Contemporary Issues

Weather related fatal general aviation accidents: Can spatial disorientation training be an effective intervention strategy?

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ABSTRACT

Weather related general aviation accidents have become a safety concern **globally. Of the weather related accidents, Visual Flight Rules (VFR) flight into Instrument** Meteorological **Conditions (IMC) as a subset has attracted attention because of the high rates of fatalities associated with them. Aviation safety research professionals are attempting to explain the genesis and mechanisms of such accidents. This paper attempts to explain the dynamics of weather related accidents and re-evaluates** the **significance of Spatial Disorientation (SD) in such accidents. The discussion justifies the** role **of SD training in aviation as the final barrier to prevent fatalities in weather related SD accidents.**

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A series of weather related general aviation crashes in India in 2001, led to a review of the system of acquisition, maintenance and operation of small aircraft. The recommendations of the expert committee set up thereafter, that were reported on 17 April, 2002, included "strengthening of pilot training for meteorology, Indian climatology, and aerodynamics, besides the availability of advanced technological features like weather radars" [1]. It is not that weather - related accidents are a new problem limited to aviation in India, but as recent reports would suggest. they are a global aviation safety hazard [2, 3]. It is thus, that this paper is being authored based m the findings of current research being undertaken worldwide to address this problem.

Civil flights (non-military) in the United States U.S.) are classified as either General Aviation (GA) or _:r earner operations. GA activities include recreational flying, flying flight instruction, agricultural operations, sightseeing, and business travel [4]. The aircraft involved in GA flying may be piloted by a variety of people with a valid pilot license and medical certificate, but belonging to a wide range of age groups.

Despite the rapid technological advances related to forecasting and displaying weather hazards such as icing, turbulence, lightning and wind shear, weather continues to be identified as a causal factor in about 30% of all U.S. aviation accidents [5]. For the period 1995-1998, while GA accident rate was reported to be 7.58 accidents per 10,000 flying hours, the rate of GA weather related accidents was 1.50 per 10,000 flying

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hours. Fatal GA weather related accidents occurred at the rate of 0.41 accidents per 10,000 flying hours [6].

The biggest causes of factors in fatal weather accidents have been described as scenarios where pilots initiated, continued or attempted Visual Flight Rules (VFR) flight into Instrument meteorological Conditions (IMC) [7]. Between 1990-1997, 2.5% of the more than, 14,000 GA accidents in the National Transportation Safety Board (NTSB) accident database were classified as involving VFR flight into IMC and accounted for approximately 11% of the fatalities in that 8-year period. [7] Goh and Wiegmann report that three out of every four (75%) VFR-IMC accident flights are fatal [2]. Clearly, this is an area that has and is receiving much attention from everyone related to aviation safety. Researchers are engaged in. an attempt to address this safety issue from different perspectives. However, it is essential to understand the dynamics of weather related accidents clearly, before any recommendation can be considered to address the problem.

Dynamics of Weather Related Accidents

In the last decade, researchers have been attempting to understand why VFR pilots continue to fly into adverse weather and what can possibly be done such that the occurrence of weather - related fatal accidents could be reduced [2, 6, 7]. Dynamics of a weather related aviation accident can be very simply and empirically summarized in 3 stages (Fig 1).

The preflight conditions / factors would encompass issues of pre-flight planning such as route selection, weather reports and briefing, and weight and balance considerations, besides pilots characteristics such as experience, self-confidence and his or her psycho-physiological state. Social and organizational pressures can play a role both before and during the flight.

Within the pilot characteristics, various studies * have documented that an average GA pilot likely to be involved in a fatal weather related accident is low on total flying hours, [2,7] not have an instrument rating [2] and generally holding a private pilot license [2]. The pilot on such a flight would usually not file any flight plan [7]. Pilots involved in weather related accidents "would generally be overconfident in personal abilities" [2] and would rate themselves high on judgement ana skill [8]. and thus, probably, underestimate the risk involved or over estimate his / her ability to handle the prevailing weather conditions [8]. Some studies have found that such flights are more likely to be over the weekend [7].

In-flight conditions / factors would include factors that provide updated and current weather information, besides pilot decision making characteristcs. It has been reported that in-flight, the pilot is more likely to continue intentionally into (76%) rather than inadvertently encounter (24%) adverse weather [2]. These intentional decision of continuting into bad

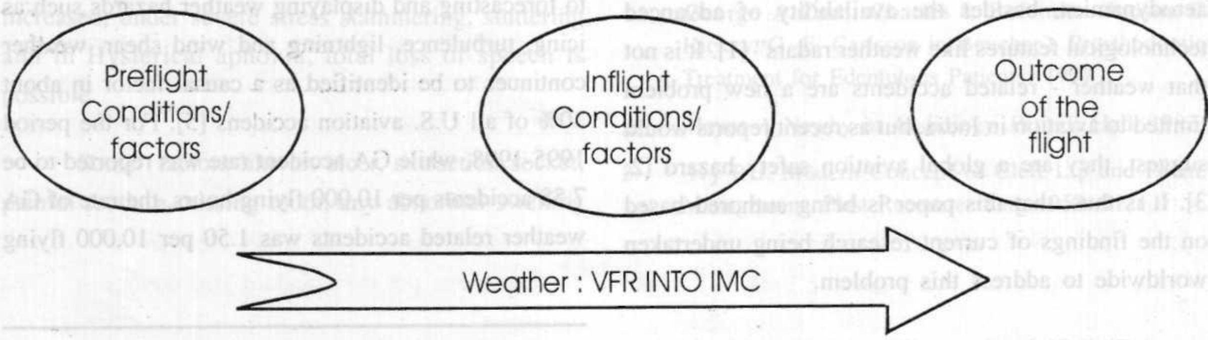

Fig 1. Dynamics of a weather related accident.

weather despite frequently receiving cues of deteriorating or hazardous weather have been reported in various studies [9, 10]. Orasanu, Martin and Davison [11] as cited in [12] have termed these actions as Plan Continuation Errors (PCE). Cognitive and contextual factors that may be responsible for or related to such PCE's include lack of weather knowledge, lack of sufficient and unambiguous weather information, time pressure, organizational or social pressures or internally induced pressure [12].

Sadly, a major part of the reported weather related studies and research ends here. It fails to focus on the mechanism and nature of the final outcome once a pilot encounters or continues into adverse weather. Kirkham attempted to explain that flight into inclement weather usually led to Spatial Disorientation (SD) and both interacted in a significant fashion to produce fatal outcomes [13]. Experimental research provides confirmation to this hypothesis [14]. Researchers concluded that a pilot with or without a current instrument rating could expect to live an average of 178 seconds after experiencing SD in poor visibility conditions [14].

SD in aviation refers to an incorrect self-appraisal of the attitude or motion of the pilot and his / her plane with respect to the earth. [15]. SD has attracted greatest attention in military aviation where high-performance aircraft are involved. SD has been implicated in 10-26% of fatal military accidents in the United States Air Force (USAF) [16, 17] and continues to be a problem [18]. Barnum and Bonner's [17] description of the average USAF pilot involved in SD mishap clearly shows that SD is not merely a problem of low time inexperienced pilots, but can affect experienced pilots as well. Should SD, therefore, be a matter of concern in GA flying where the aircraft are slower and pilots are not subjected to the high acceleration manouvres of military planes? The answer is probably, yes, as would be evident form the ensuing discusion.

Kirkham et al [13] carried out an analysis of SD in GA accidents in the U.S. While SD was recorded in about 2.5% of GA accidents every year, 90% of the accidents where SD was a cause, ended in a fatality. Also, SD was involved in 16% of all fatal accidents. Moreover, SD was a cause in 35.6% of all weather involved fatal accidents in small fixed-wing aircraft, thus illustrating the potential fatal interaction between inclement weather and SD [13]. In 84.4% of the weather-related fatal accidents with SD as a cause / factor, the final outcome was collision with ground or water followed by an in - flight breakup in 12.8% of the accidents ("SD leading to loss of control causing the pilot to over stress the airplane in attempting to correct attitude / direction") [13]. In these, too, as in weather-related accidents described earlier, flight plan was not filed in 64.7% of the accidents, fog was present in 56.8% of the cases, and pilots generally had less than 500 hours (60.8%) of total flying [13]. There are obvious similarities among the pilots involved in VFR - IMC flight as described earlier and those involved in SD. It is logical to conclude that SD is a manifestation soon after a pilot encounters adverse weather in flight, and SD / VFR-IMC accident can be considered as two sides of the same problem.

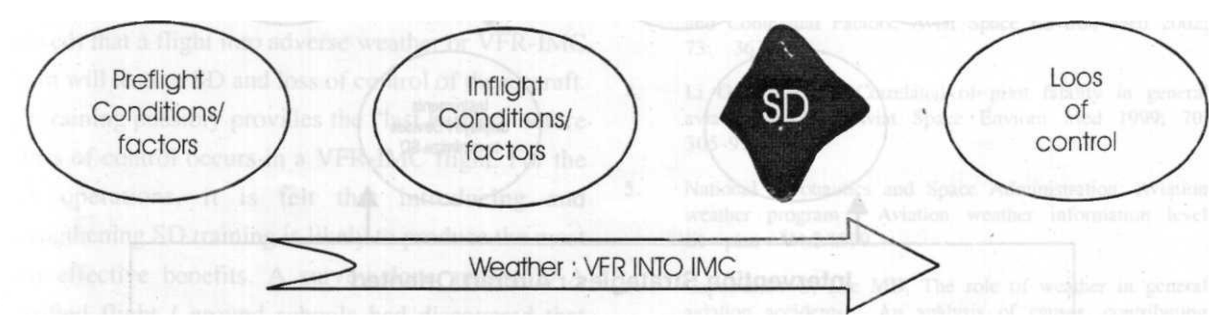

Fig 2. Dynamics of a weather related - SD accident.

Dynamics of **Weather** Related **Accidents : Expanded**

This leads us to propose the following expanded model of the dynamics of a weather related accident involving SD. This model (Fig 2) **provides sound theoretical basis to suggest interventions that can possibly minimize these fatal accidents.**

Various preflight and in-flight factors as enumerated in Figure I may interact in a way such that the pilot finds himself / herself in inclement weather or IMC conditions. Once the aircraft has entered IMC conditions, high probability exists that the **pilot would experience SD and it would be merely a matter of time (average 178 seconds) that control of** the **aircraft would be lost. This loss of control would generally be subsequent to a "graveyard spiral" or "roller coaster like oscillations." [14]. Once having lost control, the final outcome would in most cases be impact with terrain or ground / water** [13].

Intervention Strategies

Intervention Strategies

Research leading to possible intervention strategies can and logically should be focused at all the three stages and can be classified as technology or person oriented. Pilot training in instrument flight would be one such measure targeted at pilot characteristics in the preflight stage. As stated earlier, research is also focused on the factors surrounding PCE's [2. 12]**. Another area of research is looking at technological improvements in displaying weather information to the pilots under a broad category called Aviation Weather Information System (AWINS) [6]. Such empirical research is of critical significance in recommending interventions that could minimize the occurrence of fatal weather-related accidents in GA (Fig** 3).

However, it is the third stage where intervention strategies may possibly be the most effective, and

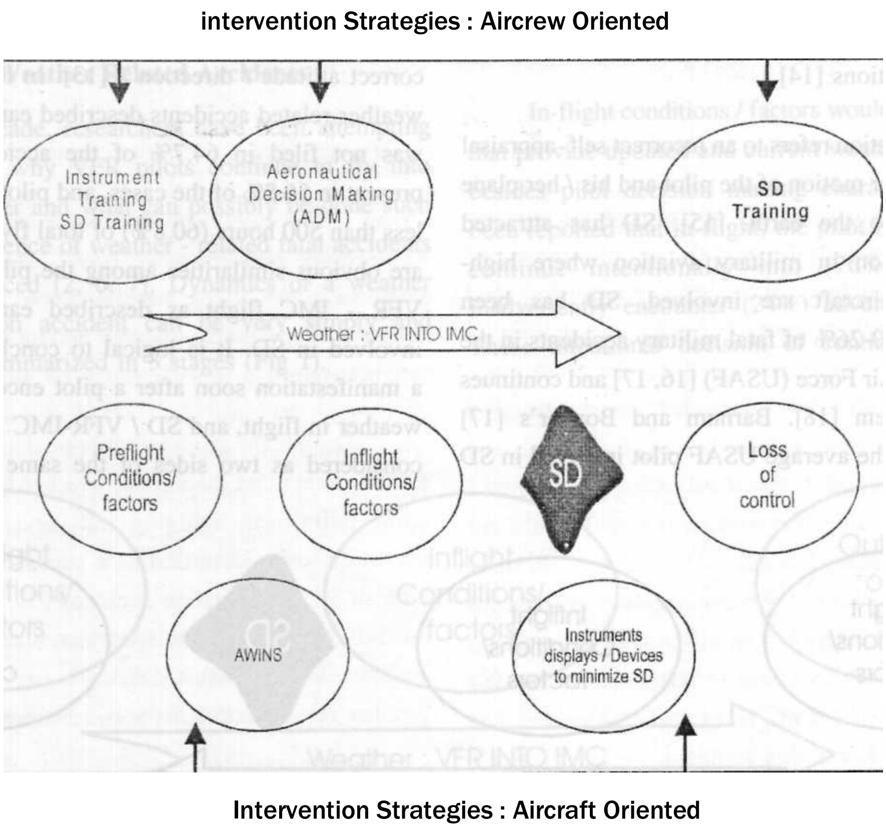

Fig 3. **Possible intervention strategies for weather related SD accidents.**

sadly, though, has been the most neglected and underplayed. There have been studies and reports on weather accidents in GA in the recent past [1, 6, 7]. Surprisingly, despite the exhaustive nature of analysis, SD has merited little or no mention in these reports. Possible reasons, why the role of SD has been underestimated in these and other reports have been dealt at length in an earlier report [13]. On the contrary, the fact that SD continues to be a problem in both military and civil aviation was bought out in a recent report [18], wherein it was documented that the rate of USAF, Army, Navy and FAA (civil aviation) SD related mishaps per 100,00 flying hours have changed little in the last three decades [18j.

Human error continues to be responsible for 60-80% of civil as well as military aviation accidents [8, 9, 19. 201. Humans by their very nature err, and it is unreasonable to expect them not to commit errors. Implicit in the above, is the notion that despite all the interventions targeted at stage 1 and 2 of our model, pilots will, albeit in a smaller number, continue to encounter bad condition in flying and therefore, intervention strategies need to be adopted to mitigate the consequences of such an event / error.

The effort to reduce SD related mishaps can be broken down into three general areas : "improved training materials and techniques, development of technologies to minimize the occurrence of SD and assist in the recovery from SD and research into (he physiological mechanisms leading to SD" [18]. The issue of SD training for aircrew rests on the premise that if the pilot has not undergone SD training / demonstration, and is not aware of the physiological limitations and mechanism of SD, it is very likely (as proved) that a flight into adverse weather or VFR-IMC flight will lead to SD and loss of control of the aircraft. SD training possibly provides the "last barrier" before 3 loss of control occurs in a VFR-IMC flight. For the GA operations, it is felt that introducing and strengthening SD training is likely to produce the most cost effective benefits. A survey done among FAA certified flight / ground schools had discovered that disorientation-training programs were evaluated as inadequate by more than one third of the respondents [21]. It is pertinent to conclude with a quote from a FAA article that pilots need to experience SD in a controlled setting, to dispel a myth that "continued flight into adverse weather of flying VFR into IMC conditions are the real causes of many of the aviation accidents". The truth is that "what really caused the accident was SD. What pilots often don't understand is that weather; especially poor visibility leads to SD. Because pilots have never experienced SD in a controlled situation, they do not know how incapacitating it can be or how to avoid it" [14J.

Conclusion

The above discussion attempts to place in perspective the often-fatal interaction between a VFR flight into IMC and SD. The significance of SD in GA undoubtedly, appears to have been underestimated. It is suggested that effective SD training should form an integral part of any flight training program, if meaningful reductions in fatalities associated with weather related accidents have to be achieved. It goes without saying that the dynamics of aviation safety hazards can usually be generalized across countries and hence the relevance of the present effort to GA operations worldwide.

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