2.7 Situational Awareness

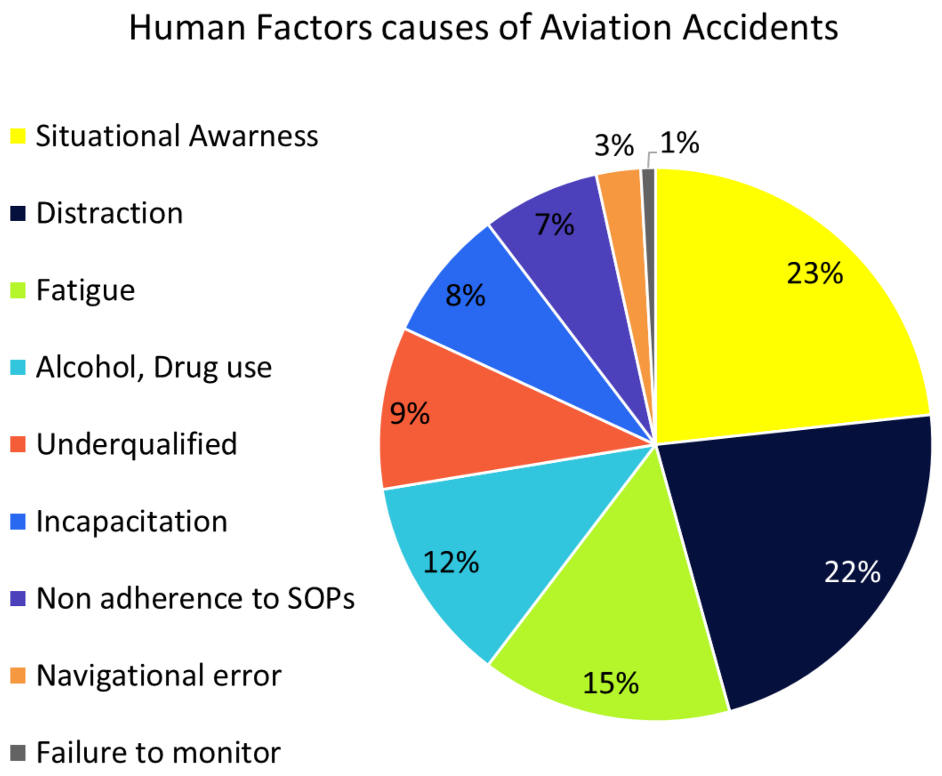
When novelist Barry Eisler wrote "The difference between being a victim and a survivor is often a low level of situational awareness"[i], he may have been speaking about the artist on this beach depicted here. The artist gives their full attention to meticulously matching the correct shade of green of the sea creature, but in doing so fails to appreciate the danger posed by the creature and is ultimately consumed by it. The failure to develop a clear mental picture of the environment and consider what could happen next proved costly.

Aviation too has potential killers and hazards that must be seen, understood, and mitigated. Many threats remain latent until the moment they appear; and when they do appear the consequences can be catastrophic. Survival in these worlds require a mind that is fully aware of all that is going on with and around it, and as aircraft operate in a three-dimensional plane, a healthy awareness of what may happen next.

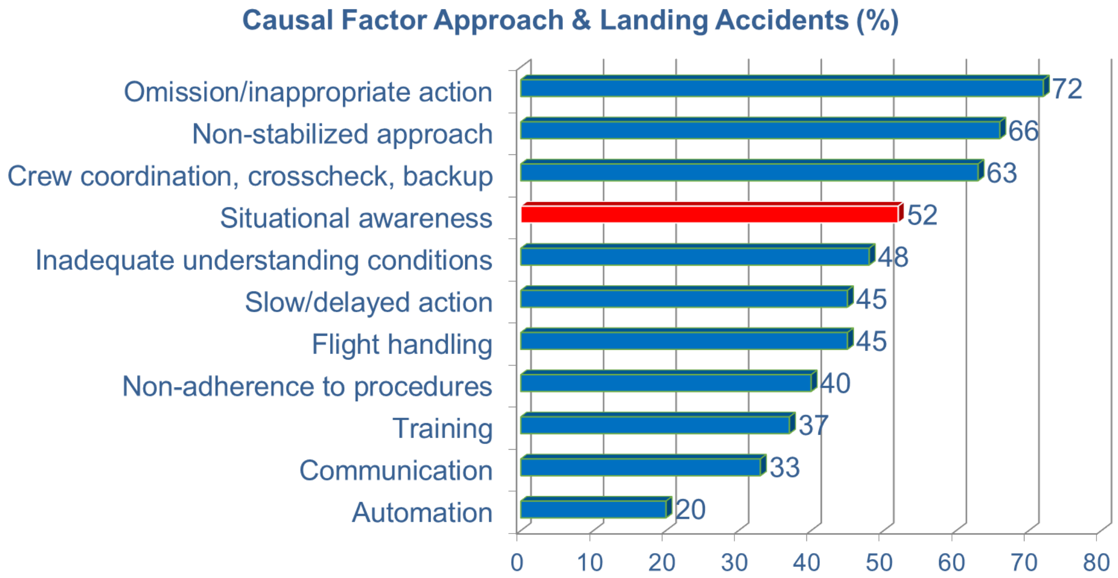
To describe the knowledge, understanding and appreciation of these elements, the term Situational Awareness (SAW) is used.

Situational Awareness and Management of Information: Perceives, comprehends, and manages information and anticipates its effect on the operation. [ii]

Research shows SAW as the most prominent human factors issue next to distraction[iii].



The Flight safety Foundation ALAR toolkit[iv] shows SAW raised as a causal factor in 52% of approach and landing accidents.



Most often this type of error is associated with momentary *task distractions* or *high workload level*.

Observable Behaviors of Good Situational Awareness

Whilst loss of SAW continues to be identified frequently in aircraft accident investigation reports, human factors advisor at the Keil Centre, Melanie Todd[v], argues that by saying the pilot lost situation awareness or that they had poor situational awareness does not get anyone anywhere.

"You need to be promoting the actual behaviors and the techniques around situational awareness."

The CAE observable behaviors for SAW define what can be done to maintain a high level of SAW,.

SAW Observable Behaviors[vi]	**SAW 1:** Monitors and assesses the state of the aeroplane and its systems.
	SAW 2: Monitors and assesses the aeroplane's energy state, and its anticipated flight path.
	SAW 3: Monitors and assesses the general environment as it may affect the operation.
	SAW 4: Validates the accuracy of information and checks for gross errors.
	SAW 5: Maintains awareness of the people involved in or affected by the operation and their capacity to perform as expected.
	SAW 6: Develops effective contingency plans based upon potential risks associated with threats and errors.
	SAW 7: Responds to indications of reduced situation awareness

Building SAW

Building and maintaining SAW of the operating environment can be a challenging and tiring task. here are three stages to producing effective SAW:

1. *Perception* of factors affecting flight,
2. *Understanding* what the factors mean,
3. *Projection* to potential future states.

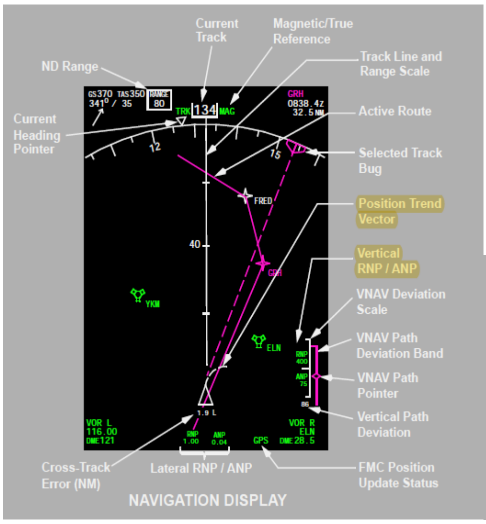
To construct a complete mental picture the pilot needs to be aware of many parts of their operation:

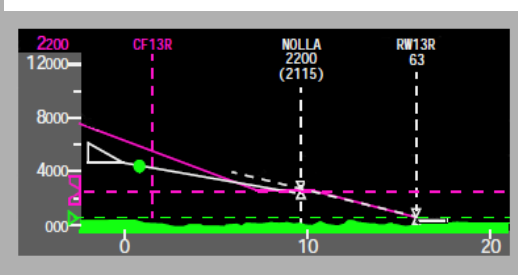
- *Geographical SAW* – location, other aircraft, terrain, airports, cities, danger/restricted areas, descent point and approach type.
- *Spatial SAW* – attitude, altitude, heading and speed, fuel/time, ATC, and ETA.
- *System SAW* – system status, communications, navigation, and radar.
- *Environmental SAW* – weather, icing, turbulence, IFR vs VFR conditions and cold temperature corrections.
- *Tactical SAW* – identification and flight dynamics of nearby aircraft and possible conflicts.

Once these factors have been considered, there is the need for the pilot to comprehend the effect on their operation and project ahead.

SAW is often limited by a pilots' own limitations of attention and memory. Experience does help to develop these skills and prioritize the assessment of threats, as a long-term memory capacity based on our experiences has been developed over time.

The flight instrumentation of modern aircraft is a valuable asset to pilots in assisting them to visualize the projected flight path by projecting the horizontal and vertical flight path trend vectors on the pilots Nav Display.





Maintaining SAW

By effectively managing SAW a pilot should be able stay ahead of a situation and avoid being caught off guard or unprepared. Pilots need to develop it, practice it, maintain it, and monitor cues which indicate that situational awareness might be compromised.

Proficient pilots get ahead of their aircraft and stay ahead of their aircraft. The faster the aircraft is flying the further ahead they need to be. Here are some techniques to improve and maintain SAW:

- ***Pre-flight planning***: Start the planning on the ground. Thoroughly review the weather at departure, en-route, destination, and alternates. Anticipate encounters with hazardous weather. Review NOTAMS and check the terrain. Begin to build a good mental model of the flight and what could be expected based on the data that you have reviewed.
- ***Contingency***: Consider "what if?" scenarios to anticipate what may happen next and prepare for unplanned events. This can also help prevent fatigue and complacency.
- ***Identify threats:*** Monitor, detect and recognize the factors that pose a risk. Weather and traffic outside the cockpit, but also fatigue, distractions, overload, and complacency can be threats inside the cockpit.
- ***Current State***: Monitor and evaluate the current status – flight path, fuel quantity and endurance (in minutes) based on the pre-flight plan. Crosscheck findings and reassess your first conclusions regularly.
- ***Prioritize tasks***: Do one thing at a time and ensure that each task is completed. Methodically pay attention to what is happening in the aircraft, then the projected flight path and the weather and ATC environment. It is a balance -do not be distracted, but don't become obsessed with one task neglecting the rest of the flight tasks. A tool to help this can be to consider what needs to be done in the next 3 mins, 30 mins, and 3 hours?
- ***Avoid complacency***: particularly on longer flights it is difficult to stay vigilant all of the time. Plan to take short "mental breaks" in low workload phases of flight. Assign tasks to yourself, recalculate your endurance, a PNR or CP, and most importantly stick rigidly to standard operating procedures, they can be your last safety net.
- ***Communicate***: Keep everyone in the loop. Solo pilots should seek information from any available sources, their maintenance base or operations, other pilots, and ATC. *ATC can also be a distraction at times of high workload and stress*. If flying a part of a multi pilot crew and feel that you are losing SAW, tell the other crew members. Be aware for signs of degraded SAW in your other crew members.
- ***Learn to trust your instincts:*** There is normally a reason something does not "feel" right! Stop what you are doing and consciously scan the cockpit, then monitor your flight path and environment. Trust your sixth sense.

Low Situational Awareness

Given the challenges to building a high level of SAW it's important for pilots to learn the signs that may signal a low or lost SAW. Whilst this is a very individual process, there are some general warning signs to look for whilst you begin to build your own personal warning signals.

- *Confusion*: are you uncertain or uneasy about a situation?
- *See and avoid*: is there too much heads-down inside the cockpit?
- *Fixation*: are you focused on any one task to the exclusion of others?
- *Attention span*: are you missing inbound and outbound ATC calls?
- *Navigation*: have you failed to meet an expected checkpoint on the fight plan?

Operators who have survived accidents where the main contributing factor was a loss of situational awareness, made statements during post-accident interviews such as:

- 'I didn't realize that …'
- 'We were very surprised when …'
- 'I didn't notice that …'
- 'I was so busy attending to …'
- 'I wasn't aware that …'
- 'We were convinced that …'

Some common errors that contribute to low SAW are:

Level 1: Failure to perceive information or misperception of information.
- Data not available
- Hard to discriminate or detect data.
- Failure to monitor or observe data.
- Misperception of data
- Memory Loss

Level 2: Improper integration or comprehension of information.
- Lack of or incomplete mental model
- Use of incorrect mental model
- Over-reliance on default values

Level 3: Incorrect projection of future actions of the system.
- Lack of or incomplete mental model
- Over projection of current trends

Consider the amount of information presented to the pilot by the instrumentation in today's modern aircraft. Apart from the requirement to notice and process large amounts of information, there are many environmental and human system factors that impact a pilot's ability to achieve and maintain a high level of SAW.

- *Stress* – noise, vibration, temperature, boredom, fatigue, anxiety, and time pressure etc.
- *Overload and underload* – too much work can overload a pilot and too little can lead to boredom and fatigue, both can lead to low SAW.
- *System design* – modern aircraft cockpits send the pilot a lot of information, at times it is difficult for even an experienced pilot to comprehend it all. The training aircraft of today have cockpits of similar design to modern airliners. At times, the amount of information provided to the pilot can be overwhelming.
- *Complexity* – with the advances in system design on modern aircraft, the complexity of the many systems that a pilot needs to operate these aircraft has become a major factor in challenging a pilot's ability to maintain a high level of SAW.
- *Automation* – many modern aircraft "innovations" have actually been designed to do the task of a pilot or greatly assist the pilot and they do a very good job of it. The sophistication of many of these new innovations have however had the effect of removing the pilot "from the loop" as they transfer from the role of operator to that of system monitor, further challenging their ability to maintain a high level of SAW.

Case Studies

Mt Erebus[vii]

Air New Zealand 901, a DC-10, crashed into Mt Erebus in 1979 after confusion of their position. Facts from the last 30 seconds of the flight.

- IMC at 1500 ft agl, the crew are confused about their proximity to a 15,000 ft mountain they know is in their vicinity.
- The Flight Engineer (FE) says “I don’t like this.”
- The crew consider a 180 degree turn but continue on track, the Captain says, “Actually these conditions don't look very good at all, do they?".
- Moments later they are startled by a GPWS warning “Whoop-whoop, pull up. Whoop-whoop, pull up” and do not respond.
- FE calls “500 ft” from the radio altimeter, again no response from the pilots.
- GPWS warns “Pull up,” the FE says, “400 ft”.
- GPWS warns “Whoop-whoop, pull up. Whoop-whoop, pull up.”
- Captain: “Go-around power please.”
- GPWS begins another warning “Whoop, whoop, pull.”

Cockpit voice recorder ends. 257 people die.

What may have saved them:

SAW 1, 3: The crew perceived and assessed the environment; they knew there was a mountain in their vicinity. However, they could not see it, and did not anticipate the possible outcomes if they continued on their track without locating the mountain.

SAW 2, 4, 7: Unsure of their position and in IMC the crew did not develop contingency plans. Uncomfortable with the situation they discuss a 180 degree turn but did not implement the plan. Had they anticipated the flight path, considering “what if,” evasive action could have been implemented.

SAW 5, 6: Startled by the first GPWS warning the crew do not respond. Sadly, later simulator recreations indicated that had an immediate response been actioned, the aircraft would have out climbed the mountain.

- Learn to trust your instincts – the Captain and the FE verbalized concern about the situation but failed to act.
- The crew were unsure of their position and discussed it without implementing any corrective action.
- The crew waited until the third GPWS warning before initiating appropriate action.

IMC VNAV

The crew of a Boeing 777 are conducting an approach in IMC using VNAV PATH (Vertical navigation, the aircraft is following a vertical path not an ILS glideslope). The crew are not aware that they have set the incorrect altimeter setting and the aircraft was actually lower than their altimeters were indicating. In VNAV the aircraft will follow the calculated slope to the end of descent point, in this case the ground; the aircraft would impact the ground approximately 1 NM short of the runway without pilot intervention.

- The Captain was pilot flying and had developed the practice of checking the Nav Display (ND) at the "1,000" (ft) auto callout.
- He knew that the aircraft was on the correct slope if the end of the runway symbol was right on the 3 NM green TCAS ring.
- When the aircraft called "1,000" the Captain checked the ND and saw that the runway symbol was well above the 3 NM TCAS ring, indicating that the aircraft was low on slope.
- He checked the altimeters and saw that they were indicating 1,300 ft above the airport elevation – the aircraft is 300 ft lower than indicated by the altimeters. The radio altimeter is a direct read of the aircraft height above the ground.
- The Captain says, "there's something wrong here!" He asks the First Officer to check the QNH (altimeter setting) with ATC and immediately they realize that their altimeter setting is incorrect.
- The aircraft is now 700 ft RA (agl).

The Captain calls "go-around". The crew perform a go-around, correct their altimeter settings, and conduct a successful second approach and landing.

What saved them: SAW 1, 2, 4, 6, 7

- This was a safe and successful outcome because the Captain displayed most of the behaviors identified by ICAO as a sign of high situational awareness.
- He has developed his own personal slope/distance check for each approach, so he is immediately aware of any deviation from the correct 3-degree path to the runway, and still at a safe height above the ground. He assessed the situation and identified a threat; the aircraft was 300 ft lower than required. He managed the threat by involving his crew to check the altimeter setting and established they have made an error in the setting; he anticipated accurately what could happen to the VNAV PATH calculation by changing the altimeter setting and decided as they were close to the ground the safest option was to go-around and attempt another approach. A possible catastrophe averted and a successful outcome due mainly to high situational awareness by the pilot.

Summary

Situation Awareness (SAW) relates to a pilot's ability to develop and maintain an accurate mental model of their operational status. This includes the aircraft's position in time and space, its technical status, including the potential effects of any abnormalities, and the impact of environmental factors on present and future operations. It is all about knowing what is going on around you. And then anticipating what may be to come.

- Planning, communication, anticipation, and coordination of upcoming flight phases are essential ingredients of situational awareness.
- Inattention, distraction, and high workload threaten situational awareness.
- Three proven ways to prevent the loss of situational awareness are to:
    - Adhere to company standard operating procedures.
    - Implement proven best practices.
    - Look for signs of fatigue and manage workload.

Further Reading

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