Accidents, SAR and survival at high altitudes

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The high-altitude accident provides a conundrum for even the experienced accident investigators because of the multiplicity of operational, meteorological, physiological and psychological factors which impinge on the aircrew-aircraft complex in these regions. As regards search and rescue (SAR) and survival situations, these are much more easily quantified and predicted. The authors bring out the special problems leading to variations in causes of accidents and affecting the SAR process. Factors of specific reference to survival in these high-altitude areas are also presented and discussed.

Keywords: High alitutde; Accidents; Survival.

The causes which lead to flying accidents is an extremely difficult task because of the very large number of factors which can impinge on the man machine complex and lead to accidents. At high altitudes (HA) the additional problems which add to the already confused and difficult-to-analyse matrix are the high stress levels as a result of proximity to dangerous terrain, the high difficulty levels of the flying task, and the extremely low margins for errors, given the closeness of operation to the aircraft-operating envelope. Therefore, it becomes difficult to quantify factors like hypoxia, cold, etc., and their effects on performance decrements. Any analysis of an accident must include these factors mainly based on theoretical considerations.

One of the factors which complicates HA fighter operations is that most of these machines are launched from low-altitude bases where daytime temperatures are quite high. To provide for a survival situation, it becomes necessary to clothe the aviator in bulky warm clothing, which causes a deterioration in his flying performance and makes him much more uncomfortable. Another problem of HA fighter flying is of ejection at high altitudes. We know that HA ejections involve high parachute-opening shock. Also, the ambient terrain altitude is so high and the operating altitude of the aircraft so low that decisions about what to set on the barostat of the parachute is always a compromise. Any setting which is safe for high-altitude flying is unsafe once the pilot has returned to his low-altitude region. It, therefore, becomes necessary to warn pilots to be prepared for manual opening of the parachute canopy, which adds yet one more factor in the already critically overburdened situation. Operation at higher clearances, autopilot facilities, relatively lower speeds of operation, better survivability on force landing, etc., make survival prospects better for transport aircrew. Helicopter crew are committed to force-land the aircraft in case of any malfunction or error. Therefore, the option of escape before ground contact does not exist in this group of aircrew, at least at this time.

However, in the search and rescue (SAR) situation quantification of factors is very different, and it is possible to predict accurately the outcome of any accident based on certain variables.

The primary factor in SAR may be represented by the survival equation:

survival time ⩾ rescue time.

The individual factors affecting the survival equation are shown in Figure 1. It is possible to look at the various factors individually and improve the overall SAR environment.

Factors of special significance affecting the rescue time at HA are briefly discussed below.

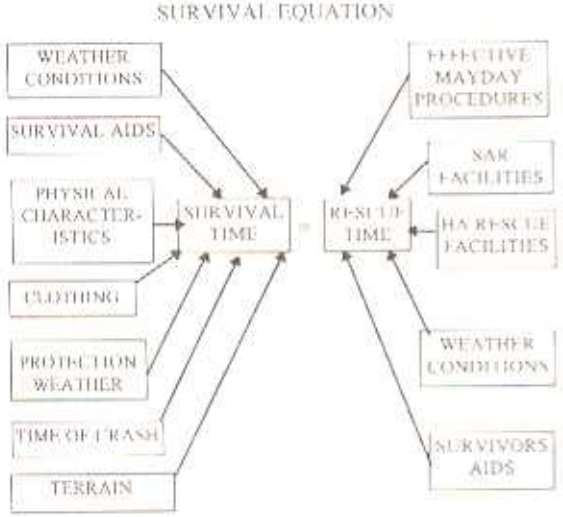

Figure 1. The survival equation(modified from Sowood and Allao [1])

Effective overdue action. Effective overdue action, the so-called Mayday procedures, forms the basis of any SAR operation. Any time that an aircraft becomes overdue, appropriate SAR action needs to be initiated on priority basis so as to enable early location and quick recovery. However, in high-altitude areas flying operations have several limitations which may change the flying programme, such as bad weather and delay in land conveyance of the passenger to the airfield. When it is not possible to communicate this change in the flying programme to the base, it becomes incumbent for the operating base to launch SAR. However, over a period of time, because of awareness of this frequent need for change and difficulty in communications, the operating base often delays the launch of SAR until some definite information is received. While this may be justified on the basis of the everyday occurrence of delays, it can on occassions lead to a delay in SAR in case of a real accident.

SAR facilities. The important factors involved are shown in Figure 2. The first issue to be addressed in this regard is the location and range. Very often, in the case of HA accidents

SEARCH AND RESCUE
- LOCATION AND RANGE
- READINESS
- CAPABILITY
  - WEATHER
  - NIGHT
  - FOG
- AIDS
  - LOCATION
  - RESCUE
  - COMMUNICATIONS
- TRAINING

Figure 2. Search and rescue operation.

both location and range may be unknown. Even where the appropriate location is known, the terrain may necessitate a much longer flying route than may be apparent on the map. Readiness for SAR is a factor is being strictly followed at HA. Capability of SAR at HA is restricted to fair weather daytime operations, with good visibility. It is not possible to have an all-weather capability in these areas. Location aids like survival beacons, etc., also become extremely difficult to use at HA because of the problem of intervening ridges. As a result, as and when SAR is required, it can only be carried out under ideal conditions and may require to be delayed by a whole night.

Weather conditions. The weather at HA is extremely unpredictable and is regional, i.e. it is independent of the systems which cause weather in the overall geographic region. Fog, mist, localized rain or snow, or even localized high-velocity wind storms can occur in particular valleys with little or no warning. In addition, we have the problems of up-drafts and down-drafts also affecting the weather.

Survival aids. These include location and communication aids. Due to weight limitations, these are usually reduced to the barest minimum, and when put to test can provide some aid if the terrain is relatively flat. However, in the worst scenario, multiple ridges between the crash site and base may not permit radio signals to be received.

On the survival side of the equation there are a large number of factors which affect the outcome.

Physical characteristics. Physical characteristics which affect the survival outcome are the age and body fat of the aviator and the state of his HA and cold acclimatization. Other factors like the presence of injury can also affect the outcome.

Availability and effective use of survival aids. These aids primarily consist of protective clothing by way of good wind-proof clothing to keep out the wind and to control the wind chill factor down clothing to provide protection from cold, head gear and suitable goggles to protect from UV radiation and prevent snow blindness. In the case of having to spend the night a good down sleeping bag and a mattress to enable insulation from the ground are required. Water exclusion against melting of snow and adequate insulation are the prerequisites for an effective survival.

Weather. Weather is a factor which is the single most important factor affecting the survival time. If it is sunny and clear, the temperatures are higher and the pilot's requirement for protective clothing is not so critical. In a way, therefore, the time of the crash is one of the most important factors determining the weather at the crash site and, thereby, the survival time. The apparent good weather also provides a fillip to the morale of the aviator since he knows that the SAR can be launched immediately.

Training. Survival in the mountains or in any high-altitude area is an extremely difficult task because of the terrain involved. Aviators need to be trained in preventing hypothermia, protection of their extremities from frost bite, protection from snow blindness, these being the very basic needs to survive. Even though the aviator is well trained in navigation, this is very different from the ground navigation which he will need in case he is to an attempt make to the nearest road-head. There is a strong possibility that such a person, being used to thinking in straight lines on a map, may grossly underestimate the time and distance for a day's march and end up spending the night without shelter. It

Figure 3. Chances of survival after HA crash (modified from Sowood and Allan [1])

Table 1. Percentage of recovery of time slotwise

Time (h)	HA (%)	Plains (%)
< 1/2	14.3	64.4
1/2–1	7.1	19.49
1–2	7.1	11.02
2–3	14.3	3.39
3–4	14.3	0.85
4–24	Nil	Nil
24–48	7.1	Nil
> 48	35.7	0.85

is seen that pilots and artillery officers who know the most about map reading often tend to overestimate their capabilities in terms of the time required to attain an objective. This is one of the reasons why aviators are advised to stay with the aircraft. It is much easier to locate an aircraft wreckage from the air than a single or two figures walking across a slope.

Based on these considerations we can hypothesize a flow chart as shown in Figure 3.

A study of rescue times of accident victims in the Indian Air Force conducted by Kapur *et al.* [2] has shown that 65% of the crew in accidents were picked up in the first 30 min after the accident. This study considered all accidents occurring in the subcontinent, and these figures cannot with any validity be extrapolated to HA operations. Based on data at the Directorate of

Flight Safety, IAF, the HA rescue time can be definitely established as being much longer. A comparison of HA and low-altitude rescue times is shown in Table 1.

One reason why our pilot recovery rate is good is that the Indian Air Force has implemented the policy that all single-engine flying at HA should be by aircraft operating in pairs. This facilitates the location of the aircraft in case of crash and enables speedy SAR. Another policy relates to the time of flying at HA. Any routine flying task must be launched before noon, thereby automatically allowing 4–5 h of daylight in the event of SAR requirement.

SAR on normal terrain is within 6 hours. At HA an attempt to shorten this period is advisable. This can be achieved by provision of newer-generation equipment like satellite-based location aids to HA aircrew. Establishment of a trained HA medical rescue team capable of being para-dropped and skilled in ski-based travel and rescue may help in further reduction in the rescue time and thereby improve aircrew salvage at HA.

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