AD-A064 374 CAE ELECTRONICS LTD MONTREAL (QUEBEC) F/G 1/3

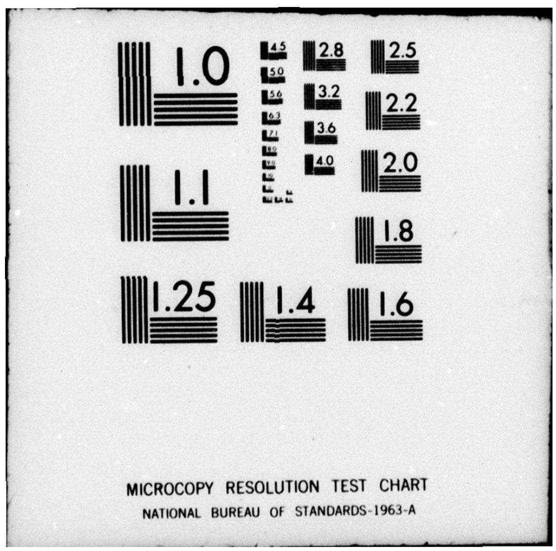
TRAINER PERFORMANCE SPECIFICATION FOR THE AH-64 HELICOPTER FLIG--ETC(U)

OCT 77 N61339-77-C-0047

UNCLASSIFIED NL

1 OF 2

AD A064374


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL II

1

ADA064374

cae

TRAINER PERFORMANCE SPECIFICATION FOR THE AH-64 HELICOPTER FLIGHT AND WEAPONS SIMULATOR DEVICE 2B40

DDC FILE COPY

D D C
RECEIVED
FEB 8 1979
B

CONTRACT NUMBER: N61339–77–C–0047

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

79 01 02 041

cae CAE ELECTRONICS LTD.

Note: This draft dated 5 OCT[redacted]77

[redacted]

LEVEL II

CONTRACT NUMBER: N61339-77-C-0047

ITEM NUMBER: 0004

TRAINER PERFORMANCE SPECIFICATION

FOR THE

AH-64 HELICOPTER

FLIGHT AND WEAPONS SIMULATOR

DEVICE 2B40

Prepared by:

Approved by:

Approved by:

DDC
RECEIVED
FEB 8 1979
B

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

CAE ELECTRONICS LTD.

P.O. Box 1800, Saint-Laurent, Montreal, Quebec, H4L 4X4 Canada

79 01 02 041

TABLE OF CONTENTS

PER LETTER
A

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

TRAINER PERFORMANCE SPECIFICATION
FOR THE
AH-64 HELICOPTER
FLIGHT AND WEAPONS SIMULATOR
DEVICE 2B40

1. SCOPE

1.1 This specification covers the requirements for the design and fabrication of Device 2B40, the AH-64 Helicopter Flight and Weapons Simulator (FWS) Trainer. The AH-64 is a twin engine, rotary wing aircraft designed as a stable, manned aerial weapons system to deliver point, area and rocket fire. The trainer will consist of two trainee stations (cockpits); a copilot/gunner (CPG) position (front seat) and a pilot position (rear seat); an instructor station, motion system and visual display for each station; and a digital computation system with peripheral equipment. The system complex is depicted in Figure 1.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of issue of this specification, form a part of this specification to the extent specified herein.

SPECIFICATIONS

<u>Federal</u>

L-P-383	Plastic Material, Polyester Resin, Glass Fiber Base, Low Pressure Laminated

<u>Military</u>

MIL-R-9673	Radiation Limits, Microwave and X-Radiation Generated by Ground Electronics Equipment (as Related to Personnel Safety)
MIL-T-23991	Training Devices, Military, General Specification for
MIL-P-25421	Plastic Materials, Glass Fiber Base Epoxy Resin, Low Pressure Laminated
MIL-C-29025	Communication Systems for Training Devices, General Specification for
MIL-I-82356	Instruments, Simulated, for Aircraft Training Devices; General Specification for

-A-

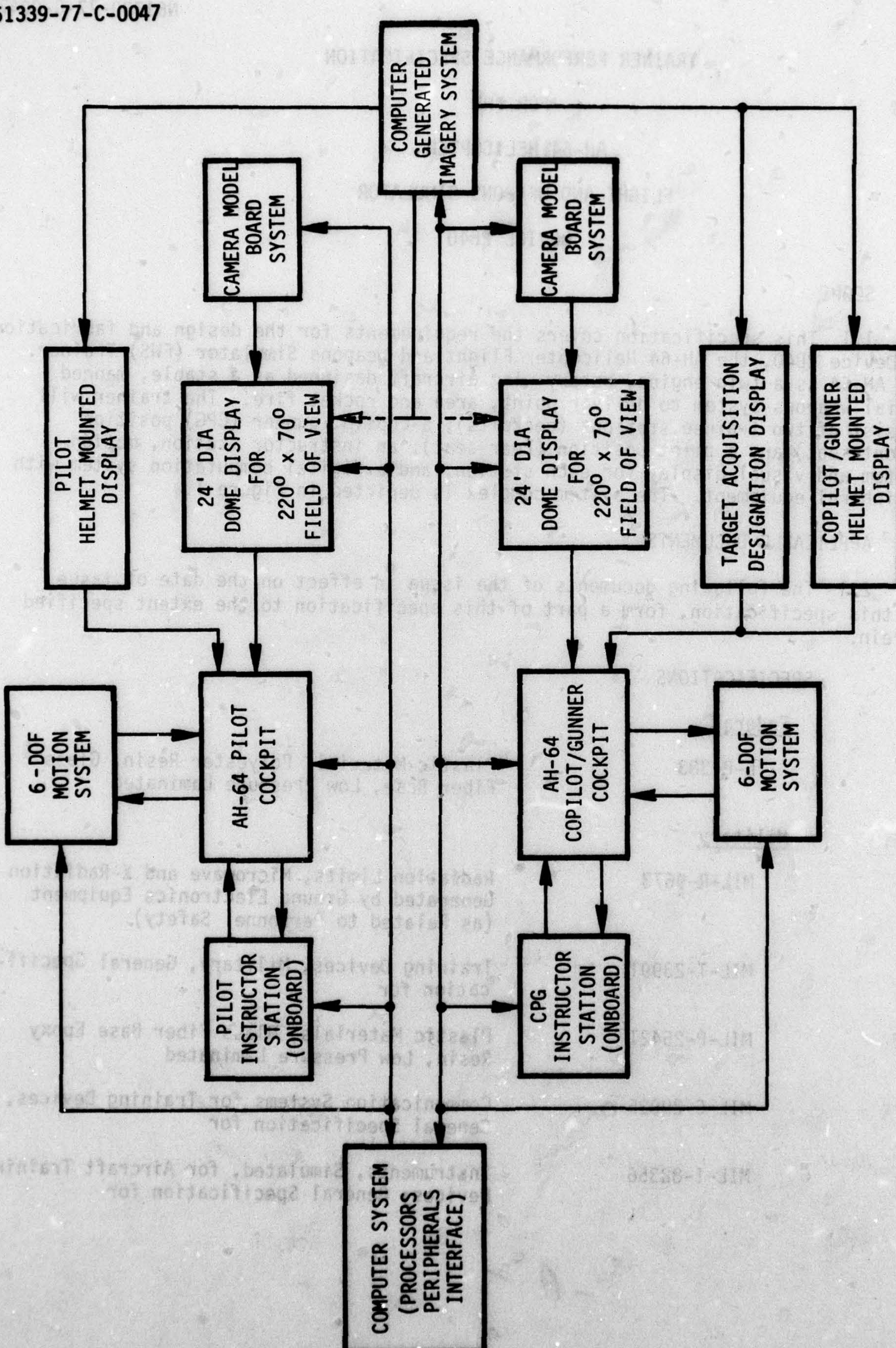


Figure 1 - AH-64 Helicopter FWS System Diagram

STANDARDS

Military

MIL-STD-143	Specifications and Standards; Order of Precedence for the Selection of
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-749	Preparation and Submission of Data for Approval of Nonstandard Parts
MIL-STD-781	Reliability Tests : Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1378	Requirements for Employing Standard Hardware Program Modules
MIL-STD-1389	Design Requirements for Standard Hardware Program Electronic Modules
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

PUBLICATIONS

Military

MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-472	Maintainability Prediction

Department of the Navy

SECNAVINST 3560.1	Tactical Digital Systems Documentation Standards

Naval Training Equipment Center (NAVTRAEQUIPCEN)

NAVSO P-3097	Automatic Data Processing Glossary
Bulletin 301-2A	Parts, Nonstandard; Design Selection; Procedures for

Naval Ordnance Systems Command (NAVORDSYSCOM)

XWS 6788	Brayco 745

Department of the Army

AR 70-44	DoD Engineering for Transportability
DRC-DP-AAH-4020A	Prime Item Development Specification for Target Acquisition Designation System (TADS)
DRC-DP-AAH-4020A Appendix II	YAH-64 (Hughes) TADS peculiar design requirements
DRC-DP-AAH-4030A	Prime Item Development Specification for Pilot Night Vision System (PNVS)
DRC-DP-AAH-4030A Appendix II	YAH-64 (Hughes) Peculiar design requirements

(Copies of specifications, standards, publications, and drawings required by suppliers in connection with specific procurement functions shall be obtained from the procuring activity or as directed by the Procuring Contracting Officer).

2.2 Other publications.- The following documents form a part of this specification to the extent specified. Unless otherwise indicated, the issue in effect on date of issue of this specification shall apply:

Federal Aviation Regulation (FAR)

AIM Part 1 COM-1-AGA-3	Airman's Information Manual

United States Committee on Extension to the Standard Atmosphere

U.S. Standard Atmosphere, 1962

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402).

Hughes Aircraft Corporation

AMC-SS-AAH-H10000A	Advanced Attack Helicopter System Specification
AAH-64-1 Vol 3 Book 23	TADS/PNVS Interface data

3. REQUIREMENTS

3.1 Materials, parts, and processes.- Materials, parts, and processes shall be in accordance with MIL-T-23991 and as specified herein. Materials, parts, and processes used in the design of the digital computers and visual system assemblies shall conform to good commercial practices and standards. The design of the trainer shall be such as to limit the number of types and quantities of electromechanical and electronic parts which do not conform to Group I specifications as defined by MIL-STD-143. Procedures for requesting specific waivers to use nonstandard items and the data requirements for obtaining approvals for these requests shall be as specified in MIL-T-23991 and MIL-STD-749. Procedures applicable to electronic type items are detailed in Bulletin 301-2A.

3.1.1 Plastics.- Plastic material used to fabricate the cockpit shell shall be in accordance with L-P-383 or MIL-P-25421, type I, class I.

3.1.2 Standard electronic modules (SEM's).- Standard and predeveloped special SEM's will be considered as standard parts and no written approval to use will be required. New special SEM's that may be developed for this contract must comply with the requirements of MIL-STD-1378 and MIL-STD-1389. Deviations from MIL-STD-1378 must be approved by the buyer.

3.2 Design.- Design shall be in accordance with MIL-T-23991 and as specified in 3.2.1 through 3.2.6 of this specification.

3.2.1 Design basis.- The trainer shall provide training in aircraft control, cockpit preflight and starting procedures, normal and emergency procedures, navigational and instrument flight procedures, tactical terrain flight, use of weapon systems under battle conditions in daylight, reduced visibility and nighttime visibility. The design basis aircraft shall be the AH-64 helicopter production unit Number 1. The performance characteristics of the various modes of operation of the trainer shall reflect the characteristics of the operational aircraft within such tolerances as to result in fidelity of simulation necessary for the training of student pilots. General tolerance parameters are provided in 3.6.1.15.

NOTE: Much of the aircraft data and, in fact, the final aircraft configuration will be undefined at time of issue of this specification. In order to provide acceptable fidelity of simulation, performance flight test data shall be used in the trainer design as soon as available.

3.2.1.1 Strength.- The trainer shall withstand, without damage, stresses incident to movement, handling in transit, hoisting, and tiedown aboard transporting vehicles, final installation, and use.

3.2.1.2 Housing.- The trainer shall be designed for installation in permanent housing to be provided by the United States Government. A soundproof enclosure shall be provided by the buyer for the hydraulic pump unit.

3.2.1.3 Cooling.- Except as otherwise specified herein, trainer cooling shall be in accordance with MIL-T-23991. Facility air conditioning will be furnished by the United States Government (see 3.10.1.5). The trainer shall be designed to meet the climatic conditions of MIL-T-23991 by utilizing ambient room air to the maximum extent possible. The use of supplementary air ducting shall be minimized. Temperature and air flow warning devices shall be mounted at equipment cabinet exhausts to sense potential "over temperature" conditions.

3.2.1.4 Lighting.- Simulator illumination shall be in accordance with Table XIX of MIL-STD-1472 and as specified herein.

3.2.1.4.1 Instructor station lighting.- Illumination shall be provided at the instructor station to adequately illuminate all panels, displays, recorders, instruments, controls, and work surfaces. This lighting shall not provide glare or other distractions to the instructor or to the trainees. The lighting system shall not cue the trainees of instructor actions through shadows or flickering of lights.

3.2.1.4.2 Maintenance lighting.- The existing utility power circuit shall be used to provide lighting in the trainee station area, under the trainer, and in any other normally dark or dimly lit areas where maintenance may be required. All bulbs shall be guarded from accidental breakage. Each group of lights shall be controlled by conveniently located ON/OFF switches. Reel-type extension cords may be utilized.

3.2.1.4.3 Emergency lighting.- An emergency light set in accordance with MIL-T-23991 shall be provided.

3.2.1.5 Acoustical noise.- The control of acoustical noise generation and penetration shall be in accordance with MIL-STD-1472. Except in the trainee station where sound characteristics shall be in accordance with 3.6.1.9 the acoustical noise level in operational areas of the trainer shall not exceed noise criteria of MIL-STD-1472.

3.2.1.6 Ash receptacles.- Ash receptacles of appropriate design shall be permanently installed at convenient locations throughout the trainer. There shall be at least one ash receptacle for each trainee position, one for each instructor position, and any other console or manned location. Provisions shall be made for convenient removal of the contents of ash receptacles.

3.2.2 Mechanical design.- Mechanical design shall be in accordance with MIL-T-23991 and as specified herein and in 3.10.2.

3.2.2.1 Trainer construction.- Major components of the trainer shall be of modular construction such that installation, assembly, and disassembly can be accomplished without special equipment. Components shall be interconnectable by cable assemblies and hydraulic lines with easy disconnect connections so that the trainer general arrangement and configuration may be changed with minimum effort. Means for leveling each major component shall be provided. Each major component shall have provisions for lifting and moving by forklift.

3.2.3 Electrical and electronic design.- Electrical and electronic design shall be in accordance with MIL-T-23991 and as specified in 3.10.2.

3.2.4 Optical systems.- Optical system design shall be in accordance with MIL-T-23991.

3.2.5 Human factors and training.- Design, selection, and arrangement of equipment shall be such as to insure ease, efficiency, and safety of operation in the performance of all necessary functions by instructional, maintenance, and trainee personnel in fulfilling the intended use of the trainer. Efficient and effective development of desired trainee skills and performance of all associated training functions shall be the primary consideration in all decisions affecting the design of the trainer and its component parts. In this regard, particular emphasis shall be placed upon design for training of the visual display and its interface with the trainee.

3.2.5.1 Human factors engineering.- The human factors engineering data and requirements of MIL-STD-1472 shall apply to the design of all work places and man-equipment interfaces. All aspects of trainer layout and configuration involving personnel access or use (except as may be required to simulate the configuration of the design basis aircraft) shall be governed by the dimensions of the human male using the 5th to 95th percentile range as a minimum standard.

3.2.6 Modes of operation.- The trainer shall be designed to operate in three modes: integrated crew training, independent crew training and data processing. Training at one trainee station will not be possible when the trainer is operating in the data processing mode of maneuver creating or editing, or during automated tactical situation control or setups and unusual attitudes creation (refer to 3.10.3). The trainer will be used in the integrated crew training and independent crew training modes with the visual displays and motion systems in operation. The use of the trainer when a visual system and/or a motion system are inoperative shall be possible during both integrated and independent crew training modes. The characteristics of the modes of operation shall be as follows:

3.2.6.1 Integrated crew training mode operation.- In the integrated crew training mode, the pilot and CPG trainee stations shall operate together through computer control. The administration of training student crews occupying the pilot and CPG trainee stations shall be possible by one or two instructor(s) situated in either the pilot or CPG instructor's station. The instructor shall be aided by the provision of an automated performance evaluation, manual activated or event activated lesson plan, automated performance recording, automated tactical scenarios and automatic demonstrations. The use of lesson plans shall allow the instructor through the use of controls and displays at either instructor station to manually initiate tactical situations, performance evaluation, malfunctions, environmental conditions as a preplanned lesson step. Initiation of the step shall also be possible automatically on the occurrence of an event in the training mission. Information displayed at the instructor station shall be continuously updated to reflect the status of the training mission, the training scenario and of the simulated aircraft.

3.2.6.2 Independent crew training mode operation.- In the independent crew training mode, the pilot and CPG trainee stations shall operate independently in separate training environments. Control of the pilot training environment shall be by the pilot instructor situated behind the pilot trainee station and control of the CPG training environment shall be by the CPG instructor situated behind the CPG trainee station. Both instructors shall have controls and displays which allow them access to the same facilities described in 3.2.6.1.

3.2.6.3 Data processing mode operation.- When training activities are not in progress at one of the trainee stations and maintenance requirements permit, the computer complex shall be capable of being used for the development or modification of automated demonstrations, training program setups, unusual attitudes and automated tactical scenarios.

3.3 Reliability.- The reliability program shall be in accordance with the United States Government approved Reliability Program Plan of the contract. The contractor shall, as part of the overall reliability program management, include appropriate reliability planning and assessment techniques to allow for the appropriate anticipation, measurement, and assessment of achieved reliability, throughout the contract. The Reliability Program Plan shall reflect the requirements of MIL-STD-785, MIL-T-23991 and the following (with the exception of 3.3.2):

3.3.1 Reliability objectives.- The trainer design shall include all practicable features that will result in a reliable and stable design. The use of stress derating, redundancy, stress-strength, and other reliability-oriented techniques shall be implemented for new design on the trainer, especially where critical items or potentially critical failure modes are encountered. As far as is practicable, these techniques shall also be applied to off the shelf equipment to determine adherence to the reliability objectives.

3.3.2 Quantitative requirements.- The quantitative reliability requirements for the contractor furnished equipment are:

(a) Specified Mean-Time-Between-Failures (MTBF) (θ_0) = 50 hours.

(b) Minimum acceptable MTBF (θ_1) = 25 hours.

3.3.3 Reliability apportionment and prediction.- Reliability apportionment and prediction shall be in accordance with the following:

(a) Develop a block diagram indicating the required functional reliability arrangement of all system elements in series, parallel, or standby configuration.

(b) Identify hardware and nonhardware system elements required for the execution and support of each function.

(c) Apportion required system probability of training mission success to each function.

(d) Determine the reliability of hardware items and other system elements executing or supporting each function.

(e) Produce reliability estimates and predictions relating to the developed functional model. For the trainer, most elements are in line or series connected and the product rule of reliability (an element failure will result in a system failure) is applicable, that is

$R_S = R_1 \times R_2 \times R_3 \ldots R_N$, where R_S = system reliability, R_1 through R_N = reliability of elements 1, 2, 3, etc., and N = total number of elements in the system.

(f) Obtain failure data from MIL-HDBK-217, failure rate data (FARADA), field experience, and manufacturer's data.

3.3.3.1 Reliability prediction updating.- Reliability prediction updating shall be in accordance with the following:

(a) Assure that the proposed design and other relevant changes are reflected in the functional model and that significant effects of changes on system reliability are brought to the attention of management.

(b) Update operational reliability predictions using applicable test data and identify problem areas for timely corrective action.

3.3.3.2 Parts reliability.- Parts shall not be used in new design without knowledge of their capabilities and reliability as determined from current or previous testing or use. Parts having established quantitative reliability requirements (failure rate levels) shall be used wherever possible. The best available estimate of a reliability index under the applicable stress levels shall be assigned to each part, component, or subassembly.

3.3.3.3 Failure mode and effect analysis.- A failure mode and effect analysis (FMEA) shall be performed on new design areas of the trainer where quantitative reliability requirements have not been previously established. The primary purpose of the FMEA is to identify potential system weaknesses; it (the FMEA) shall be carried out to a functional subsystem level sufficient to identify these weaknesses. Each potential failure shall be evaluated to determine its effect on accomplishment of training missions and ranked as to its criticality. Critical failures or modes of trainer operation susceptible to failure shall be further investigated to determine design improvements to eliminate failure causes or reduce failure risks to allowable levels. The FMEA shall be planned as a continuing effort to give design guidance and provide data for consideration during design review.

3.3.4 Failure criteria.- Failure criteria shall be in accordance with the following:

(a) When the failure is due to: adjustment (maintenance or installation) design defect, manufacturing defect, any other part defect, workmanship, misapplication, part wear, or unknown reasons, the failure shall be categorized as relevant.

(b) When the failure is due to: accidental damage, adjustment (operator), drawing error, failure of another part (secondary failure), installation error, operator error, scheduled replacement, or failure of test equipment or facility, the failure shall be categorized as nonrelevant. Nonrelevant failures are not counted for determining reliability, but are recorded in order that corrective action may be taken as required.

(c) When two or more failures of the same part occur in identical or equivalent application, whose combined failure rate exceeds that predicted, the failure(s) shall be categorized as a pattern failure. When two or more secondary failures of the same part occur, whose combined failure rate exceeds that predicted, and which are due to more than one primary failure, the secondary failure shall be categorized as a relevant pattern failure.

3.3.5 Availability.- Scheduled availability as specified in MIL-T-23991 shall not apply.

3.4 Maintainability.- Maintainability shall be in accordance with the Government approved Maintainability Program Plan of the contract, MIL-STD-470, MIL-T-23991, and the following:

3.4.1 Quantitative requirements.- The quantitative requirement for Device 2B40 which includes the computer and peripheral equipment is:

Mean time to repair (MTTR) = 40 minutes.

3.4.1.1 Prediction techniques.- The supplier's maintainability prediction technique shall be in accordance with MIL-HDBK-472.

3.4.2 Design for maintainability.- Design for maintainability shall be in accordance with MIL-STD-1472.

3.4.3 Maintenance intercommunications system (MICS).- The trainer shall be provided with an independent maintenance intercommunication system (separate from the simulated intercommunication system) for communication between the trainee area, the instructor area, the maintenance area, the computer area (1 MICS station shall be provided for at least every 3 cabinets in the computer area), the pump room(s), the visual system equipment area, and any other area requiring circuit or equipment adjustment or calibration. Controls and audio/visual alerts shall be provided at each MICS station to enable communication selectively with any other station, to select either the headset or speaker, or both, and to control the volume. One headset for each MICS station, which includes the microphone suspended from the headset, shall be provided (separate from those required for the simulated intercommunication system).

3.4.3.1 Emergency intercommunications system.- An emergency intercommunications system, independent of all cockpit power shall also be furnished.

3.4.4 Maintenance and maintainability provisions.- Maintenance features and maintenance provisions shall be as follows:

(a) The built-in test facilities.

(b) Maintenance, diagnostic, calibration and test programs.

3.4.4.1 Built-in test facilities.- A built-in, noncontinuous, manually-initiated, fault detection and locating system shall be provided to detect performance degradation and failures. Maximum use of the digital computer verification and debugging programs shall be made to evaluate actual operating values against predetermined optimum performance values. The system shall provide an assessment of the overall training device integrity in not more than fifteen minutes upon command. The overall evaluation program shall isolate problems to a major area of the device, e.g., cockpit, interface, visual. Subroutine programs shall then evaluate the systems (exclusive of the visual system) and isolate the faulty hardware to a level not greater than five (three desired) circuit boards in the computer, board level in interface equipment, or to the assembly for analog equipment, up through the input to the cockpit and instructor station equipment.

3.4.4.2 Maintenance and test programs.- Maintenance programs shall test the operation of all training device equipment. When a malfunction occurs, these programs shall assist the operator in the location of the malfunction. Programs shall be capable of running with a minimum of operator intervention. Programs shall be in accordance with 3.7.3.3.2(e).

3.4.5 Maintenance test bench.- The contractor shall provide a maintenance test bench. The test bench shall have a flat working surface of at least 2000 square inches. The bench shall have a minimum of three duplex outlets to provide power to associated equipment. The bench shall contain slide-out drawers for stowage of drawings, spare parts, and support equipment.

3.4.6 Roll-about maintenance stands.- Roll-about maintenance stands with safety caster locks shall be provided for maintenance access to trainer components not otherwise conveniently accessible or when catwalks are not incorporated into the trainer designs. Hand and guard rails of a nonconducting material shall be included around the periphery of the stairs and work surface. All steps and work surfaces shall be covered with permanently installed nonskid, nonconducting rubber matting. A capability to ground the stand shall be provided. A neat method of ground line storage shall be provided on the stand.

3.4.7 Cockpit instruments and control panels.- Slack shall be included in the cables behind the cockpit panels to permit removal of each instrument or aircraft control panel and disconnection from its associated cables from inside the cockpit in one maintenance operation. The need for rear access to disconnect or reconnect the equipment from its associated mounting shall be prevented by the selection and use of appropriate hardware fasteners. Aircraft instruments shall be used wherever technically possible.

3.4.8 Instructor station panels.- Where disconnection and equipment removal are not from the same side of a panel or where rear access is required for equipment troubleshooting, the panel shall be hinged to permit accessibility to both sides from the front of the instructor station. The hinge hardware shall not prohibit easy removal of the entire panel when required. Hinges shall not be required on instructor control panels.

3.5 Transportability.- The trainer shall be transportable by standard commercial transportation. Each module shall be constructed such that it can be put into operation without soldering, welding, unsoldering, cutting, crimping or destruction of material. All modules shall be designed for moving by forklift.

3.6 Performance.- The flight and ground performance of the design basis aircraft shall be simulated as specified in 3.6.1 through 3.6.1.15.8 of this specification and as detailed in the approved design criteria. Unless otherwise specified herein, all mention of the operation or performance of the aircraft, equipment, subsystems, controls, instruments, and the like, shall be understood to mean simulated operation in both flight and ground operations under instrument and visual conditions, including tactical terrain flight.

3.6.1 Simulation performance.- The trainer shall simulate in real time applicable normal and emergency aircraft operation of both transient and steady state flight dynamics, engine performance, flying qualities, aircraft systems operations, radio communications and navigation systems operation, environmental effects, and ground operations. The trainer shall also simulate applicable weapon systems and weapon ballistics and free flight dynamics. The simulation of weight and balance conditions due to fuel, stores and weapons shall be provided. The simulation shall be statically and dynamically correct for all conditions of aircraft operations within the tolerances specified in 3.6.1.15. Such simulation shall be reflected by appropriate trainee and instructor station instrument and aural indications, control reactions, visual cue presentations, and display traces responding to trainee, instructor, and programmed control inputs.

3.6.1.1 Indication response.- Trainee station instruments and other visual and aural indications responding to computer equipment signals, resulting from trainee and instructor control actuation, shall duplicate the static and dynamic indications of the design basis aircraft in accordance with the design criteria. Instrument oscillations, rates of change, and lags experienced in the operation of the design basis aircraft shall be simulated. Pilot trainee station information displays shall correspond to information displayed at the CPG trainee station. Agreement shall be achieved between cockpit instrument responses and the operational situation depicted by the visual simulation scenes such that discrepancies are imperceptible.

3.6.1.2 Control response.- Trainee station cockpit controls shall reflect feel, damping, friction force, inertia, and response effects representative of similar control positions and modes of operation of the design basis aircraft for the required synthetic flight and aircraft system. Both normal and emergency operation conditions shall be included as specified herein and as incorporated into the design criteria. Additional controls which may be included but are not functionally activated shall be operable with regard to appearance, friction, feel, and normally available movement.

3.6.1.3 Complete system dynamic response.- Relative responses of the motion system, cockpit instruments, and visual systems shall be coupled closely to provide integrated sensory cues. The total time lag error of the trainer shall not exceed 150 milliseconds for all cues. In addition, the difference in time lag error between any two cues shall not exceed 20 milliseconds. Time lag error is considered to be any lag in excess of that experienced in the real aircraft. It is found by measuring the time from control input to when the system response reaches 50 percent of the commanded output and then subtracting the corresponding time experienced in the real aircraft. The above shall be the governing criteria for the dynamic reresponse of the complete system and for all components of the system.

3.6.1.4 Aerodynamic performance.- The aerodynamic performance simulated by the trainer shall have complete freedom along and about the right-hand orthogonal axes. The forces and moments along and about these axes shall be in accordance with the design data and shall provide a simulation of the three-dimensional flight path and aircraft attitude within the tolerances specified in 3.6.1.15.

3.6.1.5 Powerplant performance.- The powerplant performance shall simulate the operation of the T700-GE-700 turboshaft engines during all phases of operation. The powerplant performance shall respond appropriately to the simulated earth's atmosphere of 3.6.1.8 and to the malfunctions of 3.6.1.14. Simulation shall be in accordance with the tolerances of 3.6.1.15.

3.6.1.6 <u>Aircraft systems</u>.- The trainer shall include complete and automatic simulation of all systems of the AH-64 aircraft with which the pilot and CPG may interact during normal and emergency operations. The simulation shall appropriately affect the flight characteristics, control responses, and instrument readings, and all warning, caution, and advisory lights. Each system shall be a complete analog of the helicopter's system so that the functional programmed flow diagrams of the simulated systems shall correspond to the functional schematics of the actual system. Characteristics of the system such as motors, valves, and regulators shall be included to produce the correct static and dynamic performance of the system. System operation shall be as specified herein and in the design criteria. The systems to be simulated shall include powerplant systems, flight control system, transmission system, fuel supply system, rotor systems, electrical power supply systems, auxiliary power unit, hydraulic power supply systems, landing gear system, fire extinguisher system, anti-icing systems, fire control systems, and other relevant systems.

3.6.1.6.1 <u>Powerplant systems</u>.- The powerplant systems shall be simulated in real time as required for 3.6.1.5.

3.6.1.6.2 <u>Flight control systems</u>.- All components and functions of the flight control system shall be simulated. Major components shall include cyclic stick, collective pitch lever, directional control pedals, automatic stabilization equipment (ASE) and the backup control system (BUCS). The simulation shall include, but not be limited to, the effects of trim systems and hydraulic malfunctions. Provisions shall be included to implement and propagate the effects of the failure of all or part of the ASE system.

3.6.1.6.3 <u>Transmission system</u>.- The simulation of the complete transmission system, including impending transmission system failure (i.e., receiving hit from ground fire, oil coolers, pumps, or blowers) with associated oil temperature and pressure and chip detection response shall be provided.

3.6.1.6.4 <u>Fuel supply system</u>.- Simulation of the fuel supply system, including fuel management and the pressure and quantity caution lights and indicators shall be provided.

3.6.1.6.5 <u>Rotor system</u>.- Simulation of the rotor system shall be provided. The effects of the rotor brake shall be simulated.

3.6.1.6.6 <u>Electrical power supply system</u>.- The electrical power supply system, including cockpit circuit breakers, external power electrical distribution, ac electrical power generator switches, generator caution lights, ac loads, dc electrical power, battery, switches, caution lights and dc loads shall be simulated. Electrical controls and circuit breakers shall be installed; those affecting any instrument or component located in the cockpit area or affecting any condition of flight or system operation shall be activated; others will be duplications of the actual equipment. Effects of tripping of circuit breakers affecting flight or aircraft systems shall be simulated.

3.6.1.6.7 <u>Hydraulic power supply system</u>.- The hydraulic power supply system including primary and utility hydraulic systems with associated caution lights and indicators shall be simulated.

3.6.1.6.8 <u>Landing gear system</u>.- The functions of any wheel controls, brake pedals, and associated caution lights shall be provided.

3.6.1.6.9 Fire extinguisher system.- Simulation of the fire extinguisher system shall include the engine fire detector test and control panel associated controls, warning lights, and test switches.

3.6.1.6.10 Anti-icing systems.- The engine, pitot, and windshield anti-icing systems shall be simulated. The windshield anti-icing shall be nonfunctional, except for controls and indicators.

3.6.1.6.11 Auxiliary power unit.- The auxiliary power unit consisting of the GTP36-55(c) gas turbine engine with associated controls, caution lights and indicators shall be simulated.

3.6.1.6.12 Armament subsystem.- All components and functions of the armament subsystems shall be simulated. Major components shall include the point target subsystem, area weapon subsystem and aerial rocket subsystem.

3.6.1.6.13 Fire control subsystem.- Simulation of the fire control subsystem, including the target acquisition designation system (TADS), air data sensors, attitude and velocity sensors, IHADSS and associated controls and displays shall be provided. The AH-64 fire control computer and TADS symbol generator shall be incorporated in the simulator.

3.6.1.6.14 Radar warning system.- The AN/APR-39(v)1 radar warning system shall be simulated in accordance with approved data.

3.6.1.6.15 Weapons performance.- The aerodynamic properties of the AH-64 weapons shall be simulated to approved data. Simulation shall include calculation of 30 millimeter gunfire, 2.75 inch rockets and Hellfire missile trajectories and kill effectiveness.

3.6.1.6.16 Line of sight calculations.- Calculations of the line of sight between the simulated aircraft and the following items shall be included as part of the simulation. Calculations shall decide whether the path between the simulated aircraft and the following items is obstructed and if so calculate azimuth and range.

(a) Points designated by the TADS laser designation system.

(b) Rocket and missile positions.

(c) Radar emmitting vehicles.

(d) Threat target positions within 5000 meters.

(e) Tuned UHF and VHF stations within reception range.

3.6.1.7 Communication/navigation systems simulation.- The communication/navigation equipment controls and indications shall be operable so as to afford, in conjunction with the respective simulated surface radio facilities, simulation of the operation of the design basis aircraft equipment as specified in 3.6.1.7.2. Such simulation shall include operational effects such as warmup or unreliable signal conditions and line of sight range and attenuation effects.

3.6.1.7.1 Instructor-trainee communication system.- A voice communication system shall be provided to enable the instructor to control and monitor the communications environment and to act as a ground or airborne communicator. The system shall provide the capability for the instructor to transmit at any time, regardless of trainee control settings.

3.6.1.7.2 Aircraft radio equipment simulation.- Trainee station radio communication and navigation equipment controls and indicators shall be fully operable. In addition, volume of auto-training audio shall be controllable. A minimum of two headsets shall be provided. Navigation capabilities prescribed herein for specific radio sets, shall be simulated. The following AH-64 aircraft equipment shall be simulated:

(a)	AN/ASN - 128	Lightweight Doppler Navigation Set
(b)	AN/ARC - 114	VHF - FM Radio Set
(c)	AN/ARC - 115	VHF - AM Radio Set
(d)	RT1167/ARC - 164	UHF Radio Set
(e)	AN/ARN - 89	Automatic Direction Finding Set
(f)	AN/ASN - 76	Heading Attitude Reference Set
(g)	AN/APR - 209	Radar Altimeter

Control panel selections shall be repeated on a CRT page for following equipment:

(h)	AN/APX - 100	Transponder Set
(i)	TSEC/KY - 28	Communication Security Set

3.6.1.7.3 Surface communication/navigation facilities.- Simulated surface communication/navigation facilities shall have the capability of providing synthesized signals to the simulated communication/navigation equipment. The operation of the simulated surface facilities shall simulate that of the operational ground facility with regard to signal strength, range, operational tolerances, and other characteristics in accordance with programmed surface facility variables and with appropriate trainee and instructor control inputs. Activation, tuning, and in-range conditions between the selected airborne equipment and the surface facility shall be indicated to the instructor. Station selection shall be made on the basis of station location and frequency. In addition, operational effects such as static shall be simulated, and radio jamming sounds, shall be simulated through the headsets and be controllable by the instructor.

Each facility shall be capable of being defined by any or all of the following parameters, as applicable:

(a) Channels or frequencies

(b) Facility identification - Morse code identifier only

(c) Geographic location in increments not greater than 0.05 nautical mile north and east of latitude and longitude.

(d) Elevation from sea level to 12,000 feet above sea level in no greater than ten foot increments.

(e) Runway heading (magnetic) from 0^{o} through 360^{o} in increments no greater than 0.1^{o}.

(f) Marker beacon patterns shall be designed to provide satisfactory instrument training. Middle marker beacons and outer marker beacons shall be located in accordance with data published for the facility being simulated.

(g) Magnetic variation of the geographic area represented by the simulated facilities shall be in accordance with published data for that facility.

3.6.1.7.4 Facility programming.- The main trainer program shall include all information required to describe ground radio navigation stations and landing fields within the problem world (see 3.6.1.7.5). It shall be possible to relocate communication/navigation facilities over any area of the problem world. The communications/navigation facilities shall consist of a mixture of LF/ADF, GCA, UHF, VHF and FM (voice secure). The capability shall be provided to access data for up to 5000 communication/navigation facilities placed anywhere in the world. Fort Rucker environs shall be provided, and shall include all facilities within reception range.

3.6.1.7.5 Problem world.- A problem world shall be provided within which the simulated design basis aircraft shall operate.

(a) Instrument flight.- For instrument operation of the aircraft, the problem world shall simulate all the atmospheric and electromagnetic effects characteristics of the real world after which it is modeled consistent with other requirements stated herein. The problem world shall encompass any longitude and latitude, anywhere in the world. The problem world shall meet the requirements of 3.6.1.8.

(b) Visual flight.- For operation of the aircraft in the simulated visual flight environment, the problem world shall include the area encompassed by the visual system terrain models or the computer generated imagery. When operating in a simulated visual environment, aircraft instrument indications shall be correctly correlated with the visual scene presentations.

3.6.1.8 Media.- The earth's atmosph[illegible] shall be simulated in accordance with the U.S. Standard Atmosphere 1962 to affect the performance of the simulated aircraft as specified in 3.6.1.8.1 through 3.6.1.8.6. [illegible] simulated atmosphere shall extend from 300 feet below sea level to 32,768 feet above sea level. Density altitude shall be simulated.

3.6.1.8.1 Barometric pressure.- Barometric pressure shall be variable to reflect any altimeter setting value from 950 through 1060 millibars in increments of one millibar. The values selected shall affect the indicated altitude in accordance with standard pressure altitude relationship charts. In the setting of the trainee station altimeters to correspond to that programmed, the indicated altitude shall correspond to the selected field elevation ± 20 feet when the trainer is on the ground.

3.6.1.8.2 Wind magnitude and direction.- Wind magnitude shall be variable from 0 to 100 knots continuous in one knot increments. Wind direction shall be variable from 0^{o} through 360^{o} in one degree increments. The reaction of the aircraft to wind should immediately be apparent to the student and/or instructor in the cockpit module. In the proximity of the ground model, the local wind velocity and direction shall be modified by the local ground slope and ground objects such as trees, buildings, hills.

3.6.1.8.3 Temperature.- Ground level temperature shall be selectable from $-40^{o}C$ to $+50^{o}C$ in one degree increments. The temperature lapse rate shall be variable from $-4^{o}C$ to $+4^{o}C$ per thousand feet. Using the selected increment as a basis, temperature shall vary with altitude in accordance with the U.S. Standard Atmosphere 1962. All temperature indications shall be displayed in centigrade.

3.6.1.8.4 Magnetic variation.- Magnetic variation shall be automatically inserted into the navigation computation from the variation at the surface facilities closest to the aircraft position. Magnetic variation changes shall be with no discontinuities; i.e., interpolation between facilities shall occur.

3.6.1.8.5 Rough air controls.- Rough air simulation shall be provided. It shall be randomly programmed and applied to the simulator as a force vector. The character of the rough air shall be readily adjustable in percentage. Rough air as applicable shall produce an appropriate effect on those variables actually affected in the aircraft including airspeed, angle of attack, sideslip, rate of climb, etc. Effects on instruments, motion and visual shall be automatic and it shall be possible to fly out the turbulence. In the proximity of the ground, the rough air shall be modified by local ground objects such as trees, buildings, hills.

3.6.1.8.6 Icing conditions.- An icing condition shall exist if the computed total air temperature (TAT) is in the range of $4^{o}C$ to $-40^{o}C$, and the instructor has selected icing conditions. The instructor's setting determines the maximum icing and the rate at which the ice builds up to its value. The effect shall be cancelled automatically and gradually when appropriate measures are taken by the trainee, provided the ice protection system is available. If the icing setting is changed, the ice buildup shall change gradually to correspond to the new setting. In the case of the TAT being higher than $4^{o}C$ all ice shall be removed automatically within 2 minutes. If icing conditions are permitted to prevail, the results shall affect the instruments, engine and aircraft performance appropriately, including low frequency main rotor vibration caused by asymmetric self-shedding ice.

3.6.1.9 Aural simulation.- Normal and abnormal sounds which provide useful cues to the pilot in the aircraft crew compartment during all phases of flight and ground operations shall be simulated with respect to location, frequency, and amplitude. Aural simulation shall include, but not be limited to, the following:

(a) Airflow (at normal and at maximum speeds including changes in pitch tones, intensity, and the like, associated with changes in speed, altitude, or configuration)

(b) Systems:

(1) Engine sounds

(2) Rotor sounds

(3) Transmission sounds

(4) Compressor sounds

(5) Electrical sounds

(6) Hydraulic sounds

(c) Droop stop pounding

(d) Warning sounds

(e) Cockpit ventilation

(f) Auxiliary power unit operation

(g) Ground starting

(h) Ground and taxi operations

(i) Runway rumble

(j) Gear touchdown and bounce

(k) Crash

(l) Sounds associated with tactical actions including AH-64 weapons release, friendly and hostile fire, and impact of projectiles on the aircraft. Audio aspects of tactical action shall be controllable by the instructor as described in 3.7.3.3.3(g)(5).

(m) Tactical jamming sounds

(n) Sounds associated with malfunctions

The amplitude of sounds shall be controllable in ten steps from none to normal. The intensity shall be limited to 90 decibels. Extraneous trainer sounds, such as the device hydraulic system air compressor, ventilation system, motion system, motor generator, teletypewriter, and the like, shall not be audible inside the trainee station when the aural simulation equipment is in operation. The output of the sound system shall be through speakers or other devices located as appropriate to simulate the noise environment of the aircraft. Abnormal sounds shall be based on recorded samples of the AH-64. Sounds shall be muted during a freeze condition.

3.6.1.10 Motion simulation.- Motion simulation shall be included to provide motion cues for normal and emergency conditions as specified in 3.7.4.

3.6.1.11 Visual simulation.- Visual simulation shall be included to provide visual cues for normal and emergency conditions as specified in 3.7.5.

3.6.1.12 Simulation of weight and balance conditions.- The gross weight, moments of inertia and center of gravity (C of G) of the aircraft shall be simulated and shall be controllable by the instructor during training mode operation. The gross weight and C of G shall be calculated from the basic operating weight of the aircraft plus the addition of fuel and stores as initiated by the instructor. The gross weight and C of G shall be continually computed while fuel is being consumed and as stores are being released. The moments of inertia appropriate to the aircraft configuration and approved data shall be calculated continually. The gross weight and C of G shall be limited to the AH-64 minimum and maximum design values.

3.6.1.13 Crash.- When the trainee has exceeded aircraft design limits or the situation determines that he has contacted the ground in an abnormal attitude of flight, which would result in partial or complete loss of the aircraft, the trainer shall freeze and the instructor shall be alerted by a flashing indicator on the display CRT. The instructor shall be able to return the simulated aircraft to a preprogrammed initial position or to override the crash condition and allow the problem to continue without repositioning the aircraft.

3.6.1.14 Emergencies/malfunctions.- The trainer shall be capable of providing training in all emergencies/malfunction procedures that apply to the aircraft. The following malfunctions and failures are considered representative of those to be provided:

(a) APU failures or malfunctions:

(1) High exhaust gas temperature

(2) Overspeed

(b) Flight instruments failures:

(1) Pilot's electronic attitude direction indicator (EADI) power loss.

(2) Copilot's attitude indicator, vertical gyro failure. The vertical gyro topples.

(3) Pitot pressure system blocked. Pitot pressure instruments freeze in position.

(4) Barometric altimeter sticks in position.

(5) Turn indicators fail.

(6) Pilot's horizontal situation indicator. Sticks in position.

(c) Engine instruments failures:

(1) Gas producer (N_1) tachometer drive shaft failure.

a. Stays at zero in engine start

b. Decreases to zero while engines run

(2) Engine accessory drive shaft failure

a. N_1 indicator decreases to zero

b. Oil pressure decreases to zero

(3) Oil pressure indicators

a. Decrease to zero

b. Low oil pressure (below 40 pounds square inch)

(4) Oil temperature indicators

a. Freeze at value

b. Decrease to minimum (-60°C)

c. Increase to maximum (+160°C)

(5) Rotor tachometers (N_2) and/or indicators

a. Decrease to zero (pilot's)

b. Small fluctuations for 30 seconds then both fail (rotor tach generator).

c. A 4 rpm mis-sync will exist between the two rotor tachometers (pilot and CPG).

(6) Turbine Inlet Temperature (TIT) indicators decrease to zero.

(7) Torquemeter system failures

a. Pilot torquemeter failure. Both No.1 and No.2 torque indications fluctuate (±5% to ±15%) in random fashion.

b. Engine No.1 torque transducer failure. Pilot/CPG No.1 torque indication goes to approximately zero.

(d) Engine system failures

(1) No start - starter circuit breaker pops

(2) Hot start - TIT exceeds 927°C temperature

(3) Hung start - N_1 hangs up below 35 percent and TIT continues to increase above 927°C if engine condition lever is placed in flight position

(4) Engine fires (internal and/or external)

a. During start - extinguish with both bottles

b. During flight - extinguish with both bottles

c. During shutdown - TIT above 350°C

d. False fire - fire light no fire

(5) Flame outs - restart possible

a. Left engine

b. Right engine

c. Both engines

(6) Engine power variation

a. Malfunctioning fuel control unit engine surging

b. N_2 overspeed governor drive shaft failure. No normal or emergency beep trim response.

(7) Engine beep trim failures

a. Low side

b. High side

c. Static

d. Fail emergency beep trim

(8) Variable inlet guide vane failures

a. Engine No.2 (Fail closed)

b. Engine No.1 (Fail open)

(9) Bleed band failures

a. Engine No.1 (Fail closed)

b. Engine No.2 (Fail open)

c. Intermittent (popping) Engine No.2

(10) Gas producer (N_1) actuator failures

Fail to respond to any change in engine condition lever

(11) Loss of engine oil

a. Loss of oil, possible bearing seizure

b. Low quantity light

(12) Metal chips in engine

a. Engine No.2 light only

b. Engine No.1 light followed by power fluctuating and engine failure after 3 minutes

(e) Fuel system failures

(1) Boost pump failure

(2) Fuel quantity unbalance

Uneven fuel burning of 400 lbs. differing in main tank quantities after 30 minutes operation

(f) Hydraulic and flight control system failures

(1) Loss of primary hydraulic system

(2) loss of utility hydraulic system

(3) Accessory drive shaft failure

(4) Loss of automatic stabilization equipment (ASE)

(5) Hardovers in ASE (individual axis)

(6) Inputs and oscillations in ASE

(7) ASE engagement errors pitch axis

(8) Longitudinal force feel control failure

(9) Collective control jams in position. Free when selecting backup control system (BUCS)

(10) Longitudinal cyclic control jams in position. Free when selecting BUCS

(11) Flap jams in position

(g) Transmission system failures

(1) No.1 main transmission

a. Low oil pressure

b. Low oil quantity

c. High oil temperature

(2) No.2 nose gear box

a. Chips detected

b. High oil pressure

c. High oil temperature

(3) Tail rotor gearbox high oil temperature

(h) Rotor blade vibrations (main and tail)

(1) Rotor blade out of track (moderate) (main only)

(2) Rotor blade out of balance (moderate)

(3) Loss of tail rotor blade

(i) Electrical system failures

(1) Battery relay failures

(2) Generators

a. Failure of one ac generator

b. Failure of both ac generators

(3) Transformer - rectifiers

a. Failure of one transformer rectifier

b. Failure of both transformer rectifiers

(4) AC loadmeters failed static

(5) AC bus tie relay failure

(6) DC ammeters failed static

(7) DC bus tie relay failure

(8) Circuit breakers

a. AC circuit breakers

b. DC circuit breakers

(9) Panel lights

a. Pilot flight instrument lights (nonoperational)

b. CPG's flight instrument lights (nonoperational)

(10) Anti-icing system failures - associated circuit breaker failures of (8) above.

(j) Communication and navigation system failures

(1) FM transmitter and/or receiver

(2) UHF transmitter and/or receiver

(3) VHF transmitter and/or receiver

(4) ADF receiver failures

(5) Doppler failures

a. loss of signal

b. velocity errors

(6) HSI failures

a. Heading indication freezes

b. Course deviation fails

(7) Gyrosyn compass failures, compass cards precessor oscillate or spin (directional gyro failure)

(k) Armament malfunctions and visionics

(1) Runaway 30 millimeter gun

(2) Hung rocket

(3) Hellfire hang fire

(4) PNVS fails

(5) TADS TV fails

(6) TADS FLIR fails

(7) Symbol generator fails

(8) Laser designator fails

(9) TADS direct optics fails

3.6.1.15 Tolerances.- The trainer shall be designed to operate in accordance with the design criteria of the operational aircraft, within the tolerances specified in 3.6.1.15.1 through 3.6.1.15.8. These tolerances shall be applicable throughout the entire range of operation specified in 3.2.1, regardless of whether the range can be considered normal or abnormal. The performance to which the tolerance applies shall be a function of all variables specified in the design criteria. The variable for each of the items for which tolerances are listed herein shall be as indicated in the design criteria. Unless otherwise specified, the tolerance figures specified in 3.6.1.15.1 through 3.6.1.15.8 shall be construed to mean plus or minus the values. Where two or more tolerance values are specified for one particular parameter, the greater value for a point of interest shall govern. The tolerances specified herein shall be applicable at any place the values may be read i.e., at the computer, instructor station, flight compartment, and the like. Tolerances shall be measured at the points at which the trainee senses the results of the performance characteristics. In cases where the tolerance of the operational aircraft instrument or indicator is greater than that specified, the operational aircraft design criteria tolerances shall be applicable.

3.6.1.15.1 General.- Performance of the aircraft and function of any aircraft equipment not covered by a specific tolerance listed herein shall be in accordance with design criteria of the operational aircraft with the following listed general tolerances applicable to the individual parameters involved.

(a)	Total mass	One percent
(b)	Moments of inertia	One percent, or 0.1 percent of maximum value

(c)	Angular accelerations	Five percent
(d)	Linear accelerations	Five percent

3.6.1.15.2 Curve slope.- In addition to the tolerances specified in this specification the shape of any curve of trainer performance shall be similar to that of the design criteria of the operational aircraft. The sign of the second derivative of any section of the trainer performance curve and the operational aircraft design criteria shall be the same. Where a section of a curve is represented by a series of straight lines, the sign of the second derivative shall be implied by the trend of slope change of succeeding segments. Where a section of a curve obtained from operational aircraft design criteria and a trainer performance curve are linear and continuous, the slope of the two curves at the X value shall be the same $\pm 10^{o}$. Prior to comparing the curve slopes, they may be translated in X and Y to obtain the best fit, provided no point of the trainer performance curve falls outside the tolerance boundaries of the design criteria curve before or after translation. The comparison of curves shall be permitted only when the trainer curve and operational aircraft design criteria curve are at the same scale.

3.6.1.15.3 Powerplant tolerances.- The powerplant tolerances shall be as follows:

(a)	Angular displacement of power lever	0.5 percent of maximum value, 2 percent at or above 75 percent power, or 5 percent below 75 percent power
(b)	Fuel flow	2 percent, or 0.5 percent of maximum value
(c)	Fuel flow rate of change	25 percent
(d)	Fuel depletion rate	5 percent, or 0.3 percent of maximum value
(e)	Rotor rpm	1 rpm
(f)	Engine acceleration	10 percent, or 1 percent of maximum value
(g)	Ground and flight idle detent	Per operational aircraft tolerance
(h)	Gas producer speed	2 percent or 0.1 percent of maximum value
(i)	Turbine inlet temperature	1.5 percent, or $10^{o}C$
(j)	Turbine inlet temperature rate of change	25 percent
(k)	Oil temperature	10 percent
(l)	Oil temperature rate of change	25 percent

(m) Oil pressure — 5 percent

(n) Oil pressure rate of change — 25 percent

(o) Torque pressure — 1 percent

(p) Torque pressure rate of change — 25 percent

3.6.1.15.4 Aerodynamic tolerances.- The aerodynamic tolerances shall be as follows:

(a) Control system

(1) Lateral and longitudinal control force — 10 percent

(2) Collective control force — 10 percent

(3) Directional control pedal force — 20 percent

(4) Collective pitch control position — ± (0.8^o + 5 percent)

(5) Longitudinal and lateral control position — ± (0.8^o + 5 percent)

(6) Directional control position — ± (0.8^o + 5 percent)

(b) Climb/descent, level flight, and static lateral/longitudinal stability

(1) Torque — ± (500 foot pounds + 3 percent)

(2) Vertical speed — ± (50 feet per minute + 5 percent)

(3) Longitudinal Velocity — ± (5 feet per second + 5 percent)

(4) Lateral Velocity — ± (5 feet per second + 5 percent)

(5) Indicated air speed — ± (3 knots + 2 percent)

(6)	Fuselage angular rates	± (5.0° per second + 10 percent)

3.6.1.15.5 Navigation system tolerances.- The navigation system tolerances shall be as follows:

(a)	Relative bearing	2°
(b)	Gyro precession rate	25 percent, or 2° per hour, whichever is the smaller
(c)	Turn rate	0.25° per second
(d)	Field elevation	10 feet
(e)	Signal attenuation vs distance	25 percent of signal strength
(f)	Magnetic variation	0.5°
(g)	Radio beam width	20 percent
(h)	Radio marker location	0.1 mile
(i)	Distance indicator	0.5 percent

3.6.1.15.6 System.- The system tolerances shall be as follows:

(a)	Fuel transfer rate	20 percent
(b)	Loadmeter and ammeter	5 percent
(c)	Power (electrical)	5 percent
(d)	Electrical device load	5 percent
(e)	General time delay (switch to light warm up)	10 percent
(f)	Auxiliary power unit (APU) gas generator speed	5 percent or 0.1 percent of maximum value

3.6.1.15.7 Duplicate information tolerances.- There shall be no noticeable differences in the duplicate information indicators within the trainee stations.

3.6.1.15.8 Instrument calibration tolerances.- Cockpit instrument calibration tolerances shall be read at the flight compartment as follows. All tolerances shall be construed to mean plus or minus for full instrument range.

(a) Flight instruments:

(1)	Vertical speed	100 feet per minute (± 6000 ft/min range)
(2)	Indicated airspeed	3.5 knots (20 to 250 knots range)
(3)	Attitude (pitch/roll)	0.5°
(4)	Altimeter	65 feet at 10,000 feet altitude
(5)	Turn and slip	
	Ball angle	0.25 ball width
	Turn needle	0.125 needle width
(6)	Rotor speed	0.5 percent of rated rpm
(7)	Accelerometer	0.2 g
(8)	EADI	As aircraft instrument
(9)	Radar altimeter	As aircraft instrument

(b) Engine instruments:

(1)	Gas producer speed	0.5 percent of maximum continuous
(2)	Engine torque	0.5 percent (0-120 percent)
(3)	Turbine gas temperature	5°C (0-1000°C)
(4)	Engine oil pressure	5 percent (0-150 psi)
(5)	Engine oil temperature	3°C (-60° to 160°C)

(c) Navigation instruments:

(1)	Radio magnetic indicator	0.5°
(2)	Gyrosyn compass indicator	2°

(3)	Course indicator	0.25 dot
(4)	Standby compass	3^{o} + compass calibration correction

(d) System instruments:

(1)	Hydraulic pressure (dual)	As aircraft instrument
(2)	Hydraulic pressure (emergency)	As aircraft instrument
(3)	Fuel quantity (total)	2 percent full scale (digital)
(4)	Fuel quantity (individual)	2 percent full scale
(5)	AC and DC load meters	1 needle width
(6)	Auxiliary power unit (APU) speed	0.5 percent of maximum continuous
(7)	Outside air temperature	$2^{o}C$

3.6.2 Computer speed requirements.- The computer(s) shall have sufficient arithmetic, logical processing, and memory access speeds to assure real time processing of all display, simulation, visual, and control programs with no discrete stepping, oscillating, or erratic display indications and to provide a mathematically consistent and stable solution of the system equations. Required solution rates or iteration rates for each major system shall be as follows:

(a) Aero and flight equations 20 per second

(b) Visual computations 20 per second

(c) Engine simulation 5 to 20 per second

(d) Instruments 20 per second

(e) Instructor display update as required

(f) Executive 20 per second

(g) Communications/navigation 5 to 10 per second

(h) Motion system 20 per second

(i) Malfunctions control 20 per second

(j) Flight control system 20 per second

(k) Other aircraft systems 1.25 to 20 per second

3.7 Details of components.- The trainer shall consist of the following major components in the quantities indicated:

(a)	Trainee station (3.7.1)	Qty. 2
(b)	Instructor station (3.7.2)	Qty. 2
(c)	Digital computer complex (3.7.3)	Qty. 1
(d)	Motion system modules (3.7.4)	Qty. 2
(e)	Visual simulation system (3.7.5)	Qty. 2

3.7.1 Trainee stations.- Two separate and independent trainee stations shall be provided to simulate the AH-64 helicopter. One trainee station shall consist of a reproduction of the pilot's position and the other shall consist of a reproduction of the CPG's position on the operational helicopter, including the window positions. All instruments, indicators, gauges, lights, controls, circuit breakers, switches, and other components accessible to the pilot and CPG during flight shall be furnished and located in the same position as in the operational helicopter. Cockpit components associated with all flight and ground operating conditions of the AH-64 shall simulate the operation and function of the corresponding components in the aircraft. Cockpit controls shall reflect feel, damping, friction force, inertia, and response effects encountered in the design aircraft controls during normal and abnormal aircraft conditions. All components shall have the proper operating limits marked as in the operational helicopter. Items which are not functionally integrated or operative shall be three-dimensional replicas of the operational equipment. The bulkhead behind the trainee positions need not be included in full in order to facilitate installation of the instructor stations.

3.7.1.1 Cockpit shells.- The cockpit shells shall be fabricated from metal or reinforced plastic material conforming to 3.1.1. They shall be constructed in a manner to render them as light as is feasibly consistent with the requirements for structural integrity. The cockpit shells shall be finished on both the exterior and interior, and shall preclude the protuberance of such items as bolt heads or nuts. The cockpit shell shall be free of sharp edges or coarse rough surface areas. Where feasible, external cockpit compound curvatures may be simplified; however, the gross resemblances of the forward portion of the cockpit shells to the design basis aircraft shall be maintained. The inner configuration shall duplicate the aircraft with respect to the structural mounting support of all cockpit equipment. Metal plates shall be embedded in the plastic cockpit shell where greater strength, threaded holes, and the like, are required for attaching cockpit components. Cutout panels and hinged sections shall be provided for access to all cockpit and control loading equipment. The shell shall be designed to withstand stresses and strains resulting from the motion and vibration simulation, and to support any attached trainer components such as control loading units and visual modules.

3.7.1.1.1 Mounting.- The cockpit shells shall be attached to the top of the cockpit motion equipment. The cockpit shells shall include the cockpit shell floors.

3.7.1.1.2 Trainee and instructor station provisions.- The trainee and instructor stations shall be located inside the cockpit shells with the instructor station mounted to the rear of the trainee station. That area of the cockpit shell which houses the instructor station need not conform to physical dimensions of the design basis aircraft. The instructor area seats, displays, and operating equipment shall be isolated from the trainee station oscillations and vibrations, to the greatest extent possible.

3.7.1.2 Instruments and controls.- Instruments and controls used in the flight and ground situations, which the trainer is intended to simulate, shall be synthetically activated to meet specified performance requirements. Item marking shall be in accordance with MIL-T-23991 for all simulated aircraft instruments, and instruments modified for trainer use. Workmanship and materials for simulated instruments shall be in accordance with MIL-I-82356 and shall be marked "FOR TRAINER USE ONLY". Pedestals and consoles (including all circuit breakers and communications panels and control heads) shall be simulated in accordance with the design criteria. The outside air temperature gauge and magnetic compass, with normal lead/lag characteristics (acceleration and dip error) for the problem world, shall be included.

3.7.1.3 Windshields and windows.- Material for windshields and windows within the portion of the cockpit shell which houses the trainee station shall be as required to satisfy the visual display requirements and provide the pilot clear, distortionless images. Means for manually selecting opaque and translucent window effects when the visual system is not in use or when display components have been removed from the trainee station shall be provided. All window framing members of the simulated aircraft section shall be included.

3.7.1.4 Seats.- Seats, including shoulder harnesses and safety belts, shall be functionally identical to and shall operate as those installed in the design basis aircraft.

3.7.1.5 Cockpit shell ventilation system.- The cockpit shell shall contain a ventilation system utilizing ambient air and capable of maintaining the cockpit shell interior from 65° to 75°F under all operating conditions including occupancy by up to two personnel.

3.7.1.6 Trainee station vibrations.- Characteristic continuous and periodic oscillations and vibrations of the design basis aircraft shall be qualitatively simulated by the applications of frequencies and amplitudes, and directions representative of those experienced in normal and emergency flight conditions and maneuvers, including any vibrations representative of progressive malfunctions. Trainer components interacting with the trainees shall be affected appropriately. The affected components shall include but are not limited to the following:

(a) Pilot and CPG seats (3.7.4.2)

(b) Flight controls

3.7.1.7 Trainer control loading.- Trainer control loading shall duplicate design criteria forces within the tolerances stated herein. Control loading mechanisms shall be located external to the cockpit.

3.7.1.7.1 Control loading safety provisions.- The control loading systems shall be provided with a fail/safe device that prevents control displacement during hydraulic, electrical, or mechanical system failures. The control loading system shall also be provided with a turn on timing sequence to prevent large control displacement upon energizing the system.

3.7.1.8 Provision for personal flight gear.- The trainee area shall incorporate provisions for using the pilots' personal flight gear. All connectors, fittings physical characteristics, electrical characteristics, and the like associated with personal flight gear shall correspond to that of the design basis aircraft.

3.7.1.9 Freeze and crash indicator.- A freeze and crash indicator visible only when illuminated shall be located in front of the trainees in the cockpit. Location of the indicator shall not interfere with normal operation or viewing of controls or instruments. The freeze indicator shall illuminate whenever the trainer is in a freeze condition. The freeze indicator shall flash during trainer reset. The crash indicator shall flash whenever trainer crash occurs.

3.7.1.10 Problem control unit.- A problem control unit shall be accessible to the pilot and CPG from their seated positions and capable of being placed out of their normal line of sight while performing routine aircraft tasks. This unit shall contain controls needed to freeze and unfreeze the trainer and to allow emergency stop. In addition, controls shall be provided to insert and delete malfunctions, select initial conditions, to select demonstration programs, to initiate automated lesson plans and to initialize tactical scenarios. The problem control unit shall be such that it is readily accessible to the instructor.

3.7.2 Pilot and CPG instructor stations.- The instructor stations shall be located on the motion platforms immediately to the rear of the trainee stations. To the maximum extent practicable, the instructor stations shall be isolated from vibration and audio cues presented to the trainees. All controls and indicator lighting shall be designed to preclude interference with the trainee station cockpit areas during simulated night operations. Each instructor station shall include an adjustable seat mounted on rails that will allow the instructor to move from a position in front of the instructor station to a position so that monitoring of the trainee is optimized. Each instructor station shall be provided with a console, which includes a multipurpose CRT display system and controls and indicators necessary to monitor and control the trainee station. Where applicable, combination switch units in which an indicator light is an integral part of the switch shall be employed. Switch(es) to test for proper function of all indicator lights shall be provided. Each station shall be designed in accordance with MIL-STD-1472, and shall consist of the following:

(a) CRT display system (3.7.2.1)

(b) Instructor station controls and indicators (3.7.2.2)

(c) Digital clock and timer (3.7.2.3)

(d) Intercommunications system (3.7.2.4)

(e) Instructor seat (3.7.2.5)

(f) Work surface (3.7.2.6)

(g) Storage area (3.7.2.7)

3.7.2.1 CRT Display system.- Two CRT displays with adjustment controls shall be provided at each instructor station. The display system shall be designed in accordance with the visual display requirements of MIL-STD-1472 and shall have the following characteristics:

(a) Viewing area: Each CRT shall have a rectangular data display area of not less than 180 square inches. Maximum use shall be made of the available CRT viewing area.

(b) Mounting: Each CRT shall be ruggedized and shock mounted in such a manner that movement and vibration of the motion system shall not affect its legibility, accuracy, or reliability.

(c) Location: Each CRT shall be positioned consistent with instructor use.

(d) Flicker: The phenomenon of flicker shall not be detectable. This requirement applies to any and all lines, points, letters, symbols, or other images displayed on each CRT.

(e) Symbol set size: Not less than 80 different symbols shall be included in the set available for display on each CRT.

(f) Symbol stability: Peak to peak short term drift, jittering or jumping of symbols, dots, and lines shall not be perceptible. The CRT traces shall not wander or deform. Drift shall not exceed 3/16 inch over an 8-hour period.

(g) Glare: The face plate of each CRT shall be designed to preclude glare.

(h) Symbol size: The physical size of the symbols shall be a function of the maximum viewing distance, resolution, contrast and brightness of the terminal.

3.7.2.1.1 CRT function assignments.- Each CRT shall be capable of displaying control functions, aircraft parameters, and graphical information.

(a) Alphanumeric information display.- The CRT control display shall always display the following in a permanent area:

(1) Aircraft weight and balance (3.6.1.12)

(2) Environmental conditions (3.6.1.8 and 3.6.1.9)

(3) Aircraft position (latitude and longitude)

(4) Basic flight parameters (airspeed, altitude, heading, radar altitude)

(5) Radio frequencies tuned (3.6.1.7.3)

(6) Active malfunctions (3.6.1.14)

(7) Crew name

(8) Mission time elapsed

(9) Wing stores status

(b) CRT control page formats.- A transient area shall allow for the display of control formats with which the instructor shall be able to examine or modify simulator variables and control special functions. The following control formats shall be provided:

(1) Instructor controls (3.7.2.2)

(2) Position and mapping (3.7.2.2.1(c)(1))

(3) Radio station data (3.6.1.7.3)

(4) Record and playback (3.7.3.3.3(f))

(5) GCA (3.7.2.2.1(c)(1))

(6) Unusual attitudes (3.7.3.3.3(g)(2)a.)

(7) Time history controls (3.7.2.2.1(c)(2))

(8) System malfunctions (3.6.1.14 and 3.7.3.3.3(g)(1))

(9) Checklist verification (3.7.3.3.3(c))

(10) System variables

(11) Lesson plans (3.7.3.3.3(b))

(12) Maneuver demonstration (3.7.3.3.3(a))

(13) Performance evaluation (3.7.3.3.3(e))

(14) Emergency procedures (3.7.3.3.3(d))

(15) Maneuver edit (3.7.3.3.3(a)(1))

(16) Tactical situation (3.7.3.3.3(g)(5))

(c) CRT graphical format.- The CRT graphical formats shall display engagement summary and the time history plot of two selectable parameters in a permanent area. A transient area not less than 144 square inches shall allow for the display of various graphical formats including maps and time history plots.

(1) Maps.- Ground plots displaying traces of the flight path of the simulated aircraft and radio navigation facilities shall be provided on two scales enroute (20 nautical miles (nmi) square) and terminal (5 nmi square). The design requirement shall be to display up to the most recent 30 minutes of the flight path trace at 140 knots on the appropriate plots. The terminal scale shall also display glide slope and azimuth plots for the ground controllers' approach (GCA). A contour scale shall be provided for tactical mission application. This scale (5km x 5km) shall

indicate the positions, relative to the aircraft, and tracks of the threat and friendly forces and the ground level of each. Contour lines, bridges and rivers shall be displayed. The contour plot shall clearly indicate when the aircraft is in the line of sight of any threat or vice versa. A contour overview showing the positions of all threat and friendly forces in the gaming area shall be provided. A range overview indicating the distance in meters from the aircraft to all threats in the gaming area shall be provided. The display system shall have the capability of switching from scale to scale, and center to center, in either direction and retaining the continuity of the displayed data.

(2) Time history plotter.- A facility shall be provided which shall display plots of up to four parameters versus time, simultaneously. The parameters shall be selectable from a menu of 100 parameters. Time and X axes scaling shall be changeable by the instructor.

3.7.2.2 Instructor station controls and indicators.- Keyset(s) and other controls and indicators shall be provided to enable each instructor to perform the functions associated with operation of the trainer and shall be located to facilitate utilization by the instructor. The following shall be provided:

(a) Controls for the operation of each CRT (e.g., focus, brightness, contrast).

(b) A keyboard to be used for data retrieval, for the insertion or modification of data and to perform the CRT display control functions. The keyboard shall be the primary means of communication, during training, between the instructor and the computer for the modification of training or simulation conditions within the limits specified herein. The functions of the keyboard and the limitations placed upon its functions during training shall be determined by the computer program and shall not be modifiable from the keyboard itself.

(c) Controls to select CRT pages.

(d) Controls to select CRT page lines.

(e) Controls to permit selection of map center.

(f) Controls to reposition (reset) the simulated aircraft.

(g) Controls to vary the scale of the map plots.

(h) Controls to erase the simulated aircraft track and any other vehicle tracks on the ground plot display. The erasure shall be progressive, beginning with the earliest portion of the track(s), such that the instructor can erase all or any portion of the track(s).

(i) Controls to center and reorient the map plot relative to simulated aircraft and game area center.

(j) Controls to reset the simulator and visual scene.

(k) Controls to insert or remove any malfunction.

(l) A control to freeze and unfreeze the device and indicate its status when in a freeze condition.

(m) Controls to communicate with trainees via intercom or through the simulated radio receivers. The instructor will use these controls, as appropriate, for didactic purposes and to provide voice simulation of all ground, airborne, and other voice transmitting stations.

(n) Controls to communicate via a maintenance intercom with personnel at the computer station, the other cockpit instructor station.

(o) A control to turn on and off the cockpit motion system. The control shall indicate the ON/OFF status of the motion platform. The status of each motion platform interlock also shall be indicated. An emergency stop switch shall be provided to cut hydraulic power to the motion system.

(p) A control to test for the proper functioning of all indicator lights.

(q) Controls for the adjustment of the intensity of instructor station lighting.

(r) A running time meter to indicate the total time that the instructor station and associated trainee station has been operated. The meter shall have at least five digits and shall record the time in increments of one-tenth of one hour. The meter shall be located in the simulator power cabinet.

(s) Controls to vary visual system parameters and introduce special effects.

(t) Controls to operate lesson plans.

(u) Controls to operate time history plots.

(v) Controls to slew/freeze specified parameters.

(w) Controls to operate record and playback and store/recall.

(x) Controls to set threat strike effects and modify threat reactions.

(y) Controls to request hardcopy for control, maps and time history formats.

(z) A repeat visual monitor of the crew member's PNVS and/or TADS display.

3.7.2.3 Clock and timer.- The instructor station shall contain a clock which shall indicate the actual time of day. The clock shall show hours, minutes, and seconds. A training time digital timer showing hours, minutes, and seconds with start, stop, and reset controls shall also be provided at the instructor station. Training time shall be displayed via the CRT. The training timer shall freeze when the trainer is frozen.

3.7.2.4 Intercommunications system.- An intercommunications system shall be provided to permit instructor conversation with an observer, trainees, the other cockpit, and out of cockpit building locations. Means shall be provided for audio/visual alert at each station. All jacks in the instructor and trainee stations shall be standard and shall accept both headset and flight helmet connections. A minimum of two headsets shall be provided.

3.7.2.5 Instructor seat.- An instructor seat shall be provided at each station. Convenient to operate locking devices shall be provided for the swivel and the sliding track mechanisms. A seat belt shall be provided and attached to each seat. Twenty-four inches of fore and aft adjustment shall be provided. A minimum up and down total adjustment of five inches shall be provided. Each seat shall be provided with fold-away arm rests, back cushion, and seat cushion.

3.7.2.6 Work surface.- A work surface shall be provided which can be used by the instructor for writing or placement of manuals and other data or material. It shall be located at a height convenient for writing while seated and shall extend an average of approximately eight inches in front of the instructor console.

3.7.2.7 Storage.- Storage for securing stored material shall be provided inside the cockpit shell for the temporary storage of manuals, notebooks, and similar reference material utilized by the instructor.

3.7.3 Digital computer complex.- Only commercially available equipment currently in production and in use by other than the trainer manufacturer shall be selected and used to satisfy the requirements of this specification.

3.7.3.1 Digital computer complex configuration.- The digital computer complex shall provide simultaneous computation for and control of the motion systems, trainee stations, instructor stations, visual simulation systems including the Computer Generated Image (CGI) system, and other equipment as required. The digital computer system shall consist of:

(a) A 32-bit general purpose digital computer (or a multi-processor configuration) LESS a visual simulation subsystem; with one or more special or general purpose digital computation system(s) for a visual simulation system together with interface equipment, peripheral equipment, and all software required to operate as a completely integrated computer system.

3.7.3.1.1 Multiprocessor configurations.- The digital computer system may consist of one or multiple central processors (CPU's). If the digital computer system consists of more than one central processor, the following requirements shall be satisfied:

(a) All processors (CPU's) shall be identical and completely interchangeable, or they shall all be selected from a manufacturer's family of similar processors for upward compatibility.

(b) Provisions shall be incorporated (either software or hardware) for synchronizing the timing of each CPU and for controlling all processors with common operating controls such as start, halt, and system freeze.

(c) An executive program shall be used to control the multi-processor configuration. This program shall direct the problem flow, schedule processing events, establish priority controls, and the like.

This program shall reside in the CPU designated as the master. Subordinate executive programs shall reside in each of the slave processors.

3.7.3.1.2 Multicomputer configurations.- The digital computer complex shall satisfy the following requirements:

(a) All computers shall be identical and completely interchangeable, or they shall all be selected from a manufacturer's family of similar computers for upward compatibility. The exception to this requirement may be the visual system minicomputer if it is integral to the visual system design and provided as a component by the visual system manufacturer.

(b) Each computer shall be capable of communicating directly with local input/output equipment without involving other computers

(c) Provisions shall be incorporated for synchronization of and communication between computers within each training system, and for controlling all such computers with common operating controls such as start, halt, and system freeze. This can be implemented by either software or hardware.

3.7.3.1.3 Computer control panel.- A computer control panel shall be provided with each computer. The panel may be located on a separate console or may be incorporated into a centralized panel located on the main rack or cabinet of the computer. Switches, indicators, and controls necessary for operation of the computer shall be located on the respective control panel. The panel shall incorporate provisions for manual insertion of instructions and data, and shall contain display indicators to enable operating and maintenance personnel to monitor the operation of the computer. The operator shall have the ability to control the computer from a seated position with provision for a work top area.

3.7.3.1.4 Register information display and insertion.- Display indicators shall be provided to permit selection and visual examination of the content of any memory address or program accessible register of a halted CPU. Hardware switches and associated controls shall be provided to permit insertion of information in any memory address or program accessible register of a halted CPU.

3.7.3.1.5 Halting provisions.- Means to halt the computer at any preselected program step shall be provided.

3.7.3.1.6 Single-step provisions.- Single instruction advance is required for stepping the program in the computer.

3.7.3.1.7 Running time meter.- A running time meter shall be installed in each computer and shall indicate the elapsed computer "ON" time. The meter shall display at least five digits in increments of 0.1 hour.

(a) Power fail/safe provisions.- A power fail/safe interrupt provision shall be included with the computers to sense impending power failures and permit storage of volatile registers and accomplish memory lock-up. Power failures or emergency interruptions of power to the trainer or computer shall not result in physical or electrical damage to the computer system equipments.

3.7.3.1.8 Real time clock.- A program addressable real time clock integral to each computer shall be provided with program control of the generation of necessary cycle timing intervals.

3.7.3.1.9 Computer input/output (I/O) capability.- The I/O system of the computer shall provide the following capabilities:

(a) Capability to service assigned blocks of data to and from the I/O channels and high speed magnetic core memory without restricting the operation of the arithmetic unit except for any initial setup and memory access priority delays (e.g., a direct memory access (DMA) capability through the medium of memory ports in conjunction with an I/O processor).

(b) Capability to communicate directly with all interface equipment.

(c) Capability to input or output to and from one or more units of peripheral equipment while continuing operation in the real time, simulation, and processing modes.

(d) Capability to provide, under program control, interrupt lines by which the computer can be interrupted by external discrete controls, devices, and another computer.

3.7.3.1.10 Memory requirements.- The digital computers shall be furnished with sufficient high speed random access memory to store the total system simulation, control programs, and executive programs and all constants, real time data operands, and intermediate results.

3.7.3.1.11 Computer system spare capacity.- The computer system shall provide spare memory and processing capacity as specified below. When more than one central processor or computer is used, each CPU or computer of the system shall have spare memory capacity and spare processing capacity specified.

(a) Spare memory capacity.- not more than 50 percent of the memory capability of each computer shall be used to meet the total real time program and data storage requirements.

(b) Spare processing capacity.- the total processing time required in the logical worst case path during any program iteration or solution cycle shall not exceed 75 percent of the time available for that cycle. Also, during any one second interval the time required to process all real time programs shall not exceed 750 milliseconds.

(c) Disc spare capacity.- not more than 75 percent of the disc unit specified in paragraph 3.7.3.2(d) shall be utilized.

3.7.3.2 Peripheral equipment.- Computer peripheral equipment shall be provided to support each digital computer system in meeting the requirements of this specification. The following peripheral devices shall be provided with the characteristics indicated:

(a) A ASR-35 alphanumeric keyboard/printer teletypewriter on each CPU.

(b) A CRT display system having a 1920 character display capacity and including a keyboard in teletype format.

(c) Magnetic tape transport, industry compatible, nine channel tape, 800 BPI, 45 IPS, and controller for up to four transports, including cabinet and dust covers.

(d) A disc pack drive system having a minimum storage capacity of 20,480,000 16-bit words and an average access time of 30 milliseconds. The controller unit for this system shall be capable of accomodating up to four such drives. All real time simulation programs, data maintenance programs, test and diagnostic programs, and utility and related programs shall be stored on the disc. The use of real time overlaying techniques from disc storage shall be limited to data only. It shall not be used for reducing resident real time program storage requirements for computer main memory.

(e) A standard 80-column card reader capable of operating at 300-cards per minute read speed.

(f) A Versatec 1100A printer/plotter or equivalent. The printer/plotter shall have a 132 character line, 6.6 lines per inch, 7 X 9 dot matrix font, and operating speeds of up to 500 lines per minute.

(g) An impact line printer capable of printing 300 lines per minute at 132 characters per line.

3.7.3.3 Computer system software requirements.- All programs required to operate and support device 2B40 shall be designed and documented in accordance with SECNAVINST 3560.1.

3.7.3.3.1 Program language requirements.- To the maximum extent practical, FORTRAN IV with any available extensions shall be used.

3.7.3.3.2 Program requirements.- The programs supplied with Device 2B40 shall include, but not be limited to the following:

(a) Real time simulation, control and processing programs.- The real time simulation programs shall perform all simulation, control, and processing functions specified herein.

(b) Off-line function data generation program.- For dynamic vehicle simulation, vehicle function data may be incorporated into the main trainer programs. In the event stored function data are derived by an off-line computer program, this program shall be included in the program package.

(c) Utility programs. - Trainer computer system utility programs consisting of, but not limited to, assembler, loader, data conversion, memory dump, printout, and FORTRAN compiler shall be provided.

(d) System verification programs. - Programs shall be provided to verify the simulation and display processing programs. These programs shall provide a means of checking and verifying the overall correctness of the main simulator control and other processing programs independent of the trainer stations and the computer interface equipment.

(e) Maintenance and test programs. - The maintenance and test programs shall test the operation of both the computers and peripheral equipment and the trainer simulation equipment. Maintenance programs shall include but not be limited to the following:

(1) Real time interface equipment continuous on-line diagnostic program. - Program(s) shall be designed to enable on-line program diagnosis of the training device interface equipment malfunctions. These program(s) shall be automatic and require a minimum of operator effort. They shall provide hardcopy printout of the nature of the malfunction and of the test(s) results. These program(s) shall include detection of:

a. Parity errors in either address or data between the interface controller and an individual chassis.

b. Parity errors in the data between the CPU and the interface controller.

c. Time-out due to nonresponse of a chassis or of the interface controller to computer commands.

d. Violation of the exclusive recognition of a specified interface address by more than one board in the same chassis.

(2) Real time interface checkout program. - This program shall provide for on-line checking of the real time interface input and output functions. This program shall execute on request from the operator's console and shall provide a hardcopy printout of the nature of the malfunction and of the test results. The interface shall be checked in the following manner:

a. Every power supply in each interface chassis shall be verified to be powered.

b. Every discrete input shall be read in both normal and complemented form. Failure shall be identified to the bit level.

c. The output register of each discrete output, immediately before the output relay, shall be monitored. Failure shall be identified to the bit level.

d. The voltage of every analog output channel shall be selectively monitored and compared to the requested value. Calibration of analog output power supplies shall also be monitored. Failure shall be identified to the channel level.

e. The conversion accuracy of every analog input chassis shall be monitored. Calibration of analog input chassis power supplies shall be monitored. Failures shall be identified to the chassis level.

f. The ac voltage of every synchro output shall be selectively monitored and compared to the requested value. Failures shall be identified to the individual output level (i.e., two per synchro channel).

g. The conversion accuracy of every synchro input chassis shall be monitored. Failure shall be identified to the chassis level.

The checkout program shall also allow the operator to read the conversion error of any of the following:

- Any analog output channel
- Any analog input chassis analog-to-digital converter
- Any synchro output channel
- Any synchro input chassis analog-to-digital converter

The monitoring of interface operation shall have no discernible effect or cause spurious delays in the normal transfer of data between CPU and interface. Detection of channel level faults shall not interrupt the simulation but shall result in logging of the fault on the operator's console.

(3) Computer off-line diagnostic programs. Only commercially available off-line diagnostic programs for the selected computers shall be used. The programs shall check the operation of the arithmetic unit, control unit, I/O unit, and memory unit.

3.7.3.3.3 Training programs. - The following training programs shall be provided to relieve the insturctors in the conduct of training:

- Maneuver Demonstration (3.7.3.3.3(a))
- Lesson Plan Systems (3.7.3.3.3(b))

- Check list Verification Programs (3.7.3.3.3(c))
- Emergency Procedures Programs (3.7.3.3.3(d))
- Performance Evaluation (3.7.3.3.3(e))
- Record and Playback (3.7.3.3.3(f))
- Main Trainer Program Variations (3.7.3.3.3(g))

(a) Maneuver demonstration.- Automated demonstrations of AH-64 flight and tactics techniques shall be provided. These demonstration programs shall be used in conjunction with the main trainer program. Upon activation the demonstration flight shall be executed such that the cockpit instruments, cockpit controls and the motion module exhibit the movements which would be experienced if the demonstration were actually being flown. Visual displays shall be synchronized. Prerecorded verbal explanation and commentary shall be provided for each demonstration program and shall be played back in synchronization with the demonstration flight. The demonstration programs shall be in real time or in one-half time, as selected by the instructor. The format and text of the demonstrations shall be subject to the approval of the PCO. The maneuver demonstrations shall last from 5 to 30 minutes in increments of five minutes.

(1) Maneuver demonstration formulation and capacity.- Capability shall be provided to construct automated demonstration programs using the performance recording and playback capabilities of 3.7.3.3.3(f). Computer memory (disc) shall be provided for a total of 300 minutes of demonstration programs.

(b) Lesson plan system.- A lesson plan system shall be provided to allow automated or semiautomated control of training mission environment. The lesson plan shall consist of a number of predetermined events presented in alphanumeric form on the instructor's CRT. Activation of the events shall be either through the use of a manual control on the instructor's station or automatically triggered when a preselectable phase of training mission has been reached. All functions normally available to the instructor such as malfunctions, hard copy, tactical mission evaluation, shall be available as lesson plan steps.

(1) Lesson plan compiler.- A utility program shall be provided to enable construction of lesson plans by the user. The program shall use question and answer prompting format in plain English to allow insertion of lesson plan events. Similar prompting shall allow the definition of training mission segments to allow automatic activation of lesson plan steps.

(c) Checklist verification program - Checklist verification programs shall be provided to monitor switch/control positions during checklist procedures. The results of the checklist program shall be presented on a CRT central format where noncompliant items shall be easily observed.

(d) Emergency procedures programs.- An emergency procedure program shall be provided to monitor and evaluate the timing and sequence of events during execution of an emergency procedure. The results shall be presented on a CRT control format showing a timing evaluation (good, bad) and a sequence of events evaluation.

(e) Performance evaluation.- A performance measurement capability shall be provided which, by comparing trainee performance with preprogrammed or inherent performance tolerances, automatically determines trainee errors.

(1) Performance error measurement.- During performance evaluation errors in trainee performance shall be recorded whenever his performance on a particular parameter differs from the performance which has been designated as ideal performance for that parameter, plus or minus the tolerance which also has been designated for it. Cumulative time out of tolerances shall be recorded automatically for the parameters specified for each maneuver providing a percentage result. Specific parameters to be measured for each maneuver segment and parameter tolerances for that segment shall be determined by the contractor subject to approval of the PCO. The parameters shall be selected so as to avoid continuously penalizing the trainee for errors recorded in previous maneuvers for which there is no training value in the present maneuvers.

(2) Performance parameters.- The performance parameters for which errors are to be recorded shall include the following:

a. Airspeed

b. Altitude

c. Course deviation

d. Glide slope deviation

e. Rate of climb

f. Rate of turn

g. Pitch attitude

h. Bank angle

i. Torque

j. Trim control

k. Ball angle

l. Rotor RPM

m. Proximity of rotor path to ground objects

In addition to the above parameters, procedural errors, e.g., proceeding below established minimums or failure to execute a heading change at an appropriate point, and operational errors, i.e., exceeding published aircraft "red line" parameters shall be recorded automatically.

(3) Tactical mission evaluation.- During tactical missions crew survivability and destroy effectiveness shall be measured and a summary in plain English shall be produced based on at least the following parameters:

a. Survivability

1. Time exposed to threat

2. Time under fire

3. Sequence of attack

4. Deviation from optimum course

b. Destroy effectiveness

1. Time to locate target

2. Time to identify target

3. Time to immobilize target

4. Time to destory target

5. Weapons expended to immobilize target

6. Weapons expended to destroy target

(f) Record and playback.- A record on disc of the most recent 30 minutes of trainee flight performance shall be retained. This recording shall be divided into five segments of variable length. These recorded segments shall be recallable by the instructor in less than 30 seconds for presentation in part or in whole to the trainee as a demonstration in which the simulated aircraft repeats the recorded performance. A synchronized voice recording shall be provided which shall record and playback all of the communications and instructional messages transmitted or received by the trainee during the recorded flight segments. It shall be possible to freeze or to terminate a playback at any point, and the instructor shall have the option of playing back the performance in real or one-half time. When one-half time playback is selected, the audio recording need not be used. The capability to fly-out at 10 second intervals during playback shall be provided. An aural message over the trainee headsets shall indicate transfer of control.

(g) Main trainer program variations.- The following additions to the main trainer program shall be provided to enable the instructor to vary the training situation.

(1) Failures and malfunctions programs.- Programs shall be provided to simulate the gradual or abrupt failure or malfunction of the helicopter systems or components for the conditions identified in 3.6.1.14. Failures, malfunctions, and emergency conditions (onset, incremental effects, duration, etc.) shall occur as in the helicopter. Initiation shall be via instructor station controls or be lesson plan. Failures will remain in effect until corrective action is taken by the trainee or the failure is removed by the instructor.

(2) Store/recall and setups.- The instructor shall be able to store up to five individual snapshots of the simulator configuration at any time during training and shall subsequently have the capability to reconfigure the simulator to any one of the five stored snapshots. Up to 20 permanent setups shall also be defined which the instructor shall access through a CRT control format. Recall and setup shall reconfigure all flight compartment systems, including motion and visual as they existed at store time. Total freeze shall occur once reconfiguration is completed and deactivation of total freeze transfers simulated aircraft control to the trainee.

a. Unusual attitudes.- A program shall provide the capability to demonstrate ten 30 second maneuver segments at the end of which control shall be made available to the crew. A takeover message shall be transmitted over the communications system.

(3) Problem freeze and restart provision.- It shall be possible for the instructor to freeze the total simulation problem at any time. The routine for freeze control shall permit displays, and other computer controlled outputs to retain all indications and system status conditions that existed at the time of freeze initiation. Deactivation of the freeze shall restore the system to the conditions that existed at the time of the freeze.

(4) Parameter freeze/slew.- During training the instructor shall be able to freeze/slew the following parameters, individually or in combination from the instructor console.

a. Aircraft latitude and longitude

b. Altitude

c. Airspeed

d. Heading

e. Fuel quantity

Indications of parameters frozen shall be provided on the instructor console.

(5) Tactical situation control.- The instructor shall be provided with the capability of defining threat and friendly force configurations for a tactical training mission. The instructor shall be able to vary the background level of battlefield audio throughout a training mission. Controls of the following parameters of threat and friendly force items shall be available through a CRT control page format and controls on the instructor's console:

. Position

. Heading

. Speed

. ECM class

. Vulnerability

. Shoot back class

. Shoot back signature (visual and audio)

It shall be possible for the instructor to control the flight of the simulated aircraft during independent crew training.

a. Automated tactical situation.- An automated tactical situation control program shall allow the instructor to preprogram threat and friendly force parameters and tracks defined in 3.7.3.3.3(g) (5) which can be replayed during a training mission. During creation of tracks it shall be possible to use the instructor's visual repeat monitor 3.7.2.2 (z) to display the tactical scene generated from the threat or friendly items viewpoint. Throughout the training mission the preprogrammed forces shall realistically interact with the simulated aircraft.

3.7.4 Motion system modules.- The trainer will include the following modules to generate motion cueing for trainees:

(a) One 6-degree of freedom cockpit motion system for each trainee station (3.7.4.1)

(b) One seat shaker system for each trainee station (3.7.4.2)

(c) One G-seat system for the pilot trainee station (3.7.4.3)

3.7.4.1 Cockpit motion systems.- Cockpit motion systems in accordance with the requirements stated herein shall be provided. The motion systems shall each provide a minimum of six degrees of freedom consisting of pitch, roll, yaw, vertical as well as lateral and longitudinal sway. Correct correlation of cockpit motion and visual cues is essential. A separate motion system shall be provided for each of the two trainee stations.

3.7.4.1.1 Degree of simulation.- The sensations of motion shall be representative of sensations experienced in the operational design basis aircraft resulting from changes in attitude or flight path. Representative motion caused by the following aircraft conditions shall be provided:

(a) Buffets

(b) Blade stall

(c) Blade imbalance

(d) Damper failure

(e) Blades out of track

(f) Skids

(g) Slips

(h) Banks

(i) Turns

(j) Hovering

(k) Climbs

(l) Dives

(m) Acceleration and deceleration, transition into and out of stable flight

(n) Vibrations

(o) Oscillations

(p) Ground rolling characterization

(q) Touchdown impact

(r) Atmospheric effects

(s) Ground resonance

(t) Stores release

(u) Weapon firing

(v) Impact of enemy weapons

3.7.4.1.2 Motion system computations.- The physical movement of the motion systems shall be determined by computations based upon 6-degree of aircraft freedom and movement along or about all axes of the motion systems and shall be correlated with the motion of the simulated aircraft. All aircraft stability derivatives shall be accounted for in a manner such that aircraft movement in any degree of freedom shall influence movement along or about every axis of the motion system. The motion system shall respond to aircraft center of gravity or center of pressure movements, including: fuel depletion, stores release, and normal aerodynamic effects. The acceleration of the trainee station in any degree of freedom shall not exceed the aircraft acceleration experienced under similar flight and configuration conditions of the operational aircraft simulated. Each motion system shall be driven by its own algorithms, the differences between the two dependent upon the aircraft crew station accelerations and the cueing emphasis due to the different tasks of each trainee.

3.7.4.1.3 Operational performance.- The motion system design shall emphasize onset of accelerations to provide proprioceptive cues to the trainees. Following the initial transient force, each cockpit shall return slowly and imperceptibly to its translational neutral position. The long term cockpit attitude shall depend upon the forces applied to the aircraft in order to permit the gravity vector to be used for the horizontal acceleration sensations. The aircraft instrument indications and visual display presentation shall reflect the simulated flight condition regardless of cockpit attitude. There shall be no noticeable time error between instrument response, visual display, and trainee station movement of each cockpit except normal lag associated with a given aircraft component.

3.7.4.1.4 Performance limitations.- The motion system driving inputs from the computer shall be so mechanized as to optimize the onset cues to each trainee. This shall be done in a manner such that actual cockpit motions stay within physical limitations and correctly track the frequency of the motions but not necessarily the amplitude. The envelope of motion system movement during training shall be such that the full displacement range (bottom to top, side to side, and the like) is utilized to the maximum extent.

3.7.4.1.4.1 Onset of acceleration cues.- The onset of acceleration cues provided shall be determined by the equations of motion of the aircraft.

3.7.4.1.5 Payload weight.- The normal operating weight of the lighter cockpit shall include ballast, such that the normal operating weight is within 500 pounds of the normal operating weight of the heavier cockpit.

3.7.4.1.6 Worst case maneuvers.- The motion systems shall be sized to perform the simulated vehicle worst case maneuvers in the heave direction of 0.25g sinusoidal at 1.0 Hertz for a continuous duty cycle.

3.7.4.1.7 Excursions, velocities and accelerations.- The motion systems shall perform to the criteria shown in Table I. The displacement requirements of Table I are nonsimultaneous requirements; therefore, each motion system must satisfy only one set of requirements (case) at a time. The excursion envelope about the neutral operating position shall allow simultaneous movement equal to a minimum of 20 percent of the above requirement in any four degrees of freedom combination.

TABLE I

Minimum Performance Requirements

Case	Axis	Excursions #	Excursions *	Peak Acceleration	Peak Velocity*
1	Vertical	66 inches total ±33 inches	60 inches total ±30 inches	±0.8g	24 $\frac{inches}{sec}$
2	Lateral	88 inches total ±44 inches	80 inches total ±40 inches	±0.6g	28 $\frac{inches}{sec}$
3	Longitudinal	95 inches total ±47.5 inches	86 inches total ±43 inches	±0.6g	28 $\frac{inches}{sec}$
4	Pitch	64 degrees total ±32 degrees	44 degrees total ±22 degrees	±100 $\frac{degrees}{sec^2}$	20 $\frac{degrees}{sec}$
5	Roll	56 degrees total ±28 degrees	44 degrees total ±22 degrees	±100 $\frac{degrees}{sec^2}$	20 $\frac{degrees}{sec}$
6	Yaw	68 degrees total ±34 degrees	56 degrees total ±28 degrees	±100 $\frac{degrees}{sec^2}$	28 $\frac{degrees}{sec}$

* Based upon sinusoidal movement throughout the total excursion for each case, continuous duty cycle.

\# Based on stop to stop displacement.

3.7.4.1.8 Frequency response.- The closed-loop performance of the motion system shall comply with the format in Table II.

TABLE II

MOTION SYSTEM FREQUENCY RESPONSE

Frequency Range (Hertz)	Maximum Phase Shift (Degrees)	Motion Platform Position maximum (Decibels)
0.1 - 0.5	20	± 1
0.5 - 1.0	60	± 2
1.0 - 2.0	110	+ 2 - 4
2.0 - 5.0	-	+ 2 - 4

The above criteria apply to each degree of freedom. Structural or hydraulic resonance shall not occur from 0 to 5 Hertz. Design provisions shall be incorporated to avoid activation of resonant frequencies above 5 Hertz by the simulation program.

3.7.4.1.8.1 Static accuracy.- Static error between actual and commanded platform position shall be less than 1.0 percent of full scale.

3.7.4.1.9 Smoothness.- The motion systems shall operate without hunting and shall not snub against cushion stops during normal operation. The actuator system shall raise each trainer in an attitude approximately level to the initial operational position. Oscillations of the trainee station caused by motion system instability shall not occur. Oscillations of the trainee station or any of its components as a result of structural, hydraulic, or electrical resonance shall not occur, unless such movement is demanded by the equations of motion of the design basis aircraft.

3.7.4.1.10 Rough air.- The effects of rough air shall be simulated. Appropriate operation of the trainer controls shall result in realistic correction of the rough air effects. The rough air cycle shall be so designed that repeatability will occur only after completion of a cycle pattern of at least five minutes in duration. The intensity and direction of the trainee station motion shall be a function of the rough air level, the aerodynamic configuration of the aircraft, and pilot induced maneuvers, if any, at any instant. At any time during the rough air cycle, it shall be possible, using the CRT and associated controls at the instructor station, to discontinue the rough air buffet simulation or change its amplitude. Physical motion of the trainee station shall be provided in all affected degrees of freedom while simulating rough air and shall be coordinated with instrument indications and with visual display scenery. Longitudinal, lateral, and vertical rough air effects shall be provided.

3.7.4.1.11 Hydraulic and electromechanical design.- Hydraulic and electromechanical design shall comply with the following:

(a) The design shall incorporate provisions for maintenance operations. All maintenance equipment including jacks and jack supports shall be provided.

(b) Water cooled heat exhangers shall be designed for hydraulic fluid cooling with a maximum inlet water temperature of 75^{O}F.

(c) Breakaway friction of each ram shall be minimized so that for each ram assembly the peak to peak friction acceleration transient shall be less than 0.03g, for an input signal of 10 percent of maximum range at a frequency of 0.5 Hertz.

(d) Hydraulic fluid shall conform to Naval Weapons Specification XWS-6788 (e.g. Brayco Micronic 745 or equivalent). Hydraulic fluid temperature, pressure, and level shall be monitored and equipped with sensor warning devices. Exceeded safety parameters shall automatically activate shut down of the hydraulic systems.

3.7.4.1.12 Motion and control loading system operation and controls.- The hydraulic systems shall operate as follows:

(a) Control loading systems shall utilize an independent hydraulic pump from those used for the motion systems. However, the control loading systems shall be capable of being powered by either hydraulic pump of the motion system.

(b) Each cockpit shall be independent of the other in the use of electrical and hydraulic power.

(c) The motion systems and control loading pumps shall be remotely located in a separate room.

(d) Spray shields and drip pans shall be provided to prevent drainage to trainer components.

(e) A key operated switch shall be provided to energize electrical power to the motion systems.

(f) Separate power shall be supplied to hydraulic pumps to minimize electrical interference.

3.7.4.1.13 Maintenance controls.- A maintenance control panel shall be provided and located within view of each motion system. The maintenance control panel shall provide lighted indicators for hydraulic system status, pump controls, manual controls, a system control switch for "maintenance" and "normal" operation, and an emergency stop switch. The maintenance control panel shall provide control switches and hand adjustable potentiometers so that each actuator may be independently and simultaneously positioned, or so that the cockpit may be positioned in each axis direction, that is in either the pitch, roll, yaw, longitudinal, lateral or vertical directions. In addition input terminals shall be provided so that externally generated command signals can be applied to the actuators independent of the potentiometers.

3.7.4.1.14 Safety provisions.- The ingress/egress ramp, doors, and steps shall be covered with nonskid material and provided with safety interlocks to automatically deactivate motion system hydraulics when interlocks are broken. Interlocks shall also be provided to prevent operation of the motion system during maintenance operations. The motion system floor and platform shall be provided with railings commensurate with ingress/egress requirements. A red warning light shall be provided at each motion base when the motion hydraulics are activated. The cockpit access ramps or stairways shall be fail/safe in the event of facility power failures. An emergency switch shall be provided at each instructor station, each trainee station and at the maintenance control station.

3.7.4.2 Seat shaker system.- A seat shaker system in accordance with the requirements stated herein shall be provided at each trainee station. Each seat shaker system shall provide a vertical oscillatory degree of freedom.

3.7.4.2.1 General seat shaker system requirements.- The seat shaker system shall be capable of reproducing vibration and buffet motions up to a frequency of 20 Hertz. The motions shall be representative of aircrew station buffet sensations due to:

(a) Rotor dynamics

(b) Engine vibration malfunctions

(c) Aerodynamic buffet

(d) Air turbulence

(e) Ground maneuvering

3.7.4.2.2 Seat shaker system operation.- The activation of the seat shaker system shall be determined by both the vibrational characteristics of the design basis aircraft, which is in turn dependent upon the aerodynamic condition of the aircraft, and by the malfunction condition of the simulation model. The system shall be capable of providing two independent modes of vibration. Both modes shall be independently controllable in amplitude and frequency. The vibration amplitude and frequency shall be computed as a function of the degree of penetration of the aircraft vibration envelope.

3.7.4.2.3 Payload weight.- Performance requirements shall be met with a 200 pounds payload, representing a human occupant.

3.7.4.2.4 Performance.- The seat shaker system shall be capable of the following over a frequency range of 3 to 20 Hertz.

(a) Acceleration of up to 15 feet per second^2

(b) Minimum controlled acceleration of 1 foot per second^2

(c) No structural or hydraulic resonance.

3.7.4.2.5 Hydraulic and electromechanical design.- Hydraulic and electromechanical design shall comply with the following:

(a) The design shall incorporate provision for maintenance operations. All maintenance equipment shall be provided by the seller.

(b) An accelerometer shall be installed in the seat to be used for monitoring the trainees' vibration exposure, and for warning of physiological damage.

(c) Hydraulic fluid shall conform to Naval Weapons Specification XWS-6788, or its equivalent.

3.7.4.2.6 Seat shaker system operation and controls.- The seat shaker system shall operate as follows:

(a) The hydraulic supply shall use the same pump system as the cockpit motion system.

(b) Two electronic oscillators shall provide the input command signals.

3.7.4.2.7 Safety provisions.- The seat shaker system shall be hydraulically deactivated unless the seat belt is securely fastened. An emergency off switch shall be provided for the trainee and the instructor. A warning horn shall be heard should the seat accelerometer measure a possibility of physiological damage.

3.7.4.3 G-seat system.- A G-seat system shall be provided in accordance with the requirements stated herein at the trainee pilot's station. The G-seat system shall provide a sensation of acceleration to the pilot through the control of pressure distribution in the seat cushion and backrest. The lap strap tension shall be controlled to enhance the G-seat system sensations.

3.7.4.3.1 General G-seat system requirements.- The G-seat system shall be capable of seat pan and backrest pressure distribution changes, and the lap strap shall be capable of automatic tension adjustment to impart sensations of acceleration to the seat occupant in the vertical, lateral and longitudinal directions.

3.7.4.3.2 G-seat system operation.- The activation of the G-seat cushion pressure shall be through computer controlled penumatic valves, which operate invididually on each cushion pressure call. The pressure shall be controlled as a function of the aircraft acceleration computed in the simulation mode. The activation of the lap strap tension shall be through a computer controlled electrical actuator.

3.7.4.3.3 Payload weight.- Performance requirements shall be met with the seat unoccupied.

3.7.4.3.4 Performance.- The G-seat system shall provide a range of simulated vertical acceleration cues from -0.5g to +4.0g and a range of simulated longitudinal and lateral acceleration cues of ±0.5g.

3.7.4.3.5 Response times.- The pressurization time lag of each cushion cell to a 50 percent voltage command input shall not exceed 45 milliseconds. The bleed time lag of each cushion cell to a 50 percent voltage command input shall not exceed 60 milliseconds. The pressure response to a higher input will settle to within 10 percent of the final value in 100 milliseconds.

3.7.4.3.6 Electropneumatic design.- The electropneumatic design shall incorporate provision for maintenance operations. All maintenance equipment shall be provided.

3.7.4.3.7 G-seat components.- The pneumatic system shall operate as follows:

(a) The G-seat shall use an air pump remotely located in a separate room.

(b) The G-seat pneumatic valves shall be located on the cockpit motion platform close to the pilot's seat.

3.7.4.3.8 Lap strap operation.- The electrical actuator for adjusting strap tension shall be located on the seat.

3.7.4.3.9 Safety provisions.- The lap strap fittings shall include a mechanical weak link, which shall shear in the event of possible physiological damage.

3.7.5 Visual simulation systems.- A visual system shall be provided to present real time "out of the window" color images of a simulated nap of the earth (NOE) environment to each cockpit. The two cockpits shall be capable of operating independently or as a single aircraft with full visual capability in both cases.

The "out of the window" display for each cockpit shall consist of a spherical dome screen and projection system attached to the motion system allowing a field of regard (total field of view (FOV) with head movement) of 220^{o} horizontally by 70^{o} vertically. The instantaneous FOV shall be 110^{o} by 50^{o} slaved to the pilot's or CPG's head to cover the full field of regard.

The visual system shall also provide real time monochrome images for the pilot's night vision system (PNVS) and indirect view modes of the target acquisition and designation system (TADS). A real time color image shall be provided for the direct view mode of the TADS. Provisions shall be allowed in the visual system for the display of any future missile imagery. Day and night conditions shall be simulated for all visual displays.

3.7.5.1 General visual system requirements.- The following requirements apply to the visual system.

3.7.5.1.1 System integration.- The dynamic response of the visual system shall meet the requirements of 3.6.1.3. In addition, the response characteristics of system components shall meet the minimum requirements specified for that component.

3.7.5.1.2 Image quality.- The final images displayed to the pilot and CPG shall each provide correct depth perception cues and dynamic fidelity to permit judgment of velocity and rate of closure. Any discontinuities or irregularities in the displayed images due to mosaicking of displays, insetting techniques, keying techniques or any other method involving the joining or merging of two or more images shall be minimized to the extent that the training value of the simulator is not degraded by such discontinuities or irregularities. All points in the image shall appear to be located at real world distances from any look point within each viewing volume as a result of maintaining proper linear and motion perspective in the displayed image.

3.7.5.1.3 Visual cues.- Image detail and dynamic system performance necessary to accomplish each training task shall be provided. Where such detail or performance in excess of minimum performance requirements stated elsewhere in the specification is required, the requirement established by the training tasks shall govern.

3.7.5.1.4 Design tradeoffs.- Where system tradeoffs are involved, the order of precedence for desired visual system characteristics are:

(a) Dynamic realism (i.e., motion, visual, command coupling)

(b) Resolution

(c) Distortionless image

(d) Scene brightness

3.7.5.1.5 Compatibility with cockpit motion.- There shall be no interference with the operation of the motion system; i.e., limit of the response and range of motion arising from the size, weight, inertia, or shape of those parts of the visual display systems mounted on or about the motion systems and cockpits. The visual displays shall not interfere with entrance to or egress from the cockpit. All visual display system components mounted on the motion system bases shall be able to withstand the maximum rated linear and angular motion system acceleration and jerk while performing within the visual system specification performance. That is, the television display and all optics shall remain aligned, electronic noise shall not be introduced into the video, color registration shall remain in alignment, and so forth.

3.7.5.1.6 Cleaning provisions.- All optical components shall be capable of being cleaned on site by properly trained user training device maintenance personnel without damage.

3.7.5.1.7 Radiation shielding.- Radiation shielding shall be in accordance with MIL-R-9673.

3.7.5.1.8 Light tight enclosure.- A light tight enclosure shall exclude all light transmission to the cockpit from external sources and shall allow access around the fuselage.

3.7.5.1.9 Visual system alignment and setup.- It shall be possible to perform any frequently required alignment procedures in a period of 30 minutes or less, by means of standard test equipment and/or special purpose equipment supplied by the supplier.

3.7.5.1.10 Visual system warm-up and stability requirements.- The visual system components and subsystems shall incorporate such circuitry, components, and compensation techniques so as not to require more than 30 minutes for warm-up and stabilized operation. Stabilized operation shall permit continuous operation of the visual system for a minimum period of 16 hours, after normal alignment procedures have been accomplished, without system adjustment or realignment. Picture quality as observed in the cockpit displays shall not deteriorate to a point where it fails to meet any of the performance requirements as defined in this specification at any time during the 16 hour period.

3.7.5.1.11 Visual training tasks.- The visual system shall be designed such that the following training tasks can be accomplished in day and night conditions under all visibility conditions.

(a) Basic powered flight maneuvers

(b) Ground (wheeled) taxi

(c) Takeoff to a hover

(d) Hover (in and out of ground effect)

(e) Takeoff from ground or hover

(f) Approach to hover or ground

(g) Landing from a hover

(h) Running landing (single engine)

(i) Landing roll out

(j) 180° autorotation to the ground

(k) Missed approach and go around

(l) Confined area operation

(m) Pinnacle operation

(n) Slope operation

(o) NOE flight

(p) Acquisition of targets

(q) Engage targets with appropriate weapon system

(r) Use smoke for masking

(s) Follow scout helicopter

(t) Perform mission with another AH-64

(u) Assess damage to targets

(v) Order and direct friendly artillery fire

(w) Perform mission with friendly ground support aircraft

(x) Take appropriate action when under attack

(y) Conduct and receive target handoff

(z) Update doppler navigation using laser rangefinder

3.7.5.2 Night simulation.- Night simulation in a typical NOE environment shall be considered a prime task for the trainer. It shall be possible to fly the trainer at the appropriate light levels using the unaided eye, the PNVS, the gunner night visual system (GNVS) or unmodified AN/PVS-5 night vision goggles.

3.7.5.2.1 Simulated light levels.- The following brightness levels for scene highlights shall be provided in addition to the normal full daylight level.

(a) 10^{-2} foot lamberts

(b) 10^{-3} foot lamberts

(c) 10^{-4} foot lamberts

(d) 10^{-5} foot lamberts

These brightness levels shall be capable of being selected at the instructor's console and shall be maintained over the full FOV of both pilot's and CPG's "out of the window" display.

3.7.5.2.2 Visual system performance at reduced light levels.- The signal to noise ratio, resolution and contrast shall not be degraded more than 50 percent at any of the reduced light levels.

3.7.5.2.3 Method for obtaining reduced light levels.- Neutral density filters of high optical quality shall be used to attenuate the intensity of the projected image.

3.7.5.2.4 TADS direct view.- A similar technique as described in 3.7.5.2.3 shall be used for providing the image brightness levels in the TADS direct view optics corresponding to the scene brightness specified in 3.7.5.2.1.

3.7.5.2.5 Provision for simulating TADS television.- The following parameters of the television sensor for each light level shall be provided.

(a) Signal level

(b) Signal to noise ratio

(c) Lag

(d) Resolution (static and dynamic)

(e) Gamma

3.7.5.2.6 Forward looking infrared (FLIR) simulation.- The simulation of the PNVS and TADS FLIR are specified in 3.7.5.3. The instructor shall be able to change the characteristics of the FLIR according to the diurnal cycle.

3.7.5.2.7 Use of AN/PVS-5 night vision goggles.- It shall be possible to use the AN/PVS-5 night vision goggles with the "out of the window" displays and the TADS direct view display.

3.7.5.2.8 Weapon flashes.- Bright flashes from enemy threats, friendly forces and the simulated aircraft weapons shall be simulated.

3.7.5.3 TADS/PNVS simulation.- The TADS and the PNVS shall be simulated by means of a full color CGI system. This system shall be provided as an integral part of the simulator. Displays shall be provided in the CPG cockpit for viewing the TADS indirect video in both head up and head down positions and the direct video in the head down position. The integrated helmet and display sight system (IHADSS) shall be government furnished equipment (GFE).

3.7.5.3.1 General requirements.- The simulation of the PNVS shall be sufficiently realistic so that all maneuvers which can be performed at night in the AH-64 using the PNVS can also be performed in the simulator. The simulation of the TADS shall be sufficiently realistic that all tasks performed in the AH-64 using the TADS can be performed in the simulator.

3.7.5.3.2 Image quality.- The final images displayed to the pilot and CPG shall provide correct depth perception cues and dynamic fidelity. The images shall relate to the "out of the window" imagery generated by the pilot's and CPG's visual system for all environmental conditions. Edge smoothing and/or anti-aliasing algorithms shall be used to obtain smooth continuous motion of all objects in the display. No relative motion between fixed objects shall be visible.

3.7.5.3.3 Compatibility with other AH-64 subsystems.- The image generating system shall supply video to the AH-64 symbol generator for display on the TADS indirect view display and the IHADSS. It is desirable that the TV standards as described in AAH-64-1 Volume 3 Book 23 be used to allow unmodified aircraft systems to be used for the symbol generator, IHADSS, and indirect view display. If the video is not compatible with the standards the supplier shall indicate how the final image will contain both symbology and video.

3.7.5.3.4 CGI data base for TADS direct view.- The data base for generating the direct view image shall be identical to the data base for the "out of the window" displays if these displays are a CGI system. If a model board visual is used for the "out of the window" displays sufficient face capacity and texturing shall be available to adequately model all distinguishing features of the model board. The modeling shall be deemed to be adequate if a particular feature seen in the window display can be recognized in the TADS. Whether a CGI or model board is used for the window displays, the TADS data base shall extend beyond the playing area of the simulator by an amount equal to the maximum range of the TADS.

3.7.5.3.5 FLIR and TV data bases.- The FLIR and TV data bases shall be identical to the direct view data base except that the appropriate FLIR and TV parameters shall be substituted for the direct view parameters.

3.7.5.3.6 Simulated requirements of PNVS.- All requirements specified in DRC-DP-AAH-4030A shall be simulated except any item which can be excluded from the simulation without degrading the performance of the simulation.

3.7.5.3.7 Simulated requirements of TADS.- All requirements specified in DRC-DP-AAH-4020A shall be simulated except any item which can be excluded from the simulation without degrading the performance of the simulation.

3.7.5.3.8 Use of IHADSS to display PNVS and TADS video.- It shall be possible to display either the PNVS video or the TADS indirect video (including the missile video) on the pilot's and CPG's IHADSS. The "out of the window" display shall remain fully operational at the appropriate light level when the IHADSS is in use. If a CGI system is used for the "out of the window" display faces may be reallocated to the IHADSS providing total visual performance is not degraded.

3.7.5.3.9 Use of TADS indirect view display by CPG.- It shall be possible to see PNVS video, TADS indirect video (including missile video) or recorded video in the head up position. The primary function of this viewing position is status, however good video performance is desired. The same video modes shall be seen, if selected, in the head down position through the eyepiece of the optical relay tube.

3.7.5.3.10 Use of direct view display by CPG.- In the head down position the CPG shall be able to view a full color scene at the selected magnification. The display shall be produced by a high resolution color monitor or set of monitors meeting the following standards:

(a) Color.- NTSC standard RGB capability

(b) Registration error (misconvergence).- The registration error of the direct view display shall meet the following conditions:

(1) Equal to or less than 35 nanoseconds in a circle whose diameter equals 0.8 picture height.

(2) Equal to or less than 75 nanoseconds in a circle whose diameter equals the picture height.

(3) Equal to or less than 150 nanoseconds in a circle whose diameter equals the picture width.

(4) Equal to or less than 200 nanoseconds beyond a circle whose diameter equals the picture width.

(c) Scanning linearity.-

(1) Equal to or less than ±1 percent within a central area bounded by a circle whose diameter equals the picture height.

(2) Equal to or less than +1.5 percent outside the central area.

(d) Scanning Standard.- 875 lines at 30 frames per second interlaced 2:1

(e) Resolution.- A minimum horizontal resolution of 900 TV lines picture height shall be provided.

(f) Brightness.- 25 foot lamberts

3.7.5.3.11 Target acquisition.- It shall be possible to detect and recognize targets at the required ranges in both day and night operations as specified in DRC-DP-AAH-4020A. The optimum mode for detecting and recognizing targets in the TADS for any set of environmental and operational conditions shall be the same as in the AH-64 for that particular set of conditions. It shall be possible to adjust the probability of detecting and recognizing targets to match the actual performance of the TADS in the AH-64. Twelve targets (maximum) shall be displayed in modes where recognition is possible.

3.7.5.3.12 Control of TADS and PNVS.- The control of the TADS/PNVS shall be as specified in AAH-64-1, Volume 3, Book 23.

3.7.5.3.13 CGI computational system.- The specification for the computational system shall be identical to that specified in 3.7.5.5.2.

3.7.5.3.14 Demonstration of capabilities.- The supplier shall be prepared to demonstrate a prototype version of the proposed CGI system. As a minimum the demonstration shall consist of the display on a high resolution color monitor of a tank type target in wooded terrain as it would be seen in TADS TV and direct view mode at both narrow and medium FOV. The simulated range shall be as specified in AAH-64-1, Volume 3, Book 23. The demonstration shall take place at the supplier's plant. If a dynamic demonstration is not possible the supplier shall describe how the proposed system will be built in the time frame of the project. As part of the reply to this paragraph the supplier shall indicate how the FLIR imagery would be simulated.

3.7.5.4 "Out of the window" display description.- The display system for each cockpit shall consist of a spherical dome front projection screen surrounding the simulator cockpit. A video image shall be projected onto this screen from three moveable compact high resolution color video projectors mounted above and behind the pilot's head. The three projectors shall cover a 110^{o} ($\pm 55^{o}$) horizontal by 50^{o} ($+20^{o}/-30^{o}$) vertical instantaneous FOV within a field of regard of 220^{o} ($\pm 110^{o}$) horizontally by 70^{o} ($+30^{o}/-40^{o}$) vertically. The projectors shall be slaved to the pilot's/CPG's helmet orientation.

3.7.5.4.1 Dome.- A spherical front projection screen, being a section of a 12-foot radius dome centred at the trainee eye point, covering the total field of regard of the pilot, shall be mounted around each simulator cockpit on the motion base. Arc run out shall be accurate within 0.25 inch of the true radius over an 8-inch arc length.

(a) Dome Screen.- The inner surface of the dome shall act as a neutral color reflecting surface having a brightness gain of 3, (+1, -0).

(b) Dome Surface.- The inner surface of the dome, when illuminated by pure white light from the projectors, shall not exhibit any blemishes, scratches, seams, or joins to an observer at the pilot's eye point.

(c) Dome rigidity.- The dome screen shall be sufficiently rigid such that no deflections or vibrations of the screen surface shall be visible to the pilot under simulated dynamic conditions within the normal operating limits of the motion system.

3.7.5.4.2 Projectors.- Three compact high resolution video projectors shall be used for each cockpit display. If a camera/model board system is offered 3.7.5.4.2(a) shall apply. If a CGI system is offered 3.7.5.4.2(b) shall apply.

(a) CCTV line and scan rate.- The video projector shall operate in a field sequential color mode at 925 lines per frame, 180 fields per second with a 2:1 interlace. The video projector shall consist of a high brightness projection cathode ray tube (CRT) with a rotating color wheel.

(b) CGI line and scan rate.- The video projectors shall operate in a simultaneous color mode at 875 lines per frame, 60 fields per second with a 2:1 interlace. The video projection shall consist of a light valve color projection system.

(c) Light output.- Each video projector shall provide a minimum light output of 200 lumens.

(d) Brightness uniformity.- The variation in image brightness over the field of one projector shall not exceed 20 percent of the center brightness measured on the screen from the pilot's eye point.

(e) Image format.- Each projector shall display an image 50° vertically by 37° horizontally. The raster lines shall lie along the vertical axis.

(f) Geometric distortion.- The projected video image from any single projector shall exhibit a maximum geometric distortion of 2 percent measured on the dome screen with the projector located anywhere within the horizontal field of regard and set to zero pitch. The maximum discontinuity across channel boundaries shall be 0.5°. The design goal shall be an imperceptible discontinuity.

(g) Contrast ratio.- The contrast ratio shall be 15:1 or greater measured on the dome screen from the pilot's eye point.

(h) Stability.- The projected image on the screen shall not shift horizontally or vertically by more than 0.5 percent of the vertical picture height in one hour.

(i) Color registration.- There shall be no misregistration of the primary colors comprising the displayed image on the screen.

(j) Focus.- The projected video image shall remain in focus over the entire instantaneous FOV located anywhere within the total field of regard. Variable correction systems operated under computer control may be used to achieve this result.

3.7.5.4.3 Projector servos.- The video projectors shall move under computer control to place the instantaneous area of interest FOV anywhere within the total field of regard. The movement shall be about the common projection point of the three video projectors. The rotation in yaw shall be about the vertical axis of the dome. The rotation in pitch shall be about the horizontal axis of the dome normal to the axis of the central projector.

(a) Servo performance.- The projector servos shall be capable of the following performances:

(1) Displacement.- The projectors shall be capable of rotations in the horizontal plane of ±90° from the dead ahead center position and rotations in the vertical plane of ±10° from the zero pitch position.

(2) Velocity.- The servos shall be capable of slewing the projectors at 80° per second in either axis.

(3) Stability.- With a constant position input, no movement of the image on the screen shall be detectable by an observer at the pilot's eye point.

(4) Positioning accuracy.- For any position input, the center of the instantaneous FOV shall not deviate by more than ±0.5° from the input position.

(b) Center of rotation.- The projection system center of rotation shall not deviate by more than ±0.1 percent of the projection distance, from the common projection point in either the horizontal or vertical axis.

3.7.5.5 Image generation system for "out of the window" display.- If a camera/model board visual system is offered 3.7.5.5.1 shall apply. If a CGI system is offered 3.7.5.5.2 shall apply.

3.7.5.5.1 Model board image generation system.- The image for the "out of the window" display of the pilot and CPG shall be generated from a camera/model board visual system. Two identical model boards shall be supplied, one for the pilot and one for the CPG. Each model board system shall be capable of operating completely independently of the other. When pilot and CPG are operating as if in a single aircraft the content and dynamics of the imagery shall be sufficiently identical to allow all the specified training tasks to be performed in a proper manner.

(a) Model board details.- Each model board shall be not less than 24 feet high by 64 feet long and shall consist of basically rolling countryside scaled at 500:1. It shall be possible to land on any part of the model which would allow normal operation of an AH-64. It shall be possible to fly at NOE altitudes and velocities over the entire model playing area. No prominent landmarks will be included which would make the navigation task unrealistically easy. Provisions shall be made for adding a 300 foot pinnacle to the model for practicing pinnacle maneuvers. Rural terrain features shall include but not be limited to trees, wooded areas, roads, buildings, etc. In addition, a small rural community shall be included. The percentage (by area) of urban/rural features shall be approximately 95 percent rural and five percent urban. The scene detail shall be designed to provide the pilot with realistic velocity, altitude, attitude, and range cues. All trees, whether deciduous or coniferous, shall be modeled as individual free standing, highly realistic trees, including all trees comprising forested areas. Ground textures shall be modeled with special attention paid to the scale and realism of the ground textures. Open grass, scrub fields, as well as cultivated plowed fields and fields with crops, shall be provided. All buildings shall be modeled with special attention to scale factor and realism, and shall include architectural details such as doors, windows, chimneys, porches, walkways, etc. Liberal use shall be made of fences, telephone poles, high tension towers, etc. As a means of providing height and velocity cues all vehicles shall be modeled with highly realistic detail and adherence to proper scale.

Fifty scale models of enemy threats shall be provided with provisions for positioning at various points on the model board by the user. These models shall be provided in sets of two to facilitate selection of models for each model board. Fifty scale models of friendly force armor and infantry shall be similarly provided. Exact details of the model will be approved by the procuring agency.

(1) Model board tolerances.- The position, size, and registration accuracy of and between the two model boards shall be controlled to minimize apparent position discrepancies between objects, runways, and terrains as seen in the pilot's and CPG's windows, and to minimize the possibility of the probe contacting the model boards. Minimum accuracies of the model boards shall be as follows:

a. General terrain features registration ±0.10 inches along the X and Y axes.

b. Contour registration ±0.050 inches

(2) Model boundary.- An aluminized front surface mirror shall be located perpendicular to the plane of the model board and shall extend around the entire perimeter of the model to a height of six inches above model altitude for the purpose of providing the illusion of extended terrain when flying NOE. The mirror shall have a reflectivity of 90 percent or greater and be capable of being cleaned without damage. A matt white surface shall extend above the mirror to a height of two feet six inches above the model surface to facilitate sky simulation. Terrain features which would give obvious mirror images (lakes, large cultural features, etc.) shall be located at a distance from the reflective surfaces. Line-like terrain features (roads, rivers, etc.) shall be located away from the edge or shall cross the edge at right angles to give the illusion of continuation.

(3) Model measurement.- The height of the surface of the model shall be measured at a regular grid spacing of 0.5 inch over the entire surface of the model. The data shall be stored on disc and used by the probe safety program (3.7.5.5.1(c)(3)) and line of sight program (3.6.1.6.16). It shall be possible for the user to update this data base to allow for model aging or changes to the model. Any software and hardware required to accomplish the model measurement shall be supplied as part of the simulator.

(4) Model board support.- A model board support assembly shall be provided which permits free standing installation of the model with minimum interface with the facility. The support assembly shall have sufficient strength and rigidity to ensure that no perceptible movements or vibrations of the model board or changes in alignment occur.

(5) Model board materials and finishes.- In addition to the material requirements stated elsewhere in this specification, the following criteria shall be used in selecting model board materials and finishes:

a. They shall withstand environmental vibrations without perceivable effect on the displayed image

b. Fade resistant

c. Rugged enough to withstand repeated cleaning following contractor recommended procedures

d. Heat resistant

e. Warp resistant

f. Shrink resistant

g. Flame retardant

h. Minimal nonproductive reflections

i. Ease of modification (i.e., relocate building, addition of a prominent object)

j. Optimum display image quality

k. Model boards shall be designed for a minimum operational life of 15 years or 40,000 operating hours with only minor retouching or repair.

(6) Model board illumination.- The illumination shall be the minimum compatible with the requirements of the TV camera. The illumination equipment shall be provided as part of the model board installation. Model board illumination shall be consistent with overall visual system performance requirements, safety, and power considerations. Illumination shall be uniform at all points on the model board surface. Any shadows produced by the gantry and probe/television camera carriage assembly throughout its normal operating range shall be removed with makeup lighting to maintain a uniform illumination on the model board surface. The illumination level shall not deteriorate the model board structure, texture, or color.

(b) Gantry.- Two gantries shall position the optical probe/television cameras in response to commands from the general purpose computer. All gantry servo operations shall be smooth and precise. Jitter, backlash, or time/phase lags, to an extent that is discernible in the image of the final display, shall not occur. Provision shall be made for rapid transition between different positions on the model board. A special effects generator shall be used to achieve a visual scene fade out during transition at the edge of the model board. Provisions shall be made to assure smooth attainment of commanded positions under freeze/unfreeze conditions.

(1) Gantry "out-the-envelope" track.- The gantry drive system shall slew to and track the simulated aircraft in X-Y-Z within gantry travel limitations anytime the simulated aircraft is within 30 nautical miles of the map edge, and a visual system training mode is selected. The simulated aircraft shall then reenter the map area at the correct point.

(2) Gantry maintenance overtravel.- Six feet of X-axis overtravel shall be provided to permit maintenance access to the probe/camera subsystem.

(3) Gantry and probe servo performance.- Gantry and probe servos shall be designed to meet the performance parameters specified below in addition to the other requirements of this specification. All positioning drive signals shall be derived from a digitally computed solution of the mathematical model of the equations of motion. Compensation techniques shall be utilized as required to provide for continuous update necessary to satisfy the requirements while simultaneously minimizing jitter, backlash, and time/phase lags, and to optimize the resolution and accuracy of all positioning drive signals. The dynamic parameters specified for the gantry and probe drive represent minimum performance for these components; however, the gantry and probe drive shall also provide the performance required to meet the complete trainer dynamic response specified in 3.6.1.3. Gantry and probe drive minimum performance shall be in accordance with Table III and the following subparagraphs.

a. Excursion.- The excursions specified in Table III shall be the minimum available for use in training with the visual system.

b. Static position and attitude accuracy.- The position and attitude of the gantry/probe shall not deviate from the commanded values by an amount greater than specified in Table III.

c. Maximum velocity.- The maximum velocity for simulation shall be not less than the value specified in Table III.

d. Minimum velocity.- The system shall be capable of driving smoothly at the minimum velocity specified in Table III with velocity variations of less than ±25 percent.

e. Slew velocity.- The slew velocity shall be not less than the value specified in Table III. Slew velocity requirements apply during system initialization, reset, transition between model board areas, and maintenance.

f. Dynamic velocity accuracy.- Actual translational and rotational velocities shall not deviate from the commanded value by more than the percentage of the commanded value or the actual velocities specified in Table III.

g. Acceleration.- The system shall be capable of providing accelerations which decrease linearly from the values specified in Table III at stall toward zero at maximum velocity.

h. Resolution.- The system shall respond to position and attitude command changes of the magnitude specified in Table III.

i. Stability.- For a constant commanded position and attitude the gantry/probe position and attitude shall not vary by more than the amount specified in Table III during a one minute period.

TABLE III

GANTRY AND PROBE SERVO PERFORMANCE

	LONGITUDINAL-X		LATERAL-Y		ALTITUDE-Z		PITCH-o	ROLL-ϕ	YAW-Ψ
	ACTUAL	SCALE 1:500	ACTUAL	SCALE 1:500	ACTUAL	SCALE 1:500	ACTUAL	ACTUAL	ACTUAL
Excursion limits	63 ft	9.6 Km	23 ft	3.5 Km	2 ft	1000 ft	$+25^0$ -40^0	Unlimited	Unlimited
Static position accuracy	±2 mm	1 m	±2 mm	1 m	±0.2 mm	10 cm	$\pm0.1^0$	$\pm0.1^0$	$\pm0.1^0$
Maximum velocity (not less than)	8 in/ sec	200 kts	8 in/ sec	200 kts	4 in/ sec	10,000 ft/min	45^0/sec	30^0/sec	60^0/sec
Minimum velocity (not greater than)	0.004 in/sec	0.1 kt	0.004 in/sec	0.1 kt	0.002 in/sec	5 ft/ min	0.1^0/ sec	0.1^0/ sec	0.1^0/ sec
Slew velocity (not less than)	10 ins/ sec	250 kts	10 ins/ sec	250 kts	4 in/ sec	10,000 ft/min	N/A	N/A	N/A
Dynamic velocity accuracy % of command or actual error	±1%	±1%	±1%	±1%	±1%	±1%	±1% or 0.1^0/ sec	±1% or 0.1^0/ sec	±1% or 0.1^0/ sec
Acceleration (stall)	0.2 ft/ sec^2	3g's	0.2 ft/ sec^2	3g's	0.2 ft/ sec^2	3g's	60^0/ sec^2	45^0/ sec^2	70^0/ sec^2
Resolution and stability	.002 in	1.0 in	0.002 in	1.0 in	0.002 in	1.0 in	0.05^0	0.05^0	0.05^0
Frequency response (at -3dB point)	0-2 Hz		0-2 Hz		0-2 Hz		0-4 Hz	0-4 Hz	0-4 Hz

j. Frequency response.- Each servo shall provide a response within 10 percent of the theoretical response for an ideal, second order, 0.7 damped velocity servo for both Bode plots and time histories over the minimum frequency range specified in Table III.

(c) Optical probes.- The system shall utilize two probes each having three separate output channels. Each channel shall cover 50° (+20°/-30°) vertically by 37° (±18.5°) horizontally and when combined shall cover a total contiguous FOV of 50° (+20°/-30°) vertically by 110° (±55°) horizontally. The probes shall have focus automatically adjusted under computer control in order to view the model board continuously with optimum focus and depth of field and correct position to simulate the pilot eye location (to the extent specified herein) and orientation (i.e., pitch, roll, and yaw of the line of sight) through the use of external control signals. The probes shall have been designed such that pitch, roll, and yaw rotations are accomplished mechanically with the probe and do not result in performance, magnification, or position changes in the system. The probe shall be designed for optimization of transmissivity, resolution, area of modulation under the modulation transfer curve, depth of focus, and distortions. The probes shall be capable of unrestricted use in the simulation of ground (i.e., taxi, takeoff, and confined area maneuvers) and flight operations to the extent specified herein by utilizing telecentric optics to locate the entrance pupil at the pitch axis of the heading mirror or prism. Level optical probe performance shall provide the performance required elsewhere in this specification and as follows:

- Focus - Computer controlled dynamic focus shall be provided
- Focus range - 0.7 inches to infinity
- Entrance pupil to model board distance (minimum) - .150 inch or less
- Resolution - The resolution of the probe shall be six arc minutes or better over the entire FOV
- Modulation transfer function (MTF) - (Object in plane of best focus, for all optical frequencies). On axis - 70 percent of the diffraction limited to a frequency of seven arc minutes with one millimeter pupil.

(1) Optical probe material.- Materials that are not specifically referenced herein, shall be of the best commercial quality and suitable for the purpose intended. Corrosion resistant metals shall be used in the construction of the optical scanner wherever protective finishing is not practicable. Ferrous metals that are required to obtain functional or magnetic properties shall be protected against corrosion.

(2) Optical probe repairs.- Design of the optical probes shall be such that if the probe inadvertently strikes the model board, only a small portion of the probe will be broken, and that portion shall be economically repairable. The probe shall be designed for modular construction such that the pitch assembly of the optical probe may be economically replaced in the field by maintenance personnel without the need for optical alignment.

(3) Probe protection.- Probe protection shall be provided via software control to prevent damage to the probe and camera. Protective measures shall preclude the possibility of the probe being damaged by contact with the model board assembly. The following protective measures shall be included:

a. Software shall ensure that maximum aircraft sink rates and minimum altitudes over level regions of terrain, and maximum closure rates and minimum horizontal approach distances to elevated regions are not exceeded.

b. Software shall ensure that an adequate probe height is reached before permitting X and Y excursions on resetting.

(4) Television camera.- The television image pickup systems shall consist of two separate units, the camera heads located on the terrain model board gantry, and the camera control units located elsewhere within the terrain model board enclosure. The electro-optical sensors (image tubes) incorporated in the television cameras shall be of the low stick and lag design, so as to result in no perceptible motion smearing in the visual simulator display devices at all operational rates and conditions specified in this specification. The cameras shall operate in a field sequential color mode at 925 lines per frame, 180 frames per second, 2:1 interlace and performance characteristics shall be as follows:

- Resolution.- The video channels shall be designed to optimize the area under the modulation transfer curve. A minimum resolution of 800 TV lines per picture height shall be provided.
- Signal to noise ratio (SNR).- The signal to noise ratio shall be not less than 30 decibels peak signal to RMS noise for normal operating signal current. The measurement shall include the noise of all video processors.
- Lag.- At full scan less than two percent residual signal shall remain 50 milliseconds after removal of normal operating faceplate illumination.
- Sensitivity.- Sensivity shall be compatible with model board illumination level and the other performance requirements of this specification.
- Raster burn.- There shall be no discernible raster burn.
- Spectral response.- The system shall respond to the entire visible spectrum.

- Gamma.- Gamma shall be adjustable to unity ±10 percent at pilot's and CPG's eyepoints.

- Television video bandwidth.- Television video bandwidth shall exceed 50 megahertz at the 3 decibel point.

a. Video processor and distribution unit.- The closed circuit color television (CCTV) systems incorporated in the visual system shall include circuitry to assure processing, distribution, and control of all video and associated drive signals in accordance with proven engineering techniques. This shall include all video and drive signal amplifiers, buffering circuitry, waveform shapes, phase compensation circuitry, EMI suppression circuitry, and electronic filters as required to assure stable operation of the camera, display, and all monitors in the CCCTV system. This circuitry shall be physically located at a central location, such as at the sync generator, and at remote locations, in such quantities and number of locations as required to assure that all video generation and display devices are provided with interference free signals of the amplitude and waveshape necessary for optimum performance. The video processing and control equipment shall, in addition to the above, serve two other functions:

- Provide operation on the television rasters as required for optimum input to the visual simulation display.

- Provide for generation and control of special effects, as defined in 3.7.5.5.1(c)(5).

(5) Special effects.- Special effects simulation shall be provided to effect a continuous visual scene throughout the FOV regardless of simulated aircraft position or attitude and to simulate environmental characteristics which are not included in the model board. Special effects inclusion and parameter values shall be selectable by the instructor. Special effects shall include the following:

a. Atmospheric effects.- The following atmospheric effects shall be simulated:

1. Haze

2. Fog

3. Overcast ceiling

4. Sky above ceiling

5. Horizon

b. Tactical effects.- The following tactical effects shall be simulated:

1. Muzzle flashes

2. Missile and rocket trails

3. Smoke clouds

4. Weapon impact effects

5. Dust clouds raised by moving vehicles

c. Aircraft effects.- The following aircraft effects shall be simulated:

1. Rotor blades visible in forward display

2. Dust clouds raised on landing due to rotor wash

(6) Visual system controls.- Controls for the operation and maintenance of the visual system shall be provided. Operating controls required by the instructor during the training and checkride modes of operation shall be located at the instructor station. Maintenance controls shall be appropriately located for their intended use and shall include those indicated below as well as any other required for routine maintenance and alignment. A color television monitor shall be located appropriately for use in conjunction with these controls. Provision shall be made so that any and all necessary on-line adjustments to the visual display monitor viewed by the pilots can take place without interruption of training and checkride mode activities.

a. ON/OFF as may be required for each major subassembly (e.g., camera, gantry, illumination)

b. Gantry/probe positioning and slewing

c. Model board lighting

d. Special effects generator controls

e. Probe focus, aperture, pitch, yaw, and heading adjustments

f. Television camera controls

g. Color video controls

h. Controls associated with the display monitor located in the maintenance area

(7) Scout helicopter simulation.- A television camera similar to that used on the model board scanner shall be used to view a servo driven, gimbal mounted model scout helicopter. The resulting video shall be keyed into the video for the "out of the window" displays to enable training in those missions requiring visual contact between AH-64 and a scout helicopter. The movement of the scout helicopter shall be controlled by the computer in a preprogrammed manner or by the instructor.

a. Range of scout helicopter relative to AH-64.- The minimum simulated range of the scout helicopter shall be 100 feet and the maximum simulated range shall be 1000 feet. At ranges of greater than 1000 feet the scout helicopter shall be represented by a small dot like symbol.

b. Occultation of the scout helicopter by terrain.- The scout helicopter shall be completely occulted if more than half is hidden by any terrain feature. It is desirable that partial occultation will be provided at ranges of less than 300 ft.

c. Simulation of other aircraft.- It shall not take longer than 10 minutes to replace the scout helicopter with a different aircraft.

3.7.5.5.2 CGI image generation system.- The image for the "out of window" display for the pilot and copilot shall be generated by a CGI system. Sufficient face and texturing capacity shall be provided to allow independent and combined operation of pilot and CPG cockpits with each having a full visual capacity. The CGI system using a numerically stored model and simulator flight data shall generate video signals for display to the two cockpits. The displayed images shall provide the necessary visual cues to permit the pilot and CPG to perform the tasks specified in 3.7.5.1.11. Perceptual complexity shall be provided to represent real world scene complexity to visually task load the pilot for realistic simulation. The pilot may fly in any direction or any attitude within the visual model and view the proper visual cues.

(a) Elimination of distorting visual effects.- The CGI shall eliminate all distorting visual effects that occur during the computations and processing of the image. These effects include:

(1) Scintillation of small faces

(2) Quantization due to the computations of picture elements

(3) Abrupt additions or deletions of scene detail

(4) Repetitive or periodic motions of the visual scene not computed in the main simulator

(5) Relative motions between fixed objects in the scene

(6) Effects caused by aliasing

(7) Interlace flicker

(b) TV synchro standards.- The CGI system shall be designed for 875 line/30 frames per second interlaced 2:1.

(c) Scene computations rate.- A new scene shall be computed at the TV field rate i.e. 60 fields per second.

(d) Operational envelope.- The CGI system shall possess the following processing capabilities:

(1) 20 by 40 kilometers playing area.

(2) Altitude range of zero to 2000 feet above the terrain surface.

(3) A translational rate of 60 knots at ground level and 200 knots at 100 feet above ground level.

(4) A rotational rate of 30^{o} per second.

The rates specified in (3) and (4) shall be accomplished with no loss of displayed faces. Higher rates shall be possible but a simplified data base may be used.

(e) Atmospheric effects.- The following effects shall be simulated:

(1) Aerial perspective

(2) Variable visibility (controlled by instructor)

(3) Variable transparency for smoke and clouds

(f) Targets.- The CGI system shall be capable of displaying four independently moving vehicles simultaneously. At ranges too great for detection in the "out of window" display it shall be possible for the instructor to cause the target to raise a dust cloud to enable the target to be acquired by the CPG using the TADS. The motion of the targets shall be preprogrammed or under instructor control. It shall be possible to insert a total of 26 targets in the data base under instructor control.

(g) Weapon effects.- The following weapon effects shall be simulated:

(1) Missile trails and impacts

(2) Rocket trails and impacts

(3) Cannon impacts

(4) Muzzle flashes

These effects shall originate from enemy threats, friendly forces and the simulated aircraft. The trajectories and hit probability shall be calculated by the simulator computer.

(h) Other aircraft.- It shall be possible to have at least one other moving aircraft within the FOV. This will normally be a scout helicopter at a range of between 100 feet and 1000 feet. The motions of the aircraft shall be preprogrammed or under instructor control.

(i) Crash Detection.- The CGI system shall detect and inform the simulator computer when a visual crash occurs.

(j) Data base.- A data base shall be supplied with the simulator consisting of basically rolling countryside. It shall be possible to land on any part of the model which would allow normal operation of an AH-64. It shall be possible to fly at NOE altitudes and velocities over the entire model playing area. No prominent landmarks will be included which would make the navigation task unrealistically easy. Provisions shall be made for adding a 300 foot pinnacle to the data base for practicing pinnacle maneuvers. Rural terrain features shall include, but not be limited to, trees, wooded areas, roads, buildings, etc. In addition a small rural community shall be included. All trees, whether deciduous or coniferous shall be modeled as individual free standing trees including those comprising forested areas. Ground textures shall be modeled with special attention paid to scale and realism. Open grass, scrub fields, as well as cultivated plowed fields and fields with crops shall be provided. All buildings shall be modeled with special attention to details such as doors, windows, chimneys, porches, walkways, etc. Liberal use shall be made of fences, telephone poles, high tension towers, water towers etc.

(k) Data base generation and modification.- Sufficient software and and hardware shall be provided to allow existing data bases to be modified and new data bases to be generated.

3.8 Electromagnetic interference (EMI) suppression.- The trainer shall be designed to meet the requirements of RS03, CE03, RE02, and CS06 of MIL-STD-461. In addition, EMI design practices shall be utilized to ensure trainer self-compatibility and freedom from internally generated electrical noises.

3.8.1 Electrical grounding.- The grounding and grounding systems requirements of MIL-T-23991 shall apply.

3.8.2 Electrical bonding.- The electrical bonding procedures of MIL-STD-1310 shall be utilized as a design guide.

3.8.3 Wire and cable classification.- The wire and cable classification requirements of MIL-T-23991 shall apply.

3.8.4 Audio communications systems.- The audio communications system shall be designed to meet the signal to noise and crosstalk requirements of MIL-C-29025.

3.9 Size and weight.- All unassembled units of the trainer as packaged for shipment shall conform to the size and weight limitations of AR 70-44. All units shall be capable of passing through a doorway 12 feet x 12 feet x 12 inches. The assembled trainer shall be capable of complete and unrestricted operation within the volume specified in Table IV.

TABLE IV

EQUIPMENT FLOOR AREA AND CEILING HEIGHT

	COCKPIT AREA	COMPUTER	HYDRAULIC	VISUAL
Floor Area (feet)	50 x 50 (per cockpit)	30 x 20	12 x 12 (per cockpit)	50 x 84
Ceiling Height (feet)	35	10	10	31

3.10 Support facilities and equipment.- Support facilities and equipment shall be in accordance with 3.10.1 through 3.10.3.

3.10.1 Government furnished facilities.- The trainer shall be designed for installation in a fixed base facility provided by the Government. The trainer shall be designed to fit into the space specified in 3.9.

3.10.1.1 Power.- The Government will furnish power of 120/208/277/480 volts, 3-phase, 4-wire 60 Hertz terminating in power distribution panels on inside walls of the building.

3.10.1.2 Ground system.- The Government will provide a ground system. All contractor furnished trainer grounding shall terminate on the facility ground.

3.10.1.3 Lighting.- The facility will contain (Government furnished) overall lighting of approximately 35-foot candles at floor level.

3.10.1.4 Hydraulic system location.- The hydraulic pumps and accumulators for the trainee station motion system shall be located in a soundproofed utility room which may be up to 100 feet from the trainer room. All hydraulic plumbing shall be provided by the contractor.

3.10.1.5 Air conditioning system.- The buyer will provide a year round air conditioning system in the building that will house the trainer. The system will include an air conditioning unit, ventilation equipment, and heating equipment. The contractor shall be responsible for providing a distribution system consisting of ductwork, filters, dampers, fans or blowers, controls, and other necessary equipment to tie into the Government furnished air conditioning system supplying conditioned air and exhaust. The contractor shall also be responsible for connecting the distributing system to the Government furnished air conditioning system. The Government will provide the tie in duct at the vicinity of the false floor.

3.10.2 Contractor-furnished support facilities

3.10.2.1 Lighting.- Lighting shall be in accordance with 3.2.1.4.

3.10.2.2 Power.- The contractor shall provide all necessary controls and equipment to distribute power from the power distribution panels of 3.10.1.1 throughout the trainer. An emergency POWER/ON/OFF switch shall be provided in each area of the trainer. The trainer, other than the pumps and the visual light bank, shall be capable of operation from a 120-208 volt, 3-phase, 4-wire, 60 Hertz power source. The hydraulic pumps for the cockpit motion system shall operate from a 227/480 volt, 3-phase, 4-wire, 60 Hertz power source. The light bank shall operate from a 277/480 volt, 3-phase, 4-wire, 60 Hertz - 290 ampere per phase power source.

3.10.2.2.1 Main power distribution panel.- A main power distribution panel shall be provided in accordance with MIL-T-23991. The panel shall be located near the computer complex and shall be wired in such a manner as to preclude damage to the trainer due to actuating switches in an indiscriminate sequence. The panel shall include a separate indicator/control for each of the functions which may be required for isolation of circuits, protection of equipment, and centralized activation of electrical systems associated with operation of the device. A phase warning light in accordance with MIL-T-23991 shall be provided.

3.10.2.2.2 Blown fuse indicator.- A blown fuse indicating light is preferred at each equipment rack containing fuses to indicate when a fuse has blown in that rack. As an alternate, blown fuse indicating type fuse holders may be used. Commercial off the shelf items containing fuses need not be modified to meet these requirements.

3.10.2.2.3 Trainer utility power.- Trainer utility electrical power circuits shall be designed to operate from the main power source and shall be energizable while the remainder of the trainer power is off. The utility power circuits shall furnish power for the lights, maintenance test bench, and utility power outlets, and maintenance intercommunications system.

3.10.2.2.3.1 Utility receptacles.- Externally mounted utility receptacles shall be provided in accordance with MIL-T-23991 and shall be at all areas where electrical tools, utility lamps, or test equipment will be required for servicing and repair work.

3.10.2.3 Raised floor.- Raised flooring capable of supporting the heaviest equipment rack shall be provided in the computer room so that all cabling, plumbing, ductwork, hydraulic lines, etc., between components of the device in that area shall be beneath the raised floor. Provisions shall be made for forklift access to maneuver equipment racks in place. Power lines from the building service entrance box, and lines between each cockpit and remotely located auxiliary equipment such as hydraulic pumps, compressors, etc., shall be routed in such a manner as to allow for access and maintenance while ensuring no interference with installation, removal, or maintenance of device components.

3.10.3 Problem formulation systems.- Problem formulation systems shall provide capability for developing and editing of the following data:

(a) Maneuver Demonstrations (3.7.3.3.3(a))

(b) Performance Evaluation, Tactical Mission Evaluation (3.7.3.3.3(c))

(c) Radio navigation and communication facility parameters (3.6.1.7.4)

(d) Lesson Plans (3.7.3.3.3(b)(1))

(e) Setups and Unusual Attitudes (3.7.3.3.3(g)(2))

(f) Automated Tactical Scenario Control (3.7.3.3.3(g)(5))

The method of utilization for the problem formulation systems will vary with the type of data subject to editing or development. The techniques and their respective data types are listed in Table V.

TABLE V

PROBLEM FORMULATION TECHNIQUES

Technique	Description	Application
Maneuver Recording	Recording of actual flight. Total operation performed in cockpit	Maneuver demonstrations, Setups, Unusual Attitudes
CRT Edit	Use of instructor's control format to create/edit performance evaluations.	Performance evaluations, Tactical Mission evaluation
ASR Edit	Use of ASR or CRT to modify data base	Nav radio facilities
ASR Edit	Use of ASR or CRT to create/edit lesson plans	Lesson plan creation and edit
Tactical Situation Recordings	Use of CRT control format, instructor controls and repeat visual monitor to generate threat and friendly force maneuvers.	Automated tactical situation control

All source data input format shall be in a problem oriented language which shall utilize common English terminology. The ASR and CRT edit technique shall utilize this same type of terminology and shall operate on a question and answer system for operator input.

3.11 Colors.- Colors required will be selected during the mockup conference.

3.11.1 Cockpit interior.- Colors for the cockpit interior shall be identical to the helicopter in all areas visible to the trainee.

3.12 Finish.- Finishes shall be in accordance with MIL-T-23991.

3.13 Training device nameplates and product markings.- Training device nameplates and product markings shall be in accordance with MIL-T-23991.

3.14 Government furnished property.- Any Government furnished property will be identified in the contract.

3.15 Workmanship.- Workmanship shall be in accordance with MIL-T-23991.

4. QUALITY ASSURANCE PROVISIONS

4.1 General quality assurance provisions.- Unless otherwise specified herein, quality assurance provisions shall be in accordance with MIL-T-23991. The quality assurance program shall ensure quality throughout all areas of the specification requirements, including design, development, fabrication, processing, assembly, inspection, test, maintenance, preparation for delivery, shipping, storage, and site installation.

4.2 Test conditions.- All tests shall be conducted under the following conditions.

4.2.1 Signal outputs.- Servo, integrator, and signal outputs shall be set to ensure proper test conditions.

4.2.2 Temperature.- Unless otherwise specified, tests shall be made at prevailing room temperature between $60^{o}F$ and $80^{o}F$.

4.2.3 Test equipment and instrumentation.- Test equipment shall be checked or calibrated prior to conducting the test program. Test equipment shall include a suitable electronic or mechanical control force and displacement measurement device, a timing device, a multichannel recorder, X-Y recorder, meters, and oscilloscopes. A low frequency sine wave generator, 0.01 to 10 Hertz, and a means for introducing impulse disturbances of surface deflections shall also be included. Calibration charts and conversion data shall be available during the tests.

4.2.4 Alignment.- The trainer shall be aligned by the trainer contractor prior to the initiation of the test program.

4.2.4.1 Changes during testing.- All changes made in alignment, programming, and adjustments during the testing program shall be recorded. Any test conducted prior to such adjustments shall be repeated unless it can be conclusively proven that such adjustments have not invalidated the related test data.

4.2.4.2 Changes after testing.- All modifications or change in design determined necessary as the result of a test shall be recorded. All tests run prior to such modifications shall be repeated unless it can be conclusively proven that such modifications or changes in design have not invalidated the related test data.

4.2.5 Test methods.- Tests shall be conducted in accordance with the Government approved Trainer Test Procedures and Results Report which shall be prepared by the trainer contractor in accordance with the contract schedule. The Trainer Test Procedures and Results Report shall contain tests to verify each requirement of each paragraph of this specification. The Government reserves the right to conduct other tests deemed necessary during or as a result of user pilot evaluation.

4.3 Facilities.- Facilities shall be in accordance with MIL-T-23991.

4.4 Classification of inspections.- Inspections to be performed are classified as follows:

(a) In-process inspection

(b) Quality conformance inspection.

4.4.1 In-process inspection.- The in-process inspection of MIL-T-23991 shall include all of the following items:

(a) Materials

(b) Parts (standard/nonstandard)

(c) Processes

(d) Interchangeability

(e) Safety

(f) Protection of parts

(g) Cooling

(h) Human factors

(i) Mechanical design

(j) Electrical and electronic design

(k) Reliability

(l) Transportability

(m) Maintainability

(n) Electromagnetic interference suppression

(o) Color

(p) Finish (corrosion protection and treatment)

(q) Nameplates and product markings
(r) Workmanship

(s) Wire marking.

4.4.2 Quality conformance inspection.- Quality conformance inspection shall be in accordance with the approved Trainer Test Procedures and Results Report of the contract and shall consist of the following examinations and tests:

4.4.2.1 Examinations.- Examinations shall be in accordance with MIL-T-23991.

4.4.2.2 Tests.- The trainer shall be subjected to the following tests:

(a) Functional

(b) Trainer operation

(c) Structural

(d) Electrical

(e) Grounding and grounding systems

(f) Human factors engineering compliance

(g) Reliability

(h) Environmental

(i) Electromagnetic interference suppression

(j) Electron tube shield electrical contact.

4.4.2.2.1 Functional tests.- Functional tests shall be performed to demonstrate and substantiate the performance of each functional operation of the trainer. Functional tests shall include but not be limited to these stated herein.

(a) Flight tests.- The following listing represents major areas in which flight tests will be performed to demonstrate compliance with the requirements of this specification:

(1) Static stability

(2) Dynamic stability

(3) Controllability

(4) Maneuverability

(5) Powerplant performance

(6) Hover/level flight

(7) Climbs/descents

(8) Takeoffs/landings

(9) V-n envelope

(10) In-flight malfunctions

(11) Weight and balance changes

(12) Typical mission

(b) General tests.- The following listing represents major areas in which general tests will be performed to demonstrate compliance with the requirements of this specification:

(1) Aircraft systems

(2) Powerplant systems

(3) Communications/navigation systems

(4) Flight controls; friction and breakout forces

(5) Flight control/blade angle relationships

(6) Fire control systems

(7) Surface facilities

(8) Media effects

(9) Procedures

(10) Malfunctions

(11) Crash

(12) Instruments

(13) Sounds

(14) Instructor station controls and displays

(c) Computer system software tests.- Computer system software tests shall be performed to demonstrate and substantiate the ability to meet the total software program requirements of this specification.

(1) Real time program debugging and verification.- Program debugging techniques which necessitate single step, operator controlled program operation shall be kept to a minimum. Initial verification of the trainer programs shall be achieved by processing through a contractor designed and provided verification program, utilizing the basic trainer processors. Test case data which test the main program(s) shall be divided into logical units for use in debugging procedures and isolation of error sources. Partial acceptance of the trainer and programs shall be based on computer runs made with data derived to meet the requirements of this paragraph.

(2) Cycle time measurement program.- A cycle time measurement program which determines the time needed to execute operational programs shall be designed and programmed in accordance with SECNAVINST 3560.1. Measurements provided by the programs shall include the following items of data.

a. The worst case time required for any iteration or solution cycle during the execution of the real time program. Time data per cycle shall be accumulated over a 15 minute period to assure the achievement of the worst case path condition. Time data shall be accumulated in total milliseconds remaining in each cycle. (Cycle time for this specification is 50 milliseconds.)

b. Total time required for execution of the worst case program condition during each second of operation. Time data per second shall be accumulated over a 15 minute period to assure the achievement of the worst case condition per second. Time data shall be accumulated in total milliseconds remaining in each second.

(3) Program acceptance criteria.- The acceptance of software programs shall be based on demonstrated ability to meet the total program requirements of this specification. Computer system software tests shall be conducted prior to conducting simulator functional tests.

(d) Motion system modules tests.- Motion system modules shall be tested in accordance with 4.4.2.2.1(d)(1) through 4.4.2.2.1(d)(3)a.

(1) Motion system tests.- Tests shall be conducted to verify that the motion systems meet the requirements of 3.7.4.

a. Displacement tests.- The displacement of each motion system in each degree of freedom shall be tested as follows:

1. A sine wave generator (test equipment) shall provide a command signal to any one displacement mode of the motion system.

2. The amplitude of the signal shall be increased from zero until the limits of motion system displacement are reached.

3. At any amplitude setting, the angular phase lag between the command signal and the motion system displacement shall meet the requirements of 3.7.4.1.8. Phase lag and gain decrease shall be recorded for frequencies from 0.01 Hertz to 5.0 Hertz for input amplitudes of one percent, five percent, 10 percent, 20 percent, and 40 percent of the maximum input signal.

b. Similarity tests.- The results of the tests described in 4.4.2.2.1(d)(1)a.3. shall show a gain difference between each motion system of not more than 10 percent in decibels and a phase difference of not more than 20 percent.

c. Acceleration tests.- The verification of the requirement of 3.7.4.1.7 may be demonstrated using a dummy load.

d. Smoothness tests.- Multichannel recordings of actuator displacement and velocity and of cockpit accelerations versus time shall be made for each motion system actuator to demonstrate compliance with 3.7.4.1.9 and 3.7.4.1.11(c).

e. Additional tests.- Additional tests shall include recordings of theoretical (computed) aircraft response parameters versus time. It shall be possible to record motion system translational acceleration and angular velocity, each in three axes simultaneously, on a multichannel recorder. Recordings shall be made for input signals of a one volt increasing step function followed in 1/2 second by a one volt decreasing step function; and a one volt increasing step function. The following control inputs shall be tested:

1. Lateral left and right cyclic inputs

2. Longitudinal fore and aft cyclic inputs

3. Left and right pedal inputs

4. Collective decrease from normal flight position. (In this case, the direction of the step function shall be reversed.)

The computed aircraft responses shall demonstrate compliance with the approved data. The motion system responses shall, within the limitations of the motion systems correspond to the aircraft responses for all conditions of vertical flight, transition, horizontal flight, and for all wind and gust loadings imposed.

(2) Seat shaker system tests.- Tests shall be conducted to verify that the seat shaker system meets the requirements of 3.7.4.2.

a. Frequency tests.- A variable voltage shall be applied to the frequency signal input of each oscillator in turn to demonstrate compliance with the seat frequency range specified in 3.7.4.2.4.

b. Amplitude tests.- A variable voltage shall be applied to the amplitude input of each oscillator in turn to demonstrate compliance with the seat amplitude range specified in 3.7.4.2.4, over the specified frequency range.

(3) G-seat and lap strap tests.- Tests shall be conducted to verify that the G-seat and lap strap meet the requirements of 3.7.4.3.

a. Response tests.- Pressure response time histories shall be recorded for each seat pressure cell to demonstrate compliance with 3.7.4.3.5.

(e) Visual system tests.- The visual system shall be comprehensively tested in accordance with the requirements of an acceptance test procedure (ATP) which has been prepared in accordance with the contractor data requirements list. In addition, the user shall have the right to conduct any additional procedures deemed necessary to verify that the specification requirements have been met.

(1) Systems integration tests.- Systems integration tests shall be performed by having two qualified pilots perform successfully all of the training tasks of 3.7.5.1.11 with the visual system under day and night conditions.

4.4.2.2.2 Trainer operation tests.- The trainer shall be tested to determine the suitability of controls and control circuits for satisfactory mechanical and electrical operation. The trainer shall be subjected to operation tests in normal room temperature of 68°F ± 5°, of not less than six hours duration to ensure qualitatively the proper functioning of the device including all operating controls, supply line voltage, ranges and frequencies, conditions of extreme limits, and conformance to applicable safety requirements. All components, fixtures, controls, and mechanisms shall be moved through their maximum normal displacements and shall exhibit no malfunctioning or objectionable rough operation, vibration, or irregular movements.

4.4.2.2.3 Structural tests.- The contractor shall subject typical electronic assemblies, such as amplifiers, servos, and electronic chassis to one or more tests as necessary to determine compliance with the specification requirements of 3.2.1.1. The supplier shall submit a list of assemblies to be tested for review and approval to the Procuring Contracting Officer.

4.4.2.2.4 Electrical tests.- The trainer shall be tested in accordance with the electrical tests in MIL-T-23991.

4.4.2.2.5 Grounding and grounding systems tests.- In addition to the grounding and grounding systems tests or MIL-T-23391 tests shall be conducted to verify the requirements of this specification as delineated in 3.8.1 and 3.10.2.3.

4.4.2.2.6 Human factors engineering compliance tests.- Human factors engineering compliance tests shall be in accordance with MIL-T-23991 including verification of the lighting and acoustical noise requirements of 3.2.1.4 and 3.2.1.5.

4.4.2.2.7 Reliability tests.- Reliability tests shall be as required for the reliability demonstration of 4.7.1.

4.4.2.2.8 Environmental tests.- Environmental tests shall be conducted as follows:

(a) Temperature measuring shall be performed during the conducting of trainer operation tests with all covers in place and doors closed and at the specified temperature. Temperature measuring instruments shall be placed at critical points throughout the trainer, covering suspected high temperature areas. Data shall be recorded at least once during each hour of trainer operation. Data thus obtained shall indicate location of the measuring instrument, the temperature (^{o}F) at the measured point, and the ambient temperature (^{o}F).

(b) Maximum heat generation of the trainer.

(c) Equipment cooling requirements.

4.5 Extent of testing and test conditions.- The extent of testing and test conditions required to determine quality assurance for Device 2B40 shall be as specified in 4.2.1, 4.2.2, 4.4, and 4.7.

4.6 Material to accompany training devices.- Material to accompany training devices shall be in accordance with MIL-T-23991.

4.7 Demonstrations

4.7.1 Reliability demonstration.- An in-plant reliability demonstration shall be conducted by the contractor under the provisions of the contract in accordance with the requirements of MIL-STD-781 and the Government-approved Reliability Test and Demonstration Plan to be provided. The purpose of the demonstration will be to ascertain whether or not Device 2B40 performs in accordance with the quantitative requirements set forth in 3.3.2 of this specification. The following additional criteria shall apply:

(a) Test Plan XXI, Test Level A-1, of MIL-STD-781 shall be utilized to demonstrate θ_o and θ_1.

(b) The failure criteria of 3.3.4 of this specification is applicable.

(c) The duty cycle to be maintained throughout the demonstration shall be typical of normally scheduled training operations, with all operating modes of the trainer being exercised.

4.7.2 Maintainability demonstration.- A maintainability demonstration shall be conducted in accordance with the maintainability requirements of MIL-STD-471, and the supplier prepared, buyer approved, demonstration plan. The purpose of the demonstration will be to ascertain whether or not Device 2B40 performs in accordance with the quantitative requirements set forth in 3.4.1 of this specification. The additional criteria is that the maintainability tasks to be demonstrated shall be selected from an approved list of 50 simulated tasks submitted by the contractor in accordance with MIL-STD-471, Appendix A.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery.- Since final acceptance will take place at the installation site, there is no specific preparation for delivery requirement. The trainer shall be packaged, packed, and marked in a manner that will insure acceptance by common carrier and safe delivery at destination.

6. NOTES

6.1 Intended use.- The principal use for Device 2B40 will be for transition training, gunnery training, integrated crew training, and for maintenance of contact and instrument flight proficiency in the AH-64 helicopter with emphasis on combat skills such as low level flight and anti tank operations. These applications will include concern for both techniques and procedural skills. The trainees using the device will be previously rated user helicopter pilots. Trainees will be able to perform all normal and emergency instrument and visual flight maneuvers within the constraints of the visual system. The trainer will also be used for the training of instructor pilots.

6.2 Definitions.- The definitions of MIL-T-23991 shall apply along with the following:

6.2.1 General purpose digital computer.- A general purpose digital computer is a stored program, automatic sequence digital computer possessing a memory randomly accessible at the basic machine cycle time (for both instructions and data), general input/output capability, and the ability to perform instructions in any arbitrary sequence which can be self-modified.

6.2.2 Computer word length.- Computer word length is the number of bits, establishing magnitude and sign in a single precision data operand, operated upon for computational and logical purposes in an arithmetic unit of the computer and does not include parity, check, error correcting, or other noncomputing bits.

6.2.3 Demonstration.- A demonstration is that procedure by which the student is presented with preprogrammed instrument, control, sound, etc., actuations which are representative of ideal or prerecorded aircraft or controls actions and/or reactions.

6.2.4 Automatic.- When used in conjunction with training or with functions which, in other trainers, may be performed by instructional or maintenance personnel, the term automatic indicates that an operation or function occurs in a preprogrammed fashion without the intervention, during a training period session or activity, of instructional or maintenance personnel.

6.2.5 Interface equipment.- Interface equipment is the equipment that controls, transmits, encodes, decodes, converts, or buffers analog, digital, or discrete information passing between the computer, the trainer stations, and visual system; e.g., digital-to-analog, analog-to-digital, digital-to-discrete, discrete-to-digital, digital-to-synchron converters, and the like.

6.2.6 Trainer stations.- Trainer stations consist of the software and equipment, operational or simulated, which provide the displays, motions, and controls at which the trainees, instructors, and operators act upon or communicate with the training simulator.

6.2.7 Other definitions.- In the event of any question concerning definition of computer terms other than those defined herein, additional definitions are presented in ADP Glossary NAVSO-P-3097.

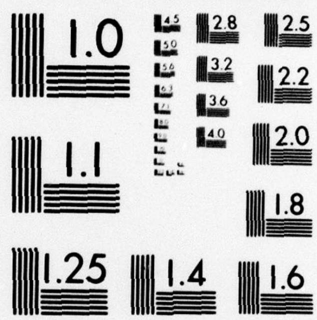
INDEX

AD-A064 374 CAE ELECTRONICS LTD MONTREAL (QUEBEC) F/G 1/3
TRAINER PERFORMANCE SPECIFICATION FOR THE AH-64 HELICOPTER FLIG--ETC(U)
OCT 77 N61339-77-C-0047

UNCLASSIFIED NL

2 OF 2
AD
A064374

END
DATE
FILMED
4 -79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TITLE	PAGE

S

T

W

SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity *(as indicated on reverse hereof)*.

SPECIFICATION

ORGANIZATION *(Of submitter)*

CITY AND STATE

CONTRACT NO.

QUANTITY OF ITEMS PROCURED

DOLLAR AMOUNT

$

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity)*

DATE

DD FORM 1 APR 63 1426 REPLACES NAVSHIPS FORM 4863, WHICH IS OBSOLETE C-0279

FOLD

DEPARTMENT OF THE NAVY

POSTAGE AND FEES PAID
NAVY DEPARTMENT

OFFICIAL BUSINESS

FOLD