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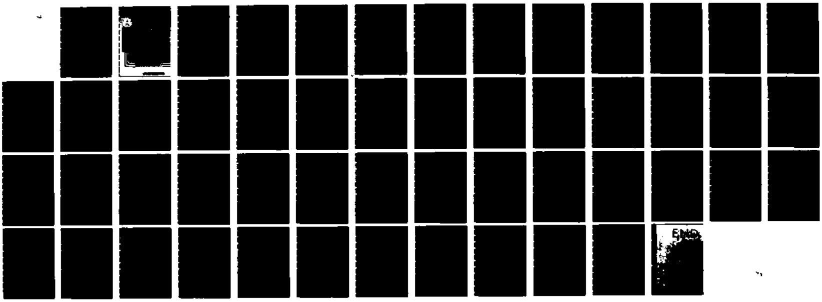

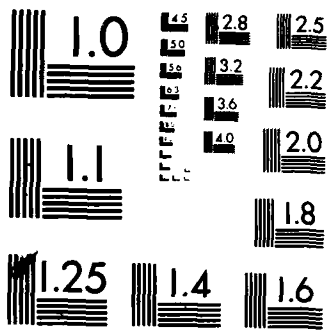

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EFFECTS OF EXTENDED USE OF AN/PVS-5 NIGHT VISION GOGGLES ON HELICOPTER PILOTS' PERFORMANCE

By
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BIOMEDICAL APPLICATIONS RESEARCH DIVISION

January 1984

U.S. ARMY AEROMEDICAL RESEARCH LABORATORY
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20. ABSTRACT:

The effects of extended use of AN/PVS-5 night vision goggles (NVG) were investigated by observing 10 NVG helicopter instructor pilots during two 6-hour missions. Each mission consisted of three 2-hour flights during which pilot control inputs and aircraft status variables were recorded in flight. Questionnaires were completed before the first mission and after the NVG mission. In order to examine for a carryover effect, subjects were flown in a crossover design in which half of the aviators flew NVG on the first mission, the other half on the second. Only the out-of-ground-effect hover showed a statistically significant carryover effect; that is, subjects who flew naked eye before NVG demonstrated a greater absolute difference in hover flight performance variability than those who flew naked eye after NVG flight. In the traffic pattern (final approach segment), there was a statistically significant difference between the visual conditions only. The postflight questionnaire responses revealed a concern over what was described as a "lack of concentration" and a "decline of mental alertness." Some physiological stress reactions were reported. None of the three maneuvers analyzed revealed a significant effect on performance across flights.

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Jean Roebuck exhibited great patience and applied considerable experience to typing the handwritten notes and tables in this report.

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INTRODUCTION

The accomplishment of continuous military operations has always been limited by man's ability to function effectively at night. Even so, U.S. Army doctrine (DA, 1982) stresses the need for round-the-clock operational capability. This doctrine also suggests that future combat scenarios may require day and night operational capability for periods up to 72 hours in a midintensity situation (DA, 1979). A recent Army Aviation Mission Area Analysis (USAAVNC, 1982) further determined that aviators flying combat aircraft may be required to fly for 6 hours or more in a 24-hour period. At least part, if not all, of that time could be flown in darkness with the aviator wearing Night Vision Goggles (NVG).

Previous studies utilizing the NVG both in the airborne setting and in the laboratory have assessed pilot performance with and without the aid of the NVG. The main difference between the conditions appears to have been an increase in the variability of both pilot and aircraft performance due to reduced field of view (Sanders et al., 1975; Lees et al., 1976; Lees, Kimball, and Stone, 1977) and degraded depth perception (Wiley et al., 1976). In addition to being somewhat restrictive, the NVG is relatively heavy and gets uncomfortable after only a short period of wear. While research continues to find ways to improve the goggles, the fact remains that NVG permit aviators to fly in conditions that would be prohibitive without them.

This current study sought to examine the aviator psychomotor (through flight control and aircraft status inputs) changes over a period of 6 hours with nearly continuous wear of the NVG. Questionnaires also were used to assess the aviators' subjective opinions regarding their own behavior.

METHOD

SUBJECTS

Ten male volunteer NVG helicopter instructor pilots were recruited from Fort Rucker, Alabama (Appendix A). Demographic information about the ten men is shown in Table 1.

TABLE 1

DEMOGRAPHIC INFORMATION

Subject	Age	Total Flying Time by Years and Hours: Years	Total Flying Time by Years and Hours: Hours	Total NVG Hours
1	36	10	3000	100
2	32	7	3000	20
3	27	2	800	30
4	31	10	3000	50
5	42	19	4000	19
6	29	4	4200	65
7	37	11	4500	15
8	30	3	950	30
9	33	10	4050	30
10	28	4	1000	30
Minimum	27	2	800	15
Maximum	42	19	4500	100
Mean	32.5	8	2850	38.9

MATERIALS

Aircraft

All missions were flown in an Army JUH-1H helicopter carrying only the subject, the safety pilot, and a technical observer to operate the Helicopter Inflight Monitoring System (HIMS). A separate helicopter was used to maintain aircraft clearance in the maneuver area.

Night Vision Goggles (NVG)

Standard issue AN/PVS-5 NVG were used throughout the study. The NVG were fitted with a standard issue daylight training filter adjusted to approximate half-moon lighting. Nonstandard items (i.e., counterbalancing weights or elastic tubing) were not fitted to the helmet or NVG.

Inflight Recording System

The HIMS (Huffman, Hofmann, and Sleeter, 1972) was used to monitor cyclic, collective, and pedal position as well as aircraft status information. The system was modified to also monitor the slip indicator position. Information was sampled continuously at a rate of 20 scans per second and recorded on magnetic tape in real time via an incremental digital recorder.

Questionnaire

Two questionnaires were administered to each subject (Appendix B). A preflight questionnaire was used to gather basic demographic data on each subject and to ascertain his current state of rest. A postflight questionnaire provided the subject an opportunity to subjectively rate the mission as to the degree of difficulty and the effects of weather, and comment as to whether if at any time during the mission he felt fatigued or noticed a change in his performance.

PROCEDURE

Data Collection

Two subjects were brought to the Highfalls Test Facility on the first day of a testing cycle. Both pilots filled out preflight questionnaires, then flew naked-eye in separate 1-hour flights during which they rehearsed each of the four maneuvers to be flown during the data collection phase:

1. A normal traffic pattern.

2. A nap-of-the-earth flight (NOE) over the U.S. Army Aeromedical Research Laboratory NOE course.

3. An out-of-ground-effect (OGE) hover at 50 feet above ground level (AGL) for 2 minutes.

4. A precision coordination exercise of approximately 8 minutes.

One of the subjects then flew the data collection phase on the second and fourth days of the cycle; the other subject flew on the third and fifth days. On each of these test days, the respective subject flew a 6-hour mission consisting of three 2-hour flights separated by just enough time to refuel the helicopter. During one of the missions, a pilot wore the AN/PVS-5 NVG equipped with daylight filters. During the other mission, he did not wear the NVG. The sequence for wearing the NVG was reversed for each half of the subjects, and pilots were allowed to remove the helmet and goggles during the refueling. Each 2-hour flight consisted of three sets of the four maneuvers previously described.

In order to read flight instruments accurately, an aviator must refocus the NVG to see the instrument panel and then change focus again to see outside. To preclude constant adjustment of NVG focal length, some normal flight procedures were altered slightly. The pilot was asked to fly headings given by the safety pilot using clock references to current aircraft heading. Initial altitudes were given to the pilot and he continued to fly that altitude as he perceived it. (The altimeters were covered.) The safety pilot instructed the subject to fly the NOE course at an altitude and airspeed commensurate with the terrain, as the subject pilot felt it appropriate. Each traffic pattern was begun and terminated at a reference mark located on the runway. Except for periods of instruction by the safety pilot, the subject remained at the controls until he had landed the aircraft or until he had been relieved by the safety pilot. Postflight questionnaires were administered after the NVG mission.

Data storage aboard the helicopter was limited to [illegible] minutes during each 2-hour flight; therefore, continuous performance was n[illegible]ecorded. It was decided to collect data for key segments of each maneu[illegible] and to record only two of the three repetitions of each maneuver in each [illegible] flight. The two repetitions were preselected so as to provide an optim[illegible]ount of data balanced for early, middle, and late sets across flights. The recorded segments consisted of the full time of the hover, the final approach part of the traffic pattern, the turns of the precision exercise, and preselected turns along the NOE course.

Data Analysis

Although recorded, the NOE data was not analyzed because subsequent examination revealed excessively large individual differences in the way pilots flew the course. The variables used in the rest of the maneuver analyses were those which reflected an input from the pilot in a given maneuver (altitude and standard deviations of control position in a hover, for example) and not those which reflected characteristic functions of the aircraft in the environment (e.g., the control position itself is determined by the weight and balance of the aircraft and changes--independent of the pilot--as fuel is consumed). A complete list of the variables examined for each maneuver is shown in Table 2.

TABLE 2

SELECTED VARIABLES FOR EACH MANEUVER

(OGE) HOVER

CFACPS (Cyclic fore/aft control position standard deviation)
CLRCPS (Cyclic left/right control position standard deviation)
COLCPS (Collective control position standard deviation)
PEDCPS (Pedal control position standard deviation)
PIT SD (Pitch standard deviation)
ROL SD (Roll standard deviation)
RA X (Mean radar altitude)
RA SD (Radar altitude standard deviation)

TRAFFIC PATTERN

CFACPS
CLRCPS
COLCPS
BALL SD (Slip indicator position standard deviation)
*PEDCPS
PIT SD
ROL SD
HEA SD (Heading standard deviation)
DESRATEX (Mean rate of descent)
*DESRATES (Rate of descent standard deviation)

STANDARD RATE TURN

CFACPS
CLRCPS
COLCPS
*PEDCPS
ROL X (Mean angle of bank)
ROL SD
TRNRATEX (Mean rate of turn)
TRNRATES (Rate of turn standard deviation)
*BA X (Mean barometric altitude)
BA SD (Standard deviation of barometric altitude)

*Dropped from final analysis.

With respect to the traffic pattern (final approach) and the standard rate turn analyses, 10 variables had originally been judged pertinent. The final analyses, however, limited the input to eight variables to satisfy restrictions on the degrees of freedom. Therefore, preliminary statistical analyses were performed to select the two variables to be dropped from the final analysis. Using the standard discriminant function coefficients as criteria, the pedal position standard deviation (PEDCPS) and the rate of descent standard deviation (DESRATES) were found to contribute least to the outcome of the traffic pattern statistical test and were dropped from further analysis. For the standard rate turn analysis, the PEDCPS and mean barometric altitude (BA X) were dropped for the same reason.

Analysis of the inflight data was patterned after the two-period repeated measures crossover design developed by Wallenstein and Fisher (1977). This procedure allowed subjects to be used as their own controls and also permitted investigators to determine if a factor in the first period (Day 1) affected results in the second period (Day 2). The design had a potential disadvantage in that if there was a statistically significant carryover effect present, the analysis could be based only on the first period data.

RESULTS

INFLIGHT

Two subjects failed to complete the 6-hour NVG profile. One resigned in extreme discomfort after 5 hours of NVG flight; the other subject was withdrawn after displaying tremulousness of the extremities during an unrecorded NOE segment 3 1/2 hours into his NVG mission. This was presumed to be fatigue related or induced. Flight behavior up to the point of withdrawal in both subjects was unremarkable; inflight data demonstrated no significant changes in performance over the period up to that point. Mild tremors also were observed in a third pilot; but they did not intensify, so he was allowed to continue.

Table 3 shows the results of the crossover analyses of the indicated maneuvers.* Asterisks mark those variables whose probability fell below the selected cutoff ($p < .05$). When the three arrays were screened via Fisher's Lambda to determine what effect they had overall (Table 4), only the OGE hover showed a significant carryover effect.

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* "Period" in Table 3 refers to a test of the first three flights versus the second three flights without regard to visual condition. "Carryover" refers to a test of the two visual conditions and the sequence in which flown.

TABLE 3

RESULTS OF UNIVARIATE CROSSOVER ANALYSES (F-TABLE)

Variable	Visual Condition (df = 1)	Period (df = 1)	Carryover (df = 1)
		HOVER	
CFACPS	1.30	0.52	2.20
CLRCPS	1.07	0.00	1.04
COLCPS	1.46	0.02	2.95
PEDCPS	5.76*	0.13	1.35
PIT SD	1.40	0.13	31.21*
ROL SD	1.14	0.02	30.38*
RA X	0.50	0.55	5.98*
RA SD	1.74	0.13	2.74
		TRAFFIC PATTERN	
CFACPS	0.03	3.23	0.84
CLRCPS	0.02	0.14	0.62
COLCPS	0.01	0.98	0.00
PEDCPS	1.75	0.36	0.11
BALL SD	1.13	0.01	2.22
HEA SD	2.36	1.66	3.42
PIT SD	0.76	0.86	0.58
ROL SD	0.39	0.30	0.15
DESRATEX	0.84	0.14	0.40
DESRATES	0.31	1.88	0.22
		STANDARD RATE TURN	
CFACPS	2.05	0.85	0.43
CLRCPS	1.32	0.11	3.85
COLCPS	0.01	0.03	0.00
PEDCPS	0.10	0.07	0.02
ROL X	0.01	0.01	0.06
ROL SD	1.17	0.02	3.77
TRNRATEX	0.04	0.01	0.01
TRNRATES	9.11*	0.25	3.11
BA X	0.06	0.21	0.18
BA SD	0.02	1.34	0.01

* $p < .05$.

TABLE 4

RESULTS OF FISHER'S LAMBDA TEST PERFORMED ON CROSSOVER ANALYSIS

	Treatment	Period	Carryover Effect
		50' HOVER	
Lambda	23.01	5.32	52.90
df	16	16	16
p	0.11	0.99	0.00
		TRAFFIC PATTERN	
Lambda	15.59	18.16	16.23
df	16	16	16
p	0.48	0.31	0.44
		STANDARD RATE TURN	
Lambda	18.25	8.03	17.11
df	16	16	16
p	0.31	0.95	0.38

As indicated earlier, demonstration of a statistically significant carryover effect would indicate that flight experience in one of the visual conditions during the first period influenced performance during the second flight period. In this case, only the hover maneuver was affected. As a consequence, the hover data was reexamined using the first and second periods separately with a multivariate analysis of variance (MANOVA) procedure developed by Hughes, LaRue, and Yost (1969). The results of the first period examination are shown in Table 5. These data indicate no statistically significant differences between visual conditions (V), 2-hour flights (F), or their interaction (VF). A statistically significant interaction between the flights and the visual conditions (VF) was noted for the second day (Table 6).

TABLE 5

MULTIVARIATE ANALYSIS OF VARIANCE ON FIRST PERIOD HOVER

HOVER						
Test	Roots	F	df hyp	df err	p	R
VF	1	0.58	16	18	0.86	0.71
	2	0.17	7	9.5	0.99	0.34
V	1	0.78	8	1	0.71	0.93
F	1	0.84	16	18	0.63	0.75
	2	0.47	7	9.5	0.84	0.51

Note: V = visual conditions, F = 2-hour flights, VF = interaction of visual conditions and flight.

TABLE 6

MULTIVARIATE ANALYSIS OF VARIANCE ON SECOND PERIOD HOVER

HOVER						
Test	Roots	F	df hyp	df err	p	R
VF	1	3.62	16	18	0.01	0.90
	2	3.19	7	9.5	0.05	0.94
V	1	1441.34	8	1	0.02	1.00
F	1	2.16	16	18	0.06	0.90
	2	0.96	7	9.5	0.53	0.64

Note: V = visual conditions, F = 2-hour flights, VF = interaction of visual conditions and flights.

Further examination using data plots provided a clear (though not statistically significant) difference between the two visual conditions on both days for each variable. The mean pitch standard deviation, for example, is displayed in Figure 1. Group 1 wore the NVG the first day and flew by naked eye the second day. The sequence was reversed for Group 0. The figure

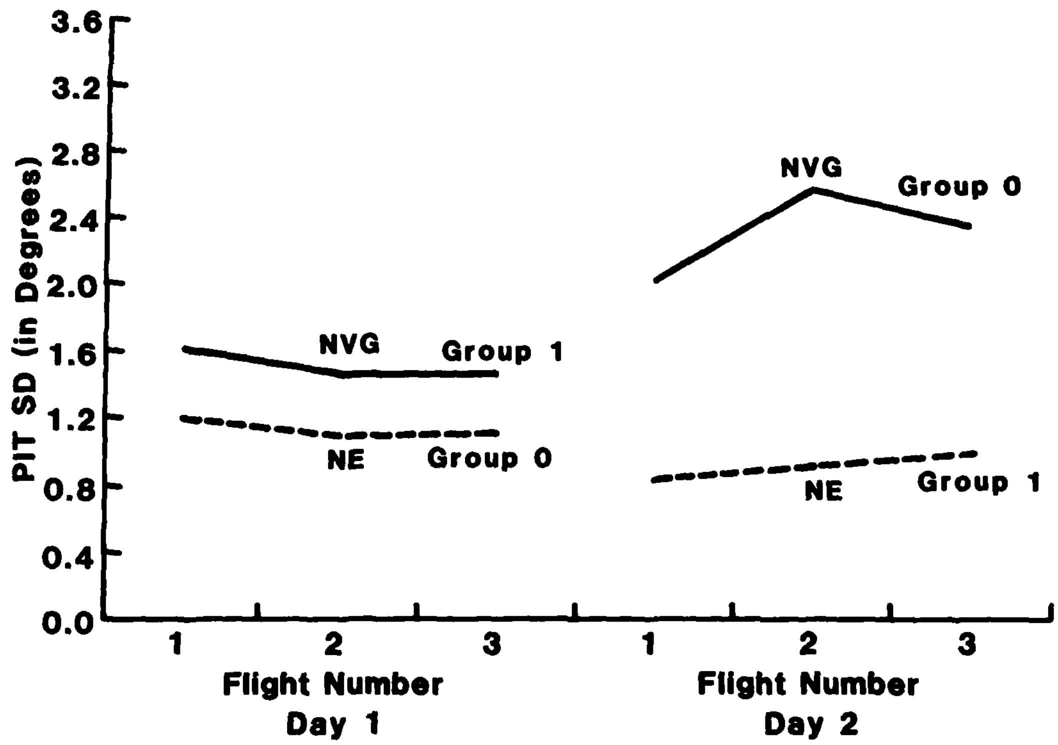

FIGURE 1. Mean pitch standard deviation for visual condition groups on each day. (Group 1 wore NVG on Day 1, Group 0 used naked eye on Day 1.)

illustrates the greater difference between visual conditions when viewed by sequence. The direction of change showed an increase between the first and second days for Group 0, where the direction of change was decreased for Group 1; and the amount of change was greater for Group 0 than for Group 1. That difference in absolute change from Day 1 to Day 2 illustrates carryover effect. (Plots of all eight variables examined in the analysis of the OGE hover are shown in Appendix C.)

The MANOVA test results for the traffic pattern and standard rate turn maneuvers are shown in Table 7. Since there were no statistically significant carryover effects in either of these maneuvers, data from both periods were combined. There were no statistically significant effects observed in the standard rate turn results. The only significant effect in the traffic pattern was for visual condition (V). Univariate F-test results for that maneuver are shown in Table 8. They identify the main contributors as the standard deviations of the cyclic (left/right) control position (CLRCPS), the collective control position (COLCPS), the pitch (PIT SD), and the roll (ROL SD); and the mean rate of descent (DESRATEX).

TABLE 7

MULTIVARIATE ANALYSIS OF VARIANCE USING BOTH PERIODS FOR TRAFFIC PATTERN AND STANDARD RATE TURN

Test	Roots	F	df hyp	df err	p	R
			TRAFFIC PATTERN			
VF	1	1.34	16	22	0.26	0.79
	2	0.80	7	11.5	0.60	0.57
V	1	37.50*	8	2	0.03	1.00
F	1	1.41	16	22	0.22	0.83
	2	0.42	7	11.5	0.87	0.45
			STANDARD RATE TURN			
VF	1	0.71	16	22	0.75	0.67
	2	0.46	7	11.5	0.84	0.47
V	1	3.52	8	2	0.24	0.97
F	1	1.91	16	22	0.08	0.85
	2	1.03	7	11.5	0.46	0.62

* $p < .05$

Note: V = visual conditions, F = 2-hour flights, VF = interaction of visual conditions and flights.

TABLE 8

UNIVARIATE F TESTS FOR TRAFFIC PATTERN VISUAL CONDITION

TRAFFIC PATTERN			
Variable	F(1,9)	Mean Square	p
CFACPS	2.22	0.07	0.17
CLRCPS	9.02	0.15	0.02
COLCPS	18.86	0.23	0.00
BAL SD	0.27	0.00	0.62
PIT SD	8.18	8.76	0.02
ROL SD	62.83	15.54	0.00
HEA SD	1.10	3.55	0.32
DESRATEX	10.81	53.60	0.01

QUESTIONNAIRES

Preflight

Data are summarized in Appendix D. All subjects reported being well rested (Items 13 and 14). Each was confident that he could fly with the goggles (item 18) at least as long as he had (reportedly) flown with them in the past (Item 17); most thought it possible to fly even longer. Each aviator reported his safe limit of goggle flight time (Item 19) as equal to or less than his respective "possible" limit (Item 18).

Items 20 and 21 provided each aviator an opportunity to express his attitude toward the goggles. Item 20 concerned the perceived benefits. Not unexpectedly, the principal benefit of the NVG was reported as some form of vision enhancement under otherwise limited visibility conditions. Item 21 asked about perceived discrepancies of the NVG. The principal item there revealed dissatisfaction with field of view across all subjects. The second most frequent entry in Item 21 was a concern over NVG weight and weight distribution on the helmet. All of the subjects complained during the flights about the weight and the chafing of the scalp (called "hot spots"). In fact, one subject withdrew as a direct result. Other complaints were reported as lack of depth perception, refocusing requirements when shifting attention between points inside and outside the cockpit, inadequate means of mounting NVG to the helmet, and poor resolution. Also, some subjects expressed concern about the lack of a backup power supply for the NVG, especially during terrain flight.

Postflight

Data are summarized in Appendix E. After experiencing some 6 hours of flying with the goggles, the aviators were given an opportunity to reassess the maximum time each thought he could wear the NVG. Five subjects adjusted their tolerance limits upward, one stayed the same, three reduced their limits, and one did not comment (Item 2). However, there was no significant change between the mean of the maximum NVG flight time they perceived possible before the NVG mission and the mean of the maximum flight time they recommended after the mission.

In response to the postflight questionnaire items 3-5, the subjects recommended reduced flight time over continuous days of NVG missions and recommended 25% to 50% decrease in flight time beyond these limits when NVG missions were flown in conjunction with daylight missions. The primary difficulties identified by the subjects (Item 6) closely paralleled the perceived problems described by them in the preflight questionnaire. The aviators also complained about "lens fogging." In several instances, the safety pilot had to take the controls while the subject wiped off the eyepieces so he could see to continue. Several subjects mentioned a lack of concentration after several hours of flight with the NVG. One pilot described the feeling as a "decline of mental alertness." One subject was so upset by a combination of hot spots and his perceived loss of concentration that he withdrew with less than an hour to go to complete the 6-hour profile. Physiological symptoms also were listed. Several pilots reported nausea, upset stomach, and eye strain. One pilot reported no difficulties at all.

DISCUSSION

As indicated earlier, reduced field of view, degraded depth perception, and discomfort are well-documented characteristics associated with the (unmodified) AN/PVS-5 NVG. In fact, a student handout used at the Army Aviation Center at Fort Rucker, Alabama, since 1979 contains an excellent summary of those problems and offers some helpful suggestions to overcome them (U.S. Army Aviation Center, 1979).

Two findings in this study were important. First, carryover effects found during the hover portion of the study and revealed by the crossover analysis suggested that aviators who flew near the ground with the NVG after having flown naked eye were affected to a significantly different degree (quantitatively) and in a different way (qualitatively) than those who flew with NVG followed by naked eye. The authors offer as a plausible explanation that the pilots who flew naked eye first became accustomed to a certain cue milieu. Subsequent flight with NVG changed those cue patterns enough to measurably affect performance. Those who had become used to the NVG-oriented cues first were not so affected when they flew later without NVG. In either case, when flying near to the ground, performance during the first period was not statistically significantly different between those wearing the NVG and those not. There was, however, a statistically significant difference between those wearing the NVG and those not wearing them on the second day. So, it would seem that flying near the ground during daylight hours followed by flying in NVG conditions would call for more pilot caution than when flying in NVG conditions followed by naked eye.

The fact that flight performance at altitude (as little as 500 feet) was not marked by similar changes in variability was probably due to the change in cues that normally accompanies a change in altitude as experienced in this study. Reduced field of view and degraded depth perception would require a pilot operating close to the ground to look well ahead of the aircraft for necessary information. At altitude, the point of regard for similar information would not likely be very different whether or not a pilot was wearing NVG. In the final approach maneuver, the reduction in altitude and correlated changes in visual cues are the probable cause of the significant differences between visual conditions (NVG versus naked eye) found in that maneuver.

The second important finding in the study was that whatever effect the NVG might have had on performance at the start, in most cases it did not change significantly over the three 2-hour flights. The authors would be remiss, though, if they left the impression that the 6 hours with NVG had no effect on the pilots. The changes in disposition brought on with the discomfort experienced by the aviators while wearing the NVG were unquestionably real. Of the two aviators who did not complete the "assigned mission," the one in whom the tremors developed may not have been able to continue flying in the relatively strict requirements of NOE flight. The one who succumbed to discomfort might have been able to continue under combat circumstances. Behavior of people under high stress is not easily predictable. Certainly, in a peacetime scenario, a flight commander would be well-advised to avoid extended periods of NVG wear (i.e., over 4 hours)--not because of any quantitative performance decrements, per se, but because of the distractive interference caused by personal discomfort. The caution is even more appropriate where NVG wear follows daylight flying.

While not specifically examined in this study, it is possible that the wide range of comfort/discomfort expressed by the aviators was largely a result of individual fitting of the SPH-4 helmet when worn with the NVG. As indicated in the student handout referenced earlier, field commanders should emphasize to their aviators that proper fit of the SPH-4 helmet is an important step toward reducing and/or delaying onset of discomfort. When the NVG is added to--or removed from--the helmet, readjustment/refit is imperative. Improper adjustments can aggravate a potentially serious problem area.

CONCLUSIONS

When operating a helicopter close to the ground, the use of NVG is associated with greater variability of aviator input and aircraft status variables; and that increase in variability is more manifest when NVG flight follows naked eye flight (daylight to darkness) than when naked eye flight follows NVG flight (darkness to daylight) The effects of extended flight (up to three 2-hour flights in a UH-1) do not significantly change the psychomotor performance of aviators under relatively unstressed situations whether or not NVG are being worn. The discomfort from wearing the NVG over the same period of time, on the other hand, could lead to individual attitude problems severe enough to affect the mission. Properly refitting the helmet with the NVG in place could effectively reduce, delay, or possibly eliminate the discomfort.

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APPENDIX A

CONSENT FORMS

PILOT'S INFORMED CONSENT
(Description of Study)

This study is designed to examine pilot performance during extended night vision goggle flight operations. The information gained will be useful in assessing proposed NVG flight limits for future combat TOE flight units.

We are concerned with physiological and psychomotor aspects of pilot performance and the safety a_pects of extended helicopter operations. Therefore, we are asking you to aid us in collecting several types of data on day-unaided flight and 6 hours of continuous day flight wearing NVG with day filters.

All profiles flown will be approximately 2 hours in duration. Before and after these flights, you will be monitored by an electromyographic (EMG) device. It will be attached to muscles on the back of your neck by means of noninvasive electrodes to record electronic impulses of your neck muscles. You may remove the electrodes immediately after your measurements by peeling them off.

Under the terms of this agreement, you may rest assured that data collected during this experiment will be grouped together with data from other aviators and treated for research purposes only.

______________________ ______________________________

Date of Briefing Signature

PRIVACY ACT STATEMENT

The information solicited in this questionnaire will be used for research and statistical analysis of the problem of Army aviator fatigue in usage of night vision goggles. It will be kept confidential and names will not be used in any reports, published or unpublished, of this data. Participants will be identified only by randomly assigned project identification numbers.

Disclosure is voluntary; however, failure to do so will seriously limit the usefulness of other data obtained from the individuals in this project.

I have read and understand the above statement and consent to the use of this information as described.

____

Signature Date

VOLUNTEER PARTICIPATION AGREEMENT

I, ____, SSN ________________________, having attained my eighteenth (18th) birthday, and otherwise having full capacity to consent, do hereby volunteer to participate in an investigational study dealing with fatigue and the AN/PVS-5 Night Vision Goggles, under the direction of Major Chester E. Duncan, MSC, and Lewis W. Stone, DAC.

The implications of my voluntary participation; the nature, duration, and purpose; the methods by which it is to be conducted; and the inconveniences and hazards which may reasonably be expected have been explained to me by Major Duncan and are set forth in Appendix C [sic], which I have signed. I have been given an opportunity to ask questions concerning this investigational study and my questions have been answered to my full and complete satisfaction.

I understand that I may at any time during the course of this study revoke my consent and withdraw from the study without prejudice.

____

Signature Date

I was present during the explanation referred to above as well as the Volunteer's opportunity for questions and hereby witness his signature.

____

Witness' Signature Date

APPENDIX B

PREFLIGHT AND POSTFLIGHT QUESTIONNAIRES

PREFLIGHT QUESTIONNAIRE

1. Name ____ Age ______

2. Are you currently rated and proficient in the UH-1H? Yes ___ No ___

3. Are you currently instrument rated and proficient? Yes ___ No ___

4. Total number of years of military flying experience _______________.

5. Total number of flight hours _______________.

6. Total number of flight hours last 6 months ____________________.

7. Are you qualified to fly with night vision goggles? Yes ___ No ___

8. Total number of hours NVG flight __________________.

9. Total number of NVG flight hours last 6 months __________________.

10. Total number of NVG flight hours in standard flight (above 125 AGL)

    __________________.

11. Total number of NVG flight hours in terrain flight (below 125 AGL)

    __________________.

12. How many drinks of alcohol or cans of beer have you had in the last 24 hours? ________________________

13. How many hours of sleep do you usually need per 24-hour period to feel well rested? ________________________

14. How many hours of sleep have you had in the last 24 hours? _________

15. Rate your use of caffeine-containing beverages in the last 24 hours (circle letter of correct response).

    a. None
    b. Less than 2 cups
    c. Less than 4 but more than 2 cups
    d. 4-7 cups
    e. 8 cups or more

16. Rate your personal level of fatigue at the present time according to the following scale (circle letter of correct response).

a. Well rested

b. Rested, but not fully rested

c. Slight fatigued, but OK to fly

d. Fatigued, OK to fly

e. Fatigued, should not fly

17. If NVG qualified, what is the maximum time you have flown without removing them? ________________

18. What is the maximum flight time (continuous) you feel you can fly with night vision goggles? ____

19. What is the maximum flight time (continuous) you feel you could fly with night vision goggles and still be safe? ________________________

20. In your opinion, what are the major benefits of NVG? (List below)

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

21. In your opinion, what are the major discrepancies of NVG? (List below)

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

POSTFLIGHT QUESTIONNAIRE

1. Rate your level of fatigue (circle letter of correct response):

   a. Feel good; could fly NVG again immediately.

   b. Slightly tired; could fly NVG again in 30 minutes to an hour.

   c. Moderately tired; could fly NVG again in 4-5 hours.

   d. Severely tired; could fly NVG again in 8-10 hours after a period of sleep.

   e. Exhausted; could not fly NVG again within 24 hours?

2. In a 24-hour period, what is the maximum number of NVG flight hours

   you would recommend? ________ Why? ____________________

   ____

   ____

3. In a 72-hour period, what is the maximum number of NVG flight hours

   you would recommend? ________ Why? ____________________

   ____

   ____

4. In a 1-week period, what is the maximum number of NVG flight hours

   you would recommend? ________ Why? ____________________

   ____

   ____

5. Were you to fly day flight (no NVG) as well as night (with NVG), how would that affect your estimates in 2, 3, and 4 above?

   ____

   ____

6. During your flight, list the primary difficulties you encountered:

a. ______________________________

b. ______________________________

c. ______________________________

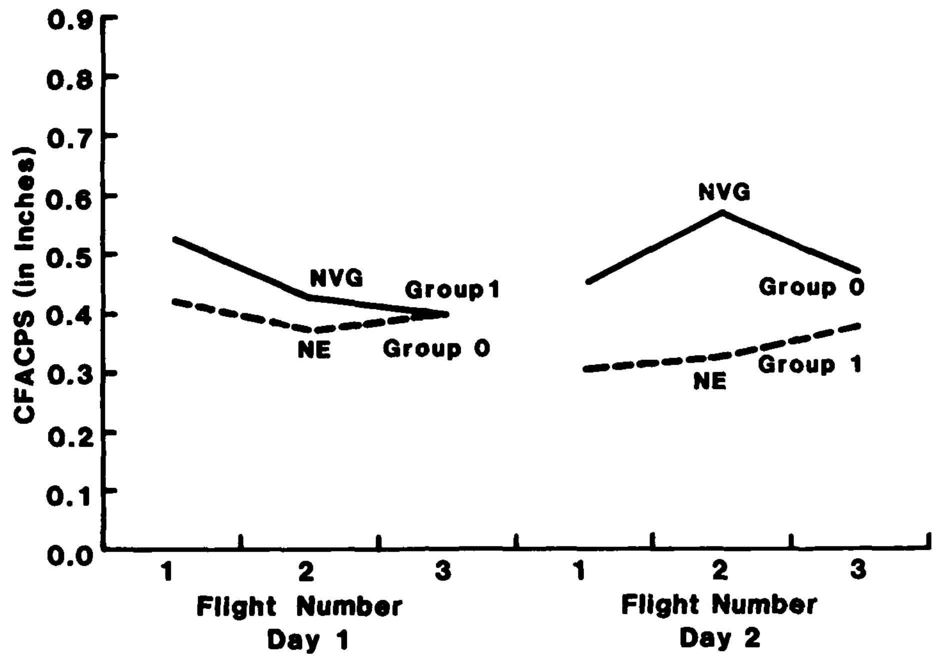
d. ______________________________

e. ______________________________

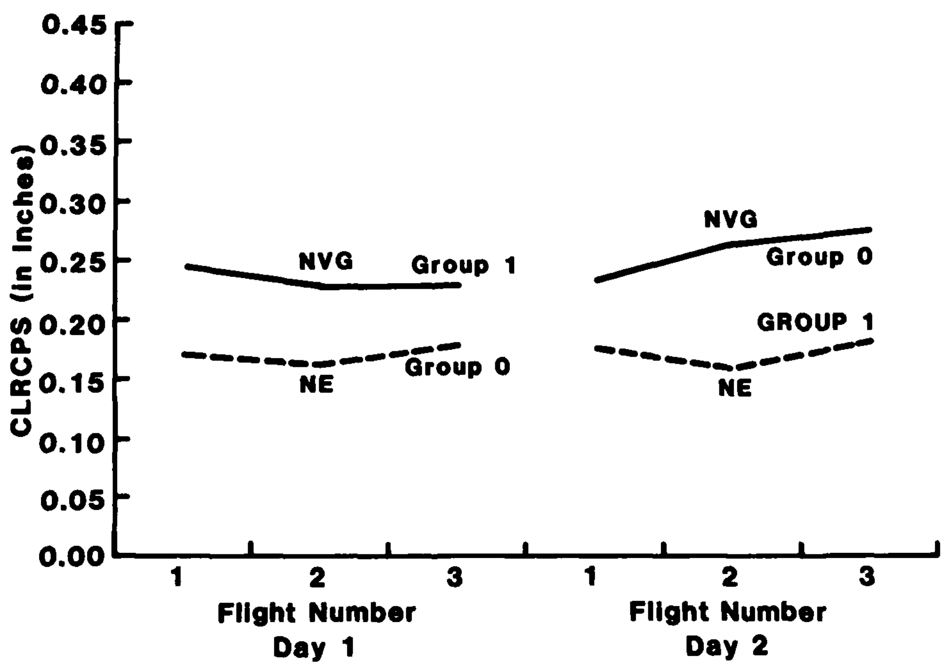
7. Comments:

APPENDIX C

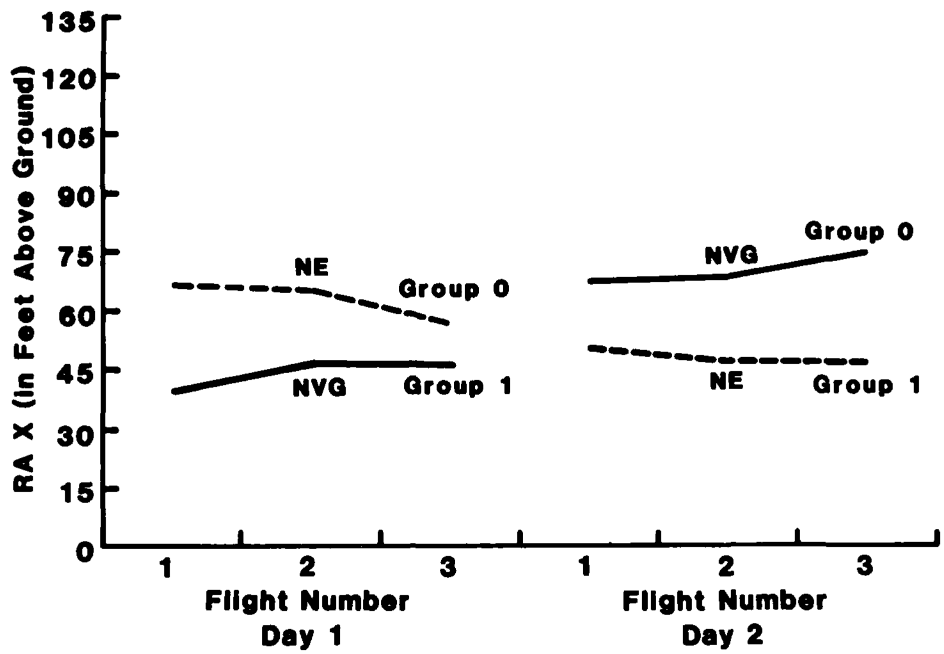
VARIABLE PLOTS BY VISUAL CONDITION, DAY, AND FLIGHT



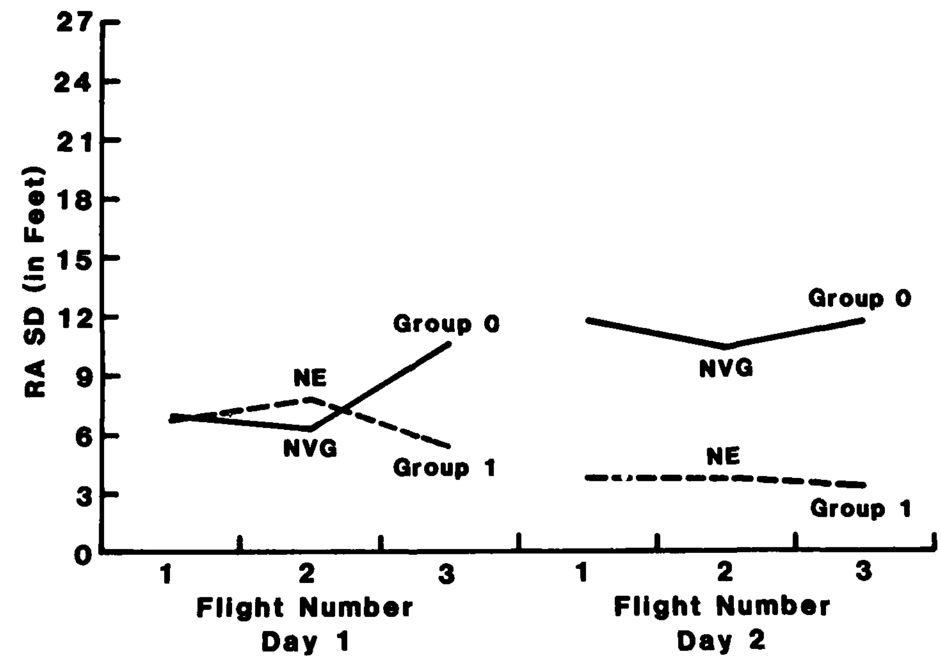
Cyclic fore/aft control position standard deviation for visual condition groups on each day.



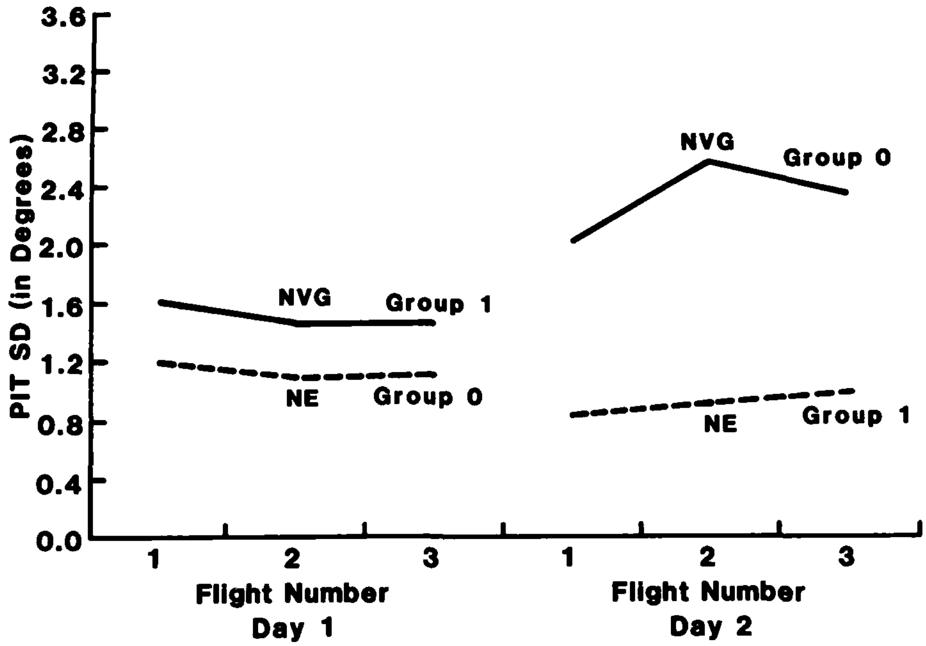
Cyclic left/right control position standard deviation for visual condition groups on each day.



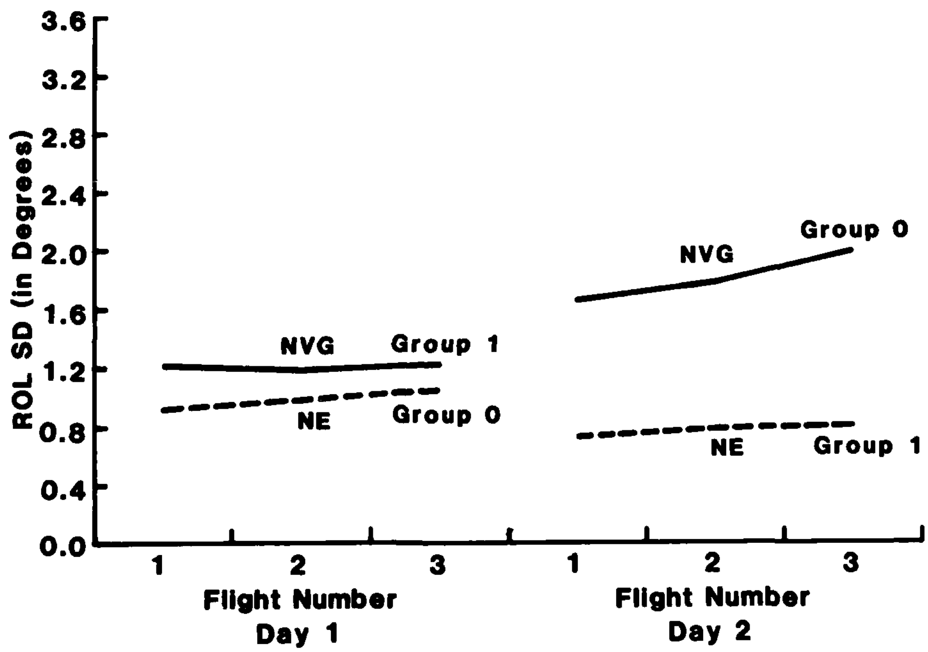
Collective control position standard deviation for visual condition groups on each day.



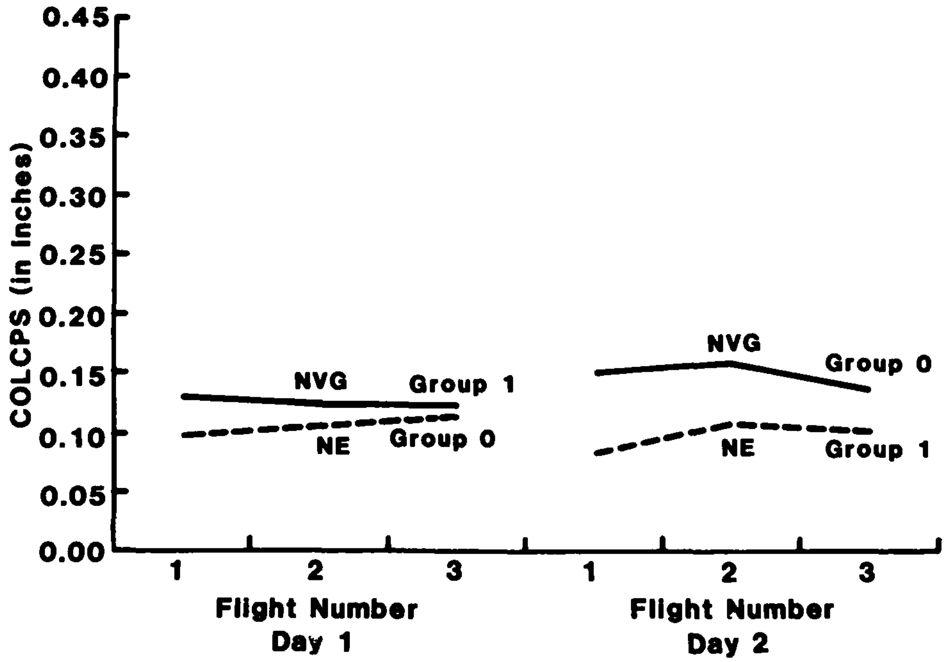
Pedal control position standard deviation for visual condition groups on each day.



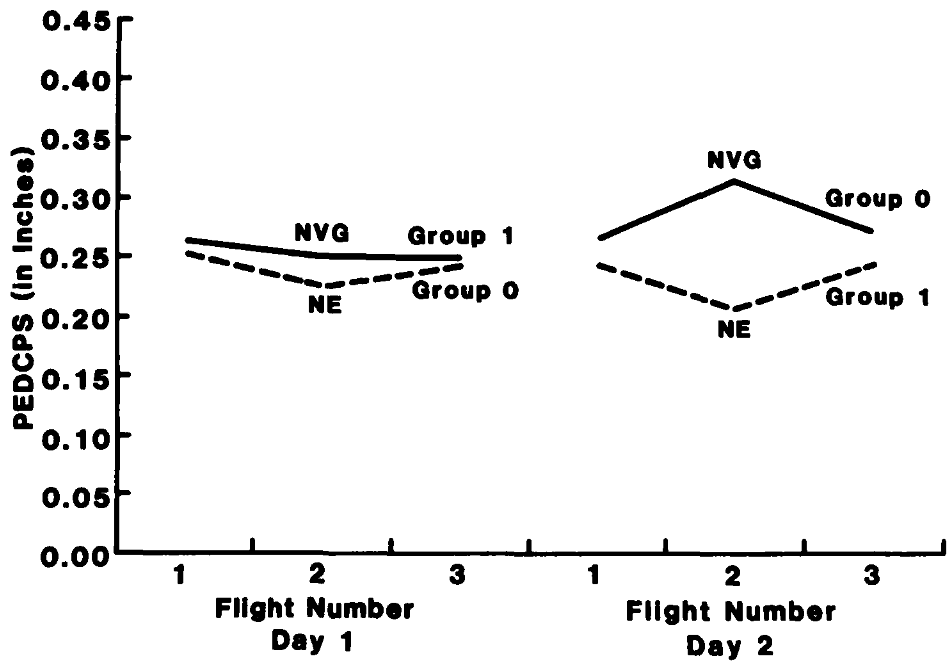
Pitch standard deviation for visual condition groups on each day.



Roll standard deviation for visual condition groups on each day.



Mean radar altitude for visual condition groups on each day.



Radar altitude standard deviation for visual condition groups on each day.

APPENDIX D

PREFLIGHT QUESTIONNAIRE SUMMARY

PREFLIGHT QUESTIONNAIRE

S	SOURCE	GROUP	1 Age	4 Years of flying experience	5 Total flight hours	6 Last Six months	8 Total NVG flight	9 Last six months	10 Total NVG above 125 ft	11 Total NVG below 125 ft	12 Alcohol in last 24 hrs	13 Sleep needed in 24 hrs	14 Sleep last 24 hrs	15 Caffeine in last 24 hrs
1	C	1	36	10	3000	100	100	0	100	0	3 beers	6-8	6	>8
2	C	2	32	7	3000	180	20	0	10	10	1	6	7	4-7
3	L	2	27	2	800	60	30	2	29	1	0	7	7	<2
4	L	2	31	10	3000	240	50	50	50	0	6	7.5-8	7.5	4-7
5	C	2	42	19	4000	110	19	19	18	1	0	7	9	4-7
6	L	2	29	4	4200	260	65	20	65	0	3	5-7	5	<2
7	C	1	37	11	4500	300	15	0	12	3	6 beers	6	8	<2
8	L	1	30	3	950	275	30	30	28	2	0	6	7	>8
9	L	1	33	10	4050	250	30	4	25	5	0	7	6	>8
10	L	1	28	4	1000	250	30	30	30	0	4	8	7	4-7
Mean			32.5	8	2850	202.5	38.9	15.5	36.7	2.2	2.3	6.78	6.95	4-7
Median			31.5	8.5	3000	245	30	11.5	28.5	1	2	7	7	4-7
SD			4.65	5.12	1438	84.24	26.2	17.25	27.84	3.19	2.45	0.75	1.12	-
High			42	19	4500	300	100	50	100	10	6	8	9	>8
Low			27	2	800	60	15	0	10	0	0	6	5	<2

NOTES: Source--L = Lowe Army Heliport, C = Cairns Army Airfield
SD = Standard

PREFLIGHT QUESTIONNAIRE (CONT)

S	SOURCE	GROUP	17 Max. Cont. NVG wear in past	18 Max. Cont NVG wear possible	19 Max. Cont. safe wear	20 NVG benefits
1	C	1	2	3	3	Ability to see under dark or near dark conditions.
2	C	2	2	4	3	Increased night operations capability, marginal weather (fog, haze) capability.
3	L	2	2	4	3	See terrain contrast, allows aviator to fly lower and remain masked in vicinity of enemy.
4	L	2	1.2	3	2	Provides discrimination of many near (hazard to flight) objects and navigation features.
5	C	2	1.5	2	1.5	Reposition an a/c short distance, ITO and preparations for ITO, NOE flights short distances, night approaches, night search and rescue.
6	L	2	1.7	Unknown	Unknown	Ability to collect and amplify ambient light, shut down capability with increase in ambient light, ability to penetrate obscuration to visibility.
7	C	1	1	7-8	5-6	Ability to continue flying during darkness.
8	L	1	3	4	4	Allows flight at night with a feeling of security, allows night terrain flight.
9	L	1	1.5	4	3	Allows better night vision than unaided with less than 50% ambient light.
10	L	1	3	3	3	Terrain definition at night.
Mean			1.89	3.83	3.11	
Median			1.85	4	3	
SD			.68	1.54	1.14	
High			3	8	6	
Low			1	2	1.5	

NOTES: Source--L = Lowe Army Heliport, C = Cairns Army Airfield
SD = Standard

PREFLIGHT QUESTIONNAIRE (CONT)

S	SOURCE	GROUP	21 NVG Discrepancies
1	C	1	Field of vision too limited, no depth perception, too heavy.
2	C	2	Weight and helmet CG, field of vision limitations, single power source, incompatibility with map reading, fixed depth of field, lack of proper available maintenance, resolution of altitude poor, goggle frame not well adapted to helmet.
3	L	2	40^{o} field of view, slower reaction time, increased fatigue due to weight of NVG, bright lights shut down NVG.
4	L	2	Weight is fatiguing; poor resolution of objects more than 300 feet away; must be refocused for rear objects in cockpit; difficult, time consuming to put on; poor resolution of details, instruments, maps, wires; extremely restricted field of view.
5	C	2	Small view angle, too heavy, not easy to remove quickly, sensitive against sweat, not well adapted to helment (many hot spots); should be built into a special helmet; battery changes too slow.
6	L	2	Weight, size, field of view, probability of failure due to single power source, attachment straps.
7	C	1	Discomfort due to the manner in which they are mounted, restricted field of vision, loss of sharpness, lack of backup power supply, inability to read maps and instruments without refocusing.
8	L	1	NVG are bulky, restrict field of vision, take away from depth perception, only work as good as ambient light level allows.
9	L	1	Inability to navigate, fatigue factor, increased cockpit workload, decreased depth perception, decreased peripheral vision, inability to use cockpit instrumentation.
10	L	1	Too heavy, field of view too narrow, difference in depth for individual goggles.

NOTES: Source--L = Lowe Army Heliport, C = Cairns Army Airfield
SD = Standard

APPENDIX E

POSTFLIGHT QUESTIONNAIRE SUMMARY

POSTFLIGHT QUESTIONNAIRE

S	1 Felt fatigue rating	2 Max. reco'd NVG flight in 24 hrs	Why	3 Max. reco'd NVG flight in 72 hrs	Why
1	C	4	Providing there are 8 hours of rest before and after, this should allow sufficient recovery time.	10	The fatigue will increase with extended exposure.
2	D	6	Present NVG harness is not adequate to support goggles comfortably, results in severe eye strain, blood restriction around headband due to tightness, severe headache.	12	Reasons above I believe are cumulative with possibility of permanent damage.
3	C	6	Three 2-hr flights with a rest period between each. This would allow a period to stretch and relax.	12	Over a 3-day period, a pilot cannot sustain the same rate. Approx 4 hrs.
4	C	4	Fatigue factor is greater during night NVG, especially if associated with tactical or field environment.	10	This would allow an adequate recovery period between flights.
5	C	1.5	After a 1.5-hr period, I always experienced a great lack of concentration.	10	Because a combat situation may keep you more awake due to its excitement, but then you might have a total breakdown
6	A	-	-	-	-
7	B	4-5	Discomfort and fatigue, especially if the pilot is in marginal physical condition.	10-12	As in #2 but to a greater degree.
8	C	4	I feel that after that amount of time, I personally become unsure of my limitations.	12	Same as above.
9	D	3 peace 4 combat	Fatigue factor of increased weight on front of helmet.	9 peace 12 combat	Same as above.
10	C	4	Boredom beginning to present itself and eye fatigue.	10	Due to cumulative effect.
Median	C	4		10	
Mean		4.11		10.89	
SD		1.39		1.17	
High	A	6		12	
Low	D	1.5		9	

POSTFLIGHT QUESTIONNAIRE (CONT)

S	4 Max. reco'd NVG flight in 1 wk	Why	5 Unaided day + NVG night
1	16	Same as #3 based upon a 7-day week.	Depending upon how many hours are involved in the day flight, 2, 3, and 4 could be reduced from 20% to 50% and eliminated beyond 8 hours.
2	21	Longer period has more cumulative effect.	Greatly reduce NVG time flown.
3	21-28	Approx 3-4 hours per day	The figures above represent NVG flight alone. If you fly day, then the number of flight hours at night under the NVG should be reduced.
4	20	Same as 3.	Reduce times by 25%.
5	22	You might stand 4 hours for the first 3 days. After that probably for 2 days, 3 hours each day and finally 2 hours for the last 2 days.	In two, no change; in three, probably a drop of 50%; in four, probably a drop of also 50%.
6	-	-	-
7	25-30	As in #2 and #3.	Would have to lower the NVG hours.
8	20-25	Because the strength that the NVG takes out of your eyes and neck muscles, seem from past experience to be cumulative.	I estimate it would cut times to half or less.
9	15 peace 24 combat	Peacetime 5 days at 3 = 15. Combat 6 days at 4 = 24.	Would decrease NVG time 1 hour per 2-hour day period in a 24-hour period.
10	14	5 days of flying with 2 days rest to offset fatigue.	Cut estimated by half due to decreased mental alertness.

Median	21
Mean	20.28
SD	4.53
High	27.5
Low	14

POSTFLIGHT QUESTIONNAIRE (CONT)

S	6 Primary difficulty	7 Comments
1	Lens fogging, weight of goggles causing them to fall, light entering goggles from side and bottom, the limited maneuvers were boring, smell of rubber around goggles became sickening.	The remarks were too numerous and lengthy to include in this summary. They are available in the raw sheets.
2	Difficulty in maintaining goggle tubes at desired position, lens fogging, constant eye strain, headache, occasional nausea, muscle shaking in extremeties applying pressure.	
3	Hot points around the back of the head, sick to the stomach at times, body fatigue.	
4	Adequate references for OGE hover, inability to concentrate during latter part of last flight.	
5	Most difficult are the hot spots, tiredness during the second period, stopped flight in third period after 1 hour due to the hot spots, and a great lack of concentration within each period after about 1.3-1.5 hours.	
6	None.	No basis for answering #2-5.
7	Difficulty in adjusting the helmet. Discomfort brought on by NVG, having to hold my head back for optimum sharpness, lack of protection for the nose (monocular adjustment).	
8	Distance from obstacles, difficulty picking out objects in shadows, lenses fog up.	
9	Helmet hot spots; sweat irritation around eye cups and nose bridge; fatigue due to weight on front of helmet; toward the end of the flight, experienced a feeling similar to driving on a long stretch of highway while very tired (attention span severely reduced, disinterested, I was following the aircraft in severe cases as opposed to me making the aircraft respond).	
10	Fogging of lens, eye fatigue, decline of mental alertness (fixation), problems adjusting daylight eye cups properly.	

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