Technical Report 442

LEVEL II

HELICOPTER ELECTRO-OPTICAL SYSTEM DISPLAY REQUIREMENTS: II.

Performance of Helicopter Pilots When Using a Low-Light-Level Television System During Simulated Night Nap-of-the-Earth Flight

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ARI-TR-442

2Q162722A765

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report 442	2. GOVT ACCESSION NO. AD-A086 855	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HELICOPTER ELECTRO-OPTICAL SYSTEM DISPLAY REQUIREMENTS: II. PERFORMANCE OF HELICOPTER PILOTS WHEN USING A LOW-LIGHT-LEVEL TELEVISION SYSTEM DURING SIMULATED NIGHT NAP-OF-THE-EARTH FLIGHT		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Aaron Hyman, Richard M. Johnson, and Paul A. Gade		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences (PERI-OK) 5001 Eisenhower Avenue, Alexandria, VA 22333		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q162722A765
11. CONTROLLING OFFICE NAME AND ADDRESS Deputy Chief of Staff for Plans and Operations Washington, DC 20310		12. REPORT DATE March 1980 13. NUMBER OF PAGES 9
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Nap-of-the-earth (NOE) flight
Night flying
Night vision

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Previous ARI research has shown that pilots feel they can successfully use a low-light-level television system as an aid in night nap-of-the-earth (NOE) flight, even when the highlight luminance of its display is as little as 0.06 footlambert (fL). Videotaped presentations were used in this prior research, and estimations of the lowest usable display luminance were established on the basis of pilot judgment. The present experiment was designed to provide more objective evidence for determining the utility of such low-luminance displays when they are used as aids in night NOE flight. Each of

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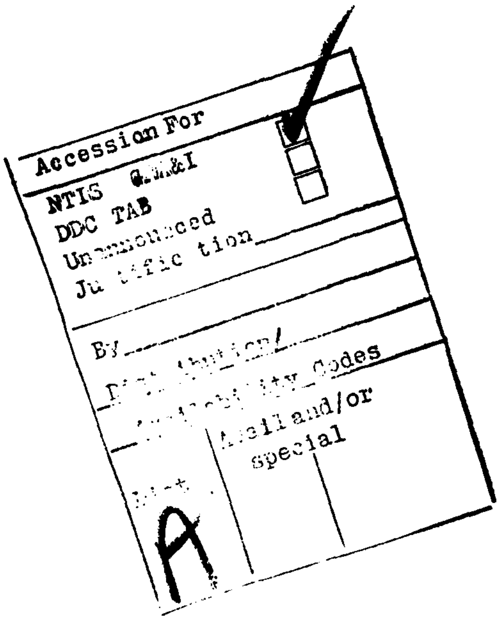
20. 24 Army helicopter pilots made 24 simulated flights over a highly realistic three-dimensional terrain model as generated from an optical probe used in conjunction with an SIT television camera. The results showed that pilots had fewer crashes when using a larger display. All pilots flew as well with displays set so that highlight luminance was about 0.05 fL as they did with displays set so highlight luminance was about 0.2 fL. This report discusses the implications of these results for designing a usable low-light-level television system for night NOE flight.



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HELICOPTER ELECTRO-OPTICAL SYSTEM DISPLAY REQUIREMENTS: II.

Performance of Helicopter Pilots When Using a Low-Light-Level Television System During Simulated Night Nap-of-the-Earth Flight

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Office, Deputy Chief of Staff for Personnel
Department of the Army

March 1980

Army Project Number
2Q162722A765

Helicopter Display Requirements

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FOREWORD

The experiment reported here is the second of three experiments designed to delineate the behavioral requirements for an electro-optical cockpit display system that would permit pilots to perform nap-of-the-earth flight at night. ARI Technical Report 441 reported the first experiment, which investigated the effects of display size, system gamma function, and type of terrain overflown on required luminance levels. This experiment assessed pilot performance at low levels of display luminance.

This research effort was begun under the direction of Dr. Aaron Hyman under Army Project 2Q162722A765 and is responsive to Human Resource Need 77-311, for the Deputy Chief of Staff for Plans and Operations.

JOSEPH ZEIDNER
Technical Director

HELICOPTER ELECTRO-OPTICAL SYSTEM DISPLAY REQUIREMENTS: II. PERFORMANCE OF HELICOPTER PILOTS WHEN USING A LOW-LIGHT-LEVEL TELEVISION SYSTEM DURING SIMULATED NIGHT NAP-OF-THE-EARTH FLIGHT

BRIEF

Requirement:

The first part of an ARI research project, described in Technical Report 441, studied the outcome of varying display luminance and display size in a low-light-level television (LLLTV) system as it might be designed to aid Army helicopter pilots during night nap-of-the-earth (NOE) flight. This research had demonstrated that the simulated cockpit displays could be effective when operated with a highlight luminance of only about 0.06 footlambert (fL). However, the stimulus presentation had been from videotapes of NOE flights, and pilots' subjective judgments had determined the lowest usable luminance levels. The second step was to corroborate these findings, using performance measures, to further establish the utility of a low-light-level television system in night NOE operations.

Procedure:

Using a flight simulator of relatively simple design, each of 24 Army helicopter pilots made 24 short NOE flights over a highly realistic three-dimensional terrain model. During these flights, they were able to control the altitude and groundspeed of the simulated helicopter. All flights were made while viewing a CRT display of the terrain model as generated from an electro-optical probe. The CRT size, its highlight luminance level, and the gamma function of the electro-optical system were varied over the 24 flights. The objective measures of pilot performance were altitude flown, speed flown, and number of crashes.

Findings:

The data on the number of crashes indicate that pilots perform better when using a 25-cm CRT as compared to a 13-cm CRT display. This corroborates the subjective impression of the pilots in both this and the previous research study. All pilots flew about as well with dim displays as with bright displays; and the contrast "enhancement" in the darker areas of the display resulting from a modification of the system gamma function seemed to have little effect. This may have been due to the type of simulated terrain traversed, since the terrain model did not have extensive wooded areas.

Utilization of Findings:

The results of this experiment suggest that CRTs used for display for a low-light-level television system designed to aid in night low-level and NOE flight need certain characteristics to be most effective. For example, such a display should be as large as cockpit space will permit and capable of being operated with a good dynamic range when set at a very dim level. Also, some sort of system gamma function modification may prove to be of value, particularly if several such functions can be devised for use with different types of terrain and display environments.

HELICOPTER ELECTRO-OPTICAL SYSTEM DISPLAY REQUIREMENTS: II. PERFORMANCE OF HELICOPTER PILOTS WHEN USING A LOW-LIGHT-LEVEL TELEVISION SYSTEM DURING SIMULATED NIGHT NAP-OF-THE-EARTH FLIGHT

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INTRODUCTION

In a high-threat environment, Army aviators must avoid exposing their aircraft to visual or electronic surveillance to prevent its destruction by enemy fire and to achieve the tactical element of surprise. Nap-of-the-earth (NOE) flight is the tactic of choice in such a situation. In NOE flight, the aviator must stay as close to the earth's surface as possible, allowing natural terrain features to mask the position of the aircraft. In daylight, NOE flight is difficult and hazardous, and at night it is more so. However, the necessity for conducting round-the-clock operations makes it desirable to include NOE tactics in nighttime operations. This research is part of a larger effort to specify display parameters for the use of a low-light-level television (LLLTV) system as an aid to night NOE flight.

In a previous experiment,[1] Army helicopter pilots viewed simulated LLLTV cathode ray tube (CRT) displays presented from videotape recordings of NOE flight. The pilots judged preferred size of the CRT display (13-cm vs. 26-cm display diagonal), display luminance, and a modified system gamma function designed to enhance the contrast of terrain features in heavily wooded areas. The results of this experiment indicated that pilots could use the LLLTV display when highlight luminance on the monitor was less than about 0.06 foot-lambert (fL). The pilots also expressed a preference for the 26-cm display. In addition, the modified system gamma function appeared to be a desirable feature, both from the pilots' preference and from their measured minimum acceptable luminance levels.

The above-mentioned experiment used videotape presentation of stimulus materials. Thus the pilots made their judgments while viewing preprogramed dynamic displays. To better assess whether pilots can operationally use the LLLTV system at low luminance display levels, some performance measure must be utilized. In this experiment, Army aviators were asked to make several short NOE flights on a simulator that used a scaled-down, three-dimensional terrain model. The simulation system allowed closed-loop control of altitude and ground speed, and its display monitor received its input from an SIT TV camera used in conjunction with an optical probe. Display parameters of size, system gamma function, and minimum acceptable luminance were investigated.

The specific objective of this research was to investigate performance of helicopter pilots, in partially closed-loop simulated NOE flight, when using an LLLTV system as a visual aid.

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[1]Hyman, A., Johnson, R. M., & Gade, P. A. Helicopter electro-optical system display requirements: I. The effects of CRT display size, system gamma function, and terrain type on pilots' required display luminance. ARI Technical Report 441, March 1980.

METHOD

Participants

The participants were 24 rated Army helicopter pilots who volunteered to participate in the study. All had normal or corrected normal vision.

Apparatus

The study was conducted using a selected configuration of the NOE visual flight simulation facility developed by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) and described in detail elsewhere (Hyman, Johnson, & Gade, 1980).

The work station used provided a visual display simulating certain critical aspects of a 6-degrees-of-freedom NOE flight presentation. The subfacility comprised (a) a 4-by-6-foot, three-dimensional, full-color, terrain model designed to simulate a partially wooded terrain at a 1:300 scale; (b) a monocular optical probe for viewing the board directly; and (c) a suitable TV camera and probe/camera interface for presenting the visual display on a remote monitor when needed (see Figure 1). The 3 degrees of translation could be dynamically controlled during a simulated flight. The experimenter sets a fixed value for Y (different for the successive simulated flights), and the pilot controls ground speed (rate of movement along X in this case), and altitude (movement along Z). The 3 degrees of rotation, although adjustable, currently remains set during a simulated flight.

The optical probe was fabricated from off-the-shelf components. It has a telecentric symmetrical optical system with unit magnification, a 60-degree circular instantaneous field of view (FOV), good color correction, and very little distortion. In viewing through the probe directly, the 20/30 line of a Snellen eye chart could be resolved anywhere in the FOV. Depth of field for 20/30 resolution was from about 20 cm to infinity (i.e., for a 1:300 scale from 61 m to infinity). At 5 cm (i.e., at 15.24m for a 1:300 scale) resolution was about 20/70.[2] The observer sees a full-color display of the terrain when viewing at the probe's eyepiece. However, since an SIT TV camera is used for simulating an LLLTV cockpit display, that display is monochrome. Strobe lighting, synchronized with the vertical synch pulse of the TV camera, can be used to improve dynamic resolution (i.e., to reduce video smear during simulated flight).

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[2] Snellen 20/30 resolution is comparable to approximately 3 arc minutes resolution per line pair; and Snellen 20/70, to approximately 7 arc minutes resolution per line pair.

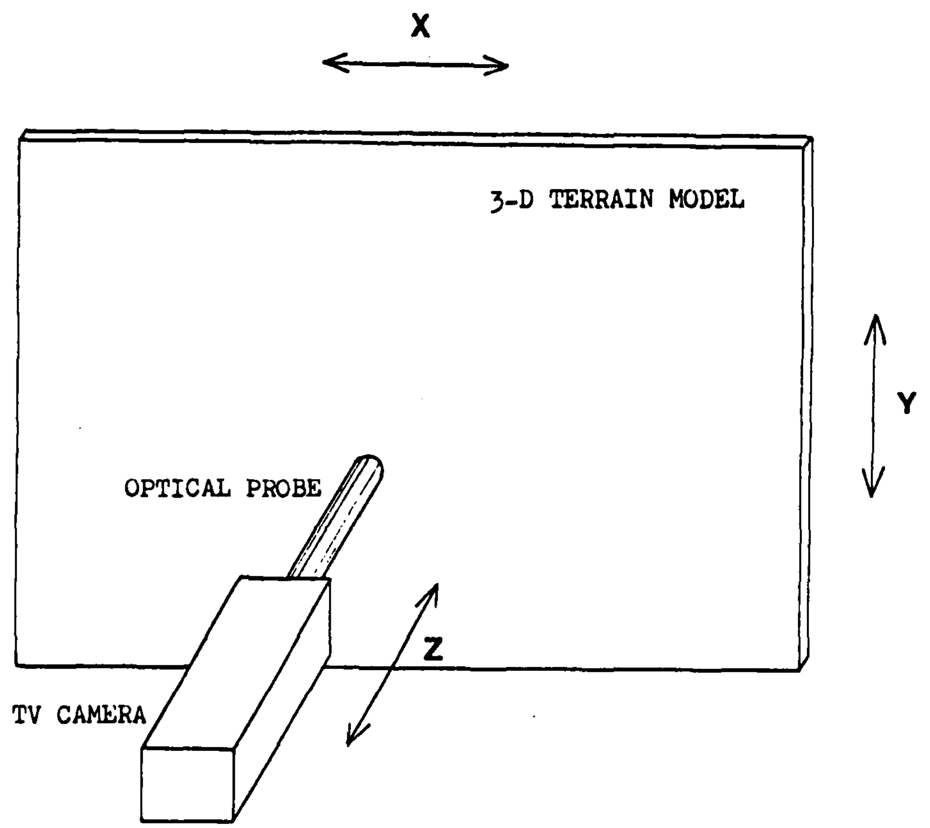

Figure 1. Schematic presentation showing the approach used for obtaining translational movement of the simulated helicopter.

For the data obtained in this study, the pilots viewed CRTs of 13-cm and 26-cm diagonal measure situated at an appropriate viewing distance for a panel-mounted instrument in an AH-1 helicopter (approximately 71 cm). With the stimulus material originating from a 1.22-by-1.83-m, three-dimensional terrain model, a straight run of approximately .5 km was possible. Movement of the terrain model in the x and z axes was under the control of the pilot, simulating forward groundspeed from a hover to 45 knots and altitude from 61 m. The climb and descent rates of the system approximated those of an AH-1 attack helicopter. The pilots regulated these movements by means of simulated collective pitch and cyclic controls while viewing the CRT display.

The CRT display provided a 42-degree horizontal and 31-degree vertical field of view with a downlook angle fixed at 14 degrees. The optical probe was configured to simulate a camera mounted on the nose of the aircraft. Thus, the skids were located approximately 2.3 m below the camera. The pilot controlled the display luminance by means of a fixed and rotating polaroid filter system.

The terrain model could be set to any one of 16 starting positions or "runs" for which terrain profiles were stored in an INTER DATA 90 computer. After the completion of a run, the experimenter was provided with a plot of the terrain and a profile of the pilot's flight path on a CRT display. Any point where the flight profile intersects the terrain profile indicates that a contact or crash occurred. These crashes were actual contacts of the optical probe with a terrain features. If a "light contact" (e.g., brushing of tree limbs) occurred, the flight continued. If a "solid contact" took place, the flight was terminated and the optical probe was reset. A hard copy of flight and terrain profile, number of contacts, airspeed, and altitude was provided for each run.

Procedure

Before the experiment, each pilot was briefed on the major purpose of the study and the task to be performed. The pilot was then seated in a light- and sound-attenuating booth that contained a panel CRT display and the simulated flight controls. The pilot was provided with a headset and intercom system that enabled continuous communication with the experimenter. The pilot was instructed to fly each run under NOE flight rules, but with the understanding that lateral movement was not possible. The pilot was allowed 5 minutes of free practice to become familiar with the control characteristics. During this practice period, the participant was given information concerning real-world FOV, downlook angle, altitude, groundspeed, and control characteristics.

After the practice period, the pilot made a total of 32 runs for data collection purposes. Using a display aspect ratio of 3:4, two sizes of CRTs (13-cm and 26-cm diagonal) and three display luminance conditions were presented. In one condition, a bright display (0.20 fL highlight luminance) with a normal system gamma function (BN) was used. In a second condition, the display again had a normal system gamma function but the pilot was asked to set display luminance so it was as dim as possible and yet judged to allow for safe performance of an NOE mission. This was the dim-normal (DN) condition. In a third display condition, the pilot's dim setting was retained, but the system gamma function was modified to enhance contrast in the darker portion of the display (DM). The modified system gamma function was designed to enhance the visibility of green foliage in heavily wooded areas and did not meaningfully affect the average luminance of the total area.

Each pilot made four runs at each of the two size and three display luminance conditions, for a total of 24 runs. The other eight runs were used as additional practice (P): four runs under the BN display at the beginning of the 13-cm CRT condition and four at the beginning of the 26-cm condition. The order of display size and luminance condition was counterbalanced among subjects. After 16 runs, the pilot was given a 10-minute rest while the display size was changed. After all runs were completed, the pilot was shown the complete experimental setup and examples of the flight profiles, and he was encouraged to make comments about the displays used during the experiment.

RESULTS

Three dependent measures were analyzed for the two CRT sizes (13 cm and 26 cm) and four display luminance conditions (P, BN, DN, DM) in three separate 2 x 4 within-subject ANOVAs.

One dependent measure was the mean altitude differences between the terrain profile and the pilot's flight profile. This measure gives an average height (in meters) that the pilot maintained above the terrain features. Thus, a lower number would reflect better NOE performance. The means for this analysis are presented in Table 1. The only significant factor was display size (F (1.23) = 7.32, $p < .05$), with pilots flying about 60 cm lower with the 13-cm than with the 26-cm display. No statistically significant effect of display luminance nor interactions was obtained.

Table 1

Mean Altitude in Meters

Display condition	CRT size 26 cm	CRT size 13 cm	Mean
P	14.60	13.70	14.15
BN	14.22	14.22	14.22
DN	14.95	13.90	14.42
DM	14.15	13.36	13.76
Mean	14.48	13.79	14.14

Table 2 presents the mean number of crashes for each condition. Again, the only difference approaching statistical significance was for display size ($\underline{F}$ (1.23) = 3.98, $\underline{p}$ < .10). This finding would indicate that although the pilots maintained a lower altitude with the 13-cm display, they had more crashes. In terms of individuals having no crashes or contacts, 43% of the pilots had no crashes with the 26-cm display as compared to 33% with the 13-cm display. Thus, the altitude results considered with regard to the crash data would tend to indicate better overall performance using the 26-cm display.

Table 2

Mean Number of Crashes

Display condition	CRT size 26 cm	CRT size 13 cm	Mean
P	1.38	2.46	1.92
BN	1.25	1.42	1.34
DN	1.13	1.38	1.28
DM	1.33	1.71	1.52
Mean	1.28	1.74	1.51

Table 3 shows the mean speed in knots for each condition. The ANOVA revealed no significant effects for this measure. Regardless of the display size or luminance, an average groundspeed of about 34 knots was maintained.

Examination of individual data made it clear that a wide range of performance was exhibited in the sample. The pilots' average altitude ranged from a low of 8.23 m to a high of 31.10 m. Flying at an altitude of 31.10 m above terrain features would not constitute NOE flight, and obviously there would be few crashes and little likelihood of a display effect. The best five performers and the worst five performers, in terms of flight altitude, were selected and their data reanalyzed, with high versus low flying as a between-subjects variable and the display size (two conditions) and display luminance (four conditions) as the within-subject variables.

The altitude measure was significant because it constituted the selection criterion ($\underline{F}$ (1,8) = 97.67, $\underline{p}$ < .01), with the high group flying at a mean altitude of 17.68 m above the terrain and the low group flying at a mean altitude of 11.28 m. No other effects of display size or luminance were obtained.

Table 3

Mean Groundspeed (in Knots)

Display condition	CRT size 26 cm	13 cm	Mean
P	34.17	35.42	34.79
BN	35.50	35.58	34.54
DN	34.50	34.42	34.46
DM	34.83	34.42	34.63
Mean	34.75	34.46	34.60

In the analysis of crashes, again there was no main effect for display brightness. However, there was a significant effect for display size, (F (1,8) = 15.40, p < .01), and a group by size interaction (F (1,8) = 11.79, p < .01). The means in Table 4 reflect these main effects and interactions. It is not surprising that the high-flying group had fewer crashes than the low-flying group, since it was unlikely that the former would come close to terrain features. The means for the main effect of size are not an accurate reflection of crashes, since the high-flying group had very few. Thus, the group by size interaction is most important. The number of crashes was essentially the same, and very low, for the high-flying group. However, for the low-flying group, a clear indication of superior performance using the 26-cm display was manifested.

Table 4

Mean Number of Crashes for CRT Size and Performance Group

Display condition	CRT size 26 cm	13 cm	Mean
High-flying	.25	.35	.30
Low-flying	2.85	4.35	3.60
Mean	1.55	2.35	1.95

In the analysis of groundspeed used, only the group by display brightness interaction was significant (F (3,24) = 3.46, $p < .05$). Table 5 presents this interaction. The main component of the interaction is in the dim display conditions. The high-flying group flew faster with the DM than with the DN display. Perhaps this occurred because at higher altitudes object texture subtends a smaller angle. At any rate, contrast enhancement of texture seemed to be helpful to this group. On the other hand, the low-flying group produced the opposite pattern of results. At present there seems to be no apparent interpretation for this pattern of results.

Table 5

Mean Speed in Knots for Group and Display Condition

Display condition	Group: High-flying	Group: Low-flying	Mean
P	39.20	32.20	35.70
BN	41.30	32.10	36.70
DN	38.20	34.30	36.25
DM	41.00	29.50	35.25
Mean	39.92	32.02	35.97

CONCLUSIONS

The most clear-cut conclusion evident from the analyses of this experiment is that performance is better with the 26-cm CRT display as compared to the 13-cm CRT display when both altitude and number of contacts or crashes are considered. This result is consistent with the nearly unanimous subjective evaluations of the pilots, which showed a strong preference for the 26-cm display. Most of their comments were to the effect that the 26-cm display was more "lifelike" and afforded better depth perception. It is to be noted that the 26-cm display, with the probe setting used, provides about a 2.5x minification with respect to real-world visual angles as compared to the approximately 5x minification for the 13-cm display. Neither display provides stereoscopic depth cues, but the larger display may permit easier utilization of the available depth information, e.g., closing rates and angular rates of change are nearer to real-world values when viewing the 26-cm display.

The lack of a statistically significant effect for display brightness can be construed as a positive finding. It indicates that the pilots can perform about as well with dim displays, near the limits of photopic vision, as they can with brighter displays. This means that relatively dim displays can be used when the maximum level of visual dark adaptation is needed.

The absence of superior performance with the modified system gamma function also deserves comment. In a previous study (Hyman et al., 1980) the pilots expressed a preference for the modified function when overflying heavily wooded areas such as those near Fort Rucker, Ala. Although the terrain model used in the present study presented some wooded areas, they were not of the density that pilots had observed in the previous experiment. Thus the merit of being able to vary the system gamma function must be determined in a more detailed study.

An important consideration is the incidence of crashes or contacts with terrain features. Ideally, there would be no crashes. In the present study it was not possible to unequivocally distinguish between a contact that would result in aborting the mission and one that would leave inconsequential effects. Pilots who had extensive experience with NOE flight in combat frequently stated that on a "good" NOE flight, it was not unusual to have tree branches and leaves hanging from the skids. While certain contacts seem inevitable, their seriousness must be reduced. Therefore, further research and development of night vision displays, in particular stereo vision displays for NOE flight, appear desirable.

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1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO–E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC–CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL–NV–SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB–DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–TD–S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS–CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEX–GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTS–OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP–MT–S
1 HQ, TCATA, ATTN: Tech Library
1 HQ, TCATA, ATTN: AT CAT-OP-Q, Ft Hood
1 USA Recruiting Cmd, Ft Sheridan, ATTN: USARCPM-P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ, USARPAC, DCSPER, APO SF 96558, ATTN: GPPE-SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean-MCI
1 HQ, USMC, Commandant, ATTN: Code MTMT
1 HQ, USMC, Commandant, ATTN: Code MPI-20-28
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaison Ofc, AMC, Alexandria, ATTN: AMCGS-F
1 USATRADOC, Ft Monroe, ATTN: ATRO-ED
6 USATRADOC, Ft Monroe, ATTN: ATPR-AD
1 USATRADOC, Ft Monroe, ATTN: ATTS-EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
2 USA Aviation Test Bd, Ft Rucker, ATTN: STEBG-PO
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV-ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE-T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL-AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST-T-RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST-D-A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD-TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
1 US Military Academy, West Point, ATTN: Serials Unit
1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE-GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR-5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
1 AFHRL (FT) Williams AFB
1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL-4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000-Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
1 Nat Clearing House for MH-Info, Rockville
1 Denver Federal Ctr, Lakewood, ATTN: BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copenhagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.-Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeris van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands