ARMY RESEARCH LABORATORY

Assessment of the Human Factors Characteristics of the AH-64D Apache Longbow Crew Stations

David B. Durbin

ARL-MR-527 MARCH 2002

Approved for public release; distribution is unlimited.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

ARL-MR-527 March 2002

Assessment of the Human Factors Characteristics of the AH-64D Apache Longbow Crew Stations

David B. Durbin
Human Research & Engineering Directorate

Approved for public release; distribution is unlimited.

Abstract

The human factors characteristics of the AH-64D Apache Longbow helicopter crew stations were assessed. The assessment was based on a survey administered to 43 AH-64D pilots. Results of the assessment indicate that crew workload is manageable during missions and that crews experience lower workload levels, greater situational awareness, and are able to make decisions more quickly in the AH-64D than in the AH-64A. Results also indicate that pilots have not experienced significant problems when using most of the AH-64D crew station controls, displays, and subsystems.

Contents

Executive Summary 1

1. Overview 3
1.1 AH-64D Manpower and Personnel Integration (MANPRINT) Program 3
1.2 Human Factors Issues 4
1.3 System Description 5
1.4 Crew Station Controls and Displays 6

2. Method 8
2.1 Participants 8
2.2 Procedure 9
2.3 Data Analysis 9
2.4 Limitations of Assessment 10

3. Results 10
3.1 Pilot Workload 10
3.2 Situational Awareness 11
3.3 Decision Making 12
3.4 Crew Station Interface 12

4. Summary 16

5. Recommendations 16

References 19

Appendices

A. Bedford Workload Rating Scale 21
B. Summary of Workload Ratings 25
C. Summary of Situational Awareness Ratings 31
D. Summary of Decision-Making Ratings 35
E. Summary of Pilot Responses Regarding Menu Navigation on the Multipurpose Displays (MPDs) 41
F. Summary of Pilot Responses Regarding Readability of Information on the Multipurpose Displays (MPDs) 49
G. Summary of Pilot Responses Regarding Ease of Interpretation of Symbology on the Multipurpose Displays (MPDs) 53
H. Summary of Pilot Responses Regarding Data Entry on the MPDs 57
I. Summary of Pilot Responses Regarding Canopy Reflections 61
J. Summary of Pilot Responses Regarding Physical and Visual Access to Controls and Switches 65

K. Summary of Pilot Responses Regarding Accidental Activation of the Emergency "Zeroize" Switch and Labeling of Items 71
L. Summary of Pilot Responses Regarding Stowage Space 75
M. Summary of Pilot Responses Regarding Readability of Data on the UFDs 79
N. Summary of Pilot Responses Regarding IDM, FM1 and FM2 Radios 83
O. Summary of Pilot Responses Regarding the Environmental Control System (ECS) 87
P. Summary of Pilot Responses Regarding the System and Weapons Processors 93
Q. Additional Comments Regarding the Human Factors Engineering Characteristics of the AH-64D Crew Stations 97

Distribution List 101

Report Documentation Page 107

Figures

1. AH-64D Apache Longbow 6
2. Pilot Crew Station 7
3. CPG Crew Station 7

Tables

1. Demographic Characteristics of Pilots 9
2. Summary of Workload Ratings for the AH-64D and AH-64A . . . 11

Executive Summary

A survey was administered to 43 AH-64D Apache Longbow pilots to assess the human factors characteristics of the AH-64D crew stations. The human factors issues addressed in the survey were pilot workload, situational awareness (SA), decision making, and the crew station interface. The pilots used the Bedford Workload Rating Scale to rate workload in the AH-64D versus the AH-64A. They also rated SA and decision making in the AH-64D versus the AH-64A. This provided a comparative assessment between the two systems and helped evaluate whether the AH-64D has met its operational requirements of (a) imposing less workload on aircrews than the AH-64A, and (b) increasing aircrew efficiency by increasing pilot SA and reducing the time needed to make decisions compared to the AH-64A. In summary, the pilots reported that

- They are not experiencing excessive workload during missions in the AH-64D;

- Crew workload in the AH-64D is lower than in the AH-64A;

- The AH-64D provides significantly greater SA of battlefield elements than the AH-64A;

- Their decision-making process for performing flight and mission tasks is quicker in the AH-64D than in the AH-64A; and

- They have not experienced significant problems when using most of the AH-64D crew station controls, displays, and subsystems.

The pilots commented on the survey and reported in interviews that workload is lower, SA is greater, and the decision-making process is quicker in the AH-64D because a large amount of useful information is presented on the crew station displays. They indicated that the amount of information and the format in which it is presented to the aircrew in the AH-64D is superior to that of the AH-64A.

The pilots' survey responses indicate that the AH-64D is meeting the operational requirements of (a) imposing less workload on aircrews than the AH-64A, and (b) increasing aircrew efficiency by increasing their SA and decreasing the time they require to make decisions when compared to the AH-64A. This is encouraging and helps validate the effort that is being invested in the AH-64D manpower and personnel integration (MANPRINT) program.

INTENTIONALLY LEFT BLANK

ASSESSMENT OF THE HUMAN FACTORS CHARACTERISTICS OF THE AH-64D APACHE LONGBOW CREW STATIONS

1. Overview

An assessment of the human factors characteristics of the AH-64D Apache Longbow crew stations was conducted by the Human Research and Engineering Directorate of the U.S. Army Research Laboratory (ARL). The assessment was based on a survey of 43 Apache Longbow pilots and was conducted from April to June 2000 at Fort Hood, Texas, and Fort Campbell, Kentucky. The following human factors issues were evaluated:

- Pilot workload
- Situational awareness (SA)
- Decision making
- Crew station interface

1.1 AH-64D Manpower and Personnel Integration (MANPRINT) Program

The assessment was conducted as part of the AH-64D MANPRINT program. This program manages the integration of human performance variables in the design and modification of the AH-64D to optimize soldier-system performance. The assessment addressed the following MANPRINT requirements (Dept. of the Army, 2001a):

- Assessment of the AH-64D for potential improvements that could enhance MANPRINT aspects of the system;
- Collection of lessons learned data that could be applied to other Army aviation systems; and
- Validation of AH-64D system performance.

To address validation of AH-64D system performance, the following operational requirements (Dept. of the Army, 1994b) were assessed:

- Does the AH-64D impose less workload on aircrews than the AH-64A?
- Are aircrews more efficient in the AH-64D than in the AH-64A?

Several questions in the survey addressed crew station interface issues that are monitored by the AH-64D MANPRINT Integrated Process Team (IPT). The

questions were included in the survey to assess (a) whether the crew station interface issues were resolved by recent hardware or software changes in the aircraft, or (b) the impact that the crew station interface issues have on pilot and aircraft performance.

1.2 Human Factors Issues

1.2.1 Pilot Workload

A common definition of pilot workload is "the integrated mental and physical effort required to satisfy the perceived demands of a specified flight task" (Roscoe, 1985). It is important to assess pilot workload because mission accomplishment is directly related to the mental and physical ability of the crew to effectively perform their flight and mission tasks. If one or both AH-64D pilots experience excessive workload while performing flight and mission tasks, the tasks may be performed ineffectively or abandoned.

To estimate the level of workload that AH-64D pilots experience during missions, the pilots rated workload for 21 flight and mission tasks. The flight and mission tasks were adopted from Training Circulars 1-251 (Headquarters, Department of the Army, 2000) and 1-210 (Headquarters, Department of the Army, 1995). The pilots were also asked to rate workload for the AH-64A so that a comparison could be made between the AH-64D and AH-64A. This helped determine if the AH-64D met its operational requirement of imposing less workload on aircrews than the AH-64A. The pilots used the Bedford Workload Rating Scale to rate workload for the flight and mission tasks.

1.2.1.1 Bedford Workload Rating Scale

The Bedford Workload Rating Scale (see Appendix A) has been used extensively by the military, civil, and commercial aviation communities for pilot workload estimation (Roscoe & Ellis, 1990). It requires pilots to rate the level of workload associated with a task on the basis of the amount of spare capacity they feel they have to perform additional tasks. Spare workload capacity is an important commodity for pilots since they are often required to perform several tasks almost simultaneously. For example, the AH-64D copilot-gunner (CPG) must often perform navigational tasks, monitor radios, and assist the pilot with flight tasks (e.g., maintain airspace surveillance) within the same time interval. Mission performance is reduced if pilots are task saturated and have little or no spare capacity to perform other tasks.

1.2.2 Situational Awareness (SA)

SA can be defined as the pilot's mental model of the current state of the flight and mission environment. A formal definition (Endsley, 1988) is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." It is important to assess SA because it has a direct impact on pilot

performance. Good SA should increase the probability of good decisions and good performance by AH-64D pilots. To estimate the level of SA that AH-64D pilots experience during missions, they were asked to compare their SA of several battlefield elements in the AH-64D versus the AH-64A. This helped determine if the AH-64D met its operational requirement of increasing aircrew efficiency by increasing pilot SA in comparison to the AH-64A.

1.2.3 Decision Making

Andriole and Adelman (1995) define decision making as "higher order cognitive skills that utilize memory and attention skills for effective problem solving under high workload conditions." It is important to assess decision making in the AH-64D because pilots need to be able to make quick and accurate decisions on the basis of information presented to them in the crew station. They should be able to rapidly filter, correlate, and evaluate the information so they can effectively perform flight and mission tasks. To estimate how quickly AH-64D pilots are able to make decisions, they were asked to compare the time required to make decisions in the AH-64D versus the AH-64A when they conducted flight and mission tasks. This helped determine if the AH-64D met its operational requirement of increasing aircrew efficiency by reducing the time needed to make decisions in comparison to the AH-64A.

1.2.4 Crew Station Interface

The crew station interface directly impacts pilot workload, SA, and the capability to make rapid and accurate decisions during a mission. Controls and displays that are designed to support the cognitive and physical abilities of pilots will enhance their performance and overall system performance. It is important to assess the crew station interface to identify (a) problems that should be resolved and (b) positive design characteristics that could be applied to other Army aviation programs. During the survey and interviews, pilots were asked to identify any problems they have experienced with various crew station interfaces.

1.3 System Description

The AH-64D Apache Longbow (see Figure 1) is a twin-engine, four-bladed attack helicopter. With a tandem-seated crew consisting of the pilot in the rear cockpit and the CPG in the front cockpit, the AH-64D is self-deployable and carries an array of battlefield armaments.

The AH-64D can carry as many as 16 Hellfire missiles. With a range of more than 8000 meters, the Hellfire is used primarily to destroy tanks, armored vehicles, and other "hard" material targets. The AH-64D can also carry 76 2.75-inch folding fin aerial rockets for use against enemy personnel, light armored vehicles, and other soft-skinned targets. The armament system includes 1,200 rounds of ammunition for its 30-mm automatic gun.

Figure 1. AH-64D Apache Longbow.

The AH-64D has a target acquisition designation sight (TADS) and a pilot night vision sensor (PNVS) that enable the aircrew to navigate and conduct precision attacks in day, night, and adverse weather conditions. The AH-64D also has a fire control radar (FCR) that provides the capability to detect, classify, and prioritize stationary and moving targets on the ground and in the air.

The AH-64D is powered by two General Electric gas turbine engines rated at 1890 shaft horsepower each. The maximum gross weight of the helicopter is 17,650 pounds, which allows for a cruise air speed of 126 knots per hour and a flight endurance exceeding 3 hours.

1.4 Crew Station Controls and Displays

The primary controls and displays that AH-64D pilots use to process data and information in the crew station are the multipurpose displays (MPDs), keyboard unit (KU), mission control grip on the collective[1], optical relay tube (ORT) hand grips, and "up front" display (UFD). The controls and displays are depicted in Figures 2 and 3.

[1]The collective permits full authority vertical input.

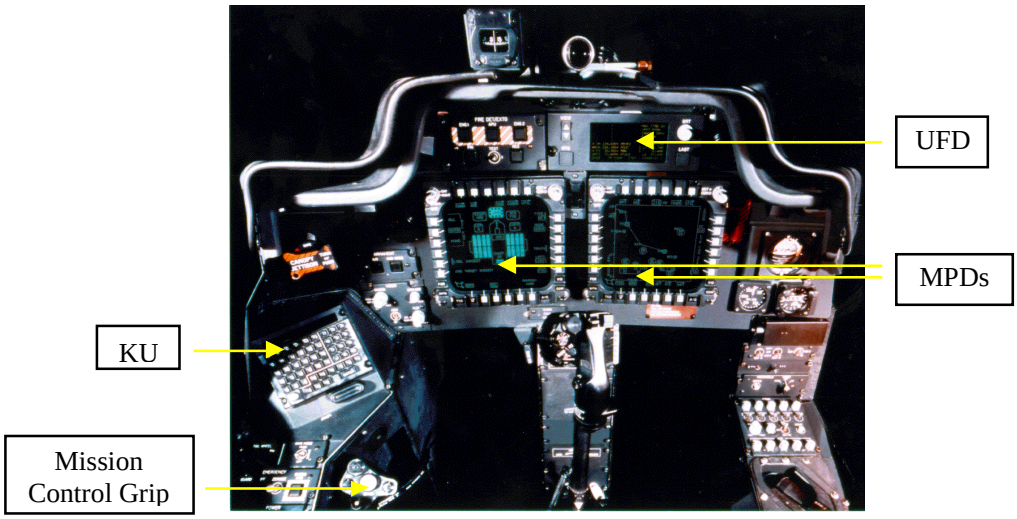


Figure 2. Pilot Crew Station.

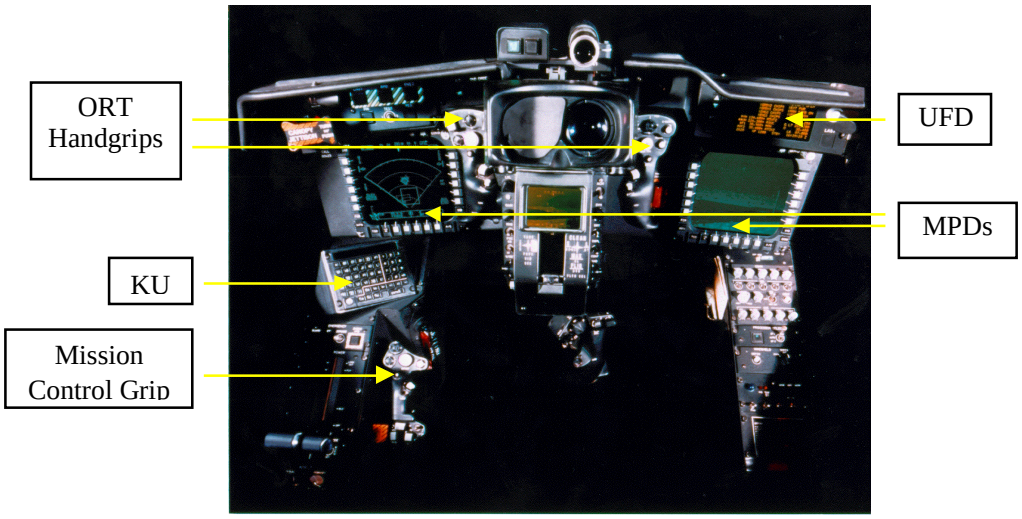


Figure 3. CPG Crew Station.

1.4.1 Multipurpose Displays (MPDs)

The MPDs are color active matrix liquid crystal displays. They provide the capability to control the aircraft and weapons systems and serve as the primary targeting display for the FCR. There are two MPDs in each crew station. The size of each MPD is approximately 6.0 inches vertical by 6.0 inches horizontal. They can be customized by each pilot to support the way he or she monitors aircraft and weapons systems. Each MPD has independent controls for brightness, contrast, and day-night mode. The day-night mode control varies the operating range of the brightness and color of the display during day or night ambient lighting conditions. Data are entered on the MPDs via the keyboard unit,

collective mission grip, ORT hand grips, or bezel buttons along the periphery of the MPDs.

1.4.2 Keyboard Unit (KU)

The KU is a multipurpose control through which the pilots can enter alphanumeric data on the MPDs. It consists of a scratch pad display, alphanumeric pushbuttons, calculator function buttons, special function buttons, and a scratch pad display brightness control. When there is no MPD data entry operation, the KU can be used as a notepad to enter data. There is one KU in each crew station.

1.4.3 Mission Control Grip

Each pilot has the capability to select options on the MPDs through the use of cursor controls mounted on the collective mission control grip. Control of the pilot and CPG MPD cursor symbols in each crew station is independent of the other crew station. The pilot positions the cursor on the MPD by providing a force input in the direction of desired movement. Cursor speed increases when the pilot applies increased force. The pilot positions the cursor on another display by moving it to the adjacent edge of the MPD and then "double bumping" it to the adjacent MPD. There is one mission control grip on the pilot collective and another on the CPG collective.

1.4.4 ORT Hand Grips

The CPG has the capability to select options on the MPDs through the use of cursor controls mounted on the ORT hand grips. As with the mission control grip, the CPG positions the cursor on the MPD by providing a force input in the direction of desired movement. Cursor speed increases when the CPG applies increased force. The CPG positions the cursor on another display by moving it to the adjacent edge of the MPD and then double bumping it to the adjacent MPD.

1.4.5 "Up Front" Display (UFD)

The UFD is a monochrome light-emitting diode display. It displays warnings, cautions, and advisories, as well as the status of the communication system (e.g., radio frequencies). The size of each UFD is approximately 2.25 inches vertical by 4.5 inches horizontal. There is one UFD in each crew station.

2. Method

2.1 Participants

Participants were 43 male Army pilots from the following units:

2-101st Aviation Regiment, Fort Campbell, KY - 19 pilots

1-227th Aviation Regiment, Fort Hood, TX - 15 pilots
21st Cavalry Brigade, Fort Hood, TX - 9 pilots

They represented a group of low to moderately experienced pilots with a range from 40 hours to 850 hours of flight time in the AH-64D. The relevant demographic characteristics of the pilots are listed in Table 1.

Table 1. Demographic Characteristics of Pilots (N = 43)

Summary of Demographic Characteristics	Age (years)	Flight Hours in AH-64D Apache Longbow	Flight Hours in AH-64A Apache	Total Flight Hours (all aircraft)
Mean (M)	34	264	875	1737
Median	34	200	600	1500
Range	24 to 50	40 to 850	40 to 2750	300 to 6050

2.2 Procedure

The pilots were given a brief overview of the purpose of the survey and then provided time to complete it. Upon completion of the survey, the pilots participated in discussions with ARL personnel regarding the human factors characteristics of the AH-64D. During the discussions, the pilots clarified and provided additional information about the issues addressed in the survey.

The survey was developed in accordance with published guidelines for proper format and content (Babbitt & Nystrom, 1989). A brief pre-test was conducted to refine the survey and to ensure that it could be easily understood and completed.

2.3 Data Analysis

Pilot responses to the human factors survey were analyzed with averages and percentages. The responses were further analyzed with the sign test to compare workload ratings between the AH-64D and AH-64A, the chi-square goodness-of-fit test for rating scale responses, and the binomial test for yes-no responses. The sign test was used to identify any statistically significant differences in workload ratings between the AH-64D and the AH-64A. The chi-square goodness-of-fit test and binomial test were used to identify any statistically significant response distributions for survey questions about SA, the decision-making process, and the usability characteristics of the crew station controls and displays. Statistically significant distributions indicate that the responses provided by the pilots to the survey items were not random but were likely attributable to strongly favorable or unfavorable opinions regarding workload, SA, decision making, and the usability characteristics of the crew station controls, displays, and subsystems.

2.4 Limitations of Assessment

The pilots lacked extensive experience flying the AH-64D. Their lack of extensive experience reflects the short time the aircraft has been in the fielding process. Information and data listed in the Results and Summary sections of this report should be interpreted on the basis of this limitation.

3. Results

3.1 Pilot Workload

The pilots rated workload in the AH-64D as lower than in the AH-64A for all 21 flight and mission tasks (see Appendix B). The pilots reported that they typically have sufficient spare workload capacity (i.e., able to attend to additional tasks) when they perform 18 of the 21 (86%) flight and mission tasks in the AH-64D. Conversely, they reported that they typically have sufficient spare workload capacity when they perform only 3 of the 21 (14%) flight and mission tasks in the AH-64A (see Table 2).

When flying in the AH-64D, the pilots reported that they typically experience "insufficient spare workload capacity for easy attention to additional tasks" when they perform 3 of the 21 (14%) flight and mission tasks. Conversely, they reported that they typically experience "insufficient spare workload capacity for easy attention to additional tasks" when they perform 10 of the 21 (48%) flight and mission tasks in the AH-64A. Finally, pilots reported that they typically experience "reduced spare capacity and additional tasks cannot be given the desired amount of attention" when they perform 8 of the 21 (38%) flight and mission tasks in the AH-64A.

The average workload rating for the AH-64A for all 21 flight and mission tasks was 4.24. For the AH-64D, the average workload rating was 3.18. The difference in average workload ratings between the AH-64A and AH-64D is statistically significant (nonparametric: sign test, $\underline{N} = 42$, $\underline{z} = -18.20$, $p < .001$). For each flight and mission task, the differences in workload ratings between the AH-64A and AH-64D are statistically significant at $\alpha < .01$. This indicates that the pilots strongly perceive that workload is lower in the AH-64D than in the AH-64A for the 21 flight and mission tasks they rated. The pilots commented on the survey and reported in interviews that workload is lower in the AH-64D because a large amount of useful information is presented on the crew station displays. The amount of information and the format in which it is presented to the aircrew is superior to that of the AH-64A.

Table 2. Summary of Workload Ratings for the AH-64D and AH-64A

AH-64D Apache Longbow	AH-64A Apache
Pilots reported that they typically have sufficient spare workload capacity when performing 18 of the 21 flight and mission tasks	Pilots reported that they typically have sufficient spare workload capacity when performing 3 of the 21 flight and mission tasks
Pilots reported that they typically experience "insufficient spare capacity for easy attention to additional tasks" when performing Movement to Contact Actions on Contact Mission Change	Pilots reported that they typically experience "insufficient spare capacity for easy attention to additional tasks" when performing Target Engagement Observing Named Areas of Interest Battle Transfer (hand over) Zone Reconnaissance Screen Deliberate Attack Nap of the Earth (NOE) Flight Mask / Unmask Battle Damage Assessment and Reporting Information Management in the Back Seat (pilot)
----------	Pilots reported that they typically experience "reduced spare capacity¾ additional tasks cannot be given the desired amount of attention" when performing Target Detection Target Acquisition Movement to Contact Actions on Contact Tactical Navigation Mission Change Communications Information Management in the Front Seat (CPG)

3.2 Situational Awareness

The pilots reported that the AH-64D provides greater SA than the AH-64A for the following battlefield elements:

Location of enemy units
Location of friendly units
Location of non-combatants
Location of own aircraft
Location of other aircraft in the flight
Route information (e.g., way points)

All the differences in SA ratings between the AH-64A and AH-64D were statistically significant at $\alpha < .01$ (see Appendix C). This indicates that the pilots strongly perceive that SA is greater in the AH-64D than in the AH-64A for the six battlefield elements they rated. The pilots reported in interviews that SA in the AH-64D is higher because a large amount of useful information is presented on the crew station displays. The amount of information and the format in which it is presented to the aircrew are superior to that of the AH-64A.

3.3 Decision Making

The pilots reported that their decision-making process takes less time in the AH-64D than in the AH-64A when they perform the following flight and mission tasks:

Targeting
Navigation
Pilotage
Communication

All the differences in ratings for the time required to make decisions in the AH-64A compared to the AH-64D were statistically significant at $\alpha < .01$ (see Appendix D). This indicates that the pilots strongly perceive that the decision-making process takes less time in the AH-64D than in the AH-64A for the flight and mission tasks they rated. The pilots commented on the survey and reported in interviews that decision making takes less time in the AH-64D because a large amount of useful information is presented on the crew station displays. The amount of information and the format in which it is presented to the aircrew is superior to that of the AH-64A.

3.4 Crew Station Interface

3.4.1 Navigating Through the MPD Pages

Most pilots (93%) reported that they can “quickly” navigate through the MPD pages to acquire information and perform flight and mission tasks (see Appendix E). They also reported that functions are logical, consistent, and require minimal steps to complete for the following MPD pages:

Flight page
Engine pages
Tactical situation display pages
Fire control radar pages
Menu page
Weapons pages
Aircraft pages
Aircraft survivability pages
Data management system pages

Forty-seven percent (47%) of the pilots reported that too many steps are required to complete a function on the Communication pages. The most frequently cited

problem was the number of steps required to "set up" radios. Several pilots commented that setting the altimeter on the Flight page requires too many steps.

3.4.2 Readability of MPDs

Most pilots (77% to 100%) reported that they "never or seldom" have trouble reading or interpreting information on the MPDs because of problems with

Sunlight readability (77%)
Brightness of displays (77%)
Contrast between symbols, text, and the display background (89%)
Display size (91%)
Display vibration (93%)
Color of symbols and text (94%)
Legibility of text (96%)
Off-axis viewability (100%)

Several pilots from the 2-101st commented on the survey and reported during interviews that they have experienced problems with the MPDs flickering or "blanking" during missions (see Appendix F).

3.4.3 Interpretation of Symbology on MPDs

Most pilots (75% to 100%) reported that reading and interpreting the symbology on the MPDs is "very easy or easy" for

Determining whether the FCR, radio frequency interferometer (RFI), or APR-39 detected the targets (75%)
Distinguishing between friendly and threat icons (86%)
Distinguishing between moving and stationary icons (95%)
Distinguishing between lock-on after launch (LOAL) and lock-on before launch (LOBL) missile icons (95%)
Understanding navigation symbology (98%)
Understanding flight symbology (100%)

Although most pilots (58%) reported that it is "easy" to distinguish between icons that are displayed at half intensity versus full intensity on the MPDs, 42% of the pilots reported that it is "borderline" (35%) or "somewhat difficult" (7%) to distinguish between the icons (see Appendix G).

3.4.4 Data Entry on the MPDs

Most pilots (58% to 79%) reported (see Appendix H) that they can quickly enter data or select options on the MPDs by using the

Collective mission grip (58%)
Keyboard unit (68%)
ORT hand grips (79%)

Several pilots commented that entering data with the keyboard unit would be easier if the keys were arrayed like a computer keyboard (i.e., "QWERTY" format).

3.4.5 Canopy Reflections

Most pilots (93%) reported that canopy reflections from the MPDs "never" (43%) or "seldom" (50%) interfere with their out-the-window (OTW) visibility at night in the front seat (CPG) of the aircraft (see Appendix I). Canopy reflections in the back seat were rated as more problematic, with 39% of pilots reporting that reflections "occasionally" interfere with OTW visibility and 7% of pilots reporting that that reflections "frequently" interfere with OTW visibility at night.

3.4.6 Physical Access to Controls and Switches

Fifty percent (50%) of pilots reported that controls and switches are difficult to reach in the crew stations (see Appendix J). The controls and switches listed as difficult to reach include the

Display adjustment panel switches
Circuit breakers
Generator reset panel in pilot's crew station
Intercom system (ICS) switches

3.4.7 Visual Access to Controls and Switches

Most pilots (63%) reported (see Appendix J) that they do not experience problems when viewing controls, displays, and switches in the crew station from their normal seated position. Thirty-seven (37%) of the pilots reported that they have difficulty viewing the following displays and switches:

MPDs (because of blockage by ORT hand grips)
Collective grip switches (need to be backlit)
ORT grip switches (need to be backlit)
Tail wheel lock switches

3.4.8 Emergency "Zeroizing" Switch

Most pilots (95%) reported that they have never accidentally activated the emergency "zeroizing" switch[2] while trying to activate the rotor brake switch in the pilot's crew station (see Appendix K).

3.4.9 Labeling

Most pilots (98%) reported that no items in the cockpit are improperly labeled (see Appendix K).

3.4.10 Stowage

Most pilots (74%) reported that stowage space in the crew station is inadequate (see Appendix L). The pilots commented that lack of stowage space for flight publications is the primary problem.

[2] The zeroizing switch deletes sensitive data when it is activated.

3.4.11 "Up-Front" Display (UFD)

Most pilots (98%) reported that it is easy to read and understand data presented on the UFD (see Appendix M).

3.4.12 Improved Data Modem (IDM), FM1 and FM2 Radios

Most pilots (81%) reported that the IDM, FM1, and FM2 radios "never" (14%) or "seldom" (67%) lock up during a mission (see Appendix N).

3.4.13 Environmental Control System (ECS)

Most pilots (84%) reported that the ECS effectively keeps them cool during missions when the outside air temperature is above 80° F (see Appendix O). Several pilots commented that the ECS thermostat fluctuates, causing the ambient temperature in the cockpit to fluctuate.

Fifty-three percent (53%) of the pilots reported that the ECS micro-switch (in the canopy door lock) "occasionally" (44%) or "frequently" (9%) fails, thereby causing the air conditioner to shut off (see Appendix O). The pilots commented on the survey and reported during interviews that if they cannot temporarily "fix" the problem by jamming a piece of paper into the microswitch, the failure can cause a mission abort (on a hot day) because of high temperatures in the crew stations.

Sixty percent (60%) of the pilots reported that they had not experienced any instances of water spraying or dripping out of the ECS "gaspers" (i.e., air vents) in the 6 months before they completed the survey (see Appendix O). Most of the pilots who had experienced water spraying or dripping out of the gaspers commented that the volume of water was small.

3.4.14 System and Weapons Processor Switchover

Most pilots (71% to 89%) reported that they had not experienced any problems (e.g., unexpected changes in the navigation, communication, or weapons subsystem operation) during a system processor switchover (75%), weapons processor switch-over (89%), or when the aircraft engaged (71%) (see Appendix P).

3.4.15 Forward Looking Infrared (FLIR) System

Several pilots commented on the survey and during interviews that the FLIR on the AH-64D needs to be improved. The pilots who made the comments reported that improving the FLIR is the most important enhancement that can be made in the AH-64D.

4. Summary

In summary, the pilots reported that

- They are not experiencing excessive workload during missions in the AH-64D;

- Workload in the AH-64D is lower than in the AH-64A;

- The AH-64D provides significantly greater SA of battlefield elements than the AH-64A;

- Their decision-making process for performing flight and mission tasks is quicker in the AH-64D than in the AH-64A;

- They have not experienced significant problems when using most of the AH-64D crew station controls, displays, and subsystems.

The pilots commented on the survey and reported in interviews that workload is lower, SA is greater, and the decision-making process is quicker in the AH-64D because a large amount of useful information is presented on the crew station displays. The amount of information and the format in which it is presented to the aircrew is superior to that of the AH-64A.

The pilot responses indicate that the AH-64D is meeting the operational requirements (Department of the Army, 1994b) of (a) imposing less workload on aircrews than the AH-64A, and (b) increasing aircrew efficiency by increasing their SA and decreasing the time they require to make decisions when compared to the AH-64A. This is encouraging and helps validate the effort that is being invested in the AH-64D MANPRINT program.

5. Recommendations

The following recommendations are made on the basis of survey responses provided by the AH-64D pilots:

- Pilots' responses provide data and information that could aid in the development of other Army aviation systems and concepts. These include the RAH-66, UH-60M, CH-47F, Virtual Cockpit Optimization Program, and requirements for the Army fixed wing concept. A copy of this report should be distributed to the program managers for these systems and to the Directorate of Combat Developments, Fort Rucker, Alabama.

· As pilots gain more experience with the aircraft, they should be surveyed to assess trends in their responses to workload, SA, and the decision-making process they experience in the AH-64D. ARL should continue to conduct annual surveys of the AH-64D pilots.

· The pilots reported problems with the usability of some of the crew station controls, displays, and subsystems. The problems include the number of steps required to “set up” radios (i.e., via entries on the software menu displayed on the Communication Page on the crew station displays), the number of steps required to set the altimeter on the Flight Page, flickering and blanking of the MPDs, stowage of gear in the crew station, canopy reflections in the back seat at night, visual and physical access to specific controls and switches, and reliability of the ECS microswitch. These problems should continue to be addressed by the AH-64D MANPRINT IPT until they are resolved.

INTENTIONALLY LEFT BLANK

References

Andriole, S., & Adelman, L. (1995). *Cognitive systems engineering for user-computer interface design, prototyping, and evaluation*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Babbitt, B., & Nystrom, C. (1989). *Questionnaire construction manual.* Fort Hood, TX: U.S. Army Research Institute.

Grubb, G.N., Simon, R.A., Leedom, D.K., & Zeller, J.L. (1995). *Effect of crew composition on AH-64 attack helicopter mission performance and flight safety*. Fort Rucker, AL: Army Research Institute.

Department of the Army (2001a). *Manpower and personnel integration (MANPRINT) in the system acquisition process* (Army Regulation 602-2). Washington, DC: Author.

Department of the Army (1994b). *Operational requirements document (ORD) for the modernized apache attack helicopter.* Fort Rucker, AL: Author.

Endsley, M.R. (1988). Design and evaluation for situation awareness enhancement. In *Proceedings of the Human Factors Society 32nd Annual Meeting* (pp. 97-101). Santa Monica, CA: Human Factors Society.

Headquarters, Department of the Army (1995). *Aircrew training program, commander's guide to individual and crew standardization* (Training Circular 1-210). Washington, DC: Author.

Headquarters, Department of the Army (2000). *Aircrew Training Manual, Attack Helicopter, AH-64D (Lots 1, 2, 3, and 4)* (Training Circular 1-251). Washington, DC: Author.

Roscoe, A.H. (1985). *The airline pilots view of flight deck workload: A preliminary study using a questionnaire* (Technical Memorandum No. FS (B) 465). Bedford, UK: Royal Aircraft Establishment.

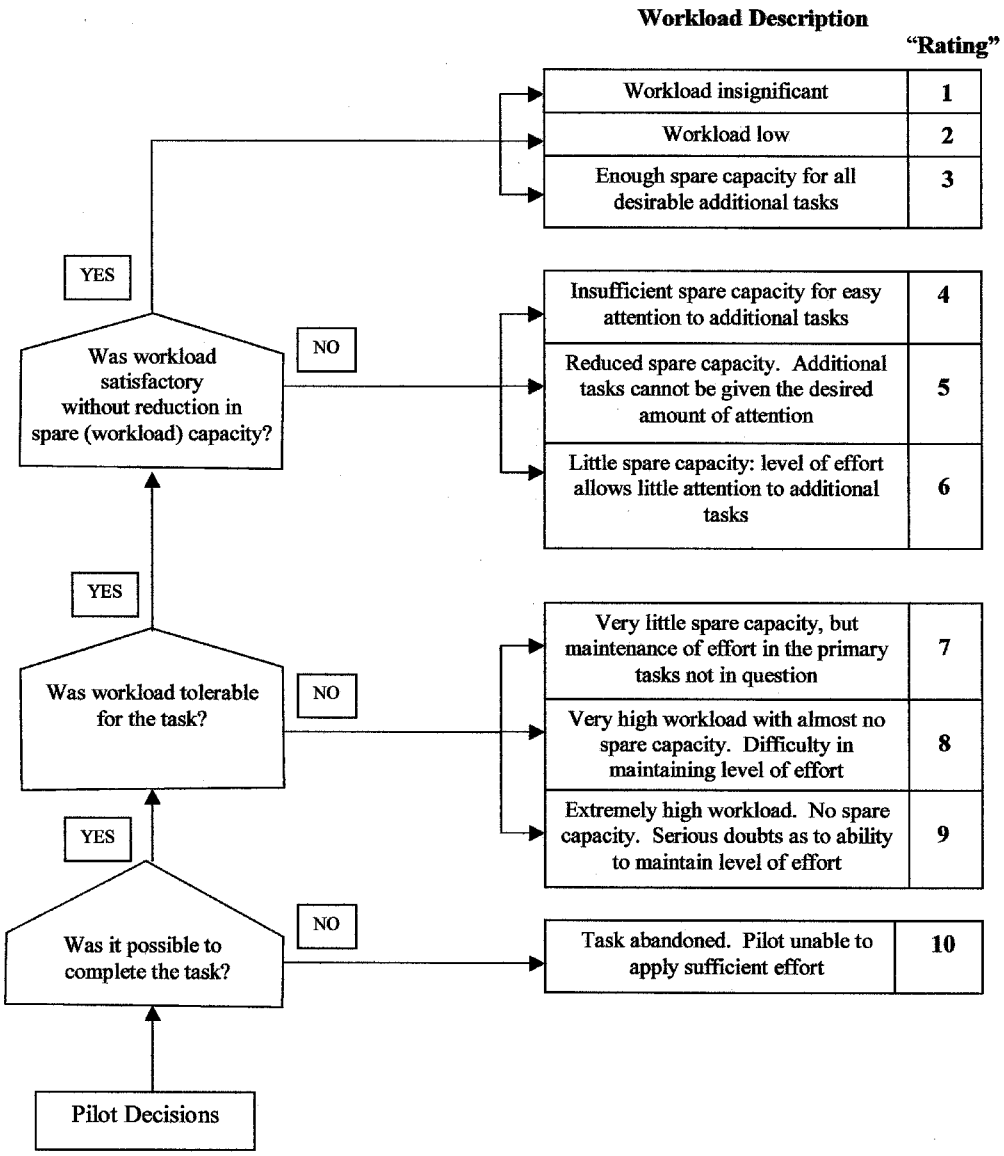
Roscoe, A.H., & Ellis, G.A. (1990). *A subjective rating scale for assessing pilot workload in flight: A decade of practical use*. Bedford, UK: Royal Aerospace Establishment.

INTENTIONALLY LEFT BLANK

APPENDIX A

BEDFORD WORKLOAD RATING SCALE

INTENTIONALLY LEFT BLANK


Workload Description
"Rating"
Workload insignificant
1
Workload low
2
Enough spare capacity for all desirable additional tasks
3
YES
Was workload satisfactory without reduction in spare (workload) capacity?
NO
Insufficient spare capacity for easy attention to additional tasks
4
Reduced spare capacity. Additional tasks cannot be given the desired amount of attention
5
Little spare capacity: level of effort allows little attention to additional tasks
6
YES
Was workload tolerable for the task?
NO
Very little spare capacity, but maintenance of effort in the primary tasks not in question
7
Very high workload with almost no spare capacity. Difficulty in maintaining level of effort
8
Extremely high workload. No spare capacity. Serious doubts as to ability to maintain level of effort
9
YES
Was it possible to complete the task?
NO
Task abandoned. Pilot unable to apply sufficient effort
10
Pilot Decisions

INTENTIONALLY LEFT BLANK

APPENDIX B

SUMMARY OF WORKLOAD RATINGS

INTENTIONALLY LEFT BLANK

Flight and Mission Tasks[a]	Workload Rating for the AH-64D Apache Longbow	Workload Rating for the AH-64A Apache
Target Detection	3.17	4.87
Target Acquisition	3.29	4.73
Target Engagement	3.17	4.39
Movement to Contact	3.85	4.67
Actions on Contact	3.85	4.75
Observing NAIs	2.77	3.82
Battle Damage Assessment and Reporting	2.70	4.02
Mission Change	3.82	5.23
Battle Transfer (“hand over”)	3.05	4.48
Tactical Navigation (Contour / NOE)	2.60	4.85
Communications (battle command, tactical fire direction system [TACFIRE], etc.)	2.97	4.53
Zone Reconnaissance	3.48	4.46
Screen	3.33	4.12
Deliberate Attack	3.10	4.35
NOE Flight	3.16	4.00
Contour Flight	2.69	3.45
Low Level Flight	2.19	2.97
Mask / Unmask	2.40	3.50
Hover	2.04	3.00
Information Management in the Front Seat (CPG)	3.35	4.71
Information Management in the Back Seat (Pilot)	3.05	4.35

[a]Differences in workload ratings for all flight and mission tasks (AH-64D versus AH-64A) significant at $\alpha < .01$

Comments regarding positive impact on workload:

- AH-64D has / provides excellent situational awareness, excellent navigation, easier target acquisition and awareness; radios are easier to monitor, etc.
- I feel the routes and obstacles posted aid significantly with overall workload.
- Multi-function display (MFD), tactical situation display (TSD), etc. ease navigation and situational awareness workload.
- Radar eases workload for moving target detection.
- Much better situational awareness and the ability to do more from both seats allows for better delegation of duties.
- Navigation – Time on target is simple in the 'D' model. You already know what frequencies are on each radio, and which ones the other crew member is monitoring. Weapons status – remaining ammunition can be checked at a glance. Tanks are automatically leveled. Hold modes much improved. Do I need to continue?
- Workload is somewhat lower because everything for the most part is right in front of you. Everything depends on your initial set-up before take-off.
- The ability to have TSD which aids in navigation greatly reduces workload. If you have functioning embedded global positioning – inertial navigation system (EGI) and a low position confidence, it greatly frees up the front seater to work on gunnery or scanning tasks while the pilot keeps the aircraft itself safe.
- AH-64D is great for workload because fuel transfer / fuel management, navigation – excellent! (i.e., TSD, EGIs). Hold modes are excellent! 100% better than the 'A' model.
- Communications excellent! – especially the way they are set-up on UFD and ability of either crew member to tune either radio. Symbology also has significant improvements.
- Better situational awareness in the Longbow lends more attention to critical tasks.
- Graphic representation of way points (WPs), present position (PP), phase lines (PLs), routes, etc. allows crew much more flexibility in concentrating on movement to / from objective and actions in the battle position (BP) or attack by fire (ABF).
- World of information at your fingertips in the 'D'… It is easier but how hard is it to look at your knee board compared to pushing a few buttons?
- There is much less work in the navigation and communication areas with the AH-64D. I am no longer tediously punching in grid coordinates or taking up valuable time trying to tune radios. I also virtually cannot get lost in this aircraft. It is leaps and bounds above the 'A' model in these respects.
- Lower information management and situational awareness is much better in the AH-64D.
- Workload seems to be lower, however, we are presented with so much information about so many different systems, it is easy to become focused inside more than necessary sometimes. I force myself to focus outside so I don't get caught up on the inside.
- Reduced in some areas, increased in others, but I like it.
- The work is the same, if not more in the AH-64D, but it is better organized in the 'D' making it easier.
- So much of the "busy" tasks in the AH-64A are now either routine or transparent in the AH-64D.
- Situational awareness allows for a reduced workload.
- Workload is greatly reduced from the AH-64A. Love that about the aircraft. I can concentrate more on flying than navigating. As far as ease of navigation and target engagement en route, I believe that I can effectively act as flight lead, navigate, and engage targets and still be on time and on target because of reduced workload and superior situational awareness. Next to impossible in the AH-64A.
- More situational awareness in 'D'. If capable and manageable, more information in 'D' is better. Thus, workload lower in 'D' model. Also, quicker to use controls in 'D' model if continual flight training is being conducted.
- Better crew station management but more buttons to push.
- Workload could be much lower in the Longbow; however, it is only marginally so.

Comments regarding increased workload in crew stations.

- There is simply more information to manage. For example, getting a PP of the wing requires many button pushes instead of just asking and plotting on the map. If you don't continue inquiring the wing, the aircraft symbol displayed is "old" when wing moved and it becomes confusing.
- The information management piece and interpolation along with all the added capabilities increase the pilot and CPG workload in the 'D' model (especially during routine missions). However, in the Longbow, added flight control systems and capabilities are less workload in the 'D' model than the 'A' model (i.e., hover hold modes, TSD, dual GPS, navigation).
- Information overload.
- Aircraft gives me more situational awareness, ease of finding and engaging targets, and less system management, but it has not decreased my workload. It has actually increased it. Instead of one perishable skill (in the AH-64 flying pilot night vision system [PNVS]), I now have two (flying PNVS and navigating the MFD pages). There are more tasks to perform.
- Longbow has more information and does more with information and allows for more situational awareness so that unfortunately, the front seater in the lead aircraft is busier than ever. Instead of briefing priority fire zone (PFZ) or no fire zone (NFZ), now you pull into a battle position, draw it (taking time) sending RF "hand-overs" (RFHOs) or targets to other aircraft.
- Because of increased capabilities, the aircrew has even more to do, i.e., improved data modem (IDM), target "hand over," free text, battle damage assessment (BDA), etc.
- More data required to input if not existing or part of pre-mission planning.
- A lot of time inside pushing buttons.
- Low use of the system (negatively impacts workload).
- With no trainer or flight experience (due to maintenance / groundings), you use it or lose it. We are losing it badly!!
- The main problem is lack of training for the FCR. There has never been a good training program for it.

Other comments:

- Should be able to link target acquisition detection system (TADS) to FCR without sight selecting FCR in front seat.
- Entering latitude / longitude grids can be hard without practice.

INTENTIONALLY LEFT BLANK

APPENDIX C

SUMMARY OF SITUATIONAL AWARENESS RATINGS

INTENTIONALLY LEFT BLANK

Battlefield Elements	AH-64D Provides Much Greater SA (percent)	AH-64D Provides Somewhat Greater SA (percent)	AH-64D Provides About The Same Amount of SA (percent)	AH-64D Provides Somewhat Less SA (percent)	AH-64D Provides Much Less SA (percent)
Location of Enemy Units[a]	**74**	**21**	**5**	**0**	**0**
Location of Friendly Units[a]	**70**	**25**	**5**	**0**	**0**
Location of Non-Combatants[a]	**21**	**36**	**41**	**2**	**0**
Location of My Aircraft During Missions[a]	**88**	**12**	**0**	**0**	**0**
Location of Other Aircraft in My Flight[a]	**77**	**23**	**0**	**0**	**0**
Route Information [a]	**93**	**7**	**0**	**0**	**0**

[a]Significant at $\alpha < .01$

List any problems with situation awareness in the AH-64D Longbow:

Comments:

- Location of enemy, friendly, and civilian units is somewhat the decision of who is programming the Aviation Mission Planning System (AMPS).
- The location of friendly units is only as good as your S-2 because these data are placed in the aircraft via AMPS.
- The situational awareness is only as good as what is put into the AMPS and how well the IDM is working. If incorrect information is put into the AMPs or the IDM is not working properly, then it is no better than the 'A' model.
- Enemy location is only as good as the intelligence…
- No problems. Love the greater awareness it provides. It allows focus to be placed elsewhere.
- People need to fly more to get used to the TSD.
- If the radios aren't talking with one another, it is harder to maintain the instant status of situational awareness – either caused by radio lock-up or insufficient power to transmit in hills and mountain area.
- It takes a very long time to receive PP from other aircraft in flight during missions. Also, the IDM messages as a whole are slow and somewhat unreliable in attack aviation due to low altitude of aircraft. All present radios need line of sight to receive/transmit to other aircraft.
- It also confuses the pilot because of all the false target returns and "old" updates of aircraft positions and FCR targets.
- It is still a map, not an overlay.
- Pilot error of leaving TSD page frozen gives false sensation of positive situational awareness.
- FCR type targets in relation to the number of false target returns. Many, many false targets.
- FCR is a tool not available on all AH-64Ds.
- This is more true if compared to non-EGI AH-64A.
- Need to have a dedicated system to continuously update all aircraft positions at all times. Real-time TSD icons moving (i.e., something like what is used in the Tactical Environment Support System [TESS]).
- PP query is nice, but it's only a snapshot.

APPENDIX D

SUMMARY OF DECISION-MAKING RATINGS

INTENTIONALLY LEFT BLANK

Tasks	Decision-Making Process Takes Much Less Time in the AH-64D (percent)	Decision-Making Process Takes Somewhat Less Time in the AH-64D (percent)	About The Same Amount of Time is Required to Make Decisions (percent)	Decision-Making Process Takes Somewhat Longer Time in the AH-64D (percent)	Decision-Making Process Takes Much Longer Time in the AH-64D (percent)
Targeting Tasks[a]	30	44	23	3	0
Navigation Tasks[a]	77	23	0	0	0
Pilotage Tasks[a]	30	56	14	0	0
Communica-tion Tasks[a]	30	60	5	5	0

[a]Significant at $\alpha < .01$

If you rated decision making in the AH-64D Longbow as quicker or slower than the in AH-64A, briefly explain why:

Positive comments regarding decision making:

- Navigation with GPS is excellent.
- Radios easier to manage with preset frequency and push buttons.
- Just overall, AH-64D easier to use.
- Navigation – Time on target is simple in the 'D' model. You already know what frequencies are on each radio and which ones the other crew member is monitoring. Weapons status – remaining ammunition can be checked at a glance. Tanks are automatically leveled. Hold modes much improved. Do I need to continue?
- AH-64D is great for workload because fuel transfer / fuel management, navigation – excellent! (i.e., TSD, EGIs). Hold modes are excellent! 100% better than the 'A' model. Communications excellent! – especially the way they are set up on UFD and ability of either crew member to tune either radio. Symbology also has significant improvements.
- With the TSD, I'm able to make tactical navigation decisions much quicker. Being able to tune radios with one or two button pushes allows me more time to communicate and assess situations around me much quicker.
- All information is displayed in both seats so crew coordination can happen much quicker.
- AMPS is very helpful. Changes in flight are simple because we have added contingencies into the AMPS – makes decisions somewhat easier.
- More is displayed = greater situation awareness. Easier to make decisions. Better video helps, too.
- Both crew members have access to the same radios / systems.
- Again, "busy" tasks are now routine or non-existent in the AH-64D.
- Target – if you have FCR, makes it quicker on some targets. Communications – increased capability of communications added to the process, making some items easier.
- Targets still need to be visually identified, but acquisition is faster.
- Targeting task time is reduced only if TSD has valuable and accurate information. Otherwise, no time is saved.
- Information graphically represented, easier to access. Radios (FM, UHF) easier to program.
- Much more user friendly. More information available than you can possibly ever use. The only trouble is selecting what you really need from what is just nice to have.
- Communication architecture and TSD for navigation contribute to quicker decision making.
- Acquiring targets takes much less time with an FCR.
- Targeting with FCR is fast, even with a visual ID (link TADS). It is faster than the 'A' model. Navigation with good pre-mission planning is almost effortless.
- Elimination of constant map usage is great.
- Easily tell what radio you are tuned to.
- "Last" function for communications is super.
- Targeting in 'D' will be much quicker if Xflot; otherwise, visually ID targets before engagement to avoid "friendlies".
- Although it may take a little longer to work on accurate AMPS load, once you perform a master load in the aircraft, very little "fat fingering" work is required by the crew.

Other comments:

- Targeting is still pretty much the same. Even if you pick up FCR targets, you still have to identify them before engaging. The generation 1 FLIR still stinks!!
- Targeting tasks are not always quicker than in the 'A' model. When the FCR is showing false target data, you spend more time working with the TADS than you would if you just used the TADS to search for targets.

- Aircraft pulls you inside more. This could lead to an aircraft striking an object.
- Because of GPS interface, the navigation/communication data are much more reliable than the 'A' model. However, because of increased ability to detect targets with the FCR/RFI, you have more targeting decisions to make, while the acquisition time is greatly increased.
- In order to function on the battlefield successfully, the communications page has to be set up correctly.
- False targeting of FCR requires more time due to re-scanning and linking to find real targets!
- The AH-64D allows the pilot and CPG to manage more and more information but requires more decision making because of the amount we can now manage.
- Navigational skills of aviator have diminished in AH-64D community due to the reliance on TSD.

INTENTIONALLY LEFT BLANK

APPENDIX E

SUMMARY OF PILOT RESPONSES REGARDING MENU NAVIGATION ON THE MULTIPURPOSE DISPLAYS (MPDs)

INTENTIONALLY LEFT BLANK

Any functions that are not logical and consistent?	Any functions that require too many steps to complete?
Flight (FLT) Page[a] Yes 5% No 95%	Flight (FLT) Page[a] Yes 23% No 77%
Engine (ENG) Pages[a] Yes 7% No 93%	Engine (ENG) Pages[a] Yes 9% No 91%
Tactical Situation Display (TSD) Pages[a] Yes 7% No 93%	Tactical Situation Display (TSD) Pages[a] Yes 16% No 84%
Communication (COM) Pages[a] Yes 23% No 77%	Communication (COM) Pages Yes 47% No 53%
Fire Control Radar (FCR) Pages[a] Yes 2% No 98%	Fire Control Radar (FCR) Pages[a] Yes 2% No 98%
Menu Page[a] Yes 0% No 100%	Menu Page[a] Yes 0% No 100%
Weapons Pages[a] Yes 9% No 91%	Weapons Pages[a] Yes 14% No 86%
Aircraft (A/C) Pages[a] Yes 5% No 95%	Aircraft (A/C) Pages[a] Yes 5% No 95%
Aircraft Survivability Equipment (ASE) Pages[a] Yes 2% No 98%	Aircraft Survivability Equipment (ASE) Pages[a] Yes 2% No 98%
Data Management System (DMS) Pages[a] Yes 5% No 95%	Data Management System (DMS) Pages*[a] Yes 5% No 95%

[a]Significant at $\alpha < .01$

If you answered yes to any of the questions, describe problems you have experienced and how the page(s) could be better organized or streamlined:

Problems with COM Pages:

- COM Pages – Radio set up during "run-up" is a major time consumer. It should be easier to set up radios (tactical communications). If one aircraft fails a specific set-up, the remainder of the flight defaults to the failed settings.
- On communication system, should not have to go to COM UTIL page to change from FH to SC (or HQ page) when entering EMER guard button on Emergency Panel.
- COM Page – Searching to build a net. When you find a company / battalion call sign and frequency, have all frequencies for that company / battalion on that page.
- Timing of HQ radio is inconsistent. If you know the system, you can work around problems to get the system to GPS time. If not, you will not get the radio to FH.
- COM – I was never able to store "ALL IDM communications-electronics operation instructions (CEOI)" when received via the IDM from other helicopter.
- COM – It would be better if the own "call sign" and "originator" could be entered on the main COM page. We were never able to talk HQ II and secure on KY-50 at the same time!! or UHF!!
- Cipher / Plain should be on each radio page.
- COM – Would like to see a fixed action button (FAB) for transponder on / standby.
- Communication is far simpler than the 'A' model, but once again, had to go to several pages such as FM / Sinc Ops. It would be nice to access Cipher from Sinc Page along with power settings.
- COM – To change a Freq. Hop preset, you must go frequency hop (FH) / Master, then edit, then change it and go back to FH. Should be simpler.
- COM / Sinc page – I think it is illogical to access electronic counter-counter-measure remote fill (ERF) send function in order to edit a Net ID.
- COM – Without the AMPS, communications setup could potentially force a mission to depart late.
- COM Pages – Not intuitive on naming Net so I.D. shows on UFD when selected.
- COM Pages – Too many steps to set "ownship" call sign (C / S) and subscriber.
- COM Page – Changing / editing a "hopset" requires way too many button pushes.
- ATHS – The whole thing needs to be more user friendly.

Problems with Flight Page:

- FLT Set – When entering data on the altimeter, the need to enter decimals (i.e., 29.92)
- FLT page – Too many steps to change the altimeter. Put altimeter on a top level page.
- FLT Page – Takes almost 12 button pushes to change altimeter setting.
- FLT page – should have an up / down arrow for pressure altitude on flight page (not flight set page then keyboard unit (KU) function).
- FLT Page – Changing altimeter setting requires too many steps.
- FLT Page – Need an up / down or increase / decrease altimeter that would incrementally change the setting (similar to setting a clock radio's time).
- FLT Page – Too many steps to change the altimeter.
- FLT Page – Problem with altimeter settings.
- FLT Page – Too many steps to change the altimeter setting.
- On FLT SET is the selection for nautical miles (NM) or kilometers. That should be located somewhere in the TSD pages (i.e., utility [UTIL] or show [SHOW]).

Problems with Weapons Pages:

- Weapons page – Missile code changes are hard to locate. Put them on the semi-active laser (SAL) page.
- During gunnery weapons engagements, it has taken a few extra seconds to access and set up weapons systems because of having to go to multiple levels (pages). Example altimeter / pri Hellfire to where as the 'A' model is just a switch.

- Load page – Rounds should be entered / checked from area weapon system (AWS) page and rocket type should be entered from the rocket page – Eliminate LOAD page.
- Weapons Utility Page is underused – should be able to run BIT or Weapons, Sensors from one page.
- While any weapon is "actioned," it would be nice if you could still change settings on another weapon. While the gun is actioned in the back seat, the back seat cannot affect the MSL page.

Problems with TSD Pages:

- TSD – Routes, waypoint and CM sometimes show up on MPD in back seat, but not in front seat and vice versa.
- TSD – Display of name of line or EA is only last three letters.
- TSD – To enter the threat SA-8, you must enter "space," "8". Should be able to just enter "8" or even "08," just like SA-4, SA-6, etc.
- TSD Pages – Too many steps to turn Allocation and Distribution of Fires (ADF) on.
- The ADF button is two pages deep. Default it "on".
- TSD – Building routes can be a tedious task.

Problems with Engine Pages:

- As an IP, I would like to access ENG page in the same manner I access FLT page – 1 bump for FLT, 2nd bump for ENG page.
- Engine pages! - 2 Power Lever to fly. FLT Mode boxes should go away. Show more information.
- ENG Page – Performance page Go / No-Go numbers don't jive with Power Projection Command (PPC). They may mean the same but aren't presented in a format I recognize.

Problems with DMS Pages:

- On the DMS Utility Boresight Page, when "verifying" the correctors, it can be confusing when choosing between the "verify" and "edit" buttons. If the verify button is pressed, correctors can get dumped or lost. Reversing the role of those two buttons may be more helpful. When I'm verifying correctors, instinctively I start to hit the verify button.

Problems with HIT Page:

- HIT Page needs to include all the following information as well as the ability to calculate HIT (torque [TQ], turbine gas temperature [TGT], baseline numbers, temperature, and ability to turn anti-ice on) all on one page.
- Hit Check page should have inlet anti-ice selection.
- Problem with HIT Check baseline.

Positive Comments:

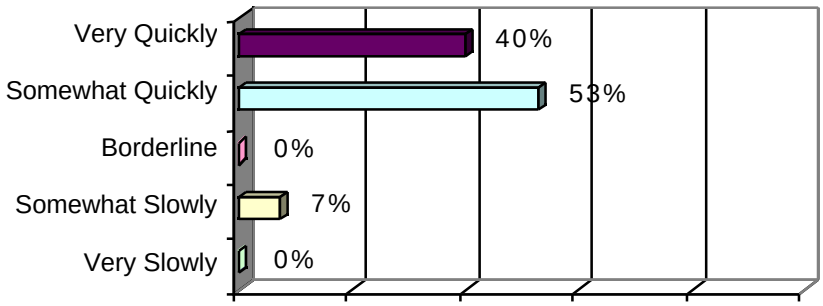
- I am extremely pleased with MFD functions. They seem logical and consistent from my perspective. It does take time, as with any new system, to learn location and function. However, with that accomplished, information access is a breeze. It is user friendly as far as I'm concerned.
- Lot 4 improvements are very good – much better than Lot 1-3.

Other Comments:

- Default TADS / PNVS to "off", in SP software. This will expedite maintenance when one operator is performing an maintenance operational check (MOC) on a component other than TADS / PNVS. In the current configuration, the possibility exists (and probably happens daily) of a hard shutdown of the TADS / PNVS.

- Should not have to push buttons to check Bleed Air “on’.
- Should be able to test backup computer system (BUCS) in / from either seat.
- It would be easier if the SET Page were omitted.
- Menu Page is not used. It is much easier to use FABs.
- Sometimes, needed information is hidden.
- Sometimes, menus or selections become cluttered.

Overall, how quickly are you able to navigate through the MPD pages?[a]



If you circled 'Somewhat Slowly or Very Slowly', explain why:

- Repetition overcomes illogical page locations.
- Very perishable. If you fly often, can move very quickly.
- Navigating through the MFD pages is a perishable skill and we just do not get enough flight time in the aircraft to maintain proficiency. Nearly all aviators (except for IPs) require waivers in flight time. 70 hours every 6 months is not enough time to maintain proficiency, and we're getting much less. This semi-annual period, I believe I have 10 hours in this aircraft and the last semi-annual period I had a total of 25 hours for that 6-month period.
- Note: Highly perishable skill. If you miss flying for any amount of time, your speed of navigating through the pages will decline.
- Still trying to figure out the "in's and out's" of this system. It's not user friendly to a newcomer.
- No trainer!!! No consistent flying due to maintenance and groundings!!!

[a]Significant at $\alpha < .01$

INTENTIONALLY LEFT BLANK

APPENDIX F

SUMMARY OF PILOT RESPONSES REGARDING READABILITY OF INFORMATION ON THE MULTIPURPOSE DISPLAYS (MPDs)

INTENTIONALLY LEFT BLANK

Display Characteristics	Never Have Trouble (percent)	Seldom Have Trouble (percent)	Occasionally Have Trouble (percent)	Frequently Have Trouble (percent)
Legibility of Text[a]	**77**	**19**	**0**	**4**
Contrast Between Symbols, Text and the Display Background[a]	**56**	**33**	**11**	**0**
Brightness of Displays[a]	**37**	**40**	**21**	**2**
Vibration of Displays[a]	**70**	**23**	**7**	**0**
Off-Axis Viewability (viewing the displays at an angle)[a]	**71**	**29**	**0**	**0**
Size of Displays[a]	**68**	**23**	**9**	**0**
Sunlight Readability (sunlight washing out displays)[a]	**19**	**58**	**23**	**0**
Color of Symbols and Text on the Displays[a]	**49**	**45**	**6**	**0**

[a]Significant at $\alpha < .01$

Describe any problems reading and understanding information on the MPDs:

Problems with flickering and blanking of MPDs:

- In almost all aircraft, the MPDs will flicker on / off in certain brightness ranges. The MPD brightness setting will occasionally change without pilot input.
- Brightness on some MPDs will flicker on and off if knob is not set in a "magical" spot.
- Some aircraft have bright (BRT) knobs that are very touchy and the MPD brightness flickers, which tends to be very annoying during night flight.
- In night mode, brightness flickers and is unable to set at appropriate level.
- Brightness – some brightness knobs move under vibration and some flicker between too bright and unreadable.
- There is a major problem with some MPD brightness at night. When I set the brightness to mid-range or less, aircraft vibration (?) can cause the MPD to go black. Tighten the rheostat specifications, and this problem will go away.
- Can't turn the MPDs way down during night operations without the MPD totally blacking out. Back seat can sometimes have difficulty with glaring MPDs from the CPG station. Bat wings too much trouble and cumbersome.
- Brightness knob on some MPDs are very sensitive and may cause the screen to flash between high brightness and a lower one.
- Sometimes problems with the brightness adjustment – sometimes turn down past midrange and MPD blacks out.

Problems with sunlight readability:

- Sunlight doesn't affect display readability; it does affect color recognition at times.
- The sun sometimes makes it very difficult to read the MPD. That's why I usually fly with Bat Wings during the day.
- During some maintenance flight tasks when the sun is over the shoulder on either side of the front seat, it makes the MPD on that side hard to read.

Problems with size of display:

- TSD symbols are too cluttered for a small area. Engagement areas (EAs) become too cluttered with information. Need an additional scale size larger than scale 5 zoom (i.e., scale 2.5 for once you arrive in an ABF.
- I sometimes have trouble "CA^{Q}-ing" (cursor acquisition) on a target because the TSD target / threat symbols sometimes overlap – even when in scale 5.

Other comments:

- Color – The "partial intensity" was sometimes a problem but was corrected with Lot 4. However, it should be called brown or orange, not partial intensity.
- MPDs are great. If dual display processor (DP) failure, then nothing. Standby / emergency power should be made available to at least one MPD (air-driven alternator / generator through auxiliary power unit (APU) / engine exhaust?).
- Lot 4 is a big improvement.

APPENDIX G

SUMMARY OF PILOT RESPONSES REGARDING EASE OF INTERPRETATION OF SYMBOLOGY ON THE MULTIPURPOSE DISPLAYS (MPDs)

INTENTIONALLY LEFT BLANK

Symbology Characteristics	Very Easy (percent)	Somewhat Easy (percent)	Borderline (percent)	Somewhat Difficult (percent)	Very Difficult (percent)
Ease of distinguishing between friendly and threat icons[a]	**45**	**41**	**12**	**0**	**2**
Ease of distinguishing between moving and stationary threat icons[a]	**53**	**42**	**5**	**0**	**0**
Ease of distinguishing between LOAL and LOBL missile icons[a]	**46**	**49**	**5**	**0**	**0**
Ease of determining whether the FCR, RFI, or APR-39 detected the targets[a]	**42**	**33**	**25**	**0**	**0**
Ease of distinguishing icons that are displayed at full intensity versus half intensity[a]	**28**	**30**	**35**	**7**	**0**
Ease of understanding flight symbology (velocity vector, etc.) [a]	**77**	**23**	**0**	**0**	**0**
Ease of understanding navigation symbology (way points, hazards, etc.) [a]	**72**	**26**	**2**	**0**	**0**

[a]Significant at $\alpha < .01$

If you rated a symbology characteristic as 'Somewhat or Very Difficult', explain the impac that it has on your mission performance:

Problems with symbology clutter:

- Sometimes a mass amount of threat icon will cause confusion as to what detected the target and where priority is.
- Often times, symbols placed close to one another (such as BPs) do not change size, and it is difficult to distinguish the difference.
- The number of icons that can be on heading tape can be confusing.
- Scale size is a key.

Other comment:

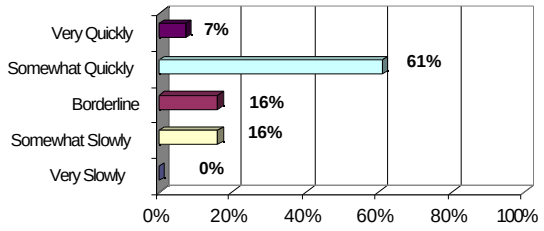
- It sometimes slows the movement in the cockpit (full intensity versus partial intensity). If you don't see the icon change intensity, it may take a couple of seconds to decipher.

APPENDIX H

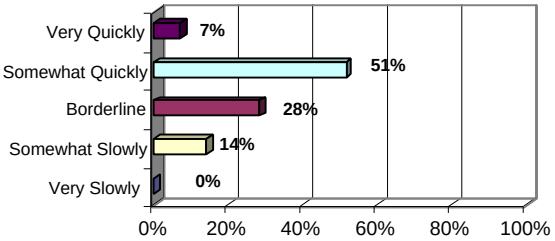
SUMMARY OF PILOT RESPONSES REGARDING DATA ENTRY ON THE MPDs

INTENTIONALLY LEFT BLANK

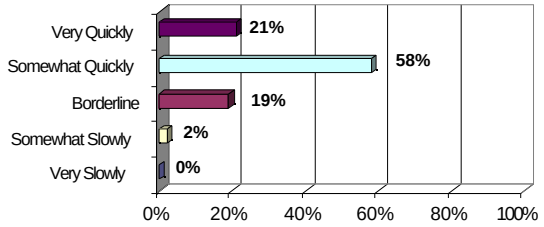
How quickly are you able to enter data or select options on the MPDs, using the Keyboard Unit (KU)?[a]



How quickly are you able to enter data or select options on the MPDs, using the cursor controls on the Collective Mission Grip?[a]



How quickly are you able to enter data or select options on the MPDs, using the cursor controls on the ORT hand grips?[a]



[a]Significant at $\alpha < .01$

Comments regarding the Keyboard Unit:

- I search too long for alpha on KU. Backspace doesn't seem quite right.
- Keyboard layout should be aligned as a computer keyboard.
- Using the keyboard and entering grid coordinates – you have to enter the whole identifier and the grid every time.
- The KU being in alphabetical order makes inputting data somewhat slow.
- KU entry slow because I'm used to QWERTY style keyboard.
- Keyboard unit not set up like typical key pad. I spend a lot of time hunting and pecking.
- KU layout (is a problem). If we had a simulator, this would not be a problem.
- As with anything, speed comes with repeated use. However, I would have rather had the keypad on the right side of the panel. Most people are right-handed and the knee boards with the information are typically on the right knee. I constantly have

to look back and forth across the cockpit when entering information.

- KU should have been placed on right side.
- What about a QWERTY keyboard?
- The KU alphanumeric layout can make entering data difficult but mainly because I am now conditioned to the PC keyboard layout.
- The KU is not bad. However, I can spend forever looking for an "A". A button press on the KU to activate it will cause me to not enter the first character of information. Bad when entering latitude/longitude.
- The Lot 4 change to enter only the 8-digit grid instead of the entire identifier has accelerated the process. The keyboard not being designed like a standard computer keyboard still creates some problems.
- Entering grid locations can take some time (e.g., 16SDR12345678). Maybe shorten the required amount to enter.
- I think the keypad itself should have been laid out like a standard keyboard rather than in sequence. Most people are more familiar with this type of format.
- Letters not arranged in similar manner to typewriter letters. Slows text input time.
- The more data you have to type, the longer it takes – especially when you can only push one letter or one number at a time (this is normal).
- Should be the same as a typewriter. Am used to that type of keyboard and am always searching for letters.
- The logic for the lettering on the data entry keyboard (DEK) is annoying. Should be done like a computer or typewriter.

<u>Comments regarding the cursor controls on the Collective Mission Grip:</u>

- Cursor controls on the mission grip – a lot of controls in one area.
- Mission Grip – To enter data and fly at the same time can be difficult.
- Collective grip (i.e., cursor) – a lot easier and faster to use FAB on MPD.
- Collective controls not as common to use – usually confirm with a visual.
- It is very difficult to use the cursor control while flying the aircraft. It keeps you inside the aircraft too long.

<u>Comments regarding the cursor controls on the ORT:</u>

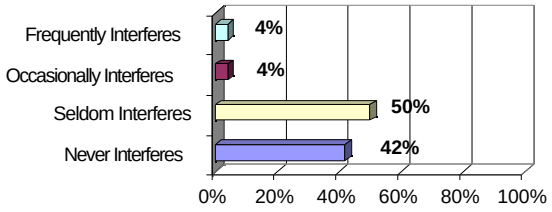
- Cursor control on ORT useless most of the time. A lot easier to use VAB/FAB.
- I do not use the cursor. It is quicker to select the desired function using its corresponding button.
- Using the cursor for functions other than acquisition is slow.

APPENDIX I

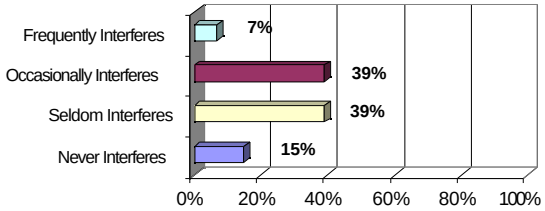
SUMMARY OF PILOT RESPONSES REGARDING CANOPY REFLECTIONS

INTENTIONALLY LEFT BLANK

How often do the canopy reflections created by the MPDs interfere with your OTW visibility at night in the front seat?[a]



How often do the canopy reflections created by the MPDs interfere with your OTW visibility at night in the back seat?[a]



[a]Significant at $\alpha < .01$

Comments regarding canopy reflections caused by MPDs:

- Sometimes the brightness of the CPG MPDs reflects off canopies in the pilot line of sight.
- Main problem is pilot seeing CPG MPD reflections in canopy.
- CPG station MPDs glare on the CPG canopy, which interferes with the pilot station visibility at night.
- When the bat wings are used, very few problems have been encountered. Sometimes, the reflection may draw your attention away from clearing the aircraft momentarily if proper light management is not used.
- Not much problem in front seat. Back seat is not much problem if CPG dims his lights. ORT heads-out display needs brightness dimming as effective as MPDs. ORT heads-out display is too bright, even with filter.
- If CPG does not have bat wings up, it can become difficult seeing anything out front, depending on the brightness.
- At night, unaided flight is interfered with reflected light from the MPDs if the bat wings are not properly employed.
- The problem occurs but is usually remedied by the CPG turning down his brightness level to where it is still readable and does not glare on the pilot's windows.
- In either seat, MPDs at full brightness interferes. Proper brightness settings for night causes no problem.
- Dependent on the CPG and how bright the displays are set.
- If the front seat doesn't use his "bat wings," the reflection on the side can be a distraction.
- Unaided night flying from back seat is sometimes hard if CPG has MPDs too bright.

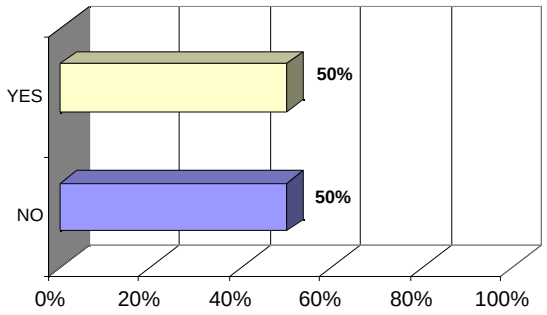
INTENTIONALLY LEFT BLANK

APPENDIX J

SUMMARY OF PILOT RESPONSES REGARDING PHYSICAL AND VISUAL ACCESS TO CONTROLS AND SWITCHES

INTENTIONALLY LEFT BLANK

Are any controls or switches difficult to reach in the AH-64D cockpits?[a]



Comments regarding the Display Adjustment Panel (DAP) switches:

- DAP adjustments cause some unnecessary maintenance delays when only minor adjustments need to be made.
- DAP adjustments. Different pilots set these differently or armament sets them wrong. In the back seat, it is impossible to set the DAP without help.
- Would be nice if pilots could better reach the DAP.
- The DAP is still in a hard spot to reach when a crew chief is not available to make adjustments.
- Integrated helmet and display sighting subsystem (IHADSS) size and centering.

Comments regarding circuit breakers:

- The IDM circuit breaker – sometimes when the "IDM" locks up, the solution is to reset the circuit breaker. It's in a bad spot to reach in flight.
- Circuit breakers in the pilot's compartment.
- Circuit breakers are all difficult to reach once I'm seated. Due to the high volume of maintenance resetting for the AH-64D, these controls need to be more accessible.
- I would have thought that having the APU and AWS circuit breakers in the cockpit would be an advantage rather than in the extended forward avionics bay (EFAB).

Comments regarding generator reset panel:

- Pilot generator reset panel next to door handle resulted in inadvertent generator test.
- Generators 1 and 2 reset. Because two panels are beneath the data transfer cartridge (DTC) module, it's difficult to read the panels. Extend them and angle up/in toward pilot.
- Under night vision system (NVS) conditions, pilot generator reset requires a head movement and a cross-handed control transfer.

Comments regarding ICS switches:

- ICS volume when "on the controls". Having the intercom system (ICS) control panel on the left half of the crew station would be a huge benefit.
- Under NVS conditions, reset of ICS switches require a head movement and a cross-handed control transfer.

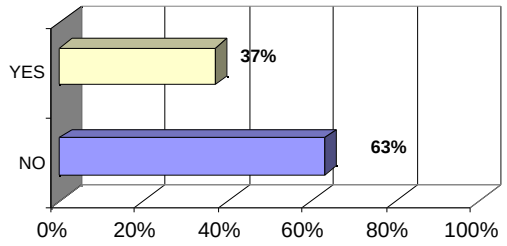
Other comments:

- It seems as if the cockpit lighting could be increased, it would be easier to find controls and switches.
- Out front boresight adjustment.
- Brightness and contrast buttons need to have more resistance to turning. It is too

easy to bump the knobs when one is selecting "arm" switch.

- Communication panel is at reach limit and on "cyclic" side of cockpit. Better on left side for adjustment, if necessary, while flying.
- Would be nice if pilots could better reach the "Track / radar switch for rotor smoothing.
- What about a "button" for main brakes?
- Chop button – The wire tie makes it impossible to use your thumb for that cover.
- Field of view (FOV) switch and weapon action switch (WAS) switch are alike.
- Tail wheel unlock – I have short fingers – no impact on ability to unlock the tail wheel.
- In the CPG station, the symbology switch on the cyclic is difficult to action. I (almost) have to release the cyclic in order to get my thumb on the switch. This has been noted with other pilot and IPs that experience the same problem.
- In the pilot station, the rotor brake switch has absolutely no protective device against placing the switch into the lock position while one is trying to place it in the brake position.
- Because of my 38-inch arm length, I tend to use the mission grip (collective) for most flight maneuvers. I often try to "un-cage" the tail wheel lock.
- High power switching module (HPSM) reset.
- ORT hand grips are not backlit.
- Under NVS conditions, wiper controls reset require a head movement and a cross-handed control transfer.
- Keyboard unit – I have some difficulty typing with my left hand.
- The bright / contrast and level / gain positions should be reversed. The level / gain is in front of my left knee and affects optimization during flight. I think I've bumped it with my knee before.

Are you unable to see any controls and/or displays from the normal seated position, which cause you problems during missions?



Comments regarding ORT grips blocking view of MPDs:

- The ORT column can sometimes limit viewing of the MPDs. Front seat, in general, is kind of crowded.
- The ORT can sometimes cause problems in seeing both MPDs when flying instruments when I have a flight page on one side and the automated direction finding (ADF) page on the other.
- CPG station – once you begin weapons employment, you will place your hands on the ORT grips. Once you do that, 66% to 75% of the MFDs can no longer be seen. This can cause more unnecessary movement of hands on and off ORT grips in order to see vital mission information on the MFDs.

Comments regarding backlighting of collective grip switches:

- The collective grips need to have backlit switches. I do not have the switches memorized. A quick glance at a backlit switch would increase speed and safety.
- Collective switches are not backlit.
- Collective grip not lighted at night. Makes it difficult to ID correct switch unless using lip light, etc.

Comments regarding backlighting of ORT grip switches:

- ORT hand grip selections should be backlit for easier ID at night.
- ORT controls are not backlit.

Comments regarding tail wheel lock switches:

- I think moving the tail wheel unlock up to just below the sunscreen of the dash would be a big improvement.
- Tail wheel lock.

Other comments:

- Bottom 4 switches (2/side) on ORT hand grips.
- CPG compartment master warning/master caution lights above the ORT don't attract attention.
- Volume on certain radios in order to listen to information on just one radio. Only bad during high radio traffic.
- Should be able to reset APX100/Mode IV circuit breaker in flight.
- Generators 1 and 2 reset. Because two panels are beneath the DTC module, it's difficult to read the panels. Extend them and angle up/in toward pilot.
- Difficulty in seeing UFD because of dashboard lip.
- The DAP needs to be moved to a position were the pilot can easily make adjustments.
- Standby flight instruments would give me vertigo if I had to use them.

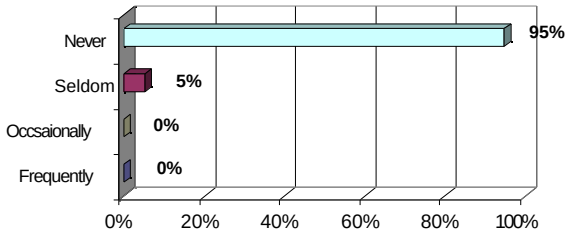
INTENTIONALLY LEFT BLANK

APPENDIX K

SUMMARY OF PILOT RESPONSES REGARDING ACCIDENTAL ACTIVATION OF THE EMERGENCY “ZEROIZE” SWITCH AND LABELING OF ITEMS

INTENTIONALLY LEFT BLANK

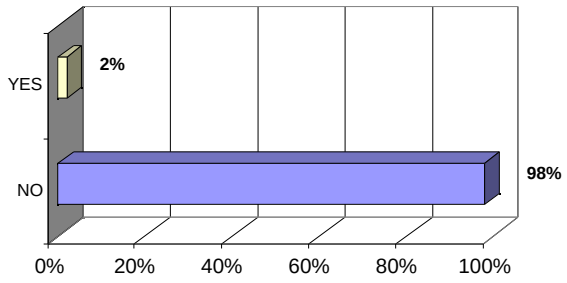
How often have you accidentally activated the emergency "zeroize" switch while trying to activate the rotor brake switch in the back seat?[a]



Comments

- Once; I always check now.
- The press to test button on the lighting panel and the selected stores jettison are real close together.
- Almost once.

Are any items in the cockpit improperly labeled?[a]



Comment:

- Pedals say "Hughes" on them.

[a]Significant at $\alpha < .01$

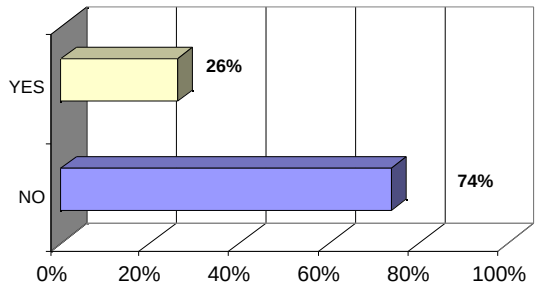
INTENTIONALLY LEFT BLANK

APPENDIX L

SUMMARY OF PILOT RESPONSES REGARDING STOWAGE SPACE

INTENTIONALLY LEFT BLANK

Is there adequate stowage space (e.g., for maps) in the cockpits?[a]



[a]Significant at $\alpha < .01$

<u>Comments regarding lack of stowage space for flight publications in crew stations:</u>

- No room for publications bags in either cockpit.
- Not room for publications bag in pilot station; I lay mine on helmet display unit (HDU) compartment lid. In front seat, I set it behind my head in the little space behind the seat. CPG map compartment isn't readily accessible with seat full down.
- Flights normally require some sort of publications bag. Need an adequate storage area (approximately 5 in. x 10 in.) in both crew stations.
- Publications bags contain many publications. Standing Operating Procedure (SOP), AR 95-1, Approach plates, F/H….. cannot go under seat. Sometimes I'll use the HDU storage door to hold bag against canopy.
- On long missions, you may need to have several different maps and a flashlight, etc. The stowage down below beside your leg is not feasible for use.
- Ask an instrument examiner (IE), instructor pilot (IP), and a pilot in command (PIC) what they are required to carry and make a spot for it. Or find the size of the above average publications bag.
- Front right map slot too small for anything else. Not much room for a flashlight, publications bag, or canteen.
- The flight bag that every pilot carries is always in the way. No space for storage. It is possible that this unsecured bag could become a flying projectile and/or get lodged between the controls.
- When flying tactical missions in the front seat, many times I have no room to put all my maps. Publications, publications bag, bottle of water, and various other items that I have needed for a long mission.
- No space for flight publications, but it was like this for the 'A' model. So most of us are used to it.
- No place to put instrument flight publication bag. I have a standard bag approximately 8 in. (W) x 5 in. (H) x 10 in. (D) that has publications required to be in the cockpit during flight. I have to set it on right console in both cockpits. It won't fit in "map stowage".
- In the CPG station, there is not adequate space to put my publications bag. I hook it to the door handle on top of right control panel.
- There are no places to put the "maps," publications, and other equipment in either seat.
- Not enough space for publications, maps without having to put them on places like on top of the glare shield or against the cockpit door.
- Map boxes could be bigger for publications and maps.
- Very limited stowage space for publications in the pilot's station. Most put their publications on the dash.
- Not really room for the publications bag in the front that is practical and out of the way. In the back, the collective can be impeded by the constantly growing –10 operator manual by our feet.

- Most aviators fly with additional check packets, required maps, flashlights, etc. Currently, the items are placed up on the console by the blast shield or forward glass canopy. In an accident, these materials can be deadly.
- No room in the front to stow maps unless you put on dash or under your right arm.
- Need a place for publications and a storage compartment for a standard Army flashlight.
- The CPG station DOESN'T (does not) have adequate stowage space for all the maps and other publications required to fly.
- Consider the average aviator with the necessary knee board, local flying area map book, and all the required IFR books and checklists. Typically, I end up with a map book and checklist on top of the dash and IFR publications sitting on top of the IHADSS stowage. All of this continually has to be picked up and moved to one place or another.
- There is no place to store publications (pilots maps, flips bag) in the front seat.
- Must place publications bag on glare shield (scratches). –10 operator's manual too big for compartment!! It is then placed under seat (crash survivability no-no)!!
- Not enough space/room for *ALL* required publications.
- Publications bag is difficult to store.
- There is no real efficient location for the required flights publications (publications and bag) to be stored (and easily accessed) during flight.
- My publications hang on the chemical, biological, radiological (CBR) mount (left of seat). My map goes along the left window visor. Publications on dash during instruments.

Other comments:

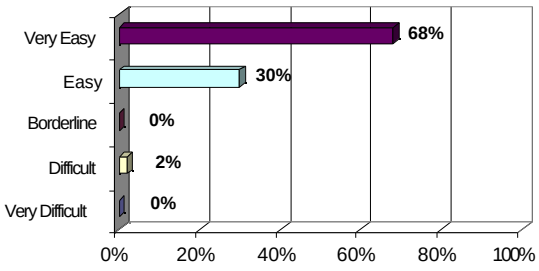
- Although in the pilot's station there is adequate stowage, it isn't marked for stowage of publications.
- Need helmet hooks near left side hand holds of both cockpits (inside).
- Stowage space in both cockpits is too limited. Need a space the same size as the map case in the 'A' model.
- Always placing items on glare shield. Others place items under the seat, which reduces crash survivability.
- Excellent stowage capabilities.
- CPG is good.
- Inadequate space.
- Front seat needs more places to put stuff.

APPENDIX M

SUMMARY OF PILOT RESPONSES REGARDING READABILITY OF DATA ON THE UFDs

INTENTIONALLY LEFT BLANK

How easy is it to read and understand data presented on the UFD?[a]



Comments regarding problems in viewing UFD with bat wings deployed:

- Needs to be relocated in the CPG station so that it can be seen at night fully with the bat wings up.
- At night, there are times when the right "bat wing" obscures the top half of the UFD (CPG station).

Other comments:

- Recommend placing an up / down radio selection on the UFD. It is a time killer to have to go from the UHF all the way around to get to the VHF radio.
- Difficult to see UFD because of dashboard lip.
- There are many abbreviated items on the UFD; again, if you're grounded for any amount of time, information is lost.
- Once again, familiarity breeds success.

[a]Significant at $\alpha < .01$

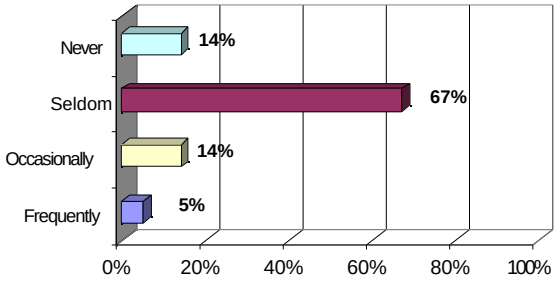
INTENTIONALLY LEFT BLANK

APPENDIX N

SUMMARY OF PILOT RESPONSES REGARDING THE IDM, FM1, AND FM2 RADIOS

INTENTIONALLY LEFT BLANK

How often do the IDM and FM1 and FM2 radios "lock up" during a mission?[a]



Comments regarding impact on performance:

- Seldom, but when it happens, it is very detrimental to communication.
- When it does occur, we have to rely on minimal voice traffic over secure radios (HQ, good FM).
- When it happens, I have to turn around, ID the circuit breaker, and pull it, reset it, hope it works this time. All this during NVS formation flight.
- It causes attention to shift inside, usually to re-time the radios.
- Somewhat degraded.
- You have one less radio that was planned on. Loss of situational awareness.
- Digital data xmsn / xfer decrease significantly; aircraft without digital capability becomes "autonomous".
- Reduction in IDM traffic / secure communications. Have reset circuit breakers over my left shoulder – bad.
- Usually shutting down (APU off) and restarting will fix it.

Other comments:

- Had several IDM failures and radios have failed totally, but I wouldn't call it a "lock-up".
- Control-ALT-Delete usually fixes this.
- Seldom for IDM.
- They don't "lock up". We get "not acknowledged" (NAK) messages. I don't know why we get the NAK.
- Have not seen this in a long time.
- Never. However, when sending selected IDM messages, there is a tendency to get NAK messages on the UFD more than 50% of the time.
- IDM will occasionally lock up during flight. Integrated built-in test (IBIT) will normally resolve problem.
- Not since upgrade.
- IDM is main problem.
- IDM locks up. FMs work well.

[a]Significant at $\alpha < .01$

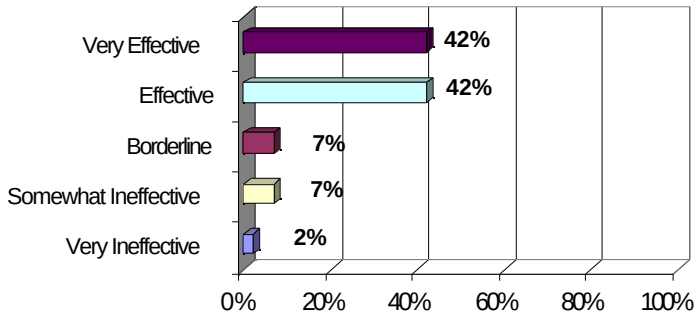
INTENTIONALLY LEFT BLANK

APPENDIX O

SUMMARY OF PILOT RESPONSES REGARDING THE ENVIRONMENTAL CONTROL SYSTEM (ECS)

INTENTIONALLY LEFT BLANK

How effective is the ECS in keeping you cool during missions when the outside air temperature is above 80° F?[a]



[a]Significant at $\alpha < .01$

Comments regarding reliability problems with the ECS:

- Frequent system failures!!!
- We have more ECS failures as the outside air temperature increases.
- Good when it works; if/when it fails = mission abort.
- If the canopy open switch fails, after 1 minute, the ECS stops making cold air. The switch is the weak link.
- Lots of ECS failures.
- The canopy open switch will not function, causing the UFD to display "canopy open" and no air flows.
- During the summer of 1999, we had numerous ECS's go bad at Fort Hood (training). Since the beginning of this summer, no problems have been encountered.
- Canopy open indication on the UFD restricts ECS air flow. Plus, when canopy switches break, they have created problems in flight. Cockpit temperatures should have no bearing from a canopy open.
- ECS micro-switch in door – breaks often.

Comments regarding problems in maintaining desired temperature setting:

- Sometimes – constantly resetting to maintain constant temperature. Goes in extreme direction – mostly during heading mode.
- High humidity causes water to be released from the vents. Temperature fluctuation in the cockpit despite the chosen temperature.
- Thermostat seems to struggle/ECS works good.
- The air conditioner/heater both seem to struggle holding temps under more extreme conditions. This can and has led to nausea.
- In the heating mode, the ECS constantly "hunts" above and below the desired "set" temperature.
- It sometimes fluctuates very much, although nothing is obstructing the temperature sensors.
- Temperature control stinks. Set a temperature and you may get cockpit temps anywhere from ±8° F of the setting. Same problem at all OATs. Very distracting!!!
- Some of the aircraft tolerances are too wide. Temperature is set to 70° F – some will hold a range of 62° to 80°, and others will maintain the temperature within a couple of degrees.
- Cockpit temperature sensors are starting to be inaccurate so the cockpit becomes too cold or too hot.
- Many times, I have had the temperature set at 68° F and the cockpit temperature is reading 60° F and cold air is still blowing out of the vents.
- Had problems with the outside of the canopies fogging up. Have to play with temps

a lot in some aircraft for comfort – they will either be very cold or go into heating mode.

- The problems occur when cockpit temperature is close to desired setting. The heater kicks in, fogging up the canopy and HDU when the dew point is close to outside temp (high humidity). 'A' model is much better.

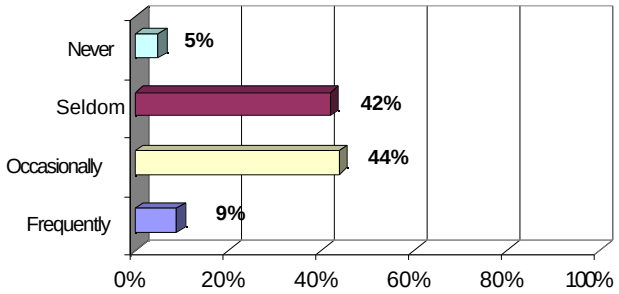
Comments regarding fogging of canopies:

- Canopies fog up during high humid days when cooling mode is on.
- When ECS switches from cold to heat, I have experienced IFR conditions inside the cockpit on at least five (5) different occasions.

Other comments:

- Works great, unless degraded.
- I experienced one problem when OAT was over 100° F.

How often does the ECS micro-switch (in the canopy door lock) fail, causing the air conditioner to shut off?[a]



[a]Significant at $\alpha < .01$

Comments regarding impact on performance:

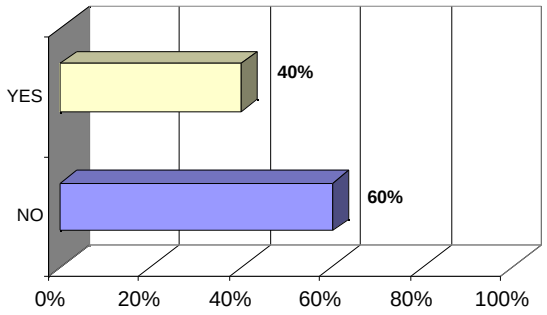
- Cancel or abort mission!!! The temperature will climb fast.
- If on a hot day, we abort the mission.
- Cancelled mission usually.
- Cockpit temps can be as high as 122° F. If the switch is broke with high temps, it must be fixed before launch. Otherwise, a training mission abort.
- Good when it works – if / when it fails = mission abort.
- Quite a large distraction if weather is really hot or cold. You either end up freezing or burning up or continually trying to shut the door so the sensor will perform normally.
- Sweat like a son of a gun until you can wedge some paper in it to make it work.
- Performance is reduced due to cockpit heat.
- Have to spend time trying to isolate door.
- Highly degraded (performance).
- If it's hot, what do you think? Sit in one of these things on a sunny day with the doors shut. Bet you wouldn't last 10 minutes.
- In warmer months, cockpit became very uncomfortable. This situation should really be corrected. Pilots find that jamming paper in the micro-switch is only way to trick the system.
- Very uncomfortable. Cockpit temp easily reaches 90° F.
- In a sealed all-glass cockpit, temperature control is crucial. Wastes time on ground and in-flight trying to fix switch.
- Makes temperature control difficult. On hot days, makes it uncomfortable.
- Negligible impact. A good wrapped piece of paper usually is a good temp repair.

- Not much; had maintenance repair on the spot.

Other comments:

- Canopy micro-switch is usually inoperative. Jamming paper in it helps.
- Air still works if squat switch is in air mode.
- It has only occurred twice to me, but I know others have had trouble as well.
- If the canopy open switch fails, after 1 minute, the ECS stops making cold air. The switch is the weak link.
- Switch is poor!! Design was acceptable for the 'A' model, but the ECS depends on it now. Have replaced them in all aircraft at least once since fielding.
- This has happened enough times to write this down… Why did that switch get installed?
- Seen this maybe three times in 2 years.
- Seems this is a common problem with both heater and air conditioner.

In the last 6 months, have you experienced any instances of water spraying or dripping from the ECS "gaspers"?



Comments regarding amount of water spraying / dripping from "gaspers":

- Get a few droplets of water, and vents seem to fill with condensed water.
- Varies from a couple drips; on one flight, I needed a rain jacket.
- Not much, but some water from pilot right upper gasper.
- Just slight ice particles. Nothing that would create problems.
- Spray. Very small amounts.
- Just enough to be refreshing.
- Back seat, water droplets were sprayed on the blast shield.
- Approximately one drop every 2 seconds.
- Not often, but the mist looks way too much like smoke.
- From CPG station, water was spraying onto my visor. I selected heating mode and water dissipated.
- Small amounts.
- Seems to occur on very humid days. Small amount, but enough to wet the cockpit floor sometimes.
- Not enough to be a major problem. I'd rather have the leaking canopy fixed!!
- I have experienced this at least three times in the last year.
- Small amount spraying. Typically gets on my visor, but wipes off easily.
- Close to what would be if I squirted your average spray bottle at you 3 to 4 times.
- Enough to wet papers on knee board and flight suit.
- One-fourth cup.

Other comments:

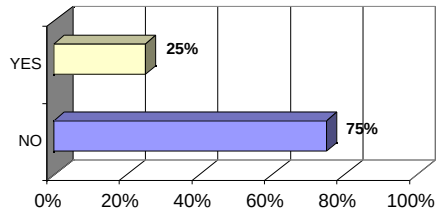
- No, but winter just passed and we haven't been flying.
- Thank you for fixing that.
- I have only flown in winter time.

APPENDIX P

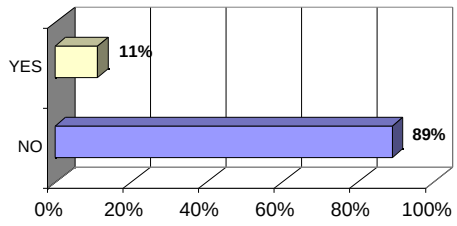
SUMMARY OF PILOT RESPONSES REGARDING THE SYSTEM AND WEAPONS PROCESSORS

INTENTIONALLY LEFT BLANK

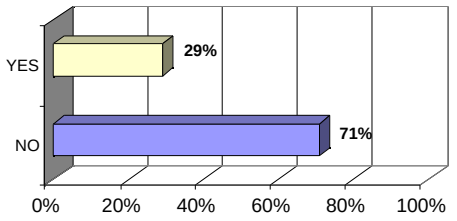
During a system processor "switch-over," have you experienced any problems such as unexpected changes in subsystem (Nav, Com, Wpns) operation?[a]



During a weapons processor "switch-over," have you experienced any problems such as unexpected changes in subsystem (Nav, Com, Wpns) operation?[b]



During aircraft "power-up," have you experienced any problems such as unexpected changes in subsystem (Nav, Com, Wpns) operation?[a]



[a]Significant at $\alpha < .05$
[b]Significant at $\alpha < .01$

If you answered "Yes" to any of the questions above, describe:

1) how often the problem occurs and its impact on the mission
2) whether the aircraft was on the ground or in flight when the problem occurred
3) any changes you noticed on the MPDs, UFDs, and/or ORT display
4) date when the problem(s) last occurred
5) any faults you noted on the DMS fault page
6) the primary SP after the switch-over occurred
7) the primary WP after the switch-over occurred
8) the SP, WP, and DP software versions (if known)
9) aircraft tail number (if known)

- SP switchover "Lot 2" – Twice in flight, lost all displays (MPD, HDU, TADS) until reset of SP. SP1 to SP2, Lot 2.
- 1) – Usually solvable. 2) – ground
- Hasn't happened within last 6 months. All switch-overs occurred on ground with the exception of one SP. All other information too long ago to recall.
- 1) – Sometimes, 2) – Ground start-up, 3) – UFD, 4) June, 5) Yes. Example: On start-

up, sometimes systems will open in a failed status. Shut down and back up will clear problem.

- Initially, there would be faults present on the DMS page at APU start-up. They vary from communication problems to SP/DP faults. Often times, the APU could be shut down and restarted and the faults would be cleared, sometimes never to reappear.
- 1) Only occurred a few times with negative impact. 2) Aircraft on ground. 3) Local times would change to Zulu on UFD, MPDs would “blink”. 4) Around March 00. 5) SP SRU fault. 6) SP1. 7) N/A. 8) Lot 3. 9) Unknown.
- The only problem I have encountered after an SP switch-over is that manual input of external fuel remaining was lost.
- 1) Not often, but AARs were submitted for all occurrences.
- Basically, I can’t pinpoint the problems, but numerous aircraft sometimes “wake up” kind of stupid. Usually, powering down all the way and starting over will bring things back on line. This has happened to people many times.
- During SP switch-over, many things have occurred to include time going from local to Zulu, radios coming off of flight secure to single channel.
- Noticed a momentary delay in system picking up loads.
- A lot of “ghost” messages on the “fault” page (I think) cause a loss of time and manpower troubleshooting system that have nothing wrong with them (in general).

APPENDIX Q

ADDITIONAL COMMENTS REGARDING THE HUMAN FACTORS ENGINEERING CHARACTERISTICS OF THE AH-64D CREW STATIONS

INTENTIONALLY LEFT BLANK

List any additional positive or negative comments regarding the human factors characteristics of the AH-64D crew stations:

Comments regarding FLIR:

- FLIR still is substandard. Better FLIR systems are out there. It would make this aircraft way better, considering our missions are mainly at night.
- Same old FLIR! Our biggest restriction!
- Everything is awesome except 1) TADS FLIR – targets still a guessing game past 3K. This almost negates the range capability of the Hellfire, rocket, and FCR. 2) PNVS FLIR should be better.
- We need a next generation FLIR badly (impacts on safety and target detection).
- I definitely feel I could be more effective in the front seat if I had the capability to find/detect targets with a better FLIR and the ability to view 12 in the same package!
- The 'D' will continue to be a "spruced up" 'A' model until you get next generation FLIR/I2 installed,
- Upgrade TADS/PNVS! This would truly make the Longbow one awesome machine.
- Need second generation FLIR.
- FLIR is inadequate for pilotage and targeting.
- We need a better FLIR!!! The FLIR is the same old 60's and 70's technology. The current FLIR can only positively ID targets at about 1400 meters. The FLIR is currently the greatest obstacle to proficiency in this aircraft.

Comments regarding positive characteristics of the AH-64D:

- Overall, the 'D' model much improved on mission success.
- The 'D' model makes it easier to get to the target on time, find it once I'm there, and engage it rapidly. Does anything else matter?
- Much better battlefield awareness.
- I can't say enough about the increased situation awareness. Long overdue for Army aviation.
- Overall, very pleased with and proud to fly the AH-64D.
- Overall, the Longbow is a better aircraft to fly than the 'A' model. It flies better, the navigation systems are better, situational awareness is better, and it gives the crew member added capabilities. Information management is still the most difficult part in the 'D' model. Currently, with the lack of a simulator device, I would say that air crew proficiency and confidence in the system's capabilities are low.
- Situation awareness is great, but we need to train to use it effectively.

Comments regarding Aviation Mission Planning System (AMPS)

- Some of our problems are the AMPS and ability we have to communicate stuff to the helicopter.
- Need an AMPS that is much more user friendly!!
- AMPS: old version was much better.

Comments regarding specific items that should be fixed/enhanced:

- The generator problem – even now with my flight time and experience I don't see it as a major problem (i.e., execute the EP and land), but, with the average experience of the future aviators declining, it could be a major problem for them (i.e., catastrophic).
- The generator fix stinks.
- Make airborne target hand-over system (ATHS) a one-page item.
- Allow loading of current CEOIs information through an improved DTC.
- More complex piece of equipment requires more training time (i.e., flight time).
- Need a compatible simulator that is current with Lot changes.

- I would like to see the ability to switch from one single channel ground and airborne radio system (SINCGARS) FH set to another by selecting the last button. I also cannot stand the sound of a bell ringing when an IDM message is received.
- Another problem is the frequency and problems we see with system anomalies.
- I wish the scale of icons on the TSD were selectable.
- I think map underlay would greatly enhance the aircraft.
- ECS seems to be labor intensive (from a non-maintenance guy).
- Everything is awesome except FCR is not reliable.
- Our decreased power margin is on the borderline. Although our normal pilotage workload has decreased, the number of tasks that have to be performed has increased. We need more personnel for maintenance, more money for parts, and training ammunition and more flight time. Our skills are essential for successful 101st mission. If we do not train and maintain, those skills will perish. We need a compatible simulator to keep our skills sharp.
- The 'D' will continue to be a "spruced up" 'A' model until you get rid of that NDB radio.
- ATHS works but can be confusing.
- Put in some sort of "Master Reset" or "Re-boot" button. It's a pain in the butt to shut down APU to try and reset malfunctioning systems.
- Need a place to stow pubs, and 701C engines on all aircraft. Get rid of the ORT.
- The HPSMs need to be redesigned…..and soon!
- Front seat is still too crowded with the presence of the ORT. Other than that, I'm very happy with function and layout.
- Please remove the ORT ASAP.
- MFD – lack of knee room is bad.
- Again, because of my height, I find the front seat to be most difficult to fly. In the 'A' model, the dash was much higher, giving me plenty of leg room. In the Longbow, my shins are resting on the MFDs. This causes pedal control problems as well as difficulty seeing the entire display on the MFDs (not to mention discomfort).
- Place an aviator in the CPG station with cold weather gear, NBC equipment, flak vest, chicken plate, aviation life support equipment (ALSE), helmet and then attempt to move around the ORT, see the MFDs, and fly the aircraft. Then try to get out of that seat with all that gear in an emergency (for an average size guy like me, that is very tough).
- IDM messages appear on the UFD. When in the process of managing the battle, it can be quickly overseen that IDM information has been sent to your aircraft. No recommendable fixes, but it is a problem.

NO. OF COPIES	ORGANIZATION
1	ADMINISTRATOR DEFENSE TECHNICAL INFO CTR ATTN DTIC OCA 8725 JOHN J KINGMAN RD STE 0944 FT BELVOIR VA 22060-6218
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL CI AI R REC MGMT 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL CI LL TECH LIB 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL D D SMITH 2800 POWDER MILL RD ADELPHI MD 20783-1197
1	DIR FOR PERS TECHNOLOGIES DPY CHIEF OF STAFF PERS 300 ARMY PENTAGON 2C733 WASHINGTON DC 20310-0300
1	OUSD(A)/DDDR&E(R&A)/E&LS PENTAGON ROOM 3D129 WASHINGTON DC 20301-3080
1	CODE 1142PS OFC OF NAVAL RSCH 800 N QUINCY STREET ARLINGTON VA 22217-5000
1	WALTER REED INST OF RSCH ATTN SGRD UWI C COL REDMOND WASHINGTON DC 20307-5100
1	CDR US ARMY RSCH INST ATTN PERI ZT DR E M JOHNSON 5001 EISENHOWER AVENUE ALEXANDRIA VA 22333-5600
1	DEF LOGISTICS STUDIES INFO EXCH ATTN DIR DLSIE ATSZ DL BLDG 12500 2401 QUARTERS ROAD FORT LEE VA 23801-1705

NO. OF COPIES	ORGANIZATION
1	HEADQUARTERS USATRADOC ATTN ATCD SP FORT MONROE VA 23651
1	CDR USATRADOC COMMAND SAFETY OFC ATTN ATOS PESSAGNO/LYNE FORT MONROE VA 23651-5000
1	DIRECTOR TDAD DCST ATTN ATTG C BLDG 161 FORT MONROE VA 23651-5000
1	HQ USAMRDC ATTN SGRD PLC FORT DETRICK MD 21701
1	CDR USA AEROMEDICAL RSCH LAB ATTN LIBRARY FORT RUCKER AL 36362-5292
1	US ARMY SAFETY CTR ATTN CSSC SE FORT RUCKER AL 36362
1	CHIEF ARMY RSCH INST AVIATION R&D ACTIVITY ATTN PERI IR FORT RUCKER AL 36362-5354
1	AIR FORCE FLIGHT DYNAMICS LAB ATTN AFWAL/FIES/SURVIAC WRIGHT PATTERSON AFB OH 45433
1	US ARMY NATICK RD&E CTR ATTN STRNC YBA NATICK MA 01760-5020
1	US ARMY TROOP SUPPORT CMD NATICK RD&E CTR ATTN BEHAVIORAL SCI DIV SSD NATICK MA 01760-5020
1	US ARMY TROOP SUPPORT CMD NATICK RD&E CTR ATTN TECH LIB (STRNC MIL) NATICK MA 01760-5040

NO. OF COPIES	ORGANIZATION
1	DR RICHARD JOHNSON HEALTH & PERFORMANCE DIV US ARIEM NATICK MA 01760-5007
1	PROGRAM MANAGER RAH-66 ATTN SFAE AV RAH BLDG 5681 WOOD RD REDSTONE ARSENAL AL 35898
1	NAVAL SUB MED RSCH LAB MEDICAL LIB BLDG 148 BOX 900 SUBMARINE BASE NEW LONDON GROTON CT 06340
1	USAF ARMSTRONG LAB/CFTO ATTN DR F W BAUMGARDNER SUSTAINED OPERATIONS BR BROOKS AFB TX 78235-5000
1	ARI FIELD UNIT FT KNOX BLDG 2423 PERI IK FORT KNOX KY 40121-5620
1	STRICOM 12350 RSCH PARKWAY ORLANDO FL 32826-3276
1	CDR USA COLD REGIONS TEST CTR ATTN STECR TS A APO AP 96508-7850
1	GOVT PUBLICATIONS LIB 409 WILSON M UNIVERSITY OF MINNESOTA MINNEAPOLIS MN 55455
1	DR RICHARD PEW BBN SYSTEMS &TECH CORP 10 MOULTON STREET CAMBRIDGE MA 02138
1	DR ROBERT C SUGARMAN 132 SEABROOK DRIVE BUFFALO NY 14221
1	DR ANTHONY DEBONS IDIS UNIV OF PITTSBURGH PITTSBURGH PA 15260

NO. OF COPIES	ORGANIZATION
1	MR R BEGGS BOEING-HELICOPTER CO P30-18 PO BOX 16858 PHILADELPHIA PA 19142
1	DR ROBERT KENNEDY ESSEX CORPORATION STE 227 1040 WOODCOCK ROAD ORLANDO FL 32803
1	GMC N AMER OPERATIONS PORTFOLIO ENGINEERING CTR HUMAN FACTORS ENGINEERING ATTN MR A J ARNOLD STAFF PROJ ENG ENGINEERING BLDG 30200 MOUND RD BOX 9010 WARREN MI 48090-9010
1	DR MM AYOUB DIRECTOR INST FOR ERGONOMICS RSCH TEXAS TECH UNIVERSITY LUBBOCK TX 79409
1	US ARMY ATTN AVA GEDDES MS YA:219-1 MOFFETT FIELD CA 94035-1000
1	CDR US ARMY RSCH INST OF ENVIRONMNTL MEDICINE NATICK MA 01760-5007
1	HQDA (DAPE ZXO) ATTN DR FISCHL WASHINGTON DC 20310-0300
1	HUMAN FACTORS ENG PROGRAM DEPT OF BIOMEDICAL ENGNG COLLEGE OF ENGINEERING & COMPUTER SCIENCE WRIGHT STATE UNIVERSITY DAYTON OH 45435
1	CDR USA MEDICAL R&D COMMAND ATTN SGRD PLC LTC K FRIEDL FORT DETRICK MD 21701-5012
1	PEO ARMORED SYS MODERNIZATION US ARMY TANK-AUTOMOTIVE CMD ATTN SFAE ASM S WARREN MI 48397-5000

NO. OF COPIES	ORGANIZATION
1	PEO COMMUNICATIONS ATTN SFAE CM RE FT MONMOUTH NJ 07703-5000
1	PEO AIR DEF ATTN SFAE AD S US ARMY MISSILE COMMAND REDSTONE ARSENAL AL 35898-5750
1	PEO STRATEGIC DEF PO BOX 15280 ATTN DASD ZA US ARMY STRATEGIC DEF CMD ARLINGTON VA 22215-0280
1	JON TATRO HUMAN FACTORS SYS DESIGN BELL HELICOPTER TEXTRON INC PO BOX 482 MAIL STOP 6 FT WORTH TX 76101
1	CHIEF CREW SYS INTEGRATION SIKORSKY AIRCRAFT M/S S3258 NORTH MAIN STREET STRATFORD CT 06602
1	GENERAL ELECTRIC COMPANY ARMAMENT SYS DEPT RM 1309 ATTN HF/MANPRINT R MCLANE LAKESIDE AVENUE BURLINGTON VT 05401-4985
1	OASD (FM&P) WASHINGTON DC 20301-4000
1	CDR US ARMY AVIATION CTR ATTN ATZQ CDM S FT RUCKER AL 36362-5163
1	CDR MARINE CORPS SYSTEMS CMD ATTN CBGT QUANTICO VA 22134-5080
1	DIRECTOR US ARMY AEROFLIGHT DYNAMICS DIR MAIL STOP 239-9 NASA AMES RSCH CTR MOFFETT FIELD CA 94035-1000
1	DIR AMC-FIELD ASSIST IN SCIENCE & TECHNOLOGY ATTN AMC-FAST FT BELVOIR VA 22060-5606

NO. OF COPIES	ORGANIZATION
1	CDR US ARMY FORCES CMD ATTN FCDJ SA BLDG 600 AMC FAST SCIENCE ADVISER FT MCPHERSON GA 30330-6000
1	CDR I CORPS AND FORT LEWIS AMC FAST SCIENCE ADVISER ATTN AFZH CSS FORT LEWIS WA 98433-5000
1	HQ III CORPS & FORT HOOD OFC OF THE SCIENCE ADVISER ATTN AFZF CS SA FORT HOOD TX 76544-5056
1	CDR HQ XVIII ABN CORPS & FT BRAGG OFC OF THE SCI ADV BLDG 1-1621 ATTN AFZA GD FAST FORT BRAGG NC 28307-5000
1	SOUTHCOM WASHINGTON FIELD OFC 1919 SOUTH EADS ST STE L09 AMC FAST SCIENCE ADVISER ARLINGTON VA 22202
1	HQ US SPECIAL OPERATIONS CMD AMC FAST SCIENCE ADVISER ATTN SOSD MACDILL AIR FORCE BASE TAMPA FL 33608-0442
1	HQ US ARMY EUROPE AND 7TH ARMY ATTN AEAGX SA OFC OF THE SCIENCE ADVISER APO AE 09014
1	CDR HQ 21ST THEATER ARMY AREA CMD AMC FAST SCIENCE ADVISER ATTN AERSA APO AE 09263
1	CDR HEADQUARTERS USEUCOM AMC FAST SCIENCE ADVISER UNIT 30400 BOX 138 APO AE 09128

NO. OF COPIES	ORGANIZATION
1	HQ 7TH ARMY TRAINING CMD UNIT #28130 AMC FAST SCIENCE ADVISER ATTN AETT SA APO AE 09114
1	CDR HHC SOUTHERN EUROPEAN TASK FORCE ATTN AESE SA BLDG 98 AMC FAST SCIENCE ADVISER APO AE 09630
1	CDR US ARMY PACIFIC AMC FAST SCIENCE ADVISER ATTN APSA FT SHAFTER HI 96858-5L00
1	AMC FAST SCIENCE ADVISERS PCS #303 BOX 45 CS-SO APO AP 96204-0045
1	ENGINEERING PSYCH LAB DEPT OF BEHAVIORAL SCIENCES & LEADERSHIP BLDG 601 ROOM 281 US MILITARY ACADEMY WEST POINT NY 10996-1784
1	DIR SANDIA NATL LAB ENGNRNG MECHANICS DEPT MS 9042 ATTN J HANDROCK Y R KAN J LAUFFER PO BOX 969 LIVERMORE CA 94551-0969
1	NAIC/DXLA 4180 WATSON WAY WRIGHT PATTERSON AFB OH 45433-5648
1	DR SEHCHANG HAH WM J HUGHES TECH CTR FAA NAS HUMAN FACTORS BR ACT-530 BLDG 28 ATLANTIC CITY INTNATL AIRPORT NJ 08405
1	TACTICAL SHOOTER ATTN J D TAYLOR 222 MCKEE ST MANCHESTER CT 06040

NO. OF COPIES	ORGANIZATION
10	ARL HRED AVNC FLD ELMT ATTN AMSRL HR MJ D DURBIN PO BOX 620716 BLDG 4506 (DCD) RM 107 FT RUCKER AL 36362-5000
1	ARL HRED AMCOM FLD ELMT ATTN AMSRL HR MI D FRANCIS BLDG 5464 RM 202 REDSTONE ARSENAL AL 35898-5000
1	ARL HRED AMCOM FLD ELMT ATTN AMSRL HR MO T COOK BLDG 5400 RM C242 REDSTONE ARS AL 35898-7290
1	ARL HRED USAADASCH FLD ELMT ATTN AMSRL HR ME K REYNOLDS ATTN ATSA CD 5800 CARTER ROAD FORT BLISS TX 79916-3802
1	ARL HRED ARDEC FLD ELMT ATTN AMSRL HR MG R SPINE BUILDING 333 PICATINNY ARSENAL NJ 07806-5000
1	ARL HRED ARMC FLD ELMT ATTN AMSRL HR MH C BURNS BLDG 1002 ROOM 206B 1ST CAVALRY REGIMENT RD FT KNOX KY 40121
1	ARL HRED CECOM FLD ELMT ATTN AMSRL HR ML J MARTIN MYER CENTER RM 2D311 FT MONMOUTH NJ 07703-5630
1	ARL HRED FT BELVOIR FLD ELMT ATTN AMSRL HR MK P SCHOOL 10170 BEACH RD FORT BELVOIR VA 22060-5800
1	ARL HRED FT HOOD FLD ELMT ATTN AMSRL HR MV HQ USAOTC S MIDDLEBROOKS 91012 STATION AVE ROOM 111 FT HOOD TX 76544-5073

NO. OF COPIES	ORGANIZATION
1	ARL HRED FT HUACHUCA FIELD ELEMENT ATTN AMSRL HR MY M BARNES GREELY HALL BLDG 61801 RM 2631 FT HUACHUCA AZ 85613-5000
1	ARL HRED FLW FLD ELMT ATTN AMSRL HR MZ A DAVISON 3200 ENGINEER LOOP STE 166 FT LEONARD WOOD MO 65473-8929
1	ARL HRED NATICK FLD ELMT ATTN AMSRL HR MQ M R FLETCHER NATICK SOLDIER CTR BLDG 3 RM 341 AMSSB RSS E NATICK MA 01760-5020
1	ARL HRED OPTEC FLD ELMT ATTN AMSRL HR MR H DENNY ATEC CSTE PM ARL 4501 FORD AVE RM 870 ALEXANDRIA VA 22302-1458
1	ARL HRED SC&FG FLD ELMT ATTN AMSRL HR MS R ANDERS SIGNAL TOWERS RM 303A FORT GORDON GA 30905-5233
1	ARL HRED STRICOM FLD ELMT ATTN AMSRL HR MT A GALBAVY 12350 RSCH PARKWAY FT LEAVENWORTH KS 66027-2326
1	ARL HRED TACOM FLD ELMT ATTN AMSRL HR MU M SINGAPORE 6501 E 11 MILE RD MAIL STOP 248 WARREN MI 48397-5000
1	ARL HRED USAFAS FLD ELMT ATTN AMSRL HR MF L PIERCE BLDG 3040 RM 220 FORT SILL OK 73503-5600
1	ARL HRED USAIC FLD ELMT ATTN AMSRL HR MW E REDDEN BLDG 4 ROOM 332 FT BENNING GA 31905-5400
1	ARL HRED USASOC FLD ELMT ATTN AMSRL HR MN R SPENCER DCSFDI HF HQ USASOC BLDG E2929 FORT BRAGG NC 28310-5000

NO. OF COPIES	ORGANIZATION
1	ARL HRED HFID FLD ELMT ATTN AMSRL HR MP D UNGVARSKY BATTLE CMD BATTLE LAB 415 SHERMAN AVE UNIT 3 FT LEAVENWORTH KS 66027-2326
1	CDR AMC - FAST JRTC & FORT POLK ATTN AFZX GT DR J AINSWORTH CMD SCIENCE ADVISOR G3 FORT POLK LA 71459-5355
	ABERDEEN PROVING GROUND
2	DIRECTOR US ARMY RSCH LABORATORY ATTN AMSRL CI LP (TECH LIB) BLDG 305 APG AA
1	LIBRARY ARL HRED BLDG 459 APG-AA
1	ARL HRED ATTN AMSRL HR MB F PARAGALLO BLDG 459
1	US ATEC RYAN BLDG APG-AA
1	CDN ARMY LO TO ATEC ATTN AMSTE CL RYAN BLDG

INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 2002	Final

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Assessment of the Human Factors Characteristics of the AH-64D Apache Longbow Crew Stations	AMS Code 622716 Project No. AH70
6. AUTHOR(S) Durbin, D.B. (ARL)	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425	10. SPONSORING/MONITORING AGENCY REPORT NUMBER ARL-MR-527

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT *(Maximum 200 words)*

The human factors characteristics of the AH-64D Apache Longbow helicopter crew stations were assessed. The assessment was based on a survey administered to 43 AH-64D pilots. Results of the assessment indicate that crew workload is manageable during missions and that crews experience lower workload levels, greater situational awareness, and are able to make decisions more quickly in the AH-64D than in the AH-64A. Results also indicate that pilots have not experienced significant problems when using most of the AH-64D crew station controls, displays, and subsystems.

14. SUBJECT TERMS			15. NUMBER OF PAGES
Army aviation	human factors	workload	112
AH-64D	situation awareness		16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	