Case report

Orientation error accident: A case report

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Spatial Disorientation (SD) will occur at one time or another in a pilot's flying career. The worst outcome of SD is the Orientation Error Accident (OEA), and each year a number of pilots lose their lives and aircrafts crash due to this malady. A classical case of an OEA is presented, which has been taken out of the accident files at Air HQ. This case shows-up the many nuances of SD and involves a 27 year old fighter pilot who flew in operational conditions conductive for SD. In this fatal accident the pilot experiences all the 3 types of SD. This paper revisits this accident and analyses the Court of Inquiry Proceedings and the Cockpit Voice Recording to draw conclusions as to how and why the accident occurred.

Keywords: Spatial disorientation, accident analysis

Evolution ensured that humans acquired sensory systems well suited for a stable IG environment and for manoeuvring under their own power, on the surface of the Earth. But man was poorly suited for the aerial environment. Even the birds, whose primary mode of locomotion is flying, are unable to maintain orientation and fly safely when deprived of vision or when they encounter fog and clouds. Considering our phylogenetic heritage, it therefore comes as no surprise that Spatial Disorientation (SD) occurs [1].

A case of a classical orientation error accident is presented, which has been specially selected to draw attention to the problem of SD and its many nuances. In this case the cause of the accident remained a mystery until the cockpit voice recorder was recovered from the crash site and analysed. This accident has been attributed solely to SD and highlights certain varied aspects of SD[4]. Spatial Disorientation is today a major area of concern and needs urgent attention at all levels to prevent repetitions[1].

Case Report

A 27 year old fighter pilot, fully Ops, instrument rated Green, A1G1 medically with a total of 883 h of flying experience and 338 h on type (44 h of which were undertaken at night) on detachment to a base, which was located in a desert like area. He was detailed to undertake a low level navigation sortie as part of the Dark-phase night

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strike syllabus. In this low level exercise 8 way points were planned with the last culminating over the base. The entire sortie was for a total of 32 minutes. The weather at that time was good, with 2-octa clouds, base 3 km and visibility of 6 km. The terrain over which this navigation exercise was planned is sparse, desert like and with little inhabitations.

The pilot had completed the Moon-phase portion of the night strike syllabus and had recently commenced the Dark phase. He had successfully operated solo, steep turns, zoom climbs and decent. The day prior he had done a dual check of a low level nav sortie after which he was cleared for this solo sortie.

Prior the sortie, the Squadron Flight Commander briefing included instructions to fly the nav not below 1000 feet AOL, to watch out for scanty lighting conditions, to set the radio altimeter warning to 10% below operating height (which was 1500 feet), to rely on instruments as he would be flying in SD prone conditions, give R/T calls, open ful throttles and gain height if feeling disoriented, and in the eventuality of no reprieve from Disorientation to abondon aircraft.

The pilot after due pre-flight checks attempted a take-off at 1904h, but due to a faulty HUD aborted the same. He thereafter changed his aircraft and finally got airborne at 1941h. After take-off he initiated a turn to the left, changed his R/T channel from Base Tower to Base Homer and gave a call on attaining the requisite altitude of 1500 feet. This was the last R/T call made by the pilot. Since the nav. was planned for a total of 32 minutes duration, on expiry of this period the ATC initiated overdue action. Late at night the smouldering wreckage was located near the second way point 5 minutes 52 seconds flying time away from the base.

At the crash site it was determined that the impact angle was shallow 21 degrees and the attitude of the aircraft appeared to be slightly nose-up with left bank. The debris scatter indicated a high speed at impact. The ADR with CVR was recovered from the site. Only 300 gms of body tissue of the deceased were retrieved from the site.

The pilot's profile revealed a young bachelor officer from a well to do family. He had no financial or any other liabilities. Was not emotionally involved with anyone at that time. He was of a cheerful disposition and maintained moderate habits. The pilot had returned recently after a month's leave. Post his leave period he had logged in some 22 hours of flying both day and night. His flying record shows him to be accident free and rated as average in his flying skills[4].

Spatial Disorientation

SD is defined as a state characterized by an erroneous orientational percept i.e., an erroneous sense of one's position and motion relative to the plane of the Earth's surface[1,3,5]. Operationally SD is an erroneous sense of any of the flight parameters displayed by aircraft control and performance instruments [3,5]. The significance of SD lies in the fact, that it affects mission accomplishment, flight safety, produces distractions, impairs performance, produces anxiety reactions and as its worst causes accidents with loss of life and material [2].

The Spatial Disorientation phenomenon has been classified into 3 types [1,3,5] A Type-I-SD is one that is not recognized, the pilot is unaware of any error in his aircraft control and performance, in fact he is quite oblivious of the fact that SD is occurring. His control of the

aircraft is therefore based upon a false percept whose final outcome is collision with the ground. This is a straight case of CFIT (Controlled Flight Into Terrain). This form of SD is also called Misorientation. A Type-II SD is the recognised form and for which almost every pilot can relate an episode of . Herein the pilot is aware of conflicting inputs from his body orientation mechanisms and from what he is gleaning through the aircraft instruments. Most often the pilot is able to resolve the conflict in favour of believing his instruments and thereby recovering the aircraft. The last, Type-III SD is the recognised, incapacitating form of this malady. The pilot knows that he is disoriented but because of incapacity is unable to recover the aircraft. This can be brought about by a number of ways, such as vestibular-ocular disorganisation which can be to such a degree that he is unable to read his instruments nor obtain a stable view of the outside world. The pilot can also be incapacitated by strong vestibular spinal relaxes to the shoulder and arm that he is unable to manipulate the controls. Lastly, the pilot may be incapacitated by intense fear so that he is unable to make a rational decision and he freezes on the controls [1,3,5].

Conditions, Manoeuvres and Factors Conducive to SD

There are certain environmental conditions and weather that makes SD occurrence a high possibility. Flying over featureless terrain like sea, snow and over the desert make altitude appreciation a problem. Operating in Instrument Meteorological Conditions such as at night, in white out conditions, in fog, rain, mist, snow degrades visibility making a person susceptible to vestibular opportunism and false sensations. The monsoon and cloud penetration are conditions to be avoided where SD is concerned[1,2,3].

There are also certain flight manoeuvres which can induce SD. Prolonged linear and angular turns, acceleration and deacceleration, aerobatics, formation flying, recovery from prolonged rolls and spin, and in helicopters during hover[1,2,3].

Looking at some of the aircrew factors implicated in pilot disorientation are factors such as fatigue, lack of sleep, illness, lack of experience, inadequate training, return from leave, flight stress and emergencies. On the personal side are factors such as drugs, alcohol, life events, emotions and state of arousal[1,2,3].

SD Statistics

Navathe and Singh in 1990 have conducted one of the largest surveys with respect to SD on 413 aircrew. The prevalence rate of SD was 75% in fighters. There was no significant variation with age, flying experience day or night had no variation, increased incidence in fully ops pilots and in those returning back from leave. 65% of the aircrew reported SD at night, 55% in cloud, 35% in poor visibility and 5% in clear weather. Recovery procedures 87% went onto instruments, 13% engaged autopilot, 2.4% handed over controls and 0.8% had no idea how the a/c recovered [6]. The authors also conducted a retrospective analysis with respect to Orientation Error Accidents in the IAF, for the period 1970-1990. They reported a total of 141 accidents related to SD, out of which 54 were major and 42 fatal [6]. These figures and statistics are not very different form those in other countries [1,2,3,7].

Discussion

When we look at this case in hindsight and in

light of the ADR analysis it is seen, that there were a number of pointers towards the high probability of the pilot becoming Spatially Disoriented on this particular sortie.

Firstly, though the pilot had reasonable amount of flying experience to his credit, he was still inexperienced so to say, with respect to Night flying in general (he had only 44 h night flying on type) and more specifically to the Dark-phase portion of the night strike syllabus. Though experience does not confer any immunity to the occurrence of SD, this basically reflects his instrument flying capability and proficiency. Secondly, Dark-phase night flying is highly conducive to produce SD and is an operational condition one has to be wary about. Thirdly, he was on detachment to this base and so was not too familiar with the terrain and the landmarks though he had undertaken the same route on the previous night. Fourthly, he was to fly a low level navigation sortie over featureless terrain which was sparsely inhabited, (a fact which was brought to his notice in the briefing), a situation in which altitude assessment is anyway difficult, the sparse lights on the ground making it worse. Fifthly, the scanty lighting conditions on ground due to sparse inhabitation could have lead to a ground light - star light confusion. Sixthly, the pilot could have been in a higher state of arousal at start up, due to annoyance following the faulty HUD, the first sortie being aborted, a change of aircraft and finally a delay in launching off. Seventhly, the pilot seemed a bit distracted with a song he kept repeating, instead of maintaining a higher order of vigilance, especially when flying in a high risk SD scenario. And lastly the pilot had returned form leave barely 17 days prior, could have lost vestibular habituation making him more susceptible to erroneous vestibular inputs.

Throughout the initial phase of the flight the pilot is distracted by the few lines of the song, as indicated by the flaps warning which comes on because he has not put the flaps in. Also he keeps up a running conservation with himself. Singing during take-off phase is considered unusual as this is a critical period when the pilot is required to take some vital actions. Further the excessive chatter could be due to two reasons, that the pilot is apprehensive and nervous about the Dark night solo sortie or since he had flown the same sortie the previous night was somewhat careless and complacent. In both cases his concentration could have been affected and this also reflects a low vigilance level.

In all this chatter the pilot allows himself at some point in time to get into a type-I SD, wherein which he is unaware of one wing dropping and the aircraft gradually pitching up. With all the prerequisite conditions narrated earlier, it is not surprising that this occurs barely 3 minutes 50 seconds after take-off.

Subsequently during an instrument scan he notices the anomaly and immediately straightens out the aircraft to wings level, but still failing to notice the increase in altitude and in pitch. For some period of time he keeps making control inputs with the stick to correct a right bank which was varying between 4 to 13 degrees. At this stage was he fighting the Leans? The feeling of bank when straight and level can be very disconcerting and if it persists can be very distracting to even the most experienced flyer. However he is still distracted with his song and maybe he was concentrating a bit too hard to correct his roll that it is only after some 28 seconds post levelling the aircraft that he is able to realise that his aircraft is in a pitched up state, of 34 degrees and that he was at almost 6000 feet altitude. He now knew that things were not too good and that he was disoriented-Type-II SD. He uses the standard SOP and gets down onto instruments, by this time his aircraft had climbed to 9200 feet AGL. A few seconds later the pilot gives a panicky call when he notices that the

aircraft speed has dropped dangerously low to 138.6 knots. He brings the nose down and starts descending.

Forty eight seconds after his first recognition of SD the pilot is in the clutches of Spatial Disorientation and has severe problems in the control of his aircraft. Within another 5 seconds the aircraft stalls for the first time. The pilot had now gone into a Type-III SD, he begins to hyperventilate, due to the anxiety and goes into a state of hyperarousal. His control inputs are not sufficient to get a grip on the aircraft. He had gone into the descending portion of the classical Yerkes-Dodson curve of arousal versus performance. It became a vicious cycle which was further aggravated by the Hyperventilation. In all this period, the aircraft climbs to 11720 feet when again the nose comes down and he loses 2500 feet altitude in 20 seconds. The aircraft thereafter stalls. In between the calls when he invokes his mother's help, 8 seconds lapse, in this time the aircraft actually recovers from the unusual attitude. The unfortunate part is that the pilot had not realised the fact that the aircraft had recovered. This was in all probability due to his hyperaroused state. Thereafter the aircraft stalls again, recovers, then attaining a nose up attitude climbs to almost 13000 feet from where it pitches down violently with a bank to the port side. The pilot is totally unaware that now the aircraft has flipped on its back, he continues to try to control his panic by loudly telling himself to relax.

Thereafter, in a near vertical dive the aircraft loses height at a rate of almost 14000 feet per minute. During this period the pilot tries to calm himself down, however his hyperventilation had reached a rate of almost 36 times per minute. In all probability he had regressed mentally and frozen on the controls. Other possibilities include that in the powered dive lasting 40 seconds he experienced a Somatogravic illusion and felt as if the aircraft was pulling up and climbing out and therefore never made any control inputs. Or maybe he was in a state of visual compromise under the influence of vestibular opportunism and false vestibular sensory inputs. Another possibility includes the occurrences of strong vestibular-spinal reflexes that may have prevented him from giving control inputs. Whatever be the cause of the Type-III SD it was sufficient enough to incapacitate him.

The aircraft finally impacted the ground in a shallow attitude with a nose up angle of 8 degrees, at a speed of over 515 knots IAS leading to disintegration and wide scatter of the debris some of which was located almost 1.5 km away.

In this accident like in many others certain additional questions come to mind which has mystified investigators. Why are so many pilots, even those who know that they are Disorientated, unable to resolve and recover the aircraft? In this case also, the pilot was hopelessly disoriented, knowing this fact, why was he unable to resolve the conflict inspite of getting onto instruments? What made a reasonably experienced pilot remain glued to his seat and go down with his aircraft? Why did he not make any attempt to utilise his ejection system?

The answer to this lies in the understanding of the acute physiologic stress of SD which results in disintegration of higher order learned behaviour including flying skill. The disintegration of flying skill begins perhaps with the pilot realization that his spatial orientation and control over the motion of the aircraft have been compromised. Under such circumstances the pilot pays more heed to whatever orientation information is naturally available, monitoring it more and more vigorously. This all leads to heightened arousal. The net effect is that more erroneous vestibular information is processed and incorporated into the pilot's orientational percept. This

makes only matters worse and a vicious cycle is thus formed, with heightened arousal and degradation of performance. Unfortunately, complex cognitive and motor skills tend to be degraded under the conditions of psychological stress. Secondly under these situations there is a tendency to revert to more primitive behaviour, even reflex action. Thus the highly developed newly acquired skill of instrument flying can give way to primal protective responses during SD stress thereby making appropriate recovery action unlikely. Thirdly it is often suggested that disoriented pilots become totally immobilized, frozen to the aircraft controls by fear or panic as this disintegration process reaches its final stage. [1,3]

Conclusion

This Orientation Error Accident has been brought out for the simple reason that in this case there is a conglomerate and a host of SD factors, conditions, manoeuvres which each by itself could have produced disastrous results. This study also highlights the potential and innate capability of this aeromedical stress to swiftly and surely take a pilot into its folds and then into the ground. Orientation Error Accidents pose a difficult problem for investigation. For if the pilot is dead or is unable to remember what happened immediately before the accident, then the evidence which substantiates the identification of Orientation Error is at best circumstantial at worst cojectural. In many perhaps most of SD accidents an element of uncertainty must remain [2].

One problem with the mishap statistics related to SD accidents is that they are conservative representing only those mishaps in which disorientation was stated to be a possible or probable factor. In actuality many mishaps resulting from SD were not identified as such because other factors such as distraction, task saturation etc initiated the chain of events leading to the mishap. It can therefore be inferred that SD causes more aircraft mishaps than reported. This could be in the order of 2-3 times more[2].

"We should all bear one thing in mind when we talk about an airman who has been killed in a flying accident. He called upon the sum of all his knowledge and made a judgement. He believed in it so strongly that he knowingly bet his life on it. That he was mistaken in his judgement is a tragedy not a stupidity. Every superior and contemporary whoever spoke to him, had an opportunity to influence his judgement, so a little bit of all of us goes in with every airman we lose" - **USAF Flight Safety Poster.**

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