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Disorientation Accidents and Incidents in U.S. Army Helicopters

1 January 1980 - 30 April 1987

By

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Accident data was obtained from the U.S. Army Safety Center for all U.S. Army helicopter spatial disorientation accidents which occurred during the period beginning on 1 January 1980 and ending on 30 April 1987. During this time, there were 129 accidents caused by spatial disorientation which were responsible for 37 fatalities and 56 disabling injuries. Major causal factors are analyzed and recommendations made for changes in aircrew training, education and aircraft instrumentation. Also discussed are the effects of operations undertaken in hostile environments.

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Introduction

The last major review of U.S. Army helicopter disorientation accidents took place over 10 years ago and was concerned with disorientation accidents that occurred during the fiscal years 1967-1971 (Hixson and Spezia, 1977). Most of the data were concerned with helicopter accidents that occurred in Vietnam, and the predominant aircraft studied was the UH-1. Since 1977, there have been a number of improvements in aircraft instrumentation and pilot training, and a general increase in awareness of the importance of disorientation in accident causation. A number of new aircraft types now are in widespread use throughout the world and there has been a significant increase in the use of night vision aids by U.S. Army helicopter pilots.

Therefore, it is pertinent to study the present situation to ascertain if the pattern of disorientation accidents remains the same, what can be done to prevent further accidents, and to assess the likely effect of such accidents on future combat operations.

Background

Spatial disorientation long has been recognized as a causal factor in the occurrence of aviation accidents. Anderson in his excellent book, The Medical and Surgical Aspects of Aviation, published in 1919, makes the following farseeing comment: "It has been assumed that a sound equilibration and muscle sense is essential in flying, so that the aviator would be conscious of his position in space, realise at once any deviations therefrom, and correct these quickly. But, in fog, it has been found almost impossible to detect any deviations during a flight. Time and again aviators coming out of dark clouds or fog have found themselves flying one wing down, and it has been recorded that some have flown upside down without knowing it. Thus, it is obvious that most of the impressions which control balance in flying come through the eyes."

That disorientation is a common cause of problems during flight and visual factors are paramount in its prevention may have been obvious to Anderson, but it is to be regretted that only since the 1960s has there been a concerted effort to reduce helicopter disorientation accidents by research and training. This is unfortunate as it is widely recognized that helicopters are conducive to the occurrence of disorientation due to their ability to move in any direction--true three-dimensional flight. Until recently, helicopters were poorly instrumented compared to their fixed-wing brethren and, despite this handicap, were expected to operate in difficult environmental conditions at extremely low altitudes and (in military operations) at ever-increasing speeds. True, some modern helicopters now are equipped with comparatively sophisticated automated stabilization equipment and improved instrumentation, including Doppler navigation and radar altimeters. Military flight crews all receive instrument training during flight school and, also, some basic instruction in the principles of disorientation. However, improved aircraft design and enhanced crew training are counterbalanced by the ability to operate in more difficult areas and by the current requirement for aircrews to make use of visual devices such as night vision aids. Also to be considered are the limitations likely to be imposed by the use of aircrew chemical defense assemblies, etc.

Literature review

Ogden, el al. (1964), studied some 36 U.S. Army helicopter orientation error (OE) accidents that occurred during the period July 1957 to December 1963, and they reported on the results of a questionnaire answered by 350 pilots. Their major conclusions were as follows:

a. Of all major accidents, 3.4 percent were attributed to OE and these accounted for 30.7 percent of all the fatalities.

b. Of all occupants involved in OE accidents, 38.5 percent died as compared to only 4.4 percent in all rotary-wing major accidents.

c. Of all OE accidents, 44.4 percent occurred during level flight and 27.8 percent during the landing phase.

d. The questionnaire revealed that 214 pilots experienced 545 disorientation incidents during their flying careers.

Hixson and Spezia (1977) studied the incidence of disorientation accidents over a 5-year period from 1967-1971. As already stated, the majority of these accidents occurred in Vietnam and the predominant aircraft type was the UH-1. They found helicopter OE accounted for 7.4 percent of all accidents and 16.5 percent of all fatalities. Seventy-two percent of the OE accidents were attributed to the UH-1 and this aircraft also was responsible for 75 percent of all OE fatalities.

A further questionnaire discusses a survey of U.S. Navy pilots involving 104 pilots (Tormes and Guedry, 1974).

Fifty-six percent admitted to one or more severe episodes of disorientation and 8.6 percent on five or more occasions. This survey was repeated in a modified form on Royal Navy (RN) pilots (Steele-Perkins and Evans, 1978) and, again, more recently (Evans, Turner, and Yeung, 1987). The results of these two surveys are similar, but the latter is more valid as the response rate to the questionnaire was in excess of 88 percent. The most common experience of spatial disorientation was the leans--a false sensation of bank when the aircraft is in level flight--which was listed by 94 percent of the respondents. Interestingly, 21 percent reported occasions when both pilots became disorientated, either simultaneously or during the same flight. The use of night vision aids or NBC equipment was quoted by 8 percent as a predisposing factor in causing disorientation. Five percent admitted to being involved in an accident or incident directly caused by OE.

A review of United Kingdom Army Air Corps helicopter accidents (Edgington and Box, 1982) reveals just over 15 percent of all major accidents were caused by disorientation and these accidents were responsible for 34 percent of all the fatalities sustained.

Discussion

Even a cursory review of the above data would indicate spatial disorientation as a major cause of peacetime and wartime fatalities and that the majority of pilots will experience one or more episodes of disorientation during their flying careers. Of more concern to the field commander is the effect this likely is to have on his ability to operate under hostile conditions. The available information is not conducive to complacency. Aircraft losses due to accidents have always outstripped attrition due to enemy action during periods of hostility. It is recorded (Baldes, 1971) that the U.S. Army lost over 45,000 aircraft during the training program alone in World War II. This involved the deaths or injuries of 30,000 aircrewmen. Another example from WWII involves the 15th Army Air Force where, during the period November 1943-May 1945, 69.2 percent of total casualties were the result of operational aircraft accidents (Link and Coleman, 1955). Only 18.5 percent of flying personnel casualties were the result of direct enemy action. Accidents during this period were not further classified, but the statistics impressively stand alone.

Military helicopter losses appear to follow a similar pattern. During the Vietnam War, over half the total helicopter losses of 4,500 were caused by accidents not directly related to enemy action. Hixson and Spezia (1977) record the accident rate in Vietnam was 2.4 times greater than the mean for worldwide U.S. Army aviation accidents and the OE accident rate was 3.4 times greater than the mean U.S. Army helicopter OE accident rate worldwide.

More recent data, particularly pertinent to helicopter operations, concerns British Royal Navy helicopter losses during the Falklands Campaign (Vyrnwy-Jones 1987). Five of the six major naval helicopter accidents which occurred during this campaign can be attributed partly or wholly to disorientation subsequent to operations which were undertaken in extreme weather conditions and under very stressful circumstances. These accidents accounted for all of the deaths and injuries sustained by RN helicopter aircrews and passengers during this campaign. These accidents are listed in Table 1.

These facts highlight the difficulties likely to be experienced by any operator who intends to employ helicopters manned by single pilots in the demanding wartime role. The use of NBC equipment and NVGs, etc., will, of course, compound the problem.

Table 1

Royal Navy helicopter disorientation accidents
(Falklands Campaign)

Aircraft type	Circumstances	Fatalities/ injuries
Wessex	Total whiteout conditions in extremely severe weather	1 minor
Wessex	As above	-
Sea King	Fly-in to sea on dark night	21 fatal 3 major 3 minor
Sea King	Fly-in to sea on dark night after radar altimeter failure	-
Sea King	Fly-in to sea on dark night during circuit to deck landing.	1 fatal

Method

All U.S. Army Class A, B, C, D, and E OE mishaps involving rotary-wing aircraft during the period 1 January 1980 to 30 April 1987 were analyzed in this study. The classifications are defined below:

a. Class A. A mishap in which the resulting total cost of property damage and personnel injuries is $500,000 or greater; or an Army aircraft is destroyed; or an injury/occupational illness which results in a fatality or permanent disability.

b. Class B. A mishap in which the resulting total cost of property damage and personnel injuries is $100,000 or more, but less than $500,000 or any injury/occupational illness which results in permanent partial disability or hospitalization of five or more personnel.

c. Class C. A mishap in which the resulting total cost of property damage and personnel injuries is $10,000 or more, but less than $100,000; or an injury/occupational illness which results in a lost workday case with days away from work.

d. Class D. A mishap in which the resulting total cost of property damage and personnel injuries is less than $10,000; or an injury/occupational illness which results in a lost workday case with days of restricted work activity or a nonfatal case without lost workdays.

e. Class E. An event with no damage cost and no injury or occupational illness; or injury only requiring first aid; or other circumstances resulting in, for example, forced landing, precautionary landing, human factor event.

The decision was made to include Class E mishap data in the general analysis as they represent accidents that almost occurred and serve to demonstrate trends in the OE area.

Data were obtained from the computer database held by the U.S. Army Safety Center, Fort Rucker, Alabama, which is the agency responsible for encoding aviation mishaps from all active Army, Army Reserve, and Army National Guard organizations, worldwide.

Definition of a disorientation accident

At present, there is no internationally agreed upon definition of what constitutes an OE accident or incident. This is compounded further by the differing accident and incident classifications that exist between countries and among different organizations. In this report, the term OE or disorientation accident or incident is used to describe any incident in flight where the aviator fails to sense correctly the position, motion, or attitude of his aircraft or of himself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. Also, this is taken to include those occasions when the aviator's perception of his own position, motion, or attitude to his aircraft, or of his aircraft relative to other aircraft is erroneous.

Specifically excluded from the analysis are those accidents and incidents which are the result of geographic disorientation; i.e., navigational errors. It is not always simple to separate the effects of OE from simple mishandling of the controls; for instance, a pilot at a hover may be unaware of a drift which results in a collision with an obstacle, or the collision may be simply due to mishandling of the flight controls. The former would be classified as an OE accident, the latter would not. Autorotation accidents particularly are difficult to classify as these are sometimes the result of poor flying technique or may be due to perceptual errors. Only those cases where the latter is definitely the case are considered in this report. It is difficult to assess accurately an accident as OE if the result was the death of all the occupants, but in the cases considered here this conclusion has only been drawn when all the available evidence indicated OE was the most likely causal factor.

The accident data, which for the period under study covers over 32,000 class A, B, C, D, and E accidents and incidents already had been classified by Safety Center staff. The author further reviewed the available data on those accidents/incidents classified as OE and excluded any which did not comply with the already stated definition. All other accidents classed as pilot error were reviewed. This was restricted to class A-C accidents as it was not possible to manually sort through more than 30,000 class D and E accidents and incidents.

Accidents involving wire, tree, and obstacle strikes also have been excluded, although it easily could be argued some of these are attributable to OE. During the time period of this study, there were 134 class A-E wire strikes, 704 class A-E tree strikes and 1,183 class A-C obstacle strikes. The main point to be borne in mind is the total of cases studied is an underestimation; nevertheless, there is enough data available to demonstrate the magnitude of the problem.

Results and Discussion

During the period of the study from 1 January 1980-30 April 1987, there were 129 class A, B, C, D, and E orientation error mishaps involving 129 aircraft. These accidents were responsible for 37 fatalities and 56 disabling injuries. This information is summarized in Table 2. Details of the mishaps are contained in Tables 3-8 which are listed by aircraft type for convenience.

Table 2

Summmary of class A - E disorientation error accidents
1 January 1980 - 30 April 1987

Aircraft type	Mishap classification A	B	C	D	E	Fatalities	Injuries
AH-1	6	3	7	2	8	0	6
CH-47	1	0	0	4	1	6	0
OH-58	10	2	4	0	2	8	5
OH-6	0	2	0	0	0	0	0
UH-1	20	6	18	6	8	15	33
UH-60	5	2	6	5	0	8	12
TOTAL	42	15	35	17	19	37	56

Table 3

U.S. Army AH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
1	C	During night OGE hover the aircraft was allowed to descend into trees. Rotor induced dust produced hazy conditions.	00	00	Night	Hover OGE	1. IP failed to detect descent. 2. Decision to maintain hover when visibility was reduced by dust. 3. Poor crew cooperation. 4. NVGs.
2	A	While attempting a precautionary landing in a snow covered field, the IP lost visual clues due to whiteout.	00	00	Day	Approach	1. Whiteout. 2. Continued flight into adverse weather. 3. Lack of good weather information.
3	B	While hovering at 45 feet AGL the aircraft was allowed to drift into a tree.	00	00	Night	Hover OGE	1. Failure to detect drift. 2. Crew had flown 6 hrs that day. 3. Pilot had marital problems.
4	C	Brownout during approach to landing strip.	00	00	Night	Approach	1. Brownout. 2. Incorrect procedures for landing in dusty conditions.
5	C	Dusty conditions and dirty canopy caused pilot to allow aircraft to drift into trees.	00	00	Day	Hover taxi	1. Brownout. 2. Coning of attention on firing task. 3. Poor crew cooperation. 4. Dirty canopy.
6	E	Darkness and poor ground reference made normal approach path difficult to assess. Engine was overtorqued to cushion landing.	00	00	Night	Approach	1. Lack of visual clues.

Table 3 (cont)

U.S. Army AH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
7	B	After an abortive attempt to fire an illuminating rocket, the aircraft was allowed to drift backwards in a nose-up attitude resulting in a tail rotor strike.	00	00	Night	Hover OGE	1. Lack of visual clues. 2. Failure to follow standard procedures. 3. Lack of artificial illumination. 4. Pilot exhibited an abnormal psychological fear of darkness.
8	E	Aircraft inadvertently entered a high rate of descent during a OGE hover. Conditions were hazy with a full moon.	00	00	Night	Hover OGE	1. Poor visual clues. 2. Poor instrument scan.
9	A	During attempted takeoff from an unlighted confined area, the aircraft drifted to the rear into the trees.	00	00	Night	Takeoff	1. Poor visual clues. 2. Incorrect procedure for takeoff.
10	C	Aircraft drifted into trees while pilot was observing another aircraft. Pilot was acting as an exercise evaluator.	00	00	Day	Hover	1. Failure to prevent drift. 2. Coning of attention. 3. Task overload.
11	C	Aircraft was engaged in firing night illumination rounds when copilot noticed aircraft was in high rate of descent and applied full collective causing aircraft to spin.	00	00	Night	Hover	1. Poor visual clues. 2. Coning of attention on task. 3. Little crew experience. 4. Crew rest policy for prior 24 hrs had been contravened.

Table 5

U.S. Army OH-58 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
1	C	Tail rotor struck tree after inadvertent rearwards drift.	00	00	Night	Hover	1. Pilot failed to perceive drift over a snow covered unlit landing spot. 2. Use of flashlight for pre-flight checks may have compromised night vision. 3. Landing site should have been lighted.
2	A	Aircraft control was lost during an attempted VHIFR subsequent to inadvertent entry to IMC.	03	00	Night	Cruise-climb	1. Pilot failed to execute correct VHIFR recovery procedure. 2. Very limited IFR experience on type.
3	A	While concentrating on an observation task, aircraft descended into a position from which recovery was not possible.	00	01	Day	Cruise-turn	1. Coning of attention. 2. Poor crew cooperation. 3. Lack of written procedures.
4	A	Pilot lost control of aircraft after deliberate entry into IMC.	01	00	Day	Cruise-climb	1. Continuance of flight into adverse weather conditions. 2. Aircraft was not cleared for IFR. 3. No copilot present.
5	C	Aircraft was allowed to drift to the rear till it struck an adjacent aircraft.	00	00	Day	Hover	1. Pilot was concerned about a possible sticking collective lever. 2. Copilot and observer were engaged in studying map.

Table 5 (cont)

U.S. Army OH-58 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
6	C	Aircraft was allowed to descend into trees from a high hover while pilot was studying map.	00	00	Day	Hover OGE	1. Coning of attention. 2. Lack of crew cooperation. 3. Lack of experience on part of aircraft observer.
7	A	Aircraft flew into lake during cruise flight.	00	02	Day	Cruise	1. Lack of visual clues over water. 2. Pilot's attention diverted by boats on lake.
8	C	Aircraft allowed to drift into tree while aircrew were studying map.	00	00	Day	Hover	1. Coning of attention. 2. Lack of crew cooperation.
9	B	IP using NVGs while hovering over snow covered ground lost control of aircraft which entered a 45-degree bank to the left before striking the ground.	00	00	Night	Hover	1. Lack of visual clues. 2. Unsuitable landing site. 3. Lack of instructions to guide pilot in use of NVGs under such conditions.
10	E	Pilot had to overtorque engine in effort to cushion landing during a practice night tactical approach.	00	00	Night	Approach	1. Restricted visual clues.
11	A	Aircraft was on a night formation flight when it entered a fog bank. Aircraft was seen to climb and reversed course before entering a descending turn prior to impact.	01	00	Night	Cruise	1. Inadvertent entry to IMC. 2. Low night and IF experience. 3. Solo operation.

Table 5 (cont)

U.S. Army OH-58 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
12	A	While cruising at 100 kts and 100-feet above lake, crew flew aircraft into water during an attempt to reduce airspeed prior to penetrating a heavy shower.	00	00	Night	Cruise	1. Lack of visual clues. 2. Inadequate instrument scan. 3. Copilot was distracted by flashing lights from fishing boats. 4. Low level of copilot experience.
13	B	Recirculating snow resulted in white-out.	00	00	Day	Hover taxi	1. Incorrect technique for snow operation. 2. Failure to initiate VHIRP.
14	E	During descent aircraft entered fog bank and pilot had to overtorque engine to avoid collision with ground.	00	00	Night	Cruise descent	1. Inadvertent entry to IMC. 2. Pilot was not monitoring his instruments at the time.
15	A	Inadvertent entry into IMC at night resulted in loss of aircraft control and subsequent impact.	00	02	Night	Cruise	1. Inadvertent entry to IMC. 2. Low experience level. 3. No IF simulation training for aircraft type. 4. No weather update.
16	A	During a night NVG sortie the aircraft was flown into a hill at cruise speed.	01	00	Night	Cruise	1. Workload for single pilot operating with NVGs under deteriorating weather conditions was too great. 2. Inadequate mission briefing. 3. NVGs.

Table 5 (cont)

U.S. Army OH-58 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
17	A	Aircraft which was part of a formation of five was turning onto finals having just entered a bank of ground fog. The aircraft was seen to descend rapidly towards the ground. NVGs were in use.	02	00	Night	Approach decelerative altitude	1. Decision to continue with approach having entered IMC. 2. Possible distraction caused by the rest of the formation. 3. NVGs.
18	A	Aircraft was attempting a night low level tactical approach over a snow covered field. The aircraft impacted the ground 150 meters short of the selected landing zone.	00	00	Night	Approach	1. Lack of visual clues. 2. Pilot had exceeded recommended crew duty hours during the prior 48-hour period.

Table 6

U.S. Army OH-6 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
1	B	Visual references lost due to brown-out. Aircraft drifted into tree. Visibility was further degraded by use of landing light.	00	00	Night	Hover	1. Brownout. 2. Nonstandard procedure. 3. Inadequate rest and sleep during previous 24 hours.
2	B	During NOE approach to landing over lake, aircraft was flown into water. Impact occurred one-half mile from landing area.	00	00	Night	Approach	1. Lack of visual clues. 2. Poor instrument scan.

Table 7

U.S. Army UH-60 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
1	C	Copilot at controls of 2nd aircraft in two-ship flight, allowed aircraft to descend and strike trees.	00	00	Night	Cruise and turn	1. Inadequate cross reference to instruments. 2. Lack of crew cooperation. 3. Inexperience.
2	C	During formation approach recirculating sand caused brownout, with subsequent hard landing. Night was very dark.	00	00	Night	Approach	1. Brownout. 2. Incorrect decision to come to a hover.
3	C	While hovering in a confined area, an inadvertent drift commenced resulting in a tree strike.	00	00	Night	Hover	1. Pilot unable to detect drift of aircraft.
4	A	Pilot inadvertently allowed his aircraft to drift 35 feet into high tension wires.	00	03	Day	Hover	1. Pilot failed to detect drift. 2. Lack of crew cooperation.
5	C	During NVG operations brownout occurred during an approach. Visual references were lost and aircraft struck a pole and the limbs of an oak tree.	00	00	Night	Approach	1. Brownout. 2. NVGs. 3. Landing site not reconnoitered.
6	C	Pilot using NVGs allowed aircraft to drift into tree line.	00	00	Night	Hover	1. Pilot continued to hover in conditions where he had lost the ability to see. 2. NVGs.

Table 7 (cont)

U.S. Army UH-60 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
7	B	While on a circling approach to a pickup zone, the pilot allowed the aircraft to descend into trees 350 meters short of landing site, which was illuminated.	00	00	Dawn	Approach	1. Coning of attention on landing site. 2. Inadequate crew cooperation. 3. Low crew experience.
8	A	During formation NVGs training, number 2 aircraft abruptly turned right and crashed into trees along valley.	04	00	Night	Cruise NOE	1. Lack of visual clues plus moon angle and sloping ridges of valley may have produced an illusion of the aircraft being banked. 2. NVGs.
9	D	Pilot inadvertently allowed aircraft to descend onto underslung load.	00	00	Night	Hover	1. Possible lack of depth perception caused by use of NVGs.
10	A	Inadvertent entry to IMC while trying to negotiate a pass. Low cloud with ground fog.	04	06	Day	Hover taxi	1. Decision to continue flight into deteriorating weather and difficult terrain.
11	D	Visual clues lost due to brownout.	00	00	Day	Approach	1. Brownout.
12	B	Aircraft entered ground fog at night during underslung load operations. Aircraft descended into trees and load was jettisoned. NVGs were in use.	00	00	Night	Cruise-low level	1. Inadvertent entry into unforecast IMC conditions. 2. NVGs.

Table 7 (cont)

U.S. Army UH-60 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
13	C	During NVG underslung load operations aircraft entered IMC conditions. Subsequent attempt at VHIRP forced crew to jettison load.	00	00	Night	Cruise	1. Inadvertent entry to unforecast IMC. 2. Both aircrew suffered from sensations of vertigo on initial entry to IMC. 3. Copilot not properly qualified on NVGs for UH-60.
14	A	Whiteout conditions encountered during attempt to land on sloping ground.	00	00	Day	Approach	1. Whiteout. 2. Incorrect decision to attempt snow landing on sloping ground. 3. PIC was flying infrequently at time of accident. 4. Lack of recent snow landing experience.
15	D	Whiteout conditions caused hard landing.	00	00	Day	Hover	1. Whiteout.
16	D	Aircraft collided with obstacle during takeoff due to recirculating dust.	00	00	Day	Take off	1. Brownout.
17	A	During a NVG training circuit, master and servo caution lights illuminated. Aircraft was subsequently allowed to descend onto the ground.	00	03	Night	Cruise-circuits	1. Improper crew cooperation due to coning of attention. 2. Snow covered ground limited terrain contrast. 3. NVGs.

Table 7 (cont)

U.S. Army UH-60 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
18	D	During a formation approach using NVGs recirculating dust resulted in one aircraft sustaining a hard landing.	00	00	Night	Approach	1. Brownout. 2. NVGs.

Table 8

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
1	A	Copilot without IFR rating lost control of aircraft during attempt to climb to IMC on top. PIC was unable to recover situation in time to prevent impact overwing.	01	03	Day	Cruise climb	1. Pilot without instrument rating allowed to fly in IMC. 2. Supervision by PIC inadequate.
2	C	Aircraft on emergency rescue mission encountered total whiteout conditions while flying NOE over snow. Aircraft suffered a hard landing during attempt to land.	00	00	Day	NOE slow turn	1. Whiteout. 2. Lack of snow flying experience. 3. Inadequate classroom training.
3	B	During cruise flight the aircraft was allowed to descend from 200 feet AGL into trees. Visibility was poor, low ambient illumination.	00	00	Night	Cruise	1. Poor instrument scan. 2. Poor crew cooperation.
4	C	While landing in a confined area the aircraft was allowed to drift into a tree while pilots attention diverted by dusty conditions and sloping ground at intended touchdown point.	00	00	Day	Hover IGE	1. Dusty conditions. 2. Pilots' attention focused on sloping ground.
5	A	Aircraft crashed immediately after an attempted instrument takeoff from a pinnacle in a remote area.	03	00	Day	Takeoff	1. Failure to scan instruments in order to establish climb. 2. Probable poor crew cooperation. 3. Limited flying experience. 4. Peer pressure.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal actors
6	A	Aircraft crashed inverted after attempting a formation landing on a snow covered LZ.	00	02	Day	Approach	1. Whiteout. 2. Lack of unit training in snow landings.
7	C	The CP while on the controls lost ground reference and developed a a high rate of descent which the PIC could not correct in time.	00	00	Night	Cruise	1. Loss of ground reference in poor visibility. 2. PIC was preoccupied with monitoring radio traffic concerning a concurrent fatal accident.
8	A	Aircraft allowed to enter a slow descending left turn and struck the ground with 55 degree left bank and descent rate of 3000 fpm.	03	00	Night	Cruise	1. Loss of visual references due to poor visibility. 2. Possible degradation of night vision due to presence of bright lights from nearby village. 3. IP had been on duty for 35 hrs of the 48 hrs prior to to the accident.
9	C	While leading a flight of four aircraft landing at an airfield during darkness, the pilot lost visual references and misjudged the sink rate and rate of closure. This resulted in a hard landing.	00	00	Night	Approach	1. Loss of visual contact with the intended landing site. 2. Unreported rainshowers and fog patches. 3. Lack of night flying training.
10	D	Pilot complained of vertigo during controlled approach to airfield. At one stage was 80 degrees off track with a 1700 fpm rate of descent.	00	00	Day	Cruise-approach	1. Possible coriolis effect.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
11	A	Low-level autorotation with NVGs resulted in excessive ground run. Aircraft rolled over.	00	02	Night	Autorotation	1. Failure of IP to correct maneuver. 2. NVGs.
12	A	While descending on a night VFR approach, the pilot lost all visual reference after entering a low fog bank.	00	02	Night	Approach	1. Loss of visual references in fog. 2. Poor crew cooperation. 3. Inadequate crew rest. 4. Inadequate recent night flying experience.
13	E	During IMC flight unusual attitude entered which resulted in engine being overtorqued.	00	00	Night	Cruise	1. Unusual altitude developed in IMC flight.
14	A	During a low-level flight over a lake the aircraft was flown into the water.	01	02	Day	NOE-cruise	1. Lack of depth perception over water.
15	E	Pilot allowed an excessive rate of descent to develop during an approach to a snow-covered field.	00	00	Day	Approach	1. Snow covered terrain reduced visual clues available.
16	E	During a formation approach to bowl shaped LZ, The aircraft encountered whiteout conditions.	00	00	Day	Approach	1. Whiteout.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
17	C	Brownout conditions encountered during night approach to a field location. A hard landing ensued.	00	00	Night	Approach	1. Brownout.
18	E	Pilot overtorqued aircraft in effort to avoid whiteout conditions on takeoff.	00	00	Day	Take off	1. Whiteout.
19	E	Engine overtorqued while attempting a go round during a formation approach to a snow-covered LZ.	00	00	Day	Approach	1. Whiteout.
20	C	During formation approach recirculating dust caused loss of all external visual clues. A hard landing resulted.	00	00	Day	Approach	1. Brownout.
21	C	Whiteout caused hard landing.	00	00	Night	Approach	1. Whiteout.
22	C	During a night approach to an unimproved airfield, the pilot experienced reduced visibility due to recirculating dust. This resulted in a hard landing.	00	00	Night	Approach	1. Brownout.
23	A	During final stages of a night approach to a dusty strip, total brownout conditions were encountered. Subsequent hard landing caused the aircraft to invert.	00	03	Night	Approach	1. Brownout. 2. Improper decision to come to hover. 3. Poor crew cooperation.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
24	B	Pilot lost visual references during a night formation approach to a dusty road. The aircraft rolled over on its right side.	00	01	Night	Approach	1. Brownout. 2. Incorrect decision to come to hover. 3. Inadequate rest during previous 24 hours.
25	C	Down slope of terrain at landing site caused pilot to misjudge his altitude.	00	00	Night	Approach	1. Visual illusion. 2. Low level of illumination.
26	E	During night formation approach to a LZ marked by lights from a jeep, the pilot lost all visual references resulting in a hard landing.	00	00	Night	Approach	1. Brownout.
27	A	During formation approach to a snow-covered LZ, whiteout conditions caused control of the aircraft to be lost.	00	04	Night	Approach	1. Whiteout. 2. Incorrect snow landing technique. 3. Failure to select a suitable LZ.
28	C	Pilot flew aircraft into trees while attempting to land in whiteout conditions.	00	00	Day	Approach	1. Whiteout. 2. Copilot was wearing contact lenses and was taking antihistamine therapy.
29	C	Recirculating snow reduced visual references resulting in rearwards drift of aircraft into object.	00	00	Day	Hover IGE	1. Whiteout.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
30	C	Pilot attempting to land aircraft on snow-covered ground. Due to fresh snow and overcast conditions the crew was unaware of the uneven surface and a hard landing ensued. The aircraft was also engulfed in recirculating snow; the aircraft was picked up again and set down very hard.	00	00	Day	Approach	1. Whiteout. 2. Incorrect decision to land on unprepared surface. 3. Decision to take off again rather than remain on ground.
31	C	During a formation NVG approach brownout occurred resulting in loss of aircraft control.	00	00	Night	Approach	1. Brownout. 2. Incorrect approach procedure. 3. Inadequate crew cooperation. 4. Crew chief was not wearing NVG.
32		While attempting to hover taxi though a saddle the crew inadvertently entered IMC. During subsequent attempt at VHIRP they collided with a tree.	00	00	Day	Takeoff	1. Incorrect decision to continue flight into deteriorating weather. 2. Incorrect decision to continue flight with low fuel reserve. 3. Malfunction of windshield wiper.
33	C	During final stages of aircraft approach, a TV crew turned on bright lights blinding the aircrew. The resulting loss of night vision caused hard landing.	00	01	Night	Approach	1. Night blindness caused by use of high intensity lighting. 2. Poor coordination between unit and TV crew.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
34	A	During IFR conditions, aircraft was requested to reposition for a late takeoff. Aircraft entered IMC while attempting to hover over a tree. Control was lost and the aircraft crashed.	03	00	Night	Hover OGE	1. Inadvertent entry into IMC when in high hover. 2. Incorrect decision to request repositioning in adverse weather. 3. Low flight and IF experience of mishap crew. 4. Lack of weather update.
35	C	Crew continued flight into adverse weather and attempted to remain VFR. Subsequent attempt at landing resulted in hard touchdown.	00	01	Day	Approach	1. Pilot's decision to fly into deteriorating weather. 2. Incorrect landing technique. 3. Fogging of canopy.
36	A	During a single pilot approach in heavy rain, ground reference was lost resulting in loss of aircraft control.	00	02	Night	Approach	1. Loss of visual clues due to heavy rain and reflection from landing light. 2. Inexperience of pilot. 3. Selection of inexperienced pilot to carry out a solo night MEDEVAC in marginal weather conditions.
37	A	Aircraft control was lost in whiteout conditions during an attempted precautionary landing to a snow-covered airfield.	00	00	Day	Approach	1. Whiteout. 2. Pilot had no experience of snow landing technique.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
38	A	Aircraft was being hover taxied over snow covered field when pilot mis-judged his hover height and allowed aircraft to strike the ground.	00	00	Day	Hover taxi	1. Lack of depth perception over snow covered terrain.
39	A	Aircraft struck a tree and crashed during an attempted go-round after brownout conditions occurred during approach.	00	01	Night	Approach	1. Brownout. 2. Lack of sleep during previous 24 hours.
40	A	During the final approach phase of an ILS approach the aircraft flew into the ground in a level altitude. Airfield was below IFR minimal. Pilot had just gone round on a missed approach procedure.	00	03	Night	Approach	1. Pilot disregarded rules. 2. Very poor visibility. 3. High cockpit workload.
41	A	During a NVG training flight, the aircraft crashed 2 minutes after off. The pilot had neglected to turn on the radar altimeter.	00	04	Night	Take off-climb	1. Failure to maintain visual ground references. 2. Pilots attention was focused on the radar altimeter. 3. NVGs.
42	A	Pilot inadvertently allowed aircraft to descend into water during an over water circuit. NVGs were in use.	00	00	Night	Cruise-circuits	1. Inadequate instrument scan. 2. Inadequate crew cooperation. 3. NVGs.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
55	D	Engine was severely overtorqued during landing in brownout conditions.	00	00	Night	Approach	1. Brownout.
56	A	Aircraft crashed into an 80-ft tree 4 minutes after takeoff on a MEDEVAC mission in conditions of darkness, rain and fog.	04	00	Night	Cruise-NOE	1. Incorrect decision to fly in such conditions at low altitude and high speed. 2. Poor visibility.
57	C	Brownout conditions resulted in a hard landing.	00	00	Day	Approach	1. Brownout.
58	B	Brownout conditions resulted in a hard landing.	00	00	Day	Approach	1. Brownout.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
49	C	During hover taxiing recirculating snow caused loss of outside visual references.	00	00	Day	Hover taxi	1. Whiteout. 2. Incorrect snow technique. 3. Poor crew cooperation.
50	D	Aircraft encountered heavy rain and attempted to land. Overcast sky and heavy rain caused pilot to misjudge approach which terminated in a hard landing.	00	00	Night	Approach	1. Overcast sky and heavy rain impaired depth perception. 2. Pilot failed to assess weather conditions. 3. Weather was unforecasted.
51	E	Aircraft entered inadvertent IMC, emergency was declared and PIC took controls from CP who was disorientated.	00	00	Day	Cruise	1. Inadvertent entry to IMC.
52	D	Brownout caused loss of all external visual clues during approach to confined area. A hard landing ensued.	00	00	Day	Approach	1. Brownout.
53	B	Aircraft drifted into another helicopter when recirculating dust obscured vision.	00	00	Day	Hover taxi	1. Brownout. 2. Poor crew cooperation. 3. Low flight experience of CP.
54	B	During desert NVG operations recirculating dust obscured vision during hover taxi. Aircraft drifted to left and rolled over.	00	00	Night	Hover taxi	1. Brownout. 2. Incorrect decision to use unprepared helipad. 3. NVGs.

Table 8 (cont)

U.S. Army UH-1 disorientation accidents

SER	AMC	Circumstances	FTLS	DSAB	Night/day	Flight phase	Major causal factors
43	C	Pilot lost visual references just prior to touchdown in whiteout conditions.	00	00	Day	Approach	1. Whiteout. 2. Copilot at controls had never completed a snow landing before. 3. PIC had had inadequate rest during the prior 48 hours.
44	E	Hard landing due to inability to judge rate of descent in confined area.	00	00	Night	Approach	1. Lack of visual clues due to moisture and reflections on the windscreen.
45	D	Pilot misjudged altitude on approach to snow covered sloping ground.	00	00	Day	Approach	1. Snow-covered ground with lack of terrain contrast.
46	A	During a formation flight the aircraft was flared to maintain separation distance. The resultant rate of descent went unnoticed due to lack of visual horizon and snow-covered ground. Aircraft flown in.	00	01	Day	Cruise	1. Snow-covered ground and snowfall reduced visual clues. 2. CP at controls was inexperienced. 3. Lack of crew cooperation.
47	A	Visual references lost due to whiteout after lifting to hover.	00	01	Day	Hover IGE	1. Whiteout. 2. Incorrect snow operating procedure.
48	D	Brownout due to dusty conditions on tank trail caused a hard landing.	00	00	Night	Approach	1. Brownout.

Table 9 shows in abbreviated form data concerning all Army rotary-wing mishaps for the same period and shows the percentage of accidents accounted for by disorientation.

Table 9

Summary of all U.S. Army helicopter mishaps
1 January 1980-30 April 1987
Compared to disorientation mishap data

AMC	Total all helicopters	Total OE	Percent caused by OE mishaps
A	297	42	14.140
B	132	15	11.360
C	1,372	36	2.620
D	1,417	17	1.200
E	28,863	19	0.066
Total	32,081	129	0.400
Fatalities	250	37	14.800
Disabling injuries	589	56	9.500

The immediate fact to strike home is only 0.4 percent of the accidents are responsible for 14.8 percent of the fatalities and 9.5 percent of the disabling injuries. OE accounts for over 14 percent of class A rotary mishaps. In fact, 32.6 percent of OE mishaps are class A as opposed to only 0.8 percent for all rotary-wing mishaps. This large discrepancy almost certainly is explained by OE accidents being often accompanied by partial or total loss of aircraft control, the subsequent impact forces being consequently greater.

Phase of flight prior to mishap

Study of the phase of operation in which the aircraft were engaged immediately prior to the mishap reveals some interesting facts. Table 10 lists the phase of flight just prior to the mishap occurring in descending order of frequency.

This represents a very different picture from the data available in 1964 (Ogden, et al.) which is shown below, for comparative purposes, in Table 11. Unfortunately, it is not possible to directly compare the two sets of data, as the methods used to delineate the exact phase of flight differ. However, it is possible to draw some conclusions.

Table 10

Phase of flight prior to mishap
U.S. Army helicopter OE accidents
1 January 1980-30 April 1987

Phase of flight prior to mishap	Number	Percent
Approach to land	48	37.2
Cruise	27	20.9
Hover (out of ground effect)	16	12.4
Hover (in ground effect)	14	10.8
Hover taxi	8	6.2
Takeoff	8	6.2
Nap-of-earth	6	4.7
Autorotation	1	0.78
Go around	1	0.78
Total	129	100.00

Table 11

Phase of operation in disorientation accidents (after Ogden et al., 1964)

Phase of flight prior to mishap	Number	Percent
In flight	16	44.4
Landing	10	27.8
Hover taxi	6	16.7
Takeoff	1	2.8
Go around	1	2.8
Autorotation	1	2.8
Unknown	1	2.8
Total	36	100.0

The most obvious difference is that the in flight or cruise phase of operations only accounts for 20.9 percent of all OE accidents as opposed to 44.4 percent in 1964. Also, there is a definite increase in the number of accidents which occur during the approach to landing phase of operations. Analysis of the present data reveals that flight over snow clad ground, recirculating snow and dust, use of NVGs, and the distraction caused by lights or flares are directly and indirectly responsible for the majority of the accidents and incidents studied. Tables 12 and 13 list these causal factors. The term physiological refers to those accidents where the pilot complained of nausea, dizziness or some other physical symptom.

Table 12

Major causal factors in US Army Helicopter OE accidents
1 January 1980-30 April 1987

	Number	Percent
Poor visibility, bad weather, etc.	38	30.2
Brownout	31	24.6
Whiteout	17	13.4
Inadvertent entry to IMC	13	10.3
Flight over snowclad ground	11	8.7
Over water flight	6	4.8
Distraction by lights or glare	4	3.2
Physiological	4	3.2
Lack of instrument rating	1	0.8

Table 13 lists factors which were contributory to the accidents studied, but were not considered to be the main causal factor. Some accidents had more than one contributory factor and all are listed.

Table 13

Contributary factors in U.S. Army OE accidents
1 January 1980-30 April 1987

	Number of reported cases
Poor crew coordination	22
Lack of experience or training	22
Night vision aids	21
Formation flight	17
Coning of attention	16
Incorrect operating procedures	16
Poor decisionmaking	11
Poor instrument scan	10
Poor supervision	10
Inadequate rest/excessive duty	8
Unforecast weather/inadequate brief	6

Time of day when accident occurred

Although it is possible to obtain data which records the exact hour when an accident took place, this may not, in itself, be very useful as it does not reveal the light conditions prevailing at the time. The method employed here was to use the period of the day, namely, dawn, day, dusk, and night. Table 14 shows the percentage of OE accidents which occurred during the various time bands and compares this to all pilot error accidents other than those classified as OE.

Table 14

Period of day when OE and pilot error accidents occurred
U.S. Army helicopter accidents
1 January 1980-30 April 1987

Period of day	Percent OE accidents	Percent all pilot error accidents
Dawn	0.78	1.44
Day	43.00	80.50
Dusk	0.78	3.23
Night	55.00	14.80

There is a very obvious preponderance in the number of OE accidents that occur at night (55 percent as opposed to 14.8 percent in pilot error accidents). This is exactly what one would expect to find as visual clues are reduced and the problems facing the pilot are compounded by the use of NVGs. It also reflects the increased amount of time currently spent engaged in night flying operations. Ogden, in 1964, found that 64 percent of all OE accidents occurred during daylight hours, but noted that 70 percent of all reported incidents in the survey occurred at night.

Age of pilots

This is recorded only for class A, B, and C accidents. For comparative purposes, Table 15 shows the age of pilots involved in OE accident as compared to the age of pilots involved in all other pilot error and materiel failure accidents for the time period covered by the study.

Table 15

Age of pilots involved in OE, pilot error and materiel failure accidents

Age	Percent OE accidents	Percent pilot error	Percent materiel failure
18-20	5.1	2.0	3.4
21-25	21.4	23.4	28.9
26-30	29.6	30.7	31.3
31-35	34.7	24.6	15.2
36-40	7.1	12.9	11.0
41-50	2.0	1.6	8.5
>50	0.0	1.1	1.7

Pilot experience

Total pilot flying hours and pilot instrument weather hours also are shown in Figures 1 and 2. These total hours are compared with the same data derived from pilots who were involved in helicopter accidents caused by mechanical failure which occurred during the same period of time. Data concerning flying experience for all U.S. Army aviators currently are not centrally collated. It is assumed those pilots involved in materiel failure accidents represent a reasonably accurate sample of the actual pilot flying and instrument flying experience in the entire U.S. Army aviator population. As can be seen by study of the graphs, the experience level in both groups is very similar, implying that total flying and instrument experience are not necessarily directly correlated with one's chances of being involved in an OE accident.

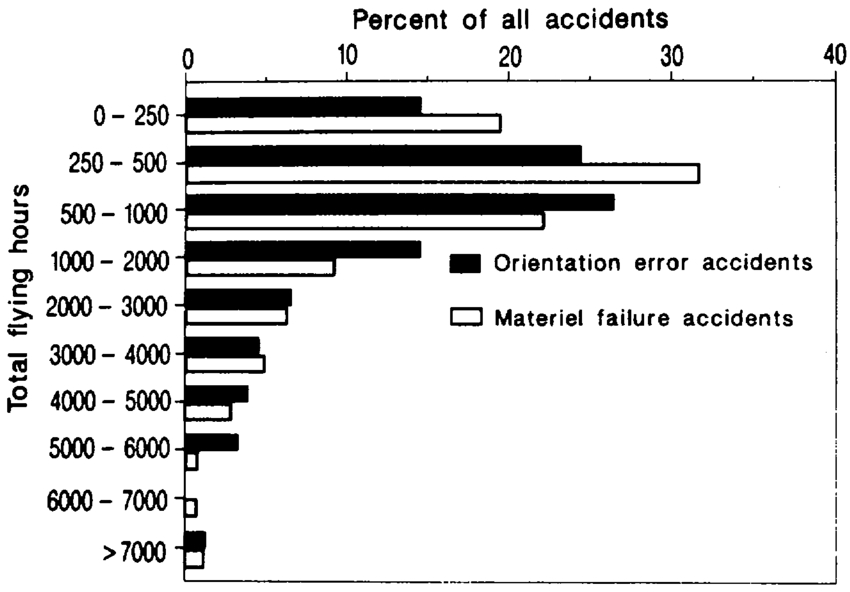

Figure 1. Percentage of all orientation error and materiel failure accidents expressed as a function of total flying experience.

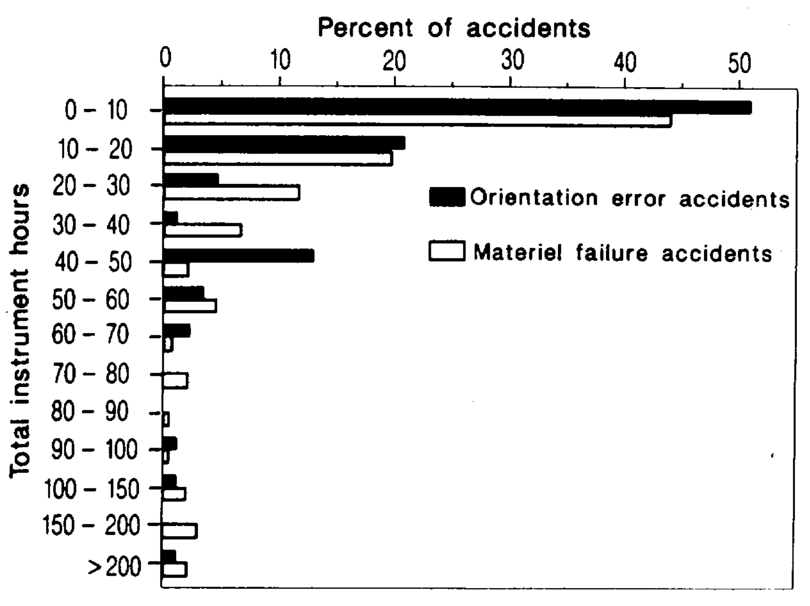

Figure 2. Percentage of all orientation error and materiel failure accidents expressed as a function of total instrument weather flying experience.

Instrument design

It has been mentioned that current helicopters have inadequate instrumentation for the display of accurate flight path, attitude, and position information to the pilot, especially during low speed operations or the hover mode. Most of the accidents considered in this report occurred during the low-speed portion of the flight envelope. For instance, a pilot who is experiencing a whiteout situation is fully aware of the lack of external visual clues and the subsequent per ceptual conflict that is likely to arise, but is unable to resolve the problem by reference to his instrumentation. This provides him with little or no information pertaining to drift in any axis. For aircraft attitude, he must rely on the atti tude indicator, an instrument that is effective in forward flight, but which was never designed for use in the helicopter during the hover. Even in cruise flight, this instrument is not always directly compatible with the helicopter's mode of flight. For example, a pitched down attitude in a fixed-wing aircraft will indicate descent and a pitched up attitude indicates a climb. Of course, this may be vice versa in a helicopter and the pilot is required to correlate this information with that available from other instruments such as the vertical speed indicator, airspeed indicator, and altimeter. This inevitably increases the pilot's workload.

The only effective way to deal with such a situation is to take the control of the aircraft away from the pilot and rely on stabilization and automatic hover equipment to maintain the position of the aircraft accurately over the ground with minimal drift in any axis under any environmental conditions. Unfortunately, currently this is not possible even in the most modern helicopters. Presently, we have to rely on pilots never getting into such situations, or being able to recover from them by using the appropriate techniques. This objective has not been achieved in peacetime and the position is certain to be accentuated by operations in hostile environments.

One instrument design that has been widely studied, but never introduced into military service is the Malcolm Horizon or peripheral vision display (PVD). Currently, this device employs a laser to project onto the instrument panel a bar of light whose movements are correlated with those of the true horizon (Malcolm, Money, and Anderson, 1975). Its theoretical basis, which draws largely on Leibowitz's notion of two visual systems (Leibowitz and Post, 1982), depends on the fact that the conventional attitude indicator subtends only a few degrees of visual angle and, therefore, must be processed by foveal vision. In contrast, the PVD depends on peripheral vision and, therefore, only requires a minimal amount of conscious attention.

The problem with the research carried out to date is that flight times have been limited or the trials have suffered from experimental constraints (Gillingham, 1984; Hixson and Spezia, 1977; Knotts and Gawron, 1984).

Perhaps the use of a state-of-the-art simulator would enable firm conclusions to be drawn concerning the PVD's efficacy in flight conditions which include flight at night, marginal weather conditions, and sudden entry into flying environments which entail a high work load. At best, the PVD should decrease the pilot's workload and increase awareness of aircraft attitude. It will not resolve the problem of inadvertent drift detection already alluded to.

Use of NVGs and OE error accidents and incidents

The use of NVGs in U.S. Army aviation now is commonplace and some concern has been expressed over the number of accidents and fatalities that have occurred in recent years. The AN/PVS-5 is still the only type of night vision aid in common usage in U.S. Army aviation and originally was designed for use by ground troops and only later developed for aviation. This is the type of goggles involved in the accidents under study here. However, it has been modified from the original design and incorporates a cutaway face plate which provides a "look under" capability and also is compatible with aircrew spectacles. The newer AN/AVS-6 NVGs, which employ Generation (Gen) III tubes, currently are not widely issued, but will be over the next few years and they should serve to improve the situation. It should be noted that because of the differential sensitivity and enhanced gain, visual detection with AN/AVS-6 NVGs may not always be better than with AN/PVS-5A goggles. For instance, under certain illumination conditions, the greatly enhanced sensitivity of the AN/AVS-6 system eliminates contrast gradient, thereby precluding detection.

Flying with NVGs requires new techniques and skills. It could be said the AN/PVS-5 has made the aviator's life more difficult, enticing him to fly in conditions that may exceed his physical and psychological limits (Durnford, 1984). Gen III tubes, while undoubtedly being easier to fly with, are likely to increase the aviators' workload--first, by extending the mission profile and, second, by depriving the aviator of his traditional night's rest.

The major problems associated with the use of NVGs are well known and include:

a. A reduction in the central field-of-view (FOV) to 40 degrees.

b. A marked reduction in visual acuity to 20/50 (Gen II) and 20/40 (Gen III). These figures relate to the best obtainable under laboratory conditions and rarely are achieved under field conditions.

c. Depth perception is reduced due to degraded visual acuity affecting analysis of image size, texture, and parallax.

d. The decreased resolution obtainable with NVGs results in a significant decrease in stereopsis, which is the binocular component of depth perception.

In addition to all these problems is the increased likelihood for aviators to fly unwittingly into deteriorating weather conditions or, even worse, the possibility of a sudden entry into IMC under high workload conditions. Also reported is "abrupt decentration," a condition where turbulence, sudden aircraft attitude change, or movement of the aviator's head may cause the helmet to shift. The best visual acuity obtainable through NVGs occurs with central viewing. As the line-of-sight moves away from the central axis of the tube, acuity decreases.

A recent report (Rosenthal, 1987) analyzed all U.S. Army Class A helicopter NVG accidents during the period November 1980 through 14 April 1987. In 86.4 percent of the NVG-related Class A accidents and 90.3 percent of the fatalities associated with these accidents, the accidents occurred in illumination conditions when the moon was less than 30 degrees above the horizon and/or its surface was less than 23 percent illuminated. Under these conditions, the electronics of the AN/PVS-5 are working at the limit of their capacity and the image will be masked by tube noise. Without adequate external visual clues, the aviator is forced to switch to cockpit instrumentation but, probably, will not develop a full instrument scan. Therefore, he is working in that twilight zone where the decision to switch from visual meteorological conditions (VMC) to IMC has not been made. That disorientation under these operating conditions becomes a problem of considerable proportions is hardly surprising.

NVGs were involved in 21 of the 129 cases studied here and were considered to be at least contributory if not the major causal factor of these accidents or incidents. There were 9 class A, 4 class B, 5 class C, 3 class D, and 1 class E mishaps resulting in 13 fatalities and 14 disabling injuries. The helicopter types involved were, respectively: UH-60 (8), UH-1 (6), OH-58 (3), AH-1 (2), and the CH-47D (2). Eight additional autorotation accidents which occurred when NVGs were in use were not included in the analysis due to lack of sufficient data in the accident records. However, as the final stages of a successful autorotational approach depend entirely on adequate peripheral vision and depth perception as well as good control coordination, there is little doubt NVGs were at least partly responsible.

The types of accidents that occurred are predictable as they depend on reduced field-of-view, lack of visual clues, increased cockpit workload, and lack of adequate depth perception. These accident categories and the number involved are included in Table 16 for convenience. Further details may be obtained by reference to Tables 3-8.

Table 16

U.S. Army OE NVG helicopter accidents
1 January 1980-30 April 1987

Type of accident	Number of accidents
Brownout	5
Inadvertent entry to IMC	4
Coning of attention in cockpit	3
Overwater flight	2
Failure to judge height over underslung load	2
Fly-in during cruise flight	2
Undetected drift in hover	1
Loss of control in hover over snow clad ground	1
Autorotation	1

NVGs now account for over 17 percent of all OE accidents and 35 percent of the fatalities. Also, it is difficult to predicate what losses are likely to be under combat conditions, when many of the peacetime restrictions concerning the use of NVGs are likely to be disregarded.

A study (Flightfax, 1987) of current NVG operational trends reveals a continuing increase in the number of hours flown at night using NVGs. Some units report as much as 65 percent of the total flying hour program being devoted to NVG NOE operations. The increased flight time in this high risk environment goes far to explain the increased incidence of NVG-related accidents.

Category of OE accident

It is customary to classify OE accidents and incidents into two major categories: Type I, in which the aviator does not appreciate that his perception of aircraft orientation is incorrect, and Type II, in which the aviator experiences some form of perceptual conflict. As can be observed from a study of Table 12, almost 50 percent of OE accidents are accounted for by whiteout, brownout, and inadvertent entry into IMC. In the majority of these cases, the crew is aware of some form of perceptual conflict, but it is unable to resolve this, and an accident occurs. As discussed, current helicopter instrumentation is based on that designed for fixed-wing applications and this is not optimized to function in the low speed envelope often occupied by helicopters. Therefore, the pilot is left with little or no visual information to aid him when he most requires it. This lack of instrumentation goes far to explain the preponderance of Type II accidents in the present series. Fixed-wing OE accidents usually are ascribed to Type I (Benson, 1978). Interestingly, Kraus (1959) describes a series of experiments which were performed to demonstrate the time it took pilots flying an F-100F, when deprived of all visual clues, to enter an attitude from which recovery at 10,000 ft would have been impossible. These times varied from as much as 135 seconds in straight and level flight to 20 seconds in a 30-degree banked turn. The same type of experiment now could be perfomed using a sophisticated helicopter simulator to emulate conditions such as decelerative attitudes in snowy or dusty conditions. The major difference is the pilots would lose only their external references and not their view of the instrumentation. It is to be expected that coordinated control will be possible only for a few seconds.

Examples of OE accident

The major types of OE accidents and their contributory factors are best illustrated by brief descriptions of selected accidents and incidents.

a. Case 1. AH-1 (Whiteout). While dispersing aircraft during a simulated air attack, the flight encountered reduced visibility in heavy snow showers. It was decided to carry out a precautionary landing in a snow-covered field as visibility had been reduced to 200 meters with an overcast ceiling. The pilot of the accident aircraft selected a level landing spot and began a normal snow landing approach. At approximately 5-foot height, he experienced total whiteout conditions and lost control of the aircraft which impacted banked to the right with subsequent main rotor strikes which caused the aircraft to invert. The pilot was unable to go round or effect a helicopter vertical recovery procedure as there were power cables in the immediate vicinity.

b. Case 2. OH-6 (Brownout). During a night visual flight rules (VFR) tactical training sortie, the pilot of the lead aircraft, after lifting into a hover, lost all contact with external visual references due to blowing and recirculating dust. The pilot turned on his landing lights, but this only served to reduce visibility further. The helicopter remained in the hover for a further 20 seconds, but due to an undetected drift the tail and main rotors struck a large tree.

c. Case 3. UH-1 (Inadvertent entry into instrument meteorological conditions (IMC) at night). While attempting to locate a field landing site at night, the pilot began a series of left orbits at 500 ft above ground level (AGL) and during the course of these maneuvers entered low clouds which had not been forecast. The pilot attempted to retain control of the aircraft and initiated a climb and informed Air Traffic Control (ATC) of his emergency. The pilot was unable to retain control of the aircraft which impacted at high speed into some tall trees before coming to rest on its right side.

d. Case 4. AH-1 (Flight over snow-covered ground). The crew of the accident aircraft were engaged in battle drill training which took place over open, relatively flat, snow-covered terrain. A combination of the snow-covered gound, lack of terrain definition, and preoccupation with flight tasks prevented the crew from noticing the change in ground contour, which had started to rise. The aircraft struck the ground, tearing off the landing gear.

e. Case 5. UH-60 (Poor visibility/coning of attention). During night-vision goggles (NVG) training in the traffic pattern at 200 ft AGL, the pilot and copilot became absorbed in cockpit tasks due to the illumination of caution lights. The helicopter began a slow inadvertent descent and impacted with the ground. Lack of external visual references due to snow-clad ground and poor ambient illumination contributed to the accident.

f. Case 6. UH-1 (Physiological). A pilot was engaged in an instrument flight evaluation and was in the process of conducting a controlled approach to an airfield. The pilot became incapable of making the correct control inputs to modify his flight path, although he said there was no conflict between the instruments and his "seat-of-the-pants" sensation. He inadvertently allowed a 1700 fpm rate of descent to develop and turned more than 80 degrees from the approach path before having to terminate the approach under instruction from ATC. Afterwards, he complained of dizziness and nausea.

g. Case 7. UH-1 (Distraction by lights). During a night single-pilot approach in heavy rain, the pilot became blinded by the reflection of the landing light from airborne water droplets and moisture on the canopy. The pilot attempted to transition to instrument flight, but lost control of the aircraft which subsequently impacted some large trees.

h. Case 8. UH-1H (Over water fly-in). During a NVG training mission, the pilot allowed the aircraft to descend onto the surface of a lake at 80 knots indicated airspeed (KIAS). The pilot had previously recovered from a disorienting experience and, consequently, the altitude of the aircraft also was being monitored by the instructor pilot (IP) who had cautioned the pilot concerning his loss of altitude. Despite this, the accident occurred.

i. Case 9. UH-1H (Lack of instrument rating). A copilot without an instrument rating was allowed to control the aircraft during an attempt to climb through clouds to IMC on top. An extreme unusual attitude was developed and the pilot in command (PIC) was unable to recover in time to prevent impact occurring. The aircraft was destroyed.

Disorientation training

All U.S. Army pilots now receive some basic disorientation training during their ground and flight instruction phases at Fort Rucker, Alabama. The ground phase covers the theory and causes of spatial disorientation and the most efficacious methods of preventing or reducing its effects. Also, students experience the effects, first hand, on a Barany-type chair which is soon to be replaced by a multistation disorientation trainer. During flight school, students are shown how to recover from unusual attitudes during the instrument phase of their training program. There is no further formal disorientation training during the basic flying course.

As already explained, whiteouts and brownouts are major causes of present OE accidents and incidents. However, these types of events are not given prominence during the training which concentrates on the classical causes of disorientation such as visual illusions and the vestibular mechanisms. Indeed, the usual method taught for combating disorientation ("Get on instruments, stay on instruments and control the aircraft based on the instrument readings") is not going to work in a whiteout or brownout environment. Even the most modern helicopters do not have instrumentation capable of allowing a pilot to detect the motion and attitude of the aircraft rapidly and accurately enough to enable him to remain in control. Instead, the pilot must rely on flying techniques which avoid or reduce the production of recirculating snow and sand or, in extreme cases, attempt a vertical recovery procedure. Unfortunately, this is not always possible and the pilot is forced to attempt to land the aircraft with no visual or instrument references. The result is likely to be catastrophic.

Training in snow and dust landing techniques usually is carried out at unit level (Aircrew training program--Commander's Guide, 1986) but this often will be difficult as the arrival of the necessary weather conditions often will find the whole unit in need of either refresher or initial training. Formation approaches are of particular concern as blowing dust or snow from other aircraft reduces visibility. Also, pilots tend to fixate their attention on maintaining a safe separation rather than concentrating on the actual approach, or vice versa.

An alternative approach to disorientation training in the United Kingdom makes use of in-flight demonstrations of various flight parameters which are conducive to the production of spatial disorientation. This is discussed in full by Edgington (1982) and currently is used by the British Army during basic flight training for helicopter pilots. One major advantage of the in-flight demonstration is the student becomes aware of his limitations in an aircraft with which he already has become thoroughly familiar. He discovers that clues such as harness pressure, rotor and engine noise are not reliable indications of the aircraft's motion and will realize fully his total inability to control a helicopter at a hover without adequate visual clues.

Conclusions

1. Helicopter losses due to OE are likely to be significant under wartime operational conditions.

2. Current OE statistics for helicopters are almost certainly an underestimation.

3. Although only accounting for a small percentage of all U.S. Army helicopter accidents and mishaps, OE is disproportionately represented by the number of fatalities and disabling injuries.

4. The phase of flight most commonly engaged in prior to an OE accident is the approach to land.

5. Major causal factors are flight in poor visibility, brownout, whiteout, inadvertent entry to IMC, and flight over snow-clad ground.

6. Major contributory factors are poor crew coordination, lack of training and experience, use of NVGs, and formation flight.

7. In many helicopter OE accidents, the crew is aware of the perceptual conflicts, but is unable to resolve them by reference to the aircraft instrumentation, especially in the low speed or hover mode of flight.

8. Disorientation training is limited in the flight school phase of pilot education, and classroom teaching is based largely on fixed-wing classic disorientation theory which is not always relevent to helicopters.

9. OE accidents occur much more commonly at night compared to other types of pilot error accident.

10. NVGs were involved in over 16 percent of all OE accidents and accounted for 35 percent and 25 percent, respectively, of the total fatalities and disabling injuries.

11. The pilot who is involved in an OE accident or incident is likely to be 31-35 years of age and have 500-1000 hours total flying experience with only limited weather instrument hours.

12. Current rotary-wing instrumentation is not always applicable to the modes of flight actually engaged in by helicopters and is almost entirely based on fixed-wing cockpit design.

13. Two flight crewmembers will be required for the forseeable future unless helicopter cockpit, instrument design, and control characteristics are improved significantly.

Recommendations

1. Aviation commanders in the field need to be reminded of the extensive loss of helicopters due to OE, which may occur as a result of operations undertaken in wartime conditions.

2. The large number of accidents caused by brownout and whiteout indicate that training in these aspects needs refinement.

3. Disorientation training for helicopter pilots should reflect those factors actually relevent to rotary-wing operation, rather than the traditional fixed-wing theory.

4. Helicopter instrumentation needs to be designed for the unique characteristics of helicopter flight.

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