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A HUMAN PERFORMANCE/WORKLOAD EVALUATION OF THE AN/PVS-5 BIFOCAL NIGHT VISION GOGGLE

by

L. W. Stone
M. G. Sanders
D. D. Glick
R. W. Wiley
K. A. Kimball

FIELD RESEARCH AND BIOMEDICAL APPLICATIONS DIVISION

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U.S. ARMY AEROMEDICAL RESEARCH LABORATORY
FORT RUCKER, ALABAMA 36362

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Reviewed:

Kent A. Kimball, Ph.D.
Director, Field Research & Biomedical Applications Division

David D. Glick, MAJ, MSC
Chairman, Scientific Review Committee

Released for Publication:

STANLEY C. KNAPP
Colonel, MC
Commanding

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Eight experienced US Army aviators performed various maneuvers in an instrumented helicopter to test the relative usability of two bifocally configured night vision goggles. Both configurations were statistically better than the unmodified arrangement when looking at a pilot's ability to hold a precise altitude at night. The subjective data, supported by flight performance observed between the two bifocals, further suggested that a 24% bifocal version

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20. ABSTRACT (Cont'd)

was more desirable than a 14% configuration. The inference is that the reduced inside field-of-view presented by the 14% bifocal interferes with a pilot's ability to rapidly locate instruments once he has directed his attention inside the cockpit.

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INTRODUCTION

Combat rotary wing aircraft are being flown closer and closer to the ground to take advantage of the concealment and protection afforded by trees, man-made structures and terrain features (FMI-I 1976). These obstacles greatly reduce the likelihood of any effective enemy acquisition for antiaircraft purposes. At the same time, however, the obstacles present a considerable threat to flight; and under the added cover of darkness, operation in such an environment would be virtually impossible without some sort of visibility enhancement device.

One such device, the AN/PVS-5 Night Vision Goggle (NVG), has become an integral part of the Army's round-the-clock helicopter operational capability (TC 1-28 1976). Its use, in fact, frequently marks the difference between successful completion of the mission and no mission at all. Still, most pilots would agree that the NVG is not ideal. There are problems of fit, of weight and weight distribution, of visibility interference due to outside lights, of restricted field of view, and of goggle accommodation (Sanders and others 1975). It is to this latter problem that the current investigation is addressed.

Sanders (1975) looked at aviator control inputs and some aircraft parameters under three NVG configurations and the unaided dark-adapted eye. The NVG configurations included a 40° field of view (FOV) and a 60° FOV. A second 40° FOV NVG was modified to pre-focus the lower 30% of each eye piece at about 26 inches. The purpose of the bifocal, of course, was to allow the aviator to shift his attention between the flight path and the instrument panel without having to let go of a control to manually adjust the focus. The investigators in that study found a slight improvement in overall performance with the NVG as opposed to the unaided eye. They also found that when confronted with a choice of greater resolution at the cost of field of view, the pilots chose resolution. The aviators preferred the 40° NVG with good resolution over the wider (60°) FOV NVG with its poorer resolution.

It was also noted that the bifocal arrangement was preferred over the unmodified version during low altitude enroute flight, but not during NOE and other maneuvers performed close to the ground.

Presumably, the larger bifocal cut aided the pilot where his instrument panel was important, but caused interference when attention to the flight path was critical.

The current investigation, accepting the bifocal premise as beneficial, sought to determine if a smaller bifocal cut would show a similar increase in efficiency but would be acceptable to aviators performing close to the ground. The potential reduction of tension, anxiety and fatigue in the pilot flying in this hostile environment warranted the further research.

METHODOLOGY

SUBJECTS

Subjects for this investigation were eight volunteer US Army aviators from Fort Rucker, Alabama. These aviators had extensive experience in rotary wing flight having flown an average of 2726 hours in rotary wing aircraft. All aviators had previous experience with the AN/PVS-5 NVG (average total flight hours with NVG was 81.2) as well as 314 night flight hours. Four of the aviators were Method of Instruction (MOI) Instructor Pilots (IP's) with the NVG and had several hours of recent experience with 112.5 average flights hours with the NVG. The other four aviators held positions which did not require NVG flight; therefore, these aviators had fewer total hours (50) with the NVG (see Table 1 for the flight hour summary data).

TABLE 1

SUMMARY OF FLYING TIME AS REPORTED BY INDIVIDUAL PILOT SUBJECTS

Pilot	Total Flying Time	Total Rotary Wing	UH-1	Total NVG Time	Night Time
1	2300	2300	1953	100	500
2	4285	4040	3070	150	300
3	2672	2672	1582	100	350
4	2276	2276	560	25	100
5	4391	4220	3520	100	600
6	3584	3159	1307	40	600
7	2144	2144	1102	60	300
8	1300	1000	950	75	300
Low	1300	1000	560	25	100
High	4391	4040	3520	150	600
$\overline{X}$	2869	2726	1755.5	81.25	341

APPARATUS

General Description

The goggles weigh 1.9 pounds (.86 kg). They are 6 inches long (150 mm) by 6 1/2 inches wide (160 mm) by 4 3/4 inches high (120 mm). They are powered by a 2.7 volt mercury battery. The system contains two monocular units comprising a binocular system. Each monocular unit consists of an objective lens assembly, an image intensifier tube assembly, and an eyepiece assembly. The monocular units are mounted in an aluminum frame assembly. The frame is mounted to a face mask assembly which is held by head straps to the user's helmet. The monocular units may be adjusted to compensate for interpupillary distances between 55 and 72 mm (DA Spec No. Cla 2105020100). They may also be adjusted in a fore and aft direction through a range of 1 cm and, finally, may be tilted in a superior and inferior direction through approximately 25°. A light emitting diode is mounted in the face mask to provide an auxiliary light source effective to a range of approximately 2 meters. The light emitting diode has a peak output at 830 nm ± 20 nm with a half band width greater than or equal to 42 1/2 nm. The goggles have unit magnification. The system also contains an arctic adapter assembly for keeping the battery warm when used in cold climates and a demist shield to reduce fogging of the eyepiece. All flights were conducted in USAARL's instrumented helicopter.

Detailed Description

Detailed description is from Department of the Army MIL-N-49065A(EL).

Objective Lens (Figure 1, Optical Schematic). The objective lens has an equivalent focal length of 26.6 mm ± 0.2 mm. The linear distortion of the objective lens at the edge of its 18 mm format is 7 1/2% ± 1% barrel distortion. Field of view of the objective lens is $40^{\circ} \pm 1^{\circ}$ for an 18 mm format.

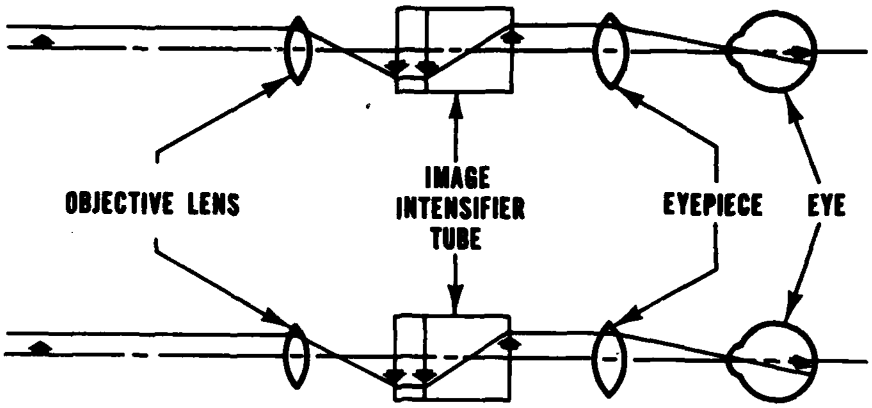


FIGURE 1. Optical Schematic--Night Vision Goggles

Eyepiece Lens Assembly. The equivalent focal length of the eyepiece is 26.9 mm ± 0.2 mm. The linear distortion of the eyepiece at the edge of its 18 mm format is 8 1/2% ± 1% pincushion distortion. The field of view of the eyepiece is 40° ± 1° for its 18 mm format. The exit pupil diameter is 10 mm ± 0.2 mm at an eye relief of 15 mm + 0.0, -0.2 mm for a zero diopter setting. The transmission of the eyepiece is at least 80% over the full eyepiece aperture of the spectral output of the P20 phosphor.

Far Focus Resolution. Each modular assembly has an on-axis resolution at the infinity stop of not less than 20 line pairs/millimeter (lp/mm) or 5 lp/mm less than the maximum tube resolution of each monocular, whichever is greater, and has an on-axis resolution at the true infinity setting of not less than 23 lp/mm, or 4 lp/mm less than the maximum tube resolution of each monocular, whichever is greater.

Close Focus Resolution. Each monocular assembly has an on-axis resolution at the close focus stop of not less than 23 lp/mm for a target at a distance of not more than 25 cm.

Diopter Focus Resolution. The minimum diopter focus range is from +2 to -6 at a 15 mm eye relief.

Image Intensifier Assembly (18 mm microchannel wafer). (MIL-I-49052A). The image intensifier assembly, an 18 mm microchannel wafer, has a minimum useful photocathode and phosphor screen diameter of no less than 17.5 mm. The assembly employs an S-20 photocathode with extended red response (Figure 2). The assembly includes a high voltage multiplier and oscillator and is encapsulated with a hard surface insulating sleeve and assembled into a metal housing. The assembly employs a microchannel electron multiplier plate with proximity focus on the input and output and contains a fiber optic input faceplace and fiber optic inverter as an integral part of the tube envelope.

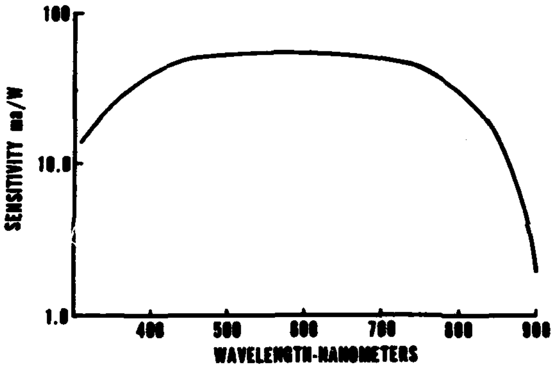


FIGURE 2. Spectral Characteristics of S-20 (Extended Red) Photocathode.

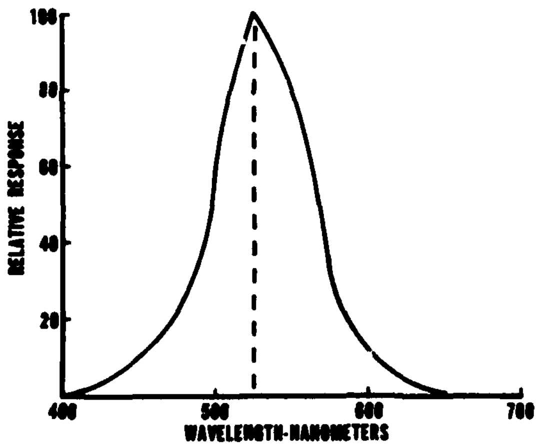


FIGURE 3. Spectral Output Characteristics of Phosphor RCA #10-52.

Phosphor Screen. The phosphor screen is an RCA F2126, type 1052, or equivalent (Figure 3).

Power Supply Assembly. The power supply is a solid-state electronic device employing hybrid microelectronic circuitry to convert unregulated 2-3 volt DC primary input to multiple DC output voltages for operating the assembly. The power supply is a wraparound modular construction consisting of regulated oscillator and multiplier modules and is an integral part of the assembly. The power supply assembly operates from the battery through a range of temperatures from +45°C to -17.8°C.

Image Inversion. The fiber optic inverter performs a 180° ± 2° image inversion.

Photocathode Sensitivity. The luminous sensitivity is approximately 240 microamperes per lumen for radiation with a color temperature of 2856 ± 50° K. The radiant sensitivity is not less than 0.015 amps per watt at 830 nm.

Luminance Gain. The assembly has a room temperature luminance gain and high light level saturation as shown in Table 2.

TABLE 2

SATURATION REQUIREMENTS FOR LUMINANCE GAIN

Nominal Input Light Level (fc)	Minimum Allowable Gain	Minimum Allowable Output(fl)	Maximum Allowable Gain	Maximum Allowable Output(fl)	Input Current (ma)
$2x10^{-6}$	7,500	N/A	15,000	N/A	16
$2x10^{-4}$	1,500	N/A	4,500	N/A	16
1.0	N/A	0.3	N/A	0.9	N/A
20.0	N/A	0.3	N/A	0.9	N/A

Bright Source Protection. The assembly is designed so that it will not be damaged when a bright source is concentrated on the photocathode for up to one minute. In addition, the assembly has a luminance gain saturation characteristic throughout the applied illumination period such that the light output is no greater than 3 millilumens nor less than 0.37 millilumens. This requirement is met within one second after the input illumination is applied.

Signal-to-Noise Ratio. The signal-to-noise ratio of the assembly has a minimum value of 3.3 projected back to t = 0.

Output Brightness Uniformity. When the photocathode is uniformly illuminated with light at a color temperature of 2856 ± 50°K, the output brightness uniformity is such that the ratio of the maximum to minimum brightness variation over the useful screen area does not exceed 3:1. Under the same conditions, when the screen is viewed with the 10 power magnifier, the background shading is uniformly graded with no distinct lines of demarcation between the light and dark areas.

Center Resolution. The peripheral resolution, referenced to the photocathode, is at least 25 lp/mm. This requirement is met at two points separated by 90° spaced on a 14 mm diameter circle concentric with the optical axis.

Modulation Transfer Function. With an input illumination on the photocathode of not greater than 2×10^{-4} footcandles, the minimum assembly specifications are as follows:

1. 86% modulation transfer at 2.5 lp/mm.
2. 58% modulation transfer at 7.5 lp/mm.
3. 20% modulation transfer at 15 lp/mm.

Test Vehicle. The test vehicle was a JUH-1H helicopter instrumented to measure and record pilot control inputs and aircraft position, rates and accelerations. The Helicopter In-Flight Monitoring System (HIMS) measures aircraft position in six degrees of freedom while simultaneously recording cyclic, collective and pedal inputs and aircraft status values. These data were recorded in real time on an incremental digital recorder. Continuous information from twenty pilot and aircraft monitoring points was recorded for all flights. A more detailed description of HIMS can be found in USAARL Report No. 72-11. Table 3 contains a list of those directly measured and recorded parameters along with a partial listing of derived measures. It should be noted that the potentiometer attached to the collective was inoperative during this evaluation; therefore, collective control input data is not available.

TABLE 3

PARAMETERS MEASURED AND DERIVED

Parameters Measured	Derived Measures
Pitch	Pitch Rate
Roll	Roll Rate
Heading	Rate of Turn
Position X	Constant Error, Average Absolute Error, RMS Error
Position Y	Ground Speed, Constant Error, Average Absolute Error, RMS Error
Acceleration X	
Acceleration Y	
Acceleration Z	
Roll Rate	Roll Acceleration
Pitch Rate	Pitch Acceleration
Yaw Rate	Yaw Acceleration
Radar Altitude	Rate of Climb, Average Absolute Error, Constant Error, RMS Error
Barometric Altitude	Rate of Climb
Airspeed	
Flight Time	
Rotor RPM	
Throttle	
Cyclic Stick (Fore/Aft) Cyclic Stick (Left/Right) Collective Pedals	Control Position, Absolute Control Movement Magnitude, Positive Control Movement Magnitude, Negative Control Movement Magnitude, Absolute Average Control Movement Rate, Average Positive Control Movement Rate, Average Negative Control Movement Rate, Control Reversals, Instantaneous Control Reversals, Control Steady State, Control Movement

PROCEDURES

Familiarization and Testing

All familiarization and testing took place at Highfalls Stagefield. Throughout the evaluation the 40° plano tubes and the top portion of the bifocal configurations were focused at infinity. The bottom of the bifocals was pre-focused at 22-26 inches. The aviator subjects were allowed to fly one traffic pattern with each of the bifocal NVG configurations for familiarization. These practice flights occurred immediately before testing on these conditions. The order of testing of the four visual sets was counterbalanced across subjects to minimize order of effect bias (Table 4).

TABLE 4

FLIGHT TEST SCHEDULE

Subjects		Visual	Conditions	Counterbalanced
1 and 5	Unaided	40° Plano NVG	14% Bifocal	24% Bifocal
2 and 6	40° Plano NVG	14% Bifocal	24% Bifocal	Unaided
3 and 7	14% Bifocal	24% Bifocal	Unaided	40° Plano NVG
4 and 8	24% Bifocal	Unaided	40° Plano NVG	14% Bifocal

Maneuvers

The evaluation required approximately three hours of flight time per subject. The following maneuvers were flown by each subject under each of the four visual conditions:

1. Forward hover at 3 feet AGL for 300 feet.

2. Three hundred and sixty degree left pedal turn at 3 feet AGL.

3. Precision hover at 10 feet AGL, held for 5 minutes.

4. Takeoff and traffic pattern around the stagefield with specified airspeeds, altitudes, and headings.

Illumination

Illuminance measurements were taken during the test flight using a Spectra Pritchard Photometer with cosine integrater. Summary information concerning the light levels during the testing are presented in Table 5.

TABLE 5

PERCENTAGE OF MOON ILLUMINATION AND ILLUMINANCE MEASURED

Pilot	Date Jan 1978	Time	Moon Illumination (%)	Illuminance Measured Mean ($FCX10^{-3}$)	Illuminance Measured SD ($FCX10^{-3}$)
1	18	1800-2100	68	5.00	3.19
2	23	1830-2130	98	19.35	8.61
3	26	2030-2330	97	No Data	No Data
4	27	0000-0300	97	No Data	No Data
5	27	2130-0030	93	3.88	.99
6	28	0130-0430	93	7.74	.19
7	28	2200-0100	87	2.64	1.28
8	29	0130-0430	87	4.49	.12

Survey

A questionnaire (Appendix A) was developed to survey the aviators' opinions about the flight performance capabilities provided by the four visual conditions evaluated as well as comparison of the four conditions. The questionnaire also addressed a number of other areas related to the use of the NVG. The "small segment bifocal goggles" referred to in the questionnaire means the NVG with 14% bifocal segments; the "large segment bifocal goggles" refers to the 24% segments.

Data Handling

After processing (from digital data to engineering units), the recorded objective data was filtered for those variables pertinent to the respective maneuver. The variables remaining included:

1. Absolute magnitude mean for control movements of cyclic foreaft (abbreviated CFAACMMX in accompanying tables and figures), cyclic left-right (CLRACMMX), (although one physical control, the cyclic directions are conceptually separated for analysis) and pedals (PEDACMMX).

2. Number per second for absolute control movements in each of the three remaining channels: cyclic fore-aft absolute control movement per second (FAACMN/S); cyclic left-right absolute control movement number per second (LRACMN/S); and pedal absolute control movement number per second (PEDACMN/S).

3. Standard deviation of pitch (PIT SD), roll (ROL SD), heading (HEA SD), and radar altitude (RA SD).

4. Mean of radar altitude (RA X).

RESULTS AND FINDINGS

TEN FOOT HOVER

Control Input Workload

The data were submitted to a multivariate analysis of variance program (Schori, 1976) in three groups--one representing pilot control inputs, one for aircraft status variables, and the third to examine the altitude separately. The results of the sets are shown in Tables 6 and 7 respectively. The overall significance indicated in Table 6 for the control activity/ workload data was subsequently negated when an examination of the univariate tests and the greatest characteristic root distribution parameters failed to support a significant difference between the groups. Figures 4, 5, and 6 illustrate the lack of difference in the control input workload data across the four visual conditions.

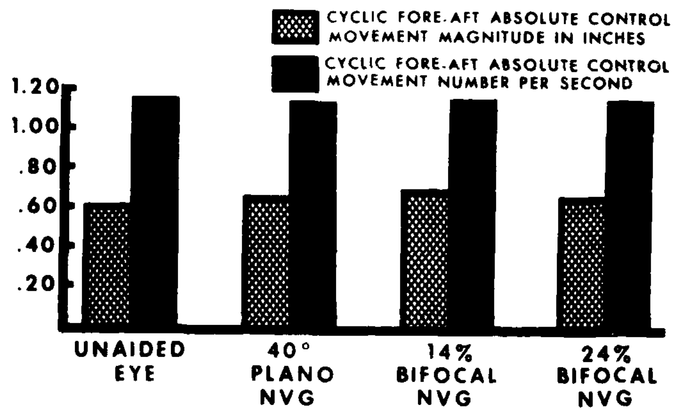


FIGURE 4. Cyclic Fore-Aft Control Input Data--10-Foot Hover NVG Bifocal Evaluation

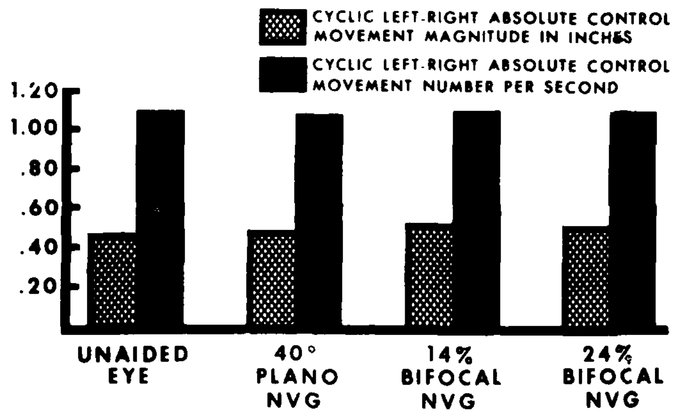


FIGURE 5. Cyclic Left-Right Control Input Data--10-Foot Hover NVG Bifocal Evaluation

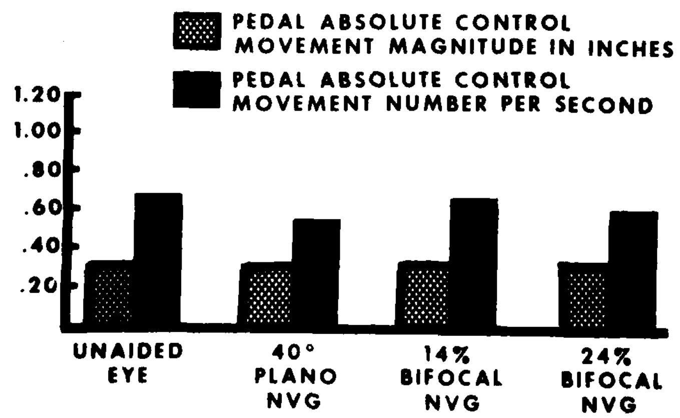


FIGURE 6. Pedal Control Input Data--10-Foot Hover NVG Bifocal Evaluation

TABLE 6

MULTIVARIATE ANALYSIS OF VARIANCE: 10-FOOT HOVER CONTROL ACTIVITY/WORKLOAD SUMMARY DATA

Variable	Unaided Eye	Mean Scores for Control Activity/Workload Data: 40° Plano NVG	14% Bifocal NVG	24% Bifocal NVG	F[1]
CFAACMMX	0.61	0.66	0.70	0.67	0.97
FAACMN/S	1.16	1.14	1.16	1.16	0.18
CLRACMMX	0.46	0.48	0.52	0.51	2.34
LRACMN/S	1.09	1.08	1.10	1.10	0.12
PEDACMMX	0.31	0.29	0.32	0.31	1.18
PEDACMN/S	0.67	0.54	0.65	0.60	1.61

Total Discriminatory Power (Estimated Omega Squared) = 0.65

Overall Multivariate Test of Significance

Chi-Square = 41.33, df = 18, p = 0.001

Greatest Characteristic Root

B = 0.575, S = 3, M = 1, N = 7; not significant at the .05 level

[1]Univariate F-ratio, df = 3 & 21; none of the variables were significant at the .05 level.

Aircraft Status

The results of the aircraft status examination shown in Table 1 also indicate an overall significance. In this analysis, two of the variables were potentially affected by system failures at data collection time. For each of the four points, a missing cell estimate was calculated after Yates (Kirk, 1968) and the univariate F tests were computed with appropriately fewer degrees of freedom for error. The RA SD was found to be significantly different across groups as indicated in Table 7. A Newman-Keuls equal n test subsequently applied to that variable indicated that the difference between the 40° plano NVG and all other groups was signficant at (or below, in two cases) the .05 level.

TABLE 7

MULTIVARIATE ANALYSIS OF VARIANCE: 10-FOOT HOVER AIRCRAFT VARIABILITY SUMMARY DATA

	Mean Scores for Aircraft Status/Variability Data				
Variable	Unaided Eye	40° Plano NVG	14% Bifocal NVG	24% Bifocal NVG	F
Pitch SD	0.96	1.46	1.37	1.34	2.83[1]
Roll SD	1.00	1.11	1.13	1.15	1.60[1]
Heading SD	2.50	3.57	3.21	3.23	1.41[2]
Radar Altitude SD	1.73	8.55	4.40	2.93	6.50**

Total Discriminatory Power (Estimated Omega Squared) = 0.57

Overall Multivariate Test of Significance

Chi Square = 31.55, df = 12, p = 0.002

Greatest Characteristic Root

B = 0.483, S = 3, M = 0, N = 8; not significant at the .05 level

[1]Univariate F-ratio, df = 3 & 19
[2]Univariate F-ratio, df = 3 & 21
**Significant at the .01 level, df = 3 & 21

Radar Altimeter

Figure 7 presents the means evaluated in analysis of variance ($f = 4.30$, $df = 3$ & 21, $p = .02$) for the radar altimeter. Because this analysis indicated an overall difference between groups, a Newman-Keuls test was also performed on these results. In addition to having an overall significance at less than the .02 level, the Newman-Keuls test indicated a significant difference between the 40° plano and the unaided groups and between the 40° plano and 24% bifocal groups. These differences are significant at less than .05 probability.

Interaction

Results of the analyses of both the control position and aircraft status variables suggest that the various NVG configurations neither aided nor interfered with efforts to hold the aircraft steady during the 10-foot hover. Also an important difference in pitch, roll, and heading across the four visual conditions could not be detected. These findings were supported by the similar lack of movement among the controls. The perceptual cues needed for lateral position holding are apparently not affected to any significant degree by the presence or absence of the NVG. Altitude data, on the other hand, indicated that there was a drastic difference in vertical position holding associated with the plano NVG tube (Figure 7). A similar behavior was noted in terms of radar altitude standard deviation between the groups (Figure 8). The altitude variability stabilized somewhat in the bifocal conditions.

Comment

Two very important points should be made relative to the data presented in Figures 7 and 8.

1. The aviator's ability to hold the desired altitude of ten feet during the unaided eye condition was due, in part, to the fact that:

a. These flights occurred on high light level nights (reference Table 5); and

b. The aviators were able to utilize the radar altimeter during the hover.

2. The second key point in the interpretation of these data is the fact that the aviators were not able to see the radar altimeter when flying with the 40° plano NVG. Therefore, all height above ground level cues for this condition were obtained from ou[illegible]ide viewing alone.

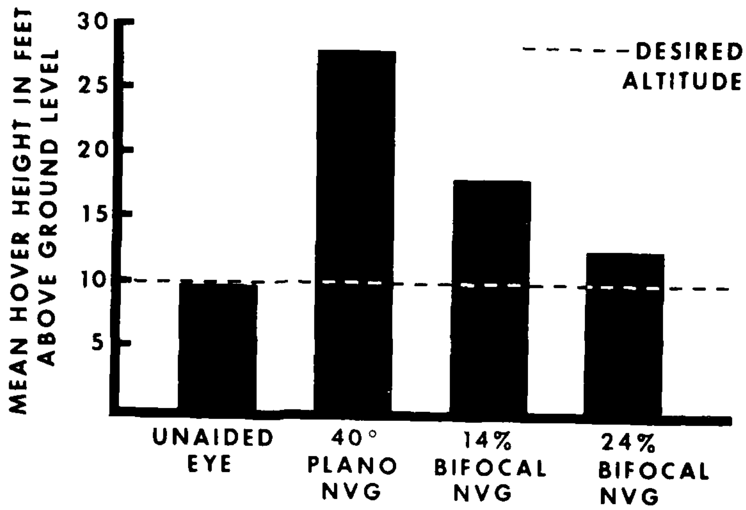


FIGURE 7. Mean Hover Height Across the Four Visual Conditions--10-Foot Hover Maneuver

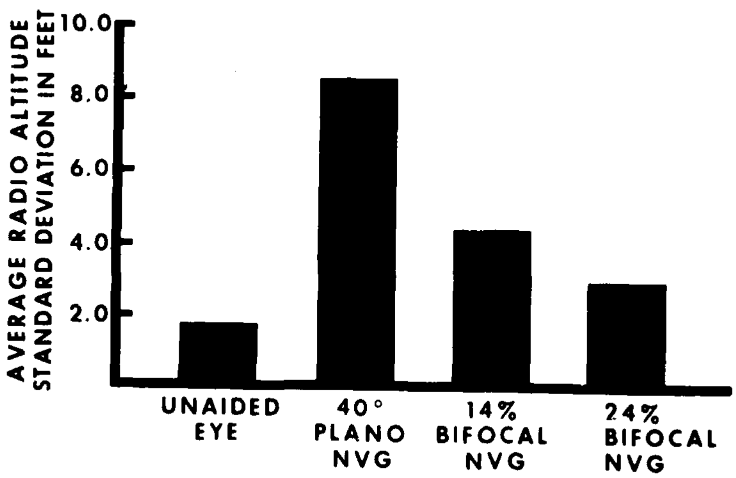


FIGURE 8. Standard Deviation in Hover Height Across the Four Visual Conditions--10-Foot Hover Maneuver

Questionnaire

In the subjective responses, most of the pilots remarked to the effect that the bifocals did enhance their ability to see the instrument panel, but differentially. The 14% bifocals gave better visibility outside the aircraft but the 24% bifocals provided better inside viewing because a large portion of the instrument panel could be seen (reference Appendix D). The 24% bifocal seemed to reduce the instrument search time markedly. A return to the data showed that the mean altitude (reference Figure 7) was indeed closer to the ideal in the 24% condition than in the 14% condition. The variability, as mentioned earlier, reflected the same trend--there was greater variability with the 14% cut than with the 24% cut (reference Figure 8). When one considers that the bifocal cut inversely affects the overall viewing area, it seems that the reduced outside viewing capability of the 24% bifocal did not significantly affect the depth perception of this group and the increased inside viewing capability made the radar altimeter information more readily available.

HOVER FORWARD

Control Input Workload

No differences were found across the four visual sets when the pilot control input measures were examined statistically (reference Figure 9, cyclic fore-aft control inputs; Figure 10, cyclic left-right control inputs; Figure 11 pedal control inputs). Therefore, the visual set did not significantly affect psychomotor workload of the aviators during the performance of the hover forward maneuver.

Aircraft Status

No differences were found across the four visual sets when the aircraft status variables (pitch, roll, heading, standard deviation) were examined. Therefore, one can assume that the visual set utilized did not significantly affect the flight performance (in terms of aircraft steadiness) of the aviators when performing the hover forward maneuver.

Radar Altitude

A significant difference was observed when the mean radar altitude values in feet above ground level were examined (f= 4.66, df = 3 & 21, $p < .05$). The mean radar altitude value for each set during the hover forward is graphically presented in Figure 12. A Newman-Keuls equal n test subsequently applied to that variable indicated that the difference between the 40° plano NVG condition and the 24% bifocal NVG condition was significant at the .05 level.

360° LEFT PEDAL TURN

Control Input Workload

A statistical analysis (again using Schori's Versatile MANOVA) indicated that there were no overall multivariate differences among the four visual conditions when the cyclic fore-aft (reference Figure 13), cyclic left-right (reference Figure 14), and pedal (reference Figure 15) control input or workload data were examined. In fact, the similarity is noteworthy in terms of the number and average magnitude of the control inputs for all three control channels across all four variables.

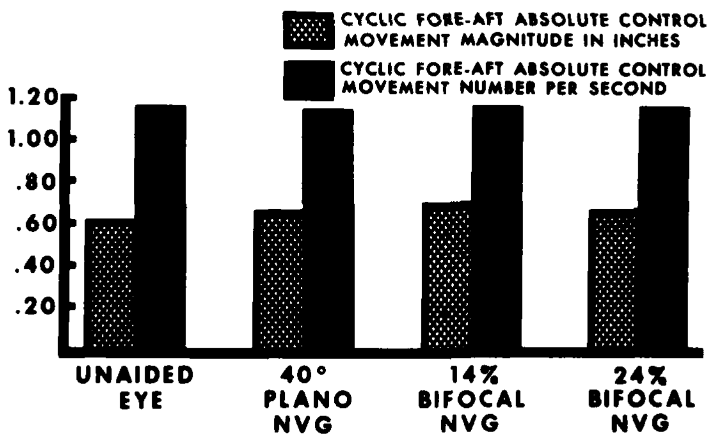


FIGURE 9. Cyclic Fore-Aft Control Input Data--Hover Forward Maneuver NVG Bifocal Evaluation

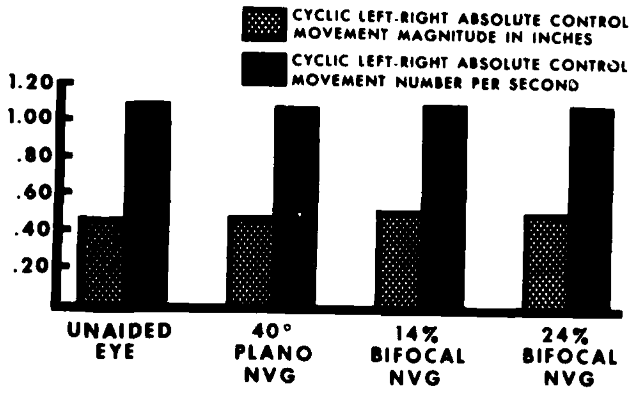


FIGURE 10. Cyclic Left-Right Control Input Data--Hover Forward Maneuver NVG Bifocal Evaluation

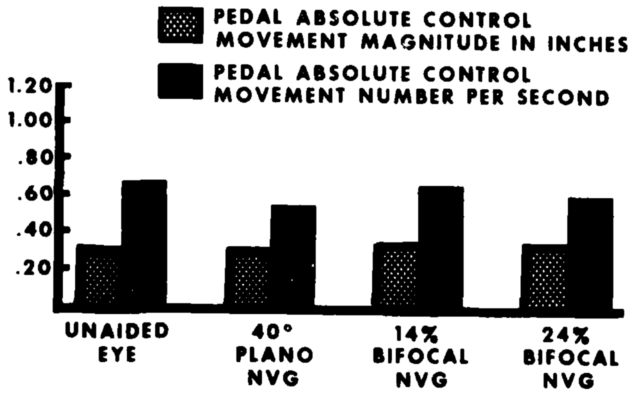


FIGURE 11. Pedal Control Input Data--Hover Forward Maneuver NVG Bifocal Evaluation

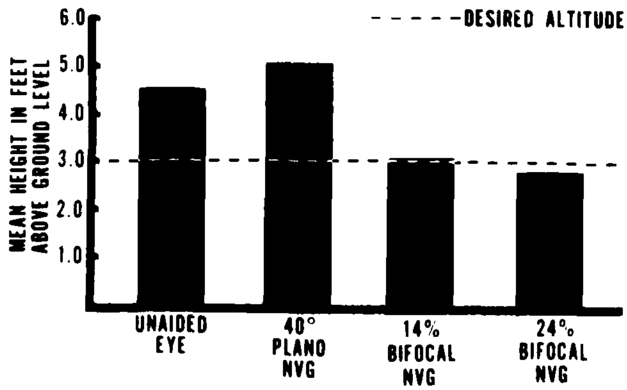


FIGURE 12. Mean Height Across the Four Visual Conditions Examined During Hover Forward Maneuver

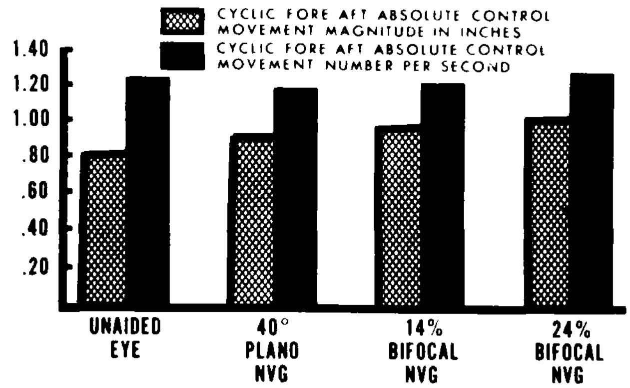


FIGURE 13. Cyclic Fore-Aft Control Input Data--360° Left Pedal Turn Maneuver NVG Bifocal Evaluation

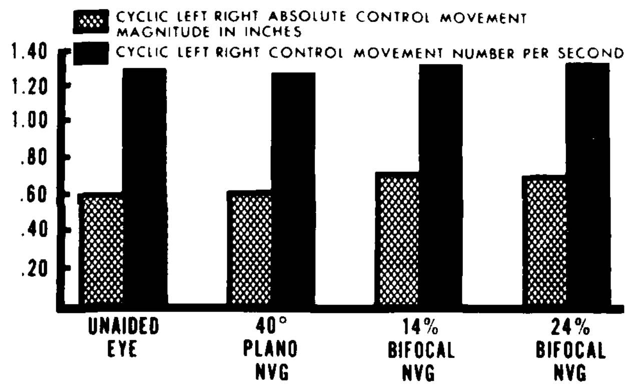


FIGURE 14. Cyclic Left-Right Control Input Data--360° Left Pedal Turn Maneuver NVG Bifocal Evaluation

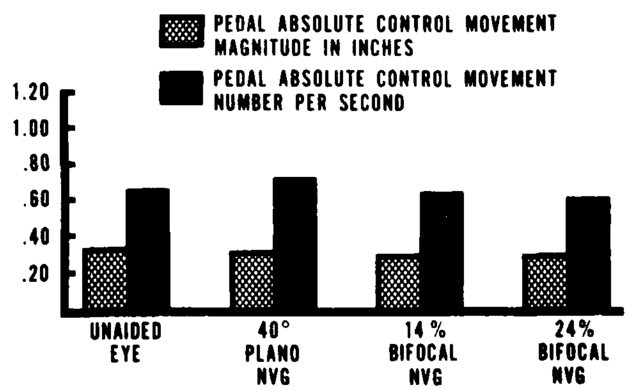


FIGURE 15. Pedal Control Input Data--360° Left Pedal Turn Maneuver NVG Bifocal Evaluation

Aircraft Status

The multivariate analysis of variance of the aircraft stability summary data for this maneuver indicated no overall group differences at an acceptable significance level (reference Table 8).

TABLE 8

MULTIVARIATE ANALYSIS OF VARIANCE: 360° LEFT PEDAL TURN MANEUVER AIRCRAFT VARIABILITY SUMMARY DATA

Variable	Unaided Eye	Mean Scores for Aircraft Status/Variability Data: 40° Plano NVG	14% Bifocal NVG	24% Bifocal NVG	F
Pitch SD	1.31	1.80	1.32	1.45	2.97
Roll SD	1.11	1.24	1.27	1.51	3.88*
Radar Altitude SD	1.47	3.30	2.01	1.78	3.01*

Total Discriminatory Power (Estimated Omega Squared) = 0.60

Overall Multivariate Test of Significance

Chi-Squared = 32.09, df = 9, p = 0.0004

Greatest Characteristic Root

B = 0.410, S = 3, M = -0.5, N = 8.5 (not significant at the .05 level)

* p = < .05 Level of Significance, df = 3 & 19 for Roll SD and df = 3 & 21 for Radar Altitude SD.

However, two of three variables analyzed were found to be significantly different across visual sets at the .05 probability level. The means for these variables are graphically presented in Figure 16. A Newman-Keuls equal n test applied to the roll standard deviation variable indicated that the difference observed between the unaided eye condition and the 24% bifocal NVG condition was significant at the .01 probability level.

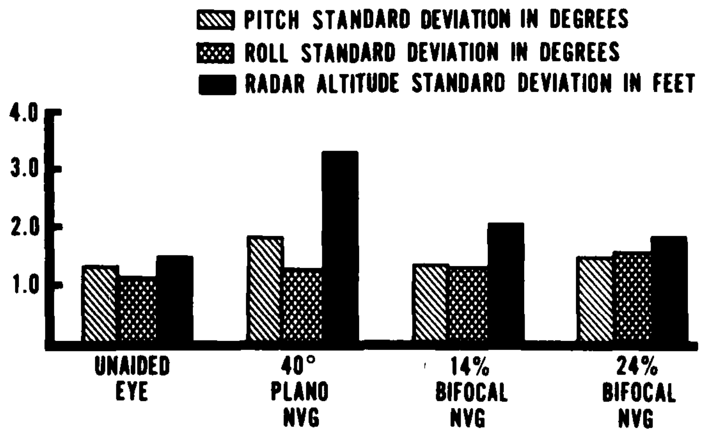


FIGURE 16. Aircraft Variability Summary Data--
360° Left Pedal Turn Maneuver

Radar Altitude

The differences across the four visual sets for the radar altitude standard deviation in feet (or altitude variability) were significant univariately ($f = 3.01$, df 3 & 21, $p < .05$). The Newman-Keuls equal n test applied to these data indicate that the difference between the unaided eye condition and the 40° plano NVG condition was significant at the .05 level (reference Figure 16).

Univariate Analysis of Mean Radar Altitude Data

A univariate analysis of the mean radar altitude data indicated that the differences observed in Figure 17 are significant at the .05 level ($f = 4.97$, df = 3 & 21). A Newman-Keuls equal n test indicated that 40° plano NVG mean radar altitude was significantly greater than all three other conditions. Again the command altitude for the performance of this maneuver was three feet AGL.

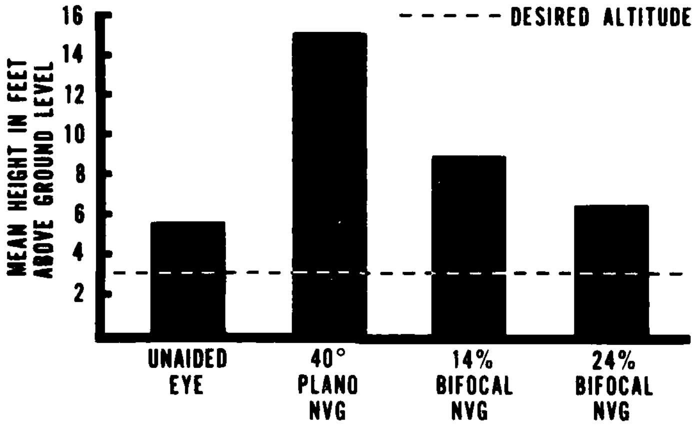


FIGURE 17. Mean Height Across the Four Visual Conditions Examined During the 360^0 Left Pedal Turn Maneuver

TRAFFIC PATTERN

The large amount of between-subject variability in the performance of the traffic patterns prevented the examination of this maneuver with standard statistical analysis techniques. Therefore, the X-Y plots of the traffic patterns, obtained during data collection, were separated by subject. The X-Y plots of the traffic patterns were attached to second-by-second plot of the radar altitude of the aircraft throughout the flight of the associated traffic pattern. Fifteen aviators were asked to rank the traffic patterns of each subject relative to each other. The values from the traffic patterns associated with each visual set were averaged across all eight flight subjects. The ranking sheets used and the instructions provided can be seen in Appendix B. The results of the Friedman Two-Way Analysis of Variance Test applied to these data indicated that slight differences observed across the four conditions were not significant at the .05 level (χ^2 = 2.84, df = 3). Reference Table 9 for the average rankings of the traffic patterns. Appendix C provides X-Y plots of all traffic patterns flown under each visual condition, grouped by subject.

TABLE 9

TRAFFIC PATTERN RANKING RESULTS

	Unaided Eye	40° Plano NVG	14% Bifocal NVG	24% Bifocal NVG
Rater 1	2.5*	3.0	2.3	2.1
Rater 2	2.6	2.8	2.1	2.3
Rater 3	2.5	3.2	2.2	2.0
Rater 4	2.1	2.7	2.6	2.5
Rater 5	2.8	2.6	2.2	2.2
Rater 6	2.3	2.8	2.6	2.1
Rater 7	2.8	2.7	2.6	1.7
Rater 8	2.3	3.0	2.5	2.1
Rater 9	3.0	2.7	2.5	1.7
Rater 10	2.5	3.2	2.5	1.7
Rater 11	2.6	2.8	2.1	2.3
Rater 12	2.8	2.7	2.[illegible]	1.8
Rater 13	2.5	2.8	2.6	2.0
Rater 15	2.8	2.2	2.6	2.2
ΣX =	39.6	42.6	36.3	31.3
$\bar{X}$ =	2.6	2.8	2.4	2.0

Friedman Two-Way Analysis of Variance
χ^2 - 2.84, df = 3)
The differences observed were not significant at the .05 level of probability.

*Each score represents an average ranking of all eight traffic patterns under each visual set.

DISCUSSION AND CONCLUSION

CONTROL INPUT WORKLOAD

The pilot workload (in terms of pilot control inputs on the cyclic and pedals) was not significantly changed by flight under any of the four visual conditions. That is, the amount of psychomotor workload required to perform the maneuvers examined did not change from one visual condition to the next. The figures provided earlier readily illustrate the similarity in workload requirements regardless of the visual flight condition. However, it should be noted that when these control input data, obtained during night flight, are compared to previously collected data (USAARL Technical Report No. 78-14) which were obtained during daytime performance of similar maneuvers, it is obvious that the psychomotor workload requirements at night are two-three times greater than that seen during the daytime.

AIRCRAFT STATUS

The pilots' ability to hold a stable aircraft with minimal aircraft variability in pitch, roll, yaw and altitude was not, in general, affected by the visual condition utilized. No differences were observed in aircraft stability across the four visual conditions during the 10-foot hover maneuver and the hover forward maneuver. Some minor differences were observed during the performance of the 360° left pedal turn maneuver.

RADAR ALTITUDE

The only real differences observed across the four visual conditions were in the aviators' ability to hold the designated altitudes AGL. In general, on the three maneuvers performed close to the ground, the unaided eye, 14% bifocal NVG and 24% bifocal NVG visual conditions, could be considered equivalent in their capability to provide the information required to hold the correct altitude. Conversely, the 40° plano NVG visual condition was consistently less adequate in providing the visual cues required to hold the proper altitude. The aviators' ability to hold the designated altitudes more precisely (in general) with the unaided eye, 14% and 24% bifocal NVG conditions was due in part to the following three facts:

1. All flights occurred on high light level nights.

2. All aviators were able to see the radar altimeter except when flying with the 40° plano NVG. Therefore, all height above ground level cues for the 40° plano NVG condition were obtained from outside viewing alone.

3. A previous investigation indicated a serious degradation in relative depth discrimination for observational distances less than 20 feet and also for distances greater than 500 feet when observers viewed with the NVG (Wiley and Glick 1976). The pilots in the current study reportedly fixated on a point not in the chin bubble as is usually done in this aircraft (Frezell 1973). Instead, they selected a point out front. In the darkness-oriented, cue-barren hover site over an open field next to a runway, the fixation point can only be guessed at for now. However, the pilots could have conceivably changed altitude forward and rearward without changing the perceived angle subtended at the eye. In other words, within limits they would perceive themselves as nearly stationary. Another review of the data (the pitch SD in Table 7) suggests the plausability of such a phenomenon. All of the NVG configurations show an increased, although statistically not significant, standard deviation. The implication is that loss of binocular depth (or distance) cues may have been the primary cause of the altitude fluctuations that were observed in this investigation.

OTHER FACTORS

Other research (Sanders and others 1977) found that the copilot/navigator spends only about 5% of his visual time checking engine and flight instruments and the warning light during terrain flight navigation which leads to several very important points.

1. The pilot and copilot workload has increased significantly with utilization of terrain flight techniques. This high workload has created a division of duties and a need for a high degree of team work between the pilot and copilot.

2. Monitoring the instrument panel only 5% of the time indicates that the instruments are rarely checked by either crew member since the pilot's responsibility is to keep his eyes outside the cockpit at all times.

Also, when the pilot needs information in critical situations, he must currently take his hands off one of the flight controls and manually refocus or ask the copilot to check the instruments. The copilot may not be focused inside, therefore, a time delay is imposed for focusing followed by other time delays due to reading the appropriate instrument and transmitting the information to the pilot for his control action.

With the bifocal NVG the engine and flight information is always available with a quick glance. Even if the pilot's eyes are outside the cockpit for 97% of the time, the other 3% of the time might be used for very quickly checking vertical velocity, attitude or radar altitude or other critical information and thus could prevent an accident.

SUMMARY

In summary, both NVG bifocal configurations were statistically better than the 40° plano NVG configuration when looking at the pilot's ability to hold a precise altitude at night. The subjective data, supported by flight performance observed between the two bifocals, further suggest that a 24% bifocal NVG arrangement is more desirable than a 14% configured bifocal. The inference is that the reduced inside field of view presented by the 14% bifocal interferes with a pilot's ability to rapidly locate instruments once he has directed his attention inside the cockpit.

REFERENCES CITED

Department of the Army. 1976. *Image Intensifier Assembly, 18 Millimeter Microchannel Wafer.* Washington, DC: Dept of the Army. (Mil Spec MIL-I-49052A (EL)).

Department of the Army. 1976. *Night Vision Goggles, AN/PVS-5* Washington, DC: Dept of the Army. (Mil Spec MIL-N-49065A (EL)).

Department of the Army. 1973. *Night Vision Goggles, AN/PVS-5* Washington, DC: Dept of the Army. (Spec No. Cla 2105020100).

Department of the Army. 1976. *Rotary Wing Night Flight* (TC 1-28). Washington, DC: Dept of the Army.

Department of the Army. 1976. *Terrain Flying* Washington, DC: Dept of the Army (FMI-1).

Frezell, T., Hofmann, M., and Oliver, R. 1973. *Aviator Visual Performance in the UH-1H.* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 74-7.

Huffman, H. W., Hofmann, M. A., and Sleeter, M. R. 1972. *Helicopter In-Flight Monitoring System.* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 72-11.

Kirk, R. E. 1968. *Experimental Design: Procedures for the Behavioral Sciences.* Belmont, CA: Brooks/Cole.

Sanders, M. G., Kimball, K. A., Frezell, T. L. and Hofmann, M. A. 1975. *Aviator Performance Measurement During Low Altitude Rotary Wing Flight with the AN/PVS-5 Night Vision Goggles.* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 76-10.

Sanders, M. G., Simmons, R. R., and Hofman, M. A. 1978. *An Evaluation of Perceptual-Motor Workload During a Helicopter Hover Maneuver.* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 78-14.

Sanders, M. G., Simmons, R. R. and Hofmann, M. A. 1977. *Visual Workload of the Copilot/Navigator During Terrain Flight.* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 78-5.

Schori, T. R. 1976. *Versatile MANOVA: Design and Documentation* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 76-26.

Wiley, R., Glick, D., Bucha, C. and Park, C. 1976. *Depth Perception with the AN/PVS-5 Night Vision Goggles* Ft. Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 76-25.

APPENDIX A

Research Questionnaire

UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY

NIGHT VISION GOGGLE EVALUATION

FOR OFFICIAL RESEARCH PURPOSES ONLY

1. Using the numbers below, rate the visual sets for each maneuver.

VISUAL SETS
1. Unaided eye
2. 40^0 plano goggles
3. Small segment bifocal goggles
4. Larger segment bifocal goggles

MANEUVERS	Best	2d Best	3d Best	Worst
Hover forward	___	___	___	___
360^0 pedal turn	___	___	___	___
10 ft hover	___	___	___	___
Take-off	___	___	___	___
Traffic pattern	___	___	___	___
Precision landing	___	___	___	___

2. Rate the visual sets for best judgement of altitude (depth perception) 1 = best, 4 = worst.

Unaided eye ________
40^0 plano goggles ________
Small segment bifocal goggles ________
Larger segment bifocal goggles ________

3. Rate the visual sets for best judgement of airspeed, 1 = best, 4 = worst.

Unaided eye ________
40^0 plano goggles ________
Small segment bifocal goggles ________
Larger segment bifocal goggles ________

4. Could you distinguish, while flying, between the two different pairs of bifocal goggles? Yes_____; No_____. If yes, what were the differences between the two?

5. What visual set would you choose for tactical flight?

6. Which pair of bifocals would be best for tactical flight?

_____1. Smaller segment bifocal
_____2. Larger segment bifocal

7. Did one pair of bifocals offer better inside viewing than the other? Explain.

8. What factors influenced your hovering capabilities under each of the visual conditions?

a. Unaided eye

b. 40° plano goggles

c. Smaller segment bifocal goggles

d. Larger segment bifocal goggles

9. Mark the technique you used while flying: fixating on a point or constantly moving your head from side to side.

	Fixate	Side to Side
Take-off	____	____
Traffic pattern	____	____
Landing	____	____
Hover forward	____	____
360° Pedal turn	____	____
10 ft hover	____	____

10. Did the narrow 40° field of view present any particular problems during any specific maneuver? Yes ____; No ____ (If yes, please explain).

11. What maneuvers and/or altitudes, in your opinion, will be most compatible with the night vision goggle bifocals?

PSYCHOPHYSIOLOGICAL EFFECTS:

1. Have you ever become nauseated while wearing the goggles? Explain the circumstances.

2. A. Have you had headaches or any related problems while wearing the NVG's?

   B. How long did you wear the goggles before the headaches appeared?

   C. What action relieved this condition?

3. Has your neck bothered you when flying with the NVG's?

4. Have you ever felt particularly closed in (claustrophobia) while wearing the NVG's?

5. Have you at any time experienced vertigo while wearing the NVG/s? If yes, what do you think contributed to it?

6. Did you feel more tense (higher pucker factor) when first flying with the PVS-5's than with the unaided eye? If yes, what bothered you the most about flying with the goggles?

7. How long, in your opinion, could you wear the NVG's if you were to go on an extended mission?

EQUIPMENT CONSIDERATIONS:

1. A. Have you experienced any difficulty with the helmet mounting for the goggles?

   B. If yes, what problems were encountered?

2. A. Was the weight of the goggles equally distributed across your helmet and liner?

   B. If no, where did you feel most of the weight or pressure?

C. Do you feel that any additional pressure relief pads are necessary? _____Yes; _____No. If yes, where should they be located?

D. Do you have any suggestions on how to mount the goggles so that they would be easier to use or more comfortable?

3. A. Did you ever experience fogging over the lenses of the goggles? _____Yes; _____No.

B. If yes, how much of the time did the fogging occur?

C. How did you remedy the fogging problem?

D. Was the temperature hot or cold when the fogging occurred?

4. Did any aircraft features affect the use of the goggles (for example, blockage of vision by structural member, lights, etc)?

5. Did you experience any problems which have not been discussed? If yes, what were they?

TRAINING, ACADEMIC:

1. How much classroom or ground time do you feel should be devoted to the goggles before flying with them?

Topics	Time Needed
Mounting	________
Focusing	________
Other Adjustments	________
Background info on the NVG and Light Levels	________

Other topics you suggest that should be covered:

Topics	Time Needed
____________________	__________
____________________	__________
____________________	__________

2. What would be the first and second most important areas covered in the academic training?

TRAINING, FLIGHT:

1. (Assume a student is at the end of the tactical phase of training) In your opinion, how much time would a tactics student pilot need before taking over the controls while wearing the goggles?

2. Do you think that the Aviation School should provide all initial rotary wing students with:

_____1. NOE night vision goggle introduction and familiarization?

_____2. NOE night vision goggle full qualification?

3. A. How many flight hours would be essential for an introduction to PVS-5 use? ____________________________

   B. How many flight hours would be essential for a full qualification with the PVS-5's? __________________________

4. What maneuvers do you feel are the most difficult to accomplish with the bifocal NVG? Why?

5. Do you think that night vision goggle instruction to initial rotary wing students should be given by: ______(1) The NOE IP's or ______(2) by a special group of IP's assigned solely to night vision training? (Check one above) Why?

6. How many academic hours should be dedicated to the instruction of IP's who will train students in the use of NVG?__________

____

7. How many flight hours with the NVG's should be required of IP's before training students in the use of NVG's? _________________

____

8. What are the most important factors affecting a large scale NVG training program?

9. What should the student-instructor ratio be for night vision goggle training?

10. What supplemental illumination techniques have you seen to be the most useful in aiding night vision goggle flights? Explain briefly their mode of operation.

11. Have you experienced any weather conditions (e.g., rain) which influenced the use of the night vision goggles? Describe the condition(s) and its(their) effect(s).

BACKGROUND INFORMATION

1. Your name (please print) ______________________________
(Last) (First) (Middle)

2. Age ____ 3. SSN __________ 4. Today's Date ______________

5. Present rank ______ 6. Current duty assignment ______________

____

7. Approximate total hours of flying experience VFR and IFR by aircraft type. Please estimate hours as accurately as possible.

	Rotary Wing	Approx Hrs.	Approx Hrs.	Approx Hrs.
	______	______	______	______
A/C Model Type	______	______	______	______
A/C Model Type	______	______	______	______
A/C Model Type	______	______	______	______
A/C Model Type	______	______	______	______
	Fixed Wing			
A/C Model/Type	______	______	______	______
A/C Model/Type	______	______	______	______
A/C Model/Type	______	______	______	______

8. Please fill in appropriate blocks:

Military Tickets and Rating	Date Earned or Student Hours	FAA-Civilian Licenses & Ratings	Date Earned or Student Hours

9. Approximate total hours of night flying experience.____________

10. Approximate total hours of NOE night flying experience.________

11. Approximate total hours of NOE daytime flying experience. _______

12. Approximate total hours of flight experience with the AN/PVS-5 NVG's _______.

APPENDIX B

Research Questionnaire

Traffic Pattern Evaluation

TRAFFIC PATTERN RATING
(Subject 2)

SUBJECT 1--Pattern	1	2	3	4
Rating	4	3	1	2
SUBJECT 2--Pattern	5	6	7	8
Rating	1	2	3	4
SUBJECT 3--Pattern	9	10	11	12
Rating	2	1	3	4
SUBJECT 4--Pattern	13	14	15	16
Rating	4	1	2	3
SUBJECT 5--Pattern	17	18	19	20
Rating	4	3	2	1
SUBJECT 6--Pattern	21	22	23	24
Rating	4	3	1	2
SUBJECT 7--Pattern	25	26	27	28
Rating	1	3	2	4
SUBJECT 8--Pattern	29	30	31	32
Rating	4	1	2	3

For each of the four traffic patterns for each subject, rank the traffic patterns relative to each other. Rank the traffic patterns from 1 to 4 (1 = best; 4 = worse). Place the appropriate ranking under each traffic pattern number.

Instructions for Traffic Pattern Evaluation

X-Y Plots:

1. Large squares equal 300 feet.

2. Vertical mark at the top of the traffic pattern indicates the starting and ending points.

3. The arrow indicates the direction of the takeoff.

4. The traffic patterns were all flown using right traffic procedures, 200 feet above ground level.

5. All patterns were performed at night.

Radar Altitude Plots:

1. The bottom dotted line represents the ground.

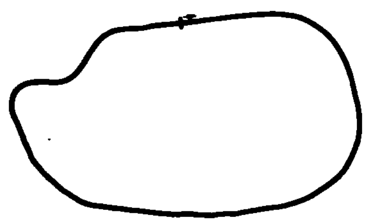
2. The dotted lines above that are at 300 feet increments above ground level.

APPENDIX C

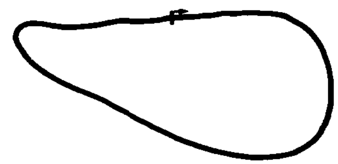
Research Questionnaire

Flight Pattern Evaluations

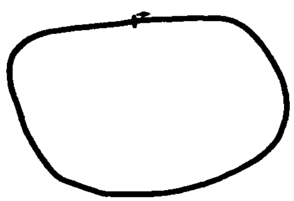
FLIGHT SUBJECT NUMBER 1



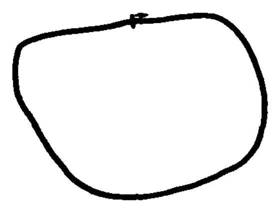
Unaided Eye



40° Plano NVG

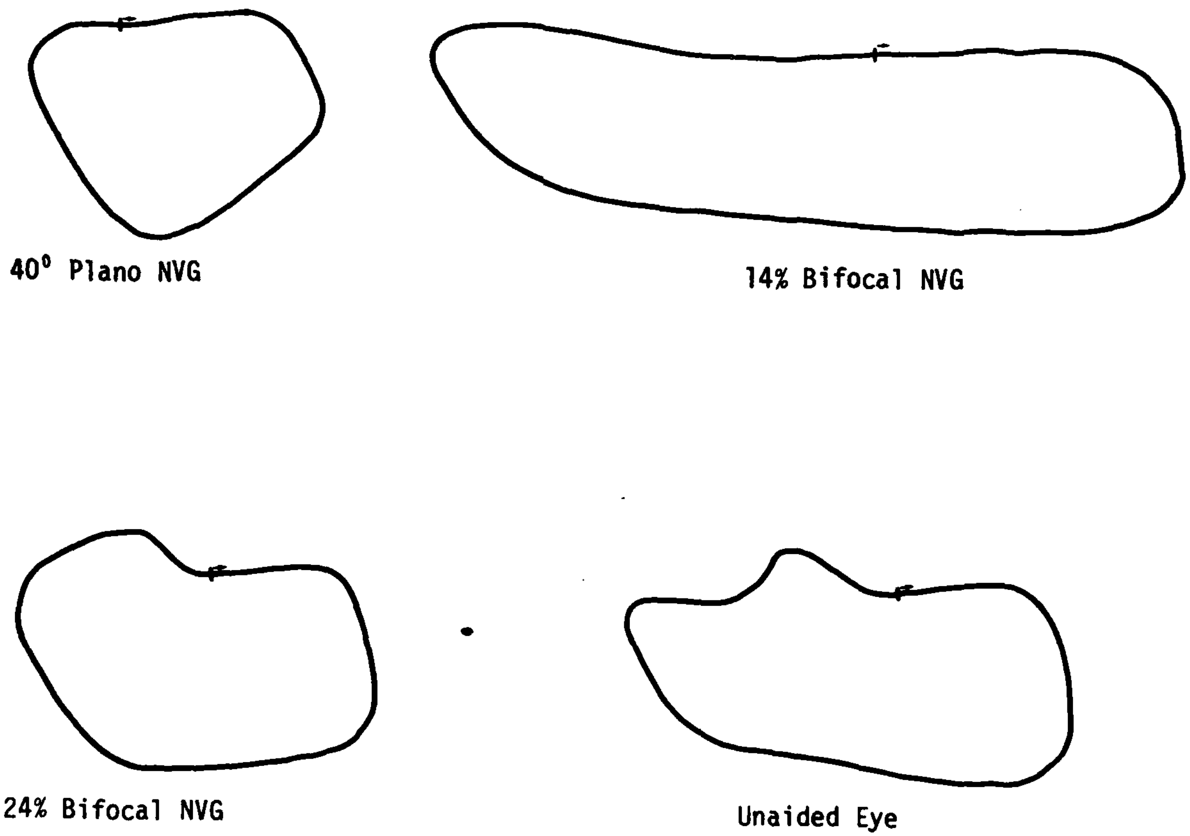


14% Bifocal NVG



24% Bifocal NVG

FLIGHT SUBJECT NUMBER 2



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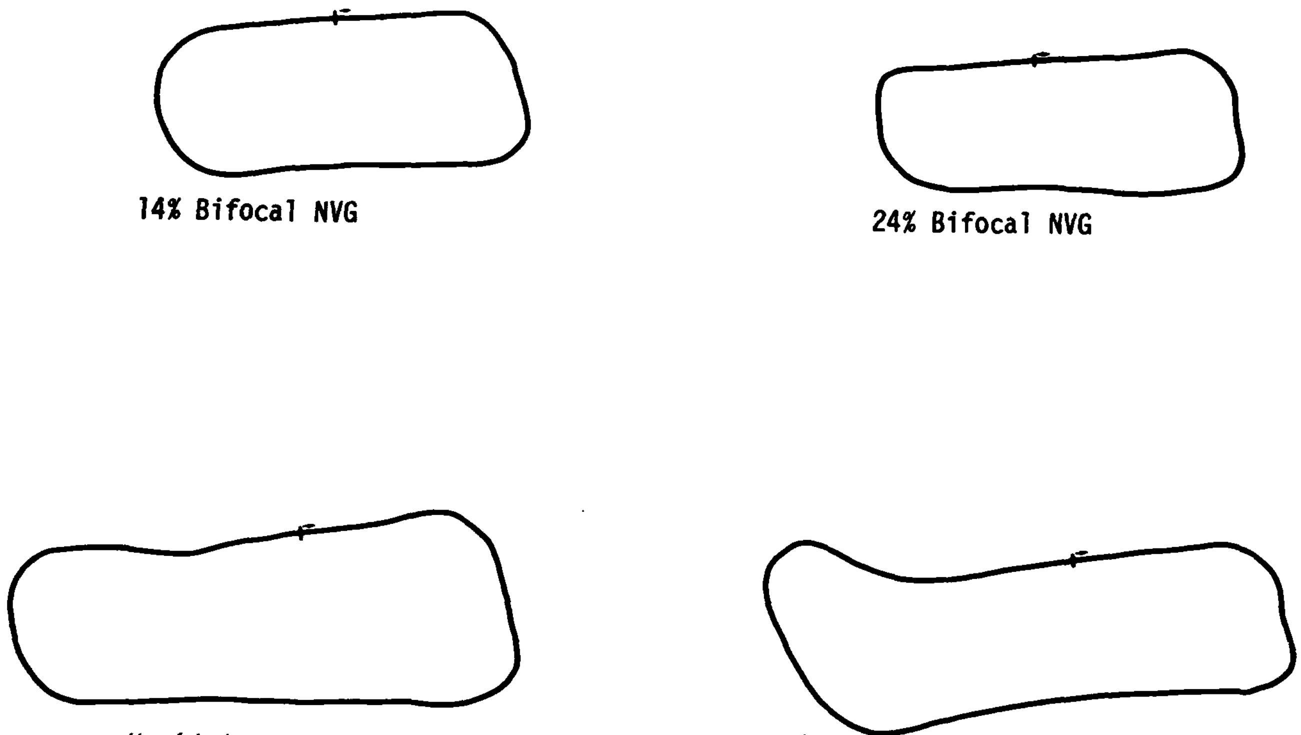

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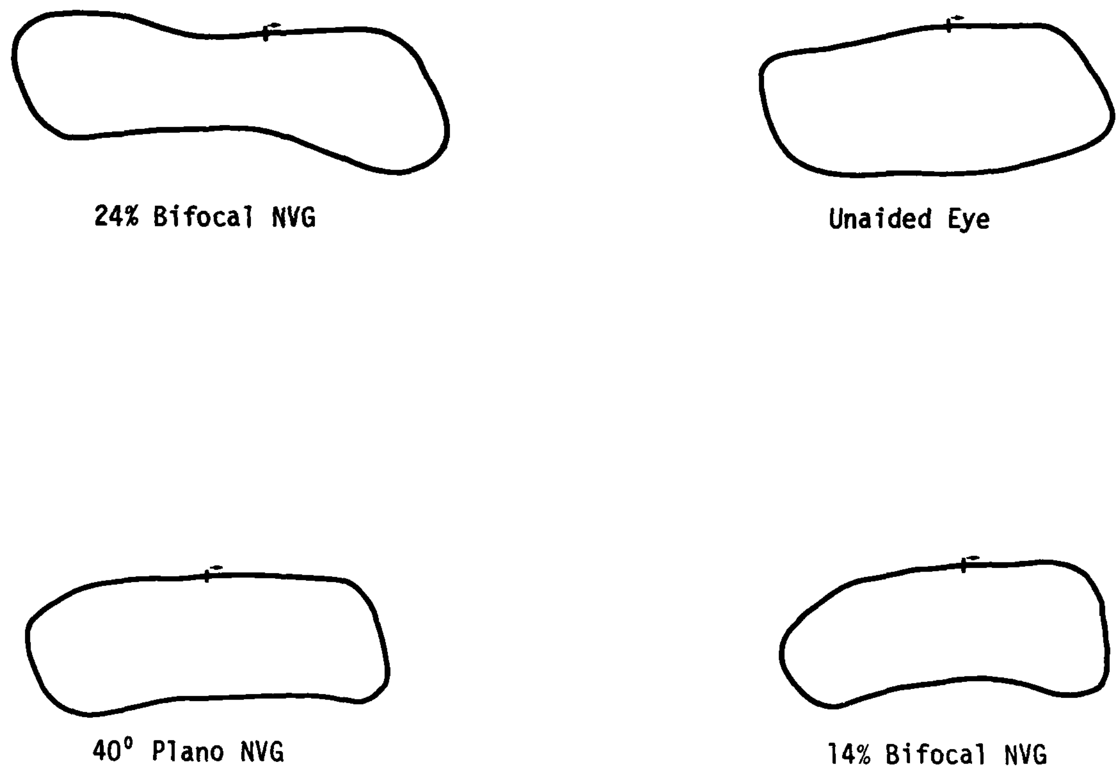
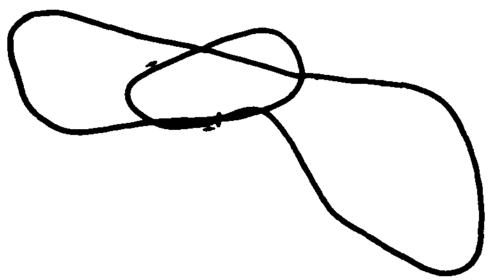
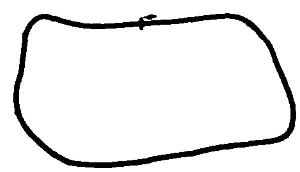


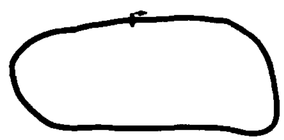
FLIGHT SUBJECT NUMBER 5



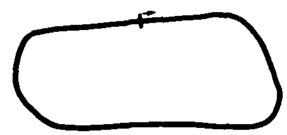
Unaided Eye



40° Plano NVG

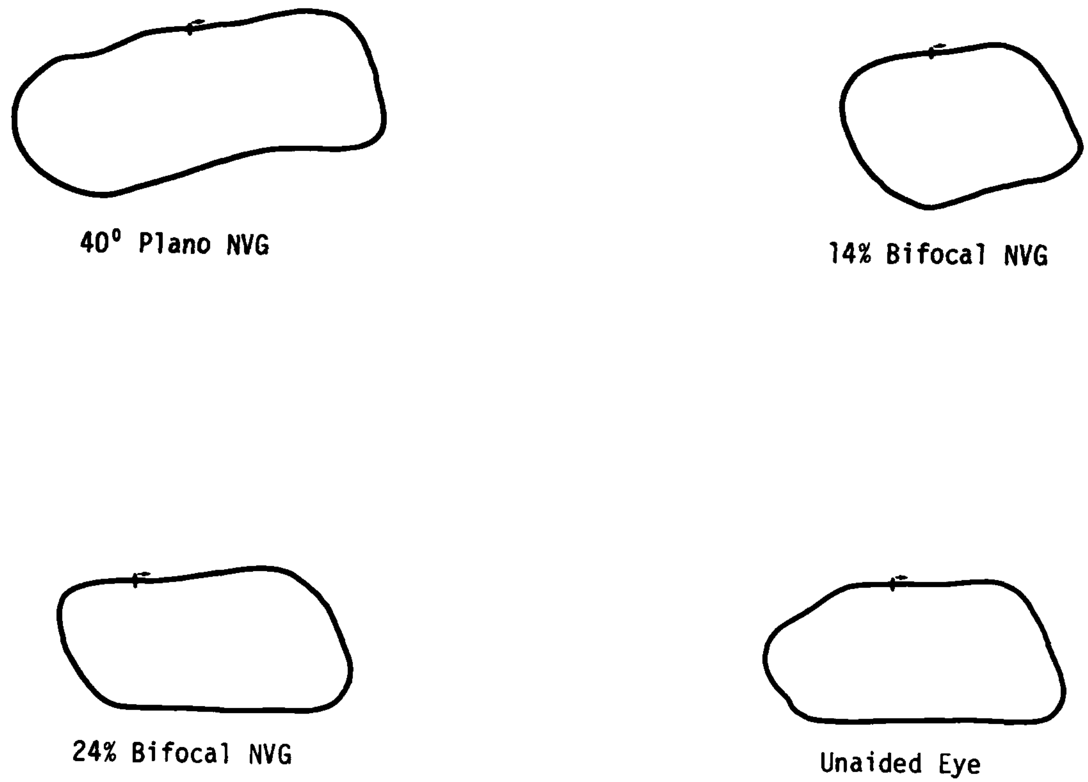


14% Bifocal NVG



24% Bifocal NVG

FLIGHT SUBJECT NUMBER 6



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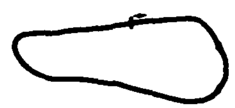
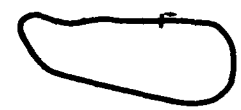
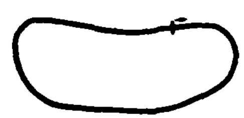


14% Bifocal NVG



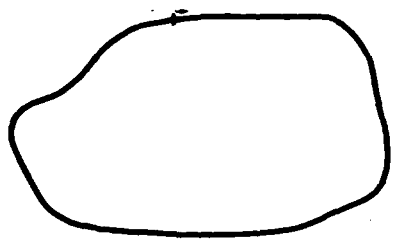
24% Bifocal NVG



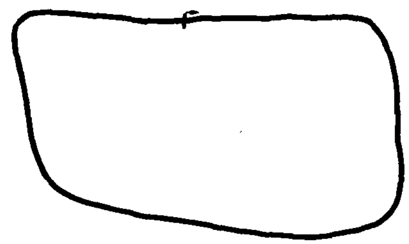
Unaided Eye

40° Plano NVG

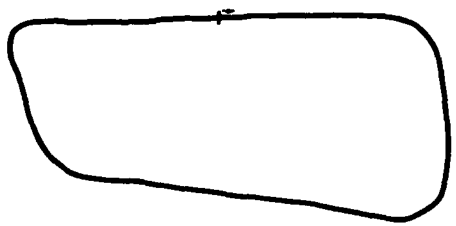
FLIGHT SUBJECT NUMBER 8



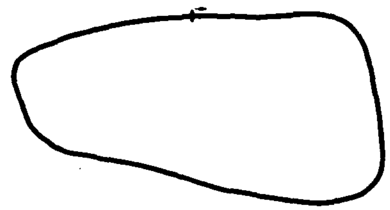
24% Bifocal NVG



Unaided Eye



40° Plano NVG



14% Bifocal NVG

APPENDIX D

Research Questionnaire

Summary of the Pilot Questionnaire Responses

1. Using the numbers below, rate the visual sets for each maneuver.

1 = Best; 4 = Worst

Visual Sets	Maneuver	UA	40°	SS	LS
		Average Rating			
Unaided eye (UA)	Hover forward	2.1	2.4	2.6	2.9
40° plano goggles (40°)	360° pedal turn	2.4	1.8	2.8	3.1
Small segment bifocal goggles(SS)	10 ft. hover	2.4	1.9	2.8	3.0
Larger segment bifocal goggles(LS)	Takeoff	2.6	1.8	2.6	3.0
	Traffic pattern	2.4	2.1	2.6	2.9
	Precision Landing	2.9	1.6	2.5	3.0

Comments: Subject 3 - When hovering with bifocals, I was able to see the radar altimeter for my altitude. Without the radar altimeter, the plano would have been better for hovering.

2. Rate the visual sets for best judgement of altitude (depth perception).

1 = Best; 4 = Worst

Visual Set	Average Rating
Unaided eye	1.6
40° plano goggles	2.1
Small segment bifocal goggles	3.0
Larger segment bifocal goggles	3.2

3. Rate the visual sets for best judgement of airspeed.

1 = Best; 4 = Worst

Visual Set	Average Rating
Unaided eye	1.5
40° plano goggles	3.0
Small segment bifocal goggles	3.0
Larger segment bifocal goggles	2.5

4. Could you distinguish, while flying, between the two different pairs of bifocal goggles? Yes 8 ; No 0 . If yes, what were the differences between the two?

Subject 1 - The larger bifocals cut down so much on outside references that they made the picking up of visual cues quite difficult.

Subject 2 - 14% required lots of scanning to check the instruments once. 24% did not require as much scanning. It seemed easier to judge altimeter while hovering with 14%.

Subject 3 - I could see more of the instrument panel with the larger segment bifocals, plus visual acuity of the panel was a lot better with the larger set. When flying at altitude, the larger set makes it very easy to monitor the instrument panel, but for low altitudes it blocks one of the more important areas of scanning for rate of closure and depth perception. In a deceleration for an autorotation, this would block a very important area, also when flying NOE.

Subject 4 - The smaller bifocal provided adequate vision for cross checking the instrument panel as well as better vision for the landing phase. The larger bifocal provided better viewing of the instrument panel; however, for the entire flight phase (entire traffic pattern, to include takeoff and landing), the smaller bifocals were preferable.

Subject 5 - Smaller segment did not give enough information causing pilot to spend more time looking at instruments.

Subject 6 - Ease of reading instruments with the larger segment bifocal.

Subject 7 - The size of the bifocal cut. The small (14%) cut was too small to use effectively and the 24% cut was too large. The 24% cut eliminated the lower quadrant visual cues required for hover out of ground effect.

Subject 8 - Too much vertical head movement required to enable myself to see the instruments.

5. What visual set would you choose for tactical flight?

Unaided	0
40° plano	4
Small segment bifocal	1
Larger segment bifocal	2
Undecided	1

Subject 1 - No comment.

Subject 2 - With two or three rated aviators in aircraft.

Subject 3 - Instrument panel is second to being able to detect and identify terrain features.

Subject 4 - They provide optimum outside visibility as well as a means of viewing the instrument panel.

Subject 5 - Not having had enough experience with the bifocal, I hesitate recommending them in a tactical environment. When the first goggle came out, it was awkward. The bifocal is the same way; however, I believe after getting use to it, it would prove to be as good as the plano in flight and superior for checking instruments and with a different magnification suitable for the navigator.

The small bifocal is inferior due to added time looking for instruments.

One problem I had in flight with regard to maintaining altitude was the nonstandard configuration. I was not receiving VSI information. With a standard configuration and large bifocal lens, it would have been in view a+ a glance.

During protracted hover work, the concentration required with the large bifocal is far greater than the plano goggle. This naturally will increase fatigue.

Subject 6 - No comment.

Subject 7 - No comment.

Subject 8 - No comment.

6. Which pair of bifocals would be best for tactical flight?

   1. Small segment bifocal. 5
   2. Larger segment bifocal. 3

7. Did one pair of bifocals offer better inside viewing than the other? Explain.

   1. Small segment bifocal. 0
   2. Larger segment bifocal. 8

Subject 1 - Larger segment bifocals were very good inside the cockpit. Even tried reading the aircraft checklist with them and it was quite simple.

Subject 2 - 24% offered better viewing of the instruments, less scanning of instruments to see all of them. However, you had to scan much harder closer to ground to judge altimeter while hovering.

Subject 3 - Larger segments were better because I could see the panel more clearly and more of it, so then you can get the big picture as to what is happening to your aircraft, i.e., could see airspeed low, altitude high at same time so correction only to speed up with one look inside without having to scan as much with the others.

Subject 4 - The larger bifocals provided better inside viewing because larger portion of instrument panel could be seen.

Subject 5 - Larger. Less time spent looking for instruments.

Subject 6 - Yes, the larger segment bifocal was easier to read instruments.

Subject 7 - The 24% cut provided better inside viewing but degraded the outside viewing. I believe a cut of 18% to 20% would be optimum.

Subject 8 - Larger segment bifocal provided easy viewing of instruments on inside cockpit without a lot of head movement. It was only necessary to move eyes.

8. What factors influenced your hovering capabilities under each of the visual conditions?

   a. Unaided eye.

Subject 1 - The low ambient light made it difficult to gain any terrain definition.

Subject 2 - (Misinterpreted question)

Subject 3 - Able to see shadow of skid of the aircraft to judge altitude and radar altimeter; able to judge drift faster.

Subject 4 - Outside references, side of runway.

Subject 5 - (Left blank)

Subject 6 - Peripheral vision gained.

Subject 7 - High level made it relatively easy.

Subject 8 - Greater peripheral vision.

b. 40° plano goggles.

Subject 1 - No major problems.

Subject 2 - (Left blank)

Subject 3 - Hard to judge altitude but easier to judge drift than other goggles.

Subject 4 - Side of runway, wind sock, distinguishable patches of vegetation.

Subject 5 - (Left blank)

Subject 6 - (Did not use instruments) Same as 40° plano.

Subject 7 - Loss of lower quadarant visual cues--depth perception.

Subject 8 - Poor fit on bridge of nose.

d. Larger segment bifocal goggles.

Subject 1 - Same problem as above but to a large degree. Also, there were lateral movement probems.

Subject 2 - (Left blank)

Subject 3 - Best for altitude; worst for drift control without radar altimeter. The 40° plano would be better for altitude control also.

Subject 4 - Same as smaller.

Subject 5 - (Left blank)

Subject 6 - Gained instruments for reference.

Subject 7 - Same as smaller.

Subject 8 - Field of view outside decreased.

9. Mark the technique you used while flying: fixating on a point or constantly moving your head from side to side.

	Fixate	Side to Side	Other
Takeoff	1	6	1
Traffic pattern	1	5	2
Landing	0	6	2
Hover forward	0	6	2
360° pedal trun	0	7	1
10 ft. hover	3	3	2

Other:

Subject 4 - (Under takeoff) Used both fixate and side to side.

Subjects 3 and 4 - (Under traffic pattern) Used both fixate and side to side.

Subject 3 - (Under landing) Used fixate and front to side.

Subject 4 - (Under landing) Used both fixate and side to side.

Subject 3 - (Under hover forward) Used front to side.

Subject 4 - (Under hover forward) Used both fixate and front to side.

Subject 3 - (Under 360° pedal turn) Used front to side.

Subject 3 - (Under 10 ft. hover) Used front to side.

Subject 5 - Used fixate and side to side and straight ahead with occasional side checks.

10. Did the narrow 40° field of view present any particular problems during any specific maneuver? Yes 6 ; No 2

Subject 2 - It is hard to remain over a fixed point with all three sets. Seemed harder with 24% bifocal.

Subject 3 - When you are looking at something, you miss a lot of information you may have needed that was on the other side. With the 40° plano, I overshot the lane because I was looking at my turn and trying to stop it on the heading and then fly that when I started my scan for the lane; I did not see it until looking very far to my right. This is something I have learned. If it is not to your right front when you first look, then you've passed it.

Subject 4 - During turns in the traffic pattern, clearing the aircraft to the side, looking to the side then back to the front and cross checking the instrument panel.

During 360° turns referencing to the side and forward to attempt to remain over a fixed position.

When pilot's attitude indicator was inoperable, a more frequent cross check with instrument and outside visual references was required.

Subject 6 - Lack of peripheral vision causes a laçk of depth perception.

Subject 7 - 360° turn and disorientation in traffic pattern.

Subject 8 - Only when using bifocal and a small percentage (14%) was devoted to the outside. (See question 4)

11. What maneuvers and/or altitudes, in your opinion, will be most compatible with the night vision goggle bifocals?

Subject 1 - I can think of no flight maneuvers or altitudes that would be best suited with bifocals. The only advantage of bifocals would be for work inside the cockpit, i.e., instrument readings or map reading.

Subject 2 - Straight and level flight--preknown heading--turns to known heading--low altitudes 50-200 ft. To me this would be the only use the bifocals would be good for--when doing any hover work, approaches, running landings, autos. As much of your attention should be directed to outside as possible and the bifocals do take some of this away from you.

Subject 3 - With radar altimeters, when doing sling loads, the bifocals would be a must when working under low light levels. Pilot would be able to see his altitude and obstacles in the area. Also, the radar altimeter and bifocals would be needed for working over water. One area that I do not have much time for is flying in the desert. I know with the unaided eye under low light levels, you have to always monitor the panel, but I have never flown with the goggles in the desert and it needs to be checked into. I feel that the radar altimeter and bifocals would be good for flat terrain like the desert at El Paso or the southern part of Vietnam when flying NOE.

Subject 4 - Low level tactical flight, to include all maneuvers involved with NOE flight. Maneuvers within close proximity to the earth. The obstacles can be seen and a successful maneuver accomplished (especially NOE maneuvers and landings and take-offs) with the goggles whereas it would be unsafe to accomplish these maneuvers without illumination.

Subject 5 - Same as plano goggle.

Subject 6 - All standard NOE maneuvers and altitudes below 300 ft AGL.

Subject 7 - Traffic patterns and night flight at altitude where precise airspeed and altitude is used. In night NOE or low level flight I don't use flight instruments; that is copilot's responsibilility. I believe the bifocal NVG would aid in night navigation and allow easier reading of map and correlation with terrain features.

Subject 8 - Maneuvers below 400 ft AGL; those not requiring abrupt or quick motion.

Psychophysiological Effects.

1. Have you ever become nauseated while wearing the goggles? Explain the circumstances.

   Yes __0__; No __8__

   Subject 2 - But I have had numerous headaches and have become extremely fatigued when flying more than two hours.

2. A. Have you had headaches or any related problems while wearing the NVG's?

   Yes __5__; No __3__

   Subject 1 - Only at first due to poor helmet fit. After adjustment of the helmet, there were no problems.

   Subject 2 - Yes. Headaches numerous times; hot spots in helmet over long flight periods.

   Subject 3 - Yes. Sinus headaches because of the pressure on my face. I try to wear the goggles so they rest on my cheek bones so as not to get the pressure and be able to breathe without any blocked feeling.

   Subject 4 - Yes. The SPH-4 helmet has to be better adjusted to the individual for goggle fit as opposed to flight without goggles because of "hot spots" and adjusting the helmet for comfort to be able to tolerate the goggles for a given period of time.

   Subject 5 - Yes. Headaches seem to be more frequent during goggle training.

   Subject 6 - No. (No comment)

   Subject 7 - No. (No comment)

   Subject 8 - No. (No comment)

   B. How long did you wear the goggles before the headaches appeared?

Subject 1 - See 2A above.

Subject 2 - Sometimes 15 minutes; sometimes 2 hours.

Subject 3 - Depends on whether I have any congestion in my sinuses and what day of training it is. After wearing the goggles for three or four nights straight, I can wear them for two and a half to three hours without problems; the first night only for one to two hours.

Subject 4 - Headaches were not experienced because the helmet was properly fitted and adjusted with the goggles before flight.

Subject 5 - Varies.

Subject 6 - N/A.

Subject 7 - (Didn't answer; answered "no" to question 2A).

Subject 8 - (Didn't answer; answered "no" to question 2A).

C. What action relieved this condition?

Subject 1 - Helmet adjustment.

Subject 2 - If it was an early headache, re-positioning helmet would relieve it. If it was from flying long periods, nothing relieved it but removing the goggles.

Subject 3 - Re-positioning the goggles if I felt the blocking of my sinuses when I first put them on when in flight, but the only thing for the neck pain and sinus headaches was to take them off, rest and relax.

Subject 4 - (See 2B response).

Subject 5 - Aspirin and sleep.

Subject 6 - N/A.

Subject 7 - No response.

Subject 8 - No response.

3. Has your neck bothered you when flying with the NVG's?

Yes 7 ; No 1

Subject 1 - Yes. Not after first 10 hours.

Subject 3 - Yes. My neck size has increased by one inch after wearing them for two classes in a row.

Subject 5 - Yes. At first, and now if I fly over 1.5.

Subject 6 - Yes. Just gets tired at the base of head due to additional weight.

4. Have you ever felt particularly closed in (claustrophobia) while wearing the NVG's?

Yes 1 ; No 7

Subject 5 - Yes. During initial training.

5. Have you at any time experienced vertigo while wearing the NVG's? If yes, what do you think contributed?

Yes 0 ; No 8

Subject 2 - No. But I have become lost to the point where I had to remove the goggles to orient myself.

Subject 4 - No. However, a greater reliance upon the instruments is required and the use of bifocals would eliminate a possible vertigo producing situation by not having the additional workload of adjusting one eyepiece to check the instruments and the re-adjusting the eyepiece to infinity again. This is critical on approaches and NOE maneuvers where a frequent cross check is required.

Subject 6 - No. But it could easily happen if you did not use constant head movement to compensate for tunnel vision.

6. Did you feel more tense (higher pucker factor) when first flying with the PVS-5's than with the unaided eye? If yes, what bothered you the most about flying with the goggles?

Yes 4 ; No 4

Subject 1 - Yes. Because of the restricted field of view.

Subject 2 - Yes. 40% field of vision; not being able to judge rate of closure as well.

Subject 3 - No. But when I started with the unaided eye, the light level was low and my IP let me hit the ground hard one night. I had some anxieties about auto's because he also did not see the ground. With the goggles I could see. My students normally feel more tense with the goggles unless they got to fly on a low light with their eye only.

Subject 4 - No. The only discomfort felt was the narrow FOV; however, the ability to "see" at night, especially during maneuvers close to obstacles, greatly outweighs the FOV discomfort.

Subject 5 - No.

Subject 6 - Yes. Lack of side vision.

Subject 7 - No.

Subject 8 - Yes. Reduced peripheral vision and decreased depth perception.

7. How long, in your opinion, could you wear the NVG's if you were to go on an extended mission?

   Average 2.9 hrs

   Subject 1 - 5-6 hours.

   Subject 2 - Without extreme fatigue--2 to 2 1/2 hours.

   Subject 3 - With a good PT class and training with goggles--3 or 4 days just ahead of mission; 4 to 5 hours longer if mission is not too demanding (like we have to do in the units--2 to 3 hours).

   Subject 4 - With head positioning or re-positioning, as required to rest, possibly 1 hour.

   Subject 5 - Comfortably 2 hours.

   Subject 6 - 4 to 6 hours.

Subject 7 - 3 hours maximum. I have in the past flown more than 3 hours with NVG's but my performance dropped rapidly after 3 hours.

Subject 8 - 1-2 hours.

Equipment Considerations.

1. A. Have you experienced any difficulty with the helmet mounting for the goggles?

   Yes 4 ; No 4

   B. If yes, what problems were encountered?

   Subject 2 - Yes. Numerous hot spots; difficulty in preventing the helmet from sliding down or forward.

   Subject 6 - Yes. The weight causes goggles to fall down over nose. Most comfortable with standard straps furnished.

   Subject 7 - Yes. Getting the NVG to fit properly and comfortably on my face.

   Subject 8 - Yes. The fit under the helmet. Also the face padding and frame are too small for my face, thereby causing discomfort to bones around my outer eye and cheeks (nose too in certain cases).

2. A. Was the weight of the goggles equally distributed across your helmet and liner?

   Yes 3 ; No 5

   B. If no, where did you feel most of the weight or pressure?

   Subject 2 - No. Weight was forward; pressure around the head band.

   Subject 3 - No. On the forward liner.

   Subject 4 - No. The weight was distributed on the front half of the helmet where the goggles were mounted. The adjustments, i.e., up and down adjustments on bifocals, made goggles more comfortable so as to be able to wear them at least one hour per flight.

   Subject 6 - No. Not with standard straps. On bridge of nose.

   Subject 7 - No. Nape strap.

C. Do you feel that any additional pressure relief pads are necessary? Yes 3 ; No 5 If yes, where should they be located?

Subject 2 - Yes. Possibly a nose pad mounted on goggles, between tubes, in case tubes or helmet slides forward.

Subject 4 - Yes. Possibly, if aft of the ear approx. 2 inches but it doesn't seem practical.

Subject 8 - Yes. Should have different sized face masks.

D. Do you have any suggestions on how to mount the goggles so that they would be easier to use or more comfortable?

Yes 3 ; No 5

Subject 4 - Yes. Possibly a bungee or a shock recoil suspended from top of inside of cockpit.

Subject 6 - Yes. Adapt a stretch cord to attach from base of back of helmet and hook to center of goggles. I use a makeshift cord to relieve weight problem and can fly longer with it. It shifts the weight to rear of helmet some.

Subject 7 - No. I have tried everything I can think of and they are still uncomfortable after about 1 1/2 hours of flight. The major problem is the forward CG and discomfort in the neck after about 1 1/2 hours of flight with NVG.

Subject 8 - Yes. CPT Wiseman used an elastic strap with hooks on either end taped vertically on the outside of his helmet--one end hooked to the back bottom of his helmet, and the other to the front top of the goggles. This kept the weight off of his nose and cheeks.

3. A. Did you ever experience fogging over the lenses of the goggles? Yes 5 ; No 3

B. If yes, how much of the time did the fogging occur?

Subject 1 - Yes. Only at first for approximately 5 minutes. This is a recurring problem.

Subject 2 - Yes. Most of the time in cold or damp weather.

Subject 3 - Yes. During October and over the Christmas holidays when I flew goggles; any time you talk while hovering, they fog. We try to place our mikes so they are touching the top lip and bend outward at the bottom; it helps some. I had one student who breathed out his mouth and his goggles stayed fogged until takeoff or hovering sidewards. He finally stopped and breathed through his nose because he could not see. Still they fogged a lot.

Subject 4 - Yes. .05% momentarily. However, I removed the fog by moving my index finger, with felt gloves on, across the lens. If the opening above the nose was longer, it would facilitate fog removal.

Subject 5 - Yes. On very cold nights.

C. How did you remedy the fogging problem?

Subject 1 - I took them off and used lens paper. It seemed hard but if I opened my window, it helped alleviate the problem. Also, I could take off with one lens fogged and within 30 seconds it cleared and did not recur.

Subject 2 - Heat the aircraft or goggles. Turn the aircraft heater on and this, in turn, would bring the temperature of goggles up.

Subject 3 - (See 3B answer).

Subject 4 - (See 3B answer).

Subject 5 - Lifting goggles away from face; turning lower part of mike away from lips to direct breath down.

D. Was the temperature hot or cold when the fogging occurred?

Subject 1 - Either hot or cold. However, it occurred more in cold temperature.

Subject 4 - Hot in cockpit with approximately 29°F outside.

3 Subjects - Cold.

3 Subjects - N/A.

4. Did any aircraft features affect the use of the goggles (for example, blockage of vision by structural member, lights, etc.)?

Yes 7 ; No 1

Subject 1 - Yes. The upper piece of flexiglass above the entrance door window.

Subject 2 - Yes. The yellow painting around the doors marking the emergency exits. Each time you look in that direction, the goggles become ineffective.

Subject 3 - Yes. To read the instruments without adjusting to inside, you need your IR light on. When you turn your head to the right, you get a lot of reflection because of the yellow paint. This yellow paint is not needed on the door (also door frame). If it could be moved back in new aircraft or not as thick, it would help a good bit.

Subject 4 - Yes. Pilot's right vertical canopy and door support member. Reflections were minimal because intensity of instrument lights could be adjusted to a usable level.

Subject 5 - Yes. Column on aircraft reflects back IR light, also wide window at top.

Subject 6 - Yes. Red tail lights reflect off structural frame of windshield and pilot door obstructs vision.

Subject 7 - Yes. UH-1H door and structural supports around door; also IP in right seat. AH-1S, the SM-73 rocket site and canopy structural supports.

5. Did you experience any problems which have not been discussed? If yes, what were they?

Yes 3 ; No 3 ; Undecided 2

Subject 3 - Cleaning of the lens is hard with the lip that is around the lens. Dirt collects in the lip area. The diopter adjustment ring on several of the goggles is very hard to turn.

Subject 5 - Occasional drying of eyes with large head; rubber seal of goggles sits on edge of my eyes.

Subject 7 - The narrow field of view causes the operator to fixate. A scan pattern must be established by the pilot but it is very easy to fixate on a single items which provides a good visual cue.

Training, Academic.

1. How much classroom or ground time do you feel should be devoted to the goggles before flying with them?

Topics	Average Time Needed	
Mounting	36.9 mins.	(From 6 subjects)
Focusing	15.0 mins.	(From 5 subjects: subject 6 less than 1 hr).
Other Adjustments	17.5 mins.	(From 4 subjects)
Background info on the NVG and Light Levels	1.4 hrs.	(From 7 subjects; subject 3-10-15 mins.; subject 4-1 hr. with demonstration similar to night lab)

Other topics you suggest that should be covered:

Topics	Average Time Needed	
Combination of Mounting, Focusing, Other Adj.	2.0 hrs.	(From 2 subjects)
SFTS	1.5 hrs.	(From 1 subject)
Care of NVG	1.0 hr.	(From 1 subject)
Goggles in SFTS	5.0 hrs.	(From 1 subject; day flight with goggles and with daylight lenses)
Tunnel Vision	30.0 mins.	(From 1 subject)
Hazards of Tunnel Vision and Remedial Action	1.0 hr	(From 1 subject)
Effect on Body/Mind During Day	1.0 hr	(From 1 subject)

Practical Demonstration, Indoors and Outdoors Familiarization	1.0 hrs.	(From 1 subject)
Use of IR Light, Cleaning (e.g., Don't turn them on in daylight with lens cap off and why)	5.0 mins.	(From 1 subject)
Goggles Failure in Critical Conditors (e.g., What would an IP do if he had a goggle failure during an auto after he pulled initial pitch?)	10.0 mins.	(From 1 subject)
NVG Scan Techniques	1.0 hrs.	(From 1 subject)
NVG Emergency Procedures	1.0 hrs.	(From 1 subject)

2. What would be the first and second most important areas covered in the academic training?

<u>Subject 1</u> - 1. Mounting
2. Focusing

<u>Subject 2</u> - 1. Fitting helmet and mounting goggles
2. Goggle failure during ciritical conditions.

<u>Subject 3</u> - 1. Background light levels, cleaning, cautions on battery and turning on with caps off in sunlight.
2. Mounting
3. Focusing

<u>Subject 4</u> - Need for NVG's and background info with a brief demonstration to illustrate effectiveness. A possible video tape on what different objects appear to look like with and without NVG's and how much of a benefit they can be in tactical environment.

<u>Subject 5</u> - Aeromedical factors related to goggles, i.e., low grade fever, psychological effects, fatigue and day problems such as driving.

<u>Subject 6</u> - 1. Hazards of tunnel vision and remedial action.
2. Operation of goggles.

Subject 7 - 1. Mounting and fitting of NVG.
2. Simulator flight with NVG.

Subject 8 - No response.

Training Flight.

1. (Assume a student is at the end of the tactical phase of training) In your opinion, how much time would a tactics student pilot need before taking over the controls while wearing the goggles?

   Average Time 6.4 hrs (from 5 subjects)

   Subject 3 - I do not know because I have not flown with student pilots. A guess would be 1 to 2 hours but I do not think he would be safe.

   Subject 4 - Spontaneously with training and with safety pilot and safety (crash) aircraft for NOE flight--approximately 2 hrs. flight time.

   Subject 5 - I do not believe initial entry students have the experience or control touch needed. I think this training should be given at unit level.

   Subject 6 - Would depend on total flight experience.

   Subject 7 - To be goggle qualified would require 15 to 20 minutes.

2. Do you think that the Aviation School should provide all initial rotary wing students with:

   1. NOE night vision goggle introduction and familiarization?

      Yes 6 ; No 2

   2. NOE night vision goggle full qualification?

      Yes 2 ; No 6

3. A. How many flight hours would be essential for an introduction to PVS-5 use? 4.4 hrs

   Subject 1 - 10 hours for initial entry students

   Subject 2 - 2 hours

Subject 3 - 5 hours

Subject 4 - 2 one-hour flights

Subject 5 - 400-500 hours

Subject 6 - 2 hours (1 stagefield, 1 tactical)

Subject 7 - 5 hours

Subject 8 - 5 hours

B. How many flight hours would be essential for a full qualification with the PVS-5's? 18.5 hrs

Subject 1 - 25-35 hours for initial entry; 15 hours for rated

Subject 2 - 10-12 hours for initial entry; 6 hours for rated

Subject 3 - 20 hours

Subject 4 - 10 hours

Subject 5 - 400-500 hours

Subject 6 - 5-10 hours, depends on flight experience. Initial entry student requires more time.

Subject 7 - 15-20 hours

Subject 8 - 10-15 hours

4. What maneuvers do you feel are the most difficult to accomplish with the bifocal NVG? Why?

Hovering 6
360° turn 1
None 1

Subject 1 - Hovering and hovering turns. There are no close references that can be used. If you use fixation through the chin bubbles, you can remain over one spot but there are definite safety hazards evolving from it--barrier clearance, etc.

Subject 2 - (1) Hovering. Your attention is directed out and down from the aircraft, and the bifocal takes some of the downward attention away from you. (2) Termination of approach. Again your attention is directed out, down, and sideward. The bifocal robs you of some of the downward attention.

Subject 3 - Hovering, non-standard and autos. The area that is blocked is very important for drift when hovering, for rate of closure in non-standards, and in a deceleration for autos to see the area and rate of closure and depth perception.

Subject 4 - 360° turns. Need to look from side to side to accomplish the maneuver and to clear the aircraft.

Subject 5 - I had no problems with them. Using proper scan and after becoming familiar, I believe they would be the same as the 40° plano goggle.

Subject 6 - Hovering in one spot. Lack of peripheral vision and reduced depth perception.

Subject 7 - Autorotations and high hover due to loss of lower quadrant visual cues.

Subject 8 - Hovering.

5. Do you think that night vision goggle instruction to initial entry rotary wing students should be given by:

   1. The NOE IP's? __2__

   2. By a special group of IP's assigned solely to night vision training? __6__

   Why?

Subject 1 - Special group of IP's. The NOE IP's themselves do not have enough goggle time to really impart any real instruction. It is okay if they only give a brief familiarization but for qualification it is essential that instructions be given by specially assigned IP's.

Subject 2 - Special group of IP's. To fly NVG's proficiently, it is something that must be done often. If you are away from them a month, for example, you must re-train yourself. (E.g., make yourself scan; does not come naturally. Be experienced enough to relax).

Subject 3 - NOE IP's. The more exposure to different types of flying, the easier it is for a person to adapt to another type of flying. This is even more so with instructors because they have several different styles of flying and can choose which is best or any combination to help themselves or to explain it to a student.

Subject 4 - NOE IP's. They are more advantageous for NOE flight. The background, demonstration, partial use, and fitting can be accomplished in classroom. The NOE flight at night is almost identical for day, with the same requirements.

Subject 5 - Special group of IP's. Problems with adapting body to swing schedule.

Subject 6 - Special group of IP's. Hazards encountered require constant awareness of limitations of goggles.

Subject 7 - Special group of IP's. Nighthawk and NVG training require an intensively trained, highly proficient IP. The skills are very perishable.

Subject 8 - Special group of IP's.

6. How many academic hours should be dedicated to the instruction of IP's who will train students in the use of NVG?

   Average 14.3 hrs

   Subject 3 - 20 hours, to include NOE which is not required at this time but if going to a unit, it will be.

   Subject 5 - Current course is sufficient if Department of Undergraduate Flight Training would abide by guidelines, i.e., contact proficient IP's.

   Subject 7 - Self-paced instruction to a given proficiency level.

8. What are the most important factors affecting a large scale NVG training program?

   Subject 1 - Shortage of pink light filters; stagefield support qualified IP's.

Subject 2 - Morale, long periods of night flying fatigue. There is so much more stress flying nights versus days. For example, I will fly for 3 months straight at night (wife works days).

Subject 3 - Having a set schedule and having stagefields that are safe and not crowded.

Subject 4 - Cost of equipment, scheduling for classes for best ambient light conditions.

Subject 5 - Proper aircraft configuration; proper stagefields abiding by SOP; having facilities available for last shift. E.g., The club student would probably like a beer instead of coffee.

Subject 6 - Total flight experience; increased blade strikes in tactical maneuvers.

Subject 7 - Sufficient training space and equipment.

Subject 8 - Well-trained IP's with good equipment; no other duties or responsibilities and a small IP to student ratio.

9. What should the student-instructor ratio be for night vision goggle training?

__2:1__ (Chosen by all eight subjects)

Subject 2 recommended 1:1 with two-hour limit; 2:1 with one hour per student. An IP should never have to fly more than two hours with goggles.

10. What supplemental illumination techniques have you seen to be the most useful in aiding night vision goggle flights? Explain briefly their mode of operation.

Pink light filter (7 subjects)
Search light filter (1 subject)

Subject 1 - Pink light filter landing light. It refracts light into about a 60 degree cone.

Subject 2 - Pink landing light filter (most effective). Firefly-cluster lights from another aircraft at 5,000 feet.

Subject 3 - Pink light filter.

Subject 4 - Special lens that covers landing light emergency procedures can be demonstrated with little ambient light, overcast sky conditions.

Subject 5 - Pink light filters. Used when ambient lighting is too low. Firefly is hazardous and normally useless.

Subject 6 - Special filter over search light used during limited overcast nights.

Subject 7 - Pink light filter is best. Firefly light is poor.

Subject 8 - Pink light filter.

11. Have you experienced any weather conditions (e.g., rain) which influenced the use of the night vision goggles? Describe the condition(s) and its(their) effect(s).

None 5
Rain 2
Ground fog 1

Subject 2 - No. Our requirement is VFR weather one hour before and one hour after flight training period.

Subject 3 - The rain I have flown in I did not see until it was fairly heavy but was same as with unaided eye except with goggles; it did not reduce your visibility as much.

Subject 4 - NVG's work very well in rain. Rain did not present a problem.

Subject 6 - Ground fog. Moderate fog is penetrated by goggles. You can fly into dense fog without revealing it.

BACKGROUND INFORMATION:

1. Your name (please print)____
(Last) (First) (Middle)

2. Age ___ 3. SSN ____________ 4. Today's Date ______________

5. Present Rank ___ 6. Current Duty Assignment ______________

7. Approximate total hours of flying experience VFR and IFR by aircraft type. Please estimate hours as accurately as possible.

A/C Model/Type	Average Hours VFR	Average Hours AI	Average Hours Hood	Average Total
Rotary Wing				
OH-6	275.0	--	--	275.0
CH-34	250.0	2.0	40.0	292.0
UH-1	1587.5	11.75	156.25	1755.5
OH-58	257.0	.1	12.0	269.1
CH-47	225.0	3.0	11.5	239.5
TH-55	283.3	--	--	283.3
AH-1	1233.3	4.0	23.3	1260.67
Fixed Wing				
T-42	90.0	6.67	20.0	116.67
U-21	75.5	10.0	5.0	90.5
C-150,70 172,1832,180	300.0	--	10.0	310.0
01-A	25.0	--	--	25.0
Cessna 150	200.0	10.0	15.0	225.0
Cessna 310	20.0	--	--	20.0
T-41	100.0	--	--	100.0

8. Please fill in appropriate blocks:

Military Tickets and Rating	Date Earned or Student Hours	FAA-Civilian Licenses and Ratings	Date Earned or Student Hours
UH-1 Contact IP Rotary Wing			
Rotary Wing	2 Jun 69	Commercial w/inst. 2124179	1971
Instructor	1973	Commerical	1973
Instrument UH-1 IP	1974 Sep 77		
Standard	1970		
Rotary Fixed Wing Multiple Engine FW	11 Apr 67 Nov 70 Feb 71	Single land, private FW Multiple engine FW & RW Inst. Commercial	May 65 Mar 71
Army Aviator Sr.Army Aviator	4 Jun 68 4 Jun 75		
Sr. Army Aviator	4 Jun 75	RW & FW Commercial w/inst.	25 Jan 72

9. Average total hours of night flying experience: 381.[illegible]

10. Average total hours of NOE night flying experience: 25.13

11. Average total hours of NOE daytime flying experience: 263.75

12. Average total hour of flight experience with the AN/PVS-5 NVG's: 81.25

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