintenance of situational awareness in respect of other aircraft. The secondary purpose is to provide a flight crew with confidence in proper system operation and to give them time to anticipate the possibility that they may need to manoeuvre their aircraft in response to a Resolution Advisory. Although, some implementation details vary, all TCAS II traffic displays follow the same principles described in the table below.

The TCAS traffic display has certain limitations. As TCAS bearing measurement is not very accurate,

The reference for the TCAS traffic display is the aircraft's own position and, consequently, all targets on the traffic display are shown in relative motion. Combined with the lack of a speed vector on targets, this may make deducing an intruder trajectory problematic, especially if one's own aircraft is manoeuvring horizontally. Moreover, the pilot does not usually have any knowledge of the intent of other aircraft.

The two examples on the following page show how situational awareness acquired through the indications on the TCAS traffic display can provide a safety benefit but how they can also be a source of confusion and lead to a reduction in separation.

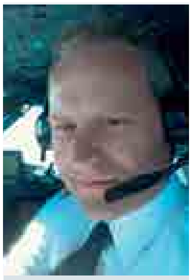
TCAS TRAFFIC DISPLAY SYMBOLOGY AND ASSOCIATED RESPONSES

Symbol	Type	Pilot action
◇ or ◇	Other traffic	Visual acquisition. Vertical speed reduction if traffic is at the level adjacent to the cleared level.
◆ or ◆	Proximate traffic: Aircraft within 6 NM and 1200 feet of own aircraft	Visual acquisition. Vertical speed reduction if traffic is at the level adjacent to the cleared level.
●	Traffic advisory (TA): Nominally generated 20-48 sec. before Closest Point of Approach (CPA)	Visual acquisition. Vertical speed reduction if traffic is at the level adjacent to the cleared level. Prepare for possible RA.
■	Resolution advisory (RA): Nominally generated 15-35 sec. before CPA	Follow the RA as indicated by changing or maintaining the vertical speed.
+04 ■↓	Vertical trend arrow and relative altitude will be shown next to each symbol (in the matching colour). The relative altitude is displayed in hundreds of feet, above the symbol if the intruder is above own aircraft and below the symbol in the opposite case.	

STANISLAW **DROZDOWSKI**

is a Senior ATM Expert at EUROCONTROL HQ in Brussels, working in the area of ground and airborne safety nets. Previously, he worked as a system engineer with Northrop Grumman and as an Air Traffic Controller in Poland and New Zealand. He is currently involved in ACAS X standardisation and validation.

CAPTAIN MAX **BUTTER**



is working as an airline training captain on A320 and has gained relevant experiences in flight safety, especially in flight data monitoring and investigations for more than 12 years. He studied electrical and industrial engineering. His academic research covers flight data monitoring, safety performance indicators and risk assessment.

Example 1

An Airbus 320 was on a departure with early left turn and an initial climb restriction of FL70. Due to the fact that there was a speed limit of 210 knots and the aircraft had a very light gross weight, the climb rate was high – more than 3000 ft/min. On checking in with the departure frequency, the crew got a clearance to continue the climb to FL90. At 5500 feet the crew received a TCAS TA and they could see descending traffic on their TCAS traffic display 3800 feet above in a 1 o'clock relative position, approximately 3 NM away. Assessing that this situation could lead to a 'nuisance' RA or even a conflict, the crew reduced their climb rate and levelled off at FL70, as originally cleared.

The pilot monitoring visually identified the conflicting traffic – an MD80 on an arrival downwind leg passing little more than 1000 feet above them. At this moment ATC called the A320 again "… confirm levelling off FL70?" The controller had inadvertently cleared the A320 to a higher level than he had intended.

By noting and interpreting the information on their TCAS display, the A320 crew was able to identify that the ATC clearance they had received might lead to an RA. Their response helped to prevent escalation of the situation, which could easily have initiated a chain reaction in dense traffic area close to a major airport.

Example 2

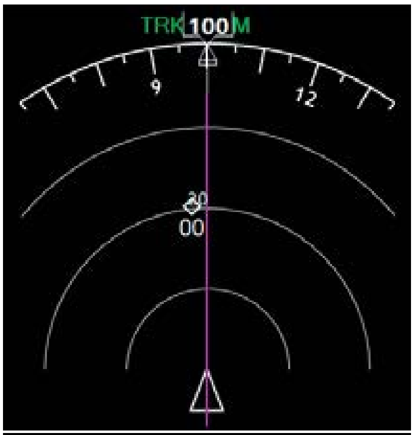
A classic example of incorrect use of the TCAS traffic display is a reaction of the B767 crew who observed another aircraft on their traffic display at the same altitude – an MD80 on a crossing track. The B767 was predicted to pass approximately 15 NM behind the MD80. Both aircraft were instructed by ATC to maintain their headings for separation. However, when the MD80 was 20 NM away, the B767 crew, decided (contrary to their ATC instruction) to turn right 20° to avoid the MD80. The B767 misinterpreted their traffic display and believed that the MD80 was coming from the opposite direction.

Following the right turn, the MD80 target remained on the left hand side on the B767 TCAS traffic display, still giving the impression that it was coming from the opposite direction. Subsequently, the B767 crew requested a descent clearance. The right turn had brought both aircraft closer together with the horizontal separation dropping to 2 NM at the closest point of approach. Both aircraft received TAs.

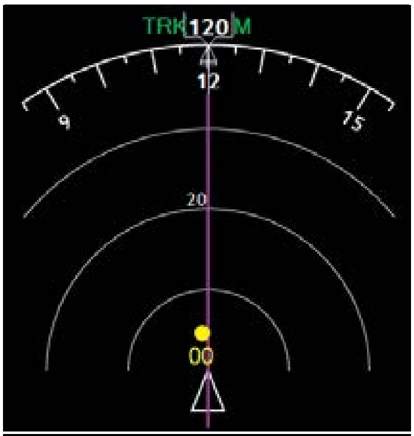
This case (fully described in ACAS Bulletin no. 6) clearly illustrates risks associated with using the TCAS traffic display for self-separation manoeuvres[1]. It is a common misconception that turning away from a displayed intruder decreases separation, a phenomenon otherwise known as confusing increasing relative bearing with increasing separation.

Conclusions

Whilst the TCAS traffic display is useful in improving situational awareness, self-separation decisions taken based on traffic display information may lead to unintended outcomes. It is sometimes assumed that having display-based situational awareness will allow a pilot to take an appropriate decision which will eliminate a potential threat, but this is not necessarily the case. A perceived threat may in fact be no threat at all and manoeuvring may bring both aircraft closer. For this reason, it is strongly recommended that pilots do not normally manoeuvre their aircraft solely using TCAS traffic display indications. Of course manoeuvring based on visual acquisition may occasionally be justified and any indicated change in vertical speed annunciated as a TCAS Resolution Advisory must be followed.



On the initial heading



After crew heading deviation

1- Other example of incorrect use of traffic display can be found in ACAS Bulletin no. 16 and no. 19)

SITUATIONAL AWARENESS **CHANGES OVER A PILOT CAREER FROM DC9 TO A340**

by Captain Johan Glantz

When preparing to write this article and Googling for a good definition of Situational Awareness, I came across not only the general definition found on SKYbrary - '*it 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 status in the near future*'-, I also found a definition used by the US Coast Guard - '*Situational Awareness is the ability to identify, process, and comprehend the critical elements of information about what is happening to the team with regards to the mission. More simply, it's* ***knowing what is going on around you.***

The final sentence, **knowing what's going on around you,** made me realise that over my now 27 year career as a commercial pilot the demands and focus of everyday normal operations situational awareness have changed. This everyday situational awareness can be defined as that which is needed not only for specific events or situations, where there are numerous articles available, but rather the everyday operational situational awareness needed in normal flight operations, that has changed depending on the equipment that's installed in the aircraft.

The drivers for this change over my career have been developments in aircraft design and new technologies resulting from a desire to increase safety and to accommodate an increase in air traffic volume and environmental demands among other thing.

The first nine years of flying was spent in the DC9. A generation 2 aircraft using a definition where present day aircraft such as B777 and A340 comes into the category generation 4 and B737 and MD80 generation 3. During my career I have managed to fly all the generations apart from generation 1 (DC3 etc.) which still is on my bucket list.

Already when training on the DC9 there were discussions on Situational Awareness, but the meaning was quite different from later on when flying A340 and A330. In a DC9 knowing "what's going on around you" often meant 'Where are we?'

The DC9 was a fantastic aircraft to fly and after some time you became more or less at one with the aircraft. Strapping yourself into the seat and almost making it an extension of yourself on a good day. There was no auto throttle, no Navigational Display (ND) that graphically tells you where you are. We were at that time trained in Mental Flight path during company training. A subject that gave us some useful techniques for building a mental "map" based on DME, VOR and ADF electro mechanical instruments, mentally calculating descent and climb restrictions and how to stay on track across the North Sea without a VOR in range either behind or in front during a cross wind.

What the aircraft was doing was more obvious to the DC9 pilot as there were very little automation and, compared to today, a simpler and in a sense more straightforward design. For example, the DC9 warning panel was immense compared to later generations as there was one specific individual lighted small panel for each possible warning or caution, When applicable one light for the Right and one for the Left system. However just like today's generation 3 and 4 aircraft, the DC9 wouldn't do anything that the pilot didn't tell it to do. The big difference is that there were limited ways to interact with the aircraft, stick & rudder, manual throttle and an auto pilot that only could be coupled to an ILS down to minima apart from the two basic modes IAS hold and V/S.

With today's high density and efficient use of airspace and airports, as well as environmental demands on navigational performance and overall noise restrictions, a generation 2 aircraft would most likely not be a viable aircraft anymore. At least not in most regions of Europe.

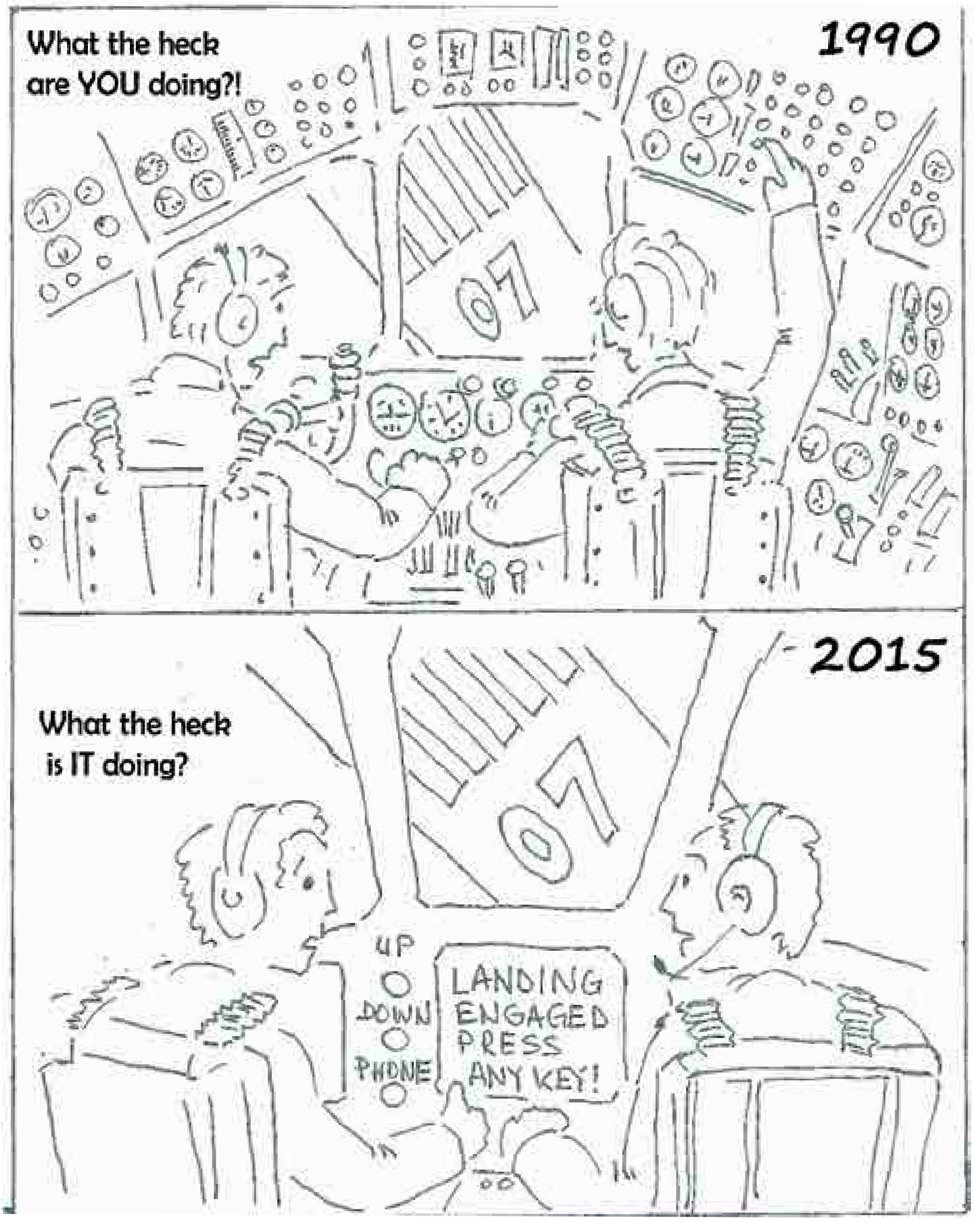
This and other commercial factors meant that when the DC9 was to be phased out I had the opportunity to be among the first to train on the new B737 NG. A very different bird with a glass cockpit. A Primary Flight Display (PFD) instead of the classic T arrangement of electro mechanical instruments. A Navigational Display (ND) with a map showing waypoints, track, terrain and weather. Automatic navigation based on GPS and IRS input as well as radio navigation with an accuracy that was well beyond the capability of the DC9 Fluxgate compass.

With this new technology also came new challenges on crew situational awareness. What is our position became less of an issue and the old DC9 joke 'what's the most common phrase in a MD80 cockpit? - what's it doing now?!', which we sometimes told about our colleagues flying the more automated MD80/90, became a reality for us too.

The issue of having knowledge of the maximum engine Exhaust Gas Temperature (EGT) can serve as an example of how new technology can affect a person's ability to create situational awareness. During training, some of our older Captains who started as FOs on the Caravelle, were frustrated by the lack of information they felt was important. Not by the technology itself but rather by the way they needed to adapt to what information was available to build their situational awareness in operating the B737NG. One such issue was the max EGT for engine start and normal operations.

They had flown their whole career and done numerous technical courses on various aircraft types and one of the more important numbers to be memorised had always been the max EGT for engine start and normal operations (usually two different temperatures, one for starting and one when the engine runs). At the time of our training, these values were not found in any of our manuals covering the B737NG. The reason for this was that there was really no need to know the numbers as the new technology with digitally created EGT displays allowed the EGT instrument to be adapted. During an engine start, the EGT instrument displays a red line indicating where the max temp is, without any number. When the engine is started and runs at idle the line will move to max operating temperature. Should an exceedance of temperature occur, the instrument will start to flash red thereby visually indicating the exceedance. A good way to increase the situational awareness of the crew during engine start. But some of my colleagues were, as mentioned, extremely uncomfortable with this. Based on their background, they felt a strong personal need to know the numbers, in order to have situational awareness during the engine start. These temperatures were eventually included in the manuals.

Perhaps the main reason for needing



looking at how different aircraft generations have made different demands on normal operations situational awareness, it can be said that the nature of situational awareness is ever changing and there is no simple solution that covers everything. What is needed depends initially on the type of equipment that is available and then specific situational awareness based on a particular situation or event.

There are a number of articles in this edition of HindSight on different scenarios with appropriate solutions to increase situational awareness for given events or situations. However, the success of those improvements, in this context is, apart from the operator/pilot previous experience and the technological level, also dependant on how well the improvement interacts with the available technology as well as procedures and warning systems already in place.

to adopt a new personal technique to gain normal situational awareness was the Flight Management System (FMS). On the FMS the flight path, both vertically and horizontally can be controlled by programming. The FMS controls the aircraft as instructed from the setting optimum take off thrust, calculating climb and descent restrictions, flying approach down to an auto land and so on. As with all computers that are programmable it does what has been programmed. Compared to the non-FMS DC9, flying an FMS-equipped aircraft therefore became, in my view, more a matter of managing the flight than directly interacting with the flight controls. Consequently, everyday normal situational awareness during a flight became, in very general terms 'is the aircraft performing as expected? If not, why not ?'

After a few years on the B737NG there was an opportunity to move to the then new (to SAS) A340/330 fleet. The latest and then most modern generation of aircraft with fly–by-wire and an electronic checklist demanding another variation on normal operations situational awareness. In my view, the difference in the context of normal operational situational awareness between generation 3 and 4 is less than that between generation 2 and 3. If anything, flying a generation 4 aircraft in normal operations is even more a matter of managing the aircraft systems than for generation 3, requiring another everyday situational awareness.

Coming back to the US Coastguard's simplified definition **knowing what is going on around** you and

CAPTAIN JOHAN **GLANTZ**

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SO WHAT DOES IT LOOK LIKE?

by Maciej Szczukowski

It was one of these days when Andrew would give a lot to have a day off rather than watch the raindrops on Tower windows and be on the receiving end of the likely effects of the sudden drop in atmospheric pressure. The sky to the north was darker than usual but he felt relieved after his assistant's call to the met observers. They had told him that due to a change in upper wind direction, the darkest sky of the day would probably miss the airport and move away to the south-east staying well away from his airspace.

At the moment, all departures to the south and west were already climbing to their cruising levels and the arrivals were only just entering the FIR. Sipping his coffee, he tried to relax a bit, watching the pre-inbound list building, with the first arrivals due in 25 minutes. "There is what there is" - he thought. The Duty Officer was doing his before peak-arrival runway check, reporting on the radio that the runway was wet but with no water patches. Happy to hear that, Andrew sorted out the arrival list and flight strips, raised his chair a bit so as to have a better view of the touchdown zone which was 4 kilometres from his position, and waited.

Then the telephone rang.

> ***Approach:*** *"Hi, it's Mike from West Approach, we have CBs on the screen but I am not sure if the picture is accurate How does it look out of the window?"*
>
> ***Andrew*** *(looking through the window): "Yeah, I was worried too, but we've only got a wet runway, no water patches and the guy at 'met' said that it'll be fine.*

Both of them were correct. Yet imprecise. Not on purpose obviously. It was the chaos theory small change – large effects 'butterfly effect' of communication which began the process of gradual loss of situational awareness. Mike knew that his weather radar was not state-of-the-art equipment and many years of experience had taught him that what's on the screen is not always what's in the air. Andrew didn't appreciate that -, he wasn't radar rated and he had never worked in APP.

But he had windows, good eye-sight and a telephone number for the 'met guys'. They were like therapists - willing to listen, then talk, often to calm down controllers' anxieties. They often used words like 'probably', 'not necessarily', 'hopefully', etc. Andrew liked them for this. Actually Andrew's brain liked them for this.

Have you ever spent time at a party, with loads of people around you creating a chaotic noise in which it is difficult to have a conversation? Suddenly, however, you have been able to hear the single word, your name, and some critical remarks about your work, your life or the colour of your socks. Then, though you haven't planned to, you have turned your attention to the critic, haven't you? Well, that is how our brains work. They act based on raw data, but always in a certain context. They select information which seems interesting enough to acquire and leave what is left to the unconscious attention (I learned about this after completing my first 12-hour night shift, having driven home but afterwards unable to recall anything from the journey. The brain favours, filters and adapts the input. The result is that we often get what we want, decide or prefer rather than "raw data". And that is the source of our awareness. In the dialog above, Mike, although he asked for 'precise' information, was looking forward to

a normal sequence of inbounds and may have biased his question by looking for subjective interpretation from Andrew. In return Andrew, who was already tired of the whole shift - a low pressure and overcast-clouds-day, may have biased his perception by basing his knowledge on the 'probably' and 'hopefully' definite message from the 'met guy'. Mike saw things as he wanted to, Andrew distracted himself by an expectation[1]. But that was the situational awareness they had. So far ...

Pilot: *"Tower, N999ZX, there's a significant change in wind direction at 2000 feet, and there's windshear and some icing too".*

Andrew: "*N999ZX, roger". (Calling Mike) "Mike, I just got a report from N999ZX about a wind change at 2000 feet. And the visibility here has dropped to 3000 meters so I can't see the runway. Can you extend the spacing by a mile to reduce the chance of go arounds?"*

Mike: *"I thought you told me it would be fine. And I have now almost 40 inbounds thanks to those from the north being late after weather avoidance. I need to keep up the tempo. Does it really look that bad through the window?*

Things had changed and the initial situational awareness had begun to deteriorate. This time, however, there was less time to 'alter' the reality. Mention of windshear[2] and 'icing' suggested that the approach speed may change[3]. And of course 'I can't see the runway' is surely not the most convenient situation for a Tower controller, yet it doesn't necessarily connect with visibility. And finally, we have 'can you' and 'you told me' the subtle duel of responsibilities, where the unclear common situational awareness due to local limitations or brain-filtered expectations leads to even more confusing messages or requests. Because what counts, when time and resources are limited, is whether 'it really looks that bad?' ...

The way we communicate, how we use language creates the reality (and our awareness about it). You have surely had the opportunity to watch the news on one TV channel and then be told about a different, parallel reality by another channel. Who was right? Nobody? Everybody? I think it was somewhere in-between. The reason why this happens comes not only from 'what was' but also 'what purpose' did one have to present the news that way. Chronology, presentation, content, form, location - it all builds into a specific, resultant image. Older information has less impact on perception, and hence on awareness, yet it may still remain crucial for others. Only then does 'the' proposal, request or resolution mirror the reality and control it (which, in fact, is the task of air traffic controller)[4]. In the meantime an hour has passed...

Karen: *"I'm ready".*

Andrew: *"Pressure is now stable, the West approach is active, You have control of runway 28L and 28R, visibility has dropped, surface wind is stable, some pilots have reported gusts but there has only been one go-around. Strips are sorted.*

Karen: *"OK, my control".*

In this particular case, this common handover-takeover scheme[5], became the next 'layer' of communication-related situation awareness limitation. Though the information that visibility had dropped was a fact, it did not convey critical information on the general weather situation and thus possible future developments. So was the information about wind gusts, accompanied by mention of a go-around helpful? The existence of gusts – a common phenomenon, does not carry any useful information unless accompanied with windshear report or a sudden change in wind velocity at a certain altitude.

So, what would be the take-away message from this made-up, yet quite probable story? I have always admired the power of mnemonic methods. It suits my brain (a common model, for sure) yet allows me to remember a lot with relatively little difficulty. The case of Andrew, Mike and Karen is a story about people asking, being asked and being told. It is a story of people who know what they've got, but don't know what they may have missed because of the nature of their communications. Therefore I would suggest three acronyms, for your everyday work: **ASK, ASKED and TOLD.**

I believe it is worth considering them in your operational work, though at the beginning it may seem tricky. On the other hand, learning can make one a master, right? Speaking of which, what about a 'master attitude' ...

The thought that what Andrew had thought before the inbound peak ('there is what there is") was not a luck-related omen. It was the representation of the simplest definition of situational awareness, the phrase used by Endsley in 1995[6]. The knowledge about 'what there is', in ATC and on board an aircraft, must contain the imminent

1- Read more about human factors in communication at http://www.skybrary.aero/bookshelf/books/852.pdf
2- Find more information about windshear recognition at http://www.skybrary.aero/index.php/Low_Level_Wind_Shear
3- Find more information about approach speed and influencing conditions at http://www.skybrary.aero/bookshelf/books/866.pdf

4- Read more about language and communication at FSF ALAR Briefing Note 2.3 – Pilot-Controller Communication http://www.skybrary.aero/bookshelf/books/852.pdf
5- see: http://www.skybrary.aero/index.php/Handover/Takeover_of_Operational_ATC_Working_Positions/Responses

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element, allow to predict and prepare for options which may happen. Yet in order to succeed we must also be able to relay and receive facts. Clearly, precisely and also briefly. If you control – try it. If you teach – learn it then teach it. To say how things are, not only what they look like.

Andrew packed his suitcase, closed his locker but decided not to put on the jacket, still having the warm feeling he usually had after dealing with an unusual situation during his shift. On the way to the car park, he saw Mike who had also finished his shift. Mike saw him too and they both looked at each other for a moment. They understood, at that very moment, that just one look in the eye can mean more than many words. They realised the value of a short and precise message. For them. Yet driving home they thought about how it may have looked to the pilots. Fortunately, by the time they both reached home, the dark skies were miles beyond their airspace.

On the next day they found out that there had been three more go-arounds. Due to windshear on final ...

PAN Airlines say again... I had an echo after your call sign... I have your data download and it's another textbook landing, although your engine temperatures seem high...

6- Wickens, C.D. (2008). Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement. Human Factors, 50(3).

ASK When you ask	ASKED When you are asked	TOLD When you receive/-d information
ANALYZE	ANALYZE	TIME
What do you actually want to ask about?	What are you asked about exactly?	When were you told?
SHAPE	SHAPE	OWNER
How do you want to ask about it?	How/what can you answer?	Who told you that?
KNOW	KNOW	LEVERAGE
Know if you are ready to receive facts?	Know if you can offer facts?	What/whom did/does this information influence?
	ELABORATE	DESCRIPTION / DETAILS
	Give necessary details (if applicable)	Were there any specific details or description?
	DISCERN	
	Did the person asking receive and understand the message?	

DETECTION OF POTENTIAL RUNWAY AND MANOEUVRING AREA CONFLICTS OR "HOW DO YOU KNOW WHO'S ON YOUR RUNWAY?"

by Richard "Sid" Lawrence

Let us look closer at the importance of maintaining our situational awareness in the aerodrome environment. Specifically, let us see how some runway incursion and manoeuvring area conflicts could have been prevented if the controllers had had better means to detect that the runway (or another part of the manoeuvring area) was already authorised occupied at the time of issuing clearance to the next aircraft to use it.

A EUROCONTROL Operational Safety Study (OSS) had a closer look at this phenomenon with the aim to provide clues why these types of events occur, what protective barriers are already in place and what we can do further to reduce the chances of them happening in the future.

Common Scenarios

We identified a number of common scenarios that are the origins of this type of event:

- Incorrect ATC clearance.
- Non-Conformance with ATC clearance due spatial/positional confusion.
- Non-Conformance with ATC clearance due to misinterpretation or mishear of the clearance.
- Non-Conformance with ATC clearance due poor CRM and forgot planned action.
- Loss of communication.

In the real-life examples of some of the scenarios that follow, we'll see how the situational awareness of the controller/pilot/driver is affected and how easy it is to slip to the very edge of the runway safety margins.

REAL-LIFE CASE STUDIES

CASE 1: Departing after receiving incorrect ATC clearance on runway already authorised occupied

During this incident, the traffic is light so TWR and APP position are grouped with only one controller dealing with both frequencies. Work is in progress in the building of the Tower with the presence of firemen testing the fire alarm which adds a lot of noise around the controller. Moreover, a military exercise is planned during the day and ATC is busy searching for information.

Start-up is approved for an E145. An Airport Ops vehicle is sent to the runway for inspection before the departure of the E145. The E145 is cleared to taxi to the runway holding point. ATC gives an initial clearance for departure to E145 and tells him to report ready for departure at the holding point.

A couple of other aircraft call for start or taxi. ATC starts coordination by telephone with a military ATC unit concerning an aircraft in transit and also the departure of the E145. During the telephone conversation, the E145 calls ATC ready for departure at the holding point. ATC does not respond. At the end of the telephone conversation, the E145 calls ATC a

second time to repeat he is ready for departure. ATC is still busy with coordination and mechanically responds to the pilot. ATC gives the surface wind and clears the E145 to line up and take-off. The vehicle driver immediately calls to confirm his presence on the runway. ATC cancels the take-off clearance given to the E145.

ATC did not look outside and did not look at his strips while giving the take-off clearance

CASE 2: Entry of runway by aircraft taxying for departure or by vehicle after non-conformance with ATC clearance due to spatial/ positional confusion, together with a landing or departing aircraft

A Raytheon 390 Premier did not taxi for a night departure in good visibility in accordance with its clearance. It entered the departure runway 03 ahead of a Bombardier CRJ200 which had just begun its take- off roll. The CRJ200 crew saw the other aircraft and rejected their take off from a low speed, coming to a stop before reaching it.

The Raytheon crew had correctly read back their taxi clearance to the holding point for a full length departure. They had then become confused at the point where the taxiway centreline on Taxiway B indicates two right turn options close together, first onto Taxiway J, which was not in use and then further on, Taxiway K (as cleared and with the centreline lit). The centreline lighting leading ahead onto taxiway 'B3' and the intermediate holding point for the runway was also lit and the aircraft followed that line instead of the right turn onto 'K'. The aircraft continued past the co-located flashing Runway Guard Lights, marked runway entry Cat 1 holding point and its four embedded and flashing lights and the painted words 'RUNWAY AHEAD' and onto the runway where they turned right.

The crew reported that they had briefed Taxiway K was the second turn and thus followed the second lit turn. They did not realise that they had passed the holding point 'B3' and only became aware that they were on the runway when they saw the white edge lighting.

At the time of the incident, both the AIP taxi chart and the proprietary charts did not correctly depict the detail of the movement area layout at the junction of taxiways. This, and the use of lit taxiway centrelines on all taxiways available for use if so cleared were probable factors. Crew expectation and vigilance also led to the incursion.

The airport was not equipped with any SMR or system for detecting potential runway occupancy conflicts.

CASE 3: Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft after non-conformance with ATC clearance due to misinterpretation or mishear of clearance

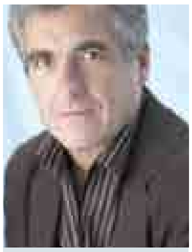
Runway 05L is used for landing and runway 05R for take-off. A towed Beluga contacts TWR on holding point short of 05L for crossing of both runways for the main apron. ATC asks him to report in sight of the "aircraft on final".
An A319 is taxying for departure runway 05R; it is cleared to line up and take-off 05R.

ATC ask the Beluga tug driver if he is in sight of the traffic on final, the driver answers he is seeing an aircraft about to land. ATC clears the Beluga tug to "cross runway 05L behind the traffic on final and then maintain holding point Lima (between 05L and 05R). The tug driver replies "Roger for crossing rwy 05L and maintaining holding point 05R"

The departing A319, on hearing this conversation asks for confirmation of its line-up and take-off clearance and to check the runway of the landing aircraft.

The aircraft on final rwy 05L is cleared to land. Some 20 seconds later, ATC instruct the Beluga tug to hold position and then asks him if he is on the runway, to which the tug driver replies that he is. ATC cancel the A319 take-off clearance and instruct the aircraft on short final for 05L to go-around.

The driver did not understand the situation and made his own interpretation of the clearance he was given, which was that the landing aircraft some 4nm out was landing on 05R not 05L. ATC did, however, detect the conflict and properly recovered the incident giving the right orders to both aircraft and the towed Beluga.



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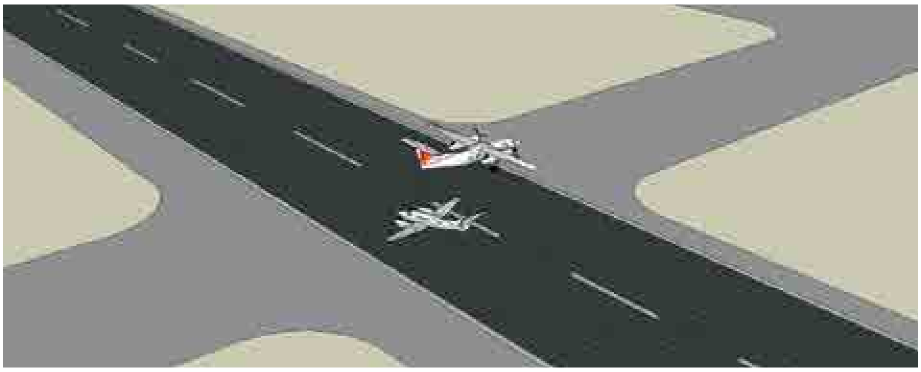
CASE 4: Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft without ATC clearance due to poor CRM or forgot planned action

A Bombardier DHC-8 landed on Runway 23. The GMC controller instructed a DHC8 to taxi on Taxiway E and hold short of Runway 27, which needed to be crossed to get to the gate. The hold short instruction was correctly read back. The TWR controller cleared a Beech A100 King Air to take off from Runway 27. Approximately 2 minutes later, the DHC8 entered Runway 27 without stopping. The BE100, which was approaching rotation speed, aborted take-off as soon as it saw the DHC8 on the runway. The BE100 veered to the left of the runway centreline and passed about 10m behind the DHC8.



On receipt of take-off clearance, the King Air crew switched on the landing lights, and without coming to a standstill, the aircraft continued its momentum to begin take-off. At this time, the flight crew of the DHC8, which was some 200m from the hold line of Runway 27, visually scanned the runway. The first officer indicated that the runway was clear to the right of the aircraft, and the captain did the same for the part of the runway to the left.

The GMC and TWR controllers simultaneously observed that the DHC8 was about to cross the runway. The GMC controller ordered the crew to stop, while the TWR controller only transmitted the DHC8 call sign. At about the same time, the DHC8 contacted the apron management service and continued travelling straight ahead, crossing the runway. The BE100 aborted its take-off at 102 knots and braked heavily. The decelerating King Air veered to the left of the runway centreline and passed at 37 knots, about 10m behind the DHC8. A few seconds later, the DHC-8 contacted ground control after being requested to do so by Apron Control.

The DHC8 pilots did not confirm between themselves the ground controller's instruction to hold short of Runway 27 notwithstanding the first officer's accurate readback of the instruction. The visual scan conducted by the DHC8 captain was ineffective and did not identify that the BE100 was on Runway 27. During the action of runway crossing, the captain of the DHC8 was talking to Apron Control, contrary to the operator's SOPs.

Contributory Factors

These 4 events only provide a snap shot of some of the most common contributory factors. The OSS has more detailed analysis and lists, inter alia, the following common **ATC** contributory factors:

- Memory – most commonly a failure to check/monitor or forgetting something.
- Perception – most commonly a failure to see something.
- Operational environment – commonly distractions, visual impairments and noise.
- Communication errors – incomplete, incorrect or ambiguous RTF.

The OSS also lists the following most common **pilot/driver** contributory factors.

- Perception
- Action (communications)
- Decisions
- CRM issues

Importantly, the OSS also found many examples where **airport procedures and equipment** contributed to incidents including, inter alia:

- Routine inappropriate use of company radio frequency whilst airside
- Use of native language to communicate with airside drivers and English for pilots
- Permitting vehicles on airside without required lighting or radio
- Taxiway centrelines being permanently lit
- Excessive lighting around WIP severely restricting the ability of ATC to interpret visual information at night.
- Inadequate directional signage and signage lighting at night.

In the next section we'll take a look at how the ATC contributory factors link to situational awareness and see how they manifested themselves in the selected cases.

Memory

In Case 1, the ongoing work in progress disturbed the controller's situational awareness and he/she momentarily forgot about the vehicle he/she had previously cleared onto the runway. The ATCO also forgot to check his/her strips and to physically check that the runway was clear before he/she 'mechanically' gave take-off clearance to a waiting aircraft. Memory lapses were an ATC contributory factor in three quarters of the actual events studied.

Perception

In Case 2, the pilot of the taxying aircraft misinterpreted visual information and did not see runway guard lights and RUNWAY AHEAD signs; this breakdown in situational awareness was compounded because the controller did not see the aircraft take an incorrect route. Although, like 'Memory', 'Perception' was a contributory factor in 16 out of the 20 actual events studied, in Case 2 systemic issues were also key contributing factors.

ATC Operational Environment

In the sample of 20 incidents, the third highest common area of contributing factors is ATC Operational Environment. Approximately half of these issues are organisational, e.g. visual impairments and noise in the VCR as in Case 1 when the controller's concentration is disturbed by the testing of fire alarms. The other half concerns job-related distractions. What this shows us is that we need to use the available 'attention' more effectively. Tasks not involving the subject aircraft are prevalent e.g. checking a situation on another runway, concentrating on correct departure wake separation or other co-ordinations.

Communications

In Case 3, the imprecise conditional ATC clearance meant the Beluga tow driver made his own interpretation of the clearance which led to a false perception of reality and he started to cross the runway instead of waiting for the landing aircraft to pass and then cross behind it. The situational awareness of the controller and the Beluga tow driver in this case was clearly different. Communication issues were, unsurprisingly, a contributing factor in just over a third of the real-life incidents analysed in the OSS.

So, what are the best ways to prevent these events happening and mitigate them when they do?

The analysis in the OSS clearly shows that some runway incursions could have been prevented if the controllers had had better means to **detect** that the runway was (authorised) occupied at the time of issuing clearance to the next aircraft to use it.

Prevention Barriers

The table below provides a theoretical ranking (highest at the top, lowest at the bottom) for 10 identified **prevention** barriers.

Barrier	Barrier Description
PB8	Input and display of ATC clearances and surveillance data (ITWP) to jointly detect non-conformance to clearance and the potential impact of incorrect clearances
PB7	A-SMGCS level 2
PB2	ATC visual detection including video and remote camera displays
PB4	ATC resolution following pilot/driver alert
PB1	ATC memory aids
PB3	ATC detection using remote camera displays
PB6	A-SMGCS level 1
PB10	Vehicle have high vis flashing or strobe lighting
PB9	Use of named HPs e.g. BARKA
PB5	Basic SMR

PB8 is the single most efficient barrier. Unfortunately this functionality is not yet widely available; however, it is due to be rolled out in at least 19 large European aerodromes and the OSS strongly supports its development and deployment.

Mitigation Barriers

The table below (again in ranking order) indicates which mitigation barriers are theoretically likely to be more effective in most operational scenarios.

Barrier	Barrier Description
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)
MB3	ATCO detection following pilot/driver report
MB2	ATCO detection using remote camera displays
MB1	ATCO direct visual detection
MB6	ATCO detection after alert from A-SMGCS level 2
MB5	ATCO detection using A-SMGCS level 1
MB7	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).
MB4	ATCO detection using basic SMR

Combined Prevention and Mitigation Barriers

In addition to PB8/MB8, the OSS assessment of the theoretical effectiveness of combined barriers suggests that proactive alerts from pilots and drivers that lead to ATC detection and resolution (PB4 and MB3) are likely to be very important barriers, especially in reducing the risk of collision in runway incursions. The actions of the driver in Case 1 are a good example and also demonstrate the value of vehicles on the runway being on the Tower frequency as a good means to improve drivers' situational awareness.

Moreover, ATC direct visual detection (PB2 and MB1) and the use of A-SMGCS level 2 (PB7 and MB6) are both strong barriers in the prevention and mitigation of runway events – in Case 4, however, the unavailability of any runway safety nets meant that by the time the controllers had seen the aircraft crossing the runway it was already too late for them to take effective action. ATC detection of incorrect runway presence, using remote camera displays (MB2) is a strong mitigation barrier as it does not necessarily depend on good visibility and line of sight. ATC memory aids (PB1) are also potentially strong barriers that aid ATC perception and memory; however, it is these areas of ATC action that fail most often in the 20 real-life events analysed in the OSS, providing an indication of the need for more technological solutions to overcome these known human frailties and help improve controllers' situational awareness.

Finally, the OSS highlights the importance of the **"one team" awareness ethos involving ATC, pilots and drivers in stopping conflicts becoming collisions** and provides empirical evidence of the effectiveness of cross-industry safety awareness training.

ARE YOU AWARE OF WHAT CATCHES YOUR ATTENTION?

by Jean-Jacques Speyer

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

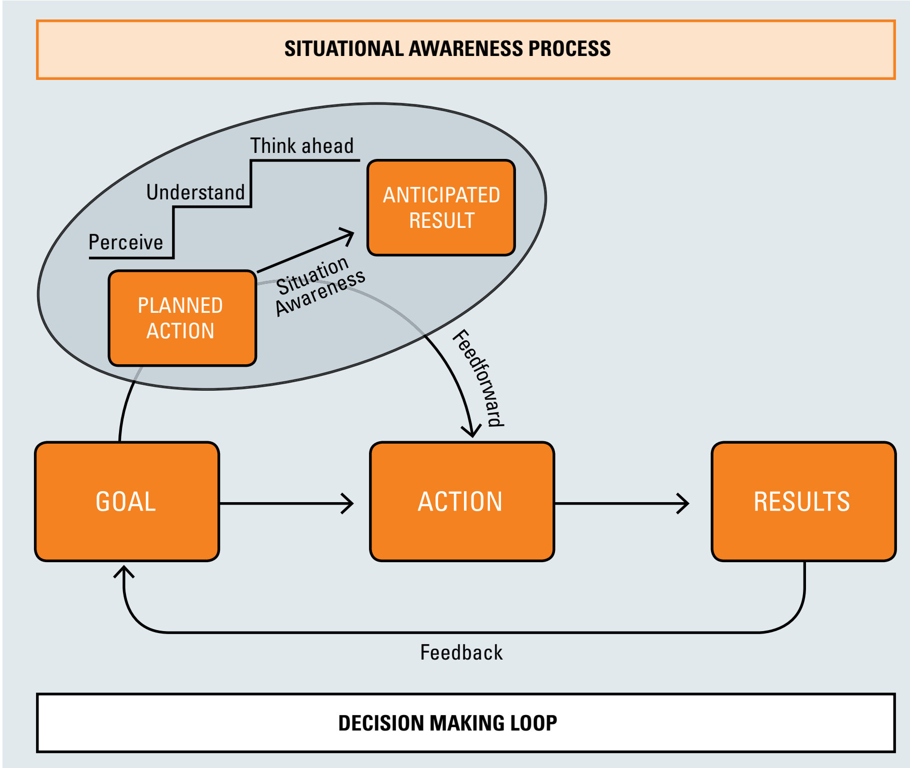
The term **"Situational Awareness"** first appeared several decades ago. In aviation, as usual with Human Factors, there was some initial hesitation about what this new "buzzword" actually meant. But the more it survived, the more we kept throwing at it, replacing the word "situation" with terms like 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.

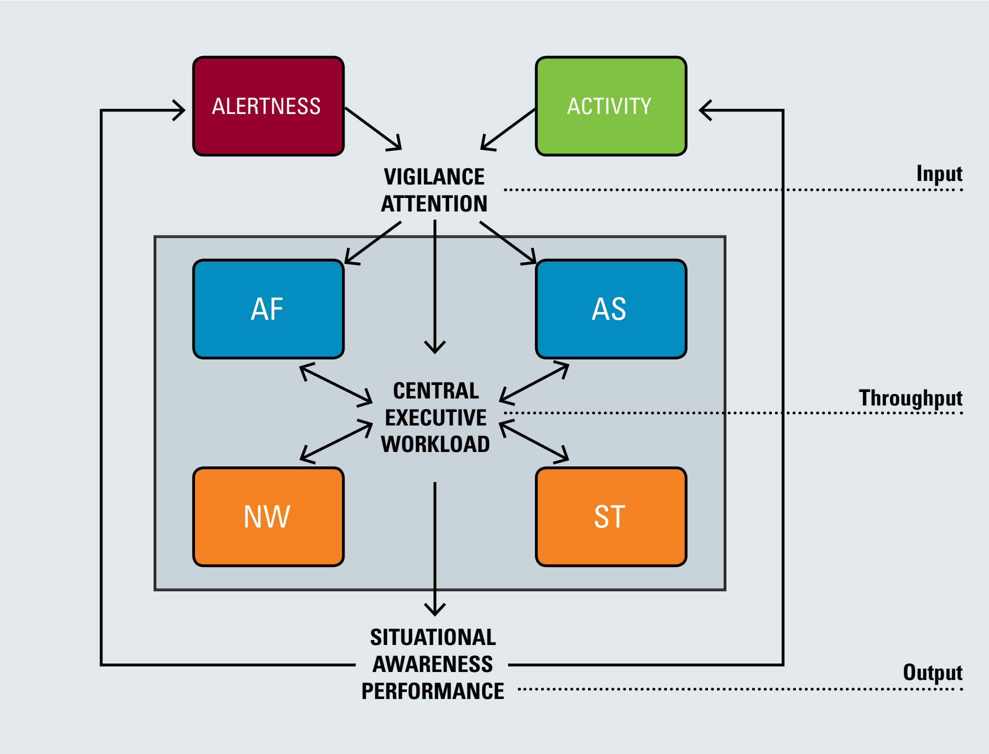


Alertness levels are influenced both by the environment and by the pilots' ***involvement***. But if sensory stimulations remain almost constant or very repetitive as with frequently recurring routines (or with highly automated processes not rigorously being attended to), this may well be related to 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.



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:

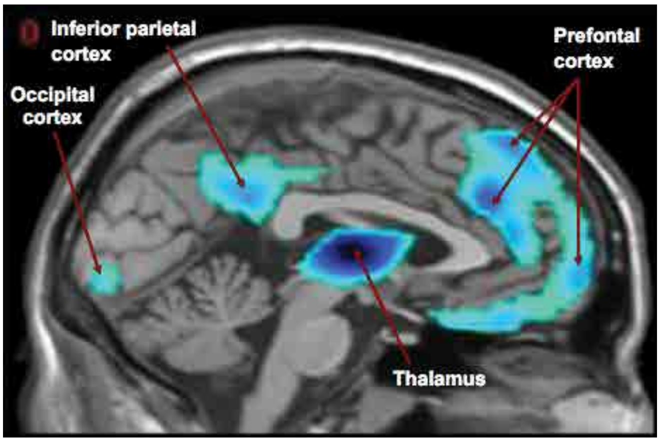
- **prefrontal cortices** (the highlighted frontal brain section) which controls executive mental functions like situational awareness and problem-solving,
- **inferior temporal cortices** (the left-side highlighted region) which conceals high-order mental subtasks such as those involved in mathematical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

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.

JEAN-JACQUES **SPEYER**

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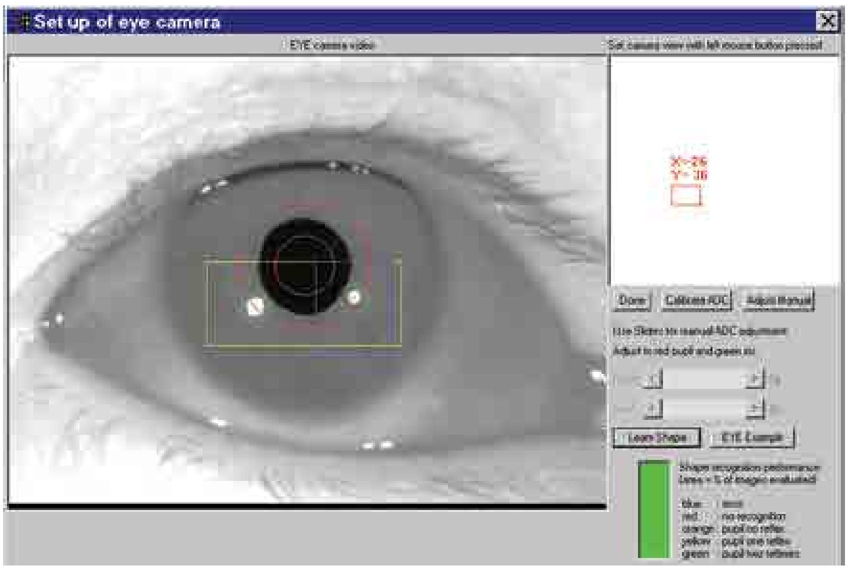
3. Stimulating Alertness using an existing Situational Awareness Procedure

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!

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DOES MORE INFORMATION EQUAL BETTER SITUATIONAL AWARENESS?

by Captain Wolfgang Starke

Compared with the flight decks of older generation aircraft, the flight deck of today's modern aircraft offer a tremendous amount of information to pilots. Basic information like attitude, speed or altitude is complemented by trend vectors, flight directors, all kinds of situation displays and much more. On top of all this information we find numerous advisory messages, cautions and warnings that are designed to direct the operator’s attention. Is all the information needed? Does more information lead to an increase in situational awareness?

Imagine a small child visiting the pilots in a flight deck of a modern airliner. Maybe the pilots turn on the light test switch that illuminates all the different lights and displays in the flight deck, giving it a very special atmosphere. One of the top 10 questions all these little children are likely to ask is "how do you remember all these lights and switches?".

Some typical answers to this question might be "oh, we have all the switches two times so you just need to know half of them" or "you need to work hard, get good marks in school and then you are able to learn all this". There is a little bit of truth in both these answers. Of course the two screens in front of the First Officer have the same content as the two screens in front of the Captain and we also go through a lengthy and intensive type-rating course to learn all the systems, switches and indications. At the end of this course we know them all.

Still, the questions of our young visitors and our answers to them in this case invite more serious consideration. The real question is not how can you remember all these switches and indications, but how can you observe all these indications, how can you build up your situational awareness with so many indications at the same time? Do we have the mental capacity to acquire all the information, process it and build up complete situational awareness?

To answer this bigger question, we need to figure out the capacity of human information acquisition and processing. In typical documentation about human performance and limitations it is mentioned that our short-term memory can "store" seven pieces of information for a couple of seconds. As the flight path of an aircraft is rather dynamic, this could mean that sometimes, we need to continuously refresh our awareness of the seven most important indications every couple of seconds if we are to maintain our situational awareness.

A very theoretic and certainly not particularly insightful way of looking at this complex question!

On the other hand there is some truth in it. You need to look over and over again at the most important information to maintain awareness of the flight path. If you look too much at other indications, your awareness of the flight path will be lost. The same is true when driving a car. Setting up the navigation system whilst making a phone call could - and probably will - reduce your attention on driving your car and observing the traffic.

Of course, the more relevant experience you have the more things you can do in parallel. I remember my first session in a Boeing 737-400 full flight simulator. Once my colleague set the thrust for take-off, I nearly lost my situational awareness completely. It was just too much of information for me as brand new Second Officer. Of course, since then my acquisition and processing of information has improved significantly! Still, it does have its limits - perfectly normal as all of us have our limits.

If we now look in a bit more detail at the question of how much information we need, I believe the amount of information should be selectable. We all have different limits so it will be hard to find a "one size fits it all" solution.

In Summer 2014, I flew a route training sector into Berlin Tegel whilst supervising a new Second Officer. As weather was good and traffic density was not too much we decided to fly a non-precision approach into runway 26R. The Second Officer did well flying the procedure and about two miles from runway threshold he decided to continue visually to touchdown and disengaged the autopilot. Now the problems started. While I was happy with all the information I had, he was starting to get increasingly overloaded. In what we call the "getting back to Mama" response, he reverted to the approaches he had first flown and concentrated on the flight director. When flying an ILS-approach, following the flight director will bring you to 50ft above the threshold on centre-line. But if you fly a non-precision approach using may be "vertical speed" and "heading select", you will certainly not arrive at this position.

After calling out the flight path deviations two or three times, I needed to make a decision. My first try was to disengage his flight director. Without his flight director, my colleague was able to process other information. He looked out of the window, saw the runway, corrected his flight path and a successful landing followed.

What I try to show with this example is that additional information sometimes takes our attention away from where it should be. Also the point at which additional information will distracting us from our main task differs from one human being to another. For any individual, that limit also depends on many more factors like time of the day, length of duty, experience, mental and physical state, problems at home and so much more. This basically means that the amount of information presented

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As long as we are flying IFR I will trust my instruments absolutely ...

to the pilot must be adjustable to their prevailing capacity. When considering information like airspeed or attitude that cannot (and should not be able to be!) deselected, this decision about what information is a "must" needs to be taken very carefully.

A good example of a non-switchable indication is the flight path vector on the Embraer E-Jets. Unlike most of the aircraft types I know that are normally flown by reference to pitch and heading, this type is flown by direct reference to a flight path target. In normal operation this is a very good concept as pilots do not need to calculate pitch or heading to adjust their flight path. Using the flight path vector pilots can directly fly by reference to the target they are aiming - their flight path.

However, remembering my type-rating course on the Embraer 190, a complete malfunction of the air data unit will cause you more of a problem than on other aircraft. Pilots become used to flying by reference to the flight path vector rather than thinking about pitch and thrust. So if the air data unit is unserviceable, the flight path vector is no longer useable and the required flight path must be achieved by reference to pitch and thrust. But even knowing this, you will tend to look at the information source you usually use, the now invalid flight path vector. Now you need to "deselect" this information in your brain cognitively. Certainly it is possible to do this but being able to simply deselect this now erroneous information would be a lot easier in a relatively stressful situation.

So, coming back to the title of this article "does more information equal better situational awareness". I think the answer is a clear "no" but certain information still can increase situational awareness.

Two things need to be done. First, the majority of information in a flight deck needs to be selectable at the discretion of the pilot. Depending on his mental capacity and the usefulness of an indication they can then select the information they need for safe operation and deselect any distracting information. The second and even more important requirement is that the information presented to the pilot must be safety-assessed taking into account the 'big picture'. Additional information does not automatically mean better situational awareness and additional information can sometimes be a distraction which diverts attention from where it should be. Major safety issues can result.

The full picture therefore needs to be safety assessed and any piece of information should be evaluated. That evaluation needs to ask whether that information is a permanent "must", can be switchable for the operator or whether the balance between distraction and added value is such that the information should not be presented at all.

Flying, especially in poor weather after a long duty is highly dynamic, can even be challenging, so a flight deck that seems very well designed when seen in relaxed circumstances on the ground can be very impracticable and unsupportive under certain in flight circumstances. The more demanding a situation is, the more focused on the most important information the displays have to be.

More information and more directive indications do not always favour situational awareness. Sometimes less is better.

SITUATIONAL AWARENESS

by Lt Col Bruno Beeckmans

Aviation has evolved over the years. The biggest safety wins were first through better airworthiness by design ands reliability and only later was the importance of human factors recognised. Now, a culture which embraces open (clear unguarded) communication, committed leadership and effective decision making is continuing to evolve globally. Situation awareness considers content and context. It zooms out to look at the big picture like a GENeralist and zooms in to look into the detail, like a specialist. If you can do the both you are a GEN-IAL-ist and have SA!

First of all it is important to understand that the human brain cannot multi-task. At best people can perform tasks in quick succession. A simple test using a blank sheet of paper may help convince you:

M	U	L	T	I	T	A	S	K
1	2	3	4	5	6	7	8	9

- **Test 1:** Start your watch, write MULTITASK on the top line then write1-9 on the next line, stop your watch.
- **Test 2:** Start your watch, write M, 1, U, 2, L, 3, etc., stop your watch.

M								
1								

Let me guess: your timing of the first task (maybe about 8 seconds) was quicker than that for the second (maybe about 13 seconds).

Any flight involves fulfilling a intention whilst performing error management so as to maintain the aircraft state vector (x, y, z, t, speed, acceleration, configuration, etc.) within intended/permitted limits. Risk is inherent in flying. An aviator must therefore master the art of risk management.

Risk management consists of identifying hazards, considering the specific component of each one, establishing the potential consequences in each case and finally determining its cause(s). Once the cause has been identified, mitigation can be put in place. That hazard is then labeled with a probability and an impact. I will limit myself to the hazard analysis.

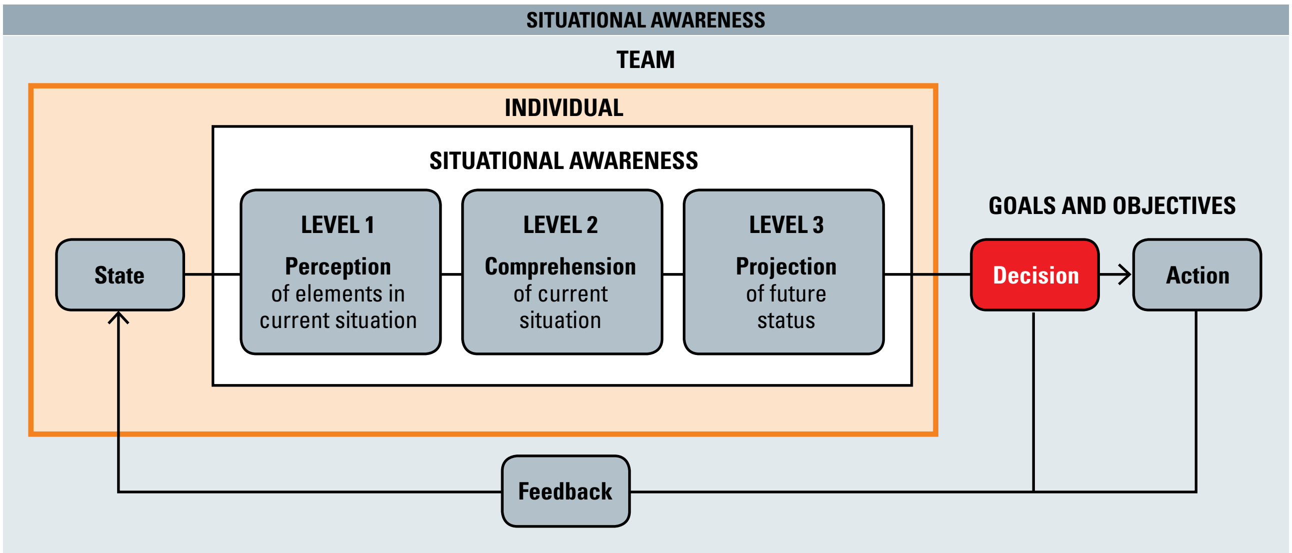
Endsley[1] has defined SA as:
"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future".

There are 3 discrete stages in SA:

- Level 1 involves **perception** of the elements in the environment. This is the identification of the key elements or "events" that, together, define the current situation
- Level 2 involves **comprehension** of the current situation - the combination of level 1 events into a comprehensive pattern, or 'tactical situation' which defines the current status in operationally relevant terms to support rapid decision making and action.
- Level 3 involves the **projection** of the current situation into the future in an attempt to predict the evolution of the tactical situation. It supports short-term planning and, when time permits, option evaluation.

A decision taken without first reaching level 3 SA would be 'jumping to conclusions' and not the right thing to do. Action taken based on Level 3 SA is likely to affect the original state and thereby create a loop which must be re-run using the new state. Of course, SA should not only be viewed on an individual level, it must take account of interacting personnel - pilots, other aircrew, ATC, fire crew, etc.

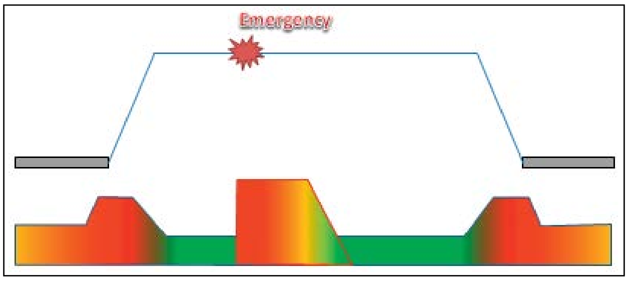
Generic hazard	Specific components of the hazard	Hazard related consequences	Causes	Existing mitigations safety controls and/or requirements



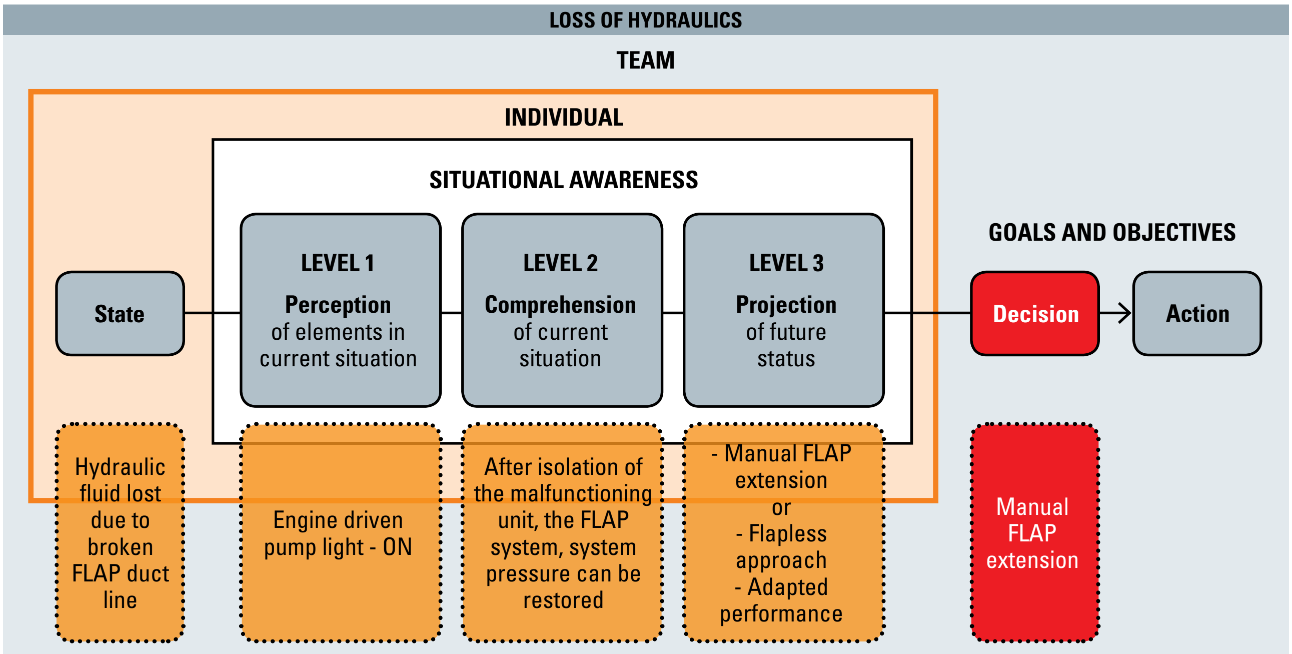
An Example to illustrate the concept

A crew takes-off on a regular mission, the profile is a standard cruise flight with associated workload as indicated - low.

In the cruise, a hydraulic leak occurs - workload becomes higher.



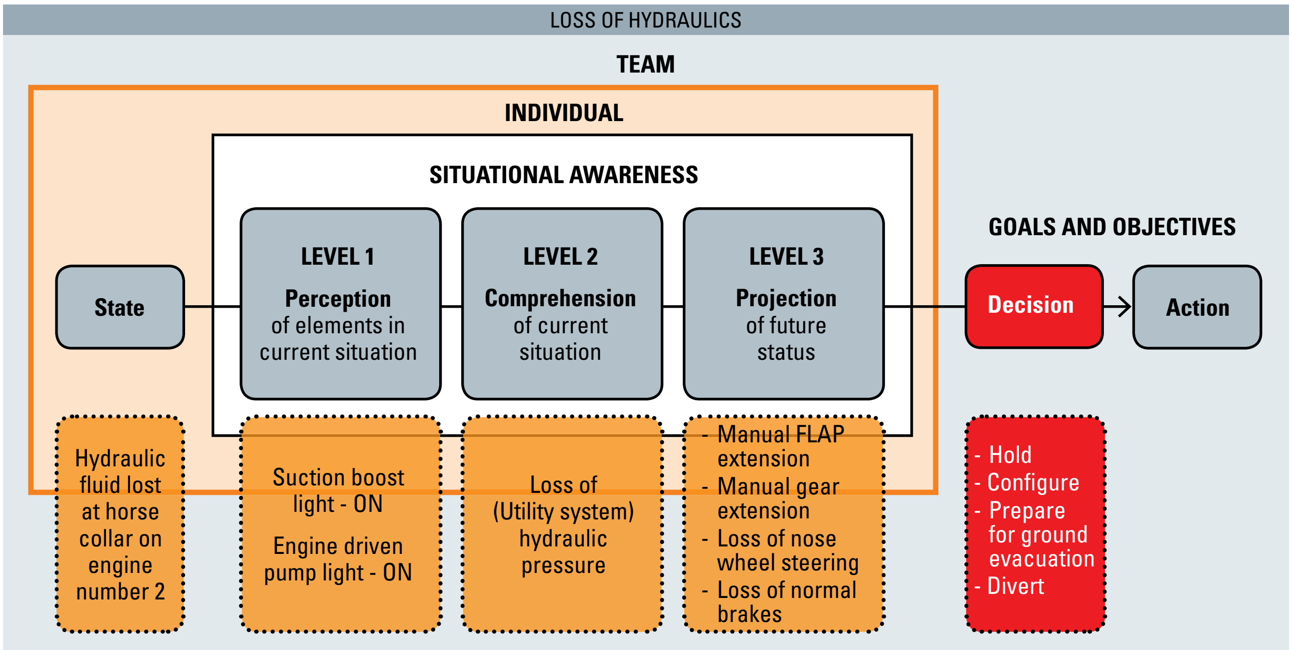
The crew is alerted to the leak by the illumination of a light in the flight deck and after isolating the leak, which is in the malfunctioning flap line, they anticipate either the extension of the flaps manually or a flapless landing.



But the action taken has reset the initial state and the loop which must be closed and the SA development process re-run. Not doing this would create a hazard which can be analysed as follows:

Generic hazard	Specific components of the hazard	Hazard related consequences	Causes	Existing mitigations safety controls and/or requirements
Focus on solution	N/A	Lacking to see new situation	Human nature. Lack of metal flexibility	Focus on hazard identification rather than solution Performing the SA feedback loop

Let's now assume that 'Murphy' is on board and that despite the earlier correct initial response, a total loss of hydraulic fluid subsequently occurs. Transposed into the SA model, the appropriate action follows. The crew works swiftly and SA is maintained throughout the team. Operational Risk Management is (again) performed using the Abnormal/Emergency Checklist and the effect of the hazard is contained. The team now includes ATC and Base operations who are informed. It is a busy time at Brussels National - the home base of the C-130 as well as the main Belgian civil airport - and when ATC are advised that after landing, the runway will be temporarily blocked because the aircraft cannot be taxied without nose wheel steering, they request that the aircraft diverts to a nearby air base at Beauvechain. Base Ops and the airbase are informed and the fire services at the latter are put on standby. A perfect example of Team Resource Management.



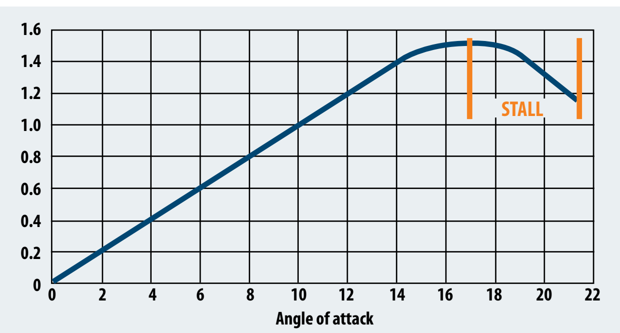
Without keeping ATC in the picture by projecting a significant consequence of the aircraft status, a short delay in clearing the landing runway could have surprised them. Keeping up with reality is part of the SA deal.

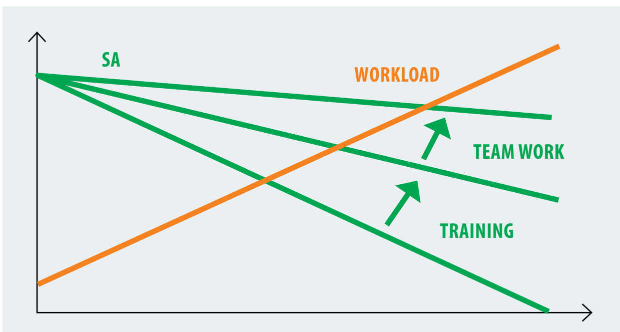
SA Examined

Now let's dig deeper into SA. The Generic Hazard of 'Loss of SA' can be based on two possibilities - the wrong decision is taken or no decision is taken. The hazard-related potential consequences are either an unsafe condition or a crash.

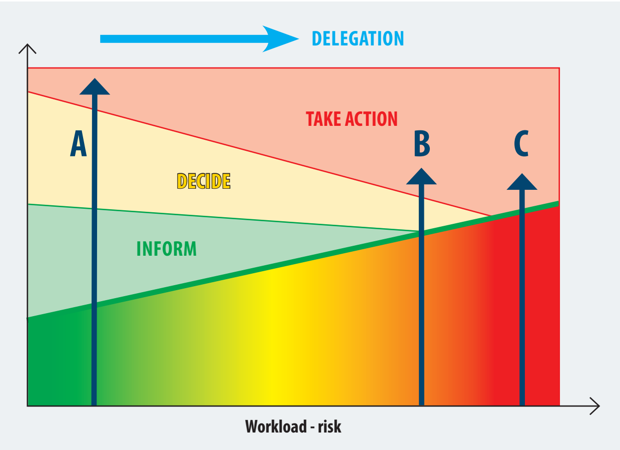
Any event during flight can be classified as normal, abnormal or emergency. Different workloads apply to each. If one views flying an aircraft as achieved through error management, which is linked to SA, then the achievement of SA can be seen as inversely proportional to workload. Any aviator will be familiar with following graph:

Take the CL axis as individual SA and the AOA axis as workload. Although the SA is not solely a function of workload, the parallel is that at some point an individual's SA is going to stall. The most important lesson to remember is that everybody subject to this law, justifying the need for both assertiveness and a questioning culture. It is useful to look at workload more closely. The steepness of the curve can be trained and increased with experience, it will be affected by the circadian rhythm, the mental freshness and mostly: the interaction with SA-feeders.





Like a stall, loss of SA is easily predicted if not gradually encountered. But workload is a personal experience. People have no gauge, so although increased workload can be apparent in observed behaviour, an individual's workload assessment should be verbalised to team members because others may not have time to observe as they may themselves be (over)loaded. In general one can state the higher the workload, the higher the need for delegation and interaction.



From the picture above we can discern 3 situations: A, B and C.

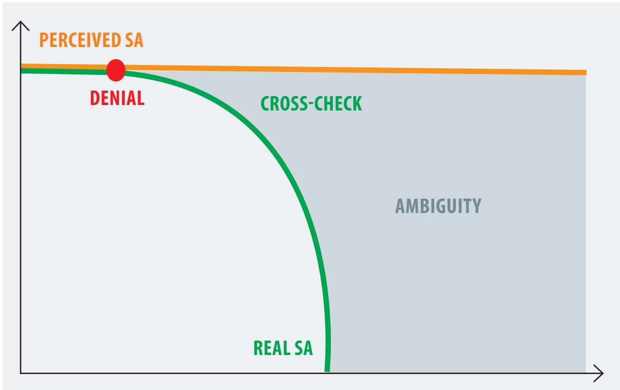
- A is a low workload/risk situation with plenty of time available so a collaborative decision on the action to be taken is possible.
- B is a medium workload/risk situation with less time to respond, e.g. reaching decision height on an approach it's 'continue/land' or 'go around'
- C is a high workload/risk situation and an immediate response is required - think of a corrective TCAS RA or an EGPWS "PULL UP" warning.

When workload is low, the information threshold should be low to ensure a smooth input on which to build SA. Understanding workload will help crew members understand when to feed information and when not to . In the event that workload increases, task distribution should be clearly defined and delegation by the aircraft commander becomes key.

Technology can be a great help in automatically setting information thresholds - by protecting cognitive capacity. The software which delivers these thresholds is predictable whereas humans are not so establishing an in depth 'Service Level Agreement' within any SOP is essential: vital information MUST be passed on to the flying pilot at all time and non-essential info-flow must be avoided. Pilots must know what to expect from each other and so standardisation is paramount. Techniques are allowed for Individual SA, whereas procedures (which are often adopted techniques) apply to Team SA. The art of communication must be understood too. Of course this can be learned 'on the job', but it is better to consider it in the classroom first!

Understanding SA means recognising that it is a time-bound concept, that it is lost rapidly the second you 'stall' because of workload or interruption or distraction. Letting people sort things out by themselves to regain SA tends to be time-consuming. A more efficient way is to admit the loss of SA and allow the rest of the Team to respond with that knowledge. To ensure shared or Team SA is maintained, , briefing is essential - before take off or during flight - and must be given time it deserves. And of course, from the shared SA perspective, the SA "state vector" extends beyond the aircraft state vector (x, y, z, t, etc) as other factors such as ATC instruction, positional awareness, aircraft energy management, Checklist status, intra crew communication come into play.

Finally, and perhaps most important of all, we must not forget that SA has two dimensions, perceived SA and real SA and it is clear that any gap between the two must be minimised. Denial of this possibility must not be an option.



In some situations a 'state' may present itself similarly for different reasons (causes) creating ambiguity. So it is paramount to perform an in-depth (engineering) analysis, i.e. to 'sniff before you buy'. Once someone puts a label on a situation it can lead to others following on that basis, so a sound questioning culture with assertiveness (not aggressiveness) is essential. A suspicion must be validated to rule out probability, assuming amounts to staking odds. Zooming out and falling back on a rule of thumb can be a helpful method to avoid being lured into false conclusions.

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ENHANCED PILOT SITUATIONAL AWARENESS THROUGH THE DIGITAL/GRAPHICAL PRE-FLIGHT BRIEFING CONCEPT

or "from smoke signals to the digital pre-flight briefing concept"

by Renée Pelchen-Medwed and Eduard Porosnicu

THE TELEPRINTER MACHINES IN THE 1920'S SUPPORTED ONLY UPPER CASE LETTERS AND THIS IS THE REASON WHY SOME PILOTS TODAY STILL HAVE TO GO THROUGH NUMBERLESS PAGES OF NOT USER FRIENDLY NOTAM FULL OF ABBREVIATIONS LIKE CLSD RWY 24L TEMPORARY DISPLACED THRESHOLD PAPI GA 3 ETC.

Not only is reading text like this not very user-friendly, it also brings the risk of misinterpretation and can even lead to dangerous situations. Accident reports sometimes identify a failure to review, properly understand and/or recall NOTAM information correctly as a contributing factor, for example in the attempted take off from a closed runway at Taipei by a Boeing 747 in 2000[1]. An analysis of investigation reports on aircraft accidents indicates that the format of the briefing documents can make the extraction of key information difficult. A pilot must be able to easily obtain comprehensible information relevant to his flight to help establish the necessary situational awareness. Relevant information will include data about the route to be flown, about the departure, destination and alternate airports and weather information, both observed and forecasted.

The means that gives the pilot this overview and provides situational awareness during the pre-flight briefing is the generic Pre-flight Information Bulletin (PIB) along with separate MET Charts, Forecasts and Reports. A Pre-Flight Information Bulletin (PIB) contains details of current NOTAM for a specified area or along the route. A NOTAM is defined by ICAO as "a notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations". And it is this "means of telecommunication" that still determines the format of the NOTAM at initial issue. NOTAM have

PRE-FLIGHT INFORMATION BU

1- see http://www.skybrary.aero/index.php/B744,_Taipei_Taiwan,_2000 retained the all-uppercase letters only and abbreviations that were needed for the Teletype machines of the 1920s that could only transmit limited information. However, despite tremendous developments in communications technology in recent decades, only very small advancements have been made in improving the usability and user-friendliness of the NOTAM system. It should also be noted that there is a significant increase in the number of NOTAM issued around the world, which has grown from around 300 000 in 2000 to more than 1.1 million in 2015. This leads to visibly longer and more complex PIB documents for pilots.

Studies recommending improvements are not new, but only since 2010, when the concept of the Digital NOTAM was defined, things have started to progress. No longer does a NOTAM need to be a hard copy text notification. Instead it arrives in a format which can be transformed, analysed and presented to the end user in a form tailored to their specific needs. The availability of Digital NOTAM will enable a complete rethink of the presentation of pre-flight information bulletins. This overdue modernisation can address safety recommendations from accident investigations concerning the need for better NOTAM clarity - in particular annotated graphics in place of text with location described by coordinates or text descriptions. “A picture is worth a thousand words”....

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*+ DE-ICING PROCESS EXPERIMENT UPON SOME TERMINALS
   2D AND 2F1 ACFT STANDS
   FROM: 17 JAN 2011 06:00   TO: 15 MAY 2011 23:59                    (A0217/11)

*+ THE DE-ICING AND ANTI-ICING PROCESS SHOULD BE MODIFIED AS
   FOLLOWS-CONFIRMATION ON DE-ICING FREQUENCIES:
     - DE-ICING/ANTI-ICING IN ONE PHASE:
   SPRAYING OF TYPE I PRODUCT ( BRAND 'CLARIANT SAFEWING MPI1938
   ECO(80)'OR ' ABAX DE950' ) MELTING OF FLUID AND WATER
     - DE-ICING/ANTI-ICING IN TWO PHASES:
   SPRAYING OF TYPE I PRODUCT WITH MIXED FLUID/WATER FOLLOWED
   WITH APPLICATION OF TYPE II PRODUCT AT 100 PER CENT
   CONCENTRATION (BRAND'CLARIANT SAFEWING MPII FLIGHT
   FROM: 22 JAN 2011 05:00   TO: 15 MAY 2011 23:59                    (A0329/11)

*+ LOCATOR RSY 356 KHZ, RSO 364 KHZ OUT OF SERVICE
   FROM: 01 APR 2011 08:00   TO: 30 NOV 2011 16:00                    (A1550/11)

*+ NOTAM SUBJECT TO QUERY RADIO NAVIGATION AIDS TO BE CONFIRMED
   NDB CGZ 370KHZ, CGO 399.5 KHZ OUT OF SERVICE
   FROM: 01 APR 2011 08:00   TO: 30 NOV 2011 16:00                    (A1551/11)

*+ TRIGGER NOTAM- AIRAC AIP SUP 018/11 IN FORCE ON 2011 APR 07TH,
   WORKS ON ACFT STANDS.AVBL ON  WWW.SIA.AVIATION-CIVILE.GOUV.FR
   FROM: 07 APR 2011 00:00   TO: 16 DEC 2011 23:59                    (A0909/11)

*+ TRIGGER NOTAM - AIP SUP 021/11 IN FORCE ON APRIL 07, 2011 :
   WORKS FOR TWY U AND C COMPLIANCE.
   CURRENT PHASE : PHASE 1.
   AIP SUP AVAILABLE ON WWW.SIA.AVIATION-CIVILE.GOUV.FR
   FROM: 07 APR 2011 04:00   TO: 26 JUN 2011 04:00                    (A0912/11)

*+ TRIGGER NOTAM - AIP SUP 020/11 IN FORCE ON APRIL 10TH, 2011 :
   PREPARATORY WORKS IN ORDER TO MODIFY THRESHOLD 08L :
   DURING THIS PERIOD, TAXIWAYS UN, UC1, UC2, UC3 AND U BETWEEN N AND
   UC3 INCLUSIVE ARE CLOSED H24
   AIP SUP AVAILABLE ON WWW.SIA.AVIATION-CIVILE.GOUV.FR
   RMK: CHANGE OF WORK ENDING DAY 09 MAY 15H00 INSTEAD OF 10 MAY
   0600.
   FROM: 06 MAY 2011 11:31   TO: 10 MAY 2011 06:00                    (A2253/11)

AERODROME (ALTERNATES)

EBBR - BRUSSELS/BRUSSELS-NATIONAL

-  PILOTS SHALL REQUEST START-UP BTN TSAT MINUS 5 MIN AND TSAT PLUS 5
   MIN.EARLY REQUESTS WITHOUT FPL UPDATE ONLY AS OF EOBT MINUS 15 MIN
   AND ONLY AFTER PRIOR PILOT CHECK ON ALL DOORS CLSD AND PUSHBACK
   AVAILABLE OR PRESENT AT THE ACFT.
   FROM: 05 JUL 2010 15:10   TO: PERM                                  A1436/10

+  ACFT STAND TAXILANE STRIP 1 CLSD DUE TO WIP
   FROM: 28 MAR 2011 06:00   TO: 30 JUN 2011 15:00                     A0476/11

+  ALS CAT I RWY 02 MISSING BARETTE 390M FM THR
   FROM: 31 MAR 2011 21:30   TO: 30 JUN 2011 14:00                     A0512/11

+  ACFT STANDS 305, 306, 307, 421, 422, 423 AND 424 CLOSED DUE TO WIP.
   FROM: 05 APR 2011 07:55   TO: 01 JUL 2011 15:00                     A0526/11

+  WESTERN PART TWY N2 ABEAM ACFT STAND 906 ONLY AVBL FOR ACFT ON
   TOW.MAX.WINGSPAN 45M. CL DISPLACED 25M TO THE NORTH
   FROM: 26 APR 2011 05:00   TO: 16 MAY 2011 15:00                     A0688/11

+  ALL ACFT DEPARTING FM APRON 9 SHALL BE PUSHED ON TO TWY N2 FACING
   EAST ABEAM ACFT STAND 903 OR FURTHER EAST. PUSHBACK DISCONNECTION
   AND ENGINE START UP ONLY ALLOWED FM THIS POSITION.
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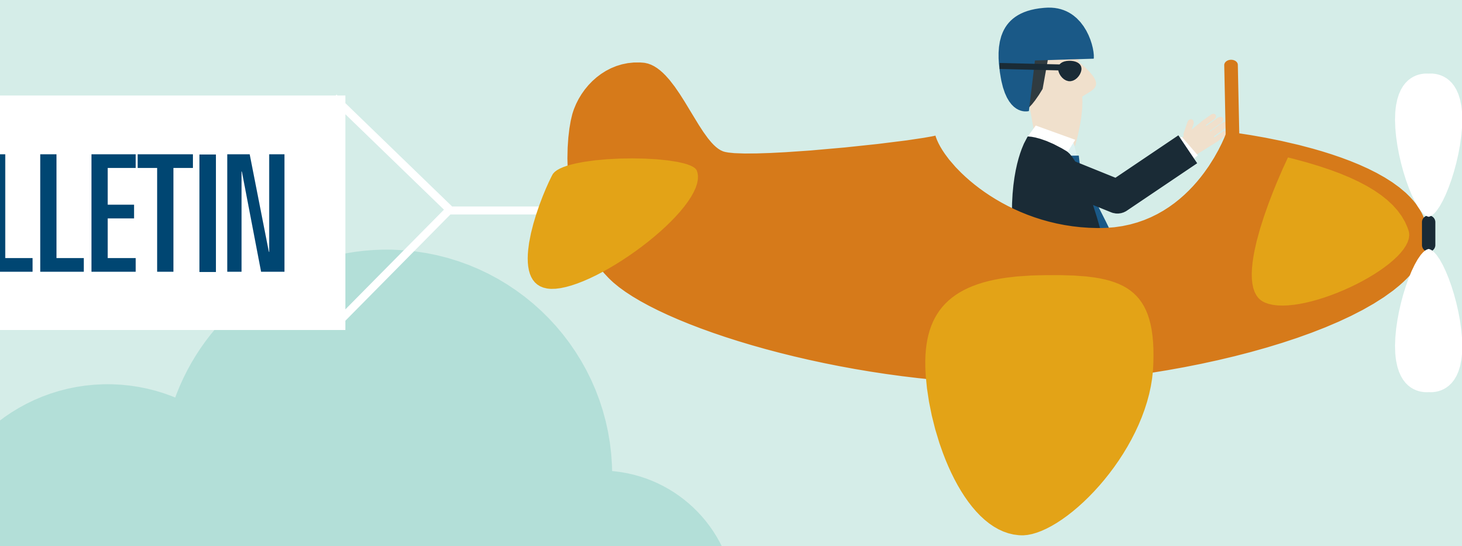
Figure 1 The NOTAM page of a traditional PIB

Within the frame of SESAR, the Aeronautical Information Management (AIM) project has recently held its final validation exercise of the digital/graphical pre-flight briefing concept. The exercise was supported by an enhanced Pre-flight Information Bulletin or "ePIB" developed to meet requirements identified in the last three years by the project partners (Frequentis, EUROCONTROL, ENAV, NORACON, DFS and Thales), with the direct involvement of some 'customers' (pilots and dispatchers). The requirements included graphical presentation of information, organisation of information per phase of flight, highlighting information events that are of particular importance and the use of normal sentence case for the text. Most of these ideas have been implemented in the prototype and validated



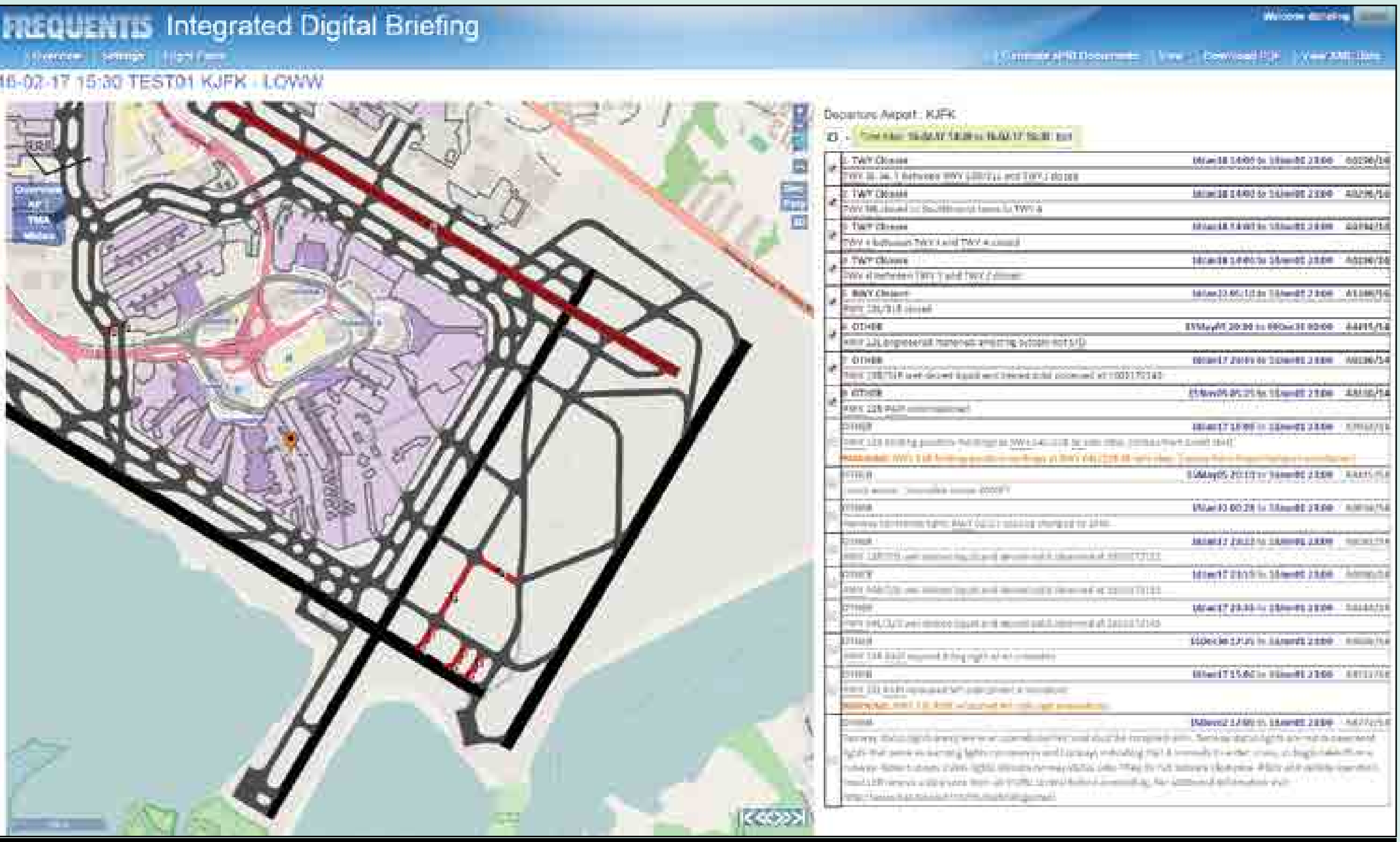


Figure 2 - The ePIB prototype presenting NOTAM on the right side of the picture with the graphical representation of an airport map

through real time simulations. The ePIB prototype also included the option to lookup the meaning of abbreviations.

One of the objectives of these real-time simulations was to provide the pilot with improved situational awareness of the status and condition of airports, airspace and the CNS environment. The validation exercise simulated an Airport Briefing Office where pilots performed a pre-flight briefing using the ePIB prototype. The Digital NOTAM included in the prototype was selected automatically based on their flight planned route including departure, arrival and alternate aerodromes and the intended departure time. The ePIB prototype also aimed to improve the pilot situational awareness of the current operating situation beyond NOTAM by integrating MET data. To be able to compare the improvements of the ePIB over the historical alternative, both scenarios were included in the validation exercise.

Examples of relevant information which would not be known pre flight except through a briefing were included in the validation exercise to see if they were more easily detected using the ePIB process. Such examples included:

- Alerts to erroneous data for the arrival airport (displaced threshold/wrong coordinate decimals)
- A SNOWTAM combined with a closed runway
- Closed taxiways and other relevant events, such as temporary obstacles at the departure airport
- Combined MET and NOTAM information in en-route phase (SIGMET and active military area)

Pilots involved in the validation exercise were invited to review information presented through both the PIB and ePIB method and assess its importance and its consequence for their planned flight. This was done by presenting them with information examples like those above with three minutes to make their assessment for each version - the traditional PIB and the ePIB. Directly after being presented with one version, structured interviews

RENÉE
PELCHEN-MEDWED

works as a Human Performance Expert at Eurocontrol HQ in Brussels. She is a registered Aviation Psychologist with more than 15 years of practical experience in the aviation industry. She joined EUROCONTROL CRDS Budapest in 2003 where she worked as a validation and human factors specialist. Since 2010 she mainly provides human performance support to various operational and technical SESAR projects.

were conducted with them to elicit their feedback. One of the questions they were asked was if they had detected an information example in both formats, how easy it was to detect it in each one and assess if it was relevant to their intended flight.

The results confirmed the expected benefits of the ePIB. This method resulted in all the information examples being detected whereas this was not the case with the traditional PIB so situational awareness was improved by the ePIB. All participants agreed that the ePIB was the better method of providing information and that the graphical representation of events using colour coding and symbols on an airport map and integration of en-route AIS and MET information was useful. An uncontroversial benefit was the display of the NOTAM in a normal case format.

Of course, this was a prototype, so although it was clear that whilst the ePIB brought many advantages for the pilot, there were still quite a lot of improvements needed including more information on airport maps such as runway and taxiway identification.
The need for standardising the graphical presentation of events such as runway closure, navaid unserviceable, airspace reservations, etc. was also identified. A first step in this domain was made by SAE International, which has released a first version of a Recommended Practice (ARP6467) for "Human Factors Minimum Requirements and Recommendations for the Flight Deck Display of Data Linked Notices to Airmen (NOTAM)".
More standardisation efforts are envisaged for the coming years.

The successful completion of this validation, complemented by other validation exercises carried out by SABRE and Honeywell, opens the way for the operational deployment of the ePIB. Soon, pilots will no longer have to read endless lists of NOTAM in upper case, but will be able to consult well-structured integrated AIS and MET information supported by graphical presentations. This will enhance pilots' situational awareness by helping them detect and easily understand the specific information they need and should greatly reduce misunderstanding and misinterpretation.

EDUARD
POROSNICU

Working in EUROCONTROL since 1998 in the Aeronautical Information Management area. Previously worked in the Romania CAA, involved in AIS and procedure design activities. Current responsibilities include the development of automation specifications, in particular thae Aeronautical Information Exchange Model (AIXM) and Digital NOTAM. Leading the SESAR AIM Operational Focus Area, which includes in particular the Digital Integrated Briefing project.

Figure 3 - picture showing the possible lengths of traditional Pre-flight Information Bulletins

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.

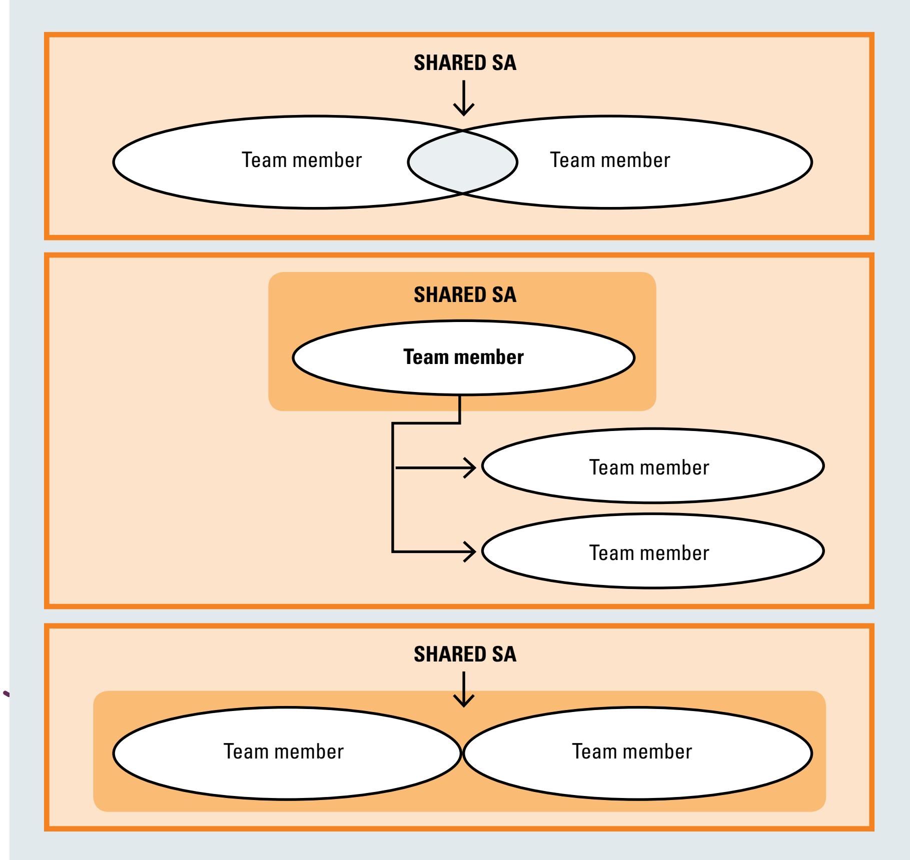
Whilst at NATS I helped with the validation and implementation of the interim Future Area Controller Tool Set (iFACTS) system into service in LACC. The iFACTS system features a number of support tools to assist the ATCO. Chief amongst these is Medium Term Conflict Detection (MTCD), which spots future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

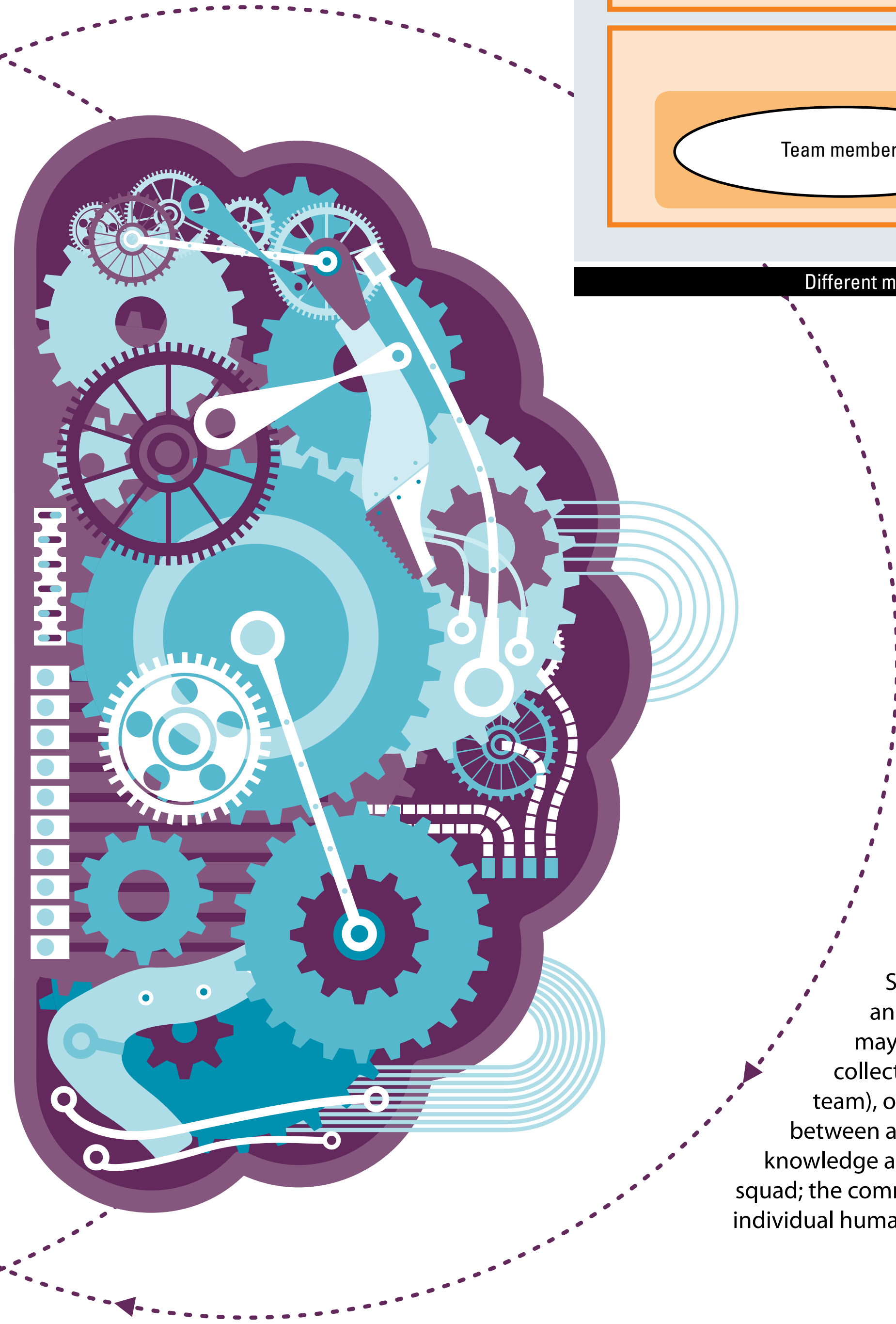
Background on Shared Situation Awareness

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



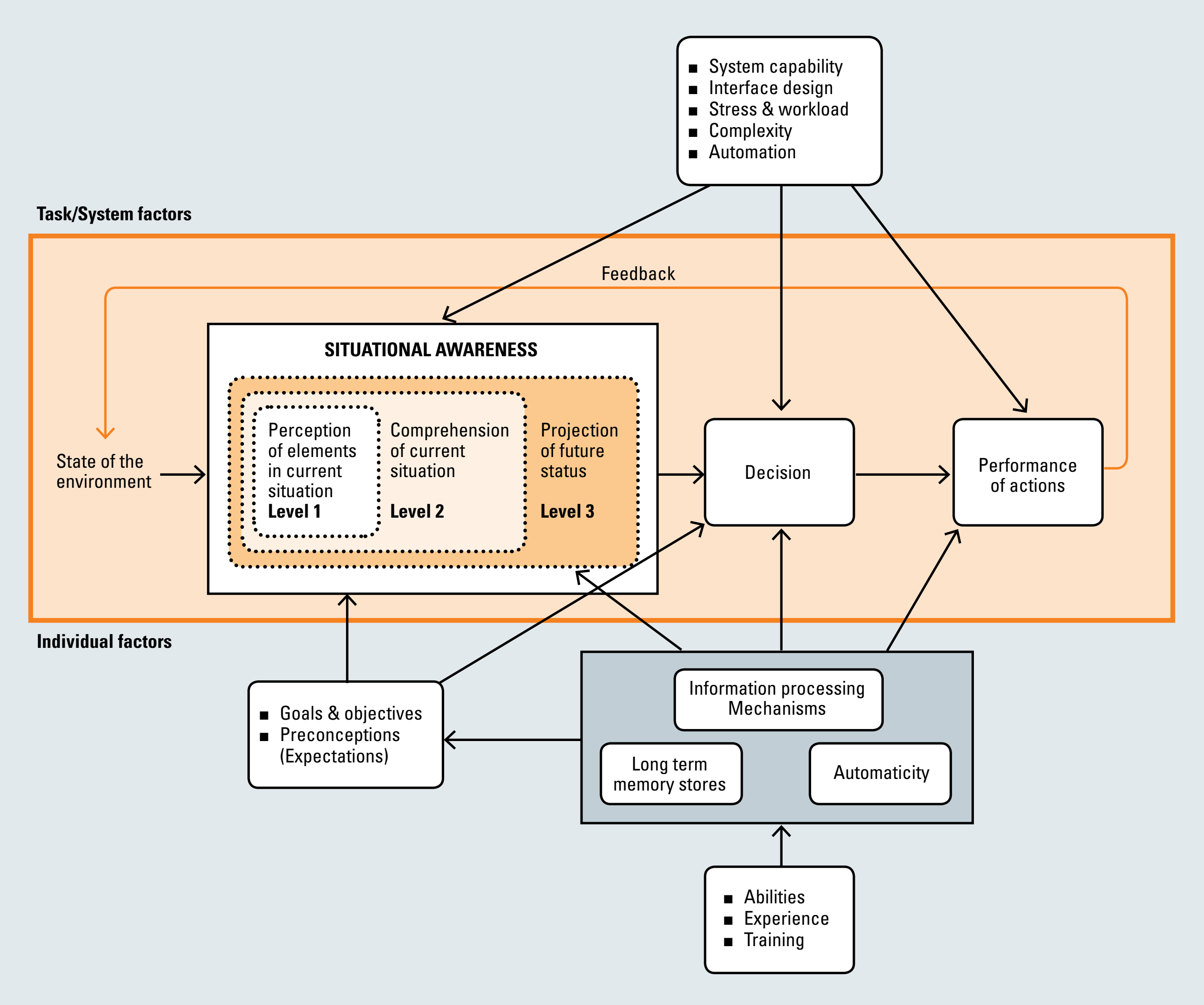
Different models of Shared Situational Awareness



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.



Mica Endsley's 1995 Model of Situational Awareness

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 Airport[1]. 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? 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?

DR DAVID **THOMPSON**

worked at NATS for several years working on new Air Traffic Control (ATC) procedures, airspace, workstations andHMI, and control rooms/towers. A highlight was providing the ergonomics and HF for the temporary airspace and revised ATC procedures for the 2012 Olympics. He now works freelance, providing HF expertise to clients in high-hazard industries. He also lectures at King's College London on the Diploma of Aviation Medicine on the topics of Aviation Ergonomics, and Situation Awareness.

1- see http://www.skybrary.aero/index.php/B772,_San_Francisco_CA_USA,_2013

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MITIGATING CFIT RISK WITH INNOVATIVE CONTROLLER RADAR DISPLAYS GRAPHICS WHICH ENHANCE SITUATIONAL AWARENESS

by Dr. A.O. Braseth

In this article, we present ongoing research into the mitigation of CFIT, which is part of a joint project between three Norwegian organisations, the Institute for Energy Technology, Edda Systems and ANSP Avinor.

CFIT is not the most common cause of aircraft accidents but it is still a significant one. It happens to modern aircraft flown by well-trained pilots - for example the 2012 accident involving a Norwegian Air Force C130J, which crashed in a mountainous region of Sweden with no survivors[1].

Pilots are responsible for the safety of their aircraft, completely so when outside controlled airspace such as that where the C130J crash occurred, but it may be that improved ATC situational awareness using more effective display graphics in radar displays based on human perception research can help. Let us start by taking a closer look at the CFIT situation itself.

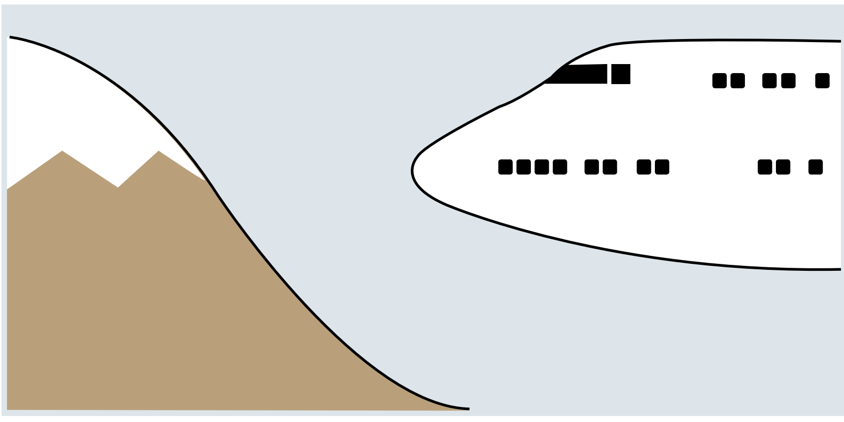
Explaining CFIT

CFIT occurs when a crew inadvertently fly their fully airworthy aircraft into terrain. This requires a complete loss of Situational Awareness (SA). Recognition by controllers that such SA has probably been lost can therefore be used to mitigate such accidents. The introduction of EGPWS dramatically reduced CFIT risk and the ground-based Minimum Safe Altitude Warning (MSAW) systems which warns controllers about aircraft proximity to obstacles and terrain has helped too.

One could argue that these technologies should be sufficient for preventing accidents. However not all aircraft are required to be fitted with EGPWS and Shorrock (2007) noted that controller radar displays are prone to errors in visual perception, which suggests that they can lead to the missing or even overlooking of MSAW activations. We have therefore sought a research-oriented foundation for more effective graphics which can help mitigate CFIT risk by first asking what information is required by controllers for rapid awareness of such situations?

Information for CFIT

SKYbrary (2014) explained how the direct cause of CFIT situations often involves loss of awareness of the aircraft position in the vertical plane in relation to surrounding terrain. The article describes further how many crash-sites are on the centreline of the landing runway and is often associated with non-precision approaches. IATA (2015) explained that the typical causes of CFIT accidents are "flight crew or human error, such as non-compliance with established procedures, inadequate

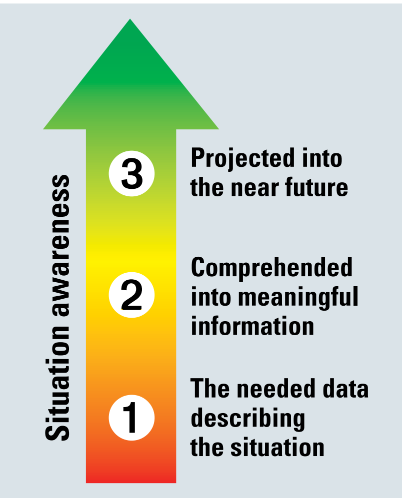


1- see http://www.skybrary.aero/index.php/C30J,_en-route,_northern_Sweden_2012 flight path management, lack of vertical and/or horizontal awareness in relation to terrain, unstable approaches, and failure to initiate a go-around when a go-around was necessary". Ladkin (1997) noted that these accidents often occur outside controlled airspace.

Based on this, we should visualise the aircraft position in relation to nearby terrain and controlled/uncontrolled airspace, paying particular attention to the vertical position. Now, as the purpose is to support a high level of SA, let us look at the definition of that concept. What does it mean for our accident category?

Situation awareness for CFIT

Endsley (2013) described how SA consists of three levels and that all three levels should be supported. We have adapted the material slightly, so encourage readers to visit Endsley´s original research material for a broader understanding of the concept.

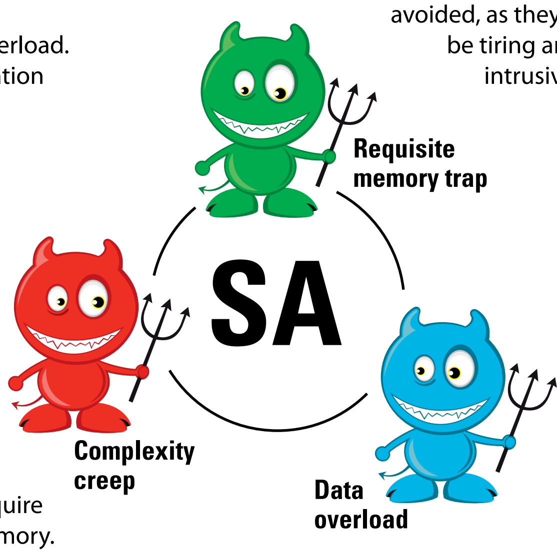


Level 1 raises the question: what are the relevant parameters, what data are needed to understand the situation? In our case, controllers must know which aircraft is involved and relevant data including its speed, flight level, and descent rate (typically found in the flight label). They must also be aware of the position of the flight in relation to uncontrolled airspace. Let us progress to SA level 2. It explains how the data in level 1 must be comprehended. Presentation in a meaningful way is essential - the information on the radar display must facilitate rapid visual perception of what is going on. To support SA level 3, a projection of the situation into the near future must be added - how is the situation expected to evolve in the next minute or so? Is the aircraft likely to enter uncontrolled airspace and where and when could a CFIT potentially occur?

Enemies of Situational Awareness

However, we must also consider the enemies of SA, which Endsley (2013) described as "demons". We will consider three "demons" relevant to the designing of CFIT-sensitive graphics.

The first of these is data overload. To avoid this, the CFIT situation should be presented using only essential data. The second "demon" is complexity creep. To avoid this, visually simple graphical components should be used. The third is the requisite memory trap. This can be avoided by designing visually explicit graphics for the CFIT situation so that their interpretation does not require avoidable use of visual memory.



Rapid perception graphics

The display graphics must be intuitive and effective, "grabbing" the attention of the controller. We will not go into detail here, but display graphics designed for these purposes must be designed to support rapid visual perception. It is therefore appropriate to take account of research into visual perception and computer graphics. Key researchers in this field include C. Ware, C.G. Healey, and J.T. Enns.

Designing visual presentations to optimise CFIT risk detection

Based on the knowledge about CFIT, SA, SA demons and rapid perception graphics, we propose the following design principles:

DR A.O. **BRASETH**

is a principal scientist at Institute for Energy Technology in Norway. He works as an interaction design researcher, and develops information graphics for complex safety-concerned domains. He has several design patents, and is author/co-author of over ten international publications on information visualization.

- The graphics should catch the attention of the controller through strong visual effects. Animated graphics are suitable. Blinking and flashing objects should be avoided, as they can be tiring and intrusive.
- The situation where CFIT risk exists must be easily perceivable and information must be given the highest visual priority. A projection into the near future must be presented.
- The design should focus on simplicity for optimal performance. Graphic objects should not burden controller visual memory, but instead offer explicit visual perception of the situation.
- The design should use visually layered graphics without ornaments or chart-junk, forming whole visual objects rather than multiple standalone elements. This facilitates rapid pattern matching abilities. The graphics should use familiar symbols (natural metaphors) to achieve an intuitive design.

Some examples of CFIT-focused graphics

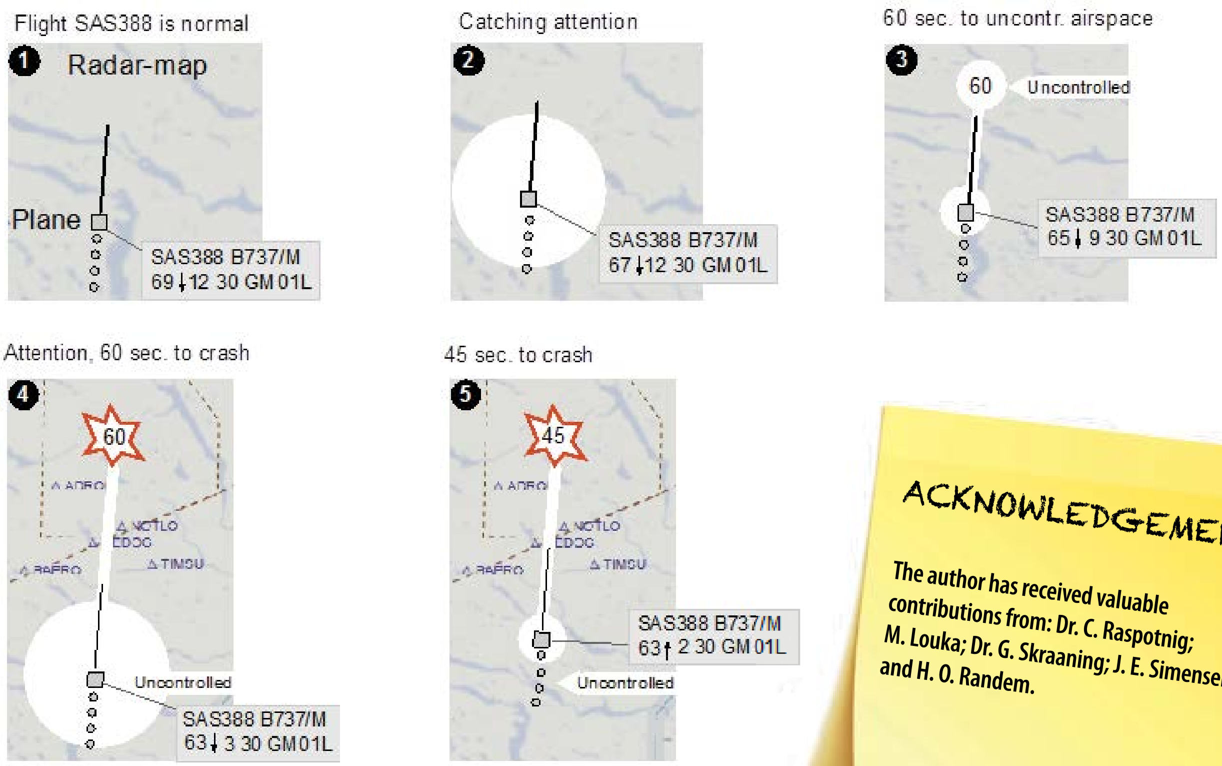
Based on these design principles, we have developed some initial prototypes that we are keen to share with you. However, we should warn that this is based on on-going research, where the design is currently being implemented on our full-scope simulator provided by Edda Systems. Controllers from Avinor will provide feedback through a trial during the spring and summer 2016 which will be used to improve the design. The small samples are for illustrative purposes and representing a small region of a radar displays.

First up is a large white circle, which shrinks rapidly in order to catch the controller´s attention: "look here, something is going on, an aircraft is entering uncontrolled airspace in 60 seconds". A timer provides a countdown; this is a projection into the near future (figures 1-3).

In this example, the flight continues on its path toward uncontrolled airspace (figures 4-5). A new, large white circle quickly catches the controller´s attention and a well-known "crash" symbol identifies the possible CFIT crash site. Again a timer counts down, representing a projection into the near future.

Although the radar coverage can be lost after the aircraft has entered uncontrolled airspace, radio communication may still be available. The last known position of the aircraft is therefore present on the map, together with the timer and potential crash site. This information might still be useful for avoiding a CFIT situation.

Our consideration of CFIT and SA has lead to design principles and a prototype design. It should be noted that final design must be harmonised with existing technologies and actual radar display design.



ACKNOWLEDGEMENT:

The author has received valuable contributions from: Dr. C. Raspotnig; M. Louka; Dr. G. Skraaning; J. E. Simensen and H. O. Randem.

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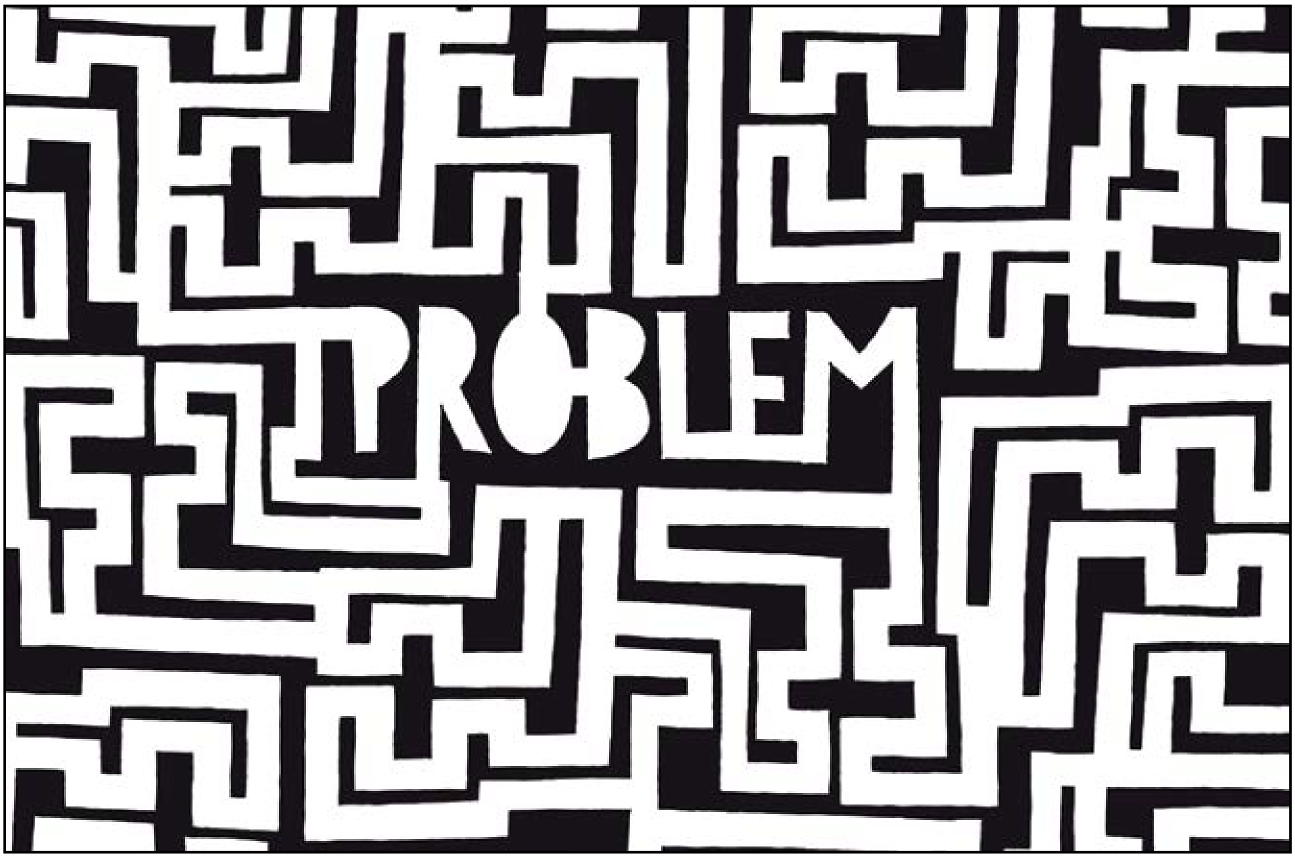
ALAN'S BAD DAY AT OFFICE

by Mike Edwards

Alan Norman Oldgit was not having a good day. It was about to get a lot worse. He was rostered to be on duty at 1400 for his fourth day in the work cycle. He had already completed two morning shifts, followed by his first afternoon shift. Yesterday he left work at 2200 and took one hour to drive the 15 miles to home. There was the usual accident where a major tourist road joined the motorway. Alan always kept well out of the way. He remembered having to attend lecture called "Defensive Controlling". He thought it was just stating the obvious, but funnily enough every time he got into his car to drive home, he said to himself "Defensive Driving Alan".



Suffice it to say that this morning he was tired and not in a good mood. His wife had told him, as she was getting into her car to go to the gym, that the backyard needed tidying and the wood store was nearly empty – both of which he already knew but it had rained every day for a week and the forecast was for more rain today. And yes, he got soaked. He drove to the ACC hoping for just a quiet afternoon. There were extra security checks on the Gate, which were fair enough but were annoying and time consuming. In consequence he was a little late getting to the Ops Room where, after exchanging the obligatory pleasantries in his usual gloomy manner, he plugged into the EMMA Sector.

The out-going controller was Yung Gun, one of those fresh-faced twenty-somethings who know everything. He liked to be called "Top" by his colleagues; partly because of the name (Top Gun) and partly because it acknowledged his controller status. Nothing bothered Yung. He didn't realise that people gave him traffic in "interesting" positions just to see what he would do. Even in the last minute before the handover, the POLLI Sector had asked him to take Chancer 181 direct to TRAPY, which was at least 40 nm south of the Flight Plan route. "Yep" said Yung in his usual laconic manner of co-ordination.

When Alan plugged in, Yung told him he was late (as if he didn't know) and then proceeded to give him a Handover something like. "As you see it, TAROT 66B at 15 under the 16, Chancer at 18, a Tyro trainer going around the houses at 8. 3 at 24 coming soon from POLLI and you can see the outbounds". Alan nodded as he tried to take it all in and Yung immediately unplugged and walked away. There is no recording of this conversation.

Alan settled himself in, adjusting the chair and radar display settings to his liking – he needed things to be a bit brighter these days. The three arrivals from the POLLI sector called one after the other, all at FL240 as per the Standing Agreement and quite tightly grouped. He would need to split them out a bit to facilitate their descent. Two more aircraft called in the climb to FL100. He checked that they were clean against the slow training aircraft at FL80 and told them to continue climb to FL140 and FL130 respectively (under the TAROT 66B at FL150). Alan was unsettled by the increase in workload so soon after taking over the sector.

Right, next job, he thought, I need to get the TAROT 66B up to FL230 to meet the Standing Agreement out to the POLLI sector. Alan quickly scanned the strips and the radar – nothing - "TAROT 66 Bravo climb FL230". Now to sort out the three at FL240. "TCAS RA TAROT 66 Bravo". Alan got as far as thinking "What the.." when he heard "TCAS RA Chancer 181". He looked at the screen in panic. He could not see Chancer 181 but the STCA was flashing over TAROT 66B and the TYRO 06 at FL80. He said the standard "Roger" and waited.

He searched the strips again. Chancer 181 should be up by NORDA, 40 miles away. He looked again at the radar, trying to make sense of a mass of "eights" and "zeros".

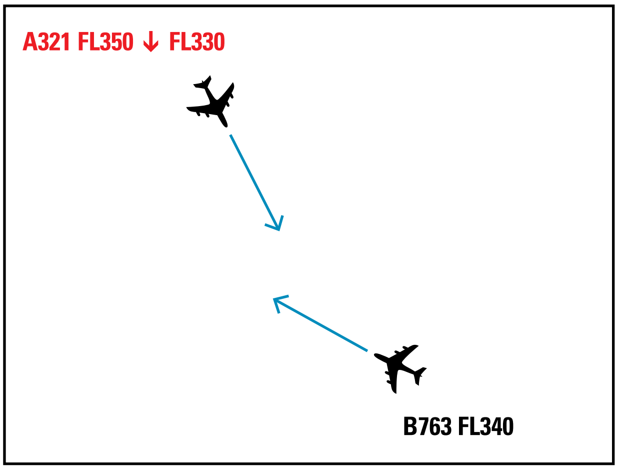
"Clear of Conflict TAROT 66 Bravo, confirm cleared FL230?" "Affirm 66 Bravo" replied Alan, who could feel people standing close behind him. Now he could see the Track Data Block for Chancer 181 at FL185 moving ahead of the slow traffic at FL80. "Okay Alan, I've got it" said a kindly voice behind him. "I didn't know that it was there, he didn't tell me that it was there" was all Alan could mutter as he walked away and towards the Supervisor's Desk.

This story about poor Alan illustrates one of the EUROCONTROL Operational Safety Studies that has recently been completed. This phenomenon is known as Controller Blind Spot. In essence it is when a controller clears an aircraft to climb or descend, often in order to resolve a future problem or requirement, and not taking into account a conflicting aircraft in its immediate vicinity.

So, how do these Blind Spot events come about?

Well, we identified four basic scenarios.

1. Loss of Separation involving a rushed vertical clearance immediately after a pilot request.
This scenario trigger occurs when a pilot makes a request for climb/ descent. This grabs the attention of the controller whose focus was elsewhere. There is a perceived need to deal with the request as quickly as possible so that the limited attention resource can be returned to other tasks. The controller does not carry out any structured scan for potential conflicts and agrees to the request. The clearance leads to a conflict.



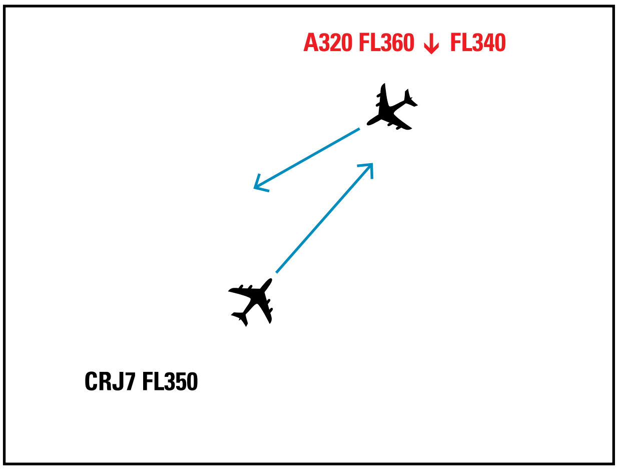
In this real event there is turbulence between FL350 and FL370 and the controllers had to deal with a lot of Flight Level change requests which increased their workload.

An A321 was southbound at FL350. Its pilot reports moderate turbulence and requests information about the turbulence on its route. One minute later the A321 requests descent to FL330. ATC clears the A321 for FL330. The B763 is westbound at FL340 crossing left to right, not yet on frequency.

A minute later a B763 makes its first contact with the sector. The A321 is descending through FL347 in its one o'clock position 10nm ahead. ATC gives the B763 it's routing but does not detect the conflict. Almost immediately STCA triggers. ATC turns the A321 30° to the right and the B763 20° to the right as avoiding action. The controller reported that he was concentrating on another area of the sector at the time and approved the descend request too quickly.

2. Loss of Separation involving an instruction to meet future constraints.
Airspace design for En-Route and TMA sectors has become complex. To accommodate the various constraints, such as the transfer of control, the task is increasingly governed by silent handovers either by standing agreements or individual electronic acceptance. The controller's attention turns to a requirement to climb/ descent an aircraft to meet these constraints and does not take into account the potential conflict ahead.

In this real example, an A320 was routing westbound at FL360, on its own navigation in the centre of the airway, with a required exit level of FL280. A CRJ7 was eastbound at FL350 and had been following the centre of an airway



immediately to the south at FL350. The track label of CRJ7 was hooked by the controller. This highlighted the aircraft but equally obscured all other aircraft within the track label area. The controller then gave the CRJ7 a direct routeing which effectively turned it left towards the A320.

The A320 was cleared to descend to FL340 as a start to its required descent. This was against a third aircraft 10 miles behind the CRJ7 at FL330. The CRJ7 was 8 miles ahead in its 11 o'clock and closing. STCA activated and the controller moved both labels. He gave 10° turns to both aircraft, including the words "Avoiding Action" but neither aircraft replied. He then instructed the A320 to stop descent. Both aircraft then reported TCAS RAs.

The controller had issued a direct routing to CRJ7 but subsequently reported that it was "possible" that he forgot that he had done so.

The controller reported that he had formulated his plan for the A320 before he gave the CRJ7 its direct routing. He then did not adjusted his plan before giving the descent clearance.

3. Loss of Separation involving an aircraft that is not following the Flight Plan Route.
Flight Data Processing (FDP) systems are designed to highlight the planned routing of aircraft. This may be via paper or electronic strips, or by information overlaid onto the radar display.

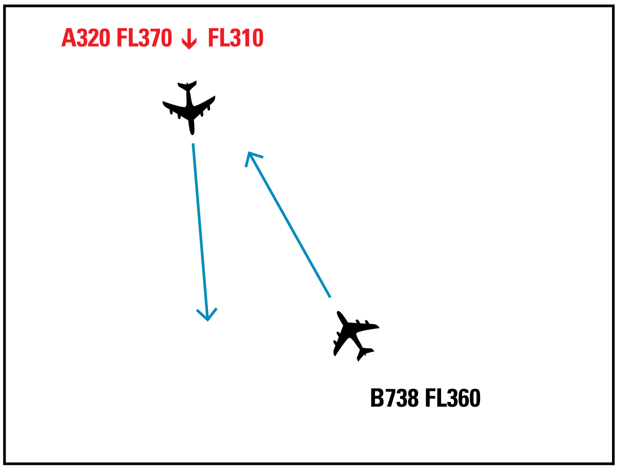
When flights do not tactically follow the pre-planned flight profile, the information gleaned from the FDP system may no longer highlight the potential conflict.

This scenario trigger involves instruction or clearance from the controller that result in horizontal deviation from Flight Planned Route. This includes the first clearance and any subsequent clearance before the aircraft re-joins the Flight Planned horizontal route, including the instruction to resume own navigation after vectoring.

In this real example an A320 was southbound, maintaining FL370 and would need descent soon to begin its approach. A B738 was northbound, maintaining FL360. It had been given a direct routing to a waypoint 25 west of its Flight Plan Route. The controller was aware of this routing but had not marked or moved any of the Flight Data to indicate the change. When contact was made with the sector the A320 was approximately 50nm in front of the B738.

The controller instructed the A320 to descend to FL310. The B738 was now 10nm directly ahead of the A320. STCA alerted the controller to the event. The B738 was instructed to turn right 60° and the A320 was instructed to climb back to FL370. Both aircraft reported visual with each other and both had TCAS TAs. The aircraft passed 2nm apart with the A320 at FL364 and the B738 at FL360.

The controller considers that she may have missed the more immediate conflict with the B738 for two reasons:



a) The B738 had made contact 6 minutes earlier and there had been no requirement to give it any instructions, such that its presence had been forgotten.

b) The strip display would normally have shown the two aircraft under the same designator. However, because the B738 was on a direct routing, the strips had become separated.

4. Loss of Separation involving conflict resolution against another aircraft further away.
A significant proportion of a controller's attention is "living in the future". Immediate issues are dealt with and filtered out as "complete".

The controller's attention can become focussed on resolving one issue and bases the next action on that resolution, while not identifying the resultant new conflict that was created by the action. This scenario trigger involves only conflict situations that were directly created by the actions to resolve another conflict. It does not involve situations where the distraction by solving a separate conflict contributed to the inappropriate attention for other conflicts. In this later case the trigger will be one of the other scenario triggers and distraction will be a contributing factor.

In this real example a B764 was eastbound at FL370. An A320 was southbound at FL360. The aircraft were under the control of a combined frequency configuration of 3 Sectors. The controller reported that he was aware from the times on his strips of a potential conflict between the subject B764 and a separate B737 which were both at FL370 on crossing tracks. As the cross was still more than 50 miles off, he decided no action was necessary at the time but cocked *the strips for the two aircraft out as a reminder to descend the B764 in good time.*

When the A320 called on his frequency, the controller reported that he identified the B764 as a confliction and therefore climbed the A320 only to FL360. He considered that he had resolved the potential confliction and moved on to other tasks.

The controller was then unable to establish two-way communications with an aircraft elsewhere in the sector despite repeated attempts. He stated that as he was doing this, he became more and more distracted and considered that the extra attention he gave to this issue increased his overall workload.

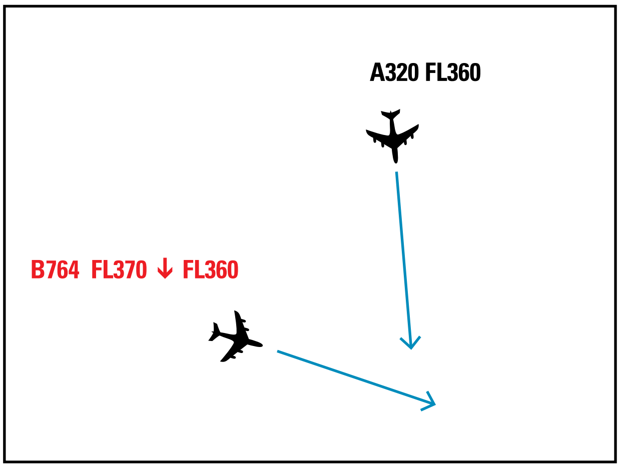
The Supervisor decided to split the sector and, in preparation for this, the controller began to transfer aircraft to the correct frequencies within the sector group. When the controller reached the B737 in his handover, he informed the incoming controller that he had cocked out the strips on B764 and the B737 as a potential conflict existed and that he would descend the B764 now to FL360 to resolve this. He stated that his decision to descend the B764 prior to transferring the aircraft to the incoming controller was influenced by the number of strips that were being put in front of his colleague and he was keen to help. He instructed the B764 to descend FL360 without referring to his own situation display or the paper flight progress strips, as he was still turned towards his new colleague. He stated that neither the A320 nor the B764 were visible on his colleague's situation display and he had forgotten about the presence of the A320. Although he wrote the descent clearance on the B764 paper flight progress strip, it was not adjacent to that of the A320. The Planning controllers did not detect the conflict as they were busy with their own sector split at the time.

The controller instructed the B764 to descend to FL360. The A320 was in its eleven o'clock position, 10 nm away, crossing left to right. STCA activated unheeded for almost a minute before the controller reported that his attention was drawn back to his own situation display by the call from the A320 "er Centre, (callsign)", which he described as being in a "questioning tone". He saw the STCA at that point and realised his mistake. He instructed the A320 to descend immediately FL350. The A320 however reported that he was responding to a TCAS RA. The B764 confirmed that it too had responded to an RA.

The following learning points were identified with the help of the controllers involved:

The controller considered that the sector split prompted him to descend the B764 much earlier than he would have done otherwise. He tried to be helpful in response to the upcoming traffic load on the adjacent sector by sorting out the potential conflict for the incoming controller. In so doing, although working to a plan he had already constructed to resolve the conflict, he would appear to have made a hasty decision which he also executed in haste.

The controller was distracted by his inability to communicate with an aircraft prior to the handover. This, coupled with the distracting effect of the sector split, reduced the controller's focus on the entire sector.



So, what are the most common Causal Factors?

The three most common factors present in the 20 real events analysed are:

a) Flight Data Display not updated to reflect change of routing away from FPL routing.
In our story Chancer 181 has been given a direct route to a new Waypoint which took it 40nm south of its FPL route, but the flight progress strip display did not show this and thus the potential conflict was not evident on the controller's data display. This was a contributing factor in more than half of the actual events studied.

b) Sector Hand Over/Take Over and immediate post Take Over period.
In our story, the Handover had no structure and was hurried. Whilst the Chancer at FL180 was mentioned, it was not passed on that it was "off-route" and to be alert to the fact. This was a contributing factor in a significant minority of the actual events studied.

c) Track labels obscured
In our story the Track Data Block of Chancer 181 at FL180 was overlying the Track data Block of TYRO 06 at FL080. It is easy to see how the display of 181. 180, 06 and 080 could have challenged the detection and interpretation of the information.

Track labels being obscured, either by function or by manual selection, was a contributing factor in a significant minority of actual events studied. This involves labels overlaps but also situations when the label was in other, unconcerned colour that makes it less visible. These include situations when the aircraft was in the volume of controlled airspace but was not under control. Some ANSPs has successfully adopted a new functionality that displays part of the track label (the Aircraft Identity) still in concerned colour in case the aircraft is not anymore under control but is still in the physical volume of controlled airspace, extended with some additional airspace buffers.

**I know... We were in your blind spot...
What's not shown on TCAS doesn't exist...?**

So, what are the best ways to prevent these events happening?

The study analysis found that there is no single tool or method that can efficiently and universally prevent all the scenarios involving 'blind spot'. A combination of 4 tools/methods seems to deliver the best reliable protection to prevent losses of separation because of blind spot events. Any combination of 2 or more of these tools/methods would be advantageous.

These tools/methods are:

a) Predictive Separation Alert Tool with ATC intentions inputs like Cleared Flight Level (CFL). This has the potential to prevent all losses of separation caused by Blind Spot. This barrier is less efficient in proactively identifying potential conflicts due to unplanned horizontal manoeuvres towards a proximate aircraft. The barrier may be affected by the consistency of inputting the Cleared Flight Level (CFL) information in the system.

b) Short Term Conflict Probe: This has the potential to prevent most losses of separation caused by Blind Spot but scenarios of clearance not following the horizontal flight planned route as the existing probes are what-if tools for vertical manoeuvres. The advantage of the probe is that it is purely preventive barrier to be used before any instruction or clearance is given. The hypothetical nature and additional time requirement can be considered by some controllers as a drawback and affect their willingness to use it.

c) Structured Scan: This has the potential to prevent most losses of separation caused by Blind Spot. There is a caveat that the information may be suppressed or diffuse. Track labels may be obscured and flight data displays may not be arranged in such a way to highlight a confliction. Time pressure and workload may erode the attention that the controller is able to give to each piece of information and working knowledge may then become layered and the filtered. When a controller becomes under pressure, a "return to basics" such as using a structured scan before making an executive decision would reduce the likelihood of controller error.

d) Predictive Separation Alert Tool with flight crew intentions inputs: This has the potential to prevent all losses of separation caused by Blind Spot blinds spot. The barrier efficiency will depend on the proximity of the conflicting aircraft and will be triggered later compared with the STCA with CFL inputs. On the other hand this barrier will not depend on the controller consistency in inputting the CFL into the system. The cases of flight crew manually manoeuvring the aircraft before entering the clearance change will be less frequent.

Finally, whilst there is no empirical evidence to confirm this, it was suggested by some ANSPs that the use of velocity leader lines from the track labels by the Controller may reduce Blind Spot occurrences.

If we assume a layered situational awareness of the controller, one layer will be fixed in "now" time and one layer – in a "future time" horizon of some minutes ahead (depending on the size and complexity of the sector). What would be left, is some "gap" in the controller's focus of attention that can be expressed in time. This "gap" in time could be viewed as the "blind spot" around the aircraft. The use of a velocity leader lines set for one, two or three minutes could help bridging this gap.

What happened to Alan and Yung Gun?

Well Alan learnt never to let any anybody unplug until he had really got the picture, not matter how pushy they were; and Yung was never called 'Top' again. S

MIKE **EDWARDS**

was until recently Head of Safety Investigation at NATS (the UK Air Navigation Service Provider). He held this role for 7 years and prior to that he was Head of Investigation at London ACC. He had been an ATCO at Edinburgh and Heathrow before becoming the manager of all student controllers and then a Supervisor at London Terminal Control. He holds a PPL with Group B rating.

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This time, one of the over 800 SKYbrary articles summarising the Investigations carried out into Accidents and Serious Incidents has been selected. It deals with the 2012 CFIT accident to a C130J in Northern Sweden which resulted from a loss of situational awareness.....

C130J, EN-ROUTE, NORTHERN SWEDEN 2012

Description

On 15 March 2012, a Lockheed-Martin C130J-30 Hercules being operated by the Royal Norwegian Air Force on a positioning transport flight from Harstad/Narvik Airport, Norway to Kiruna, Sweden flew into the side of the highest mountain in Sweden near its summit shortly after crossing the Swedish border and making a daylight descent to FL070 which took it into IMC in uncontrolled airspace. The aircraft was immediately destroyed by the violent impact, consequent explosion and fire and all five occupants were killed.

Investigation

An Investigation was carried out by the Swedish AIB. The DFDR and CVR were recovered and their data successfully downloaded and recorded radar data was also gathered and used. The ELT did not transmit and was found to have sustained major damage at impact. It was found that the response on the ground to the accident had been "characterised by very good access to resources from both Sweden and abroad" and noted that "operations lasted for a relatively long time and were carried out under extreme weather conditions in difficult alpine terrain". However, the Investigation did identify "the importance of further developing management, collaboration and training (in respect of response to remote area accidents) in several areas".

It was noted that the aircraft commander had 758 hours experience on the 'J' model of the C130 after accumulating almost all his considerable previous experience on older Hercules variant(s) with considerably less automation than the 'J'. He was accompanied by a Co-Pilot who had been acting as PF for the accident flight who had just 91 hours on the 'H' model and only 293 hours on all Hercules variants. The significantly increased level of automation on the 'J' Variant was noted to have led to the removal of a crew position for a Navigator as carried on all earlier variants. Several of the Air Force personnel interviewed by the Investigation "stated that the (accident aircraft) commander was considered to be the most experienced commander by far on the C-130" and that whilst the co-pilot was considered to have "little" experience, he was "competent", had "respect for the commander" and that it was "difficult to surpass the co-pilot with regard to knowledge of systems on the aircraft". It was additionally noted that the aircraft commander had a lower military rank than the Co-Pilot and that the Co-Pilot was his immediate superior, although no direct evidence that this situation had an effect on the conduct of the flight was found by the Investigation. Also on board the aircraft were two loadmasters and one passenger, the latter being an Air Force helicopter pilot.

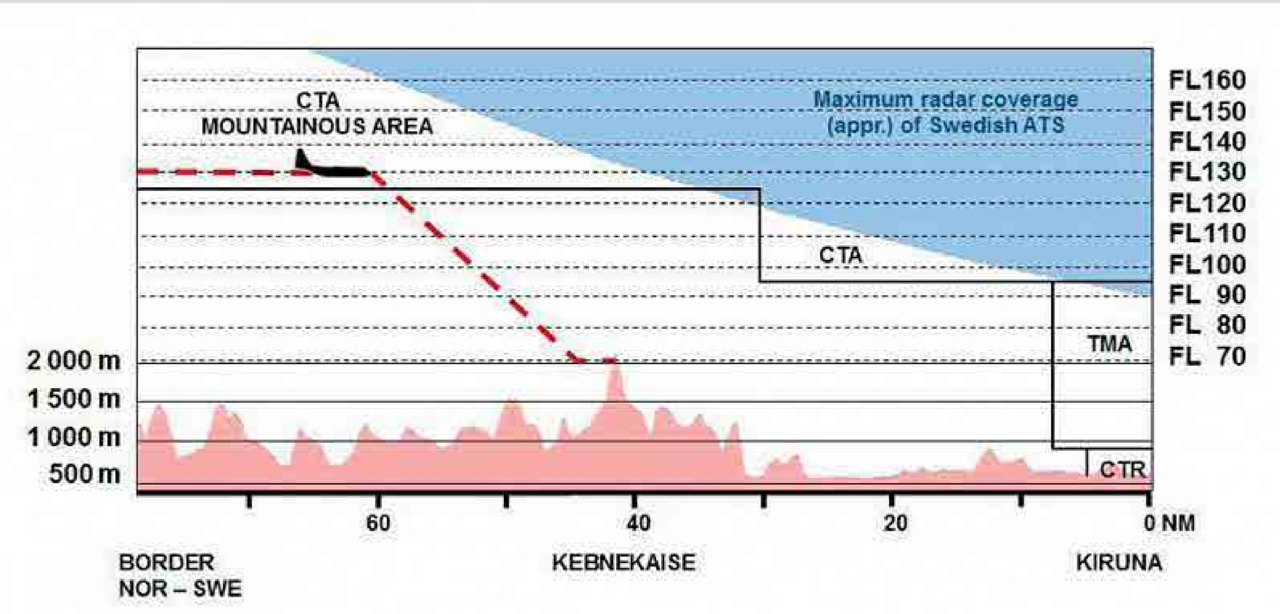
An aftercast provided by the Swedish Meteorological and Hydrological Institute stated that there had been a thick and continuous layer of cloud in the area where the accident occurred with a base of between 1000 feet and 4000 feet and a top at between FL090 and FL100. By contrast, the METAR for Kiruna issued 7 minutes before the accident gave "CAVOK".

It was established that after departing from Harstad/Narvik on an IFR FPL, the aircraft had climbed to FL 130 and taken up a holding pattern south of the airport for an hour before continuing on an easterly track towards the VOR at destination. Bodo Control had radar contact before handing the aircraft over to Sweden Control where it was cleared for descent to FL 100 "when ready" and instructed to contact TWR at destination to make their request for a visual approach. Having acknowledged the clearance, the crew then immediately commenced the descent from FL130 towards FL100 and, on checking in with Kiruna TWR, advised that they were 50 nm to the west and requested a visual approach. Kiruna TWR further cleared the aircraft which by then had descended below FL 125, the base of controlled airspace in the area, to FL 70 and the aircraft continued to descend towards that level, in the process descending below both MSA and into IMC. The aircraft reached FL70 and, based on DFDR data, it was found that 30 seconds later, in level flight and at a ground speed of approximately 280 knots, it had collided with the terrain just below the highest parts of the west side of the highest mountain in Sweden, 'Kebnekaise' some 42 nm from Kiruna. CVR data showed that the crew had been unaware of their proximity to terrain. The illustration below shows the format of the annotated 1:500,000 chart provided for the flight, on which the proximity of the intended track is clearly shown as passing over Kebnekaise. As can be seen, this chart only had "maximum elevation" figures for Norwegian airspace. On the Instrument Flying Charts carried on board, the MSA for the route was shown as 9300 feet.

Chart prepared for the accident flight by the Air Force showing the planned route with Maximum Elevation Figures (MEF) only on the Norwegian side of the border. (illustration reproduced from the Official Report)

Whilst it quickly became clear that the accident had been attributable to the way in which the aircraft was operated by the crew concerned, the Investigation identified the root cause of it to be deficiencies in the RNAF procedures which supported the operation of the aircraft. It was also found that there had been "shortcomings" in the ATC clearances issued to the aircraft. Clearances and flight information given to the accident aircraft were found not to have been in accordance with the applicable regulations. This was considered to have been a direct consequence of the ANSP *"not having…ensured that the air traffic controllers in question had sufficient experience and knowledge to guide air traffic from the west in towards Kiruna Airport in a safe manner under the present circumstances".*

Clearly one of the major questions for the Investigation to answer was why no warnings were given of the approach of the aircraft to the steeply rising mountainside which the aircraft hit. The primary - and usually very reliable - equipment which does this is the GCAS/TAWS (Ground Collision Avoidance System / Terrain Awareness Warning System). The GCAS system was activated only on the basis of downward looking radio altimeter input, which at any alert setting would not have provided a useful warning as the aircraft approached the very steep side of the mountain. The database-driven TAWS, on the other hand, would normally have been capable of generating sufficient warning of terrain ahead for a successful escape manoeuvre to be facilitated. However, as a military aircraft, the TAWS could be selected to utilise one of a choice of two databases, a commercial database provided by Honeywell when selected



The airspace and terrain profile along the route. Showing the official position on Swedish ATC radar coverage "in optimal conditions". The broken red line shows the route of the accident aircraft in schematic form (the altitude scale exaggerated. The terrain profile is derived from Google Earth (illustration reproduced from the Official Report)

The airspace and terrain profile along the route. Showing the official position on Swedish ATC radar coverage "in optimal conditions". The broken red line shows the route of the accident aircraft in schematic form (the altitude scale exaggerated. The terrain profile is derived from Google Earth (illustration reproduced from the Official Report)

Controllers at Sweden Control interviewed by the Investigation reported that the accident aircraft had not been visible on radar, and that the base of radar cover in the area varied on a day-to-day basis between FL070 and "slightly above" FL100 - a somewhat different view to the official position of the ANSP illustrated above. Kiruna ATC was a one-man TWR operation without radar.

to the default 'Normal' Mode and a higher resolution tactical database provided by the US National Geospatial Intelligence Agency (NGA) when selected to 'Tactical' Mode. However, the latter database was not available north of 60° North and, therefore, not available over most of the land area of both Norway and Sweden (although the separate Obstacle database was available worldwide from both sources - but there were no obstacles on Kebnekaise).

Early on, the accident crew had decided to select the TAWS Tactical Mode thereby, because of the high latitude, completely disabling the TAWS function. Whilst such action was contrary to the pertinent SOP, which stated that the Tactical Mode was "most suited for modified contour flight and approaches at low altitudes in accordance with Visual Flight Rules", the commander was left with absolute discretion and no mention was made of the fact that most of the Scandinavian land area is north of 60° where this mode has no terrain database. The Investigation concluded on the basis of interviews and the wording of a pilot alert on the subject following the accident that "awareness of the (C130J) TAWS system function and limitations north of 60° N….was low".

The Investigation sought possible explanations for the conscious choice of TAWS Tactical Mode by the accident aircraft crew and concluded that there were "a number of partial explanations" for this action, the most significant of which appeared likely to be "lack of understanding of the system's function".

In respect of other equipment which might have supported the use of the paper charts carried in informing proactive terrain avoidance, it was also noted that the aircraft had an advanced radar which was capable of both weather detection and, in 'ground map' mode, terrain detection with ground contour display for up to 250 nm ahead. It was also equipped with a Moving Map display that could be presented on the EFIS screens and could show current aircraft position in relation to terrain and indicate terrain elevation, obstacles, latitude/longitude and obstacle-free altitudes to an accuracy of 200 feet.

The Investigation concluded that the Cause of the accident was "the crew of the accident aircraft not noticing the shortcomings in the clearances issued by the air traffic controllers and to the risks of following these clearances, which resulted in the aircraft leaving controlled airspace and being flown at an altitude that was lower than the surrounding terrain".

It was also concluded that the following **Organisational Shortcomings** in safety rendered the accident possible:

- The Norwegian Air Force has not ensured that the crews have had sufficiently safe working methods for preventing the aircraft from being flown below the minimum safe flight level on the route.
- LFV has not had sufficiently safe working methods for ensuring, partly, that clearances are only issued within controlled airspace during flight under IFR unless the pilot specifically requests otherwise and, partly, that relevant flight information is provided.

Safety Action was noted to have been taken following the accident and during the course of the Investigation by the Royal Norwegian Air Force, The Swedish ATC Regulator, the Swedish ANSP and the aircraft manufacturer Lockheed Martin. Action reported by the latter included:

- The addition to the AFM limitations of information on the TAWS.
- The addition of QRH entry for a previously unmentioned TAWS Caution
- The addition of a new restriction on TAWS use in the Flight Manual description of the system in respect of the non availability of both databases at latitudes greater than 60°N latitude or less than 56°S.

A total of 22 **Safety Recommendations** were made as a result of the Investigation as follows - the first 11 related to the operation of the aircraft and the provision of ATC service and the remaining 11 related to shortcomings found in the processes for ensuring effective accident response in such a remote area:

- that **The Royal Norwegian Air Force** ensures that procedures are used that prevent aircraft from being flown below the minimum safe altitude or flight level en route in IFR flight. **[RM 2013: 02 R1]**
- that **The Royal Norwegian Air Force** ensures that flight crew knowledge and routines means that the system for ground collision avoidance is used in a safe manner. **[RM 2013: 02 R2]**
- that **The Royal Norwegian Air Force** further examines whether, and where necessary take measures to ensure that, the current crew configuration on the C130J attends to all aspects of the safe implementation of planning and flight. **[RM 2013: 02 R3]**
- that **The Royal Norwegian Air Force** develops clear rules, manuals and procedures, which make it easier for flight crews to conduct safe air operations. **[RM 2013: 02 R4]**
- that **The Swedish Transport Agency** ensures that an investigation of the safety culture within LFV is carried out with the aim of creating the conditions for maintaining and developing operations from an acceptable aviation safety perspective. **[RM 2013: 02 R5]**
- that **The Swedish Transport Agency** further examines whether, and where necessary take measures to guarantee that, the controlled airspace is so designed that it encompasses an area large enough to contain the published routes for outgoing and incoming aircraft under IFR for which air traffic control is to be exercised, so that aircraft can execute all manoeuvres in controlled air, taking into account the aircraft's performance and the aids to navigation that are normally used in the area. **[RM 2013: 02 R6]**
- that **The Swedish Transport Agency** ensures that air traffic controllers possess sufficient expertise and aids to manage situations that do not frequently occur. **[RM 2013:02 R7]**
- that **The Swedish Transport Agency** ensures that the discrepancies between the provisions regarding the use of QNH below the lowest usable flight level and the provisions regarding the use of flight levels above 3,000 feet (900 metres) MSL in airspace class 'G' are eliminated. **[RM 2013: 02 R8]**

- that **The Swedish Transport Agency** takes measures to remove the ambiguity of having different applications of (the Lowest Useable Flight Level). **[RM 2013: 02 R9]**

- that **The Swedish Transport Agency** ensures that the English translation of "lägsta användbara flygnivå" in AIP Sweden is changed to "lowest usable flight level" so as to be in accordance with international regulations. **[RM 2013: 02 R10]**

- that **The Swedish Transport Agency** act so that ICAO reviews its regulations with respect to "lowest usable flight level" in order to ensure that they also satisfy the circumstances in an area-type controlled airspace, or clarifies in guidance material how the regulations are to be applied in such airspace. **[RM 2013: 02 R11]**

- that **The Swedish Transport Agency** ensures that regulations and general advice for airborne rescue units are issued that cover helicopter crew training and exercises in a mountainous environment, with requirements for special training and exercise programmes and that completed training and exercises be documented. **[2013: 02 R12]**

- that **The Swedish Transport Agency** ensures that a management model is developed by the Swedish Maritime Administration for the air rescue services at JRCC (Joint Rescue Coordination Centre) that encompasses system management and operation management, including local management within the likely area of a crash involving an aircraft, and that the personnel are trained and drilled in accordance with the established management model. **[RM 2013: 02 R13]**

- that **The Swedish Transport Agency** ensures that the Swedish Maritime Administration develops, trains and drills the personnel at JRCC in a staff model adapted for air rescue services and the established management model at the air rescue centre. **[RM 2013: 02 R14]**

- that **The Swedish Transport Agency** ensures that the Swedish Maritime Administration develops documented liaison procedures for air rescue services in a mountainous environment. **[RM 2013: 02 R15]**

- that **The Swedish Transport Agency** ensures that the Swedish Maritime Administration develops planning in collaboration with concerned authorities and organisations for appropriate resources regarding search from the ground in a mountainous environment and how these are to be alerted. **[RM 2013: 02 R16]**

- that **The Swedish Transport Agency** ensures that the Swedish Maritime Administration develops and uses an objective for helicopter SAR operations that is possible to evaluate with respect to each individual operation. **[RM 2013: 02 R17]**

- that **The Swedish Transport Agency** ensures that the Swedish Maritime Administration trains and drills JRCC personnel in collaboration with air rescue services and mountain rescue services and develops procedures for this. **[RM 2013: 02 R18]**

- that **The Swedish National Police Board** ensures that police authorities with responsibility for mountain rescue services plan and organise activities in such a way that rescue operations are commenced within an acceptable time of receiving an alert and implemented with adequate resources. **[RM 2013: 02 R19]**

- that **The Swedish Civil Contingencies Agency**, in consultation with the Swedish Maritime Administration, the Swedish Transport Agency, the Swedish National Police Board, the Swedish National Board of Health and Welfare and SOS Alarm, ensures that the alerting of rescue and healthcare resources is carried out within an acceptable time, even in the case of events where there is only an imminent danger of an aircraft accident. **[RM 2013: 02 R20]**

- that **The Swedish Civil Contingencies Agency** examines measures necessary for guaranteeing that rescue operations are commenced within an acceptable time without delay and are executed in an effective manner, even in the event of parallel (simultaneous) operations with the participation of national rescue services, and thereafter inform central and local government authorities responsible for rescue services. **[RM 2013: 02 R21]**.

- that **The Swedish Civil Contingencies Agency** within the Nordic cooperation for rescue services, acts so that knowledge of the different countries' rescue service organisations becomes sufficiently familiar to the parties that may be subject to participation in rescue operations. **[RM 2013: 02 R22]**.

The Final Report was published on 22 October 2013 and made available in English translation on 31 October 2013.

Further Reading

- Controlled Flight Into Terrain
- Minimum Safe Altitude
- Terrain Awareness
- Terrain Avoidance and Warning System (TAWS)
- CFIT Precursors and Defences
- Flight in Mountainous Terrain
- Perception in ATC
- Airspace and Procedure Design
- AIRBUS FOBN – Operating Environment: Enhancing Terrain Awareness

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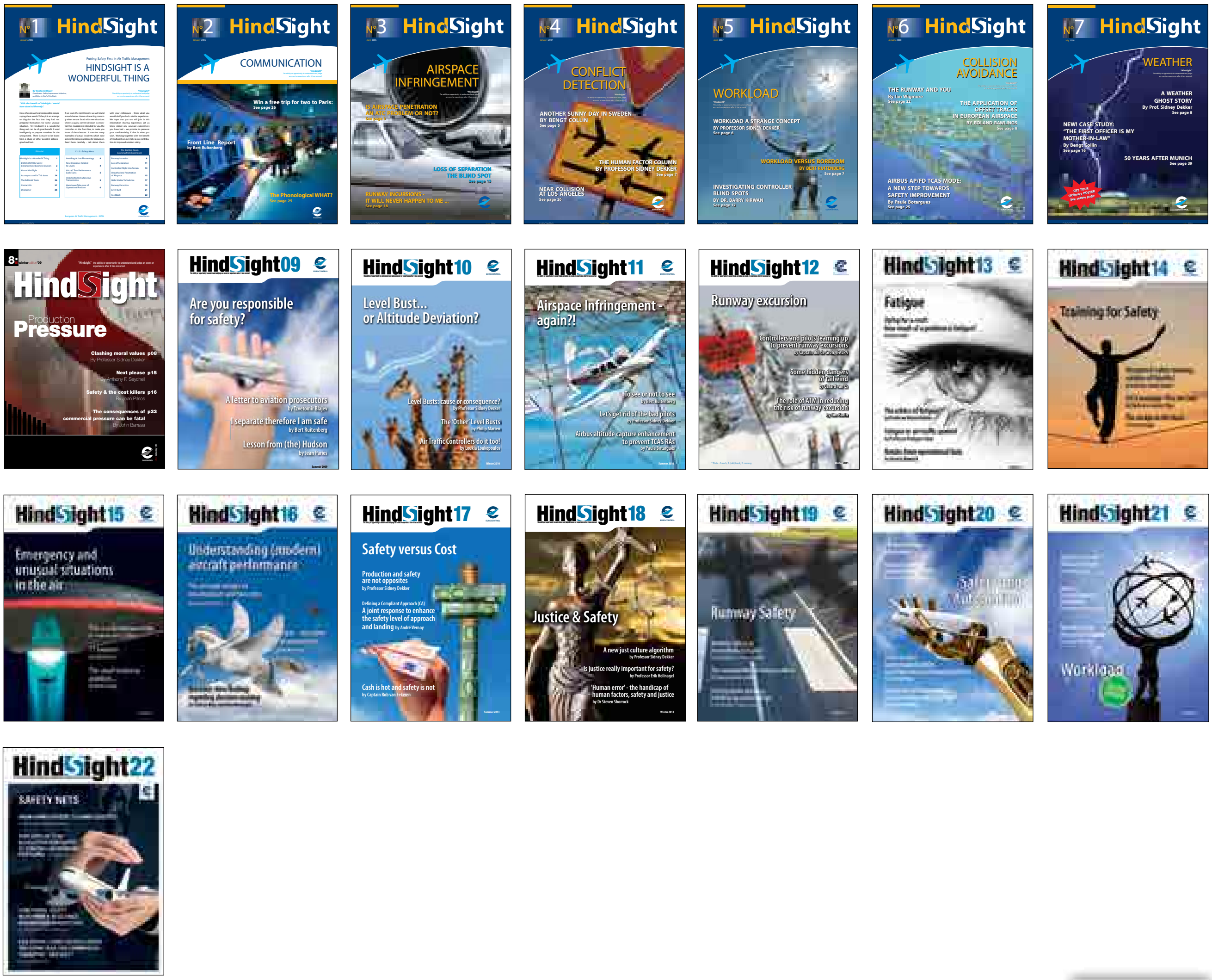

In the next issue of HindSight:
"Preventing Runway Collision"

EUROCONTROL

Putting Safety First in Air Traffic Management

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