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Visual Issues Survey of AH-64 Apache Aviators (Year 2000)

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A web-based survey was conducted investigating AH-64 Apache pilot experience with the Integrated Helmet Display Sighting System (IHADSS). A total of 216 respondents provided responses in the following areas: visual complaints, helmet fit, and acoustics. Data indicated that 92% of respondents reported at least one visual complaint either during or after IHADSS flight. Additional findings include: no association between eye preference and frequency of complaints, an increase in frequency of visual complaints from a previous 1990 study, and no correlation between frequency of visual complaints and age or experience.

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Introduction

The AH-64 Apache aircraft is the U.S. Army's most advanced attack helicopter (Figure 1). There are currently two models (A & D) of the Apache. The later D-model differs from the A-model primarily in cockpit design and the addition of a mast-mounted radar system. The Apache aviator flies using a helmet mounted display (HMD) known as the Integrated Helmet and Display Sighting System (IHADSS)* (Figure 2). The IHADSS provides pilotage imagery from a forward-looking infrared (FLIR) sensor mounted on the nose of the aircraft and aircraft parameter symbology. The IHADSS is a monocular HMD, presenting imagery to the right eye only.

Figure 1. The AH-64A (left) and AH-64D (right) Apache helicopters.

Figure 2. The AH-64 Integrated Helmet and Display Sighting System (IHADSS).

When the IHADSS is used, the visual input to the two eyes differs greatly. This situation, referred to as dichoptic viewing, gives rise to binocular rivalry, a competition between the two eyes for the information that gains attention. In the IHADSS, the left

*See Appendix H for list of acronyms.

eye views the outside real world, while the right eye views the pilotage imagery and/or symbology provided by the aircraft's sensors and computers. Rivalry between the two scenes can be resolved by suppressing visual input unilaterally, but attention may alternate involuntarily between the two scenes. Such dichoptic viewing, under extended periods of monocular viewing and suppression, places tremendous demands on the human visual system and can be expected to result in increased workload and stress levels.

The AH-64 (A-model) Apache was fielded in the early 1980s. As aviators gained experience with the use of a novel monocular HMD, complaints of visual problems began to surface. In a very limited survey of AH-64 Apache aviators, Hale and Piccione (1989) reported that flying the IHADSS at night often led to physical fatigue and headaches. Among the causes they identified were binocular rivalry, poor FLIR image quality, narrow field of view (FOV), poor depth perception, inadequate eye relief, and general system discomfort. In addition to this survey, anecdotal complaints were reported to flight surgeons and unit commanders at the Army's rotary-wing training center at Fort Rucker, Alabama. In response to the above complaints, in early 1990, the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama, conducted a study (Behar et al., 1990) using the large training population of AH-64 Apache aviators located at Fort Rucker to address the visual medical concerns associated with flying this unusual visual imaging system. The results of this study are summarized in the following section. In addition, in the Fall of 1989, Crowley (1991) distributed a questionnaire to the military helicopter community, the purpose of which was to investigate the breadth of visual illusions experienced by aviators flying with night vision devices (NVDs), to include the AH-64 Apache FLIR. Of the 242 returned questionnaires, 21 were from AH-64 Apache aviators. The results of this illusion questionnaire also are reported below.

Within the last few years, a number of foreign countries have begun fielding the AH-64 Apache helicopter. This expansion has fueled new concerns about the previously identified visual complaints associated with the AH-64 Apache IHADSS. To reinvestigate the visual issues associated with the IHADSS, USAARL has conducted an expanded follow-up survey of current U.S. AH-64 Apache aviators. This report documents the findings of this new survey.

Background

The 1989 and 1990 studies addressing visual problems associated with the AH-64 Apache helicopter and its FLIR system and IHADSS HMD both substantiated the anecdotal complaints voiced by the Apache aviator community and reported by Hale and Piccione (1989). The following are brief summaries of the results of these studies.

Visual illusions with night vision devices questionnaire

In the 1989 NVD visual illusion study (Crowley, 1991; Crowley et al, 1992), 243 questionnaires were returned. These included 221 reporting illusions or other visual effects with image intensification systems (i.e. night vision goggles) and 21 reporting

illusions or other visual effects with the AH-64 Apache FLIR sensor and IHADSS. Table 1 summarizes the environmental and operational conditions under which the visual illusions and effects were experienced for the AH-64 Apache incidents. Factors contributing to the reported incidents are presented in Table 2.

Table 1.
Conditions at time of reported event (n=21).
(Crowley, 1991)

Condition	% (n)
Illumination level	
0-24%	24 (5)
25-49%	- -
50-74%	- -
75-100%	- -
Any	33 (7)
Weather	
Clear	33 (7)
Fog/haze	24 (5)
Rain	4 (3)
Any	19 (4)
Other	5 (1)
Terrain	
Trees	33 (7)
Open field	19 (4)
Mountains	- -
Water	5 (1)
Tall grass	5 (1)
Desert	- -
Confined area	10 (2)
Snow covered	5 (1)
Any terrain	19 (4)
Other	14 (3)
Flight phase	
Cruise	29 (6)
Hover (in ground effect)	24 (5)
Approach/handling	10 (2)
Hover (out of ground effect	5 (1)
Formation flight	- -
All phases	24 (5)
Other	10 (2)

Note: Illumination level is approximated by the percent of the moon's surface that is illuminated. All table percentages are reported to the nearest integer. Table 1 reflects the number of responses to each question within NVD/aircraft category. Therefore, column totals may not equal category totals.

Table 2.
Reported contributing factors (n=21).
(Crowley, 1991)

Report	% (n)
Human factors	
Lack of experience	10 (1)
Looking inside cockpit	5 (1)
Fatigue	6 (1)
Visual fixation	10 (2)
Poor display adjustment	5 (1)
Misinterpretation of symbology	5 (1)
Internal lights	
Reflections on inside of canopy	5 (1)
External lights	
Built up areas	5 (1)

The reports from the questionnaires were classified as either reports of degraded visual cues, static illusions, dynamic illusions, or miscellaneous reports. The most common degraded visual cue was impaired acuity (14%), i.e., degraded resolution/insufficient detail; the most common static illusion was that of faulty height judgment (19%); the most common dynamic illusions were undetected aircraft drift (24%) and illusory aircraft drift (24%), followed by disorientation (14%) and faulty closure judgment (10%); the most common miscellaneous report was distracting symbology. Summaries of reports are presented in Tables 3 through 6.

Table 3.
Reports of degraded visual cues (n=21).
(Crowley, 1991)

Report	% (n)
Degraded resolution/ insufficient detail	14 (3)
Loss of visual contact with horizon	10 (2)
Impaired depth perception	10 (2)
Decreased field of view	10 (2)
Inadvertent IMC	5 (1)

Table 4.
Reports of static illusions (n=21).
(Crowley, 1991)

Report	% (n)
Faulty height judgment	19 (4)
Trouble with lights	5 (1)

Table 5.
Reports of dynamic illusions (n=21).
(Crowley, 1991)

Report	%	(n)
Undetected aircraft drift	24	(5)
Illusory aircraft drift	24	(5)
Disorientation ("vertigo")	14	(3)
Faulty closure judgment	10	(2)

Table 6.
Miscellaneous reports (n=21).
(Crowley, 1991)

Report	%	(n)
Hardware-related problems Distracting symbology	14	(3)
Crew coordination problems Mixing FLIR and image Intensification	5	(1)
Physiological effects Dark adaptation effects	5	(1)

In summary, the questionnaire responses, although based on a very limited sample size (n=21), provided additional evidence that Apache aviators flying with the FLIR sensor and IHADSS HMD were experiencing visual problems and illusions which were possibly degrading mission performance.

The 1990 Visual Issues Survey of Apache Aviators (VISAA)

The VISAA study was designed specifically to address the visual medical concerns associated with the Apache IHADSS. It consisted of three parts that addressed separate aspects of Apache aviator vision. The first part was primarily an epidemiological appraisal that documented visual problems experienced by the Fort Rucker Apache instructor pilot (IP) population. The second part was a clinical and laboratory evaluation of the refractive and visual status of a sample of these aviators. The third part assessed Apache pilots' adjustment of the IHADSS dioptric settings (i.e., focus setting).

Beginning with the lesser parts of the VISAA study, part three assessed dioptric focus setting. Twenty Apache (AH-64A) aviators served as subjects. Nine subjects were measured under nighttime conditions; the remaining 11 were measured under daytime conditions. Measurements were taken on the flight line during actual aviator preparation for aircraft launch. Following their adjustment of the helmet display unit (HDU), the aviators were instructed to hand the HDU to the investigator, who measured the focus dioptric setting using a mini-dioptometer. The range of measured settings was 0 to –5.25 diopters with a mean of –2.28 diopters. The study concluded that the required positive

accommodation by the eye to offset these inappropriate negative focus settings was very likely a source of reported headaches and visual discomfort during and after long flights. The study found no correlation between the focus settings and aviator age or experience; nor were there differences between IPs and students, or day versus night settings.

The second part of the study was a clinical visual evaluation of 10 IPs. They ranged in age from 32 to 44, mean of 38.6 years. Their average total flight hours was 4560 hours, ranging from 2800 to 5800 hours; their AH-64 Apache flight hours ranged from 400 to 1500 hours with a mean of 895 hours. The subjects estimated that they had flown, on average, 28.7 hours (range = 2 to 50 hours) in the AH-64 Apache during the 30 days prior to the study. The clinical evaluation consisted of a comprehensive visual function test battery which included assessment of visual acuity, contrast sensitivity, color vision, depth perception, sighting preference, binocular rivalry, and clinical optometric tests of manifest and cycloplegic refractions, accommodative function, and oculomotor status. No significant variation from expected normal values were found.

Part one of the 1990 study, and the motivation for the study presented herein, was an epidemiological vision survey. A questionnaire was forwarded to the 14th Aviation Regiment, Fort Rucker, Alabama, to be distributed to the Apache IP population. Fifty-eight questionnaires were completed and returned. Demographic information on the respondents is presented in Table 7.

Table 7.
1990 VISAA demographics.*
(Behar et al., 1990)

	Mean	Range
Age	35.8 years	26-44 years
Years of service	15.3 years	4-24 years
Total flight hours	3,330	1000-9000
AH-64 flight hours	664.4	150-1500 (n=55)
AH-1** flight hours	1707	150-5000 (n=54)
AH-64 hours in last 30 days	32.3	2-60
Percent of recent time in crew station		
Pilot	20	8-96
Copilot	80	10-100
	Yes	No
Night vision goggle qualified	51 (88%)	7 (12%)
Eyeglass wearer	20 (34%)	38 (66%)

*n=58 unless otherwise noted
**AH-1 Cobra attack helicopter

More than 80 percent of the aviators registered at least one visual complaint associated with periods of flying or following flight in the Apache aircraft. Many of the comments indicated that symptoms occurred during long flights and/or while flying with poor quality or out-of-focus display symbology. The most common symptom experienced was

that of visual discomfort while flying the aircraft. Fifty-one percent of the aviators indicated that they sometimes experienced visual discomfort *while* flying; only 28 percent reported a similar problem *after* flying. About one-third of the aviators reported suffering from occasional headaches and approximately 20 percent reported that they sometimes experienced either blurred vision and/or disorientation while flying. The percentages of pilots reporting headache and blurred vision remained about the same after flight, while the percentage of those experiencing postflight disorientation decreased to five. About 20 percent of all aviators reported the presence of afterimages following flight. The percentages of aviators reporting specific visual symptoms *during* and *after* flight are presented in Table 8.

Table 8.
Percentage of aviators reporting visual symptoms *during* and *after* Apache flight.
(Behar et al., 1990)

	During flight (%)			*After* flight (%)		
	Never	Sometimes	Always	Never	Sometimes	Always
Visual discomfort	49	51	--	70	28	2
Headache	65	35	--	67	32	2
Double vision	86	12	2	89	9	2
Blurred vision	79	21	--	72	24	3
Disorientation	81	19	--	95	5	--
Afterimages	NA	NA	NA	79	19	2

Several additional questions regarding visual performance with the Apache HMD were asked. The results are summarized below:

- Fifteen aviators (26 percent) reported changes in their ability to see or interpret HMD symbology during flight.

- Approximately 70 percent of all aviators used the affirmative categories (Always, Usually, Sometimes) when asked if their vision ever alternated unintentionally between the two eyes either during or after Apache flight.

- Of the 20 self-reported eyeglass wearers, only 11 responded to the question of whether the use of "modified" spectacles (specially modified pairs of glasses where the frame is reshaped for a smaller right lens and bent toward the face) interfered with the ability to see HMD imagery and symbology; of those, however, 10 responded that the spectacles interfered with the viewing and reported significant discomfort from their wear.

Visual Issues Survey (Year 2000) of AH-64 Apache Aviators

The year 2000 survey was a near complete duplication of the original 1990 VISAA survey and the Crowley 1989 visual illusion questionnaire combined, with added sections to inquire about helmet fitting and acoustic issues. This duplication allows direct comparison between aviator visual complaints and illusions across the 10-year period. This is desirable for the following reasons: (1) there is renewed interest in the presence of visual complaints with use of the monocular IHADSS, fueled by expanded fielding of the AH-64 Apache helicopter in the United Kingdom and other countries; and (2) during this period, the flight track for AH-64 aviators has changed. During the early years of the AH-64 fielding, all AH-64 aviators were experienced aviators who had transitioned from other aircraft (primarily the AH-1 Cobra). Since 1986, AH-64 aviators began transitioning directly from initial entry rotary-wing (IERW) training into flying the AH-64 Apache. In addition to this change, the respondents in the 1990 study were all experienced IPs. The present (Year 2000) study included aviators with as few as 20 AH-64 flight hours.

The Year 2000 survey questionnaire is provided in Appendix A. The questionnaire consisted of six sections: (1) demographics, (2) visual history, (3) helmet fit, (4) aviation vision, (5) acoustical issues, and (6) an open-ended comment section. The demographics section addressed gender, age, total flight hours, AH-64 flight hours, and the distribution of AH-64 flight hours by front/back seat and day/night flight. The visual history section inquired about use of vision correction (i.e., spectacles and contact lenses), previous eye disease or injury, presence of visual symptoms (e.g., headaches, eyestrain, etc., not associated with flight), and eye preference and motor laterality (handedness). In the helmet fit section, aviators were asked to provide information regarding history, quality and satisfaction of their IHADSS helmet fit. The most important section, aviation vision, asked questions about visual complaints, symptoms and illusions experienced either *during* or *after* flight using the IHADSS HMD. This section also addressed intentional and unintentional switching of attention between the left, unaided eye, and the right, sensor-fed eye. The acoustic issues section inquired about AH-64 aviator awareness of the Communication Earplug (CEP). The final section was an open-ended question asking aviators to identify additional (visual) problems not previously addressed in the questionnaire.

The survey was conducted exclusively via the Internet. The questionnaire was developed and placed at a dedicated Internet address, reachable only by knowing the direct Internet address. This address was advertised in *Flightfax*, a U.S. Army Safety Center, Fort Rucker, Alabama, publication that is distributed to all U.S. Army aviation units. The Internet survey was advertised further via emails to commanders of all AH-64 units worldwide.

Since the data presented herein are the result of a voluntary survey rather than a random sample, readers are cautioned about inferring specific findings to the general population.

There were 224 questionnaires submitted via the Internet. Eight double submissions were excluded from this analysis, producing a final sample size of n=216. The current estimated AH-64 pilot population is given as 1826 (active duty and National Guard). Therefore, the survey sample size of n=216 is approximately 12% of the population. The response rate for each question was in excess of 98 percent. The questionnaires were completed anonymously, soliciting no identifying information other than gender and age.

Demographics

Demographic data for the 216 aviators completing the Internet survey are presented in Table 9. Included in this table is a summary of age, overall flight hours, flight hours spent specifically in the AH-64, and approximate flight hours spent in the AH-64 during the 30 days prior to responding to the survey. All responses from the Internet survey were by male aviators.

Table 9.
Year 2000 study demographics.
(n=216)

	Mean	Median	Range	Stand. Dev.
Age (years)	36.5	36	23 - 53	6.7
Total flight hours	2131	1750	220 - 9500	1738.3
AH-64 flight hours	1116.4	1000	20 - 5000	823.3
Flight hours AH-64 "A" model	1056.5	950	20 - 5000	800.7
Flight hours AH-64 "D" model	227.2	200	10 - 1000	150.4
AH-64 hours in last 30 days	18.5	17	0 - 90	14.6
Percent of time (last 30 days) in pilot station	45.6	50	0 - 100	27.8
Percent of time (last 30 days) in copilot/gunner station	54.4	50	0 - 100	27.8
Percent of time in day flight	52.0	50	0 - 100	17.5
Percent of time in night flight	48.0	50	0 - 100	17.5

Age

A frequency distribution of age is presented in Figure 3. Age ranged from 23 to 53 years with both a mean and median of approximately 36 years. A cumulative percentage curve for age (Figure 4) shows approximately 20% of respondents were age 30 years or younger and 30% were age 40 years or older. The interquartile range (which includes the middle 50% of respondent ages) was 8 years, from 32 to 40 years of age. One additional feature of the age histogram (Figure 3) of special note is the small hump (mode) at 50 years. This small group was very likely composed of the older, more experienced IPs. This older age mode contributed to an age distribution that, while showing a good representation of all age groups (i.e., 20's, 30's, etc.), was slightly skewed to the right (older respondents).

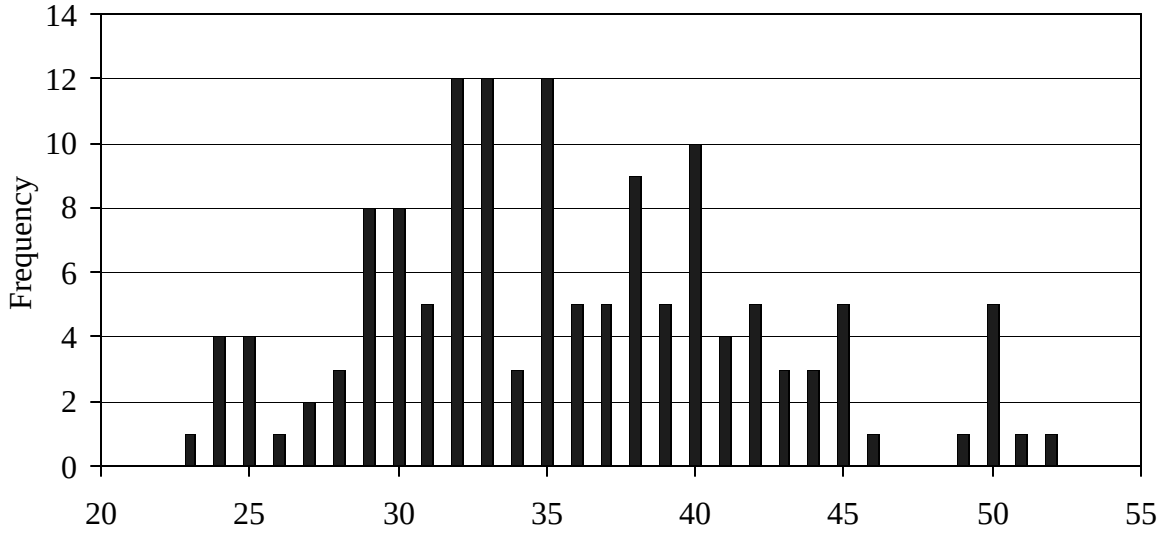

Figure 3. Frequency histogram for age (n=216).

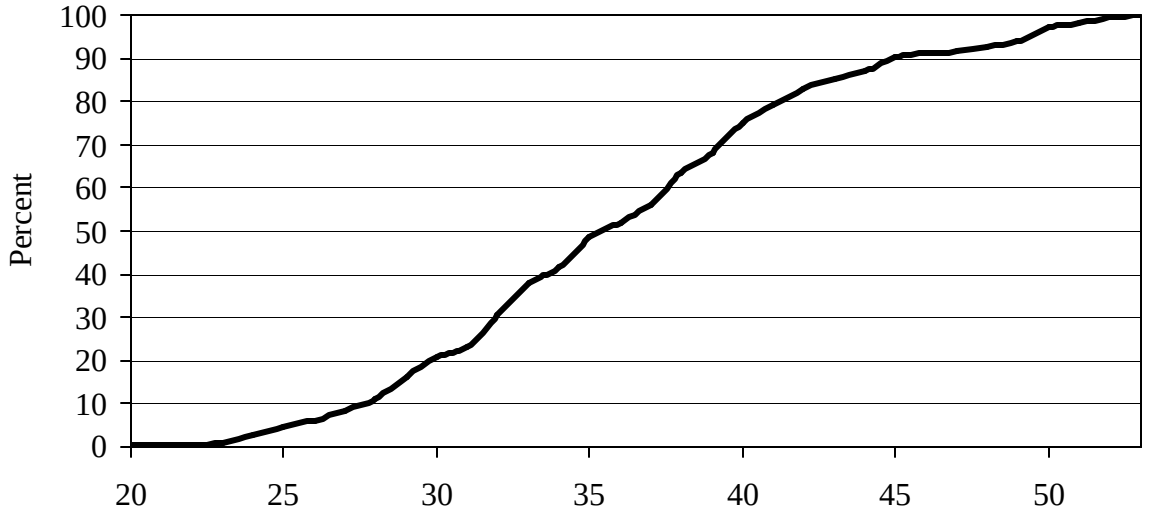

Figure 4. Cumulative percentage curve for age (n=216).

Total flight hours

Figure 5 presents the frequency histogram for total flight hours of survey respondents. As also summarized in Table 9, the total flight hours ranged from 220 to 9500 hours. The mean flight hour experience was approximately 2100 hours with a median value of 1750 hours. The histogram is skewed to the right towards more flight experience. The small group of higher flight hours (>6000 hours) correlated well with the smaller mode of older pilots seen in Figure 3.

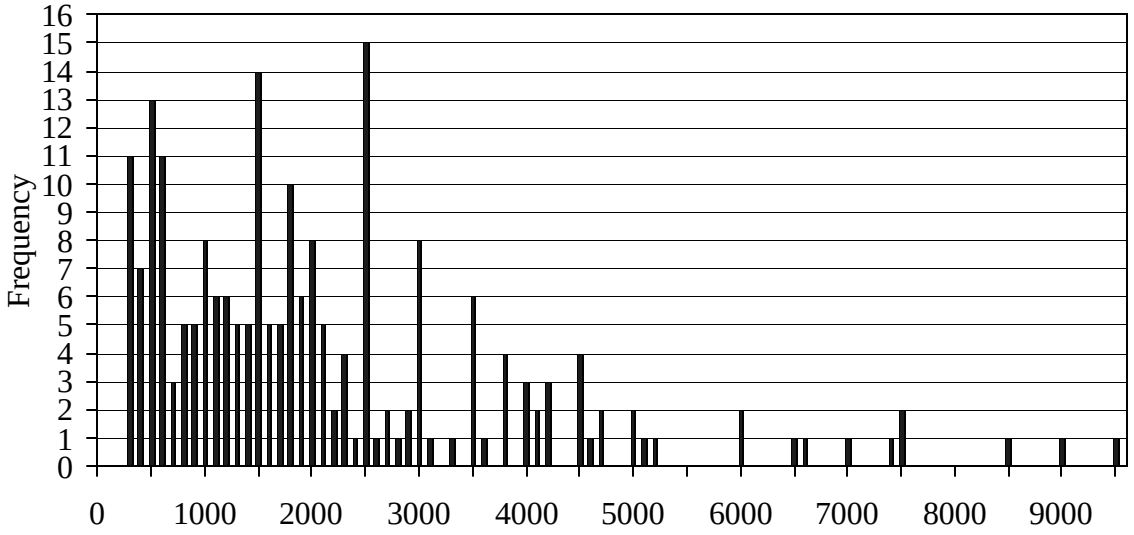

Figure 5. Frequency histogram for total flight hours (n=216).

AH-64 total flight hours

The distribution of total flight hours in the AH-64 is presented in Figure 6. Because of the single outlier value of 5000 hours, the distribution of AH-64 flight time is best represented by the median value of 1000 hours (Table 9). Flight experience ranged from 20 to 5000 hours. A cumulative percentage curve for AH-64 total fight hours (Figure 7) shows that approximately 50% of the respondents had 1000 or more flight hours in the AH-64. It is worth noting that the median value of 1000 hours for AH-64 flight hours is more than half of the median value for total flight hours (1700 hours), implying that the typical Apache pilot has gained at least half of his flight experience in the AH-64.

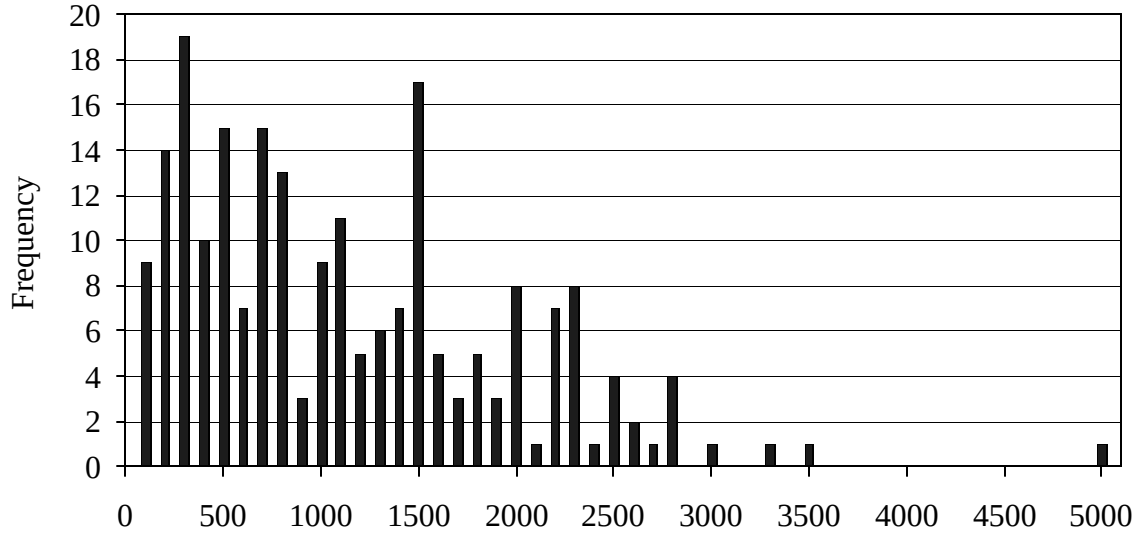

Figure 6. Frequency histogram for AH-64 flight hours (n=216).

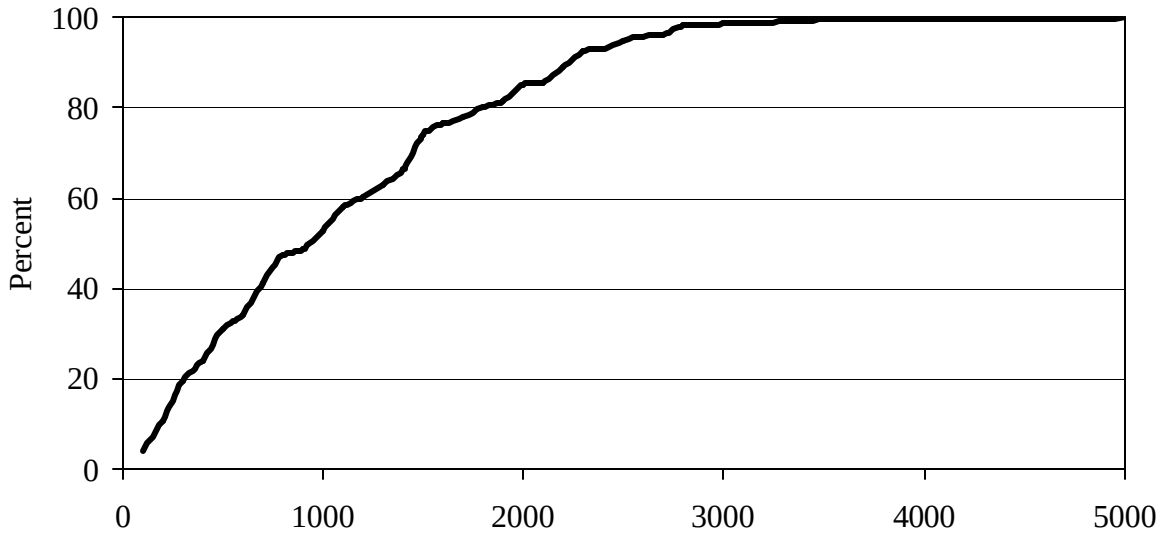

Figure 7. Cumulative percentage curve for total AH-64 flight hours (n=216).

Table 9 also includes statistics about the distribution of AH-64 flight hours between the "A-" and "D-" model aircraft types and between day and night flights. The D-model Apache varies from the A-model primarily in crewstation design. The D-model aircraft employs a "glass cockpit" crewstation design that replaces individual cockpit instruments with multifunction displays. The D-model was introduced in 1997. All respondents had some hours in the A-model. Values ranged from 20 to 5000 hours with a median of 950 hours. Approximately one-fourth (25.9%) of respondents had flight time in the D-model. For these pilots, D-model flight time ranged from 10 to 1000 hours with a median of 200 hours.

Across all respondents, flight time between day and night flights was evenly divided with a mean of 52% of flight hours during the day and 48% during the night.

AH-64 flight hours during last 30 days

The frequency histogram for AH-64 hours flown in the last 30 days preceding completion of the survey questionnaire is presented in Figure 8. AH-64 flight time during the last 30-day period ranged from 0 to 90 hours with a median of 17 hours. Of the AH-64 flight hours reported in the previous 30 days, time spent in the front (copilot/gunner) and back (pilot) seats averaged 54.4% and 45.6%, respectively.

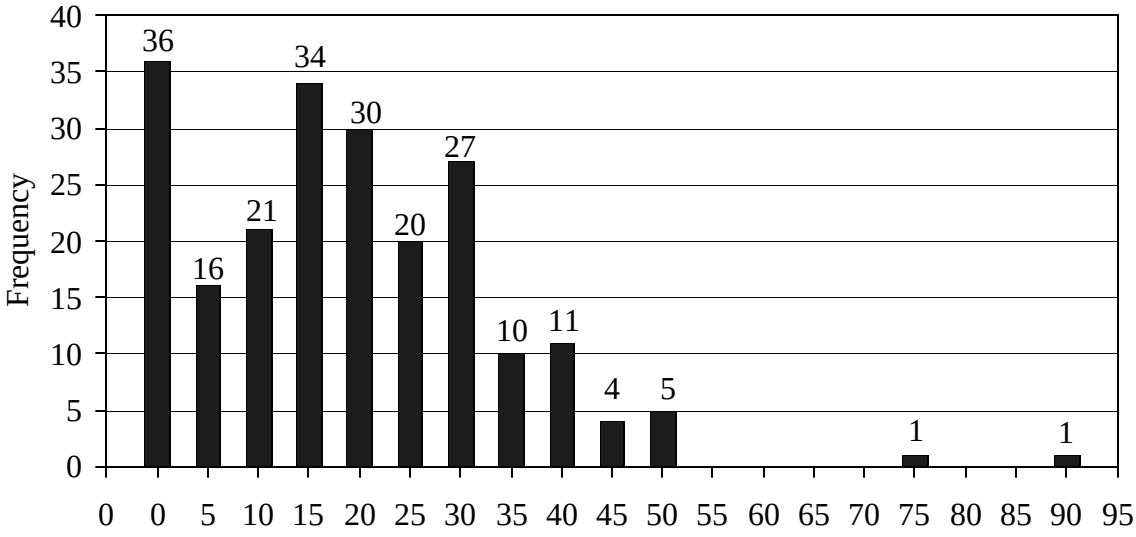

Figure 8. Frequency histogram for AH-64 flight hours for last 30 days (n=216).

Visual history

This section asked questions about aviator's visual history. Areas addressed included whether vision correction was worn, type of correction (glasses or contact lenses), age when correction (glasses or contact lenses) was first prescribed, the occurrence of any past eye disease or injury, or visual complaint (e.g., double vision, blurred vision, etc.).

Visual correction

Of the 216 AH-64 aviators responding to the survey, 29.6% (n=64) reported wearing some type of vision correction (Figure 9). The type of correction took many forms. Of those wearing correction *during* flight (n=52), 59.6% (n=31) wore some type of spectacle correction, 17.3% (n=9) wore some type of contact lens correction and 23.1% (n=12) reported wearing both (at different times). Single vision correction was the predominant mode for both spectacles and contact lenses. Summaries of vision correction worn during flight and at all other times are presented in Table 10 and Figure 10. Those aviators who wear spectacles during non-flight activities tend to also wear them during flight. However, more aviators appear to wear contact lenses for flight versus for non-flight activities.

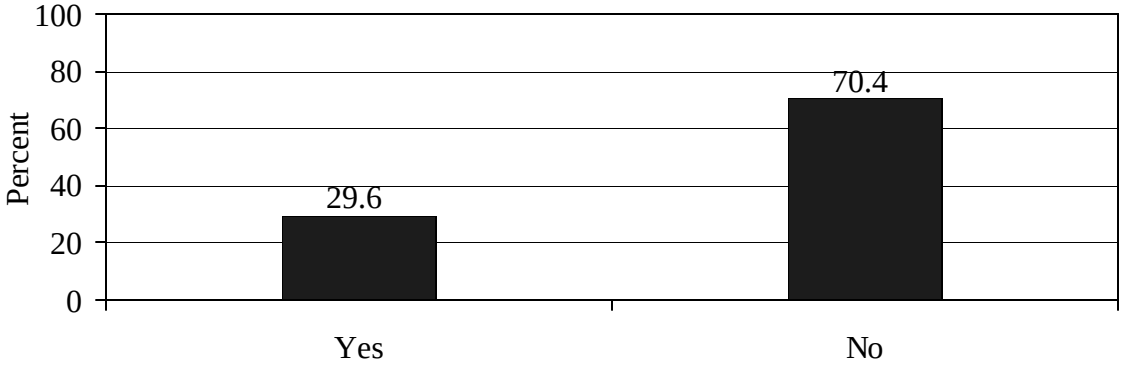

Figure 9. Use of vision correction.

Table 10.
Type of vision correction (n=64).
(expressed in percent)

Type of vision correction		During flight	Other times
Glasses	Single vision	34.4 (n=22)	35.9 (n=23)
	Bifocals	18.8 (n=12)	15.6 (n=10)
	Trifocals	0.0 (n=0)	1.6 (n=1)
	Progressive (No line)	3.1 (n=2)	6.3 (n=4)
	Readers	10.9 (n=7)	18.8 (n=12)
Contact lenses	Single vision	31.3 (n=20)	21.9 (n=14)
	Bifocal	1.6 (n=1)	3.1 (n=2)

Note: Some individuals reported using more than one type vision correction.

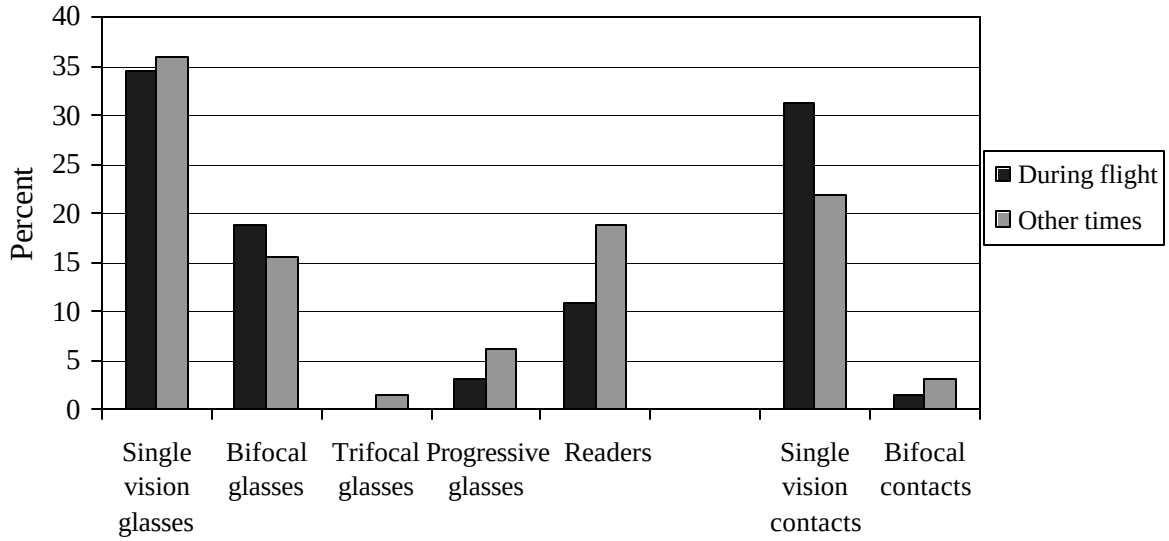

Figure 10. Type of vision correction (n=64).

While the age at which vision correction was originally prescribed varied greatly (19 to 50 years for spectacles and 24 to 48 years for contacts), these ages varied normally about a mean and median of approximately 36 years for both types. See Table 11.

Table 11.
Age at original vision correction.

Type of correction	Mean age	Median age	Range
Spectacles	36.6 years	38.5 years	19-50 years
Contacts	34.3 years	34.0 years	24-48 years

Ocular disease and injury history

Few of those responding in the survey (n=10) reported any type of eye disease in their personal medical history. A summary of eye disease history is presented in Figure 11. Among those who did report a previous problem, infection was the most commonly reported (n=6); dry eye was reported by one; and three reported other problems, retinopathy (non-inflammatory retinal disease) (n=1) and iritis (inflammation of the iris) (n=2). [Note: Each of the 10 respondents to this question indicated only one disease.]

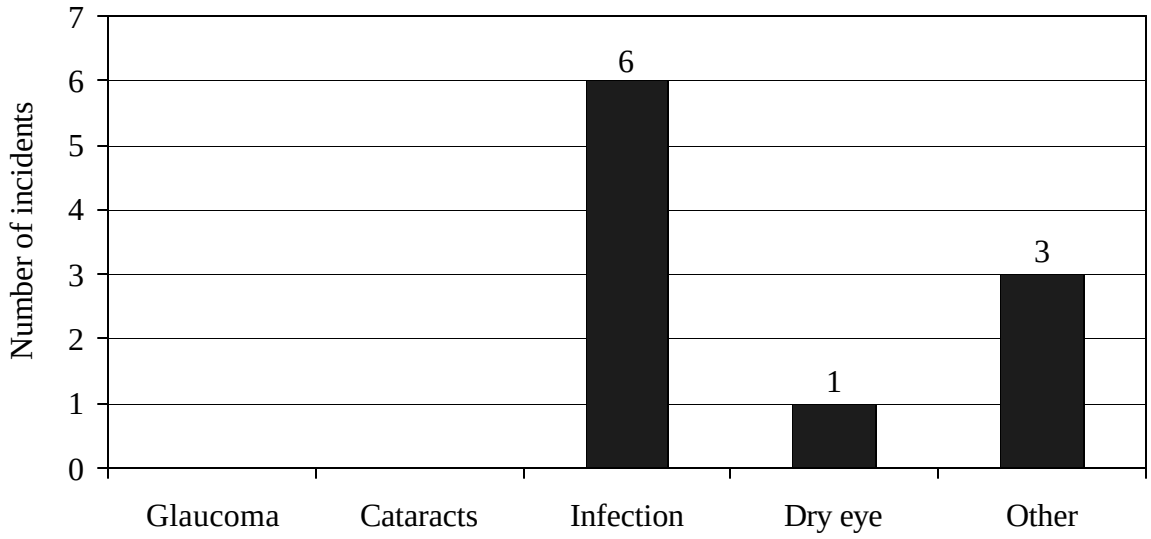

Figure 11. Summary of eye disease history (n=10).

Forty-nine aviators reported having experienced a total of 70 eye injuries. The most common injury was corneal scratches or abrasions (n=23), followed by an equal number of reports of embedded debris (n=16) and blunt trauma, such as a black eye (n=16). A summary of the types of injuries reported is presented in Table 12 and Figure 12. [Note: Some respondents reported multiple eye injuries.]

Table 12.
Summary of eye injuries reported.
(49 pilots reporting 70 incidents)

Type of injury	Number of incidents	Percent of total incidents
Debris (foreign body) embedded in eye	16	22.9
Injury from finger or hand in eye	7	10.0
Blunt trauma (black eye)	16	22.9
Corneal scratch or abrasion	23	32.9
Impact with object	8	11.4

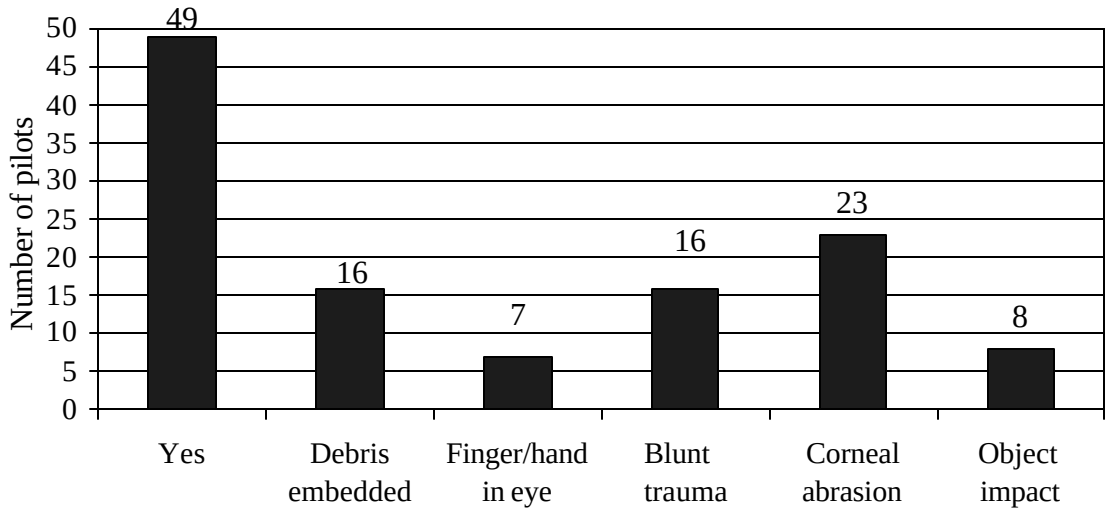

Figure 12. Histogram of reported eye injuries (49 pilots reporting 70 incidents).

Additional history of visual complaints

The most common historical visual complaint reported was eyestrain (n= 112, 51.9%), with most complaints occurring after extended periods of close work (Figure 13). Fewer respondents reported having experienced blurred vision (n= 42, 19.4%), double vision (n=7, 3.2%), and headaches caused by extended periods of close work (n=29, 13.4%).

While the survey questions for the above data were intended to investigate aviator past visual history, the comments provided with the above reports were often associated more with Apache flight rather than previous vision history. Comments for reported incidents of double and blurred vision indicated that such incidents occurred during or following extended periods of flight with the IHADSS. A full listing of comments relating to these incidents is provided in Appendix B.

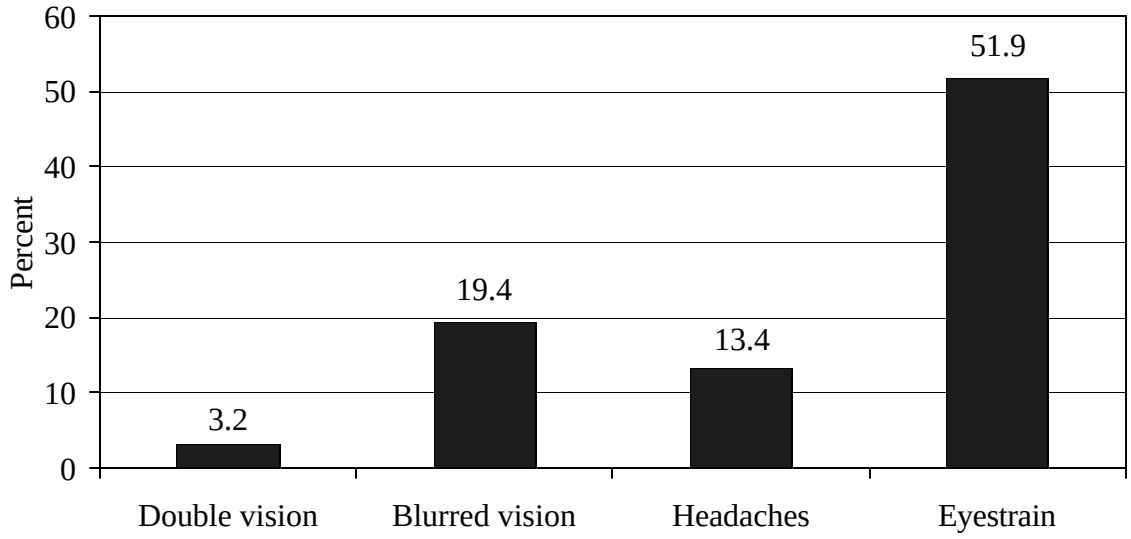

Figure 13. Percent experiencing vision problems.

Eye/hand preference

The IHADSS is a monocular display system, presenting imagery to the right eye only. The decision to provide right-eye-only capability was based on the need to constrain head-supported weight (Rash, Verona and Crowley, 1990). Beginning with the early design phases of the IHADSS, there has been concern over potential problems relating to aviators who were not right-eye dominant.

When asked about their eye/hand preference, respondents predominantly selected their right eye as the eye of choice for overall sighting (n=182, 84.3%) and telescope work, a monocular visual task (n=181, 83.8%). The majority (n=199, 92.1%) also reported a right hand preference for throwing a ball. See Figure 14.

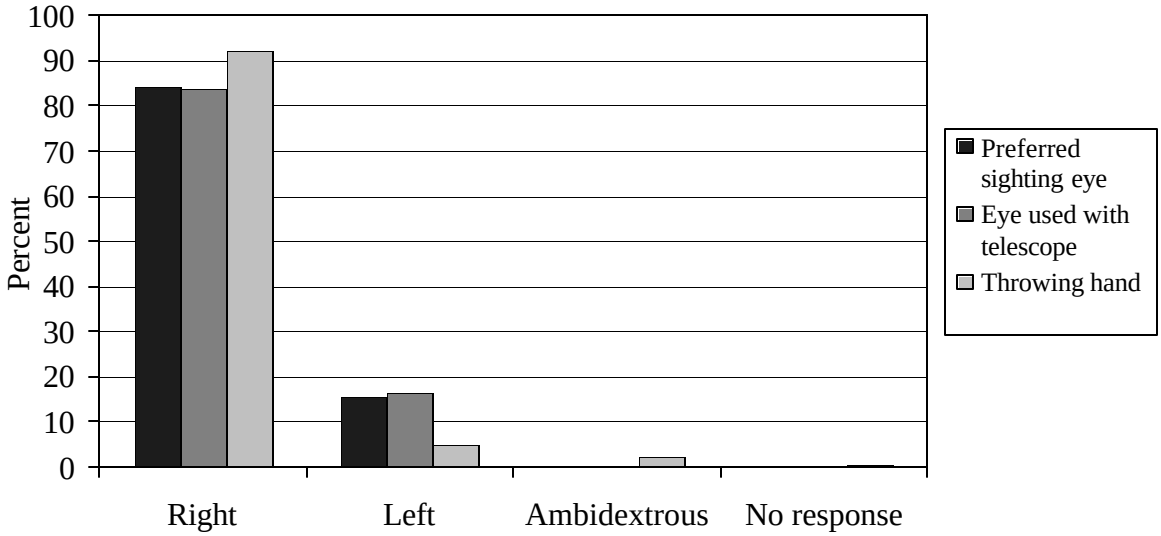

Figure 14. Eye/hand preference (n=216).

When asked if their better (preferred) eye was the same now as it was prior to AH-64 training, nearly two-thirds of those responding felt there had been no change (n=137, 63.4%), but over one-third (n=77, 35.6%) felt the vision in their better eye had changed (Figure 15).

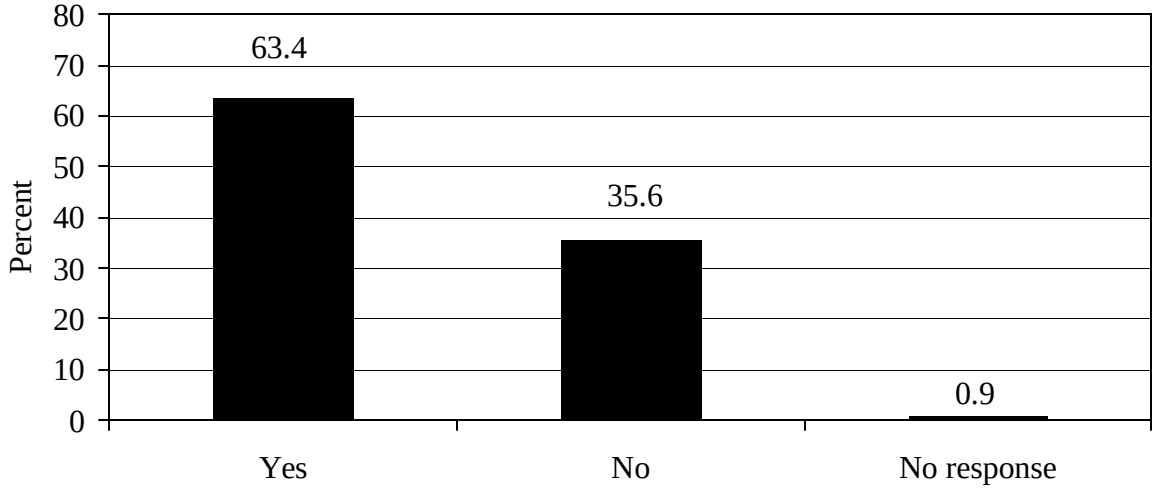

Figure 15. Better eye the same prior to training.

Helmet fit

Helmet fit is critical for the AH-64 aviator. At night, the AH-64 is flown primarily using FLIR pilotage and symbology imagery provided through the IHADSS. The IHADSS has a 10-millimeter exit pupil, which must be centered at the eye to achieve full FOV. To maintain this exit pupil in the presence of the high vibration environment of rotary-wing aircraft, it is necessary to achieve a good, stable fit. The fitting process involves numerous steps including, but not limited to, adjustments to the suspension system, proper location and alignment of the HDU (Figure 16), and final trimming of the helmet visor to accommodate the HDU when in an operating position. The objectives of this procedure are to: a) obtain a comfortable, stable fit of the Integrated Helmet Unit, which enables the aviator to achieve maximum FOV provided by the HDU when it is mounted on the helmet, and b) achieve boresight, which permits accurate engagement of weapons systems (Rash et al., 1987).

A prior study on IHADSS fit (Rash et al., 1987) indicated a need for subsequent adjustments to the helmet system after the initial fitting on the aviator. Over 80 percent of the aviators surveyed in this study indicated a need for adjustments or refits to the original fit. How successfully aviators are able to have helmets refitted has been found to vary among the Army aviation community based on the availability of trained personnel in IHADSS fitting, command emphasis on the importance of quality fit, and availability of fitting kits in all units.

Figure 16. Helmet Display Unit (HDU).

Questions placed on the current survey were intended to address this issue and gather additional information on the efficiency of the current helmet fit program. The survey requested information from pilots on the date of their last helmet fit/refit, and on overall satisfaction with current fit. In addition, the survey questioned pilots on whether their ability to view IHADDS imagery was impacted by their current fit.

Fit satisfaction

Among the aviators responding to the survey, approximately two-thirds (n=147, 68.1%) were somewhat or completely satisfied with their helmet fit (Figure 17). However, 17.1% (n=37) were either somewhat or completely dissatisfied with their current fit.

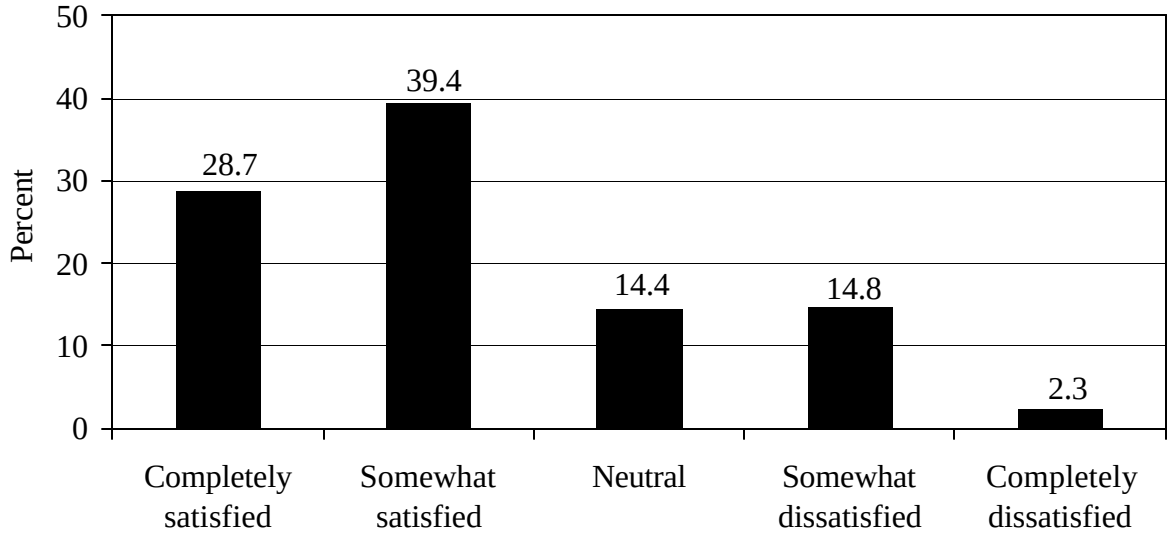

Figure 17. Pilot satisfaction with IHADSS current fit (n=216).

Fit impact on viewing IHADSS imagery

Over half of the aviators (n=128, 59.3%) believed that the fit of their helmet had an impact on their ability to view IHADSS imagery (Figure 18). In numerous comments provided by the pilots, statements on helmet fit were nearly always linked to FOV problems with the HDU. Many commented on decreased imagery through their HDU when the helmet slipped or the lining shifted. Numerous responses included complaints on ill-fitting helmets, inadequate Velcro™ straps and closures, spectacle interference, and frustration with not being able to see either the corners or sides of their display in the HDU (e.g. torque symbology). Many expressed dissatisfaction with having to turn in a well-fitting helmet when they changed duty stations, to later receive a poor-fitting one, and subsequently having to repeat the entire fitting process over again.

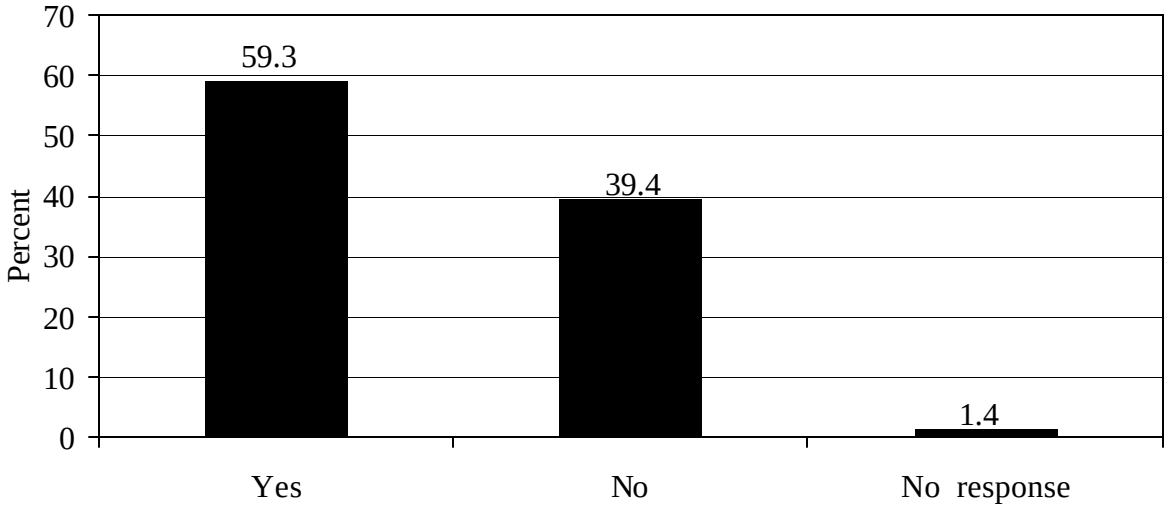

Figure 18. Does helmet fit affect viewing of IHADSS imagery?

The following is a selection of comments provided by pilots regarding the impact of helmet fit on their ability to view imagery. The importance of this issue is reflected in the fact that 57.4% (n=124) of the respondents provided additional comments. The presented user comments were selected primarily on the basis of their frequency but also on their explicitness. A full listing of comments is provided in Appendix C. (Occasionally, user comments were edited slightly to improve fragmentary responses, verbal lacunae, or misspellings. Places where this occurred are indicated with square brackets [ ].)

-- "Conflict between padding levels and HDU alignment."
-- "If helmet is not secure, HDU slips and need constant adjustment."
-- "Helmet must be turned slightly to view HDU [imagery]."
-- "Usually I have to move the helmet around to get the right 'view'."
-- "Wear and tear has caused my helmet to not sit properly elevated on my head. This has resulted in me having to shift my helmet to get a complete 30 x 40 FOV."
-- "Sometimes the IHADSS cable hangs [up] on survival vest, causing helmet to slip."
-- "Adjusting helmet for comfort during flight impacts FOV."
-- "The first problem is that every time you go to a new unit you have to get a new helmet. Sometimes it takes over a month to break in a new helmet. This break-in period directly affects the IHADSS imagery."
-- "Helmet slippage impacts ability to maintain field of view."
-- "Helmet lining shifts over time. Velcro™ system is poor."
-- "The helmet must be tightly fitted within fairly rigid parameters to be able to view all of the flight symbology."
-- "When turning my head, I sometimes lose symbology due to the IHADSS not being completely snug width wise."
-- "All helmets seem to fit differently. Once we get a good fitting helmet we should keep it until we are not flying anymore, instead of changing helmets every time we move."
-- "Each time I get a different helmet it takes several flights to get the fit right and be able to view the entire picture."

-- "No two HDUs fit the helmet exactly alike. Velcro™ is not the most comfortable material for precise fitting of the helmet, causing helmet shifting."
-- "Helmet slippage impacts ability to maintain field of view, focus of symbology and scene content."
-- "[I] lose the corners of the display."
-- "I adjust my helmet three to four times per flight to fix my IHADSS imagery."
-- "[I] lose left side of display (i.e. torque, sight status)."
-- "[With] extra-large helmet sometimes torque is obscured."
-- "When my helmet insert moves slightly I lose, or partially lose, my HDU picture."
-- "The helmet design will not allow for a good fit. I have tried two different sizes and have spent hours being fitted."
-- "Large [sized helmet] is too small, extra-large is too big, [I] have to adjust helmet on head to see imagery. IHADSS in general is not a well-fitting helmet. ALSE technicians [are] not trained on IHADSS at all."
-- "[I] can't see all of symbology when wearing glasses… any kind."
-- "My helmet size is in-between large and extra-large. I can't get a good helmet fit."

Fitting frequency

Respondents were asked for the date of their last helmet fitting. A wide disparity in time periods was reported. The provided dates were converted into values representing the number of months since last fitting and are presented as a histogram in Figure 19. The period since the last fitting ranged from zero (fitting within current month) to 171 months. The median period since last fitting was 27.96 months. A cumulative curve (Figure 20) shows that 90% of respondents had obtained a refitting within the last 75 months; however, 5% have gone 10 years or more since a complete refitting.

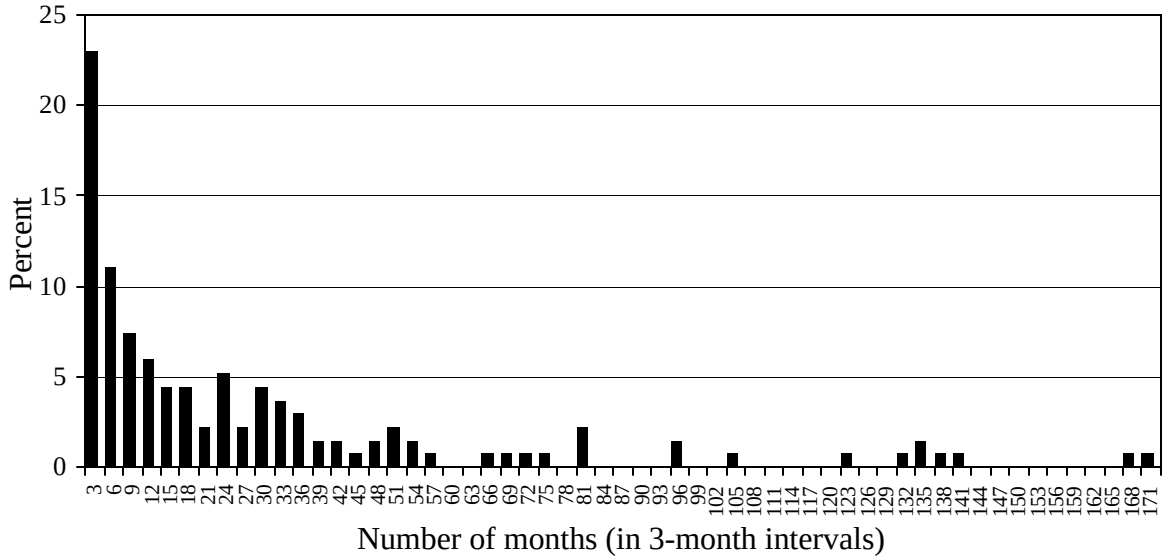

Figure 19. Number of months since last helmet fitting.

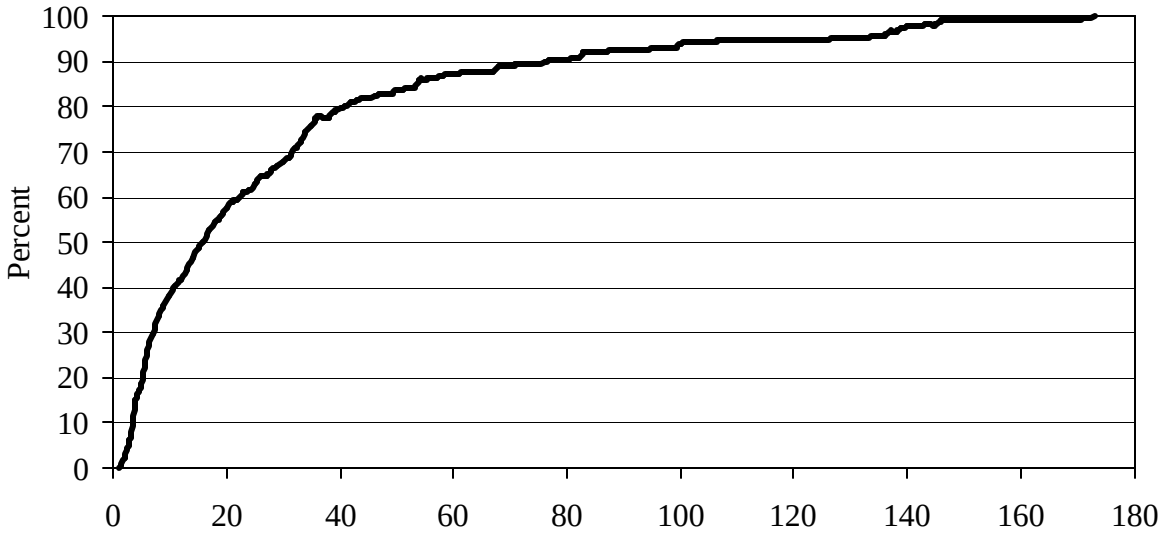

Figure 20. Cumulative percentage curve for number of months since last helmet fitting.

Aviator vision

The major focus of this survey was to investigate aviator vision with the AH-64 Apache IHADSS. The 1990 VISAA study was conducted originally to address visual medical concerns raised by unit flight surgeons (Behar et al., 1990). In the following section, the results of survey questions addressing reported visual complaints and symptoms both *during* and *after* flight are presented. In addition to being asked to report visual complaints, respondents were requested to report any instances of degraded visual cues or static and/or dynamic illusions experienced due to the use of the monocular IHADSS.

Where appropriate, a listing of selected user comments or explanations given in response to a question and an identification of trends drawn from the responses are provided. User comments were selected primarily on the basis of their frequency but also on their explicitness.

Visual complaints and symptoms

Reported visual complaints and symptoms for both *during* and *after* flight are presented in Table 13 and Figures 21 and 22. The most common visual symptom reported *during* flight was visual discomfort (n=176, 81.5%), followed by headache (n=131, 60.6%). Other complaints such as blurred vision and disorientation were reported by over one-third of the respondents. The most common complaint reported *after* flight likewise was visual discomfort (n=160, 74.1%). This was followed by reports of headache (n= 135, 62.5%), after-images (n=101, 46.8%), blurred vision (n=80, 37.0%), disorientation (n=21, 9.7%) and double vision (n=11, 5.1%).

Table 13.
Reported vision complaints.
(expressed in percent)

	During flight				After flight			
	Never	Sometimes	Always	NR	Never	Sometimes	Always	NR
Visual discomfort	18.5	76.4	5.1	0.0	25.5	66.2	7.9	0.5
Headache	38.9	59.7	0.9	0.5	36.1	61.1	1.4	1.4
Double vision	93.5	6.0	0.5	0.0	93.1	4.6	0.5	1.9
Blurred vision	66.2	33.3	0.5	0.0	63.0	36.6	0.5	0.0
Disorientation	57.4	42.1	0.0	0.5	88.4	9.7	0.0	1.9
Afterimages	70.4	27.3	1.9	0.5	51.9	41.7	5.1	1.4

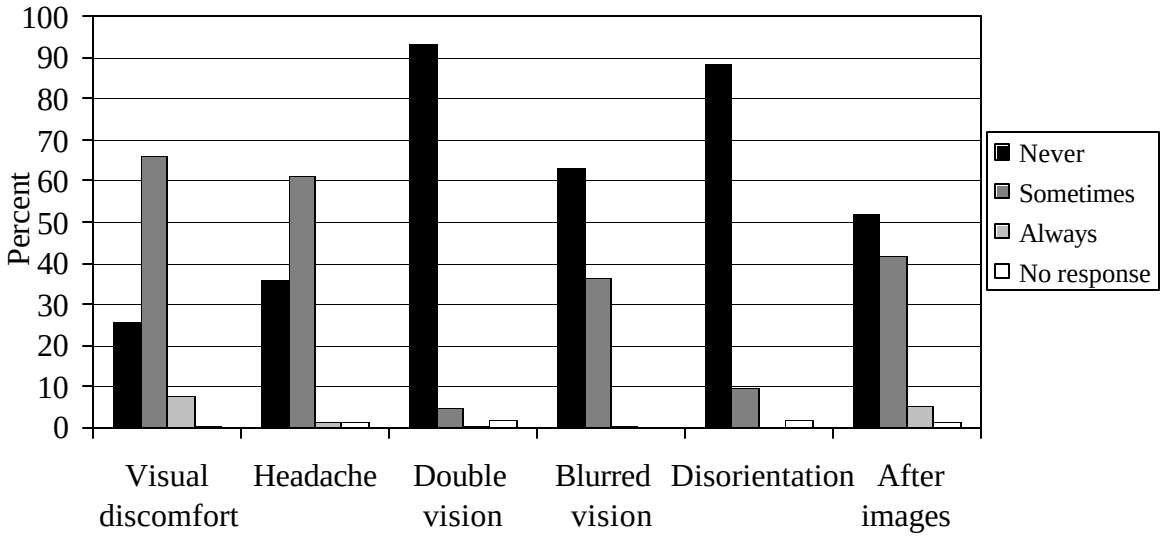

Figure 21. Visual complaints and symptoms *during* flight.

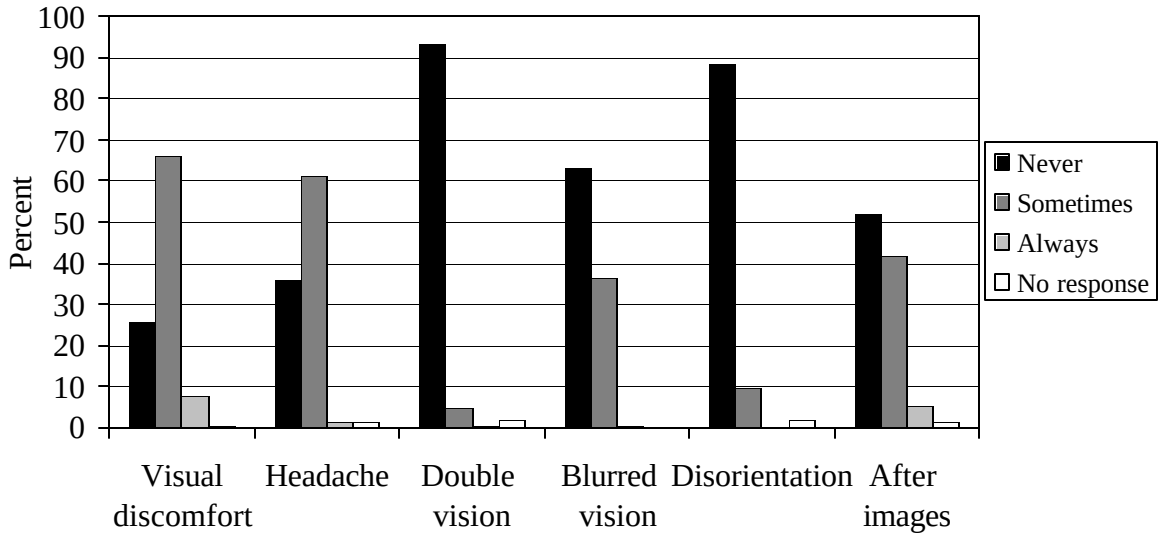

Figure 22. Visual complaints and symptoms *after* flying.

Degraded visual cues

A high percentage of respondents reported experiencing multiple losses of visual cues. The most frequently reported degraded visual cue was decreased resolution (n=195, 90.3%) (Figure 23). At least three-fourths of the respondents also reported experiencing impaired depth perception (n=183, 84.7%) and decreased FOV (n=175, 81.0%), loss of visual contact with horizon (n=164, 75.9%), whiteout/brownout (n=163, 75.5%), and blurring of image with head movement (n=163, 75.5%). The least reported degraded visual cue, but yet still reported by more than one-third (n=84, 38.9%) of the respondents, was Inadvertent Instrument Meteorological Condition (IIMC).

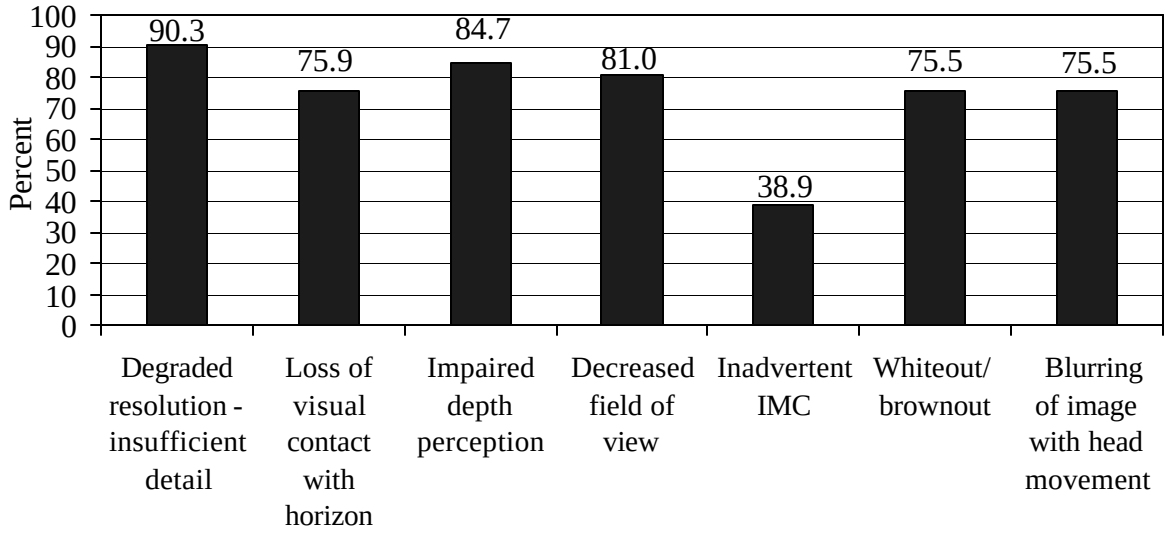

Figure 23. Degraded visual cues experienced *during* Apache flight.

Illusions

Reports of static and dynamic illusions experienced during flight with the IHADSS are reported in Figures 24 and 25, respectively. The most frequently reported static illusion was faulty slope estimation (n=173, 80.1%). Over half of the respondents also reported static illusions of faulty height judgment (n=159, 73.6%), faulty altitude judgment (n=147, 68.1%), difficulty with lights (n=130, 60.2%), and faulty clearance judgment (n=130, 60.2%). The least reported static illusion was the perceived bending of straight lines (n=44, 20.4%).

Forty-six (21.3%) respondents provided comments along with their reports of static illusions. A full listing of these comments is provided in Appendix D. Almost half of the comments regarded aviator opinion on the quality of FLIR imagery. Several respondents associated static illusions with the monocular design of the IHADSS. Representative comments are:

-- "[These illusions are] most likely due to degraded two-dimensional information (bad FLIR picture)."
-- "[We] need [a] newer FLIR system."

-- “The ‘Yes’ comments are directly related to the quality of the FLIR conditions.”
-- “Current FLIR quality is poor.”
-- “When you get close to the ground with any outside illumination I get "binocular rivalry" making it difficult to judge the actual ground contact.”
-- “Many of these [illusion] issues are common with the monocular system.”
-- “I have experienced all [of] these [illusions] while flying with [night vision] goggles also, but [they are] worse with the Apache.”

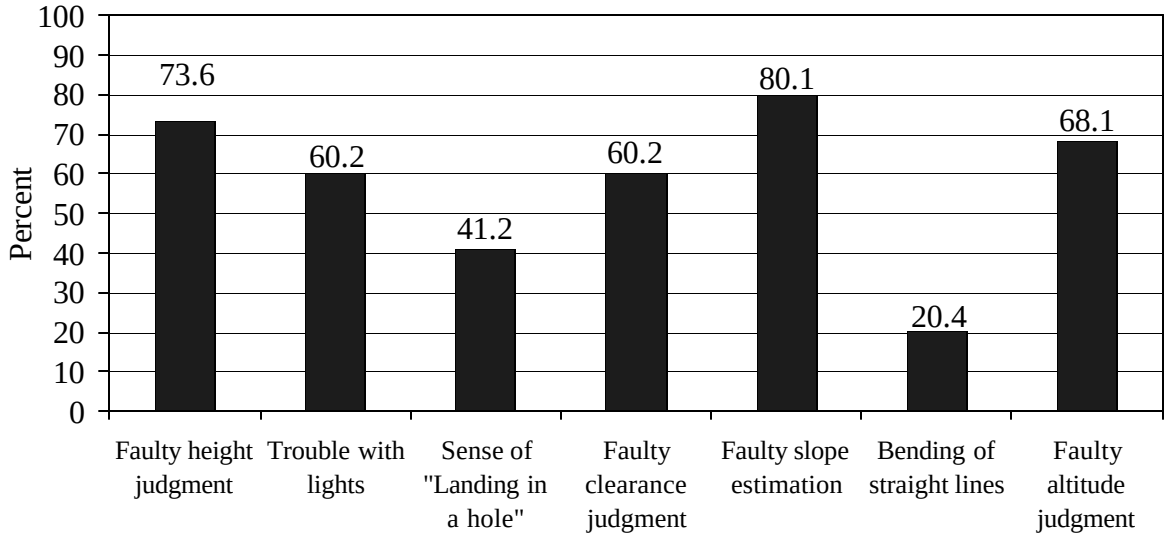

Figure 24. Static illusions experienced *during* Apache flight.

The most frequently reported dynamic illusion was undetected drift (n=169, 78.2%), followed closely by faulty closure judgment (n=163, 75.5%) and illusory drift (n=154, 71.3%). More than half of the respondents also reported dynamic illusions of no sensation of movement (n=120, 55.6%) and illusory rearward flight (n=120, 55.6%).

Twenty-nine (13.4%) respondents provided additional comments following their reports of dynamic illusions. A full listing of these comments is provided in Appendix D. FLIR image quality was the most frequently cited cause of the dynamic illusions. Several respondents commented on the use of symbology to reduce illusion effects and stated that the illusions were reduced with increased or recent flight experience. Selected representative comments are:

-- “…,’Yes’ answers [are] due to poor FLIR quality.”
-- “Symbology has assisted [in dealing with] these illusions.”
-- “…,However, flight symbology helps dramatically with the correction of many of these types of illusions.”
-- “Experience with the system makes these [illusions] less of a problem. The pilot with less than two hundred hours of NVS time is dangerous.”
-- “[These illusions are] directly related to FLIR conditions.”
-- “[Illusions are encountered] only during training, or after long periods when system is not used.”
-- “The more tired you are, the worse it gets.”

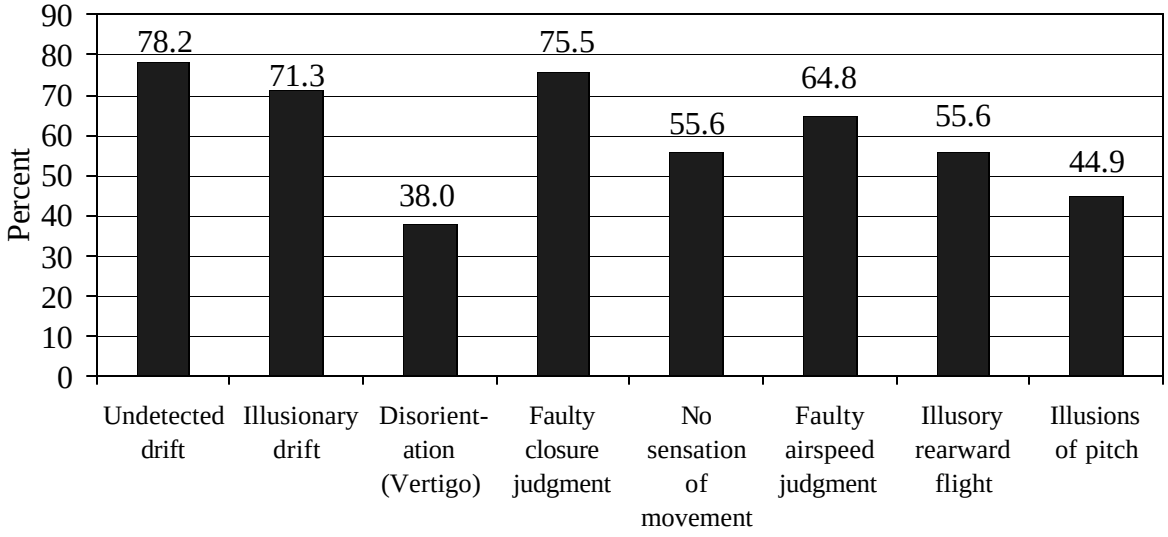

Figure 25. Dynamic illusions experienced *during* Apache flight.

HMD symbology

The IHADSS provides the aviator with video imagery that consists of FLIR [Forward Looking Infrared] pilotage or targeting imagery and aircraft symbology. The survey asked Apache aviators about their ability to see, or interpret, symbology and if they experienced difficulty in simultaneously focusing on the symbology and the external scene.

At least one out of three respondents (n=83, 38.4%) reported difficulty in seeing or interpreting HMD symbology during flight (Figure 26). Reasons offered for difficulty in viewing symbology included inability to retain symbology in the FOV and blurred vision due to fatigue. A full listing of comments is provided in Appendix E. Representative comments for this question are:

-- "If the HDU is bad, the combiner lens will slip and requires continuous adjustment throughout [the] flight."
-- "As experience increases, overall proficiency level increases."
-- "Sometimes while flying I have had to make helmet adjustments which resulted in having to readjust my HDU and combiner lens."
-- "Blooming or excess contrast with TADS covers symbology occasionally."
-- "When fatigued from extended NVS flights."
-- "Any movement of the HMD on the helmet during flight will cause [loss of symbology]."
-- "…Sometimes unable to see torque value…"
-- "If your helmet is not 'just right,' you will lose peripheral symbology depending on where your eye is looking."
-- "Glasses obscure symbology, especially torque."

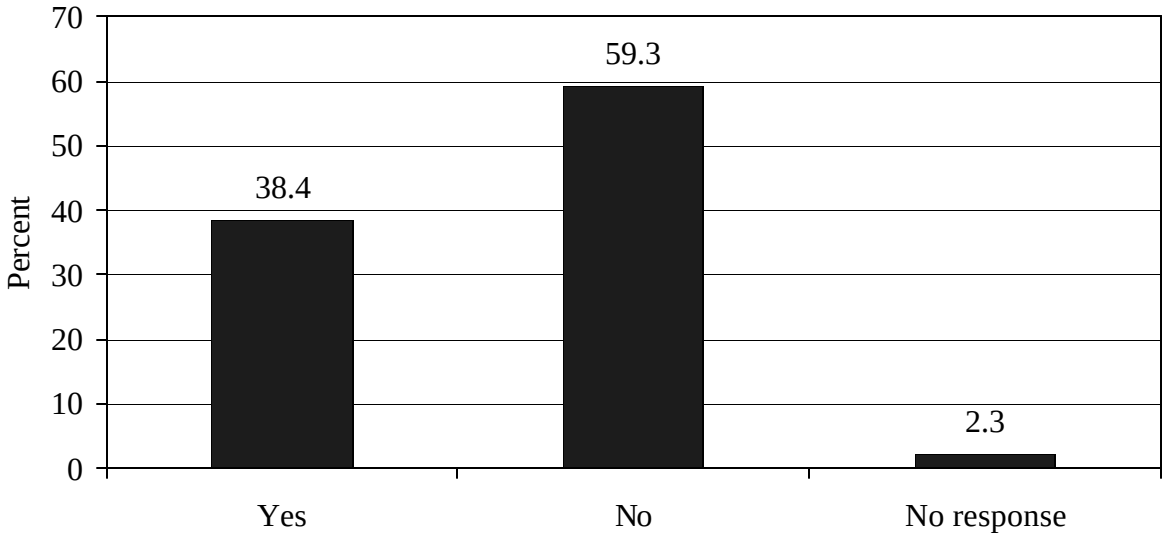

Figure 26. Pilot reporting of change in perceived ability to see or interpret HMD symbology *during* flight.

Slightly less than one-third (n=66, 30.6%) noted that when viewing through the HMD, they could not focus clearly on the external (pilotage) scene and the symbology simultaneously (Figure 27). The original intent of this question was to determine if the aviator perceived both the FLIR imagery and the symbology in the same focal plane. However, comments implied that many respondents interpreted this question as to their ability to focus between the symbology and the "external scene" in the left, unaided eye. Therefore, the representative comments below should be interpreted along both lines of thought. A full listing of comments is provided in Appendix E.

-- "I find it very difficult to focus or split my attention between a close-up symbology and the more distant object at the same time."
-- "I can see both simultaneously but I can't focus in detail on both at the same time. I might be able to see terrain and the torque, but couldn't tell you what the torque was reading unless I focused directly on the torque."
-- "Symbology will be focused while the NVS scene will be blurred."
-- "I tend to concentrate more on the symbology and less on the FLIR cues."
-- "Sometimes the symbology will overdrive the picture and vice-versa."
-- "Due to binocular rivalry, it is difficult to switch between eyes."
-- "Yes, [I] have not learned to see symbology and video image at the same time yet."
-- "[I] cannot focus on both objects at the same time, [I] must either use symbology then [switch] to visual cues from the FLIR. But, I cannot focus on both symbology and visual cues simultaneously."

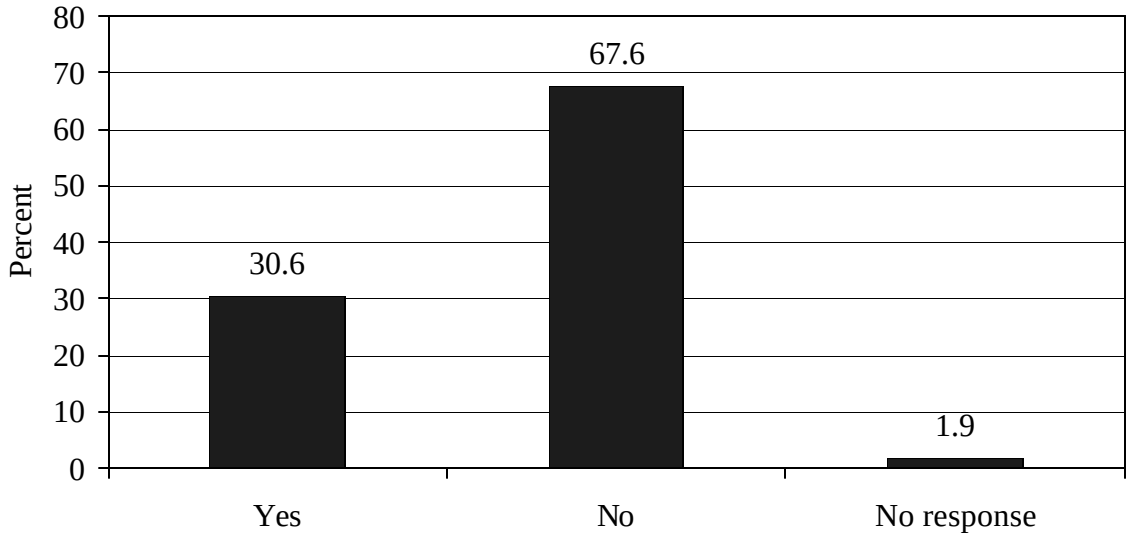

Figure 27. Pilot reporting of ability to focus clearly on simultaneous external scene and symbology.

Alternating visual input between aided and unaided eye

The IHADSS is a monocular system in which the right eye views the HMD imagery and the left (unaided) eye views the outside world. This requires the Apache aviator to switch his visual input between the two eyes, depending on the required task. Questions were asked as to their ability to purposefully alternate between the aided and unaided eye, whether any special methods are used to accomplish this alternation, and whether alternation ever occurs unintentionally.

Most pilots (n=161, 74.5%) reported it was easy to purposely alternate between their two eyes during flight (Figure 28). However, almost one out of four respondents (n=51, 23.6%) reported having some difficulty, and a few (n=2, 0.9%) reported having great difficulty in purposefully alternating. Almost half of the respondents (n=97, 44.9%) have developed methods to assist in switching their visual inputs when required (Figure 29). Examples of these methods include closing one eye, glancing away, and blinking. A full listing of comments regarding switching methods is provided in Appendix F.

Representative comments are:
-- "As experience level increases, the ability to rapidly change the focus of attention between the aided and unaided eye becomes easier to do. Consciously you only see the visual imagery presented through the eye that is the current focus of attention."
-- "Momentarily close the opposite eye."
-- "Close one eye."
-- "Experience and proficiency helps to identify and overcome binocular rivalry and also select the appropriate eye (type of vision)."
-- "Blink eye that I want to switch from."
-- "Alternate[ly] winking each eye."

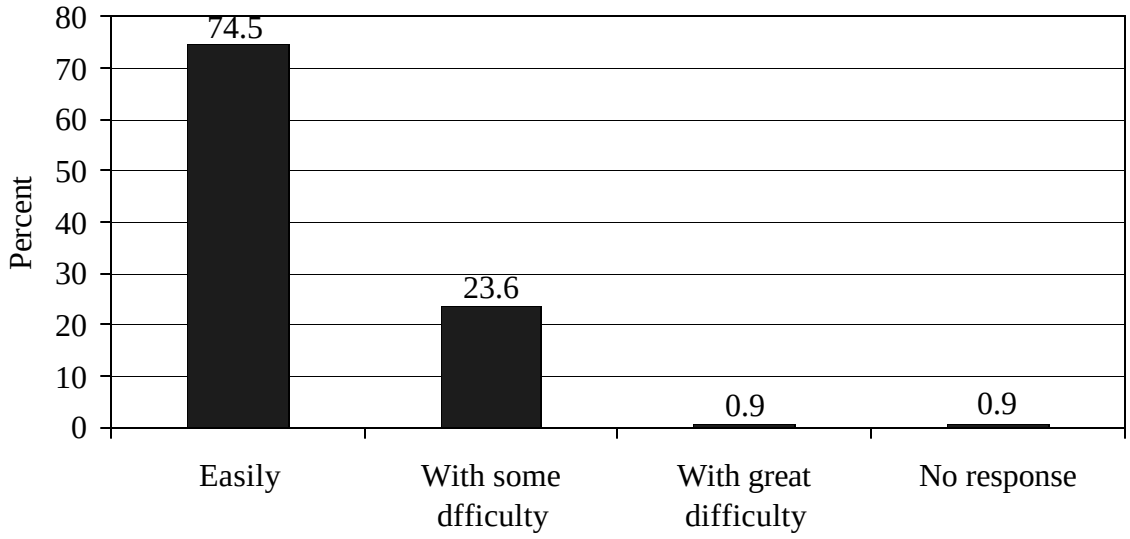

Figure 28. Pilot purposeful eye alternation.

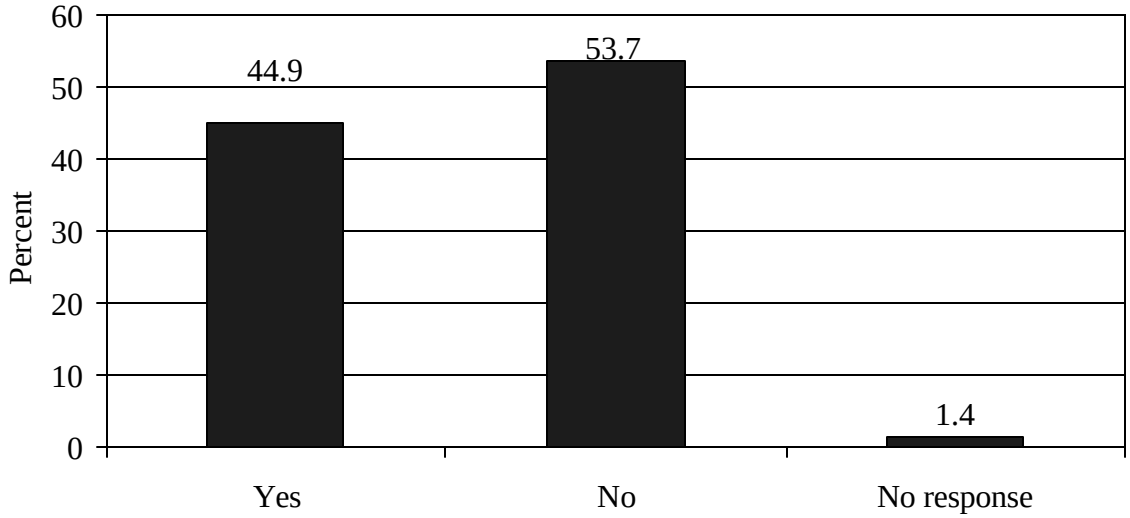

Figure 29. Pilot reporting of special method used to assist in switching (alternating) eyes *during* flight.

Approximately two-thirds of respondents (n=139, 64.4%) reported that during flight their visual input sometimes *unintentionally* alternated between the two eyes (Figure 30). Frequently cited causes included the presence of bright lights, eye dominance, and fatigue after extended flight. A full listing of comments is provided in Appendix F. Representative comments are:

-- "After prolonged period[s] of flight, [alternation] happens."
-- "Binocular rivalry due to left eye dominance."
-- "If there is a bright lighting source, my unaided eye will take over."
-- "If a bright light suddenly comes into view your unaided eye will dominate."
-- "Unaided eye picks up light sources and dominates."
-- "Early on I had some problems, but with experience it is no longer a problem."

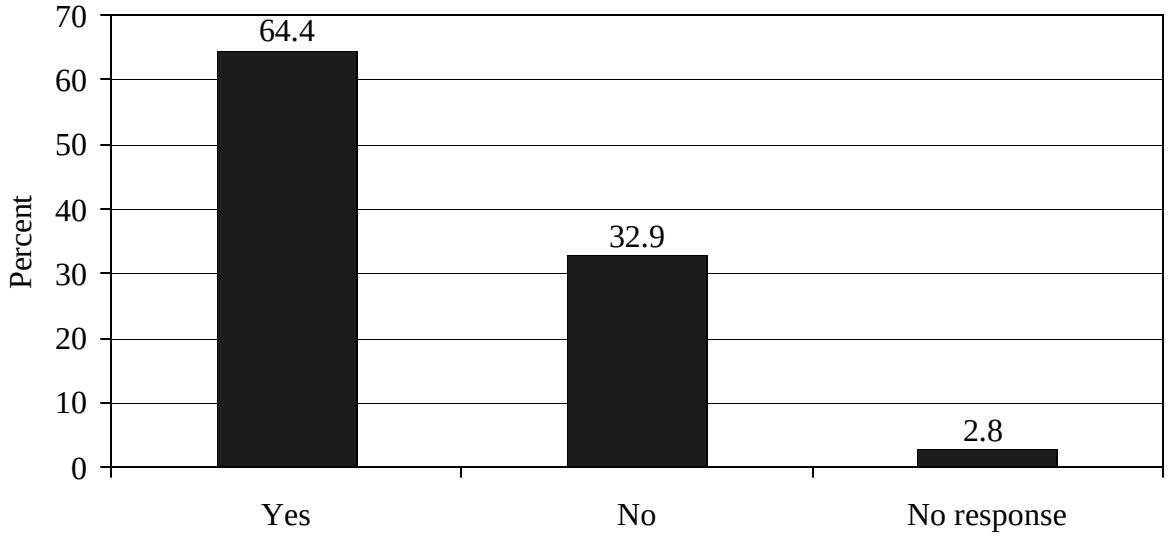

Figure 30. Unintentional alternating of pilot vision between eyes during flight.

Acoustical issues

Noise levels found in military rotary-wing aircraft often exceed noise exposure limits required by the Department of Defense. To combat this problem, two techniques have been investigated to improve sound attenuation provided to the aviator while preserving the communication signal reaching the ear. One of the techniques involves Active Noise Reduction (ANR), which utilizes electronic circuitry to manipulate and reduce the noise found inside the earcup. The other technique, the CEP, uses passive sound attenuation. Both of these techniques have been shown to reduce noise at the wearer's ear and improve speech intelligibility (Rash, 2000).

The CEP utilizes an earplug in combination with the helmet earcup, to achieve the required noise reduction (Figure 31). To improve speech communications, the earplug is attached to a miniature transducer that delivers the sound signal directly into the occluded portion of the ear canal through a small channel built into the earplug. The CEP, incorporating its miniature earphone coupled with a replacement foam earplug, can be worn in combination with the aviator's helmet and can provide hearing protection adequate for extremely high noise levels. The device also provides voice communication intelligibility that approaches asymptotic limits, near 100%, in those high noise environments.

Currently, the CEP is the only technology that has received an airworthiness release (AWR) for utilization in the Army rotary-wing environment. Donning, doffing and comfort issues for users of the CEP have been examined (Mozo and Murphy, 1997; Mozo, Murphy and Ribera, 1995) and have been determined to be within a manageable range.

Figure 31. Communications Earplug (CEP) (top) and attached to HGU 56/P helmet (bottom).

A study (Mozo and Murphy, 1997) comparing the CEP and the HGU-84 using Navy and Marine Corp aviators assigned at Quantico, Virginia, was accomplished over a 4-month period. A preference questionnaire was used to measure the volunteer's assessment of the CEP when compared to their personal helmet. The areas of interest were comfort, compatibility, communications performance, utility, and overall value added as assessed by each of the individual volunteers. The rating scale used to compare the CEP and the aviator helmet used in CH-46 and CH-53 helicopters was based on the following 7-point scale:

____7____:	____6____:	_____5____:	____4____:	____3____:	____2____:	____1____
Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately Worse	Moderately worse

A numerical rating of "7" indicated the user's highest preference value for the CEP while a rating of "1" indicated the user's highest preference value for the helmet. If the user perceived no difference between the CEP and the helmet then the volunteer indicated a rating of "4."

Results of the Mozo and Murphy (1997) questionnaire responses were analyzed to determine the overall acceptability of the CEP for use in the H-53 missions when compared to the HGU-84 helmet. Table 14 shows the results of questionnaires administered at the mid-point of the study and again at the end of the study. For most of the questions, results showed a slightly stronger preference for the CEP at the end of the study, indicating users found the CEP more acceptable with continued use. The fit and comfort of the CEP were judged to be the same as their standard helmet, indicating discomfort was not considered a factor by the user after 4 months of use. There was a difference in favor of the standard helmet in the donning/doffing process because of the extra step required to install the CEP. (It was the authors' opinion that the user would become more proficient in the procedure with continued use of the CEP. Proper planning of events that take place in the donning process would limit or eliminate problems for even the most time critical mission start.) All of the noise reduction and speech clarity responses indicated a strong preference for the CEP over the standard helmet.

Table 14.
Results of midpoint and final questionnaire assessments (15 subjects).
(Rash, 2000)

Question	Midpoint score	Final score
Average number of flight-hours using CEP	30.5	40.7
Fit and comfort of CEP	4.2	4.1
Donning/doffing	3.5	3.5
ICS clarity	6.3	6.5
Radio communications clarity	6.3	6.6
Gender clarity (male)	6.1	6.6
Gender clarity (female)	6.0	6.6
Overall clarity	6.3	6.6
Noise reduction	6.3	6.4
Ability to hear warning signals	6.0	6.6

In an effort to gather information on the use of CEP technology among U.S. Army rotary-wing aviators, the survey reported herein included a section on awareness and interest in the CEP (Table 15). Questions addressed aviator familiarity with the CEP, overall interest in the device, knowledge of the AWR, and willingness to utilize the CEP in their IHADSS helmet. Of those responding to the survey, only 5.1% had actually used a CEP, while approximately half (50.9%) reported some knowledge of the device, but no

experience with its use. While the majority (85.2%) of the aviators expressed interest in the use of CEP with the IHADSS, few of those questioned (19.9%) were aware that an AWR had been published on CEP use with IHADSS. Approximately 65.7% of those questioned indicated a willingness to incorporate the use of the CEP in their IHADSS if issued directly, and approximately 22% would use the CEP in their IHADSS even if they had to purchase it with personal funds.

Table 15.
Acoustical issues responses.
(expressed in percent)

How much do you know about the CEP? (n=216)	
42.6	Had not heard about it
50.9	Some knowledge but no personal experience
5.1	I have used CEP in SPH-4/4B or HGU 56/P
1.4	No response
How interested are you in using CEP in IHADSS? (n=216)	
53.7	Great interest
31.5	Some interest
14.4	Not at all interested
0.5	No response
Are you aware that an AWR has been published for CEP in IHADSS? (n=215)	
19.9	Yes
80.1	No
0.0	No response
If made available, would you use CEP in your IHADSS? (n= 216)	
12.0	No, not interested
65.7	Yes, but only if issued to me
21.8	Yes, even if I had to purchase it with personal funds
0.5	No response

Additional comments

To ensure that issues pertinent to understanding flight with the AH-64 IHADSS HMD were fully investigated, the survey concluded with a free-field section that encouraged respondents to provide additional comments. One hundred (46.3%) of the respondents took the opportunity to expand on their survey responses. These additional comments were often extensive and forthright. Among the issues addressed by the comments were poor FLIR quality, vision changes, helmet fit, image quality, and the acoustical aspects of the CEP. While a full listing of these comments is provided in Appendix G, a significant number are presented here, grouped by specific issue. Occasionally, user comments were edited slightly to improve fragmentary responses, verbal lacunae, or misspellings. Places where this occurred are indicated with square brackets [ ].

Vision changes

-- "I feel that my right eye vision has gotten worse than my left due to the use of the IHADSS… Just wondering what effect the display will have over the long run. I will of course continue to fly as long as I can."
-- "I have always had 20/20 vision in both eyes until recently. The vision in my right eye has degraded to 20/40."
-- "I have noticed that the vision in my left eye has gotten worse over the past 2-3 years, while the vision remains a constant 20/20 in my right eye. I have attributed this to the use of the HMD for NVS flight. I tend to strain to see real world objects with the unaided eye. Have experienced headaches after NVS flight ever since transition into the Apache 11 years ago."
-- "I feel that some of my right eye may have some acuity degradation. I cannot verify this scientifically. I still pass the annual eye exam. I would be interested in more specific day and night testing…"
-- "I have noticed that after flying extended NVS, on the way home my left eye will shut down, while driving home I suddenly realize that I am not using my left eye to see. This has only happened when I have been extremely tired. Another curiosity is that as I have hit the big 40 my eyesight in my right eye has stayed better than 20/20 while my left eye has slowly degraded."
-- "My vision in my right eye has gradually gotten worse over time. It was 20/15 before I flew the AH-64 now it is 20/25 while the left is still close to 20/20. I know this could be due to age but I have heard others with similar results and have had conversations with some who wonder if it is a result of the HDU."
-- "Visual acuity in my right eye is still good, but slower to focus than my left eye. This degradation was evident only after flying System in the AH-64. I did not notice this degradation during any of the eight years of using NVG …"
-- "Vision in my right eye has degraded to a greater degree than my left eye."
-- "I've been flying Apaches for six years and I have been losing vision in my right eye every year. I predict next year my right eye will be less than 20/20. My left eye is as strong as the day I started flying Apaches."
-- "Over the past 15 years of flying the AH-64 I have noticed that my right eye's ability to focus far has been steadily getting worse (going from 20/10 to 20/60). My near vision in my right eye has remained near 20/10. My left eye far vision has gone from 20/10 to 20/25 and close vision has remained near 20/10."

FLIR [Forward Looking Infrared] quality

-- "Come on, you want to identify and improve visual issues, give us a better FLIR!"
-- "My only comment is that I still can't believe that we are flying $30 million dollar a/c on top of the trees with a 1970's FLIR. Gen 2/3 FLIR has been out for a while and yet we still take a chance on not seeing a tower because of inadequate FLIR pictures."
-- "The primary concern is the poor FLIR quality, reduced maintenance budget, and reduced training opportunities. It takes quite a lot of training to produce a proficient and safe NVS pilot. It takes years to produce a proficient maintenance tech…"
-- "Visual illusions exist because of visual acuity. The better the vision, the less the chance of illusions. I fly several night systems. I have many hours with PVS 5's [night

vision goggles], ANVIS 6 and the PNVS. I also train civilians to fly night vision goggles using Generation 3 OMNI 4 Night vision goggles. The bottom line is that the AH-64 FLIR is unsatisfactory. I am currently on a rotation in Kuwait and the PNVS does a good job in the desert. Over the subtropical climate of Florida, where I am from, the performance is poor. The illusions with the IHADSS are more present because of the system the IHADSS has to work with. This was no different than when the SPH-4 [helmet] had to work with full-face goggles. A better IHADSS may slightly reduce the problems with illusions, but it will never approach the reduction of problems we will notice if we get a better FLIR."

-- "Overall the IHADSS is not a bad system, but it does have some limitations. The HDU FOV is too small. The DAP is also a source of difficulty. For example, if I'm having a problem focusing, is the problem with the focus of the HDU or is it the focus on the DAP or is it a combination of the two, or does it have something to do with the range focus on the CPG ORT? Why are the DAP adjustments so difficult to access? Configuration of the HDU, performing sizing and centering and gray scale adjustments are as much art as science, and only through experience does one become comfortable with the IHADSS… I honestly believe there are no real design flaws with the IHADSS, the main problem is with the outdated first generation FLIR system. You couple the poor FLIR imagery with the IHADSS inherent limitations and a source of dissatisfaction is created. In other words, if the AH-64 had a better FLIR system I am fairly certain there would be few[er], if any, visual issues with the IHADSS. The reason I bring up the FLIR is because this survey asks several questions concerning things such as 'degraded resolution/insufficient detail, slope estimation' etc. These things are not really IHADSS issues as they are FLIR issues. In conclusion, I would estimate that probably 80% of all the visual issues are associated with the FLIR and not the IHADSS. The IHADSS could use some minor refinement, the FLIR is old and needs some major help."

-- "I am totally amazed at the lack of overall accidents due to this first generation FLIR system. Sometimes this system works great. (When the stars, moon, and planets all line up). Other times it is a nightmare. The problem is not IHADSS and the use of one eye, the problem is this old FLIR system. With what is at stake here, advanced FLIR technology should be a priority…"

-- "We would be lost without the overlaid symbology. FLIR alone on many nights is just not good enough by itself. Many of these problems can be corrected using the proper procedures taught here at Fort Rucker, but it would be so much more convenient if we could make DAP adjustments (sizing, centering, etc.) easily from the two seats without having to call for outside assistance."

-- "The FLIR currently installed in the AH-64 is archaic and belongs in a museum. Every news chopper in the country has access to equipment with much higher resolution and better reliability."

-- "The IHADSS is not an entirely deficient piece of equipment, but coupled with the outdated FLIR, is a task every AH-64 pilot must master. Not easily done for low time aviators… I like the system, but would like to see some upgrades to decrease the size and weight of the IHADSS, along with better communications (i.e.- CEP)."

-- "Someone please find the guy holding the "checkbook" and tell him to take a ride at night in the front seat using the TADS and then ask him to cut the check for second gen[eration] FLIR. It shouldn't take this long especially when we are testing fourth

gen[eration] goggles. Over the years I have become accustomed to using one eye for sighting and now find it natural. Recently I became re-qualified for using goggles in the front seat and didn't like it at all. I had no symbology for flight reference and the airframe got in the way. By using the system, I am accustomed to using one eye for the FLIR image and switching unaided around highly lit areas…"

Acoustics

-- "The Active Noise Reduction Module would be a better device for the IHADSS and all other helmets. It does a better job of noise reduction and is user friendly."
-- "My unit tested the CEP, and I wanted to use the system, but due to a lack of appropriate sizes of earplugs I was unable to try the system."
-- "Would purchase CEP if it did all the things they say they do, otherwise would use only if issued. Flying night system would be a lot better with dual IHADSS."
-- "CEPs would be very helpful for the IHADSS because I have lost some hearing over the last 20 years of military flying. Some AH-64s at high-speed flight are very noisy and you combine that with an AH-64 that has a low audio level setting then it is hard to hear the radio commo [communication] from other aircraft or ICS [Internal Communication System] commo [communication] from your crewmember without taking out one of my yellow ear plugs."

Helmet fit

-- "While not directly impacting upon visual issues, the issue and turn-in of IHADSS as each aviator joins and leaves a unit does have a great impact upon fit. If we went back to the original method whereby an aviator was issued his helmet during the course and kept it through his apache career, we would see a dramatic drop-off of fit-related problems after the first year or so post AQC. The Helmet should be issued by CIF and kept on an aviator's individual clothing records until he leaves the Army. The IHADSS would be much easier to use if the TADS/PNVS were upgraded to gen[eration] two or gen[eration] three. Some research should also go into increasing the field of view of both sensors and the HDU. Perhaps cross check with the system being developed for the Comanche?"
-- "Even though I have been trained extensively on how to identify and overcome some eyestrain problems during use of the IHADDS, some problems still exist. There are very few people that can correctly fit a helmet. Like all equipment, it becomes 'worn'. If some type of compliance or refit interval was imposed, it might cause some aviators to pay more attention to their equipment. I currently have the old TPL in mine. It offers a little more comfort than not, unfortunately when I try to fly without it, my helmet has become loose. I am spending more and more time during IHADDS optimization to get good imagery in the HDU. I am almost to the point of pushing the combiner lens all the way out just so I can see all of the flight symbology."
-- "At present the students at Fort Rucker are fitted with the helmet adjustments made by ALSE. The staff does the best they can with the equipment available but it is not always satisfactory. I do not know the department on Hanchey Airfield that has the correct facilities, but the building is located on the east side of the north hanger… Prior to NVS phase, it would benefit the students to work in a dark room having had

the HDU fitted correctly and the intensity of the picture checked by an IP [Instructor Pilot]. This would give them the best possible start to the phase and hopefully alleviate any eyestrain / loss of symbology problems."

-- "…The helmets should be issued to the aviators and then the aviator should keep the helmet until no longer required, i.e. getting out of the Army, retirement, no longer flying AH-64 etc. This would help greatly. Helmet fit and comfort directly affect visual issues. The better the fit and the more comfortable the helmet, the better the visual acuity is. I have found that eyestrain, headaches etc. are reduced to minimal levels once the helmet is properly broken in. Every helmet is different and it usually requires the aviator to make adjustments to the helmet above and beyond what the ALSE personnel provide…"

-- "The HDU works fine but the root of all problems is the 10 pounds of Velcro needed to fit each IHADSS. How can it be consistent?…"

-- "I would like to see a helmet study done, with [the] results published to the common pilot, on a helmet with dual IHADSS. Maybe a helmet with the IHADSS built in to the helmet, so once it is fitted, you would not have to adjust it every time you fly."

-- "Helmet fit is my biggest complaint, with [a good] helmet fit I can get to see the entire symbology..."

-- "The IHADSS helmet is very uncomfortable. Rarely have I ever had a perfectly comfortable fit. Most of the time I have to deal with hot spots and headaches. This is a serious distracter and [a] nuisance during flight. With my head shape I cannot wear a TPL. I do use a skullcap, but that only helps to some extent. Because of this I feel that I have sacrificed some of the noise attenuating capabilities of the helmet…"

-- "Helmet fitting is a huge issue. ALSE technicians receive no training on the IHADSS helmet in the ALSE course. The only training received is from reading the TM, and passed-down knowledge. Considering the importance of the fit of an IHADSS helmet, this is a major failure in the ALSE program. ALSE technicians need to be trained in this task, by the civilians who fit helmets at Hanchey Army Air Field. The only time a pilot is ever properly fit by trained personnel is during the course at Fort Rucker. Then the pilots leave their helmets at Fort Rucker when they depart. To be issued another used helmet at their next unit of assignment. I believe that Apache pilots should be issued their helmets to keep throughout their career. This would alleviate most of the fitting problems experienced…"

-- "The constant switching of helmets after every PCS degrades helmet fit and results in loss of some visual acuity until a proper fit can be achieved (usually takes 4-6 months of regular flying)…"

-- "Because of the way the IHADSS is fitted, it is a problem to turn it in as you leave every unit. If we can't solve the accountability problem, if we could improve the fitting procedures it would help. Suggestions would be a liner or some kind of form fitted insert. Suffering through your first flights at a new unit with less than full picture is not the best way to go…"

-- "The IHADSS helmet is a terrible fitting helmet. For years I have tried to fit my helmet comfortably, but to no avail. I have had "hot spots" so bad they were actually bleeding."

Image quality

-- "Most problems that I have had are due to faulty equipment. Examples: The greyscale is not able to be properly adjusted. This leads to reduced resolution and the inability to 'break out' details. If the greyscale is overcompensated with contrast, (allowing the picture to be viewed when the system has insufficient brightness), then I will experience eye fatigue/strain. My personal preference for the greyscale is very dim, but still able to see all 10 shades of gray. The other problem I have noticed is an HDU that is blurry. The blur is uncorrectable through the focus setting on the DAP or the infinity focus knob. A compromise is then required...leading to eye strain. The same applies to distortion. Distortion adds to illusions of [aircraft] movement."
-- "…As a trainer, I have found that the staff aviators which haven't flown in a while have forgotten how to do [set up] a greyscale. After having them do a greyscale and then viewing it myself, I have found that their greyscale was about half the size it was supposed to be. This could have affected the way they flew. Maybe it is time to upgrade the IHADSS to something more up-to-date. The sizing and centering, I would think, could be made to not have to be adjusted, therefore eliminating this problem..."
-- "…The image supplied by the HDU is significantly degraded from the original (compare visual acuity of the HDU to the acuity on the tape), this coupled with the relatively poor image quality of the FLIR system, and the ease in which foreign matter (i.e. dust and grime) interferes with the picture, results in an overall poor image quality."
-- "Brightness, Contrast, Gain, Level, and Focus are all dynamic and interrelated. A change in level will, at times, appear to be a change in brightness. An improperly adjusted Contrast will affect adjustments in Gain and Level. Fatigue will affect Focus adjustments. Out of focus, ever so slightly, will induce extreme eye fatigue, headache and pain, but so will excessive brightness, which a pilot will use when the delta is low and the FLIR image is of poor quality. So what does a perfect picture look like? How do you teach that?…"
-- "…The is a very poor system in every respect. It is heavy, sloppy, provides a poor quality picture and a narrow field of view, the monocular display is annoying and uncomfortable, and the thinner versions of the cord gets wrapped around things in the cockpit. Getting a decent picture requires the combiner lens to be placed right next to the eye - anything interfering with that placement (such as NBC masks) makes it impossible to get a full field of view (and the "full" field of view isn't sufficient anyway)…"

Monocular vs. binocular design

-- "…After teaching PNVS and AH-64A flight for 6 years I wear corrective glasses for my right eye only. My left eye is 20/20! With today's technology, CRT, in my opinion, is not the best answer. Binocular rivalry can be trained away, as I, and many others, have done. I do not think that dual imagery is the full answer. With all the problems, and failures I have experienced with the HDU and its associated systems I cannot imagine what would have happened if I had both eyes obscured by a faulty system. Flying in a tight, multi-ship, formation, staggered right at night, and have the

PNVS lock in the upper right quadrant because my upper transponder antennae was on. My ability to quickly adapt to 'naked left eye' flight because of a dual-eyed system averted certain disaster. I am well aware of transfer of controls, if that's your answer, you don't fly enough."

-- " I definitely support a monocular display or at least the option of flying with a monocular display. I believe the ability to easily view the real world unaided is important."

-- "I am a PNVS current IP. I prefer the IHADSS monocular system because I always have one dark adapted eye and, on all but the darkest nights, I have some naked eye depth perception. When focused outside, the dark adapted eye provides peripheral motion cues even when the IHADSS eye is focused foveal[ly] to read symbology. Transition from inside the cockpit [display] presentations to outside imagery works well with the monocular IHADSS. I use IHADSS night and day and consider it to be an indispensable aid to flying and fighting the AH-64D day or night."

-- " …Recommend a lighter weight, binocular system with greater field of view that provides much greater distance between the eye and the combiner lens."

Spectacles

-- "I wear glasses. In order for me to use the HMD correctly I have to bend the frames into a contortion that puts the lens in contact with my eyelashes. The lens then gets covered with skin oil and sweat. I also have to position the combiner lens so close to my glasses that the sliding clip has stress on it (this has led to breakage of sliding clips). This also pushes my glasses into my skin. I have come to realize that flying the system without glasses is safer than flying with them. Contacts? They would be nice if there were some kind of reasonable program available. I have an astigmatism and getting contacts is not only 'spendy', it's next to impossible. Looking forward to [Army] Aviation medicine taking a serious look at the newer laser eye correction procedures."

-- " It seems almost impossible to correctly fit the HDU so that you can attain a full field of view with laser glasses on."

-- "…Contact lenses will help with the problem of eyeglass frames interfering with the IHADSS picture. Laser surgery may be a consideration. Looking through the system can produce three distinct images when viewing a lighted runway. Left eye runway, right eye FLIR runway, and orange lights thru the combiner lens. All three are different - just pick the center of one and land. The more natural any system is with respect to human senses the easier it will be to train and remain proficient…"

-- " Use of bifocal glasses with the IHADSS is very difficult. Right lens adjustments usually result in incomplete imagery. I've checked with other bifocal users, and they remove their right lens and adjust the focus to view the imagery. For me, this creates eye strain, but seems to be an interim fix. Also, viewing cockpit instruments with bifocals through the left eye is sometimes difficult. Near view items such as kneeboards are also sometimes difficult with night lighting…"

-- "…I find it hard to wear glasses while using the HDU. It would be great if the Army allowed Laser eye surgery for Aviators like the Navy and Air Force have just approved for their aviators."

Summary and discussion

Before beginning the discussion of the findings of this survey, readers must be reminded that care must be taken in drawing conclusions from survey data. This is especially true when, as with this survey, the respondents are solicited by advertisement. One disadvantage of this method of data collection is that there is a possibility that only individuals having very positive or very negative opinions are sufficiently motivated to put forth the effort to fill out the survey questionnaire. However, having raised this caveat, the authors wish to call attention to two points. First, an examination of the demographics shows that the respondents were well distributed across age and flight experience, with respect to both total aviation experience and AH-64 experience. Second, Army aviators are a highly disciplined and motivated population. The authors' ongoing exposure to the Army aviation community has resulted in recognizing that Army aviators take considerable interest in any opportunity to contribute to efforts that may improve aviation safety and performance. For these reasons, the authors, while not dismissing the inherent problems associated with survey sampling, feel that the aviators who responded to this survey were a realistic representation of the AH-64 Apache aviator community.

The survey responses came from a group of relatively experienced aviators whose approximate age was comparable to those surveyed in previous years (1990 survey average was 35.8 years; 2000 survey average was 36.5 years). However, the ranges of age for the two surveys have two notable differences. First, the 2000 survey included younger aviators. The 2000 survey had 15 aviators (6.9%) 28 years of age or younger versus 1 (2%) aviator for the 1990 survey. Second, the 2000 survey also included older aviators than the 1990 survey. The maximum age for aviators who participated in the 1990 survey was 44 years. The 2000 survey had 14 aviators (6.5%) aviators whose age was 45 years or older. A side-by-side comparison of demographics for the two surveys (Table 16) shows other differences. Based on total flight hours, aviators who participated in the current survey reported approximately one-third fewer mean total flight hours than those of the 1990 VISAA surveys (2131 hours in 2000 vs. 3330 mean in 1990). Also, over one-fourth (27%) of the 2000 survey aviators had less total flight hours than the minimum reported in the 1990 survey. Overall, respondents for the 2000 survey were less experienced than those surveyed in 1990. However, when AH-64 total flight hours are compared, the newer survey respondents reported a mean of 1116 hours, a 68% increase over that of the 1990 respondents. But, the range of AH-64 flight hours for 2000 respondents exceeded that for 1990, including the minimum and maximum. And, finally, for reported AH-64 flight hours flown during the past 30 days, respondents for the 2000 survey flew significantly fewer hours, an average of 18.5 hours for the 2000 survey vs. 32.3 hours for the 1990 survey. In summary, the 2000 survey respondents were more diverse in age, total flight hours, and AH-64 flight hours; less experienced on average in total flight hours; but, more experienced in AH-64 flight hours. It is also worth noting that in the 1990 VISAA survey all respondents were instructor pilots and experienced AH-1 Cobra attack helicopter aviators. In the current survey, some respondents had transitioned directly into the AH-64 Apache from IERW training.

Table 16.
Demographics comparison for 1990 VISAA and 2000 surveys.

		2000 survey	1990 VISAA survey
Age (years)	Mean	36.5	35.8
	Range	23-53	26-44
Total flight hours	Mean	2131	3330
	Range	220-9500	1000-9000
AH-64 flight hours	Mean	1116	664
	Range	20-5000	150-1500
AH-64 flight hours in last 30 days	Mean	18.5	32.3
	Range	0-90	2-60

In both studies, approximately 1 out of 3 respondents reported wearing some type of vision correction, 30% for the current survey and 34% for the 1990 survey.

Visual symptoms

The major focus of this study was to investigate aviator vision with the AH-64 Apache IHADSS monocular HMD. The approach used was to ask responding AH-64 aviators about the type and frequency of visual complaints and symptoms experienced both *during* and *after* flight in the AH-64. Approximately 92% of the aviators reported at least one complaint either *during* or *after* flight; in the 1990 VISAA survey this value was 80%. The mean number of reported symptoms was 2.5 and 2.4 for *during* and *after* flight, respectively. The most common visual symptom reported *during* flight was visual discomfort (81.5%); this same symptom was the most frequently reported as having been experienced *after* flight (74.1%). Similarly, the second most reported symptom, headache, was the same for both *during* and *after* flight. The most disturbing of the reported symptoms was diplopia (double vision). While any occurrence should be of concern, the frequencies of this symptom in the 2000 survey were fairly low, 6.5% *during* flight and 5.1% *after* flight. One aviator reported as always having experienced this symptom both *during* and *after* flight. In the 1990 survey, the reported frequencies for double vision were 14% and 11% for *during* and *after*, respectively.

The frequencies of the various reported visual symptoms were fairly large. Given the changes in the AH-64 aviator population over the last 10 years, a comparison between the 1990 and 2000 surveys with regard to frequencies of reported symptoms seems useful. In Table 17, a comparison is made for symptoms reported *during* flight. The percentages presented are based on the summation of “Sometimes” and “Always” responses.

From Table 17, it can be seen that for the five symptoms for which data were available for both surveys, the percentage of reports increased from the 1990 to the 2000 survey for all except one -- double vision. For the four symptoms that increased in reported frequency from 1990 to 2000, three were statistically significant to the .05 level based on a Z-test for proportions (Table 17).

Table 17.
Comparison of *during* flight visual complaints for 1990 and 2000 surveys.

	2000 survey (n = 216)	1990 VISAA survey (n = 58)	p value
Visual discomfort	**82%**	51%	**.0000**
Headache	**61%**	35%	**.0003**
Double vision	7%	**14%**	.0949
Blurred vision	**34%**	21%	.0554
Disorientation	**42%**	19%	**.0012**
Afterimages	29%	NA	NA

Note: Percentages are rounded to the nearest integer. **Bold** values indicate the higher of the compared values and differences which were statistically significant to the .05 level.

In Table 18, a similar comparison is made for symptoms reported *after* flight. As before, the percentages presented are based on the summation of "Sometimes" and "Always" responses.

Table 18.
Comparison of *after* flight visual complaints for 1990 and 2000 surveys.

	2000 survey (n = 216)	1990 VISAA survey (n = 58)	p value
Visual discomfort	**74%**	30%	**.0000**
Headache	**63%**	34%	**.0000**
Double vision	5%	**11%**	.2495
Blurred vision	**37%**	27%	.1432
Disorientation	**10%**	5%	.2391
Afterimages	**47%**	21%	**.0003**

Note: Percentages are rounded to the nearest integer. **Bold** values indicate the higher of the compared values and differences which were statistically significant to the .05 level.

For the six *after* flight symptoms, the percentage of reports increased from the 1990 to the 2000 survey for all except one -- double vision; this was the same as found between the two surveys for symptoms reported *during* flight. For the five symptoms that increased in reported frequency from 1990 to 2000, three were statistically significant to the .05 level based on a Z-test for proportions (Table 18). For the 1990 and 2000 surveys, the frequency of reports of double vision was halved for both *during* and *after* flight conditions, but these decreases were not found to be statistically significant ($p = .0949$ and .2495, respectively).

It is reasonable to suggest that the number of visual complaints were related to flight experience with the IHADSS. Perhaps less experienced Apache aviators had more

visual symptoms, and their occurrence lessened with flight experience. Or, perhaps the inverse was true; the incidence of symptoms increased with experience. However, when a scatter plot of the number of reported symptoms *during* flight as a function of AH-64 flight experience was performed (Figure 32), it was shown that no correlation existed between IHADSS experience and number of complaints.

Another possible correlation that might have existed was between the number of complaints and aviator age. As aviators age, numerous visual functions degrade. However, a scatter plot of number of complaints as a function of age (Figure 33) failed, again, to show any correlation.

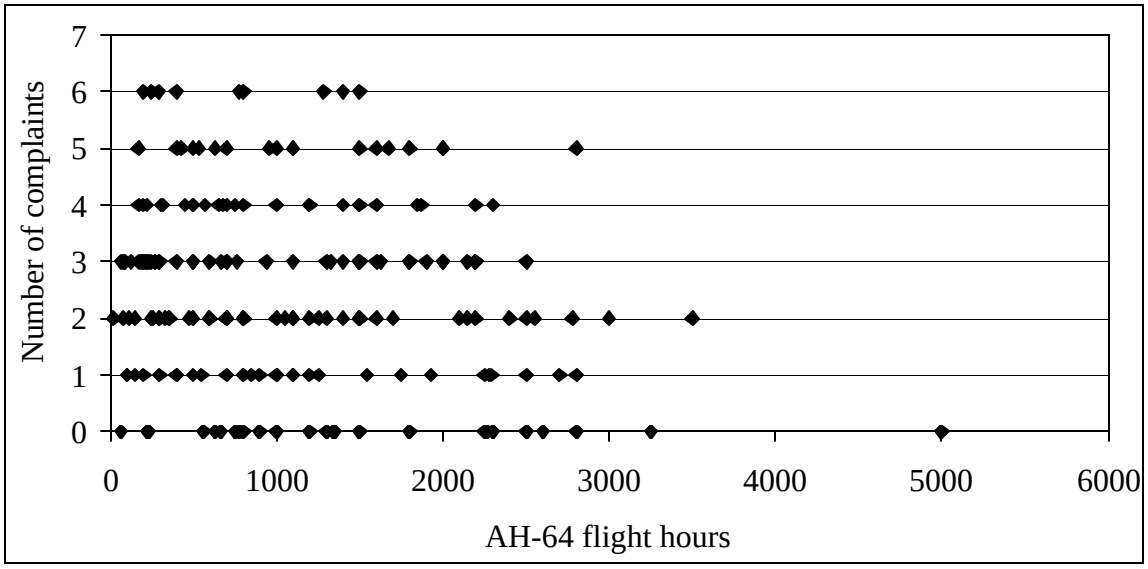

Figure 32. Scatter plot of number of complaints reported during flight as a function of AH-64 flight experience (in flight hours).

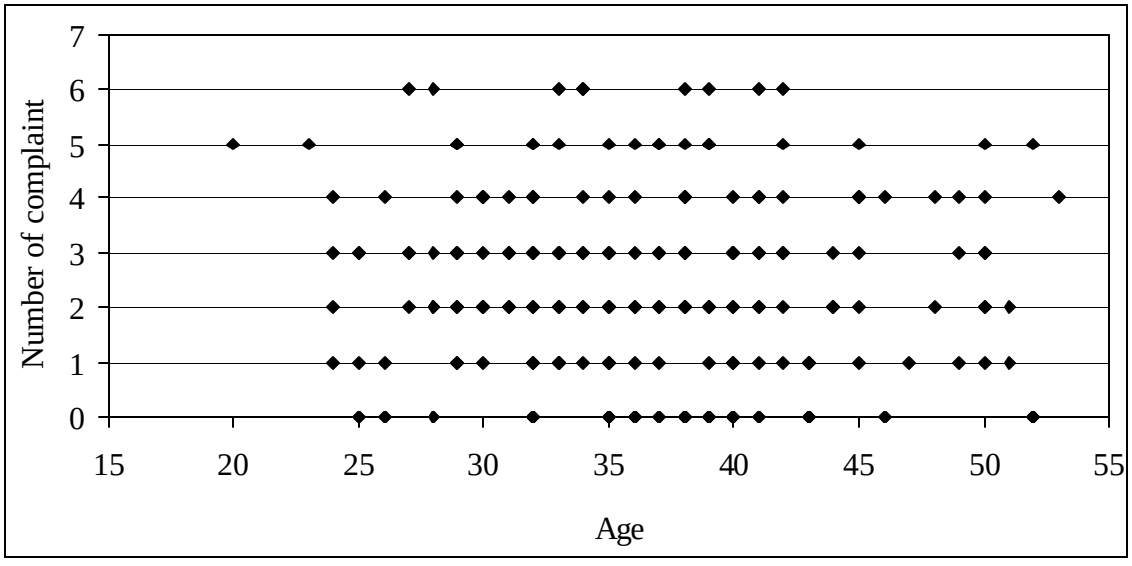

Figure 33. Scatter plot of number of complaints reported during flight as a function of age (in years)

Eye dominance

Eye dominance refers to the preference an individual exhibits to accepting visual input in one eye over the other. While eye dominance often is related to the task involved, the survey question asked for a general response of "preferred sighting eye." In the current survey, the distribution of eye preference was 84.3% for the right eye and 15.7% for the left eye. This preference distribution was somewhat different from that found in the 1990 survey -- right eye (62%), left eye (22%) and either eye (5%). [There was a 5% no response rate in the 1990 survey.]

When eye preference was compared to the frequency of visual complaints, it was found that respondents reporting a right eye preference averaged 2.5 visual complaints *during* flight and 2.4 complaints *after* flight. The mean numbers of complaints for the left eye were identical. These values are summarized in Table 19. Based on these findings, there is no reason to assume eye preference played a role in the visual complaints.

Table 19.
Relationship between eye preference, mean number of visual complaints, and unintentional switching.

	Right	Left
Mean number of complaints *during* flight	2.5	2.5
Mean number of complaints *after* flight	2.4	2.4
Proportion reporting problem with unintentional switching *during* flight	62.6%	76.5%

Unintentional visual alternation

During flight, Apache aviators using the PNVS/TADS sensor imagery to fly the aircraft are presented with two disparate views -- sensor imagery in the one (right eye) via the HDU and view of the cockpit/outside scene via the other (left), unaided eye. In the 1990 survey, nearly 70% of the respondents used the affirmative (Always, Usually, Sometimes) when asked if their vision ever alternated unintentionally between the two eyes during flight. In the current survey, 64.4% reported unintentional alternation during flight. This difference between surveys was not found to be statistically significant ($p = .3339$). Most aviators (74.5%) reported being able to switch their attention with ease. Slightly less than 1% reported having "great difficulty" in being able to switch visual inputs (between eyes) on demand. Almost half (44.9%) reported having developed a strategy to aid in switching. Such strategies included closing one eye, glancing away, or blinking both eyes.

Also included in Table 19, are proportions (in percent) of respondents who reported some level of unintentional switching, compared by eye preference. Since the IHADSS is a monocular system presenting sensor imagery to the right eye only, it was interesting that fewer pilots preferring the right eye reported problems with unintentional switching

(62.6%) than pilots preferring the left (76.5%). However, this difference was not found to be statistically significant ($p = .1210$). When this analysis was expanded to include the level of effort required to perform purposeful alternation, it was found that 24.7% of pilots preferring the right eye had some or great difficulty. This value was about the same for pilots preferring the left eye (23.5%). So, there seems to be little association between eye preference and problems with alternating between the two eyes.

Illusions

The 1989 NVD visual illusions study (Crowley, 1991; Crowley et al., 1992) was very limited in his reports by Apache aviators; only 21 of the 243 respondents were reporting on AH-64 flight with PNVS/TADS sensors and the IHADSS HMD. The most reported static illusion was faulty height judgment (19%); the most reported dynamic illusion was undetected aircraft drift and illusory aircraft drift, both at 24%. The current survey found considerably greater frequencies of reported illusions. Approximately 92% and 95% of the respondents reported at least one static or dynamic illusion, respectively.

Of the seven types of static illusions reported, five were reported by more that half of the respondents. The most reported static illusion was faulty slope estimation (80.1%) followed by faulty height judgment (73.6%).

A high incidence of dynamic illusions also was reported. Of the eight symptoms, six were reported by more than half of the respondents, with undetected drift (78.2) and faulty closure judgment (75.5%) being the most reported. It should be noted that undetected drift was the most reported dynamic illusion for both the 1990 and 2000 surveys. Illusory drift, the second most reported dynamic illusion in the earlier survey (24%), was the third highest reported in the current survey (71.3%).

Helmet fit

The IHADSS helmet was the first Army helmet developed specially for an aircraft series, the AH-64 Apache. This helmet represented a tremendous transition in helmet sophistication (Rash, Johnson, and Martin, 1989). In addition to performing the standard functions of a protective helmet, it must also serve as a platform for mounting the HDU. This additional function brings with it the added requirement for increased stability. In order to achieve and maintain the full field of view, the helmet must be fit such that the pilot's eye is located in the 10-mm exit pupil. This exit pupil position must be maintained, even in the presence of vibration, head movements, sweat, and normal wear and handling. To achieve this, the fitting system and technique must be customized to individual pilot head and face anatomy. The aviator himself normally does IHADSS fitting, with someone from aviation life support equipment (ALSE) assisting.

The first fitting is done at the Hanchey Army Airfield ALSE shop at Fort Rucker, Alabama, during training in the Aircraft Qualification Course. The fitting process is quite lengthy and involves a large number of steps and custom-cut fitting pieces. During early fielding of the AH-64 and IHADSS, ALSE personnel were provided formal

specialized training in IHADSS fitting. However, this training has virtually disappeared, with current ALSE personnel receiving only on the job training. However, fortunately for the Army, Fort Rucker has an experienced contractor fitter who has, for 17 years, provided invaluable expertise in solving innumerable refit problems.

While 120-day ALSE inspections are required on all helmets, these inspections check only the condition of the helmet components; the fit and exit pupil alignment are not checked. In practice, most AH-64 units have a "local expert," who, through experience, has become the unit "fitter."

In spite of these fit issues, the 2000 survey showed that over two-thirds (68.1%) of the respondents were somewhat or completely satisfied with their current fit. With 14.4% indicating being neutral on their satisfaction with fit, that left 17.1% as either somewhat or completely dissatisfied. Complaints included helmet shifting, having to rotate or turn helmet to adjust field of view, "sloppy fit," and hot spots.

Another major fitting issue is the inability of aviators to carry their helmets with them when they change duty stations. Currently, aviators are required to turn in their helmets prior to leaving their present assignment for a new assignment. Once the helmet is turned in, the Velcro that is used to adjust the fit is removed and given to the aviator in an effort to help with fitting the new helmet. In spite of this effort, comments provided in the survey tend to imply that helmet fit is detrimentally affected by this policy. Proper helmet sizes may not be available at the new duty station, resulting in a helmet that is either too large or too small. In addition, faced with the need for a near complete refitting, the aviator may not have the availability of an experienced IHADSS fitter.

Acoustic issues

A novel technique, the CEP, has been developed and has obtained an AWR for use in the IHADSS helmet. The CEP incorporates a miniature earphone coupled with a foam earplug. Worn in combination with the aviator's helmet, it can provide hearing protection adequate for extremely high noise levels while improving voice communication intelligibility. Previous limited testing of the CEP in the AH-64 community has been conducted. This survey took the opportunity to measure the awareness of and interest in the CEP among AH-64 aviators. While only 5.1% of the respondents had actually used the CEP, approximately half (50.9%) were aware of its development. More than three-quarters (80.1%) of the respondents were unaware that an AWR had been published for the CEP use in IHADSS. An almost equal proportion (85.2%) expressed at least some interest in using the CEP in their IHADSS helmet.

Additional comments

While the responses to the structured questions in the survey were of great importance in addressing the purpose of the survey, i.e., to investigate the visual issues associated with the use of the IHADSS HMD, the information provided by the respondents to the last, open ended, question, also was very informative. Almost half (46.3%) of the

respondents took the opportunity to expand on previous responses or provide additional insight into HMD flight with the IHADSS. The comments were loosely grouped into seven categories: Vision changes, FLIR, acoustics, helmet fit, image quality, monocular versus binocular design, and use of spectacles.

Several aviators expressed the belief their right eye vision had "gotten worse...due to use of the IHADSS." However, an almost equal number expressed the opposite belief that vision in their left eye had "gotten worse over the past 2-3 years." The survey question that had asked aviators if their better (preferred) eye was the same [now] as prior to AH-64 training, had a response of almost two-thirds (63.4%) answering in the affirmative (Figure 15). However, the remaining third (35.6%), who felt vision in their better eye had changed, is still a significant proportion. This concern over possible changes in vision due to prolonged use of the monocular IHADSS is the subject of an ongoing (2000-2010) U.S./United Kingdom collaborative 10-year study in which the visual performance of British aviators using the IHADSS in the Westland WAH-64 Apache will be followed via a comprehensive battery of vision tests (Hiatt et al., in progress).

Some of the most vehement comments addressed the quality of the imagery provided by the PNVS thermal FLIR. This nose-mounted sensor provides the visual input used by the pilot to fly the aircraft at night and during inclement weather. The current FLIR is referred to as GEN1 (1970s) to indicate first generation technology. This system incorporates a mercury-cadmium-telluride (HgCdTe) detector operating in the 8 - 12 micron range. The combination AH-64 PNVS-IHADSS system provides an equivalent Snellen visual acuity of 20/60 (Green, 1988). Of the 100 aviators providing responses to the request for additional comments, the most frequent subject of these comments was FLIR image quality. The general tone of the comments is extremely negative towards the use of 30-year old sensor technology on the Army's most advanced attack helicopter. Care must be taken to disassociate the quality of the FLIR input video signal from the performance of the IHADSS, which serves as the display for the FLIR imagery. According to the Apache Program Manager, advanced generation FLIR upgrades are programmed for the near future.

Acoustics comments generally were limited to Apache aviators who had previous exposure to the CEP. Comments indicated recognition of hearing loss due to exposure to the high ambient noise environment of helicopters and the willingness to purchase and use the CEP to address this health hazard.

Next to the issue of FLIR quality, the most frequent issue raised in the additional comments was that of helmet fit. In general, aviators commented strongly on the Army's current fitting program, the quality of fit, and the impact of the Army's requirement to turn IHADSS helmets in before each change of duty station. Aviators indicated that the impact of fit on IHADSS performance would be greatly enhanced if they were allowed to keep their assigned helmet throughout their Apache career.

Several aviators commented on the dynamic and interrelated nature of image controls available with the IHADSS/PNVS; i.e., brightness, contrast, gain, level, and focus. Inability to achieve the full grayscale reproduction also was mentioned. Again, care must be taken to separate image quality degradation associated with the IHADSS display from that associated with the input FLIR video.

While a few aviators expressed a desire for a "lighter-weight, binocular system with greater field-of-view," most of the comments in the category of monocular versus binocular design indicated a preference for a monocular display or at least the capability of using the supplied HMD in a monocular mode. The most common argument for a monocular design was the frequent advantage of having one "dark-adapted eye" during night flights.

During flight, 59.6% of the respondents indicated they wore some type of spectacle correction. All of the comments which addressed spectacle wearing with the IHADSS included references to how difficult interfacing spectacles and IHADSS is and the resulting compromise in field-of-view.

Conclusions

The AH-64 Apache, incorporating FLIR sensors and the IHADSS HMD, is an aircraft which lends tremendous capability to the Army's doctrine of night and foul weather operation. The success of the AH-64 over its near two-decade fielding provides evidence to its operational effectiveness. It's unique monocular HMD design has contributed to this success. However, the use of the IHADSS HMD has not been without issues. The most important of these issues has been the incidence of visual complaints/symptoms that manifest themselves both *during* and *after* flight. The study reported herein attempted to revisit the issue of these visual complaints, a first study having been conducted ten years ago, in 1990.

The major conclusions that can be drawn from the new survey are:

- There are sufficient data to indicate that aviators flying with the IHADSS experience a relatively high frequency of a variety of visual symptoms; 92% of respondents report at least one visual complaint/symptom either *during* or *after* flight.
- A comparison between findings in this survey and a similar one performed in 1990 show statistically significant increases in the proportion of multiple visual symptoms to include visual discomfort and headaches both *during* and *after* flight with the IHADSS, for disorientation *during* flight, and for afterimages *after* flight.

- The frequency of complaints is not correlated to age or AH-64 flight experience.

- The data do not support any association between eye preference (dominant eye) and the number of complaints or the presence of unintentional alternation (switching) between the left, unaided eye and the right, aided eye viewing the IHADSS imagery.
- The two most reported static illusions are faulty slope estimation and faulty height judgment, reported by approximately three-quarters of the respondents. There is a high incidence of dynamic illusions reported, with six of the eight identified dynamic illusions reported by more than half of the respondents. The two most reported dynamic illusion are undetected drift and faulty closure judgment, reported by more than three-quarters of the respondents.

- While a large proportion of respondents express satisfaction with helmet fit, a significant number comment on having difficulty maintaining a full field of view due to helmet slippage.

- When asked to provide additional comments, the single issue most strongly voiced by AH-64 aviators is the poor performance of the FLIR sensor. This survey does not allow the determination of what contribution the poor FLIR image contributes to the reported visual symptoms.

Recommendations

Based on the findings of this study, the following recommendations are suggested:

- Strong support should be provided to the ongoing plan to upgrade the FLIR sensors on the current Apache fleet. To attempt to separate the contributions of the current limited FLIR image quality from those of the IHADSS HMS to the incidence of visual symptoms, the vision section of this survey should be repeated following the FLIR upgrade.

- Emphasis should be placed on providing formal specialized ALSE training in IHADSS fitting techniques.

- The current Army policy requiring the turn-in of IHADSS helmets for change in duty station should be revised to allow an Apache aviator to retain his/her helmet for their AH-64 career.

- The US/UK collaborative study looking at long-term visual performance flying the IHADSS should be carefully monitored.

- A study should be conducted that attempts to identify the major contributing factors to the high incidence of visual symptoms associated with use of the IHADSS and how these factors might be mitigated through training and/or system modifications.

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Appendix A.

Questionnaire: Visual Issues Survey (Year 2000) of AH-64 Apache Aviators.

Apache (AH-64) Vision Questionnaire

***** FOR AH-64 APACHE AVIATORS ONLY *****

Purpose: **To identify and assess visual performance issues and problems relating to use on the monocular IHADSS helmet-mounted display.**

Accuracy of your responses: **It is important that you answer the questions as accurately and fully as possible. Your response will assist in the design and improvement of future and current HMDs.**

Anonymity: **Your responses are anonymous. No identifying personal data are requested. The data provided by you will be used for research purposes only.**

1. **Demographics:**

A. Age 20
B. Sex: Male Female
C. Total flight hours across all Army aircraft
D. Total flight hours in AH-64 1) Flight Hours in A/B models 2) Flight Hours in D Model
E. AH-64 flight hours in past 30-days:
1) Estimated percent in front seat/backseat 50/50
2) Estimated percent of daytime flight/nighttime flight 50/50

2. **Visual history:**

A. Do you wear any type of vision correction?	☐ Yes ☐ No If "No", skip to (B)

1). Check all that apply	During Flight	Other Times
Glasses		
Single Vision	☐	☐
Bifocals	☐	☐
Trifocals	☐	☐
Progressive (No Line)	☐	☐
Readers	☐	☐
Contact Lenses	☐	☐
Single Vision	☐	☐
Bifocal	☐	☐

2). Age when glasses first prescribed	NA

3). Age when contacts first prescribed	NA

B. Have you been treated for eye disease?	☐ Yes ☐ No If "Yes", check all that apply.

- ☐ Glaucoma
- ☐ Cataracts
- ☐ Infection
- ☐ Dry Eye

Other / Explain:

C. Have you ever had an eye injury?	☐ Yes ☐ No If "Yes", check all that apply.

- ☐ Debris (foreign body) embedded in eye
- ☐ Injury from finger or hand in eye
- ☐ Blunt Trauma (Black Eye)
- ☐ Corneal scratch or abrasion
- ☐ Impact with object / Explain

D. Have you ever experienced double vision?	☐ Yes ☐ No If "Yes" when?

E. Have you ever experienced blurred vision?	☐ Yes ☐ No If "Yes" Explain

F. Do you get headaches from extended periods of close work?	☐ Yes ☐ No

G. Do you ever experience eyestrain?	☐ Yes ☐ No If "Yes" when?

H. Which is your preferred sighting eye?	☐ Left ☐ Right
I. Which eye would you use with a telescope?	☐ Left ☐ Right
J. Is your better eye the same now (After AH-64 training and experience) as it was prior to your AH-64 experience?	☐ Yes ☐ No
K. What is your hand preference for ball throwing?	☐ Left ☐ Right ☐ Ambidextrous (evenhanded)

3. ***Helmet Fit:***

A. Date of last helmet fit: Month 1 Year

B. Satisfaction with current fit:

- ☐ Completely satisfied
- ☐ Somewhat satisfied
- ☐ Neutral
- ☐ Somewhat dissatisfied
- ☐ Completely dissatisfied

C. Is your ability to view IHADSS imagery impacted by your helmet fit (e.g., helmet slippage impacts ability to maintain field of view)? If "Yes" Explain	☐ Yes ☐ No

4. ***Aviation Vision:***

A. *While* flying the Apache, have you experienced:

Visual discomfort (e.g., eyestrain, fatigue)	☐ Never	☐ Sometimes	☐ Always
Headache	☐ Never	☐ Sometimes	☐ Always
Double Vision	☐ Never	☐ Sometimes	☐ Always
Blurred Vision	☐ Never	☐ Sometimes	☐ Always
Disorientation	☐ Never	☐ Sometimes	☐ Always
After-Images	☐ Never	☐ Sometimes	☐ Always

B. *After* flying the Apache, have you experienced:

Visual discomfort (e.g., eyestrain, fatigue)	☐ Never	☐ Sometimes	☐ Always
Headache	☐ Never	☐ Sometimes	☐ Always
Double Vision	☐ Never	☐ Sometimes	☐ Always
Blurred Vision	☐ Never	☐ Sometimes	☐ Always
Disorientation	☐ Never	☐ Sometimes	☐ Always
After-Images	☐ Never	☐ Sometimes	☐ Always

C. During Apache flight, have you experienced *any* of the following degraded visual cues?

Degraded resolution/insufficient detail	☐ Yes	☐ No
Loss of visual contact with horizon	☐ Yes	☐ No
Impaired depth perception	☐ Yes	☐ No
Decreased field of view	☐ Yes	☐ No
Inadvertent IMC	☐ Yes	☐ No
Whiteout/Brownout	☐ Yes	☐ No

Blurring of image with head movement	☐ Yes ☐ No

D. During Apache flight, have you experienced *any* of the following illusions? (Check all that apply)

Static:

Faulty Height Judgment	☐ Yes ☐ No
Trouble with Lights	☐ Yes ☐ No
Sense of Landing "In a Hole"	☐ Yes ☐ No
Faulty Clearance Judgment	☐ Yes ☐ No
Faulty Slope Estimation	☐ Yes ☐ No
Bending of Straight Lines	☐ Yes ☐ No
Faulty Altitude Judgment	☐ Yes ☐ No

Comments:

Dynamic:

Undetected Aircraft Drift	☐ Yes ☐ No
Illusionary Aircraft Drift	☐ Yes ☐ No
Disorientation (Vertigo)	☐ Yes ☐ No
Faulty Closure Judgment	☐ Yes ☐ No
No Sensation of Movement	☐ Yes ☐ No
Faulty Airspeed Judgment	☐ Yes ☐ No
Illusory Rearward Flight	☐ Yes ☐ No
Illusions of Pitch	☐ Yes ☐ No

Comments:

E. Have you noted any change in your ability to see or interpret HMD symbology during any phase of flight?	☐ **Yes** ☐ **No**
If "Yes" Explain	
F. When viewing through the HMD, do you have difficulty focusing clearly on the external scene and the symbology simultaneously?	☐ **Yes** ☐ **No**
If "Yes" Explain	
G. During flight, does your vision sometimes *unintentionally* alternate between the two eyes?	☐ **Yes** ☐ **No**
If "Yes" Comment	

H. To what degree can you purposely alternate between your two eyes?	☐ **Easily**	☐ **With some difficulty**	☐ **With great difficulty**

I. Do you have any special methods to assist in switching?	☐ **Yes**	☐ **No**
If "Yes" Comment		

5. **Acoustical Issues:**

Note: **The Communications Earplug (CEP) is a device used with the SPH-4/4B and HUG-56/P flight helmets that improves the noise protection over that provided by the helmet alone while simultaneously greatly improving speech intelligibility.**

Please provide any additional information which you feel will help in this pursuit.

A. How much do you know about the CEP? ☐ **Had not heard about it**	☐ **Some knowledge, but no personal experience**	☐ **I have used CEP in SPH-4/4B or HGU-56/P**
B. How interested are you in using CEP in IHADSS? ☉ **Not at all Interested**	☐ **Some Interest**	☐ **Great Interest**
C. Are you aware that an AWR has been published for CEP in IHADSS?	☉ **Yes**	☐ **No**
D. If made available, would you use CEP in your IHADSS? ☉ **No, not interested**	☐ **Yes, but only if issued to me**	☐ **Yes, even if I had to purchase it with personal funds**

6. Additional comments/problems:

The purpose of this study is to help identify *VISUAL* issues associated with using the IHADSS.

Submit Reset

Appendix B.

Comments: Visual history symptoms.

Double vision:
-- "[In the] early morning."
-- "If your definition means a severe problem with my eye alternating between the unaided and aided, then 'Yes' I have to close my left eye on most flights."
-- "Momentarily when shifting eyes rapidly."
-- "[After] long NVS flights."
-- "When tired."
-- "For about two weeks after gunnery, object[s] appeared bigger in one eye."
-- "After flying with the HMD, frequently."

Blurred vision:
-- "[In the] early morning."
-- "Currently having trouble focusing with HDU, vision tests [at] 20/15."
-- "After long NVS flights, two hours or greater."
-- "Sometimes after a long NVS flight when it is cold out, my right eye blurs."
-- "When very tired."
-- "Only when eyes are tired. I rub them a bit and then it goes away."
-- "After flying the PNVS/TADS for long periods of time, normally greater than two hours of system time."
-- "Usually in conjunction with a long night flight."
-- "After long NVS flights, right eye takes a few minutes to readjust and clear."
-- "Ongoing determination of blurriness due to blunt force trauma…"
-- "[After] entering a bright environment after being in a dim one. Short lived…"
-- "After working with computers for extended periods."
-- "After flying NVS for more than a couple of hours and then being off the system and trying to do something like fill out the log book."
-- "After extended NVS flight three to four hours."
-- "When I am tired and have flown a long night flight."
-- "Late at night, especially after flying the system."
-- "[When] dirt [is] embedded in eye."
-- "Left eye retinopathy. Lasted four months."
-- "At night when viewing at a distance."
-- "When contacts need cleaning or replaced."
-- "Insufficient tear layer on eye."
-- "When extremely tired I get blurred vision."
-- "After long NVS flights, focusing is difficult for a while afterwards."
-- "When fatigued during intense reading periods."
-- "Immediately after removing the IHADSS and switching over to 'vanilla' night."
-- "Recently, there have been short and sporadic periods of blurred vision when I am visually concentrating on an object."
-- "The sight in my right eye is worst than my left by far. But, I don't need glasses yet."
-- "When I failed to properly adjust the HDU."

-- “[After] long NVS flights.”
-- “After long flights I have noticed some blurring of vision on occasion.”
-- “After an NVS flight.”
-- “When tired.”
-- “When flights of long duration, four to six hours, then [I] feel closed in/confined.”
-- “Have difficulty focusing with my right eye, usually near vision.”
-- “[When] driving long distances at night.”
-- “During periods of eye exhaustion.”
-- “Yes, it comes and goes. It lasts for about ten seconds.”
-- “When fatigued.”
-- “Distant objects viewed by my right eye are not as clear as when I was in my 30's.”
-- “Lights at night appear fuzzy.”
-- “After flying with the HMD, very frequently.”

Eyestrain:
-- “[After] long NVS flights, [or] long hours in front of a computer screen.”
-- “During use of the IHADSS, my right eye vision has gotten worse.”
-- “After long periods of flight or desk work.”
-- “[After] computer work.”
-- “[When] trying to read small print without my glasses.”
-- “During, and sometimes after, flying with HDU.”
-- “During NVS flight and computer work.”
-- “After working on a computer for long periods.”
-- “When flying NVS for more than two hours.”
-- “When I have been staring at small print for more than one hour.”
-- “[After] close reading, I think mainly for my age.”
-- “After long NVS flights in excess of 2.0 hours.”
-- “Improperly focused HDU.”
-- “Whenever I am extremely tired or after flying night system for more than three [hours].”
-- “When tired.”
-- “Yes, seems only when I have inaccurately focused the HMD.”
-- “After long hours of computer work or reading, three or four hours consecutively.”
-- “After 2800 hours of using and teaching AH-64 PNVS. I wear corrective glasses.”
-- “While flying NVS.”
-- “After approximately five hours [flying the] NVS.”
-- “I have when I have improperly adjusted the focus on the HMD…”
-- “Very early in AH-64 flying, during the transition at Ft. Rucker.”
-- “When working on the computer for hours without taking a break.”
-- “Occasionally now after the recent blunt force trauma.”
-- “My right eye tears and stings every once in a while, only while using the NVS.”
-- “After working with computers for extended periods.”
-- “[After] long periods of night vision usage.”
-- “When flying the Apache at night under the system for extended periods.”
-- “After reading for extended periods.”
-- “After long NVS flights.”

-- “After not flying NVS for a while (say a month) and then flying the system for a couple of hours, the first few hours my eyes will hurt after the flight.”
-- “Occasionally after a long night system flight.”
-- “After being under the system (Night Vision System) for an extended period (three to four hours).”
-- “After lots of reading and when physically tired.”
-- “On clear nights with lots of external lights.”
-- “Extended night flights under poor FLIR conditions.”
-- “Once in a while. It has more to do with the bright sun than with flying.”
-- “Long night flights with the HDU.”
-- “If I haven't flown NVS for a while (couple [of] weeks) and hop back into it.”
-- “After pulling a 24-hours duty shift without sleep.”
-- “Poorly focused HDU.”
-- “After reading a book for an extended period of time.”
-- “After about three and a half to four hours of night system.”
-- “Night HDU optimization. It is very difficult to focus the HDU with no visible distant objects.”
-- “Improper focus of HDU.”
-- “[After] extended periods working at the computer.”
-- “Spending long amounts of time looking at computer monitor without a break.”
-- “I find myself squinting more and more.”
-- “The night system visual acuity on the Apache is poor at best. It creates a strain on the eye to try and make out details that you need to see in order to safely fly the aircraft.”
-- “After using the HMD for a long period, night or day.”
-- “When my HDU cannot be focused properly.”
-- “When transitioning from outside to inside the cockpit after long periods.”
-- “On the system.”
-- “While working with computers for an extended period of time.”
-- “When reading or flying with the IHADSS.”
-- “[After] low light reading.”
-- “NVD flight.”
-- “[After] extended technical reading, [or after] long night duration flights (4+ hours).”
-- “After about five hours of NVS flight.”
-- “When flying NVS after not flying for a while, or when there are bright lights visible to distract my unaided eye.”
-- “After reading small print for long periods of time.”
-- “After flying either day or night for over 4 hours. I always fly with the HDU day or night.”
-- “Whenever flying night system for an extended period [or] during periods of poor FLIR image.”
-- “NVS flights over two hours.”
-- “Past my 12th duty hour or so, late night.”
-- “When I am trying to discern various objects through the TADS, judge distances and identify obstacles.”
-- “When I read a lot or after flying that [expletive deleted] NVS.”
-- “After four hours of any NVD flight.”

-- “When I fail to properly perform IHADSS Video Adjustments.”
-- “Of course, everybody experiences eyestrain. Especially when flying four to five hours of night system trying to discern objects from an unacceptable FLIR picture.”
-- “[After] long flights of NVS.”
-- “When I don't fly the Night Vision System for a few weeks, and then fly [it].”
-- “During extended NVS flights.”
-- “During long periods of study or reading.”
-- “After spending hours upon hours building Power Point presentations.”
-- “[After] long periods of reading/computer work.”
-- “Bright daylight works after long NVS flights (three to five hours) the day prior.”
-- “When flying under the system.”
-- “After flying NVS.”
-- “During/after NVS flight when HDU not properly adjusted, causing eyestrain and headache behind right eye.”
-- “After extended periods of NVS flight and extended periods of work on computers.”
-- “[After] extended time flying night system.”
-- “[After] long work at computers.”
-- “When the FLIR picture is bad.”
-- “When physically fatigued, I would notice eyestrain during extended NVS missions.”
-- “After flying two or more hours of NVD I experience moderate right eyestrain.”
-- “When focusing in at instrument panel, when eyes are tired.”
-- “When focusing on near objects.”
-- “[After] driving long distance[s] at night.”
-- “Flying with the AH-64 NVS.”
-- “Near end of workday after extensive reading, computer use or flying.”
-- “[After] high levels of concentration for extended time periods, i.e. NVS.”
-- “Yes, I get a minor headache if I concentrate on small objects for extended periods of time.”
-- “When flying NVS for an extended period of time.”
-- “Only if the HDU is not focused properly or [there is] poor picture quality.”
-- “[After] working on computers for long periods.”
-- “When focus ring [is] improperly focused.”
-- “[After] working a lot with computer systems as administrator.”
-- “During extended periods flying NVS.”
-- “After extended work period at a computer, and after a long NVS flight.”
-- “After extended close work.”
-- “After longs hours of work at a computer.”
-- “[After] extended NVS flight.”
-- “My eyes get very tired and dry.”
-- “[After] extended NVS operations.”
-- “Sometimes after long NVS flights.”
-- “During extended reading periods or trying to focus on moving objects (while driving).”
-- “As a new user of the IHADSS.”

Appendix C.

Comments: Impact of helmet fit on ability to view IHADSS [Integrated Helmet and Display Sighting System] imagery.

-- "If I use my glasses at night, I lose the top left portion of the display."
-- "Conflict between padding levels and HDU alignment."
-- "It took three months to fit and refit the helmet."
-- "During ELT shake."
-- "Must have helmet fit very well to see imagery and then still not able to se…"
-- "Stable helmet fit allowing the IHADSS to be in the right position is critical."
-- "Absolutely. I often have to 'adjust' the position of my helmet to get a f…"
-- "Rarely slips."
-- "If helmet is not secure, HDU slips & needs constant adjustment."
-- "If the helmet is not sitting square on your head you can not see all of the…"
-- "Not every HDU fits the same and this causes me to have to adjust the helmet."
-- "Helmet is either too tight (hot spots) or slips a little."
-- "Helmet must be turned slightly to view HDU."
-- "The HDU mount and the length the combiner lens extends from the HDU seems to…"
-- "My HDU must be very close to my eye, so my helmet must allow for that."
-- "Usually I have to move the helmet around to get the right 'view'. Currently…"
-- "Wear and tear has caused my helmet to not sit properly elevated on my head. This has resulted in me having to shift my helmet to get a complete 30 x 40 FOV."
-- "To some degree, proper helmet fit is mandatory, the adjustments that can be made with the helmet and the HDU in place are not sufficient to correct for poor sizing and centering without having a crew chief present to make adjustments to the DAP, the location…"
-- "Helmet is insufficiently secure to prevent slipping whilst turning my head."
-- "Helmet lining shifts over time. Velcro system is poor."
-- "Typical of current configuration of all IHADSS helmets."
-- "When I turn my head to the extreme right or left (>70 degrees or so), my helmet…"
-- "Even with 'sizing Velcro' the helmet shifts when tension is put on the data."
-- "Sometimes the IHADSS cable hangs on survival vest, causing helmet to slip."
-- "If I don't rotate my helmet down (forward), I cannot view the imagery prop…"
-- "Due to certain proportions of my head I am forced to wear an X-Large. If I…"
-- "My head is in between sizes (L and XL). The adjustments are 'maxed' to see mo…"
-- "IHADSS side of helmet is obviously lopsided and starts to pull combiner lens away from eye."
-- "Adjusting helmet for comfort during flight impacts FOV."
-- "Hard to keep HDU centered and focused, I have a short neck, and sometimes hit focus knob, which causes it to lose focus and centering."
-- "The first problem is that every time you go to a new unit you have to get a new helmet. Sometimes it takes over a month to break in a new helmet. This break-in period directly affects the IHADSS imagery. Helmet slippage is a problem, if the helmet is [too big]."
-- "I have an XL helmet. The combiner lens is about 3/4 extended."

-- “Helmet slippage impacts ability to maintain Field Of View.”
-- “Yes, after putting on the HDU I have to adjust my helmet in order to obtain an adequate picture.”
-- “I know when it is time to get a haircut, because it was fitted with short hair and every 2-3 weeks it needs to be cut or my helmet will not maintain. It will not stay centered so the HDU will not be aligned directly in front of my eye. Also it looks like…”
-- “Lose the corners of the display.”
-- “Black spots appear in image as I scan the symbology due to the inability to fit the HDU close enough to my eye on my current IHADSS. Specifically, I lose the lower right corner of the image as I read Q% [Torque displayed in percent] or look left of a/c.”
-- “No.”
-- “I adjust my helmet three to four times per flight to fix my IHADSS imagery.”
-- “Helmet slips, you lose safety of flight information.”
-- “Really, no! But, it takes approximately one minute to ensure that helmet is seated correctly, because of a ‘sloppy’ (excuse the term) fit of the IHU. Other helmet fits are more ‘snug’ and comfortable without the time for adjustment!”
-- “Occasionally have to adjust helmet to gain full Field Of View.”
-- “I wear an XL helmet and cannot get the combiner lens close enough to my eye to be able to read all symbology.”
-- “The helmet must be tightly fitted within fairly rigid parameters to be able to view all of the flight symbology.”
-- “It's just difficult for me to get a good comfortable helmet fit.”
-- “If the helmet does not fit properly then the HDU will not adjust to the eye properly in order to get a full sight picture. Additionally the fit must be snug but comfortable in order to maintain that sight picture throughout the flight. If the helmet moves…”
-- “If it doesn't fit, you can't see the display properly. I've been an instructor pilot for a long time, and I know what the [expletive deleted] it's supposed to look like.”
-- “Improper helmet fit (loose) affects viewing HDU.”
-- “Seems like the HDU is not close enough to keep a good picture.”
-- “When turning my head, I sometimes lose symbology due to the IHADSS not being completely snug width wise.”
-- “If it fits correctly I can see all the information. However, if the fitter cannot do a good job I can't see the torque information.”
-- “If my helmet is not perfectly sitting on my head I will sometimes have to readjust the HDU and my helmet in order to get a good picture.”
-- “If the top strap inside the helmet gets loose, as it did the other day, the entire sight picture changes, not to mention the incredible hot spot you get.”
-- “If the helmet is at all loose the Field Of View comes and goes and becomes really difficult to maintain.”
-- “The IHADSS is a ‘Velcro Monster’ and the fit on each particular day determines HDU placement. Fit of helmet is not consistent and any change of the helmet during a flight requires HDU to be re-adjusted to see all symbology. This can be accomplished by a…”
-- “Lose left side of display (i.e., torque, sight status).”

-- “Improper fit or position will cause difficulty seeing the entire picture in the HMD.”
-- “If my helmet moves at all, the viewable picture of my HDU is moved.”
-- “Need to tilt helmet slightly back to get full view.”
-- “Ability to see all symbology.”
-- “Field Of View problems occur when the helmet is not fitted properly.”
-- “For my helmet to fit correctly, the combiner lens is digging into the portion just below my right eye causing pain about an hour into the flight.”
-- “X-large helmet sometimes [torque] is obscured.”
-- “Sometimes symbology falls out of Field Of View.”
-- “I need a medium helmet, not a large. I have only had one good fit since leaving Fort Rucker and some civilian adjusted me. Since then it has been all downhill. I believe for me a form fitted (my skull only) helmet would be best.”
-- “Sometimes, but I can usually get it positioned properly.”
-- “During NVS flights, I have noticed a tendency to adjust my helmet more due to slight changes to HDU imagery.”
-- “If your helmet is not fit properly, it causes problems in seeing your entire FOV and also problems with shadowing from the cheekbone. If your helmet isn't tight enough, your FOV, Infinity Focus, and shadowing degrade your ability to see the entire picture.”
-- “If not properly fit it is hard to get the perfect view necessary to see ALL the information.”
-- “Minor movements of the IHADSS helmet, regardless of fit, can drastically alter image view / it is considered part of the HDU adjustment process.”
-- “When my helmet insert moves slightly, I lose, or partially lose, my HDU picture.”
-- “The helmet must be rotated forward on my head to view the entire image.”
-- “You must adjust the IHADDSS about every six months to ensure the proper HDU sight picture.”
-- “Helmet slippage impacts ability to maintain Field Of View.”
-- “The helmet design will not allow for a good fit. I have tried two different sizes and spent hours being fitted.”
-- “How the helmet sits on your head determines how snug the fit can be. The helmet needs to be snug to move the sensors near their travel limit.”
-- “Yes, I am school trained in ALSE, this fitting problem is compounded by having to leave your helmet at the last duty station and redraw and refit a new helmet each time. My last PCS resulted in taking a smaller helmet, which did not fit as well.”
-- “Large is too small, X-Large is too big, have to adjust helmet on head to see imagery. IHADSS in general is not a well fitting helmet. ALSE Techs not trained on IHADSS at all.”
-- “If it is not correct I cannot see the whole image.”
-- “If the helmet is not fitted properly. Also, when utilizing [Night Vision Goggles] in the [front seat], I have to shift my helmet to the left to get good FOV with [Night Vision Goggles].”
-- “If the helmet is not properly fitted, all symbology is not in FOV.”
-- “It takes 4-6 months of flying and adjusting in order to obtain optimal fit. Often unable to read symbolic torque.”
-- “The IHADSS is more uncomfortable than other helmet I have used. I don't feel like I

get a good fit without a very uncomfortable fit. Possible the added weight of NVG's and HDU. I have a tendency to adjust the helmet too much and this affects my Field Of View."

-- "All helmets seem to fit different[ly], once we get a good fitting helmet we should keep it until we are not flying anymore instead of changing helmets every time we move."
-- "Incorrect fit will create slippage. My fit is normal."
-- "In large head turns left or right, but especially right, the IHADSS and helmet will shift position due to contact with the shoulder."
-- "With hot spots you tend to move your helmet around, and that affects Field Of View."
-- "Loose knot on top of harness requires extending the combiner lens, reducing FOV."
-- "At times must intentionally misalign helmet on head in order to see full view of HDU image."
-- "Each time I get a different helmet (new assignment) it takes several flights to get the fit right and be able to view the entire picture."
-- "Hard to use HDU with laser glasses on."
-- "When turning head 90 degrees left/right, portions of the picture 'black out'."
-- "If not fitted properly you cannot see full FOV."
-- "I have a constant trade off between helmet comfort with lack of full imagery or an uncomfortable helmet [fit] and full IHADSS imagery."
-- "Not able to completely adjust the angle needed to put it directly in the front of my eyeball."
-- "Certainly - to put the IHADSS in a good eye position where you don't have to move the helmet on your head, it has to be fitted."
-- "Helmet must be worn tighter than comfortable to prevent IHADSS image displacement when head is turned more than 45 degrees left or right."
-- "Changes angle of HMD."
-- "An ill fitted helmet causes some of the imagery to not be visible. Helmet does not slip. The helmet does not fit the same every night."
-- "Helmet must fit extremely tight to view imagery (especially torque value) through all turning movements of the head."
-- "Achieving proper HDU placement to enable boresight requires a large helmet, which then slips around on [my] head.
-- "Affects the positioning of the HDU, either some or all of the symbology is visible."
-- "Sometimes I can't extend to HDU far enough so I have to cock my helmet a little bit."
-- "The HMD does not rest in the same place in front of my (on my cheek) every time, even when having flown the same aircraft two days in a row."
-- "At times, when turning my head, the whole scene will go away. Helmet shifts."
-- "I often have to move helmet during flight to get optimal view of HDU."
-- "A critical problem with helmet fit is the fact that AH-64 aviators must continuously turn in helmets that fit well every time they PCS. This guarantees that most AH-64 aviators out there are fitted with someone else's helmet every time they PCS."
-- "Can't see all of symbology when wearing glasses...any kind."
-- "Pushing on helmet occasionally helps field of view."
-- "You can't build a house on the sand. The only thing that affects how the HDU is viewed is helmet fit. If the helmet shifts even a little bit the viewable area in the HDU suffers."

-- “Sometimes HDU digs into my eye socket causing watery eye.”
-- “If your helmet doesn't fit correctly, you won't see [expletive deleted].”
-- “If helmet is not on correctly, all symbology is not able to be seen.”
-- “No two HDUs fit the helmet exactly alike. Velcro is not the most comfortable material for precise fitting of the helmet, causing helmet shifting.”
-- “Helmet fit and HDU mounting are critical in obtaining the necessary Field Of View to conduct night operations.”
-- “Helmet slippage impacts ability to maintain field of view, focus of symbology and scene content.”
-- “The helmet rotates front to rear unless I cinch it done very tightly.”
-- “In 15 years, I have never had all the symbology visible in the HDU while properly sized and centered.”
-- “New helmet fitting was initiated to try to clear up incomplete imagery as seen through bifocals. Several other aviators have simply removed right lens from their glasses and adjusted focus ring. Doesn't seem to work for me. With bifocal glasses on, the…”
-- “If I turn my head to the full 90-degree position to the left or right then I lose some of the FOV.”
-- “The helmet needs to have a ‘poured’ liner for a better fit. Similar to the Air Force.”
-- “My helmet size is in between large and X-large. I can't get a good helmet fit.”
-- “Helmet is too loose, you can lose part of your FOV.”
-- “Inconsistent fit with HDU, don't have that ‘sweet spot’ every time.”

Appendix D.

Comments: Static and dynamic illusions.

Static:

-- "Most, if not all of these, are to be expected to some extent."
-- "Yes answers mostly due to poor FLIR quality."
-- "The FLIR system has limits and that caused the problems you see above."
-- "Percent illumination has a lot to do with this."
-- "Flight with the HDU in place and using the NVS has its challenges, I am confident in my abilities to fly and fight this aircraft using the system that is provided, except you are only getting about 60% of what I'm capable of doing. Upgrade the NVS system."
-- "I have flown with symbology failures, Doppler failures, etc. without symbology."
-- "Height / Clearance judgment: Day VMC - Difficult during NOE flight even when…"
-- "Current FLIR quality is poor."
-- "Sometimes, I just think it would be nice to see. Goggles have been a great alternative."
-- "Landing in a hole or crater illusion usually occurs while flying NVG and/or landing with the searchlight on."
-- "Most of the problems were WX [weather] related, i.e. bad FLIR night."
-- "Many of these issues are common with the monocular system."
-- "The current FLIR is simply a poor flight image. Not only is the technology antiquated, but the sensors we have are well past their useful life in most instances."
-- "I have experienced all these while flying with goggles also, but worse with the Apache."
-- "Most of these illusions have been a direct result of improper radar altitude adjustments...and their relation in symbology."
-- "4a,b,c,d.. problems are PNVS/TADS related, not vision related. Various systems perform differently."
-- "All are symptoms of visual illusions that typically occur, especially when using the NVS and monocular vision."
-- "Most of these problems have to do with the [expletive deleted] FLIR that we are forced to fly with.
-- "FLIR needs improvement in acuity to fly safely."
-- "When you get close to the ground with any outside illumination I get 'binocular rivalry,' making it difficult to judge the actual ground contact."
-- "This is normal business flying with FLIR."
-- "Radar altimeter."
-- "I integrate a constant crosscheck of symbology with FLIR imagery when I am in the cockpit."
-- "The present FLIR that we have in the TADS is ridiculous to try and fly with. I understand that it is a target acquisition and designation system and the only current backup we have other than goggles. However, with a slew rate of only 60 degrees a second."
-- "All I have to say is IHADDS and TADS."

-- "Goes with the territory. Monocular will always have to be overcome with judgment. I have never had a mishap due to NVS flight."
-- "The TADS visual resolution impacts your ability to see a clear image; remember the TADS was not designed to fly with."
-- "Retinal rivalry is not really a problem, however because of the degraded detail of the surface, judging the height above obstacles and above the ground can be challenging."
-- "After speaking to one of the TADS/PNVS developers at an AAAA convention in Louisville KY, I was told that it was not designed to be the primary mode of night vision flying."
-- "Backing up all illusion displays with scanning, unaided eye use, and symbology, solves most problems."
-- "The proper use of symbology and scanning techniques have prevented any hazardous conditions during my flights."
-- "Imagery does not rotate with head. Causes disorientation."
-- "The yes comments are directly related to the quality of the FLIR conditions."
-- "Learned to overcome and compensate for these with experience."
-- "Most problems are from faulty equipment. HDUs are being repaired and sent to the units. It appears that a distortion check is not done prior to release. It is easy to overlook once installed."
-- "Only during training or after long periods when system not used."
-- "Radar altimeter is the only height cue in close proximity to ground. Using light requires focus from aided to unaided eye, PNVS position does not allow lateral clearance judgment. Almost no judgment regarding slope severity, Again, radar altimeter is only…"
-- "FLIR [expletive deleted]."
-- "Why don't you come out to Hanchey and experience NVS flight for yourselves? It would be far more intense than taking our word for it. Our academics at the flight line encompass the visual illusions in TC 1-204 and we specifically discuss whether we get…"
-- "Do you really have to ask this question? The answer is obvious."
-- "Most likely due to degraded two-dimensional information (bad FLIR picture)."
-- "All due to the size color and resolution of the combiner lens."
-- "What is the difference between height and altitude judgment?"
-- "Need newer FLIR system."
-- "I have 500 hours of NVS time. The system is DANGEROUS and needs upgrading. I am really surprised we haven't killed more aviators. NVGs should be a mandatory backup!"
-- "I want a full-face motorcycle helmet concept with gimbal mounted sights and HDU."

Dynamic:
-- "Again, yes answers due to poor FLIR quality."
-- "Again without accurate symbology."
-- "Disorientation during route reversal, although I knew where I was."
-- "Again, many are common but are easily corrected with a solid crosscheck of symbology."
-- "These are a basic part of flying the system. It's the same for flying with goggles."

-- “Symbology has assisted these illusions.”
-- “Normal illusions that you learn to deal with and learn from.”
-- “Again, same as above, however flight symbology helps dramatically with the correction of many of these types of illusions.”
-- “Reference to the symbology should prevent any of these, but they all can be felt using FLIR picture only.”
-- “OGE Hover.”
-- “I believe these illusions are due to inexperience, not IHADDS faults.”
-- “See comments under Static. (I integrate a constant crosscheck of symbology with FLIR imagery when I am in the cockpit.)”
-- “Experience with the system makes these less of a problem. The pilot with less than 200 hours of NVS time is dangerous.”
-- “TADS/PNVS video, and the limitations of the HUD, greatly affect the pilot's sight.”
-- “You would think the Army would be the first to have state-of-the-art FLIR systems.”
-- “All overcome by sensor, symbology usage.”
-- “Symbolic references are provided on the HDU that are sufficient to prevent these dynamic illusions. Illusionary drift is common with all aircraft.”
-- “Directly related to FLIR conditions.”
-- “Learned to overcome and compensate for these with experience.”
-- “Only during training, or after long periods when system is not used.”
-- “Symbology is inaccurate, which sometimes leads to undetected or illusionary aircraft drift. Closure judgment is undetectable past five rotor disks. True airspeed is only gauge for airspeed, FLIR cues help slightly. Illusory rearward flight when symbol.”
-- “The more tired you are the worse it gets.”
-- “Most of these illusions can be treated with training. Learning when to, and when not to move your head will help determine if the picture is moving because your head is moving, the aircraft is moving, or both. False horizon illusions result from the same.”
-- “Do you really have to ask this question? The answer is obvious.”
-- “Usually associated with night gunnery, splitting the focus with the other seats mission.”
-- “All corrected for by experience and symbology.”
-- “Symbology helps prevent all the above.”
-- “The picture presented on the HMD is too poor for anything other than a perfect night. The TADS picture should NEVER be acceptable. Its’ picture is VERY poor.”
-- “The hardest thing I've ever had to do is fly NVS.”

Appendix E.

Comments: HMD [Helmet Mounted Display] symbology.

Change in ability to see or interpret HMD symbology:

-- "Loss of left side of display due to glasses blocking image."
-- "It slows after long duration flights (>2 hrs)."
-- "Visual cues degrade over time in the aircraft."
-- "See 3e above. (Must have helmet fit very well to see imagery and then still not able to see.)"
-- "During head movements to the left or right."
-- "When centering the symbology, some minor slippage obscures some symbology."
-- "The more you do it the better you get at quickly interpreting the data."
-- "Blooming or excess contrast with TADS covers symbology occasionally."
-- "Fixation."
-- "When tired, or stressed, crosscheck becomes slow and erratic, causing missed…"
-- "Sometimes while flying I have had to make helmet adjustments which resulted in having to readjust my HDU and Combiner lens."
-- "DC restoration or AC coupling, or whatever they are calling it today, is alive and well, and living in the NVS system. Numerous times during any given flight I have experienced symbology washout due to this problem."
-- "Yes, during periods of high concentration. During periods when the background..."
-- "IIMC - Whilst inexperienced, I was not advised to revert to instruments."
-- "Some HMDs do not always provide the proper FOV even when properly fitted."
-- "During lateral hover the data cables become taught and pull the HMD out of…"
-- "The system has to be constantly adjusted during flight."
-- "Already explained I have a short neck."
-- "When fatigued from extended NVS flights."
-- "Any movement of the HMD on the Helmet during flight will cause this."
-- "I've learned to compensate for most of the faulty cues. In other words, I'm finding that the more experience I have, the more comfortable I feel with this FIRST generation FLIR."
-- "The more I fly the better I can interpret HMD symbology."
-- "I have had trouble focusing on symbology after looking outside the HDU."
-- "See note above; I'll adjust the HDU 'angle' to capture what info I need at the time."
-- "As experience increases, overall proficiency level increases."
-- "Sometimes the symbology can't be seen due to old, decrepit systems."
-- "Sometimes unable to easily see torque display in HMD."
-- "During levels of fatigue. At the 2 - 2.5 hour level of demanding NVS flight my crosscheck may become a little slower."
-- "Yes, it's improved with experience. I still get illusions, but I recognize them easier."
-- "When flying is poor FLIR conditions. Moderate rain showers degrade picture to unflyable."
-- "It rarely changes. It pretty much [expletive deleted] all the time."
-- "Ability improves with experience."
-- "Difficulty in seeing all symbology to maintain flight."

-- “When turning my head to the left for left sideward flight.”
-- “Yes, when turning my head either to the left or right I sometimes lose the symbology in the HMD, especially if I am clearing the tail of the [aircraft] while at a hover. This, of course, is with enough cord to prevent the cord from yanking at the helmet.”
-- “During all phases of flight, sometimes unable to see torque value or lower left of HAD.”
-- “Symbology blends with FLIR [imagery] coupling.”
-- “Extreme head movements to the side sometimes cause the symbology to blur or be partially blocked out even with a good helmet fitting and adjustment.”
-- “As I have gotten more and more experienced, my cross check has gotten quicker.”
-- “Often lose the torque symbology.”
-- “During NVS formation flight I have been able to use the symbology to more effectively fly the aircraft.”
-- “If the HDU is bad, the combiner lens will slip and requires continuous adjustment throughout flight.”
-- “Helmet would slip and I would lose HMD Field Of View and all my symbology (usually the corners) i.e. torque and a radar height.”
-- “If your helmet is not ‘just right’ you will lose peripheral symbology depending on where your eye is looking.”
-- “Transition from hover mode to transition mode and reverse. This is due to Symbology needed for each mode. Parts of the symbology may be present, but complete symbology is needed for the flight regime.”
-- “During takeoffs, oftentimes, a vibration as the aircraft passes through ETL causes the symbology to blur or change brightness on its own.”
-- “During periods of low contrast (poor FLIR) causes image to wash out, and symbology to blend in.”
-- “Experience allows the pilot to gain a greater feel for the relationship between the symbology and the aircraft's position (attitude).”
-- “The symbology is very easy to read because it is clear and provides an alternate means of monitoring the aircraft's movements. The symbology is a tremendous help.”
-- “NOE. The TADS moves too slow to be very effective.”
-- “Digital readouts vs. analog dials or tapes require just a little longer to interpret.”
-- “With a poorly fitted helmet, (because I was forced to wear a smaller than normal helmet due to unsatisfactory helmet accountability techniques imposed by the Army.)”
-- “Blurring.”
-- “AH-64D, great improvement of symbology placement. Symbology easily viewed now.”
-- “Going from left to right eye.”
-- “During flight, helmet will shift; unable to read torque / altitude.”
-- “D Model symbology set easier to scan.”
-- “Sometimes the symbology gets blurry and [I] have to readjust the focus.”
-- “Must adjust sym [symbology] brightness vs. picture to obtain best mix during changing conditions.”
-- “Extreme dark nights when left eye cannot pick up visual cues.”
-- “Fatigue, during a long flight.”

-- "[Torque] often is hard to read."
-- "With increased experience, my ability to use or ignore information increased."
-- "Improved with experience."
-- "Too much information/slow cross check when fatigued."
-- "More flight time = more proficiency."
-- "Cannot see full symbology if wearing NBC mask."
-- "If combiner lens vibrates and moves from being loose and worn."
-- "Obviously, task overload situations channelize symbolic interpretation, i.e. gunnery."
-- "After about three hours of flight the symbology starts to get blurry."
-- "Once again, when wearing glasses, can't see all of it."
-- "Glasses obscure symbology, especially torque."
-- "Fitting a square picture into a round lens 'cuts off' the corners of the Field Of View. The only symbology this affects is the sight status section of the high action display (even with a correctly fitted helmet). A correct helmet fit coupled with corre…"
-- "Watery eye and eye fatigue."
-- "Rely heavily upon HMD symbology during NVS flight."
-- "Transitioning to IMC flight, redirecting focus to standby instruments on panel."
-- "Do to possible shift in helmet position, parts of the symbology would be out of sight picture."
-- "The more hours I have in the aircraft, then my emphasis on having a good infinity focus increases."
-- "Very perishable skill - after long periods of not flying (several months) or infrequent flights (greater than 60 days) there is always a period of 're-learning' your HMD symbology cues - not the meaning of the cues, but rather translating them into flight."
-- "Blurring of symbology occasionally, requiring adjustment of infinity focus."
-- "Interpretation skill based on experience."
-- "During head rotation the helmet may slip a small amount, changing the HMD alignment."
-- "Many, but especially while firing rockets."
-- "Task overloaded in front seat during night operations."
-- "The more I fly with the system the more proficient I become."

<u>Ability to focus clearly on the external scene and symbology simultaneously</u>:
-- "A certain amount is always to be expected. Continuous optimization is required."
-- "Retinal rivalry when there is too much ambient light."
-- "Symbology is blurry. Unable to get it to focus."
-- "I still have to make minor eye focus adjustments to view certain parts."
-- "I still haven't learned to see both. I still have to concentrate between."
-- "Sometimes the information that is presented is in an overload situation, an example would be short final into the FAR[R]P."
-- "You cannot focus near and far simultaneously. You mean instantaneously."
-- "Only when I have not flown for extended periods. Lack of experience."
-- "Use proper infinity focus procures."
-- "The infinity focus adjustment, when performed properly, avoids this problem."
-- "Symbology will be focused, while the NVS scene will be blurred. Suspect [NVS]."
-- "Just as you have a dominant eye, you have trouble focusing clearly on both

symbology and ext. scene but it's not really a problem to me."
-- "Scene content is the most important cue, symbology is there to reinforce what you are seeing. You almost look through the symbology, knowing that it is there, and knowing what it is telling you but yet not really looking at it. If you start (looking at t…"
-- "If focus is set right have never had a problem."
-- "This assumes that a proper infinity focus was accomplished."
-- "I tend to concentrate more on the symbology and less on the FLIR cues."
-- "Lens is tinted and disturbs visual acuity at night."
-- "While you can adapt slightly, there is still a workload induced by alternating between focus on the symbology scan and outside video image."
-- "I have found that no matter how well you adjust the focus, it ALWAYS moves out of focus during the flight. I have to readjust several times. IN ALL AIRCRAFT."
-- "I don't believe it can be done. You must go back and forth."
-- "Only sometimes."
-- "Usually as a result of long NOE with high visual clearance work load and poor FLIR quality."
-- "This one is HDU independent. Some HDUs are easier to infinity focus than others. Also, I know what I'm looking for."
-- "Initially, but through flight experience it can be overcome if aviator maintains proficiency."
-- "I can only use visual input from one eye at a time. I have to shut my right eye to use the left eye."
-- "I use a cross check which forces me to look at each piece of symbology and the external scene, but not always simultaneously."
-- "Eye wants to focus on one or the other."
-- "No."
-- "Seems like I am either looking at one or the other."
-- "Only when I improperly adjust the grayscale and symbology brightness."
-- "Sometimes the symbology will overdrive the picture and vise versa."
-- "Higher the stress environment, the more difficult to process both imagery and symbology at the same time."
-- "Hard to concentrate on both simultaneously."
-- "Infinity focus is not always accurate."
-- "Only sometimes."
-- "I find it very difficult to focus or split my attention between a close-up symbology and the more distant object at the same time."
-- "The biggest problem is the FLIR picture being out of focus and no ground support personnel to adjust the DAP."
-- "This just comes with practice. To newer aviators, it is merely a lack of crosscheck involving the FLIR cues."
-- "Due to binocular rivalry, it is difficult to switch between eyes."
-- "Not with the infinity focus properly done. There is very little eyestrain involved in switching back and forth from imagery to symbology."
-- "Distant images, like formation flight, are difficult."
-- "Yes, have not learned to see symbology and video image at the same time yet."

-- “External scene is difficult to interpret, find yourself relying more on symbology during poor FLIR conditions.”
-- “Yes...even after conducting an infinity focus check and registration check.”
-- “Cannot focus on both objects at the same time, must either use symbology then transfer to visual cues from the FLIR. But I cannot focus on both symbology and visual cues simultaneously.”
-- “Have to look at one or the other; normally switch between the two.”
-- “The picture has been blurred with no adjustment possible with the symbology focused.”
-- “I either focus on symbology or my surroundings, trying to focus on both gives me a headache.”
-- “’Flying symbology’ occurs often when fatigue sets in from eyestrain.”
-- “Usually one or the other.”
-- “At times, after fatigue sets in.”
-- “Have never fully been able to take advantage of focusing on external scenery and symbology.”
-- “The FLIR picture sometimes seems to be out of focus with symbology in focus.”
-- “Requires a high degree of concentration.”
-- “Have to really adjust the HMD brightness down low to see thru the HMD.”
-- “Focus and imagery acceptance by the brain must be switched.”
-- “The focal ring should be a continuous turn, every stop the eye focuses causing strain. You can end up stopping at a setting that is not the true relaxed focus point.”
-- “After extended periods of flight.”
-- “I can see both simultaneously but I can't focus in detail on both at the same time. I might be able to see terrain and the torque but couldn't tell you what the torque was reading unless I focused directly on the torque.”
-- “If I don't fly the system for an extended period.”
-- “Most of the time it's one eye or the other.”
-- “I don't look at them simultaneously, at least not consciously. I probably do subconsciously pick up symbolic cues.”
-- “Not if you adjust the focus ring with the FLIR picture at the same time.”
-- “See remarks at end.”
-- “During day as well as night flight the dominant eye views the scene but rarely, if ever, do I view the scene of both eyes simultaneously. It is just too difficult to integrate the different images.”
-- “Only if infinity focus is not adjusted properly.”
-- “I can only see one or the other, not simultaneous.”
-- “Yes, with bifocal glasses. Very difficult to focus symbology to obtain all information. Also, with left eye, I sometimes have difficulty focusing on instruments (distance of approx. 24 - 30 inches away). Bifocals adjust for up-close reading and distant.
-- “You can’t focus on what you can’t see !!! The picture is very poor. The picture blooms a lot. We need an audio warning of low altitude. When you shoot rockets and missiles, the picture and symbology disappears. An audio warning should be tied to the…”

Appendix F.

Comments: Image alternation.

Does vision sometimes unintentionally alternate between the two eyes:

-- "If magnetic compass is back-lit, it is very distracting and demands constant…"
-- "Sometimes my unaided eye will lock on to the VDU. I just close that eye to…"
-- "If a bright light suddenly comes into view your unaided eye will dominate."
-- "When distracted by strong lights."
-- "Same as above. (A certain amount is always to be expected. Continuous optimization is required)."
-- "Bright lights will sometimes draw attention from unaided eye."
-- "I have this difficulty almost every flight, however I note an increased abi[lity]…"
-- "Again, the percent moon illumination has a lot to do with this."
-- "If I haven't flown consistently/regularly."
-- "Early on I had some problem, but with experience it is no longer a problem."
-- "Unaided eye picks up light sources and dominates."
-- "Particularly around bright lights. The new object will catch the attention."
-- "I feel that it is a result of normal eye dominance problem."
-- "Normally when exposed to sudden light input, master caution/caution warning or external light sources."
-- "I have a lot of experience. Binocular rivalry is no longer an issue."
-- "Only when I have not flown for extended periods. Lack of experience."
-- "Rivalry between the two eyes seems to occur right at sundown or at first light."
-- "Sometimes after fatigue."
-- "But only in times of extremely high ambient light conditions."
-- "I experienced it only a few times during night flight."
-- "Sometimes a light will get the attention of the left eye and defocus the ri[valry]…"
-- "If a scene of sufficient illumination appears, the unaided eye will take over."
-- "After using system for a while, my eyes switch point of focus from symbology to outside lights and cues."
-- "Even when the cockpit is completely dimmed, [F]CP ([Fire] Control Panel) and magnetic compass will not dim, also external lights are always a problem."
-- "Fatigue."
-- "Flying NVS in a brightly lit area at night, your eyes will often unintentionally alternate."
-- "I.e.: bright lights."
-- "I experienced problems with lights taking over my left eye. But in balanced light I can change between eyes (aided or unaided)."
-- "Yes, more commonly after a long period (30 days or more) without flying night system."
-- "Only during times close to sunset, or when a lot of light is present outside of the aircraft."
-- "This has been my single greatest difficulty in flying the AH-64 at night. My stronger eye (left) will always dominate unless closed or smoke visor is down."
-- "No."

-- “This is common when a bright light comes into view either inside or out.”
-- “Absolutely. Rivalry kicks my butt every flight. Way too many ground lights in the ROK [Republic of Korea]. Also, the standby compass is a major distracter.”
-- “After [a] prolonged period of flight, this happens.”
-- “Conflict with bright lights on ‘un-aided’ eye. Depends on current level of proficiency.”
-- “Many times during BMNT, EENT, or high illumination nights when my left eye can acquire objects.”
-- “Rivalry occurs depending on ambient light conditions. Otherwise not noted.”
-- “Binocular rivalry due to left eye dominance.”
-- “Binocular rivalry. Bright lights. As I become more experienced this is not as much of an issue because I know how to deal with it. But it still occurs all [of] the time.”
-- “Sometimes bright lights cause unintentional eye switching, usually at the end of a long NVS flight. This is fixed by momentarily closing (winking) the unaided eye.”
-- “It happens. Binocular rivalry I think it's called. (Duh) Will close the offending eye momentarily.”
-- “Binocular rivalry.”
-- “Uh ... YEAH!!! If my left eye sees a bright light it goes off and starts tracking it... problem comes in when it drags my right eye with it.”
-- “Bright lights will force my unaided eye to take over.”
-- “Lights seems to cancel out the HDU image from the other eye.”
-- “No.”
-- “If there is a bright lighting source outside, my unaided eye will take over.”
-- “Light sources can be distracting. Gets worse if time between NVS flights increases.”
-- “Only if bright outside light (street lights, etc) are in line of vision.”
-- “Very rarely do I have this eye dominance problem anymore, but it has occurred a time or two.”
-- “During dusk, and when near high concentration of lights, i.e. a city, my left eye wants to take over and I am forced to close it in order to allow the right eye to take back over to the system.”
-- “Sometimes it happens (not often) when there is a single light source out on the horizon.”
-- “It happens all the time depending on the illumination outside and a bad FLIR picture.”
-- “Do not know why, [but] it does happen occasionally.”
-- “When I first started flying the 64, I would have problems with binocular rivalry.”
-- “The unaided eye wants to take over.”
-- “Depending on if something enters your left eye FOV.”
-- “During transition from day to night [I] have [a] hard time staying on [the] system.”
-- “Rarely, but it happens.”
-- “Bright lights or if something happens suddenly.”
-- “Big problem when brighter lights are present outside the cockpit.”
-- “Retinal rivalry is a real issue during the dusk till dawn hours. Light through the combiner less causes a washing of the picture at times. Also, the unaided eye tends to take over due to the fact it's easier to see just a light.”
-- “This can be a problem and it does happen to me. I've learned to ignore the left eye.”
-- “As I get tired, sometimes I suddenly realize that I am seeing with my left eye.”

-- “During certain phases of an approach, under System, sight will be pointed at the ground and the left eye will ‘catch’ the BRU. Closing the left eye momentarily fixes the problem.”
-- “Especially while performing approaches to an area where the lights are too bright visually. I will either shut my left eye and fly the approach, or move the HMD out of my line of sight.”
-- “Must command left eye closed sometimes to concentrate on right eye.”
-- “Retinal rivalry is common when your left eye is dominant. Happens during night when flying in an area with bright lights.”
-- “Left eye dominance if extended period between flights.”
-- “Any distracter in either eyes vision, will pull vision into that eye, i.e. light or movement.”
-- “It did frequently when I first flew Apaches, now generally I can overcome this.”
-- “Longer flights sometimes result in fatigue; controlling which eye I look through becomes difficult.”
-- “Bright lights can make the unaided eye the predominant eye.”
-- “When bright lights are present.”
-- “Not with experience, however common when first learning.”
-- “I am left eye dominant so bright lights attract my left eye quite a bit.”
-- “Only at night with bright lights around.”
-- “Not so much as when I began flying with the system.”
-- “Only had this problem a couple times. During initial training and again when fatigue is high.”
-- “Due to lights, or when tired, vision shifts between eyes.”
-- “Left eye dominant.”
-- “Occasionally with bright lights.”
-- “As my eyes become more fatigued.”
-- “Only infrequently, soon after sunset while transitioning from unaided to aided night vision.”
-- “More with fatigue/after long sorties.”
-- “Most noticeable landing at an airfield with bright lights.”
-- “If a bright light appears/ close one eye.”
-- “On very bright nights, I have experienced some binocular rivalry, particularly with the BRU assembly.”
-- “A bright light will pull my vision to the unaided eye.”
-- “At times my left eye will take over especially in highly lit areas.”
-- “Bright light causes the distraction, even cockpit lighting will be a distracter.”
-- “Dominate eye on lights when tired.”
-- “With fatigue.”
-- “Compass becomes quite clear!”
-- “With two different pictures a lot of concentration is needed to use only one eye or sight.”
-- “Usually due to visible light causing the left eye to dominate while flying system.”
-- “Early on in apache experience.”
-- “The inside of the cockpit or lights in the surrounding area always draws attention to my left eye. I really have to concentrate to view through my right eye.”

-- “See answer to "F". (Once again, when wearing glasses, can't see all of it.)”
-- “Monocular rivalry decreases with experience. Fatigue increases unintentional rivalry.”
-- “Only if there are bright lights present in the unaided scene.”
-- “Must concentrate on one or other.”
-- “Strong external light source will draw the left eye. I compensate by momentarily focusing on the altitude symbology on the HMD.”
-- “When there is a lot of external lighting, left eye wants to take over right eye visual dominance.”
-- “Binocular rivalry can occur at any time. We just deal with it (i.e. momentarily close one eye).”
-- “Yes, especially after long periods of night vision flight. Bright lights can also cause this.”
-- “After initial training, only rarely do I experience binocular rivalry. Usually stopped by simply closing one eye.”
-- “If I am tired, I find myself staring at the [magnetic] compass.”
-- “The left eye will ‘lock’ on the magnetic compass light.”
-- “Generally the one that gives me more information.”
-- “If I am tired, so I then close my left eye.”
-- “With bright lights.”
-- “Only when I haven't flown enough recently.”
-- “You must know how the system works to overcome this.”

<u>Special methods to assist in switching</u>:
-- “Closing one eye or scanning away from the HDU with both eyes.”
-- “Close the other eye.”
-- “Close one eye.”
-- “Sometimes closing my right eye.”
-- “I sometimes close one eye to allow the other to focus.”
-- “Blink one eye.”
-- “I really don't know how I do it , I describe it as the same type of thing…”
-- “I sometimes close the eye not in use.”
-- “I cock my head slightly to minimize the HDU input.”
-- “Close my left eye momentarily to allow my right eye to take back over and then try to reduce the amount of white light distractions to the left eye.”
-- “Close one eye.”
-- “Training! Lots of training. My first several hundred hours teaching this…”
-- “At the beginning I would intentionally close my right eye to see the surrou…”
-- “Proper greyscale.”
-- “I may have to close the non-dominate eye.”
-- “Close one eye.”
-- “I just ignore the HDU and view through/round it when required.”
-- “Yes, I will close the opposite eye that I do not want to view.”
-- “Close opposing eye.”
-- “Close one eye first to get the other eye adjusted.”
-- “While on system changeover is easy to non-HDU eye, going back I have to physically

close the non-HDU eye in order to be able to transition back to the HDU."
-- " Never really gave it much thought."
-- "Blink [the] eye that I want to switch from."
-- "Normally no. But if I do, I close the eye I don't want, then reopen it."
-- "After years of practice it is just a conscious decision for me. Some pilots have to close their left eye for a short period when first learning to fly AH-64s."
-- "Sometimes I close my aided eye momentarily (.5-1.0 sec) to see unaided more quickly."
-- "Close the other eye. Probably not the safest bet going, but it is all that I have found to work."
-- "Occasionally I have to close one or the other eye. Usually I can just switch. I think I close my alternate eye when there is sun glint or light distraction."
-- "The more I fly the easier it is."
-- "Cover my left eye with my hand. Makes collective inputs interesting!"
-- "As experience level increases, the ability to rapidly change the focus of attention between the aided and the unaided eye becomes easier to do. Consciously you only see the visual imagery presented through the eye that is currently the focus of attention."
-- "Sometimes I close one eye for a second to help."
-- "If needed, blink the unaided eye slowly."
-- "Alternate winking each eye."
-- "Dim the lights in the cockpit so that I am not as likely to experience binocular rivalry. If I experience binocular rivalry then I simply close one eye. Look away from the bright light etc. If the cockpit lights are good then I can switch between the left and right eye."
-- "I look at something that the other eye can't see, e.g. FLIR cues to switch to the aided eye, and cockpit or external lights to switch to the unaided eye."
-- "Practice and experience."
-- "Close them both and PRAY!!!!! MOMMMMAA!!! Seriously, I only have to close my right eye to use the left. My right eye is dominant and usually overrides the left."
-- "If having difficulty, I will close the eye I am not using."
-- "Close the alternate eye momentarily for a second."
-- "Momentarily close the opposite eye, i.e. left eye to re-establish NVS view."
-- "Just focus on one eye, if that doesn't work [then I] shut one eye quickly and it switches."
-- "If I absolutely have to see unaided and all I want to see is unaided at that particular time I will close my right eye."
-- "If it is a good clear picture no problem with both eyes open, bad picture you have to close one eye."
-- "Comes with experience."
-- "If having difficulty, I can close the dominating eye and switch the other."
-- "Momentarily close the eye I want to switch from."
-- "Close the aided eye."
-- "I just close my left eye as I need to concentrate more on symbology or flying using FLIR."

-- “Close whichever eye is causing the distraction and in a few seconds you can move on to normal vision cues.”
-- “Close eye and focus on the object I need most.”
-- “Glancing left or right.”
-- “Briefly close the eye you are switching from.”
-- “Closing one eye.”
-- “I close my left eye. Simple as that.”
-- “Just think about it.”
-- “Experience and proficiency helps to identify and overcome binocular rivalry and also select the appropriate eye (type of vision).”
-- “Visor down on helmet when unaided lights are especially bright (urban environment); [or when] cockpit lights down or off.”
-- “Momentarily close the un-needed eye.”
-- “Experience and proficiency.”
-- “Close one eye momentarily.”
-- “Either focus on the eye to be used, or shut the opposing eye.”
-- “Squinting or winking the left eye closed. The most extreme is to place my left hand over the eye to cover it. Once my mind uses the right eye images, then I can open the left eye and ignore the left eye inputs.”
-- “To view strictly unaided, I close my right eye.”
-- “Practice and concentration.”
-- “If having difficulty, you can momentarily close the eye you don't want to use.”
-- “Close one eye, concentrate on what you're seeing, open opposite eye and correlate with what you last viewed.”
-- “Close eye which currently is dominant and then images will become apparent in other eye you desire to switch to.”
-- “Close the left eye momentarily.”
-- “Momentarily closing right eye then opening.”
-- “Close/squint right eye.”
-- “Initially it was taught to momentarily close eye to reduce rivalry problems; learned thru experience.”
-- “By closing one eye.”
-- “Close one eye.”
-- “Must make a conscious effort to accomplish switching. Sometimes this is difficult with fatigue.”
-- “Close one eye.”
-- “Close the unneeded eye.”
-- “Left eye dominance.”
-- “I kind of blink and widen my eyes, and I can refocus at will.”
-- “Just comes naturally.”
-- “Blink right eye.”
-- “I'm left eye dominant... I merely close the other eye momentarily.”
-- “Close the eye with which I don't want to see.”
-- “Just takes concentration.”
-- “Close the right eye for one to two seconds.”
-- “Closing of one eye/blinking.”

-- “Concentrate.”
-- “I have to tell my brain which imagery to accept and ignore imagery from the other eye.”
-- “Closing one eye.”
-- “Close non-viewing eye for a second.”
-- “Closing either eye momentarily, or looking at a bright light through the FLIR picture.”
-- “Concentration.”
-- “Close unaided eye.”
-- “This is a learned skill that is by nature unnatural.”
-- “If it especially difficult to ‘change channels’ I will close the then dominant eye long enough to switch concentration (usually just a long wink).”
-- “Close the eye I don't want to use.”
-- “If I am tired then I can close my left eye and it will switch back to my right eye.”
-- “Blink one eye closed momentarily (same method used to combat binocular rivalry).”
-- “Experience, the more you are exposed to the system the better your ability to utilize monocular vision at will.”
-- “Just be fit, energy bar/drinks in the cockpit readily available when I get tired.”
-- “Close the other eye.”
-- “During situations that require peak SA I close the unused eye.”
-- “To get rid of the NVS image I shift my eyes to the left.”
-- “Practice all the time.”

Appendix G.

Comments: Additional comments/problems to identify visual issues.

-- "I feel that my right eye vision has gotten worse than my left due to the use of the IHADSS. I wonder if there is any documentation as to cataracts in Apache pilots in the right eye and not in the left eye. Just wondering what effect the display will have over the long run. I will of course continue to fly as long as I can."

-- "I have always had 20/20 vision in both eyes until recently. The vision in my right eye has degraded to 20/40."

-- "A major improvement in viewing flight symbology would be to give the aviator the ability [to] independently position peripheral symbology i.e., torque, airspeed, so that it could be viewed more easily during flight. As it is now, the only way to move the symbology for better viewing is to adjust the entire size of the viewing area, which is not a preferred method, as this will cause a distortion in the image size. I have been flying the Apache A model since 1985 and find that helmet fit is not a major concern. However, I believe that it is critical that the aviator be able to see all flight symbology, especially during times of poor FLIR quality."

-- "Come on, you want to identify and improve visual issues, give us a better FLIR!"

-- "I have noticed that the vision in my left eye has gotten worse over the past 2-3 years, while the vision remains a constant 20/20 in my right eye. I have attributed this to the use of the HMD for NVS flight. I tend to strain to see real world objects with the unaided eye. Have experienced headaches after NVS flight ever since transition into the Apache 11 years ago."

-- "I am an experienced SP who is currently in a position that does not allow me to fly regularly. The result is that I experience more difficulty for the first 1/2 hour or so of NVS flying when I haven't flown lately. My point is that I can describe the effects pretty easily if you're interested in getting the perspective of someone who has been both highly proficient/comfortable, and has to work hard at first after a break from flying NVS."

-- "I feel that I have not experienced many of the illusions in the survey because of the great job that the aircraft symbology does at providing situational awareness. I would not fly IHADSS FLIR at night without symbology. The current FLIR needs to be improved."

-- "The Active Noise Reduction Module (ANRM) would be a better device for the IHADSS and all other helmets. It does a better job of noise reduction and is user friendly."

-- "1.) While not directly impacting upon visual issues, the issue and turn-in of IHADSS as each aviator joins and leaves a unit does have a great impact upon fit. If we went back to the original method whereby an aviator was issued his helmet during the course and kept it through his Apache career, we would see a dramatic drop-off of fit-related problems after the first year or so post AQC. The Helmet should be issued by CIF and kept on an aviators individual clothing records until he leaves the Army. 2.) The IHADSS would be much easier to use if the TADS/PNVS were upgraded to gen two or gen three. Some research should also go into increasing the field of view of both sensors and the HDU. Perhaps cross check with the system being developed for the Comanche?"

-- "I feel that some of my right eye may have some acuity degradation. I cannot verify this scientifically. I still pass the annual eye exam. I would be interested in more specific day and night testing. While I have not been treated for eye problems, a doctor did say that I have UV damage that may require treatment in the future."

-- "Even though I have been trained extensively on how to identify and overcome some eyestrain problems during use of the IHADDS, some problems still exist. There are very few people that can correctly fit a helmet. Like all equipment, it becomes 'worn'. If some type of compliance or refit interval was imposed, it might cause some aviators to pay more attention to their equipment. I currently have the old 'TPL' in mine. It offers a little more comfort than not, unfortunately when I try to fly without it, my helmet has become loose. I am spending more and more time during IHADDS optimization to get good imagery in the HDU. I am almost to the point of pushing the combiner lens all the way out just so I can see all of the flight symbology."

-- "The HDU is a bright light approximately 1/4 of an inch from the right eye. The HDU is highly dynamic and difficult to train. Brightness, Contrast, Gain, Level, and Focus are all dynamic and interrelated. A change in level will, at times, appear to be a change in brightness. An improperly adjusted Contrast will affect adjustments in Gain and Level. Fatigue will affect Focus adjustments. Out of focus, ever so slightly, will induce extreme eye fatigue, headache and pain, but so will excessive brightness, which a pilot will use when the delta is low and the FLIR image is of poor quality. So what does a perfect picture look like? How do you teach that? After teaching PNVS and AH-64A flight for six years I wear corrective glasses for my right eye only. My left eye is 20/20! With today's technology CRT, in my opinion, is not the best answer. Binocular rivalry can be trained away, as I, and many others, have done. I do not think that dual imagery is the full answer. With all the problems, and failures I have experienced with the HDU and its associated systems I cannot imagine what would have happened if I had both eyes obscured by a faulty system. Flying in a tight, multi-ship, formation, staggered right at night, and have the PNVS lock in the upper right quadrant because my upper transponder antennae was on. My ability to quickly adapt to 'naked left eye' flight because of a dual eyed system averted certain disaster. I am well aware of transfer of controls, if that is your answer, you don't fly enough."

-- "My only comment is that I still can't believe that we are flying $30 million dollar aircraft on top of the trees with a 1970's FLIR. Gen 2/3 FLIR has been out for a while and yet we still take a chance on not seeing a tower because of inadequate FLIR pictures."

-- "A lot of my problems have been due to inexperience or [to having] not flown for extended periods of time. However after I learned how to size and focus correctly, it has amazed me, that after hot seating with another person, they were able to see with the HDU. There should be better instructions in the checklist; after all, if you can't see it you can't fly properly."

-- "At present the students at Fort Rucker are fitted with the helmet adjustments made by ALSE. The staff does the best they can with the equipment available but it is not always satisfactory. I do not know the department on Hanchey Airfield which has the correct facilities, but the building is located on the east side of the north hanger. Mr. Cherry is the gentleman the students are advised to see. Prior to NVS phase it would benefit the students to work in a dark room having had the HDU fitted correctly and the intensity of the picture checked by an IP. This would give them the best possible start to the phase and hopefully alleviate any eyestrain / loss of symbology problems."

-- "The primary concern is the poor FLIR quality, reduced maintenance budget, and reduced training opportunities. It takes quite a lot of training to produce a proficient and safe NVS pilot. It takes years to produce a proficient maintenance tech. Units are constantly cannibalizing aircraft due to lack of parts, unreliable systems, and 25-year-old technology. The AH-64 NVS needs great improvement."

-- "The biggest problems with the current system are that it is extremely difficult to teach new aviators to properly adjust the HDU for their individual requirements (sizing and centering). The second problem is that there are few people who are adequately trained to properly fit the IHADSS. Unlike a few years ago, aviators were able to keep their helmets during a PCS. Now, they must be turned in, resulting in frequent turn-in with improper fitment of a newly issued helmet due to unskilled/qualified ALSE personnel."

-- "I wear glasses. In order for me to use the HMD correctly I have to bend the frames into a contortion that puts the lens in contact with my eyelashes. The lens then gets covered with skin oil and sweat. I also have to position the combiner lens so close to my glasses that the sliding clip has stress on it (this has led to breakage of sliding clips. This also pushes my glasses into my skin. I have come to realize that flying the system without glasses is safer than flying with them. Contacts? They would be nice if there were some kind of reasonable program available. I have an astigmatism and getting contacts is not only 'spendy', it's next to impossible. Looking forward to aviation medicine taking a serious look at the newer laser eye correction procedures."

-- "Visual illusions exist because of visual acuity. The better the vision, the less the chance of illusions. I fly several night systems. I have many hours with PVS-5's, ANVIS 6 and the PNVS. I also train civilians to fly night vision goggles using

Generation 3 OMNI 4 night vision goggles. The bottom line is that the AH64 FLIR is unsatisfactory. I am currently on a rotation in Kuwait and the PNVS does a good job in the desert. Over the subtropical climate of Florida, where I am from, the performance is poor.

The illusions with the IHADSS are more present because of the system the IHADSS has to work with. This was no different than when the SPH-4 had to work with full-face goggles. A better IHADSS may slightly reduce the problems with illusions, but it will never approach the reduction of problems we will notice if we get a better FLIR.

I have flown AH-64's since 1992. I have always heard that the number one priority for the AH-64 is a new FLIR. Still hear it and nothing new is on the horizon. I fly a lot of law enforcement aircraft and the FLIR systems they use are much better than what we have. I realize they don't 'fly' with them but they use them for a type of targeting.

It is nice that one section of the Army is trying to improve its product (the IHADDS) but it is like putting a Corvette engine in a Vega."

-- "I think first and foremost, the monies should be appropriated to improve the FLIR. It is a very sad state when tankers have vastly superior FLIR capabilities than us long-range shooters. Generation II FLIR is available now and should be installed when new Longbows leave Boeing. [Expletive deleted] contracts between manufacturers and other things that stand in the way. If the Brass really cares about our safety as gun pilots, give us a better FLIR and you will see a dramatic decrease in the number of NVS related accidents. I can pretty much guarantee that a lot of answers to the above questions are dramatically different if attack pilots have at least Generation II FLIR to train and fight with. I like the HDU as it currently exists. Only real attack pilots can fly with one eye."

-- "I have noticed that after flying extended NVS, on the way home my left eye will shut down, while driving home I suddenly realize that I am not using my left eye to see. This has only happened when I have been extremely tired. Another curiosity is that as I have hit the big 40 my eyesight in my right eye has stayed better than 20/20 while my left eye has slowly degraded."

-- "I hope this helps, but surveys don't provide funding; you guys have had some great ideas over the years, but no funds were provided for those and guess what? We are only pawns in the game, but hey, thanks for asking!!"

-- "Biggest problem I see with the FLIR is loss of discrimination and texture of objects viewed. I think this is what makes it so difficult to maintain proficiency. I recently started flying NVGs in Apaches after not having flown with them since I left Cobras in 1989. It took me about 5 minutes to regain proficiency! If I go three weeks without flying NVS I notice a marked degradation in my comfort level."

-- "Overall the IHADSS is not a bad system, but it does have some limitations. The HDU Field Of View is too small. The DAP is also a source of difficulty. For example, if

I'm having a problem focusing, is the problem with the focus of the HDU or is it the focus on the DAP or is it a combination of the two, or does it have something to do with the range focus on the CPG ORT? Why are the DAP adjustments so difficult to access? Configuration of the HDU, performing, sizing and centering, and greyscale adjustments are as much art as science, and only through experience does one become comfortable with the IHADSS. The helmets should be issued to the aviators and then the aviator should keep the helmet until no longer required, i.e. getting out of the army, retirement, no longer flying AH64 etc. This would help greatly. Helmet fit and comfort directly affect visual issues. The better the fit and the more comfortable the helmet, the better the visual acuity is. I have found that eyestrain, headaches etc. are reduced to minimal levels once the helmet is properly broken in. Every helmet is different and it usually requires the aviator to make adjustments to the helmet above and beyond what the ALSE personnel provide. I honestly believe there are no real design flaws with the IHADSS, the main problem is with the outdated first generation FLIR system. You couple the poor FLIR imagery with the IHADSS inherent limitations and a source of dissatisfaction is created. In other words, if the AH64 had a better FLIR system I am fairly certain there would be few, if any, visual issues with the IHADSS. The reason I bring up the FLIR is because this survey asks several questions concerning things such as 'degraded resolution/insufficient detail, slope estimation' etc. These things are not really IHADSS issues as they are FLIR issues. In conclusion, I would estimate that probably 80% of all the visual issues are associated with the FLIR and not the IHADSS. The IHADSS could use some minor refinement, the FLIR is old and needs some major help."

-- "My vision in my right eye has gradually gotten worse over time. It was 20/15 before I flew the AH-64, now it is 20/25 while the left is still close to 20/20. I know this could be due to age but I have heard others with similar results and have had conversations with some who wonder if it is a result of the HDU."

-- "I have not heard about the CEP, but I have been flying with foam earplugs for 15 years with very little loss of hearing."

-- "It is a tremendously demanding mode of flight. Far more demanding than Night-Vision Goggles. Anything that can be done to improve FLIR quality should be done right away. The problem with pilots descending into trees during nighttime engagements of targets is widely known in Apache units. Back-seat pilots occasionally become engrossed in assisting front seat gunners in attacking a target. If the pilot stops cross checking his symbology for more than a few seconds and the aircraft develops a rate-of-descent, it will go unnoticed due to a lack of height perception in the monocular system and no audio warning system for the low altitude setting on the radar altimeter. The AH-64A should have an audio warning system installed on the radar-altimeter as quickly as it can be done. It is my observation that approximately every 18 months each AH-64 Battalion in the U.S. Army has one aircraft descend into trees during a simulated missile engagement. Each of these incidents normally includes damage to the main or tail rotor. Occasionally, the results are far more catastrophic."

-- "Have found that with constant use of the HDU in all modes of flight that the eyestrain is lessened and work through of problems is easier. After long periods of not using the device that is when problems arise."

-- "While the IHADSS is in need of an update, and I believe that a switch to a binocular HDU would greatly benefit the aviator. The single greatest addition to the AH-64A/D would be a second or third generation FLIR and also adding a I2 type sensor to the Day TV to enhance all modes of flight, targeting, and overall safety of the airframe."

-- "I am totally amazed at the lack of overall accidents due to this first generation FLIR system. Sometimes this system works great. (When the stars, moon, and planets all line up). Other times it is a nightmare. The problem is not IHADSS and the use of one eye, the problem is this OLD FLIR system. With what is at stake here, advanced FLIR technology should be a priority. This survey sounds great, with good hard questions asked."

-- "The system is old technology. It needs to be updated very soon. It is much more important to me that we improve the FLIR than it is that we change anything else in the aircraft. If the army wants to improve our vision, let us have laser surgery."

-- "I'm an IP along with a prior Armament Officer background. Out of my limited experience...4+ years in AH-64's...I have noticed the need to review proper fit of the IHADSS as well adjustment of the HDU for 'infinity focus,' and registration checks along with the 'proper' adjustments of the Greyscale to see all of the symbology! This knowledge is often misunderstood...and many of the questions that you have asked have been brought up. I hear the same complaints and after reviewing these topics...many complaints are solved.

Unfortunately, we have to review these topics more often than you would think...and the ALSE support in my last three units have not completely understood 'how' the IHADSS should 'really and completely' fit, compared to the ideas of those at Hanchey and Fort Rucker. There are exceptions. I also have found that many of the aviators that started and have numerous hours in Goggles...prefer them over the PNVS/TADS. The vice-versa is true with aviators that have been in Apaches from the beginning. We have a goggle program in our unit, and after hearing most of the conversations...the problems that we run into are aviators requesting a better acuity system than that the PNVS/TADS offers (average night, good acuity for 20-70 on a good night compared to 20-25 with other systems). On a good night, these systems are preferred over goggles...even as a monocular system.

I'm just trying to help from what I hear our aviators talking about. Many like the idea of having one eye open for Night Unaided which assist in noticing 'lights' or other cues...though these also can be misleading in certain environments...i.e.: mountains on a dark night.

Many of us have not viewed a binocular system except goggles...but rumors have mentioned them being a great asset, especially for visual stimulation in scanning.

Flight hours also become problems...and this relates to your topic because of

proficiency. We all are aware of that.

If the other aviators don't respond to your survey...what they have mentioned that they would like to see and maybe you can test or already have...are simple:

*All would like to see a new FLIR/NVG system that is part of the aircraft.

*As part of the aircraft like the HDU in the AH-64...we only have one attachment hanging off our helmet unlike our counterparts with 4-5 (a major hazard in an emergency).

*Everyone loves their symbology...after they have a good 'cross check'.

*The transparency of the HDU during a failure or during daytime flight offers many advantages that I don't know how else to replicate with staying focused outside!

*Many have 'wondered' if one thing could be added to the symbology...that being a fault if the helicopter detects one. The Longbow incorporates this system with audio, which also helps.

Once again, I am only trying to pass [on] what I hear. I know that it mostly relates to the visual night systems on the AH-64, but I hope that you might find some common ground between the two. If you have any comments or further questions...we will be more than happy to participate."

-- "I command a Brigade of Apaches in Korea. If it were up to me, I'd rip up the ISAQ and let our guys fly NVGs in either seat, despite the poor NVG compatibility of AH-64 cockpit. I commanded a UH-60 Battalion, and there is no doubt which system I prefer and I think is safer."

-- "We would be lost without the overlaid symbology. FLIR alone on many nights is just not good enough by itself. Many of these problems can be corrected using the proper procedures taught here at Fort Rucker, but it would be so much more convenient if we could make DAP adjustments (sizing, centering, etc.) easily from the two seats without having to call for outside assistance."

-- "50% of the visual problems with the HDU occur before the image reaches the eyeball of the aviator. The apache has an outdated FLIR system. The TADS was never meant to fly with. It just [expletive deleted]! At a minimum the front seat should be modified to accommodate goggles with flight symbology. This works in the Blackhawk. Why not in the Apache? The PNVS is okay and works well with the IHADSS, however this system is old and there is better equipment available for less than what it takes to maintain the existing system. Develop a binocular system that incorporates state of the art FLIR and goggle technology with symbology."

-- "The greatest improvement that can be made is an improved PNVS/TADS."

-- "The FLIR currently installed in the AH-64 is archaic and belongs in a museum. Every news chopper in the country has access to equipment with much higher resolution and better reliability."

-- "With respect, the IHADSS image from the TADS FLIR as used in the front seat, it is alarming that we are expected to identify and engage targets that we cannot positively

identify. The system that we use is grossly antiquated and in need of an immediate upgrade. It is very disturbing to watch police and E.N.G. helicopters with a FLIR that can identify a handgun in a mans hand at over a mile, and we are working with a system that we are lucky to be able to tell if a vehicle is tracked or wheeled, let alone positively identify as to whether it is friend or foe. The Army needs to upgrade their first line combat multiplier to be able to do our job to the best of our ability!"

-- "The IHADSS is not an entirely deficient piece of equipment, but coupled with the outdated FLIR, is a task every AH-64 pilot must master. Not easily done for low time aviators. As far as introducing weapons deployment into the HDU, depends totally on personal optimization. I like the system, but would like to see some upgrades to decrease the size and weight of the IHADSS, along with better communications (i.e.-CEP)."

-- "If possible, I would like to see a better method to control the sizing and centering on the HMD. Maybe a set of switches near the radios or something. A crew chief isn't always available to correct the problem. When the pilot has to work off a hard time line they don't have time to correct it, therefore they fly with it the way it is. This may one day cause an accident because someone couldn't/wouldn't take the time to correctly adjust the information in the HMD. Everyone has a different size head and bone structure. This idea would greatly benefit any male or female pilot that has to fly this aircraft. Not to mention make the aircraft more user friendly. Thank you!"

-- "The biggest problem with the IHADSS is the first generation FLIR that we are still using. The FLIR imagery must be improved by upgrading to at least the second generation FLIR. The HDU and helmet are more than adequate but the FLIR must be improved."

-- "IHADSS good, FLIR bad. Cheaper, more reliable, much better systems are being widely used by law enforcement and civilian news agencies.
Increase size of HDU field of view.
Increase slew rate of TADS."

-- "Make improving the night vision flying sensor on the AH-64A/D the number one priority for improvement. Our pilots deserve a better system. Give it to them before it is too late."

-- "Someone please find the guy holding the 'checkbook' and tell him to take a ride at night in the front seat using the TADS and then ask him to cut the check for second generation FLIR. It shouldn't take this long especially when we are testing fourth generation goggles.

Over the years I have become accustomed to using one eye for sighting and now find it natural. Recently I became re-qualified for using goggles in the front seat and didn't like it at all. I had no symbology for flight reference and the airframe got in the way. By using the system, I am accustomed to using one eye for the FLIR image and switching unaided around highly lit areas.

As a trainer, I have found that the staff aviators which haven't flown in a while have forgotten how to do a greyscale. After having them do a greyscale and then viewing it myself, I have found that their greyscale was about half the size it was supposed to be. This could have affected the way they flew. Maybe it is time to upgrade the IHADSS to something more up-to-date. The sizing and centering, I would think, could be made to not have to be adjusted, therefore eliminating this problem.

Hope these comments help your research. I am pleased with the Apache IHADSS system as it is, I just think that there is always room for improvement!"

-- "Although I have limited flight hours I still listen to my experienced IPs and they have the same problems that I do. Why doesn't the Army upgrade the generation one FLIR to newer technology? We have also returned from flights solely because the picture is just not usable. My vision has degraded from 20/20 to 20/25 in my right eye. I know that this is a direct result of the HMD. Only apache pilots understand how difficult it is to fly under the system. There isn't a day that goes by that after a system flight we sit around afterwards and laugh about what we didn't see. This is ridiculous. This address was put out after a pilot's brief and there was an uproar with 'it's about time' and 'finally, someone is looking into this [expletive deleted]'."

-- "The HDU works fine but the root of all problems is the ten pounds of Velcro™ needed to fit each IHADSS. How can it be consistent? The current FLIR is also a problem. All the visual problems have always existed but were overcome by experience. As the experience leaves the Army, the new pilots are not getting enough NVS flight time to learn how to identify and overcome these visual limitations."

-- "The problem with the IHADSS is not so much the single eye theory, but rather the poor quality of the FLIR. The eye dominance issue normally works itself out over time and experience. The limited field of view coupled with poor video can create a hazardous situation. Apache pilots have compensated for this by flying much higher terrain flight altitudes. This is the reason we have not had a large number of mishaps involving the FLIR. No pilot is going to get down close to the trees and earth with this system at night."

-- "Depth perception and rate of closure are very difficult to judge when using the HMD for NVS flight!"

-- "I personally know a pilot who has been flying AH-64 [for] 12+ years who is color blind in right eye."

-- "Visual issue is that the system is 30 years old and [expletive deleted] to fly with. We have much more modern devices available to us. Would be much more combat effective if had updated systems."

-- "I would like to see a helmet and study done with results published to the common pilot on a helmet with dual IHADSS. Maybe a helmet with the IHADSS built in to the helmet, so once it is fitted you would not have to adjust it every time you fly."

-- "The IHADSS is a horrible helmet, it should be replaced by the HGU-56 with harness adapter. The HDU seems fine after about 100 hours of NVS time even though I have experienced most of the illusions listed above."

-- "Helmet fit is my biggest complaint, with helmet fit I can get to see the entire Symbology. Additionally, my right eye had a visual acuity of 20/15 when I entered the service, currently I have an acuity of 20/25. My left Eye remains unchanged at 20/20. I have had an increase in browning over the years, and in the time it takes my eye to adapt to normal night vision, as if the rodopsin is being used up or overexposed."

-- "I think you should consider the total cockpit environment. The segmented caution panel lights are to dim to identify and react in a fast manner due to the need of having the instrument lights low to fly under NVS."

-- "I think that the concept of the HDU and IHADSS is great. It works well once you get used to it. However, pilots should be issued an IHADSS helmet in AQC to take with them to every post. It is a real pain in the [expletive deleted] to try and refit a new helmet every two to three years when it takes almost one year just to get the bugs worked out of the helmet and tailor it to what works best for you. The helmet is more expensive than others, but what other pilots besides gunpilots need to turn in their helmet when they PCS? None! They always have their own helmet.
As for the NVS as a whole, the FLIR needs to seriously be upgraded. Why not consider upgrading the FLIR systems and combining them with I^2? Then you could eliminate the need to carry goggles to an aircraft and remain working with one system, the HDU. Also, if you want a front-seater to fly by the TADS, give it a slew rate of 120 degrees per second like the PNVS so that the pilot can actually keep his head on a swivel and see possible obstacles, enemy, or terrain changes. As is, the furthest you can see on a good night and determine what is ahead is probably two kilometers. Doesn't sound bad until you realize that the aircraft is moving 120 knots. Quit putting money into all the 'gee whiz bang' [expletive deleted] and start at the basics. Fix what is broken first and then add the new things. I mean, it doesn't help to have a missile that you can fire eight kilometers when the IAT in Day TV has a maximum range of only six kilometers and manually it is only 4.5 kilometers. Think about the basics of the visual sensors and ask yourself, 'Is this system really up to par with the capabilities of this aircraft?' The HDU, it could use some work. It is bulky and doesn't allow you to fully turn your head to the right and the cord is not always long enough to turn full left. The actual image and symbology though would be fine provided we had the better sensors and better mounting brackets for the symbology generator, TEU, SEU, and PEU, etc."

-- "An upgraded FLIR is needed and long overdue. I find that I can 'make do' with the system now far better than I used to, but I get tired faster. As an IP, I often will flip the system up and out of my eye when on down wind during traffic pattern training and use the VDU/ORT to monitor my student to allow me to fly longer. On tactical missions, I wear out faster now than I did five years ago. System flying will remain the most demanding mode of flight. I like the FLIR better than goggles."

-- "Be[ing] able to adjust the IHADSS mount with a small thumbscrew or lever would help adjust the HDU for best picture. Currently, ALSE personnel must change the mounting hardware bracket with a screwdriver. It would be nice if the pilot could adjust the bracket in the cockpit."

-- "Visual acuity in my right eye is still good, but slower to focus than my left eye. This degradation was evident only after flying [Night Vision] System in the AH-64. I did not notice this degradation during any of the eight years of using NVGs.
Occasionally, if not mounted just right, black 'void' would appear in the HDU. The void was directly proportional to eyeball position (eye looks straight - no void, eye looks up or down - void). Re-adjusting the HDU and combiner lens, and slight movement of the helmet, seemed to fix the problem.
Focusing symbology is not accurate. I can get the Heading Tape focused clearly, but the Skid/Slip Ball and Field-of-Regard box will be blurred 'slightly', or vice/versa. I tend to find the happy-medium, favoring the mid to lower symbology."

-- "The IHADSS helmet is too heavy to be effective. It causes great neck and shoulder discomfort after approximately two hours of use. It cannot be fitted properly due to the fact that the fitting process relies on pre-manufactured sizes. The FLIR system on the Apache helicopter is the most dangerous system on the aircraft. The idea of using this antiquated system on a $16,000,000 aircraft is reckless and irresponsible. The Army goes to great lengths to find out why the accident rate in the Apache is so high, blaming most of the accidents on pilot error, when the fact remains that if you can't see what is in front of you, chances are---you are going to hit it. I have flown the aircraft for 600 hours with no accidents, with 1000 hours of military flying experience and 4000 hours of commercial airline flying experience. My recommendation is to let pilots design and approve aircraft systems. Unless the researchers and the developers fly the aircraft, understand what it is like to be in the aircraft, you will continue to put inferior systems on the aircraft. The fact remains that there are cheaper, longer lasting and far better systems out there. Make the systems fully upgradeable as systems become available, in short... take a clue from the Air Force. I understand the politics and fiscal reasoning behind the purchasing of Army flight systems, but unless we take more prudent measures, the next system that you put on this aircraft will be not better than what we have now.

As far as the noise level issue, there are fantastic noise attenuating systems on the open market. Try Bose™ headphones. The helmet should be made much lighter and a cast should be made of the pilot's head for a perfect fit, not just for a good fit, but a perfect fit.

Not to stray off of the subject, but when are you going to justify the ABDU flight suit? A system that is more dangerous, three times as expensive, and lasts about six months as compared to the old one-piece flight suit, which lasts about three years. If you wanted to save some money, ditch that two piece flight suit."

-- "The visual workload doubles when using the ANVIS and HMD in the CPG station during missions. The neck strain of the added weight is uncomfortable during long missions."

-- "Prior to becoming an AH-64A instructor pilot, I had numerous vision problems associated with system flying. This was largely due to my stubbornness, (I failed to pay attention to my instructors.) After graduating the IP course, I have not had any problems with the HDU or PNVS/TADS. 90% of all problems associated with IHADSS (One-eyed monster flying) are poor aviator technique. A small percentage (10%) is actual vision problems like eye dominance and compatibility. With academic training and flight experience, some people are able to overcome this. When pilots are able to understand and properly complete the ATM task, IHADSS video adjustments, combined with proper FLIR optimization procedures, NVS flying is almost as easy as day flight.
I recommend that you do not use data collected from aviators who do not have at least 750-1000 hours of AH-64A/D time. These individuals are not mature enough in aircraft specific tasks to make sound judgments as to the shortcomings of the aircraft."

-- "The IHADDS helmet is very uncomfortable. Rarely have I ever had a perfectly comfortable fit. Most of the time I have to deal with hot spots and headaches. This is a serious distracter and nuisance during flight. With my head shape I cannot wear a TPL I do use a skullcap, but that only helps to some extent. Because of this I feel that I have sacrificed some of the noise attenuating capabilities of the helmet.
The quality of the FLIR is unacceptable for flight, and you find yourself accepting it anyway because you have become accustomed to flying with a bad picture. The sharpness and clarity of the picture should be much better. I find myself concentrating on one object for far too long in order to identify what it is, and if it affects my flight. The Apache is far too advanced to be able to sacrifice due to the inability of a crew to identify and detect obstacles and/or targets. Potential for mishaps is high, and fratricide is something everyone is concerned about. The ability to detect friend or foe should be immediate, with no question. The lives of many rely on us to be able to fly in undetected, identify and kill the enemy, and return safely."

-- "Helmet fitting is a huge issue. ALSE Techs receive no training on the IHADSS helmet in the ALSE course. The only training received is from reading the TM, and passed down knowledge. Considering the importance of the fit of an IHADSS helmet, this is a major failure in the ALSE program. ALSE Techs need to be trained in this task, by the civilians who fit helmets at Hanchey AAF. The only time a pilot is ever properly fit by trained personnel is during the course at Fort Rucker. Then the pilots leave their helmets at Rucker when they depart. To be issued another used

helmet at their next unit of assignment. I believe that Apache pilots should be issued their helmets to keep throughout their career. This would alleviate most of the fitting problems experienced. The next problem is the helmet itself. The HGU-56 is a great helmet for both fit and protection, as well as its lightweight characteristics. I know that there was an AH-64 IHADSS modification made for the HGU-56, but was not purchased by the Army. Purchasing the AH-64 modification to HGU-56 would also greatly enhance the fitting and visual problems experienced by Apache pilots. The HGU-56 is also a much safer helmet in regards to protection for the aviator wearing it. IHADSS helmet costs in the vicinity of $14,000, HGU-56 is $800 I believe. IR harness to throw in the HGU-56 should be about $4 or $5,000."

-- "How long is this study to be taking place and when will results be published?"

-- "The constant switching of helmets after every PCS degrades helmet fit and results in loss of some visual acuity until a proper fit can be achieved (usually takes 4-6 months of regular flying). The image supplied by the HDU is significantly degraded from the original (compare visual acuity of the HDU to the acuity on the tape), this coupled with the relatively poor image quality of the FLIR system, and the ease in which foreign matter (i.e. dust and grime) interferes with the picture, results in an overall poor image quality."

-- "It's time to improve the quality of the image presented, and if reasonable, work towards increasing the instantaneous field of view available. Regarding the symbology set, including a local or virtual horizon may also provide improved situational awareness during inadvertent IMC situations. The USAF outlines requirements for military aircraft flight symbology sets for HUD/HMD. Local horizon is included in their requirements for an IFR symbology set."

-- "Flying under the system is difficult, especially when you are task overloaded as it is during a battle drill. It takes a lot of practice which we don't get often enough."

-- "Great study!"

-- "Lack of frequent night flight, as evident in today's Army, will seriously degrade users ability to utilize the current system. Lack of multi-color HMD prohibits safe flying. Could mix FLIR with NVG to create an amplified or more detailed picture. This should require auto mixing, with option to select either mode."

-- "Would purchase CEP if it did all the things they say they do, otherwise would use only if issued. Flying night system would be a lot better with dual IHADSS. Your questionnaire does not allow for a sometimes answer. Some of the symptoms only happen on certain occasions like being tired or flying around a lot of lights."

-- "Because of the way the IHADSS is fitted, it is a problem to turn it in as you leave every unit. If we can't solve the accountability problem, if we could improve the fitting procedures it would help. Suggestions would be a liner or some kind of form

fitted insert. Suffering through your first flights at a new unit with less than full picture is not the best way to go. Experienced aviators make the process work but this should not hide the problem."

-- "It seems almost impossible to correctly fit the HDU so that you can attain a full field of view with laser glasses on."

-- "Most problems that I have had are due to faulty equipment. Examples: The grey-scale is not able to be properly adjusted. This leads to reduced resolution and the inability to 'break out' details. If the greyscale is overcompensated with contrast, (allowing the picture to be viewed when the system has insufficient brightness), then I will experience eye fatigue/strain. My personal preference for the greyscale is very dim, but still able to see all ten shades of gray. The other problem I have noticed is an HDU that is blurry. The blur is uncorrectable through the focus setting on the DAP or the infinity focus knob. A compromise is then required...leading to eyestrain. The same applies to distortion. Distortion adds to illusions of aircraft movement."

-- "1) Lack of depth perception is biggest issue.
2) During poor FLIR nights (there are many), pilots are forced to rely on pure symbology. Very dangerous.
3) During high intensity combat at night, terrestrial lighting (artillery, missiles, explosions, etc.) aggravates binocular rivalry. Very difficult to adapt."

-- "Questions 2.h through 2.k are misleading and ambiguous. I am left eye dominant. However, I am right handed. I shoot and throw right handed because it is more physically comfortable. Because of this, I have become used to closing my left eye to use telescopes etc. However, while flying the Apache under NVS, (especially around very bright lights), I find that I have to sometimes close my left eye to concentrate on my right (aided) eye.

-- "I definitely support a monocular display or at least the option of flying with a monocular display. I believe the ability to easily view the real world unaided is important."

-- "Proper training and experience are significant factors in the use of IHADSS. You must fly with IHADSS on all AH-64 flights in all conditions to adapt and stay proficient."

-- "The biggest thing that I find is that after using the HMD during NVS operations that I see things pink in color for about an hour or more, then it goes away."

-- "Vision in my right eye has degraded to a greater degree than my left eye."

-- "I am a PNVS current IP. I prefer the IHADSS monocular system because I always have one dark-adapted eye and, on all but the darkest nights, I have some naked eye depth perception. When focused outside, the dark-adapted eye provides peripheral motion cues even when the IHADSS eye is focused foveal to read symbology. Transition from inside the cockpit MPD presentations to outside imagery works well with the monocular IHADSS. I use IHADSS night and day and consider it to be an indispensable aid to flying and fighting the AH-64D day or night. The first recommendation I would make would be to add color to IHADSS symbology to aid with emergency and situational awareness. The second would be to reduce the weight and complexity of the IHADSS system."

-- "I've been flying Apaches for six years and I have been losing vision in my right eye every year. I predict next year my right eye will be less than 20/20. My left eye is as strong as the day I started flying Apaches."

-- "The HDU is a very poor system in every respect. It is heavy, sloppy, provides a poor quality picture and a narrow field of view, the monocular display is annoying and uncomfortable, and the thinner versions of the cord gets wrapped around things in the cockpit. Getting a decent picture requires the combiner lens to be placed right next to the eye - anything interfering with that placement (such as NBC masks) makes it impossible to get a full field of view (and the 'full' field of view isn't sufficient anyway). Recommend a lighter weight, binocular system with greater field of view that provides much greater distance between the eye and the combiner lens."

-- "A swing down mount from the front upper area of the helmet would increase unaided peripheral vision. Second generation FLIR should stop getting lip service and be installed. Goggles see better, and move more than 60 degrees per second (TADS) to keep up with the direction you are looking. A more crash worthy helmet is in the inventory but the IHADDS attachment is not ready or available. A difference of software and hardware in use across the fleet. Simulation devices not compatible and maintenance poor. I got off the IHADDS a little, sorry."

-- "The system is very poor and puts a real strain on the eyes after awhile. I have noticed that I can't fly as long any more before I start to notice my eye getting tired. I have also noticed that I have grey eye longer than I use to."

-- "My two main comments are that one, I will typically get a sharp pain in the back of my right eye that translates into a headache after more than two hours of NVS flight that will sometimes last almost an hour after coming off the system. Second, I have great difficulty determining lateral distance or depth from the side of hills or trees, especially if I can't see the main rotor in the NVS."

-- "My unit tested the CEP and I wanted to use the system, but due to a lack of appropriate sizes of earplugs I was unable to try the system."

-- “System needs to advance beyond the initial 1984 stage of development....full faced goggles needed improvement and they got i.e. ANVIS 6's. We still have nothing that can be cited as an improvement in capability.....”

-- “Your survey will be skewed. Visual problems with the system are so great that many pilots are removed from or quit the AH-64 because of their inability to master or remain proficient with the night system. You will not be able to reach this database. 144 pilots have cycled through my unit since 1993. Approximately 40 had problems with the night system. Many will never fly the apache again. It would be very helpful if the symbology could be sized independently of the FLIR background image. Contact lenses will help with the problem of eyeglass frames interfering with the IHADSS picture. Laser surgery may be a consideration. Looking thru the system can produce three distinct images when viewing a lighted runway. Left eye runway, right eye FLIR runway, and orange lights thru the combiner lens. All three are different - just pick the center of one and land. The more natural any system is with respect to human senses the easier it will be to train and remain proficient. Costs of a system may be defined as purchase, maintenance and user costs. The user costs (training, proficiency and loss of pilots) due to the IHADSS are staggering. I would not be surprised if user costs equaled half the purchase price of the fleet.”

-- “Going back to the building a house on a foundation analogy--visual problems are usually due to helmet fit issues. This is already addressed in TC 1-204 App C-7b. However, instead of having a solid foundation from which to mount the HDU we ‘build our house’ on a foundation of Velcro™. The helmet we mount on the Velcro™ only contacts our head (firmly enough to steady the helmet) on the front headband, the ear cups, and some have Velcro™ in the rear of the helmet. The only other way to secure the helmet is with the nape and chinstraps. This aircraft only costs several million dollars yet we fly it at night with a helmet that is anchored with Velcro™. Even my cheap little SPH-4 was fitted with a TPL that ‘form fitted’ to my head. I would be remiss if I did not address the fact that NVGs, while mounted to a helmet, do not interfere with the aircraft seat or seat harness. The HDU, on the other hand, has that large cable coming out of the back that does interfere with the seat and or the shoulder harness "Y" (where it comes out of the seat). This results in shifting the helmet somewhat (even if tightened/fitted to the point of choking the life out of the aviator and burning holes in his head) causing the picture to shift etc, etc. Tall aviators do not have a problem with this so much as shorter people.
When you talk about visual considerations with the APACHE you cannot talk just about the display without talking about what supplies the picture. Practical application: if the picture is poor it could be a poor IHADSS optimization or a poor FLIR optimization. Furthermore, the mounting of the FLIR camera contributes significantly to our illusions/considerations. The HDU itself is a great tool. I really like having one eye aided and one unaided. Most night flying takes a combination to be safe, and it is much easier to see with an unimpaired eye than having to tilt my head to look underneath the night vision device (as with NVGs) which can also induce somatogyral illusions.
To sum it up:

-Fix the helmet fit issue. Why is it not form fitted? Without being arrogant, we deserve better than Velcro™. The Army deserves better. It's only a multi-million dollar airframe.
-In future systems consider giving the camera a third (roll) axis in addition to pitch and yaw (azimuth). Two options for controlling that axis could be by gravity (it would right itself to level at a hover independent of aircraft attitude but still stay oriented level with the aircraft in a turn (like a trim ball), or using the sighting system as we do for the current two axes.
-Change the location/angle/etc. of the cable coming out of the HDU."

-- "The IHADSS helmet is a terrible fitting helmet. For years I have tried to fit my helmet comfortably, but to no avail. I have had 'hot spots' so bad they were actually bleeding."

-- "I think a low light binocular HDU system with clear lower bi-focals, along with much improved FLIR /composite imagery, will significantly improve the pilot performance at night during increased work loads."

-- "In marksmanship we call it 'eye relief,' distance from the scope or sight to the eye. Farther is better. After proper boresighting/focusing/sizing/centering, the HDU has to be practically right on your cheekbone in order for you to attain unity magnification (relative 1:1 imagery). You have to look off toward a margin to pick up symbology. Larger display and imagery (keeping symbology same size/field of view) would allow the display to be set farther from the eye. Overall effect would be that symbology is less off center of imagery than it is now."

-- "1) As important as the fit is, why can't we keep our helmets until ETS? -- Expiration
2) To insure proper sizing and centering, change the color of the mask of the field flattening lens to a much darker shade.
3) A larger combiner lens to maneuver the FLIR picture for comfort of the user. Then Boresight.
4) Looking through eye glasses, laser glasses, HDU, blast shield, and the cockpit is pretty dangerous and leaves a lot of room for error."

-- "Use of bifocal glasses with the IHADSS is very difficult. Right lens adjustments usually result in incomplete imagery. I've checked with other bifocal users, and they remove their right lens and adjust the focus to view the imagery. For me, this creates eyestrain, but seems to be an interim fix. Also, viewing cockpit instruments with bifocals through the left eye is sometimes difficult. Near view items such as kneeboards are also sometimes difficult with night lighting. Hope you can help. It becomes quite a workout, but not insurmountable.
Thanks for the opportunity to provide some input.
Also, I would like to someday see NVG imagery with symbology overlay as an option. This is especially helpful during takeoffs and landings when FLIR imagery is limited."

-- "Over the past fifteen years of flying the AH-64 I have noticed that my right eye's ability to focus far has been steadily getting worse (going from 20/10 to 20/60). My near vision in my right eye has remained near 20/10. My left eye far vision has gone from 20/10 to 20/25 and close vision has remained near 20/10. I find it hard to wear glasses while using the HDU. It would be great if the Army allowed laser eye surgery for aviators like the Navy and Air Force have just approved for their aviators.

CEPs would be very helpful for the IHADSS because I have lost some hearing over the last 20 years of military flying. Some AH-64s at high speed flight are very noisy and you combine that with an AH-64 that has a low audio level setting then it is hard to hear the radio commo [communication] from other aircraft or ICS commo from your crewmember without taking out one of my yellow ear plugs."

-- "#5 D assumes that I am familiar with the CEP."

-- "Most visual issues are directly related to how poor the picture from the system is. Don't forget that the last place in the electronic path that the picture goes to is the HDU. We fly the system and make it work, but the Army has been lucky many times over, due to the experience level of its AH-64 aviators. That level is not there anymore. The accident level will rise. How many accidents could have been prevented had the system been of a 2000 generation? The system is old and poor. I use FLIR in my civilian job. There are much better and much newer technologies available. AH-64 aviators do not fly enough to remain proficient, and when they do, it's with a system that is so old, it's dangerous. I have had many close calls during my 12 years flying Apaches. Can luck hold out forever?

Also, I have both an SPH-5 and a HGU-56 for use with my civilian job. I do not like the HGU-56. It restricts vision and is not appreciably lighter."

-- "Give us generation two FLIR. It is not a good feeling when you have to depend on your front-seater to talk you into a FAR[R]P because he has goggles and can see the point that you can only break out with your unaided eye 25 feet prior to landing."

-- "Most of my problems are fit. The issues I have are: a. I would like to PCS with my IHADSS. b. I think I would get better protection from a full-faced motorcycle helmet concept. This helmet would have gimble mounts for HDU and microphone piece. c. I ride motorcycles and fly 64s - the helmet would help a lot. Thanks."

Appendix H.

Abbreviations and terms.

A/C	Aircraft
AAAA	Army Aviation Association of America
ABDU	Aviation Battle Dress Uniform
ALSE	Aviation Life Support Equipment
ANR	Active Noise Reduction
ANRM	Active Noise Reduction Module
AQC	Aircraft Qualification Course
ATM	Aircrew Training Manual
AWR	Airworthiness Release
BMNT	Before Morning Nautical Twilight
BRU	Boresight Reticle Unit
CEP	Communication Earplug
CIF	Central Issue Facility
CPG	Copilot
CRT	Cathode Ray Tube
DAP	Display Adjust Panel
EENT	End of Evening Nautical Twilight
ETL	Effective Translational Lift
ETS	Expiration of Term of Service
FARRP	Forward Area Refueling and Rearming Point
FCP	Fire Control Panel
FLIR	Forward Looking Infrared
FOV	Field of View
GEN	Generation
HAD	High Action Display
HDU	Helmet Display Unit
HMD	Helmet Mounted Display
HUD	Heads-up Display
I^2	Image Intensification
IAT	Image Auto Tracker
ICS	Internal Communication System
IERW	Initial Entry Rotary Wing
IFR	Instrument Flight Rules
IR	Infrared

IHADSS	Integrated Helmet and Display Sighting System
IHU	Integrated Helmet Unit
IIMC	Inadvertent Instrument Meteorological Conditions
IMC	Instrument Meteorological Conditions
IP	Instructor Pilot
ISAQ	Interim Statement of Airworthiness Qualification
MPD	Multipurpose Display
NBC	Nuclear, Biological and Chemical
NOE	Nap of the Earth
NVD	Night Vision Device
NVS	Night Vision System
OGE	Out of Ground Effect
ORT	Optical Relay Tube
PCS	Permanent Change of Station
PEU	PNVS Electronic Unit
PNVS	Pilot Night Vision Sensor
ROK	Republic of Korea
SA	Situational Awareness
SEU	Sight Electronics Unit
TADS	Target Acquisition Designation Sight
TADS/PNVS	Target Acquisition Designation Sight / Pilot Night Vision Sensor
TEU	TADS Electronic Unit
TM	Technical Manual
TPL	Thermo Plastic Liner
USAARL	United States Army Aeromedical Research Laboratory
USAF	United States Air Force
UV	Ultraviolet
VDU	Video Display Unit
VISAA	Visual Issues Survey of Apache Aviators
VMC	Visual Meteorological Conditions