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(6) HUMAN FACTORS IN HIGH SPEED LOW LEVEL ACCIDENTS - A 15 YEAR REVIEW

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ABSTRACT

HUMAN FACTORS IN HIGH SPEED, LOW LEVEL ACCIDENTS - A 15 YEAR REVIEW

The Canadian Forces introduced the CF 104G into Squadron Operation in 1963 and since that time these aircraft have operated in the high-speed, low-level environment in both the strike/reconnaissance and tactical support roles. Fifty-seven accidents involving these aircraft are reviewed with regard to cause factors. Marginal weather appears to be the one most significant factor contribution to low-level, high-speed accidents; however, several human factors such as visual contrast problems, fatigue, stress, reaction time, "mission completion" syndrome, inattention and task overload were identified. Aspects of accidents which typify human factors problems are described. Suggested possible preventive measures are outlined.

INTRODUCTION and BACKGROUND

The Canadian Armed Forces have been flying aircraft in the high speed low level (HSLL) operational mode for the past 17 years. The CF 104 operated in Europe with NATO for nine years in the strike/reconnaissance role and, more recently, for six years in the tactical air support role. In addition, the Canadian Armed Forces have also utilized the CF 5 in the close air support role for the past eleven years. During these operations, it has become clear that even with effective aircrew operational training and a vigorous flight safety programme, the high speed, low level role was dangerous and demanding - resulting in what appeared to be a significantly high rate of loss of aircraft and aircrew.

The present survey of high speed low level accidents confirms the findings of a five-year survey completed by LCol I.H. Anderson in 1969,(1) who concluded that, although the cause of most accidents in this environment cannot be absolutely determined, judgement, decision making and available reaction time are factors which almost surely have contributed to the accidents. This survey is an attempt to more clearly identify the human factors associated with HSLL flight and to make recommendations which may enhance flight safety in this role. The following mission descriptions illustrate the task workload and complexities facing aircrew involved.

Strike. A typical strike training mission in a CF 104 was as follows. A preplanned route, chosen on the basis of forecast weather was flown at 500 feet, 450 knots (800 feet during bird season, April to October). The last leg of the route was flown at 50 feet above ground and 550 knots until the simulated nuclear weapon drop. If deteriorating weather was encountered, the pilot was permitted to climb to 2,000 feet above ground level and complete the route using ground mapping radar; the weapon could be dropped "blind". Target procedures were clear-cut in that the prime considerations were to arm and drop the weapon.

Reconnaissance. Reconnaissance missions were flown at 500 feet. 420 knots. Routing and the target for each mission were different, and therefore, a new map was prepared for each. Where possible, missions were flown in conjunction with ground force exercises in progress - hence some external pressure existed to reconnoitre a particular target at a particular time and hence some psychological pressure could exist to challenge deteriorating weather. Reconnaissance of targets of opportunity was encouraged.

With the requirement to acquire visual contact with the target, reconnaissance pilots would be more prone than their strike pilot counterparts to remain VMC below cloud. A pull-up into cloud generally resulted in an aborted mission.

Pilots were trained to rely upon their visual observations and utilize elements of essential information (EEI) cards. The aircraft mounted cameras were treated as a back-up capability. Last minute decisions at the target included which cameras to utilize, exposure times and camera settings in addition to flying the aircraft and making mental notes. Some pilots resorted to flying left-handed and using their right hand to record information on their EEI cards.

Tactical Air Support. The most demanding role assumed by Canadian CF 104's is the tactical air support role. Missions are planned at an altitude of 500 feet and a speed of 420 knots. Since these missions are flown in support of ground forces, little or no flexibility exists as to the target. The route to be flown is pre-planned based on forecast weather and known threats (e.g. surface-to-air missile sites). Aircraft are usually armed with a mixture of ordnance - hence the pilot must make airborne decisions as to which weapon to employ.

When operating in conjunction with a Forward Air Controller (FAC), the pilot flies to a pre-determined area by means of a pre-planned route. Once in the area, the FAC calls target location to the CF 104 pilot by means of a map reference. While flying at 400 knots plus and an altitude of 500 to 1000 feet, the pilot refers to his 1:250,000 map, locates the target, determines his route to target, decides upon the weapon to be employed and determines his escape route. Each weapon has its' own envelope and, therefore, the speed, type of delivery (e.g. level, 10, 20, 30 degree dive angles), foul lines (for richochets) and release points vary with each weapon.

Whereas the strike and reconnaissance missions were flown as independant aircraft, the tactical air support missions are flown as formations of two, three and four aircraft. The formation leader is responsible for navigation and terrain clearance while the wingmen are responsible for station keeping and lockout for aggressor aircraft.

METHODS

All CF 104 accidents from 1963 to early 1979 were reviewed. Only those occurring while en-route on a low level mission were included in the survey, whereas accidents occurring on the airfield or during take-off or landing were not. Similarly, accidents occurring in flying operations above 1000 feet above ground level (AGL) were not included. Mission types included operational training school missions, combat ready training, and actual NATO operational flights. Where specific cause factors are available from the investigation such as engine malfunctions, bird-strikes or range richochets, these are indicated. In these cases, human factors are not significant except in the manner in which the emergency was handled. Where the cause is undetermined or obscure, the most probable cause(s) and human factors involved are allocated by the authors.

RESULTS

Of the 57 high speed, low level accidents reviewed, 28 were caused by mechanical failure, bird strike or range richochet and human factors analysis was not carried out in these cases. This is not to say that human factors did not play some part in the management of the emergency, but in many cases there was no Flight Surgeon assigned to the investigation team and human factor investigation was usually non-existant. In most of these cases, a successful ejection was carried out.

In 29 accidents, the investigating board could not determine a positive cause factor (See Table I). These investigations were studied and the following human factors were found to be present in many of the situations in varying degrees; psychological stress, fatigue, inattention, task overload, visual contrast or illusory situation, reaction time, stress of formation flying, mission completion syndrome (this will be discussed later), and pilot incapacitation. These factors were then assigned as possible primary, secondary and tertiary factors contributing to the accident. These are tabulated in Table II.

There were two fatal accidents where reduced visual contrast almost certainly caused severe disorientation leading to the accidents. One case is suspected to be incapacitation because of the autopsy findings.

DISCUSSION

Weather. There is no doubt that weather is the single most influential factor in HSLL accidents. In 13 of 29 accidents, weather was definitely a contributing factor. This is even more profound in the European environment where weather played a major part in 10 of 19 accidents. Further, if one looks at the seasons, seven of 19 European accidents occurred in the January to March time frame, and in six of these, weather was clearly a deciding factor. Typical weather conditions at the time of the accidents were low overcast or obscure ceilings with visibilities reduced to zero to one mile in snow showers. It can be fairly safely stated that fifty percent of the HSLL accidents in the European environment would not have occurred if weather conditions had been better or if the mission had not continued into deteriorating weather.

Human Factors Demonstrated

a. Visual Problems - Visual contrast or illusion are usually associated with environmetnal conditions. The most common variety of this problem is the "white-out" condition occurring when an expansive flat snow covered area blends with a high, light overcast and the horizon cannot be distinguished. It may also occur in other low contrast situations such as dust or haze. These conditions are ideal for the induction of disorientation which, in HSLL flight, is usually catastrophic.

Illusions also may cause errors in orientation and judgement. A sloping low cloud bank may be mistaken for the horizon. In one of our cases the height of desert sage brush in comparison to Canadian trees, combined with sloping ground conditions most likely contributed to the pilot's unawareness of his critically low altitude.

In one accident, a CF 104 on a target run collided with an RAF Canberra which was on an unrelated mission. In this case, the other aircraft was not detected until sufficient reaction time was simply unavailable. The relative closing speed between aircraft was estimated at 400 meters per second.

b. Mission Completion Syndrome - This is a psychological syndrome which causes a pilot to press on in dangerous weather or a dangerous flight profile in order to complete the mission. Many factors can make up this syndrome. They are mainly psychological factors involving self-image and peer pressures. It can

claimed that a common personality profile of pilots in general is a contributing factor - "Per Ardua Ad Astra". Of the eight accidents clearly exhibiting this phenomenon, seven involved experienced seasoned aircrew. They had considerable total flying time with little time on type and appeared to be attempting to become combat-ready in the shortest possible time. This would allow them to stand alert or take over supervisory duties such as those of Flight Commander. Some had considerable CF 104 time with the possible self-imposed notion that they should be capable of mission completion under the most adverse conditions. A reputation as one of the squadron's top bombers or gunners seems to contribute to this syndrome as does flying a mission in an international competition.

c. Stress - For the purposes of this paper, stress is defined as ... "The presence of one or more physical or psychological stressors generally leading to inattention and thence to task overload." The stressors identified in the accidents we reviewed were psychological stress, fatigue and formation flying.

Physical fatigue probably accounts for more inattention than we may suspect. In one case examined, it is highly likely that the pilot was physically fatigued severely enough to cause inattention. He had flown two missions two days previously and his wife commented that he was fatigued. The day before the accident he held a 24 hour alert. The accident occurred on the third trip the following day; a day of hectic briefings and debriefings with no evidence of between flight nourishment.

There were many forms of psychological stress detected in the human factors analysis of these accidents including a serious argument with a girlfriend, girlfriend pregnant, minor irritating malfunction of the aircraft, having had to rush to change aircraft at start-up, deteriorating weather, first flight as section or element lead and flying in an international competition.

Formation flying is in itself a stressful activity and especially so while low level. Station keeping on an inexperienced lead at low level is particularly stressful as one has a tendency to keep one eye on the altitude. One accident reviewed (a low level formation collision) can be attributed to this factor.

d. Task Overload - The task of conducting a HSLL mission is extremely demanding for a poorly trained, borderline pilot who is continually behind the aircraft. If adverse weather is then encountered or an in-flight emergency occurs, conditions become ideal for an accident.

Incapacitation. The one case attributed to pilot incapacitation was based on the fact that the autopsy findings revealed a 75 percent restriction in the right coronary artery.

The human factors listed above cannot be viewed in isolation since many of them interact to lay the groundwork for an accident. However, there are certain combinations evident in HSLL accidents which can be divided artifically into four basic patterns:

a. Type I

STRESS → INATTENTION → TASK OVERLOAD → REDUCED TIME FOR REACTION → ACCIDENT
(psychological or physical)

This seems to be the most common pattern probably accounting for 13 of the 29 accidents.

b. Type II

MISSION COMPLETION SYNDROME → TASK OVERLOAD → REDUCED TIME FOR REACTION → ACCIDENT

This pattern probably accounted for 10 of the 29 accidents.

c. Type III

VISUAL PROBLEM → REDUCED REACTION TIME → ACCIDENT
(low contrast illusion)
DISORIENTATION

Five of our series seemed to be this type of accident, including two almost certain cases of disorientation.

d. Type IV

PILOT INCAPACITATION → ACCIDENT

One accident in our series was thought to be this type.

The advantage of splitting the accidents into these types allows each pathway to be analyzed as if it were a disease process. As in most disease processes, there are signs (objective observations) and symptoms (subjective feelings) for various stages of each of these pathways. By evaluating the pathways with this approach, one can recognize areas where intervention may be possible in the interests of accident prevention. For example, recognition of dangerous stress levels with temporary removal of the affected aircrew from flight status may prevent some Type I accidents. A means of detecting reduced attention and a method of alerting the subject would also make it possible to interrupt this pathway. Inattention can also be detected by wingmen and perhaps some sort of challenge system could be developed to determine alertness.

Task overload is very difficult to recognize but it may be possible for a subject to make such a judgement before reaching the stage where his time for reaction is so short that he is fortunate to be able to eject from the situation.

The mission completion syndrome contains certain ingredients which are often recognizable; high total-time pilots in operational training or combat-ready training; high time-on-type pilots checking out new crews in adverse weather; pilots assigned to fly in international competition (especially those with previous weapons trophies) and other factors probably more readily recognized by operational aircrew.

Conditions which predispose to low visual contrast, loss of horizon or visual illusions are often recognizable and could act as a warning to pilots flying in these conditions.

CONCLUSIONS and RECOMMENDATIONS

In summary, 57 HSLL accidents were reviewed. Twenty-nine of these were found to have obscure causes and were assumed to involve human factors. In effect, these accidents are probably due to the pilot getting into a situation from which the time needed to recover is greater than the reaction time available. The question is what factors contribute to the development of this situation? We believe that the following factors are involved:

- physical and psychological stress leading to inattention;
- mission completion syndrome which drives a pilot to fly into dangerous conditions; and
- the visual problems which may result from poor weather and conditions of illusion.

It is conceded that these factors are often inter-related and difficult to separate, but for prevention purposes, they can be looked at separately. It is considered that positive action should be taken to attempt to identify and eliminate, as far as possible, these contributing human factors.

It is recommended that:

a. The research community study the various stress factors on aircrew with a view to providing the individual aircrew and flight supervisory personnel with some means of identifying individuals who are strained to a dangerous level.

b. The research community continue to work on developing a method of detecting dangerously reduced levels of alertness or awareness in aircrew with a view to providing them with a feed-back alerting system in such circumstances

c. The operational staffs recognize the factors which predispose to the mission completion syndrome, attempt to identify aircrew at risk, and take action to eliminate this condition.

d. The operational staffs be particularly aware of conditions predisposing to low visual contrast situations and visual illusions and to modify flying programmes accordingly when these conditions exist. In addition, attitudinal change is required. Aircrew must be convinced that it is not heroic to fly into weather which is deteriorating below safe limits.

It is appreciated that the above recommendations may be difficult to implement without compromising the effectiveness of the squadron and without destroying the "tiger" spirit in the aircrew. However, it would appear that the human factors discussed have significant accident-producing potential and efforts should be put forth in this area.

ACKNOWLEDGEMENTS

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TABLE I

SUMMARY OF ACCIDENTS INVOLVING HUMAN FACTORS

Total accidents where human factors played the major role		29
Fatalities		21
Ejections:	Successful	4
	Not Successful	1
Aircraft and aircrew safely recovered		3
Average pilot age		27 Years
Average flying times:	Grand Total	2184 Hours
	Type on Type	293 Hours
	Last 30 Days	23 Hours

TABLE II

DISTRIBUTION OF HUMAN FACTORS AS ACCIDENT CAUSES

Number of accidents where human factor was assigned as possible cause factor (n = 29).

HUMAN FACTOR	PRIMARY	SECONDARY	TERTIARY
Visual Contrast or Illusion	7	1	4
Mission Completion Syndrome	7	4	1
Inattention	5	10	7
Task Overload	4	1	2
Psychological Stress	2	6	6
Reduced Reaction Time	1	4	7
Fatigue	1	1	2
Stress of Formation Flying	1	2	0
Pilot Incapacitation	1	0	0