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Spatial Disorientation: A Survey of U.S. Army Rotary-Wing Aircrew

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A survey of 299 aircrew in current flying practice was performed at five U.S. Army airfields within CONUS. Respondents were asked a number of questions about their worst ever episode of spatial disorientation (SD) and their worst episode in the 4 months prior to the survey. They also were asked to classify episodes as minor, significant, or severe according to the threat to flight safety. Opinions also were sought on various aircraft types and flight conditions. In the final part of the questionnaire, they were asked about their experience of break-off and giant hand phenomena. Analysis of the data showed that 78 percent had suffered SD during their flying career (8 percent had suffered severely enough to put flight safety at risk). Twenty-two percent had suffered in the 4 months prior to completing the questionnaire (2 percent severely enough to put flight safety at risk). In 33 percent of worst ever episodes, the event had affected conduct of the mission while flying accuracy had been affected in 64 percent. (The figures for the 4-month data were 35 percent and 68 percent.) Brownout, whiteout, and inadvertent entry to instrument meteorological conditions (IMC) were the most easily identifiable source of severe episodes of SD, but they accounted for 13 percent of the worst ever (continued)

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episodes. The leans accounted for 44 percent of episodes. Few other episodes could be linked to well known problems. Aircrew were not initially aware of being disoriented in 43 percent of worst ever episodes (38 percent of episodes when they were looking out of the aircraft cockpit). Experience had no apparent protective effect against either the incidence or severity of episodes. The following factors did appear to increase the perceived severity of the episode: the respondent having been in command of the aircraft, both pilots being disoriented, poor crew coordination, SD related to an item of equipment, desert terrain, wartime, and visual meteorological conditions (VMC). The use of night vision devices (NVDs) did not appear to influence visual cues. Fifteen percent of aircrew reported they had suffered episodes of break-off (6 percent in the 4 months prior to the survey). Fourteen percent had suffered giant hand phenomena (5 percent in the 4-month period). Recommendations include improved training, further improvements to instrument displays, and further research into various areas including NVDs and psychological events such as break-off and giant hand.

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Acknowledgment

The assistance and interest of the aircrew taking part in this survey is gratefully acknowledged. Not only did their participation make the collection of data possible, but their interest and sense of humor at the subsequent briefings made the project feel particularly worthwhile.

"...The flight began as a checkride for me. We were in a foreign country and unknown territory... The instructor pilot (IP) told me that he would fly and I was to... perform all other aircraft duties. I was busy on radios and organizing my flight route as the IP took off. At approximately 150', the aircraft went into abrupt pitch and roll with a subsequent dive and roll. I initially thought it was a rather 'severe' unusual attitude [induced by the IP as a test]. Just as I tossed my maps aside and reached for the controls the IP said "Oh s--t, oh s--t, I have vertigo!" I took the controls, levelled the aircraft and climbed to 200'. A very short while later I heard "Holy s--t!" from the IP... [and felt] an abrupt increase in collective. At the same time, I saw the ground rapidly approaching through my chin bubble. Altitude was about 20' when the climb initiated. The IP again took the controls and the aircraft immediately pitched and rolled. I took the controls back and then realized that I was severely disoriented. I kept making the aircraft dive and bank. My hands would not respond to my brain. My body swore I was in a climbing turn and my body was responding. The IP was never able to regain control. He attempted at least four or five times without success. Since my body was not giving me any accurate information, I relied on the words of my flight school instrument instructor: "Trust your instruments." I heard him saying that over and over in my head.... Since we were in a tactical area with altitude limitation, under goggles, and in poor weather conditions, I divided my attention with a rapid and constant cross-check between the instruments and outside. We were forced to continue the flight to our unit's location since there was nothing but open desert between us and the unit. My condition never improved."

Anonymous respondent from this survey.

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Introduction

It has long been known that humans cannot maintain straight and level flight in the absence of visual cues (Anderson, 1919). It also has long been known that the human organs of balance not only fail to give sufficient cues for accurate perception of position or motion during aviation, but may give erroneous cues (for overviews see Guedry, 1974 and Benson, 1988). The common result of insufficient or misperceived cues, whatever their origin, is a state of spatial disorientation (SD), commonly defined as the predicament "...when 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..." (Benson, 1988).

The importance of SD is highlighted by the fact that some 32 percent of U.S. Army rotary-wing accidents (Class A-C) involve SD as the major factor (Durnford et al., 1995). However, this represents only a small fraction of the total number of episodes of SD, since as few as 3 percent of episodes actually lead to an accident (Durnford, 1992). Episodes that do not cause accidents may range from mild nuisances to near-accidents like the one described in the quotation at the front of this report. The cost, in terms of mission efficiency and pilot confidence, is equally variable. Modern aircraft are expensive assets and SD is a potentially large source of wasted resources, even when there is no damage to the aircraft.

Previous surveys of SD in aircrew over many years confirm that SD is a common phenomenon between both fixed-wing and rotary-wing aircrew. The career incidence is usually quoted in the range of 90-100 percent (see Eastwood and Berry, 1960; Clarke, 1971; Tormes and Guedry, 1974; Steele-Perkins and Evans, 1978; and Durnford, 1992). The persistently high incidence should not be a surprise since SD is a by-product of human anatomy and physiology, both of which are relative constants. There is, however, one factor in the genesis of SD which is steadily changing, and that is the visual and accelerative environment to which aircrew are exposed. Night vision goggles (NVGs) and forward looking infrared (FLIR) are now common pieces of equipment, and aircraft are considerably more agile than in the past. These circumstances have created new varieties of SD such as that occurring when a sensor slaved to the pilot's head position runs away (see Demitry and Ledet, 1994). Combined with these environmental changes have been changes in workload which also may influence the incidence and severity of SD by changing the attentional resources of aircrew.

This survey was designed to investigate the nature and extent of SD episodes experienced by U.S. Army rotary-wing aircrew. A sister study has reviewed the part played by SD in U.S. Army rotary-wing accidents, 1987-1992 (Durnford et al., 1995).

Main areas of study

Most episodes of SD are centered on visual, vestibular, or seat of the pants perceptions; and the bulk of this survey dealt with problems in this area.

However, the interplay with psychological factors is inescapable. Spatial orientation is such a fundamental requirement for all animals, that it has even been suggested to be the basis of cognition itself (Mirabile, Glueck, and Stroebel, 1976). The psychophysiological boundaries of SD are not easy to define, and entities such as break-off or giant hand phenomena are usually considered to fall under the umbrella of SD. The former typically consists of a feeling of detachment or unreality which may be so severe that the victim feels that he or she is actually outside the aircraft. It was originally reported in aircrew flying at high altitude in fixed-wing aircraft, but has been reported in rotary-wing aircrew (Eastwood and Berry, 1960; Benson, 1973; Steele-Perkins and Evans, 1978; Edgington and Box, 1982; and Durnford, 1992). Giant hand involves a false perception that the aircraft is not responding to the controls, and that it is actively resisting the pilot's efforts at control (Malcolm and Money, 1972 and Weinstein et al., 1991). Although it has an incidence of 7-16 percent in fast jet aircrew (Lyons and Simpson, 1989 and Weinstein et al., 1991), there were few, if any, reports of its occurrence in rotary-wing aircrew. Specific questions about these two entities were included in this survey because it was felt that aircrew might either not know of their existence or might not be aware that they are classified under SD.

Methods

The questionnaire

A questionnaire was developed that was similar to one used previously on United Kingdom (UK) aircrew (Durnford, 1992). A copy of the final version of this questionnaire is at Appendix A.

The questionnaire was entirely voluntary and anonymous, but it did ask for the respondent's rank and age. Following general details, there were sections concerning the respondent's worst ever episode of SD and his or her worst episode of SD in the past 4 months. In the final part of the questionnaire, respondents were asked to rate various aircraft, missions, and flight conditions on their tendency to provoke SD. They also were asked if they had suffered break-off or giant hand phenomena. A covering letter (as well as a verbal brief at the beginning of each session) explained the background of the survey and gave definitions. A copy is at Appendix B.

Respondents were asked to rate the severity of each episode by allocating them to one of the following categories:

o Minor: Episodes in which flight safety was not put at risk and would not have been jeopardized even under different circumstances (such as being solo or close to the ground).

o Significant: Episodes in which flight safety was not put at risk but in which it would have been jeopardized under different circumstances (such as being solo or close to the ground).

o Severe: Episodes in which flight safety was put at risk.

These classifications differ slightly from those used by other researchers (Tormes and Guedry, 1974 and Steele-Perkins and Evans, 1978) in that they focus on flight safety rather than interference with aircraft control. It was felt that this change of emphasis permitted the appropriate classification of episodes that might seriously threaten flight safety without any loss of control (such as during controlled flight into the ground).

A request was also made for copies of respondents' DA Form 759, broken down into overall flight experience and flight experience in the past 4 months. (The intention was to estimate SD rates per flying hours in the same way that accidents can be rated per flying hours.)

Administration of the questionnaires

The questionnaires were administered by one or more of the authors (always including Simon J. Durnford [SJD]) at four Army airfields. This was usually done during a flight safety meeting. A short brief on the mechanics of the survey (and relevant definitions) were given before the questionnaires were administered. Once all the questionnaires were returned, a 45- to 50-minute lecture on SD was given as a payback for the unit's participation. Care was taken to avoid any discussion of SD (beyond definitions) during the briefing phase.

The four locations visited (Fort Drum, New York; Fort Carson, Colorado; Fort Wainwright, Alaska; and Fort Hood, Texas) were chosen to give a spread of aircraft types and flying environments. It should be noted that these locations may not be representative of U.S. Army locations as a whole. Other flight environments may be more or less provocative of SD (e.g., Hawaii and Panama are said to be particularly provocative while Fort Rucker, Alabama, as a training base, may be less provocative). Nonetheless, it is considered that the true overall picture is unlikely to be very different from that described in this survey, since aircrew were able to recall episodes from previous duty stations or from temporary detachments.

Analysis

The data from the worst ever episodes and the worst in the past 4 months episodes were analyzed separately. Where the worst ever episode had occurred in the past 4 months, it was included in both groups.

The data from the survey were used to produce descriptive statistics and were further analyzed using ANOVA, t-tests, and chi-square tests. These tests were used to determine any significant links between the severity of the episode and factors such as aircrew experience, visual equipment used, and weather conditions. If data were not normally distributed on Kolmogorov-Smirnov (Lilliefors) testing, they were transformed to fit a normal distribution where necessary (details of transformations are given when each t-test or ANOVA is reported). All X^2 tables are shown in full; some make use of Conover's assertion that expected cells can be as small as 1 (Conover, 1980). Where expected cells were less than 1 (or the total number of cells was small), data was collapsed to allow a comparison between minor episodes and combined significant and severe episodes.

Aircrew ratings on aircraft types and specific missions were collated and significant patterns were identified using Friedmann analysis.

Statistica v4.5* was used for all statistical analysis. No attempt was made to allow for p-inflation associated with the numerous tests carried out, since the intention of this survey was to give a general overall picture and to highlight areas for further study (and not to provide definitive answers).

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*See list of manufacturers at Appendix C

Results

Subjects

A total of 304 questionnaires were obtained of which 299 were usable. (The others were from nonpilots.) The age of respondents ranged from 21 to 55, with a skew to the left (mean= 30.14, mode=29, and median=29). Ranks ranged from WO1 to Colonel.

Subject flying hours

Table 1 gives a breakdown of the respondents by the type of wings held, while Table 2 shows their total flying hours.

Table 1.
The type of wings held by the respondents.

	Aviator	Senior aviator	Master aviator
Number of respondents (%)	227 (79%)	53 (18%)	8 (3%)

Table 2.
Levels of flight experience.*

	0-500 hours	500-1000 hours	1000-1500 hours	1500-2000 hours	2000-2500 hours	2500-3000 hours	3000-3500 hours	3500-4000 hours	4000 + hour
Number of Respon-dents	76	81	20	14	6	5	1	7	9

*As assessed by flight hours (in 500 hour increments with the exception of the final category of >4000 hours).

We were able to obtain total flight hours on only 219 respondents. For these, overall flight hours at the time of questionnaire completion ranged from 158 to 7193 (mean 1055). These data are from DA Form 759 printouts and are reliable, but attempts to break them down in a consistent manner by aircraft type and flight conditions proved difficult. It was even more difficult to obtain details of flight hours in the past 4 months and only nine usable records were received. Therefore, we have excluded this latter data completely from the analysis.

Incidence of spatial disorientation

Table 3 gives a breakdown (by severity) of the worst ever episode of SD suffered by respondents as well as their worst episode in the past 4 months.

Table 3.
Severity of SD.*

Severity	Respondents reporting a worst ever episode	Respondents reporting a worst in the past 4 months episode
Minor	128 (43%)	03 (14%)
Significant	80 (27%)	19 (06%)
Severe	24 (08%)	05 (02%)
Totals	232 (78%)	67 (22%)

*Percent of all 299 respondents in parentheses.

It will be seen that 78 percent of respondents had suffered SD to some degree or other. Eight percent had suffered severe SD during their career (2 percent had suffered severe SD in the 4 months prior to completing the questionnaire).

Thirty-seven of the worst ever episodes were reported to have occurred in the 4 months prior to completion of the survey.

Flight experience

Mean total flying hours was 1129 for those who had been disorientated at some point in the past and 1037 for those who claimed they had never been disorientated. This difference was insignificant (p=0.69 on a t-test following log transformation). Neither was there a significant difference in the wings currently worn by the two groups (aviator, senior aviator, or master aviator; p=0.95 on X^2 testing).

We could find no significant association between the wings worn by those who admitted to having been disorientated and the perceived severity of their worst ever episodes (p=0.441 on X^2 test). There were insufficient respondents with senior and master wings for a satisfactory X^2 test on the 4-month episodes.

As measured by flying hours, experience levels were different between those who reported minor, significant, or severe episodes. The patterns were different for the worst ever and the 4-month groups, but both patterns were significant. (ANOVA following log transformation yielded p values of 0.029 and 0.0095, respectively.) The mean number of flying hours at the time of the episodes (broken down by category of episode) are given in Table 4.

Table 4.
Mean total flying hours at time of episodes.*

Severity	Worst ever episode (n=209)	Worst episode in past 4 months (n=58)
Minor	523	914
Significant	742	439
Severe	1085	2375

*Broken down by severity.

Aircraft type

X^2 testing showed no significant association between the severity of the worst ever episode and the aircraft type involved (p=0.097). Table 5 gives the number of episodes for the five common aircraft types (broken down by severity) together with the expected numbers.

Table 5.
Worst ever episodes by aircraft type.*

Severity	UH-1	OH-58	AH-64	UH-60	AH-1
Minor	51 (49.2)	29 (22.4)	19 (20.8)	07 (10.9)	11 (13.7)
Significant	33 (31.5)	10 (14.4)	14 (13.3)	08 (07.0)	10 (08.8)
Severe	06 (09.3)	02 (04.2)	05 (03.9)	05 (02.0)	04 (02.6)
Total	90	41	38	20	25

*Expected numbers in parentheses.

From aircrew total flight time (broken down by aircraft type), we were able to obtain the number of worst ever episodes reported by respondents for each aircraft type per 100k hours flown. Table 6 summarizes this data, which should be treated with caution since it reflects only the total number of worst ever episodes associated with each aircraft type and not the total number of episodes that respondents suffered with each aircraft type. Also, respondents were inclined to report episodes that were fresh in their memory (37 respondents reported that their worst ever episode was also their worst in the past 4 months). This may have biased results towards the most recently flown aircraft types.

Table 6.
Worst ever episodes, per 100k hours flown, by aircraft type.*

Severity	UH-1	OH-58	AH-64	UH-60	AH-1
Total hours flown (n)	40,015 (192)	36,277 (115)	22,722 (52)	16,147 (28)	21,744 (64)
Minor	122.4	82.7	110	37.2	27.6
Significant	72.4	19.3	83.6	49.5	23
Severe	15	5.5	26.4	31	18.4
Total	209.9	107.5	220.1	117.7	69

*Number of respondents for whom details were available are in parentheses.

There were too few 4-month data to produce a X^2 test on severity of episode by aircraft type without collapsing the data by combining the significant and severe episodes. When this was done, a surprisingly significant result emerged (p=0.0015) with the UH-60 showing the greatest disparity between observed and expected figures (86 percent of UH-60 episodes were significant or severe). The OH-58 was associated with relatively few significant/severe episodes (11 percent), as was the AH-64 (13 percent) and the AH-1 (25 percent). The UH-1 had the second highest rate (50 percent). These percentages should be treated with caution in view of the small numbers involved, although when the AH-1 was dropped from the analysis to reduce the number of small sized expected cells, the p value strengthened to p=0.000583. By contrast, dropping the UH-60 weakened the p value to an insignificant p=0.067. Table 7 gives the details.

Table 7.
Worst in the past 4 months episodes by aircraft type.*

Severity	UH-1	OH-58	AH-64	UH-60	AH-1
Minor	06 (08.4)	16 (12.5)	13 (10.4)	01 (04.9)	03 (02.8)
Significant or severe	06 (03.6)	02 (05.5)	02 (04.6)	06 (02.2)	01 (01.2)
Total	12	8	15	7	4

*Expected numbers in parentheses.

In the light of the significant finding for the 4-month data, the worst ever episodes were examined again after collapsing the significant and severe episodes. The differences between the aircraft types remained insignificant.

Table 8.
Worst ever episodes by type of flight.*

Severity	Day	Night (unaided)	Night (goggles)	Night (FLIR)
Minor	25 (20.5)	09 (11.7)	16 (19.1)	12 (10.7)
Significant	13 (17.2)	10 (09.8)	20 (16.0)	09 (09.0)
Severe	06 (06.3)	06 (03.6)	05 (05.9)	02 (03.3)
Total	44	25	41	23

*Expected numbers in parentheses.

Day and night flight

Table 8 gives the actual and expected frequencies of worst ever episodes (broken down by severity) grouped by the type of day or night flight. X^2 testing showed no significant differences between the groups (p=0.36). There were too few data to allow a X^2 test on the 4-month data even when the significant and severe data were combined.

Unfortunately, we were unable to obtain satisfactory details of respondents' flight hours broken down by day, night, night goggles, and night systems; therefore, we were unable to estimate the rates per flying hour.

Weather and hood flying

Table 9 gives the severity of worst ever episodes broken down by whether respondents were flying in weather, under the hood or in visual meteorological conditions (VMC).

Table 9.
Worst ever episodes by visual flight conditions.*

Severity	Weather	Hood	VMC
Minor	17 (17.9)	57 (46.8)	50 (59.3)
Significant	12 (11.7)	26 (30.6)	43 (38.7)
Severe	04 (03.3)	03 (08.7)	16 (11.0)
Totals	33	86	109

*Expected numbers in parentheses.

The differences across the three conditions were significant at a level of p=0.026. As one might expect, flight under the hood was associated with a relatively small number of severe episodes (3 percent). Unexpectedly, however, it appeared that it was VMC flight, and not weather, that was associated with the highest proportion of severe episodes (15 percent). In this context, it should be remembered that VMC flights may occur by night as well as by day (and may include flights employing night vision devices). Further tabulation showed no significant differences across the different visual conditions once day and night events were taken separately. (One hundred thirty-nine of the episodes occurred by day and 89 by night.)

The 4-month data showed no significant differences across visual conditions.

Outside visual references

As expected, there was a highly significant association between the severity of worst ever episodes and the reported state of outside visual references ($p=0.0017$ on X^2 testing). Table 10 gives the actual and expected rates.

Table 10.
Worst ever episodes by quality of outside visual references.*

Severity	Good	Acceptable	Bad
Minor	44 (36.8)	31 (24.1)	41 (55.1)
Significant	21 (24.5)	12 (16.0)	44 (36.5)
Severe	04 (07.6)	02 (05.0)	18 (11.4)
Totals	69	45	103

*Expected numbers in parentheses.

However, this finding was not replicated in the 63 worst in the past 4 months episodes in which visual conditions were reported.

Crew position

There also was a highly significant association between crew position at the time of the worst ever episode and the severity of the episode (p=0.0007 on X^2 testing). The results are in Table 11 and show a relatively low rate of severe cases for co-pilots (6 percent of episodes) and a high rate for pilots in command (22 percent of episodes).

Table 11.
Worst ever episodes by crew position at the time of the episode.*

Severity	Standardization/ instructor pilot	Pilot-in-command	Copilot
Minor	08 (12.2)	19 (27.2)	94 (81.6)
Significant	12 (07.6)	19 (16.9)	44 (50.6)
Severe	02 (02.2)	11 (04.9)	09 (14.8)
Totals	22	49	147

*Expected numbers in parentheses.

Standardization and instructor pilots (data combined) appear to have had a high rate of significant episodes (55 percent) at the expense of minor episodes.

The 4-month data had a similar pattern but just failed to reach significance (p=0.057).

Crew qualification

By contrast, respondents' qualifications (irrespective of their actual crew role) were not significantly related to the severity of their worst ever episodes (p=0.18 on X^2 testing). Table 12 gives details. Neither were any significant associations apparent in the 4-month data.

Table 12.
Worst ever episodes by crew qualification at the time of the episode.*

Severity	Standardization/ instructor pilot	Pilot-in-command	Copilot
Minor	14 (16.7)	36 (41.7)	68 (59.6)
Significant	13 (10.5)	29 (26.2)	32 (37.3)
Severe	03 (02.8)	10 (07.1)	07 (10.1)
Totals	30	75	107

*Expected numbers in parentheses.

Crew composition

No significant association could be found between the severity of the worst ever episodes and the number or qualifications of other crewmembers. This was true for the 4-month data as well.

Other crewmembers disorientated

A highly significant association was noted between the severity of the worst ever episode and a report that the other front seat crewmember had also been disorientated ($p<0.000001$ on X^2 testing). Table 13 shows the details. Most respondents ignored the questionnaire instructions and simply checked the appropriate boxes rather than indicating whether the other crewmember's disorientation was suspected or confirmed, and so these groups were amalgamated for the analysis. The data show that both front seat crew were disoriented in 51 (23 percent) of the episodes. The proportion raises to 40 percent of the 62 episodes that involve NVDs.

Table 13.
Worst ever episodes by whether one or both front seat crew had been disorientated.*

Severity	Both front seat crew were disoriented	Only one front seat crewmember was disoriented
Minor	11 (27.6)	112 (95.4)
Significant	28 (17.0)	48 (59.0)
Severe	11 (5.4)	07 (18.6)
Totals	50	173

*Expected numbers in parentheses.

The number of episodes in the 4-month data in which both front seat crew were disorientated was 21 (32 percent), but these data showed no significant association with the severity of episode. Both front seat crew were disorientated in 9 (33 percent) of the 27 episodes involving NVDs.

Height at onset of incident

Table 14 gives the mean height above ground at the onset of the episodes.

Table 14.
The mean height at the onset of reported episodes (in feet).

Severity	Mean height at the onset of worst ever episodes	Mean height at the onset of the worst episode in the past 4 months
Minor	1568	873
Significant	1210	1389
Severe	576	344

Log transformation followed by ANOVA showed the pattern for the worst ever episodes to be significant at a level of p=0.0013. The pattern for the 4-month data was not found to be significant.

Table 15.
Meteorological conditions at the onset of reported episodes.*

Meteorological condition	Number of worst ever episodes	Number of worst in the past 4 months episodes
In VMC	183 (84)	52 (83)
In IMC	40 (18)	08 (13)
Intentionally entering IMC	39 (18)	10 (16)
Inadvertent entry to IMC	09 (04)	03 (05)
Raining	20 (09)	04 (06)
Snowing	14 (06)	06 (10)
Nonrain, non-snow ppn	28 (13)	11 (17)

*Percent of respondents who completed this part of the survey are in parentheses.

Weather conditions

Table 15 gives the number of episodes (both worst ever and worst in the past 4 months) broken down by the meteorological flight conditions at the onset of the incident.

X^2 testing showed a significant association between inadvertent entry to IMC and the severity of the worst ever episodes (p=0.00044). Table 16 gives the details. (An expected cell of less than 1 led us to combine the significant and severe data.) There were too few 4-month episodes for analysis.

Table 16.
Worst ever episodes by involvement in inadvertent entry to IMC.*

Severity	Number of episodes involving inadvertent entry to IMC	Number of episodes NOT involving inadvertent entry to IMC
Minor	0 (05.1)	110 (104.9)
Significant/ Severe	09 (03.9)	75 (80.1)
Totals	9	185

*Expected numbers in parentheses)

Comparisons between VMC and IMC showed no significant differences (p=0.37 for the worst ever group and p=0.92 for the 4-month group). Similarly, no associations between severity of episode and rain, snow, or other precipitation were found. Neither was there any association between the severity of episodes and all forms of precipitation combined.

Light conditions

Table 17 gives the number of episodes that occurred in various light conditions. No significant relationship between severity and any of the specific light conditions could be discovered (even, for example, when the severity of episodes involving NVGs was analyzed against moon conditions).

Table 17.
Light conditions at the onset of reported episodes.*

Light condition	Number of worst ever episodes	Number of worst in the past 4 4 months episodes
In twilight	16 (07)	05 (08)
Into sun	27 (12)	05 (08)
Away from or across sun	38 (18)	12 (19)
No sun	63 (29)	22 (35)
Full moon	02 (01)	00 (00)
Part moon	45 (20)	14 (22)
No moon	58 (27)	17 (27)

*Percent of respondents who completed this question is in parentheses.

Terrain

Table 18 gives the number of episodes occurring over various terrain features.

Table 18.
Terrain conditions at the onset of reported episodes.*

Terrain	Number of worst ever episodes	Number of worst in the past 4-months episodes
Over water	11 (05)	03 (05)
Over snow	24 (11)	10 (16)
over desert	34 (17)	13 (21)
In mountains	25 (12)	08 (13)

*Percent of respondents who completed this question is in parentheses.

Table 19.
Worst ever episodes by occurrence over desert.*

Severity	Number of episodes over desert	Number of episodes NOT over desert
Minor	10 (18.5)	101 (92.5)
Significant	16 (12.2)	57 (60.8)
Severe	08 (03.3)	12 (16.7)
Totals	34	170

*Expected number in parentheses.

X^2 testing showed a significant association between the severity of worst ever episodes and flight over desert (p=0.0009). Details are given in Table 19. The association persisted even when wartime episodes were removed (p=0.021). However, it should be remembered that many episodes could have occurred during Desert Shield (prior to Desert Storm), and thus the influence of combat pressures cannot be ruled out. The 13 desert episodes from the 4-month data showed no significant increase in severity.

No other association between severity and terrain features could be demonstrated (including flight over snow or water).

Wartime

X^2 testing showed a significant association between wartime operations and the severity of worst ever episodes (p=0.014, see Table 20). This was not repeated in the 4-month data.

Table 20.
Worst ever episodes by occurrence during wartime operations.*

Severity	Number of episodes during wartime operations	Number of episodes NOT during wartime operations
Minor	04 (07.9)	107 (103.1)
Significant	06 (04.8)	62 (63.2)
Severe	04 (01.3)	14 (16.7)
Totals	14	170

*Expected number in parentheses.

There was also a significant association between troop movement missions and the severity of worst ever episodes (p=0.019, see Table 21). However, removing the four episodes associated with wartime operations reduced the significance to p=0.057 (new n=8). No other links between mission type and severity of episode could be demonstrated.

Table 21.
Worst ever episodes by involvement in troop movement missions.*

Severity	Number of episodes, troop movement missions	Number of episodes, NOT troop movement missions
Minor	10 (18.5)	101 (92.5)
Significant	16 (12.2)	57 (60.8)
Severe	08 (03.3)	12 (16.7)
Totals	34	170

*Wartime data have been included. Expected number in parentheses.

Table 22.
Flying maneuvers being performed at the onset of reported episodes.*

Flight maneuver	Number of worst ever episodes	Number of worst in the past 4-months episodes
Straight and level flight	66 (33)	18 (30)
Turning left	61 (30)	21 (34)
Turning right	60 (30)	18 (30)
Climbing	64 (31)	22 (35)
Descending	85 (41)	26 (41)
Accelerating	44 (22)	14 (23)
Decelerating	46 (23)	17 (27)
Hovering	35 (18)	18 (30)

*Percent of respondents who completed this question is in parentheses.

Flight maneuvers

Table 22 shows the flying maneuvers that respondents were performing at the time of the episode.

X^2 testing revealed peculiar patterns linking severity with flight maneuver. In the worst ever data, there were significant associations between severity and descending (p=0.0067), decelerating (p=0.04), and hovering (p=0.015). Tables 23 to 25 give details.

Table 23.
Worst ever episodes by occurrence during descent.*

Severity	Number of episodes occurring during descent	Number of episodes NOT occurring during descent
Minor	35 (45.7)	70 (59.3)
Significant	38 (30.5)	32 (39.5)
Severe	11 (07.8)	07 (10.2)
Totals	84	109

*Expected number in parentheses.

Table 24.
Worst ever episodes by occurrence during deceleration.*

Severity	Number of episodes occurring during deceleration	Number of episodes NOT occurring during deceleration
Minor	21 (25.6)	83 (78.4)
Significant	16 (15.7)	48 (48.3)
Severe	09 (04.7)	10 (14.3)
Totals	46	141

*Expected number in parentheses.

Table 25.
Worst ever episodes by occurrence during a hover.*

Severity	Number of episodes occurring in a hover	Number of episodes NOT occurring in a hover
Minor	12 (19.2)	97 (89.8)
Significant	16 (11.6)	57 (54.4)
Severe	06 (03.3)	12 (14.8)
Totals	34	159

*Expected number in parentheses.

None of these associations were repeated in the 4-month data. Instead, severity was significantly reduced for maneuvers involving turning right (p=0.018) or turning either way (p=0.0014). Details are given in Tables 26 and 27. (Further tests, combining significant and severe episodes, produced values in the expected cells of not less than 6.6 and increased the significance of the X^2 tests to p=0.006 for the right turn and p=0.0003 for turning either way.) No significant differences between left and right turns could be demonstrated. Of the 32 episodes involving turns, 11 had been identified by respondents later in the survey as the leans. This proportion was not significant (p=0.10).

Table 26.
Worst in the past 4 months episodes by occurrence during a turn to the right.*

Severity	Number of episodes occurring during a turn to the right	Number of episodes NOT occurring during a turn to the right
Minor	16 (11.4)	20 (24.6)
Significant	01 (05.4)	16 (11.6)
Severe	01 (01.3)	03 (02.7)
Totals	18	39

*Expected number in parentheses.

Table 27.
Worst in the past 4 months episodes by occurrence during a turn either way.*

Severity	Number of episodes occurring during a turn either way	Number of episodes NOT occurring during a turn
Minor	27 (20.4)	10 (16.6)
Significant	04 (09.4)	13 (07.6)
Severe	01 (02.2)	03 (01.8)
Totals	32	26

*Expected number in parentheses.

Data were combined to create straight-and-level, hovering, and maneuvering groups. X^2 showed no significant differences between these groups in either series of episodes.

Physical and mental state at the onset of the incident

Table 28.
Physical and mental state at the onset of the reported episode.*

	Number of worst ever episodes	Number of worst in the past 4 4 months episodes
Had medical problem	05 (02)	02 (03)
Had taken Alcohol/ medicines (in prev 24 hrs)	04 (02)	01 (01)
Alert	197 (88)	58 (87)
Bored	25 (11)	09 (14)
Tired	66 (30)	20 (30)
Happy	68 (31)	20 (30)
Depressed	02 (01)	01 (02)
Distracted (related to flight)	80 (36)	23 (35)
Distracted (unrelated to flight)	14 (06)	05 (08)
Pressured	115 (51)	34 (52)

*Percent of respondents who completed this question is in parentheses.

Table 28 gives a breakdown of the physical and mental state of respondents at the time of onset of the reported episodes.

No significant association could be demonstrated between the severity of the worst ever episodes and any particular physical or mental attribute.

For the 4-month data, the only significant association was an apparent increase in severity associated with being alert (p=0.032). To obtain sufficient expected values the significant and severe episodes had to be combined. Table 29 shows the X^2 table.

Table 29.
Worst in the past 4 months episodes by alertness.*

Severity	Number of episodes where the respondent was alert	Number of episodes where the respondent was NOT alert
Minor	34 (36.6)	07 (04.4)
Significant/ Severe	24 (21.4)	00 (02.4)
Totals	58	7

*Expected number in parentheses.

Of the seven reported medical problems (worst ever and 4-month data combined), nausea accounted for four and a head cold for three. Of the three respondents who reported taking alcohol or medications in the 24 hours prior to flight, one had taken atropine and two had taken beer 18 hours previously. Only one episode from these combined groups was severe, two were significant, and the other nine were minor.

Of the 115 respondents who felt pressured before suffering their worst ever episode, 108 identified a source of the pressure (for the 4-month episodes, the figure was 32 out of 34). Table 30 gives a breakdown of the sources offered. Being pressured on an instructional flight or checkride was the most commonly quoted source of pressure. Fatigue, fear of failure, and personal problems were the next most common.

Table 30.
Sources of pressure identified by respondents.

Source of pressure	Worst ever episodes (n=108)	4-months episodes (n=34)
On check ride or pressured by IP or PC	37	12
Fatigue	8	5
Fear of failure	7	0
Personal problems	4	2
NVG/NVS	4	1
NBC equipment	3	1
Difficulty reading insts	3	0
Radar failure	2	0
Others	42	11

Table 31.
Focus of attention at the onset of SD episodes.*

	Number of worst ever episodes	Number of worst in the past 4 4 months episodes
Head out of cockpit	86 (39)	40 (62)
Attending to flight insts	133 (60)	26 (41)
Attending to nav, radios or other systems	75 (35)	19 (31)
Head in for another reason	31 (15)	06 (10)

*Percent of respondents who completed this question is in parentheses.

Table 32.
Worst ever episodes by head position at the onset of the episode.*

Severity	Number of episodes, respondent head out	Numbers of episodes, respondent NOT head out
Minor	38 (47.8)	83 (73.2)
Significant	13 (29.3)	41 (44.7)
Severe	14 (07.9)	06 (12.1)
Totals	85	130

*Expected number in parentheses.

Focus of attention

Table 31 shows where respondents' attention was focused at the onset of SD. There was a significant increase in the severity of the worst ever episode if it was associated with the respondent being head out of the cockpit (p=0.0026). Table 32 gives the X^2 details. No other significant association could be found for this data or for the 4-month data. There was no significant differences demonstrable between attending to the flight instruments and attending to navigation or other systems.

Misleading and insufficient cues

Table 33 shows the number of respondents who considered they had suffered misleading or insufficient cues broken down by visual cues and seat-of-the-pants or other bodily senses. Worst ever episodes appeared to be more severe if they involved misleading visual cues or insufficient visual cues (p=0.002 and p=0.037 respectively). Tables 34 and 35 give the X^2 details. These findings were not replicated in the 4-month data.

Table 33.
Number of respondents reporting misleading or insufficient cues.*

	Number of worst ever episodes	Number of worst in the past 4 4 months episodes
Misleading visual cues	83 (37)	21 (32)
Insufficient visual cues	131 (58)	50 (77)
Misleading cues from other body senses	145 (65)	34 (53)
Insufficient cues from other body senses	53 (24)	18 (28)

*Percent of respondents who completed this question is in parentheses.

Table 34.
Worst ever episodes relevant to misleading visual cues.*

Severity	Number of episodes, misleading visual cues	Numbers of episodes, NO misleading visual cues
Minor	40 (46.2)	79 (72.8)
Significant	27 (28.0)	45 (44.0)
Severe	15 (07.8)	05 (12.2)
Totals	82	129

*Expected number in parentheses.

Table 35.
Worst ever episodes relevant to insufficient visual cues.*

Severity	Numbers of episodes, insufficient visual cues	Numbers of episodes, NO insufficient visual cues
Minor	65 (72.3)	56 (48.7)
Significant	46 (43.6)	27 (29.4)
Severe	18 (13.1)	04 (08.9)
Totals	129	87

*Expected number in parentheses.

Further analysis of the worst ever data showed a significant association between the use of NVGs (or FLIR) and misleading or insufficient visual cues (p=0.0004 and p=0.0002 respectively). Details are in Tables 36 and 37. However, no significant difference could be demonstrated between the 57 NVD episodes and the 19 night unaided episodes.

Table 36.
Worst ever episodes involving misleading visual cues relevant to the use of NVGs (or FLIR).*

	Numbers of episodes, misleading visual cues	Number of episodes, NO misleading visual cues
NVGs (or FLIR)	33 (21.9)	24 (35.1)
No NVGs (or FLIR)	47 (58.1)	104 (92.9)
Totals	80	128

*Expected numbers in parentheses.

Table 37.
Worst ever episodes involving insufficient visual cues relevant to the use of NVGs (or FLIR).*

	Number of episodes, insufficient visual cues	Numbers of episodes, NO insufficient visual cues
NVGs (or FLIR)	46 (34.3)	11 (22.7)
No NVGs (or FLIR)	82 (93.7)	74 (62.3)
Totals	128	85

*Expected number in parentheses.

No significant associations with severity could be demonstrated for cues from the seat-of-the-pants or other bodily senses.

Misperceptions of flight path

Episodes that occurred in forward flight were reviewed for indications as to whether a perceptual error had occurred in roll, pitch, or both. The results are in Table 38. No significant associations could be demonstrated.

Table 38.
Tentative estimates as to the direction of perceptual error in the worst ever episodes occurring in forward flight.*

Perceptual errors	Number of worst ever episodes	Number of worst in the past 4 months episodes
Roll	75 (45)	18 (53)
Pitch	26 (16)	08 (24)
Both roll and pitch	64 (39)	08 (24)

*Percent of group in which tentative identification was made is in parenthesis.

Type and duration of episode

Table 39 gives a breakdown of episodes depending on whether the respondent was immediately aware of being disorientated.

Table 39.
Number of respondents not immediately aware of being disorientated.*

Worst ever episodes	Worst in the past 4 months episodes
96 (43)	15 (24)

*Percent of those answering this question is in parentheses.

No significant association between severity of episode and awareness of being disorientated was evident for either the worst ever or the 4-month data groups.

For the worst ever group, 96 respondents had been disorientated for a period without knowing it (43 percent). The mean time for which these respondents had been unknowingly disorientated was 25 seconds. The range was ½ second to 10 minutes, the mode was 5 seconds, and the 75th percentile was 15 seconds.

Taking the 4-month data, 19 respondents (31 percent) reported episodes in which they had been disorientated without knowing it. For them, the mean length of time was 8.4 seconds, the range was 2-30 seconds, the mode was 5 seconds, and the 75th percentile was 10 seconds.

Log transformations followed by ANOVA showed no associations between the period for which respondents were unknowingly disorientated and the severity of the episode.

Effects on aircraft control

Table 40 lists the effects of reported episodes on aircraft control and conduct of the mission.

X^2 testing revealed significant associations between the perceived severity of the worst ever episode and the following effects: loss of flying accuracy for the full mission ($p=0.0118$, significant and severe episodes combined), effects on the conduct of the mission ($p<0.000001$, data uncombined), and aborting the mission ($p=0.0063$, significant and severe episodes combined). Tables 41-43 give details. No significant associations were found in the 4-month data.

Table 40.
Respondents handling aircraft and subsequent effects on aircraft control and conduct of the mission.*

	Number of worst ever episodes	Number of worst in the past 4 months episodes
Respondent handling the aircraft	197 (85)	54 (82)
Respondent handed over (or took over) control	67 (30)	16 (25)
Flying control remained as accurate as normal	102 (46)	34 (55)
Temporary loss of accuracy	146 (64)	45 (68)
Accuracy lost and never regained	08 (04)	03 (05)
Incident affected conduct of the mission	76 (33)	23 (35)
Mission aborted (no mishap)	05 (02)	01 (02)
Suffered a mishap	05 (02)	01 (02)

*Percent of respondents who answered the question is in parenthesis.

Table 41.
Worst ever episodes relevant to flying accuracy being lost for the duration of the mission.*

Severity	Number of episodes in which flying accuracy was lost and never regained	Number of episodes in which flying accuracy was not lost for the full mission
Minor	1 (4.5)	118 (114.5)
Significant/ Severe	7 (03.5)	87 (90.5)
Totals	8	205

*Expected number in parentheses.

Table 42.
Worst ever episodes relevant to conduct of the mission being affected.*

Severity	Number of episodes in which conduct of the mission was affected	Number of episodes in which conduct of the mission was unaffected
Minor	27 (42.2)	99 (83.8)
Significant	29 (26.1)	49 (51.9)
Severe	20 (07.7)	03 (15.3)
Totals	76	151

*Expected number in parentheses.

Table 43.
Worst ever episodes relevant to the mission being aborted.*

Severity	Number of episodes in which the mission was aborted	Number of episodes in which the mission was not aborted
Minor	0 (03.3)	116 (112.7)
Significant/ Severe	6 (02.7)	90 (93.3)
Totals	6	206

*Expected number in parentheses.

Equipment

Table 44 gives the number of episodes in which aircraft or personal equipment provoked the episode, made it worse, or made it easier to cope with.

Table 44.
Episodes affected by equipment (personal or aircraft).*

	Number of worst ever episodes	Number of worst in the past 4 months episodes
Caused the episode or made it worse	46 (20)	13 (20)
Made the episode easier to handle	94 (41)	23 (35)

*Percent of respondents who answered the question is in parenthesis.

X^2 testing showed a significantly increased severity if the worst ever episode was provoked or made worse by an item of equipment (p=0.0024). Table 45 gives details. No other significant results were obtainable from either the worst ever or the 4-month data.

Table 45.
Severity of worst ever episodes involving equipment.*

Severity	Number of episodes in which equipment provoked the episode or made it more difficult to handle	Number of episodes in which equipment did NOT provoke the episode or make it more difficult to handle
Minor	16 (25.3)	110 (100.7)
Significant	20 (15.3)	56 (60.7)
Severe	09 (04.4)	13 (17.6)
Totals	45	179

*Expected number in parentheses.

Only 28 of the comments specified the difficulties with equipment. Of these, three concerned FLIR problems and four NVG problems. These were all unusual and individual problems such as a locked PNVS or unfocused goggles. Six comments dealt with the disorientating effects of external lights and beacons. Five concerned individual instrument failures, and ten dealt with insufficiently blocked-off vision while using the hood.

There were 83 comments specifying the good points of equipment. Of these, 61 dealt with the life-saving value of the standard instrument suit. Fifteen commented on the benefits of FLIR and the PNVS symbology. Six commented on the benefits of being able to see in the dark through NVGs. One commented on the benefits of a hover/attitude hold.

Crew coordination

Table 46 shows the number of episodes in which poor or good crew coordination were considered to have contributed to the episode and it's management. X^2 testing revealed significantly increased severity of the worst ever episodes if poor crew coordination had contributed to the generation of the incident (p=0.00061) or if it had hampered recovery (p=0.042). (In the latter case the p value strengthens to p=0.012 if significant and severe episodes are collapsed to increase the values in the expected cells). Tables 46 and 47 give details.

Table 46.
Number of episodes in which crew coordination played a part.*

	Number of worst ever episodes	Number of worst in the past 4 months episodes
Poor crew coordination contributed to the generation of the event	23 (10)	06 (09)
Poor crew coordination hampered recovery	11 (05)	01 (02)
Good crew coordination prevented the incident from being worse	168 (73)	55 (83)

*Percent of respondents who answered the question is in parenthesis.

Table 47.
Worst ever episodes relevant to poor crew coordination contributing to the generation of the event.*

Severity	Number of episodes in which poor crew coordination contributed to the generation of the event	Number of episodes in which poor crew coordination did NOT contribute to the generation of the event
Minor	04 (12.2)	120 (111.8)
Significant	13 (07.7)	65 (70.3)
Severe	05 (02.1)	16 (18.9)
Totals	22	201

*Expected number in parentheses.

Specific illusions and conditions

Respondents were asked to state whether they would classify each episode they described as the leans. Forty-four percent of the worst ever episodes and 28 percent of the 4-month episodes were described as the leans. X^2 testing revealed a reduced tendency for these episodes to be significant or severe (p=0.0002 for the worst ever data, p=0.031 for the 4-month data). However, descriptions provided by respondents made it difficult to confirm or refute these episodes were true cases of the leans. It is likely that some were sensations of rolling or tilting from other causes.

Analysis of respondents' descriptions of their experiences showed the pattern given in Table 48.

Table 48.
Worst ever episodes relevant to poor crew coordination hampering recovery of the event.*

Severity	Number of episodes in which poor crew coordination hampered recovery	Number of episodes in which poor crew coordination did NOT hamper recovery
Minor	02 (06.1)	123 (111.8)
Significant	07 (03.8)	72 (70.3)
Severe	02 (01.1)	21 (18.9)
Totals	11	216

*Expected number in parentheses.

Recirculation (either of dust or snow) was a prominent feature (being involved in 22 cases in the worst ever data and in 11 cases in the 4-month data). X^2 testing showed that the worst ever recirculation episodes had a significantly increased tendency to be significant or severe (p=0.022, see Table 49). This was not repeated in the smaller number from the 4-month data.

Table 49.
Number of episodes associated with particular causes or events.*

Cause/event	Number of worst ever episodes	Number of worst in the past 4 months episodes
Brownout	15 (06)	06 (09)
Whiteout	07 (03)	05 (07)
Misled by stars/ground lights	08 (03)	03 (04)
Problems from repeatedly head in/out	07 (03)	02 (03)
Flicker effects	08 (03) (7 episodes under the hood)	
Illusions induced by peripheral vision under the hood	04 (02)	
Blown grass illusions	03 (01)	01 (01)
Relative motion illusions	02 (01)	
PNVS movement failures	02 (01)	
Near mid-air		02 (03)

*Percent of total in parenthesis.

None of the eight cases of flicker effects appeared to be true vertigo and seven occurred under the hood. Peripheral vision effects occurred in four other cases under the hood.

Descriptions of episodes provided by the respondents were reviewed by one of the authors (SJD) and tentatively categorized into those based on visual errors or those based on vestibular errors. No categorization was made in cases of reasonable doubt. (Examples of cases categorized as visual would be ones in which stars were mistaken as ground lights or the motion of another aircraft led to illusory self motion, while examples of vestibular cases would be good descriptions of the leans or of coriolis illusions.) Of the worst ever data, 55 episodes were categorized as vestibular while 45 were categorized as visual (133 were uncategorized). In the 4-month data, 9 were categorized as vestibular compared to 14 visual (38 were uncategorized). In neither data group were there any significant differences with regard to severity of episodes.

Number of episodes in the 4 months prior to the survey

Reporting of the frequency of SD episodes in the 4 months prior to the survey was poor. Only 35 of the 67 respondents who admitted to having suffered an episode during that time gave any indication of the frequency of episodes. Therefore, this data was ignored as unreliable.

Opinions on aircraft types

In section 3 of the questionnaire, respondents were asked to rate various factors for their likelihood to cause SD. Friedmann analysis of opinions about aircraft types showed no significant differences between UH-1, UH-60, AH-1, AH-64, OH-58, and CH-47.

There were, however, significant differences between the front and back seats for the AH-64 (the back seat had lower ratings, implying that aircrew were less likely to be disoriented when occupying this seat, $p=0.016$).

Aircrew were also invited to comment on specific aircraft types. The most frequent comments are summarized in Table 50.

Table 50.
Specific problems with aircraft: The most frequent comments.

Aircraft type and comment	Number of aircrew making comment
AH-64: Must lean to side in order to see instruments	12
: TADS picture needs improvement	5
: Poor FLIR picture (unspecified)	4
: Being in the 'bag' is disorientating	3
OH-58: Not instrumented to handle IMC	5
: Small Attitude Indicator	2
: Instrument hood obstructs view	2
AH-1: Limited vis because of cockpit obstructions	4
: Curved windows cause a problem	2
General: Aircraft without stabilization drift easily	3
: Sunlight through blades causes problems	3

Opinions on flight conditions

Table 51 lists (by aircraft type) the order in which aircrew ranked various flight conditions in terms of their likelihood to provoke SD.

Table 51.
Aircrew opinion on the likelihood of various flight conditions to cause SD by aircraft type.

Aircraft type (all models)	Number of aircrew giving opinion	Aircrew ranking of flight condition ('1' = MOST likely to cause SD)				
		Weather	Hood	NVG/FLIR	Night unaided	Day
UH-1	50	1	2	3	4	5
UH-60	25	2=	2=	1	4	5
OH-58	39	1	2	3	4	5
AH-1	26	2	3	1	4	5
AH-64 front	18	1	2	3	4	5
AH-64 back	22	1	3	2	4	5
Overall	116	1	2	3	4	5

Overall, weather was considered the most provocative, followed by flight under the hood, flight on NVG (or FLIR), flight at night unaided, and then day flight. The probability that the rankings reflect significant aircrew agreement was <0.00000 for each aircraft type (with the exception of the UH-60, p=0.00229). There were insufficient CH-47 opinions for analysis.

Aircrew opinion on specific situations

Table 52 shows the results of a Friedmann analysis on aircrew opinions concerning the 26 factors listed on page C-15 of the questionnaire. Only the 10 factors considered to be the most provocative are shown. The probability that this ranking reflects significant agreement among the aircrew is <0.00001 (n=121).

Table 52.
Aircrew opinion on the likelihood of specific situations to cause SD.

Situation	Aircrew ranking ('1'= most likely to cause SD)
Inadvertent entry to IMC	1
IMC flight	2
Flight over desert	3=
Flight over water	3=
Flight over snow	5
Flight in snow	6
Flight with no moon	7
Intentional entry to IMC	8
Flight in rain	9
Wartime operations	10

Aircrew were also invited to comment on bad situations. The most frequent comments are at Table 53.

Table 53.
Specific problems: The most frequently made aircrew comments.

Specific comment	Number of aircrew making comment
Loss of visual cues is prime problem	25
Inadvertent IMC is the worst	16
Pilot workload is major problem	3
Flight over water is provocative	3
There is a lack of instrument training	3
Terrain features can lead to urges to climb or descend	2

Break-off and giant hand phenomena

Table 54 shows the number of respondents reporting break-off phenomena at sometime during their career and during the past 4 months (together with the mean number of episodes reported and the range). Table 55 gives similar figures for giant hand phenomena.

Table 54.
Severity of break-off phenomena by career and in the past 4 months.*

	Number of respondents reporting episodes of break-off		
	Minor	Significant	Severe
Over whole career	34 (3.1, 1-20)	13 (1.6, 1-4)	3 (4, 1-10)
In past 4 months	15 (1.2, 1-2)	1 (1.0, 1-1)	3 (4, 1-5)

*Mean number of episodes per respondent and range in parenthesis.

Table 55.
Severity of giant hand phenomena by career and in the past 4 months.*

	Number of respondents reporting episodes of giant hand phenomena		
	Minor	Significant	Severe
Over whole career	30 (3.2, 1-10)	15 (2.2, 1-10)	1 (1)
In past 4-months	13 (2.0, 1-6)	3 (1.0, 1-1)	0

*Mean number of episodes per respondent and range in parenthesis.

Some respondents reported significant episodes but no minor episodes, therefore, the total number of respondents reporting break-off at some point during their career was 44 (15 percent), and the total number reporting giant hand was 41 (14 percent).

The number for the 4 months prior to the survey were 18 (6 percent) and 15 (5 percent) respectively.

There was some overlap between the two phenomena - 19 respondents (6 percent) reported they had suffered both types at sometime during their career. This overlap was highly significant ($p<0.000001$ on X^2 testing).

Discussion

The purpose of this report is primarily descriptive, hence the large number of tables. Nonetheless, analytical statistical tests have been carried out to highlight possible links between SD and current equipment or flying practices. The significance of these tests should be treated with caution because of the large number of comparisons performed. In general, they should be used as indicators rather than as proof of linkage. Nonetheless, many of the results fit with other reported data and with current concepts.

Another reason for caution lies in the nature of a survey like this. Asking aircrew to remember incidents that may well have frightened them is inviting subjective bias. No apologies are offered for this since the intent of the study was to tap aircrew experiences and opinions.

The incidence of SD

Although 78 percent of aircrew in this survey had suffered SD at sometime in their career, this figure is actually lower than others published. For example, a similar survey of UK Army aircrew (Durnford 1992) showed that 90 percent had been disorientated. Using identical definitions of severity, 24 percent of UK aircrew had been severely disorientated compared to only 8 percent in this survey. Similarly, 44 percent had been disorientated at sometime in the previous 4 months compared to 22 percent in this survey. The lower rates reported here may reflect a number of factors including methodological differences (the British survey was postal, and the response rate was 79 percent compared to almost 100 percent for this survey) and time span differences (the British survey took place shortly after the Gulf War had highlighted problems such as SD). Other possible nonaviation factors include semantic and cultural differences.

Given the inevitable differences between this and other surveys, it is not the small variations in the statistics that are noteworthy but their similarity. This survey shows yet again that aircrew continue to become disorientated, some severely, just as they have done for decades (Eastwood and Berry, 1960; Clarke, 1971). It shows also, that in any 4-month period, 22 percent of U.S. Army aircrew are likely to become disorientated, and 2 percent will be disorientated seriously enough to put flight safety at risk (by their own estimation). Of those who suffer, 68 percent will lose flying accuracy, even if only temporarily. Thirty-five percent of episodes will affect the conduct of the mission.

These figures complement those of a sister survey in which SD was considered the major factor in 32 percent of U.S. Army class A-C rotary-wing accidents (Durnford, Crowley, and Rosado, 1995).

The nature of rotary-wing SD

Although there is considerable overlap, the challenges posed by military rotary-wing flight are different to those associated with fixed-wing flight. In general, there is less vestibular stimulation through G-forces and more reliance on external visual cues and night vision devices. Much early work on SD was done in the fixed-wing arena and interest was focused on the vestibular components. Some of the subsequent concepts do not carry across well to the rotary-wing world (and neither do some of the terms, such as aviator's vertigo). That is not to say that vestibular misperceptions do not happen in helicopters, they do, and when they do, their very subtlety may make them dangerous. Their presence is attested by the fact that 55 (24 percent) of the worst ever episodes in this survey were tentatively categorized as vestibular in origin compared to 45 (19 percent) categorized as visual. There was no apparent differences in severity between the two groups.

Nonetheless, it was the visual component that predominated throughout much of this survey, as it has in other rotary-wing surveys. Table 10 (showing the relationship with outside visual references), Table 33 (showing the origins of misleading or insufficient cues), Tables 36 and 37 (showing the links between problem cues and NVDs), and Table 53 (showing aircraft opinions on provocative situations) all demonstrate the link between a degraded visual environment and SD.

Splitting the causes of SD into vestibular or visual categories is an artificial process, however, because vestibular, visual, and kinaesthetic inputs are all inextricably linked. For example, preattentive vision is dependent, partially at least, on vestibular inputs defining the horizontal (Stivalet et al., 1995). What aircrew consciously see has therefore already been modified by vestibular sensation. This may explain why it is so difficult to tease out specifically vestibular from specifically visual events or specifically kinaesthetic events. Even episodes that may appear to be entirely visual (e.g., misinterpretation of stars for ground lights) may have other components that induces the misinterpretation in the first place (e.g., a mistaken perception of the horizontal).

The visual predominance of rotary-wing flight makes it surprising that this survey failed to show any difference in severity between day, night, or night NVD episodes. Neither could any significant relationship between light levels (even under NVG) and the severity of the episode be shown. Furthermore, although there were significant differences between episodes involving flight under the hood, flight in VMC, and flight in IMC, it turned out it was the VMC episodes that had the highest proportion of severe episodes. This finding mirrors the survey of UK Army aircrew, where it was tentatively ascribed to large number of relatively minor episodes of the leans occurring during instrument flight. In the present survey, that is unlikely to be the full explanation since the absolute number involved (VMC accounted for 70 percent of all severe episodes) indicate that the imbalance of proportions was not simply the result of large number of less severe IMC episodes swamping a relative few that were severe. More likely the severe nature of some specific VMC problems, such as brownout or whiteout, is a cause of this finding. Indeed, the fact that inadvertent entry to IMC ranks first in the aircrew pantheon of horrors (and is significantly linked to severe SD) adds weight to the long-held belief that the sudden loss of external visual cues is more of a problem than having no external visual cues. Unfortunately, this questionnaire asked no specific questions about brownout or whiteout. Aircrew might have ranked them with inadvertent IMC, regrettably we cannot tell.

The failure to find a difference between day, night, and night NVD contrasts with the findings of the study into SD as a cause of U.S. Army rotary-wing accidents (Durnford et al., 1995). In that study, it was shown that there were 1.45 SD accidents for every 100k hours flown in daylight, 5.5 for every 100k hours flown unaided at night, 17.83 for every 100k hours flown using NVGs, and 21.48 for every 100k hours flown by Apache aircrew using FLIR. Similarly, the UK aircrew survey was able to use accurate flight records to show that night unaided flight accounted for only 7 percent of total flying hours but accounted for 26 percent of worst ever SD episodes, and that night NVG flight accounted for only 1 percent of flight hours but accounted for 5 percent of worst ever episodes. It is therefore likely that flight in conditions of impaired vision <u>is</u> provocative of SD, and that the SD can be severe. The present survey may have failed to detect the link because a relatively small number of severe episodes had to be tabulated across several factors. Aircrew were clearly of the opinion that weather flying was most provocative of SD, closely followed by flight under the hood and NVG/FLIR flight.

Specific illusion and conditions

Although several episodes of SD fall into grey areas that are difficult to classify, many fall into frequently recurring patterns.

Forty-four percent of worst ever episodes were categorized by the respondents as the leans, and these were significantly less severe than other episodes. Other surveys have reported the leans to be the most frequently experienced SD illusion (Eastwood and Berry, 1960; Clarke, 1971; Tormes and Guedry, 1974; Steele-Perkins and Evans, 1978,;and Durnford, 1992). Probably the vast majority of aircrew suffer leans at some stage or another and these episodes will remain their worst ever episodes until some other more unpleasant experience supersedes.

The more unpleasant experiences may take one of several forms. Recirculation problems such as brownout or whiteout are common (accounting for almost 10 percent of worst ever episodes and 16 percent of worst in the past 4 months episodes). They can be particularly dangerous because flight instruments give poor indications of aircraft motion in the hover, and hovering aircraft are especially unstable. This danger is reflected in the significant association between recirculation problems and a significant or severe classification. Inadvertent entry to IMC has similar effects to brownout or whiteout, but occurs in forward flight rather than in the hover. It is also a relatively frequent occurrence (4 percent of worst ever episodes and 5 percent of worst in the past 4 months episodes). Also, these episodes are associated significantly with serious or severe gradings.

A number of helicopter specific illusions (other than recirculation problems) have been reported in the past and still seem to occur. Flicker effects from sunlight through rotor blades were associated with eight (3 percent) of worst ever episodes. It was difficult to categorize these as true vertigo. Most (seven of the eight) involved powerful flickering in peripheral visual fields when practicing instrument flight under the hood. There were four other worst ever episodes that involved peripheral visual effects when under the hood; these all involved confusing visual stimuli such as perceptions of motion from passing trees.

Four blown grass illusions of motion occurred, as did two relative motion illusions (involving misperceived self-motion due to motion of another object). Of these six episodes, five occurred at night and four occurred on NVGs.

Flight in and out of cloud was also reported to be a source of SD in eight (3 percent) of worst ever episodes. This has been reported by aircrew to be a source of SD before (Durnford, 1992). Apart from the distractions caused by passing in and out of cloud boundaries, there is the difficulty of repeatedly shifting between instrument and visual flight.

Failure of the Apache PNVS system accounted for two episodes: In one case, the motor drive ran away leading to strong sensations of spinning, and in the other case, the motor drive locked (also leading to severe sensations of rolling and spinning).

Break-off and giant hand phenomena

Forty-four (15 percent) of aircrew reported having suffered break off phenomenon at some stage of their careers. Eighteen (6 percent) had suffered in the 4 months prior to the survey. This is an under-researched area that needs further attention, particularly as three (1 percent) had suffered break-off severe enough to put flight safety at risk. It should be noted that a typographical error crept into the last page of the questionnaire (section 4-1, page C-16), where the word accurate was inadvertently left out of the sentence: "This may be difficult to do but please give the most [accurate] figures that you can." It is impossible to quantify how much this affected respondents answers about break-off, but it is not considered that it affected them greatly (if only because the figures quoted are very similar to those from other surveys, such as the UK survey).

The figures for giant hand phenomenon were similar to those for break off. Forty-one (14 percent) respondents reported at least one episode during their career, and 15 (5 percent) reported at least one episode in the 4 months prior to the survey. However, only one respondent reported an episode severe enough to threaten flight safety.

Both break-off and giant hand have psychological overtones in that they fall to the cognitive rather than the physiological side of SD. It may not be surprising, therefore, that there was a significant overlap between the respondents who reported these conditions (19 [6 percent] reported both types of episodes). It is possible, however, that the overlap lies in the sort of people who will identify and report the episodes rather than in the people that actually suffer them. This is another area worthy of further research.

Experience and SD

Since the reported SD episodes could only occur during flight, one might expect a relationship between the number of hours flown and the incidence of episodes. To some extent this is confirmed by the significant relationship between mean flight hours at the time of the episode and the severity of the episode (see the next paragraph). Therefore, it is interesting that no difference could be shown between the mean total flight hours of those who claimed never to have been disorientated and those who reported episodes (1129 hours vs. 1037). This finding has been reported in other surveys (particularly the other survey most similar to this; the UK Army survey). This may reflect a sub-group of aviators who are either genuinely resistant to SD or who are resistant to recognizing or reporting SD. Terminology may play a part; it is possible that some aviators, despite careful explanations and briefs, still consider SD to be limited to specific situations such as vertigo or brownout. Nonetheless, research into personality variations and the likelihood of suffering and reporting SD would be a fruitful area (particularly as it could be postulated that aircrew who deny the existence of SD are most at risk of being unable to cope).

The patterns for mean flight hours at the time of worst ever and worst in the past 4 months episodes are not the same and are therefore difficult to interpret. For the worst ever group, the more severe the episode, the higher the mean flight time at the time of the episode. This significant finding is satisfactorily regular and can be easily explained by the assumption that the more one is exposed to flight, the more one is likely to suffer a severe episode. It also acts as evidence that experience is no protection against SD. The increase in flying skills and airmanship is not sufficient to compensate for the increased risk from high levels of exposure.

The 4-month data are also highly significant, but show a relatively high mean flight time for those reporting minor episodes (914 hours), a low flight time for those reporting significant episodes (439 hours), and a much higher flight time for those reporting severe episodes (2375 hours). It should be remembered that these are snap-shot data. Why should the more experienced aircrew be suffering the more severe episodes of SD during this brief period? And why should it be the least experienced who have the significant episodes, leaving the minor episodes to the group who have middling experience? Leaving aside the possibility of subject bias associated with different levels of experience, the first question might be answered by the hypothesis that the most difficult and provocative missions are likely to be given to the most experienced aircrew. These aircrew also are likely to be the pilots-in-command of the aircraft, and if they become disorientated, the episode is more likely to be perceived as a threat to flight safety than if they were just the copilots. By contrast, the pilots with low experience might be most likely to be impressed by an episode of SD, but because they are likely to be copilots, they may classify the episode as significant. (It will be remembered that the definition of a significant episode was one in which flight safety was not threatened but would have been threatened if circumstances been different, e.g., solo or close to the ground.)

Whatever the explanation, the 4-month data add support also to the proposition that experience is no protection against SD.

Crew position

Crew position is closely linked to experience. However, the data here, while showing a highly significant association between the crew position occupied and the severity of the episode, failed to show a relationship between the respondent's highest qualification and severity. Not only does this imply (again) that being in command of the aircraft during an episode increases the perceived safety threat, but it also adds weight to the argument that qualifications are no protection.

Other crewmembers disorientated

If SD affecting the senior member of the crew is seen as a particular threat to safety, then SD affecting both front seat members of the crew is likely to be seen as a threat as well. Therefore, It is not surprising that the data showed a highly significant association between both pilots being disorientated and a high rate of severe episodes.

More interesting are the absolute figures; 23 percent of all worst ever episodes appear to have involved both front seat aircrew being disorientated (40 percent of episodes involving NVDs). These figures are similar to those reported in the UK Army survey (16 percent overall and 44 percent of NVG episodes). The fact that both pilots are disorientated in almost half of the episodes occurring under NVDs must be a cause for concern. Having two front seat crewmembers does not, by itself, provide a sufficient measure of safety.

Crew coordination

Nonetheless, having two pilots does provide some safety back up, as is shown by the fact that good crew coordination prevented the incident being worse in 168 (73 percent) of worst ever episodes and 55 (83 percent) of the worst in the past 4 months episodes. In 30 percent of worst ever episodes, the respondent either handed over (or took) control of the aircraft. The figure was 25 percent for the 4-month data.

Unfortunately, crew communication and coordination is not always good. In 28 (12 percent) of the worst ever episodes, poor crew coordination either caused the episode or hampered recovery (or both). These episodes were more likely to be rated as significant or severe. The figure for the 4-month data was 7 (11 percent).

Equipment

Technological orientation assistance (in the form of basic flight instruments or symbology in helmet mounted displays) received 76 appreciative comments from the aircrew. These constituted the bulk of the 94 worst ever episodes in which equipment of some kind had been considered of benefit and provide strong support for the provision of flight information to aircrew through the NVG HUD or improved instrument displays.

By contrast, there were 46 worst ever episodes in which equipment had caused the SD or had made handling the episode more difficult. These were rated significantly more severe than other episodes. No specific trend could be identified from the 28 comments made by aircrew.

Aircraft type

It had been postulated that the more modern aircraft types (e.g., the AH-64) might pose particular problems in terms of night vision devices and workload, but no significant pattern linking SD to any aircraft type was demonstrated for the worst ever episodes. By contrast, however, X^2 testing on the 4-month data did reveal a significant pattern (at a level of $p=0.0015$), with the UH-60 showing a particularly high rate of significant/severe episodes (6 as opposed to 2.2 expected). Surprisingly, the AH-64 had fewer significant/severe episodes than expected, but the figures were small (2 cases against 4.6). If the UH-60 is excluded from the X^2 test, the p value drops to insignificance ($p=0.067$).

A further attempt to link aircraft type to the likelihood of SD was made by breaking down the number of episodes experienced in each type against respondents' flight hours in each type. This shows, for this data at least, that the two aircraft types with the highest rate of severe episodes per 100k hours flown were the UH-60 and the AH-64. This data should be treated with considerable caution because the information on flight hours was limited, and because respondents had a tendency to report episodes that were relatively fresh in their minds (while many hours flying may have occurred on the older types in the more distant past). Nonetheless, this finding matches the more objective and robust evidence of the survey into U.S. Army accidents, in which the aircraft types with the highest incidence of SD accidents per 100k flying hours were also found to be the AH-64 and the UH-60.

Although there may be insufficient evidence to state that the AH-64 and UH-60 are more provocative of SD than their predecessors, it certainly can be said they appear to be no better. This is not surprising, given that aircrew will fly any given machine to its limits, and increasing technical capability often means a narrower margin for error (as well as a less natural environment for the aircrew). As an example, NVGs and FLIR provide night vision that was not previously available, but the vision is considerably degraded compared to normal day vision (it is monochrome, displayed in a reduced field-of-view and of a resolution equal at best to 20/40 vision)(Rash, Verona, and Crowley, 1990). Aircrew using these systems are working with degraded cues, but are flying much the same flight profiles that they might during the day. Furthermore, the vision from NVDs is based predominantly on infrared (IR) reflectances, and therefore, provides a slightly different picture of objects than vision from visible light. In addition, the IR can see through some (but not all) weather, thus tempting aircrew to fly into unsuitable conditions. What is remarkable is not that SD occurs under these circumstances, but that it does not appear to happen often enough to show up strongly in the results of a survey like this.

Neither did it show in the analysis of aircrew opinion. No significant pattern linking aircraft types to the likelihood of suffering SD was demonstrated, although it appears that the back seat position on the AH-64 is associated with less severe episodes of disorientation than the front seat position. This may reflect differences between TADS and PNVS FLIR, or some other factor (such as the relative experience of the pilots occupying the two seat positions). No comments were written that would help identify the source of this difference, but it is an area worthy of further research.

Height and terrain

It is not surprising that the severity of worst ever episodes was linked to the height at which they occurred. It should be noted, however, that the mean height at which severe episodes occurred (576 feet) is misleading in that the distribution was skewed (the median was 100 feet, and the mode was 10 feet, indicating that the majority of events were at very low levels).

The link between height and severity is a potential confounding factor in other analyses, for example that of terrain, in which a highly significant link between desert terrain and severity was found for the worst ever episodes.

Deserts provide a difficult visual environment because there is little texture, and there are few known objects for size and distance estimations. Ridge lines or dunes may be hidden against a monotone backdrop. The absence of obstacles may induce aircrew to fly lower, and when they come to land they may suffer brownout. There are so many factors like these that it is impossible to tease out those that are particularly important. It is interesting, however, that no link with severity could be demonstrated for the visually similar environments of snow and water. (This was true even when the snow and water data were combined to give a similar number of episodes to the desert episodes.) The most obvious difference between the snow/water episodes and the desert episodes (apart from the actual terrain) is that a high proportion of desert episodes were associated with Operation Desert Storm. When episodes occurring during wartime are excluded, the significance value of the link between severity and a desert environment drops from p=0.0009 to p=0.021. This is difficult to interpret because the number drop as well from 35 to 23, and because many episodes could still have occurred under combat pressures during the build up to the war.

Wartime

Just as height may be a confounding factor in the analysis of terrain, so might terrain be a confounding factor in the analysis of combat pressure. A significant link was found between wartime and severity of the worst ever episode, but is it due to flight in the desert or to combat pressures leading to erosion of safety margins? The fact that snow/water episodes did not have a particularly high rate of severe episodes suggests that combat is the principal factor.

Further evidence for this comes from external sources. The UK Army survey also found a link between the Gulf War and both the rate of SD episodes per 10k flying hours and the severity of episodes. In addition, the survey of U.S. Army accidents found an increased rate of SD accidents in the Gulf when compared to desert accidents elsewhere.

Caution must be used in interpreting all the different factors, such as wartime and desert terrain, and the interplay between them. There are many other imponderables, such as the influence of higher nighttime/NVG rates, or the relative lack of other flight profiles such as routine instrument training. All these make definitive conclusions dangerous, other than those directly evident in the statistics; namely that when episodes are broken down by wartime and by desert, both categories show significant associations with severity. These findings in themselves should be a matter of concern for aviation commanders in charge of high priced and powerful assets. SD is not just a source of nonmilitary attrition, but is a cause of lost efficiency.

Effects of SD

Table 40 shows that five (2 percent) of the worst ever episodes led to an aborted mission, and a further five (2 percent) led to a mishap. The rates for the 4 months prior to the survey were one aborted mission and one mishap. (These each represent 2 percent of the reported episodes as well). Given that the survey covered only a small fraction of U.S. Army aircrew, the Army totals are likely to be considerably larger.

Aborted missions and mishaps may be the most dramatic results of SD, but there is a further cost in lost mission efficiency for those episodes which do not end so dramatically. Thirty-three percent of respondents stated that their worst ever episodes had affected the conduct of the mission. The figure for the 4-month data was 35 percent. Flying accuracy was lost, if only temporarily, in 64 percent of worst ever episodes and 68 percent of worst in the past 4 months episodes. These figures are similar to those revealed by the UK Army survey. (In 4 percent of UK episodes, the aircrew were unable to continue and flying accuracy was lost in 68 percent.)

Type of mission

It had been expected that attack missions might be especially provocative of SD because of the agile flight of attack helicopters and the use of night vision aids. In point of fact, the only mission profile which appeared to have a significant link with severity was troop movement (n=12, p=0.019). The significance became borderline (p=0.057) when the four wartime episodes were excluded from the analysis, however, this data matches that from the UK Army survey (in which the only significant link between severity and mission type also concerned troop insertion).

As with the analyses of wartime and terrain, there are many potential confounding factors (including wartime and terrain themselves). The UH-60 is the major troop carrier in the survey (as far as aircraft number is concerned), and it is often flown in this role under NVG. The UH-60 has already been shown to have had the highest SD rate per hours flown by respondents in this survey. It is impossible to know whether the aircraft type effects are secondary to the mission profile effects, or whether both are artifacts of desert and/or wartime conditions. What can be said is that it is not just the high profile, highly agile attack helicopters flying missions such as air combat maneuvering that deserve attention and effort.

Flight maneuvers

The relative increase in severity of the worst ever episodes associated with descending, decelerating, and hovering can be viewed as a relative reduction in severity associated with the other defined maneuvers of climbing, turning, and straight and level flight. This would then match the 4-month data in which there appeared to be a significant reduction in severity associated with turning.

Although the proportion of self-described leans amongst the episodes involving turning did not appear to be significantly larger than that for other episodes ($p=0.1$), a third of turning episodes were associated with this condition. These episodes would pose less of a threat to flight safety than, for example, brownout or whiteout (both of which involve descent, deceleration, and hovering).

The intention of the survey in asking for details of which maneuvers were being performed at the onset of SD was to shed light on whether vestibular illusions (such as g-excess illusions) were passing unnoticed. These results do not support the hypothesis that vestibular dysfunction is playing an unrecognized role in rotary-wing SD. In addition, analysis of respondents' descriptions demonstrated no significant link between severity and whether the perceptual error had been in pitch, roll, or both.

Nonetheless, it is important to note that vestibular illusions can be generated by low level g inputs of the type experienced by helicopter pilots, and that these may be insidious. As stated earlier, it is impossible to separate vestibular from visual inputs to orientation.

Misleading against insufficient cues

A distinct pattern is evident in Table 33, showing that visual cues were categorized as insufficient twice as often as they were categorized as actively misleading, while the reverse pattern was true for vestibular or seat-of-the-pants cues. Another way of sorting the data would show that 64 percent of all misleading cues were vestibular or seat-of-the-pants in origin, while 71 percent of insufficient cues were visual in origin. These data are based on the conscious perceptions of aircrew and therefore are subject to bias. Aircrew are taught to distrust vestibular or seat-of-the-pants sensations, and this may lead them to classify these cues as misleading rather than insufficient. On the other hand, the link between SD and situations involving loss of visual cues suggests that the high proportion of insufficient cues in the visual group is genuine. It is interesting that the number of reported problems from each sensory source was roughly equal (163 visual problems against 161 vestibular or seat-of-the-pants problems). There was considerable overlap, with 106 respondents reporting problems from both sensory groups.

No association could be demonstrated between the severity of the worst ever episodes and the presence of insufficient or misleading vestibular/seat-of-the-pants cues, but there were strong links between severity and the presence of either type of visual difficulty. Not surprisingly, the use of NVDs was significantly associated with both insufficient and misleading visual cues.

Types of spatial disorientation

SD is classically divided into type 1 (in which victims are unaware of being disorientated) and type 2 (in which they are aware of their predicament). Type 1 episodes can, of course, progress into type 2 (indeed all the episodes reported here must have been type 2 at some stage, by definition).

The data in this survey showed no significant link between the likelihood of being unaware of being disorientated and the sensory system involved. It is interesting that in 44 percent of episodes involving visual cues, aircrew were unaware of being disorientated at the onset of the episode. Similar high percentages have been reported before (50 percent in the UK Army survey).

In all, 43 percent of respondents were not immediately aware of being disorientated at the onset of their worst ever episodes. The length of time for which they were unknowingly disorientated ranged from 0.5 seconds to 10 minutes. The 75th percentile was 15 seconds (mean 25 seconds, mode 5 seconds). A great deal can happen to an aircraft during 5 seconds, but no link could be demonstrated between lack of immediate awareness of SD and severity of the episode. This is in contrast to other reports (e.g., the UK Army survey).

Focus of attention

In 31 (38 percent) of the worst ever episodes, respondents were unaware of being disorientated although they were looking outside the cockpit. The figure for the 4-month data was 24 percent. These proportions are very similar to those for the respondents who were "head in." Type 1 SD does not occur just when aircrew are distracted and look into the cockpit.

The largest proportion of SD episodes, of whatever type, do occur when aircrew are looking into the cockpit. (Sixty percent of worst ever episodes occurred when aircrew were attending to their flight instruments.) It is tempting to explain this large percentage in terms of the leans during instrument flight, but if this were the only explanation one would expect a relative reduction in severity for this group, and none could be demonstrated. Instead, the episodes that occurred when aircrew were attending to flight instruments appeared to be as severe as the episodes that occurred when their attention was elsewhere. This is worrying and indicates a possible need to improve flight instrumentation.

Physical and mental state

Although reporter bias cannot be ruled out, it is reassuring that so few episodes occurred in which the respondent had been ill or when taking alcohol or medicines.

Less satisfying was the lack of any demonstrable link between severity and human factors problems such as fatigue, distraction, or personal stress. As has been pointed out before, orientation in flight is a highly cognitive task, and one might expect factors affecting cognitive performance to also affect orientation.

The number of episodes involved for fatigued aircrew (e.g., 66 [30 percent] of worst ever episodes) imply that the negative findings of the survey are not due simply to lack of statistical power. That being so, it is necessary to ask why there is no link with severity. One explanation might be that there is truly no link, but two other possible explanations come to mind. Neither can be tested with this data. The first is that factors such as fatigue affect the <u>incidence</u> of SD more than they affect the severity. The second is that aircrew are capable of re-focussing themselves so efficiently that they can ignore debilitating factors (for short periods at least). There is some indirect evidence to support the latter in that the only significant association between mental state and severity of episode was a weak link between being alert and increased severity. This suggests that periods of high risk, such as coming to a hover in the desert, increased aircrew alertness (although other explanations are possible).

Interestingly, when respondents were asked to specify the source of any pressure they had been suffering, the greatest single factor appeared to be hierarchical pressure from an instructor pilot (IP) or a pilot-in-command (PC) (or stress from a checkride). Not only does this highlight how stressful these situations can be, but it suggests that aircrew have few comparable stresses from other sources.

Conclusions

The findings of this survey should be treated with the caution appropriate to a large number of statistical analyses.

Incidence and nature of SD episodes

This survey confirms that SD is a frequent and dangerous factor in U.S. Army rotary-wing aviation. Almost 80 percent of the 299 aircrew surveyed have suffered SD at sometime or other, and 8 percent have suffered severely enough for it to have put themselves and their aircraft at risk. Thirty-three percent of victims report that conduct of the mission was affected and 2 percent have had a mishap due to SD. In the 4 months prior to completing the questionnaire, five of the respondents had suffered a severe episode threatening flight safety and one had suffered a mishap.

Brownout, whiteout, and inadvertent entry to IMC were the most easily identifiable causes of severe episodes of SD. Between them they accounted for 13 percent of the worst ever episodes and 21 percent of the worst in the past 4 months episodes. Apart from the leans (which was reported in 44 percent of episodes), few of the problems commonly described in textbooks occurred. Confusion between ground lights and stars occurred in about 4 percent of episodes, flicker effects occurred in 3 percent (mostly when respondents were under the hood), and blown grass illusions occurred in 1 percent.

Fifteen percent of aircrew had suffered break-off and 14 percent had suffered giant hand illusions. Three percent had suffered break-off sufficiently severely for it to have threatened flight safety. In the 4 months prior to the survey, 6 percent of respondents had suffered break-off and 5 percent had suffered giant hand. The physiological and psychological bases for these events are obscure. It is possible that workload and attentional factors play a part in their genesis. Further research is required to confirm that aircrew are suffering these events and to investigate causes and solutions.

Contributing factors

Experience, whether measured in terms of qualifications or flying hours, offers no protection against SD.

Neither is having two pilots sufficient protection, both aircrew were simultaneously disorientated in 40 percent of episodes involving NVDs. Nonetheless, good crew coordination played an important and beneficial role in many episodes.

It was not possible to show that flight in NVDs was associated with a higher rate of severe episodes than flight under other conditions. This is no cause for complacency, however, because data from other surveys suggest that the greatest effect of NVDs is seen in an increased number of SD episodes rather than in the proportion that are severe. There was indeed a strongly significant link between the use of NVDs and the likelihood of aircrew reporting visual cues that were insufficient and/or misleading.

Similarly, it was not possible to show a significant link between aircraft type and the severity of SD episodes. Available evidence from flying hour records suggests that the UH-60 and AH-64 have the highest rate of SD episodes per hour flown. If this is so, it could be linked to many other factors, such as the use of NVDs or crew workload.

Flight over the desert and wartime were two factors linked to increased severity of episodes. The fact that there was no similar significant link for flight over snow (or water) suggests that wartime may be the key factor.

In 43 percent of worst ever episodes, aircrew were not immediately aware of being disorientated. This number was not significantly different whatever sensory system appeared to be involved. Even when they were looking outside the cockpit, 38 percent of aircrew were not immediately aware of being disorientated.

Sixty percent of worst ever episodes occurred when aircrew were paying attention to their flight instruments. These episodes were not significantly different in severity to the others, which might be considered to be evidence that instrumentation requires improvement. Nonetheless, the benefits of instrumentation or flight symbology received comment in 33 percent of worst ever episodes. Efforts to improve the provision of flight information through NVG HUDs or other instrumentation devices should continue.

Recommendations

It is recommended that:

- Efforts are made to improve training by requiring refresher education in SD at least every 3 years. Consideration should be given to introducing SD training that is more specific by simulating whiteout and brownout and inadvertent entry to IMC in addition to conventional vestibular training. Consideration also should be given to imitating the confusion generated by SD through software in simulators that can create sensory mismatches between the visual scene and the motion base cues.

- Commanders should be made aware of the incidence and nature of SD as well as of the multifactorial nature of the causative agents. They should be made particularly aware of the risks associated with wartime pressures.

- Further research should be undertaken on the particular orientation problems posed by NVDs and potential solutions. Work should progress on the NVG HUD.

- Further work should be undertaken also on improving instrument displays.

- Research into break-off and giant hand phenomena amongst rotary-wing aircrew should be performed. This should include personality profiling as well as detailed analysis of these events and the background to them.

- A further survey should be undertaken in 5-10 years.

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Appendix A

Explanatory letter

EXPLANATORY LETTER

January 1993

DISORIENTATION SURVEY 1992

Many thanks for taking part in this survey into Spatial Disorientation!

You are probably thinking "Why me, O Lord?" as you read this - but even as your heart sinks towards your boots please remember that disorientation costs lives. We need to get a better handle on it and only aviators like YOU can provide the information we need. Completing the questionnaire shouldn't take more than 30 minutes of your time.

The questionnaire is voluntary. ANY ANSWERS YOU GIVE WILL BE TREATED IN THE STRICTEST CONFIDENCE AND NO RESULTS WILL BE PUBLISHED THAT COULD IN ANY WAY LEAD TO YOUR IDENTIFICATION. INDEED, YOU WILL NOTICE THAT YOUR ANSWERS WILL BE ENTIRELY ANONYMOUS. Finally, if you really do not wish to participate please put a diagonal line across the front page and return the questionnaire to us (there will be no penalties at all for doing this).

In answering the questions, please be absolutely honest, careful and accurate.

In order that we can determine the influence of various factors we need to have a record of how many hours you have logged under various conditions - so please staple your DA 759 to the questionnaire AFTER HAVING REMOVED YOUR NAME (if you so wish).

THANK YOU AGAIN - THE INFORMATION WE GAIN CAN ONLY BE OF BENEFIT TO ALL ARMY AVIATORS.

DEFINITIONS - IT IS IMPORTANT THAT YOU READ THIS SECTION PRIOR TO COMPLETING THE QUESTIONNAIRE.

Spatial Disorientation. The classical definition of Spatial Disorientation involves being mistaken or uncertain about 'your motion, position or attitude relative to the Earth's surface or its gravitational pull'. Those of you better at interpreting small print than many of us in the medical services will note that this could include getting lost. For this survey we are NOT interested in 'Geographical Disorientation' (or getting lost) - we are concerned only about those episodes when one isn't quite sure which way is up, or in which one doesn't have the correct perceptions to fly the aircraft appropriately. Examples might include (but are by no means limited to) the 'leans', episodes of 'vertigo', brownout or whiteout, disorientation resulting from unusual attitudes, mistaken sensations of movement or failing to detect movement, 'losing it' after inadvertent entry to IMC ...etc...etc...etc..

'Break Off' Phenomenon. In a separate section of this questionnaire we ask about the phenomenon of 'Break Off' - which is a bizarre and anxiety provoking sensation of being unreal, or a feeling of isolation or detachment from one's aircraft. In some cases people have reported feeling that they were actually outside their aircraft. Not unnaturally it can be quite an unsettling experience(!) - which is why we would like to get a better idea of how common it is. 'Break Off' is commonly considered as a form of disorientation but for this questionnaire please do NOT include episodes of 'Break Off' in your answers except in the one brief section dedicated to this phenomenon.

Degrees of Disorientation. We also ask you to classify any episodes of disorientation you report as 'Minor', 'Significant' or 'Severe' according to the following definitions:

'Minor': Episodes in which flight safety was NOT put at risk (and would NOT have been jeopardized even under different circumstances such as being solo or close to the ground).

'Significant': Episodes in which flight safety was NOT put at risk but in which it MIGHT HAVE BEEN jeopardized under different circumstances (such as being solo or close to the ground).

'Severe': Episodes in which flight safety WAS put at risk.

Very many thanks again for completing this survey. I wish I could promise you a Free Gift or some sort of Money Off Voucher for your time and trouble. You can always take this letter down to the supply sergeant's stores and ask if you like......

SJ DURNFORD
LTC, UK ARMY
Research Flight Surgeon

PS. If you would like a copy of the results of this survey when they are published, please tear off this slip (having filled in your name and address) and hand it to one of us. Thankyou for your time and trouble.

Rank:________ Name:______________________________________
Unit:____
Address:____
State:______________________________ Zip:________________

Appendix B

Disorientation survey questionnaire

SURVEY APPROVAL AUTHORITY : US ARMY RESEARCH INSTITUTE
SURVEY CONTROL NUMBER : PERI-AO-93-25
RCS : MILPC-3

DISORIENTATION SURVEY QUESTIONNAIRE

PLEASE READ THE ACCOMPANYING LETTER BEFORE COMPLETING THIS QUESTIONNAIRE.

Please give your:

Age (in years): ☐ Rank: ☐

SECTION 1 - FLYING EXPERIENCE.

1.1 PLEASE ATTACH YOUR FORM DA 759 GIVING YOUR TOTAL FLYING HOURS AND YOUR FLYING HOURS IN THE PAST FOUR MONTHS. (This questionnaire is ENTIRELY confidential and NO publication or follow up of individual responses will occur IN ANY WAY WHATSOEVER. Nonetheless, please feel absolutely free to confirm your anonymity by obliterating your name from the DA 759.

1.2 Please give below your CIVILIAN flying hours:

	FIXED WING	ROTARY WING
TOTAL:		
OVER THE PAST 4 MONTHS:		

1.4 Type of wings held at present (if pilot). (Check ONE box):

AVIATOR'S	SENIOR AVIATOR'S	MASTER AVIATOR'S

SECTION 2 - DISORIENTATION EXPERIENCE (PLEASE READ THE ACCOMPANYING LETTER FOR DEFINITIONS)

(If you have never been disorientated please tick this box and go to Section 4, page 16.) ☐

2.1 PLEASE DESCRIBE - BY ANSWERING THE FOLLOWING QUESTIONS - THE MOST DISORIENTATING EXPERIENCE YOU HAVE EVER SUFFERED IN THE WHOLE OF YOUR FLYING CAREER:

Grade of Disorientation Episode (check ONE box):

Minor	Significant	Severe

Aircraft type and model (and seat occupied if AH64): ☐

Experience at time of incident (TOTAL flying hours): [ ]

Flight Conditions (check ONE box only):

AA	D	DG	DS	H	N	NG	NS	TR	W

Outside Visual References (check ONE box only, please make an estimate even if you were 'under the hood'):

GOOD	ACCEPTABLE	BAD	CAN'T REMEMBER

What was your Crew Position? (check ONE box only):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

What were your qualifications at the time of episode? (check AS MANY BOXES as appropriate):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

AVIATOR'S WINGS	SENIOR AVIATOR'S WINGS	MASTER AVIATOR'S WINGS

Crew Composition - who else was with you? (please give total numbers in each category - COUNTING EACH INDIVIDUAL ONCE ONLY ACCORDING TO HIS/HER HIGHEST QUALIFICATION):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

How many other crew members were also disorientated? (please give below the number of crew in each category, MARKING 'C' BESIDE THOSE THAT YOU ARE CERTAIN WERE DISORIENTATED AND 'S' BESIDE THOSE THAT YOU SUSPECT WERE DISORIENTATED):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

Approximate height (in feet agl) **at the onset of incident:** [ ]

Please give details of the situation that existed AT THE TIME OF ONSET OF THE INCIDENT (please answer each question):

	YES	NO	CAN'T REMEMBER
In VMC			
In IMC			
Intentionally entering IMC			
Inadvertent entry to IMC			
Raining at the time			
Snowing at the time			
Non-rain, non-snow precipitation			
Flight in twilight			
Flight into Sun			
Flight away from or across Sun			
No Sun			
Full Moon			
Part Moon			
No Moon			
Over water			
Over snow			
Over desert			
In mountains			
Mission Training			
On actual wartime operations			
Obs and Recon Mission			
Attack Mission			
Escort Mission			
Troop Movement Mission			
Medevac Mission			
Admin Mission			
Check Ride			
Please give your unit's location at the time of the incident:			

Flying maneuvers at the <u>onset</u> of incident (check AS MANY as are applicable):

	YES	NO	CAN'T REMEMBER
Flying straight and level			
Turning LEFT			
Turning RIGHT			
Climbing			
Descending			
Accelerating			
Decelerating			
Hovering			

Physical state at the <u>onset</u> of the incident:

	YES	NO	CAN'T REMEMBER
Were you suffering from any medical problem (including minor colds, allergies etc)?			
Had you taken alcohol or any medications in the previous 24 hours?			
If the answer to either of the above was 'YES" please specify:			

State of mind at the <u>onset</u> of the incident? (please answer each question):

	YES	NO	CAN'T REMEMBER
Were you alert?			
Were you bored?			
Were you tired?			
Were you feeling happy?			
Were you feeling depressed?			
Were your thoughts distracted by something related to your flight?			
Were your thoughts distracted by something unrelated to your flight?			
Did you feel pressured in any way?			
Please describe the source of any problems:			

Where was your attention focussed at the onset of the incident?

	YES	NO	CAN'T REMEMBER
Head out of cockpit			
Attending to Flight Instruments			
Attending to Systems, Nav or Radios			
Head in cockpit for another reason (please specify):			

What perceptual problems led you to become disorientated? (please answer all questions):

	YES	NO	CAN'T REMEMBER
Did you suffer from MISLEADING visual cues?			
Did you suffer from INSUFFICIENT visual cues?			
Did you suffer from MISLEADING cues from the 'seat of your pants' or other 'bodily' senses?			
Did you suffer from INSUFFICIENT cues from the 'seat of your pants' or other 'bodily' senses?			
What did you THINK your aircraft was doing (in terms of attitude, flight path and speed):			
What did your aircraft REALLY do (in terms of attitude, flight path and speed):			
Please describe what cues you would highlight as being particularly absent or misleading:			

Timing:

	YES	NO	CAN'T REMEMBER
Were you IMMEDIATELY aware that you were disorientated?			
If not, for how many seconds might you have been unknowingly disorientated?:			

Effects on aircraft control:	YES	NO	CAN'T REMEMBER
Were you handling the aircraft at the onset of the incident?			
Did you hand over or take control?			
Did your flying control remain as accurate as normal for ALL periods that you had control?			
Did you temporarily lose accuracy but then regain it before the end of the sortie?			
Did you lose accuracy and never fully regain it during the rest of the sortie?			
Did the incident prevent you completing the rest of the sortie as planned?			
Did you suffer a mishap?			

Equipment:	YES	NO	CAN'T REMEMBER
Did any personal or aircraft equipment CAUSE the incident or MAKE IT WORSE?			
Did any equipment make the incident EASIER TO HANDLE?			
If you have answered 'yes' to either question above please detail the equipments and their problems or benefits:			

Crew Coordination:	YES	NO	CAN'T REMEMBER
Did POOR crew coordination contribute to the generation of the incident?			
Did POOR crew coordination hamper recovery?			
Did GOOD crew coordination prevent the incident being worse?			

Please tick this box if you would classify this episode as 'the leans': ☐

Please give a brief description of the event and add any points that you think are relevant and which have not been previously covered:

2.2 PLEASE DESCRIBE - BY ANSWERING THE FOLLOWING QUESTIONS - THE MOST DISORIENTATING EXPERIENCE THAT YOU HAVE SUFFERED IN THE LAST FOUR COMPLETE MONTHS (do not include the present month).

If your worst episode in the last 4 months is the same incident as you have described above, please tick this box and go to Section 3 on page 14: ☐

If you have not suffered even a single episode of disorientation in the last 4 months please tick this box and go to Section 3 on page 14: ☐

Grade of Disorientation Episode (check ONE box):

Minor	Significant	Severe

Aircraft type and model (and seat occupied if AH64): ☐

Experience at time of incident (TOTAL flying hours):

Flight Conditions (check ONE box only):

AA	D	DG	DS	H	N	NG	NS	TR	W

Outside Visual References (check ONE box only, please make an estimate even if you were 'under the hood'):

GOOD	ACCEPTABLE	BAD	CAN'T REMEMBER

What was your Crew Position? (check ONE box only):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

What were your qualifications at the time of episode? (check AS MANY BOXES as appropriate):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

AVIATOR'S WINGS	SENIOR AVIATOR'S WINGS	MASTER AVIATOR'S WINGS

Crew Composition - who else was with you? (please give total numbers in each category - COUNTING EACH INDIVIDUAL ONCE ONLY ACCORDING TO HIS/HER HIGHEST QUALIFICATION):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

How many other crew members were also disorientated? (please give below the number of crew in each category, MARKING 'C' BESIDE THOSE THAT YOU ARE CERTAIN WERE DISORIENTATED AND 'S' BESIDE THOSE THAT YOU SUSPECT WERE DISORIENTATED):

SP	IP	IE	XP	ME	MP	PC	PI	CP	UT	AO	CE	OR	MO

Approximate height (in feet agl) at the onset of incident:

Please give details of the situation that existed AT THE TIME OF <u>ONSET</u> OF THE INCIDENT (please answer each question):

	YES	NO	CAN'T REMEMBER
In VMC			
In IMC			
Intentionally entering IMC			
Inadvertent entry to IMC			
Raining at the time			
Snowing at the time			
Non-rain., non-snow precipitation			
Flight in twilight			
Flight into Sun			
Flight away from or across Sun			
No Sun			
Full Moon			
Part Moon			
No Moon			
Over water			
Over snow			
Over desert			
In mountains			
Mission Training			
On actual wartime operations			
Obs and Recon Mission			
Attack Mission			
Escort Mission			
Troop Movement Mission			
Medevac Mission			
Admin Mission			
Check Ride			
Please give your unit's location at the time of the incident:			

Flying maneuvers at the <u>onset</u> of incident (check AS MANY as are applicable):

	YES	NO	CAN'T REMEMBER
Flying straight and level			
Turning LEFT			
Turning RIGHT			
Climbing			
Descending			
Accelerating			
Decelerating			
Hovering			

Physical state at the <u>onset</u> of the incident:

	YES	NO	CAN'T REMEMBER
Were you suffering from any medical problem (including minor colds, allergies etc)?			
Had you taken alcohol or any medications in the previous 24 hours?			
If the answer to either of the above was 'YES" please specify:			

State of mind at the <u>onset</u> of the incident? (please answer each question):

	YES	NO	CAN'T REMEMBER
Were you alert?			
Were you bored?			
Were you tired?			
Were you feeling happy?			
Were you feeling depressed?			
Were your thoughts distracted by something related to your flight?			
Were your thoughts distracted by something unrelated to your flight?			
Did you feel pressured in any way?			
Please describe the source of any problems:			

Where was your attention focussed at the onset of the incident?

	YES	NO	CAN'T REMEMBER
Head out of cockpit			
Attending to Flight Instruments			
Attending to Systems, Nav or Radios			
Head in cockpit for another reason (please specify):			

What perceptual problems led you to become disorientated? (please answer all questions):

	YES	NO	CAN'T REMEMBER
Did you suffer from MISLEADING visual cues?			
Did you suffer from INSUFFICIENT visual cues?			
Did you suffer from MISLEADING cues from the 'seat of your pants' or other 'bodily' senses?			
Did you suffer from INSUFFICIENT cues from the 'seat of your pants' or other 'bodily' senses?			
What did you THINK your aircraft was doing (in terms of attitude, flight path and speed):			
What did your aircraft REALLY do (in terms of attitude, flight path and speed):			
Please describe what cues you would highlight as being particularly absent or misleading:			

Timing:	YES	NO	CAN'T REMEMBER
Were you IMMEDIATELY aware that you were disorientated?			
If not, for how many seconds might you have been unknowingly disorientated?:			

Effects on aircraft control:	YES	NO	CAN'T REMEMBER
Were you handling the aircraft at the onset of the incident?			
Did you hand over or take control?			
Did your flying control remain as accurate as normal for ALL periods that you had control?			
Did you temporarily lose accuracy but then regain it before the end of the sortie?			
Did you lose accuracy and never fully regain it during the rest of the sortie?			
Did the incident prevent you completing the rest of the sortie as planned?			
Did you suffer a mishap?			

Equipment:	YES	NO	CAN'T REMEMBER
Did any personal or aircraft equipment CAUSE the incident or MAKE IT WORSE?			
Did any equipment make the incident EASIER TO HANDLE?			
If you have answered 'yes' to either question above please detail the equipments and their problems or benefits:			

Crew Coordination:	YES	NO	CAN'T REMEMBER
Did POOR crew coordination contribute to the generation of the incident?			
Did POOR crew coordination hamper recovery?			
Did GOOD crew coordination prevent the incident being worse?			

Please tick this box if you would classify this episode as 'the leans': ☐

Please give a brief description of the event and add any points that you think are relevant and which have not been previously covered:

SECTION 3 - VIEWS AND OPINIONS.

In this section we ask you to rate various aircraft and situations on their likelihood to provoke SIGNIFICANT or SEVERE disorientation. In doing so, please use the following scale:

'1' means "Much less likely than average".

'2' means "Less likely than average".

'3' means "Average".

'4' means "More likely than average".

'5' means "Much more likely than average".

3.1 Using the above scale, please rate the likelihood of the following aircraft types and conditions to provoke significant or severe disorientation. PLEASE RATE ONLY THOSE AIRCRAFT AND CONDITIONS THAT YOU PERSONALLY KNOW WELL - AND USE YOUR OWN EXPERIENCE RATHER THAN GIVE WHAT YOU THINK IS THE CORRECT 'THEORETICAL' ANSWER. THANKYOU.

	AA	D	DG	DS	H	N	NG	NS	TR	W
UH1										
MH60										
UH60										
OH6										
OH58 A/C										
OH58 D										
AH1										
AH64 Front										
AH64 Back										
CH47										
Other Mil RW										
Mil FW										
Civ RW										
Civ FW										

Please describe the problems with the 'bad' aircraft or conditions:

3.2 Please use the same scale to rate the likelihood of the following sortie types or situations to provoke significant or severe disorientation. (1=much less likely than average, 2=less likely than average, 3=average, 4=more likely than average, 5=much more likely than average.) PLEASE USE ONLY YOUR OWN PERSONAL EXPERIENCE RATHER THAN GIVE WHAT YOU MIGHT FEEL IS THE CORRECT 'THEORETICAL' ANSWER (ignore questions you do not feel able to answer):

VMC	
IMC	
Intentional entry to IMC	
Inadvertent entry to IMC	
Precipitation - Rain	
Precipitation - Snow	
No precipitation	
Flight in twilight	
Flight into Sun	
Flight away from or across Sun	
No Sun	
Full Moon	
Part Moon	
No Moon	
Flight over water	
Flight over snow	
Flight over desert	
Flight in mountains	
Mission Training	
Actual wartime operations	
Obs and Recon Missions	
Attack Missions	
Escort Missions	
Troop Movement Missions	
Medevac Missions	
Admin Missions	

Please describe the reasons behind the 'bad' situations:

SECTION 4 - 'BREAKOFF'.

4.1 Please estimate the **NUMBER** of times over the **WHOLE** of your flying career that you have suffered **BREAK OFF PHENOMENON** (a feeling of breaking away from reality while flying - see the accompanying letter for a fuller description). This may be difficult to do but please give the most figures that you can:

MINOR	SIGNIFICANT	SEVERE

4.2 Please estimate the **NUMBER** of times you have suffered **BREAK OFF PHENOMENON** over the **LAST 4 COMPLETE MONTHS** (please ignore the present month):

MINOR	SIGNIFICANT	SEVERE

SECTION 5 - 'GIANT HAND' PHENOMENON

5.1 Please estimate the **NUMBER** of times over the **WHOLE** of your flying career that you have suffered **GIANT HAND PHENOMENON** (a sensation that the control system is malfunctioning as if there were a 'Giant Hand' manipulating the aircraft in one direction or another. Victims may feel that there is a 'force' preventing their control inputs. Some have found that the only away they can overcome the 'force' is by lightening their control grip to finger and thumb only).

MINOR	SIGNIFICANT	SEVERE

5.2 Please estimate the **NUMBER** of times you have suffered **GIANT HAND PHENOMENON** over the **LAST 4 COMPLETE MONTHS** (please ignore the present month):

MINOR	SIGNIFICANT	SEVERE

SECTION 6 - FINALLY........

6.1 Please make any comments or suggestions you want to about disorientation in Army flying, its relationship to our working practices, our aircraft and equipment - and what might, could or should be done about it (add further sheets of paper if necessary):

Appendix C

List of manufacturers

List of manufacturers

Statistica v4.5
StatSoft, Inc.
2325 East 13th Street
Tulsa, OK 74104