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PRELIMINARY AIRWORTHINESS EVALUATION OF THE AH-64A EQUIPPED WITH THE AIR TO AIR STINGER (ATAS) MISSILE SYSTEM

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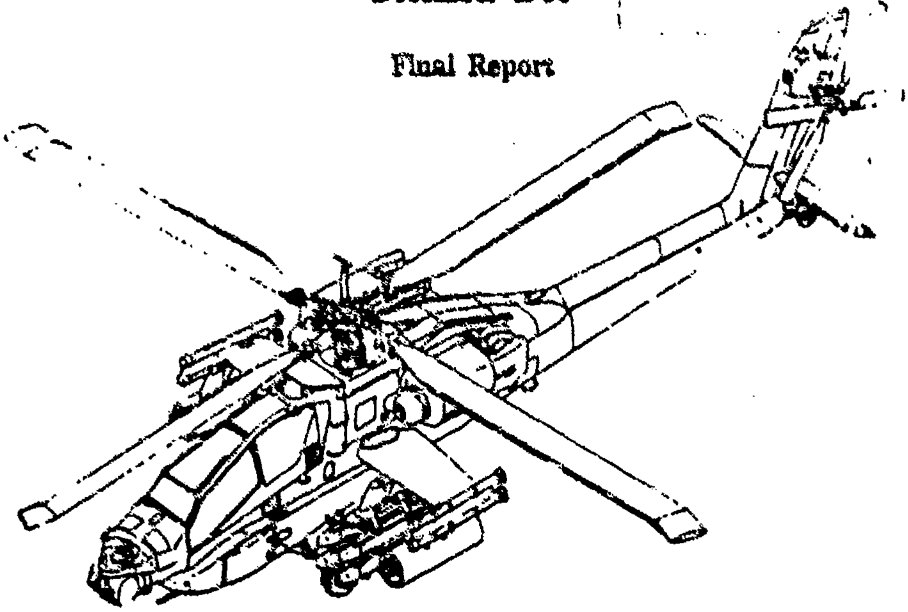

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The U.S. Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation of the AH-64A equipped with the Air-to-Air Stinger (ATAS) missile system at the McDonnell Douglas Helicopter Co. flight test facilities in Mesa, Arizona. The evaluation was conducted in two phases. The first phase was an evaluation of the effects of the ATAS installation on the handling qualities on the AH-64A, requiring 10 flights and 11.3 productive flight hours ~~over the period 18 to 28 July 1988~~. The second phase was a human factors evaluation of the installation of a fully operational preproduction ATAS system using captive flight training Stinger missiles, ~~The second phase was performed~~ during four flights totaling 4.4 flight hours ~~on 7 and 8 October 1988~~. Tests were flown in the eight Hellfire missile configuration. Two Stinger missiles with launcher and mounting hardware were mounted at each wing tip. Test results were compared with data obtained during previous testing and evaluated against the AH-64 System Specification. Handling qualities of the AH-64A with the ATAS system installed were quantitatively and qualitatively evaluated and found to be essentially the same as the basic AH-64A. Specific shortcomings associated with the ATAS system were: poor integration of the Air-to-Air Stinger missile system, which is not directly compatible with the MIL STD 1553 data bus of the AH-64; insufficient ATAS sighting symbology, which does not provide the copilot/gunner with accurate missile seeker line of sight relative to the selected sight line of sight except in FLIR wide field of view; reduction in storage

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space imposed by the ATAS installation in the aft storage bay; location of the repositioned chaff fire switch on the cyclic hand grip; and the manual reset feature of the ATAS missile sequencing logic. The absence of an altitude encoding feature in the installation of the AN/APX-100(V) transponder was a shortcoming not associated with the ATAS modification. Nine previously reported shortcomings were evaluated during this test and still exist. Seven recommendations specific to the ATAS installation are made.

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INTRODUCTION

BACKGROUND

1. The Air-to-Air Stinger (ATAS) Missile System is an aerial adaptation of the ground launched, shoulder fired Stinger missile. The ATAS system was initially designed and developed to provide the OH-58C and OH-58D helicopters with a viable air-to-air weapon. Installation on the AH-64A consists of a launcher with two Stinger missiles mounted at each wing tip. The U. S. Army Aviation Systems Command (AVSCOM) tasked the U.S. Army Aviation Engineering Flight Activity (AEFA) to plan, conduct, and report on a Preliminary Airworthiness Evaluation (PAE) of the ATAS on the AH-64A helicopter prior to missile firings from the Apache by the Army (ref 1, app A).

TEST OBJECTIVES

2. The objectives of this PAE were to determine the effects of the ATAS configuration on the handling qualities of the AH-64A helicopter and to provide data for an AVSCOM Airworthiness Release permitting firing of the ATAS from the AH-64A. An additional objective was the qualitative evaluation of a fully operational preproduction ATAS system with captive flight training missiles installed.

DESCRIPTION

3. The AH-64A is a two place, tandem seat attack helicopter manufactured by McDonnell Douglas Helicopter Co. (MDHC). The maximum mission gross weight is 17,650 pounds. A single four bladed main rotor provides the aerodynamic lift for the helicopter. The four bladed tail rotor is semi-rigid, teetering in design with each pair of blades at a 55 degree angle to the other pair. The aircraft has conventional wheel-type landing gear. The helicopter is powered by two General Electric T700-GE-701 engines rated at 1690 shaft horsepower (sea level, standard day, uninstalled). The mission equipment and weapon systems are controlled through a multiplex MIL STD 1553, dual channel bus controlled by the fire control computer or by the backup bus controller during degraded operations. Wings attached on each side of the fuselage have two weapons pylons each to provide mounting points for Hellfire missile launchers, 2.75 inch folding fin aerial rocket launchers, or external fuel tanks. A 30mm single barrel automatic gun is mounted in a turret assembly on the bottom of the aircraft between the pilot's and copilot's stations. The pilot's and copilot's stations have conventional hydromechanical flight controls with a stability augmentation system providing additional aircraft stability. An electrically actuated stabilator, designed to improve the handling qualities of the helicopter, is mounted on the lower trailing edge of the vertical stabilizer assembly. A more detailed description of the AH-64A is contained in the operator's manual (ref 2).

4. Two aircraft were used during the PAE. The engineering flight tests were conducted on the first production vehicle (PV01) AH-64A, USA S/N 82-23355, which was instrumented. The aircraft was utilized by MDHC for air vehicle structural testing, and much of the mission equipment was not installed or was replaced by dummy replicas. The ATAS installation consisted of ejector racks mounted horizontally at each wing tip.

A dummy launcher with two missile replicas was installed at each ejector rack. The external configuration of PV01 was with eight Hellfire missiles on the the inboard pylons and the outboard pylons empty and with and without the ATAS system installed.

5. The second aircraft was used for the qualitative evaluation of the preproduction ATAS system. This aircraft, PV 314, USA S/N 86-8944, was equipped with a fully functioning preproduction ATAS system and complete operational mission and armament systems. Three captive flight trainer Stinger missiles were installed on the wing tip mounted ATAS launchers. A combination of eight dummy and training Hellfire missiles were mounted to launchers installed on the outboard pylons. Nineteen shot, 2.75 inch rocket launchers were installed on the inboard pylons. A more complete description of the test aircraft and the preproduction ATAS system is provided in appendix B.

TEST SCOPE

6. The evaluation was conducted in two phases. The first phase was the PAE flown on PV01 during the two week period, 18 to 28 July 1988, and consisted of 10 flights and 13.2 flight hours of which 11.3 were productive flight hours. The second phase was a qualitative evaluation of the preproduction ATAS system consisting of four flights totaling 4.4 flight hours in PV 314 on 7 and 8 October 1988. The second phase included a cockpit evaluation of the preproduction ATAS and an in-flight evaluation of the ATAS sighting symbology using captive flight trainer missiles. The in-flight evaluation included the use of a target helicopter, the flight path of which was varied to change between a sky only background and terrain/man-made features background. Both phases were conducted at the MDHC flight test facility at Mesa, AZ (elevation 1392 ft). Phase one was flown in the eight Hellfire configuration to permit comparison of the test results with previous evaluations. The aircraft and instrumentation were maintained by MDHC personnel. The second phase of the evaluation was flown with only three Stinger captive flight trainers installed, two basic missiles and one Passive Optical Seeker Technique (POST) missile. Flight restrictions and operating limitations were established by the operator's manual (ref 2), the ATAS Supplement to the operator's manual (ref 3), and the airworthiness release (ref 4). The evaluation was conducted in accordance with the test plan (ref 5). Tests and test conditions are presented in table 1. The results of this evaluation were compared against previous AEFA reports (refs 6 and 7) and the AH-64 system specification (ref 8).

TEST METHODOLOGY

7. The flight test data were recorded by hand from test instrumentation displayed in the cockpit and by on-board magnetic tape recording equipment. Real time telemetry was used to monitor selected parameters. Instrumentation and recorded parameters are presented in appendix C. Accepted test techniques and data reduction methods in accordance with Naval Air Test Center FTM 105 (ref 9) and described in appendix D were used for the evaluation. Data recording and reduction facilities at MDHC were used to reduce and plot data. Handling Qualities Rating Scale (fig D-1) and Vibration Rating Scale (fig D-2) were used to augment pilot comments on the aircraft handling qualities

Table 1. Test Conditions[1]

Type of Test	Average Gross Weight (lb)	Average Center of Gravity (FS)[2]	Average Density Altitude (ft)	Trim Calibrated Airspeed (kts)	Remarks	
Control Positions in Trimmed Forward Flight[3]	15,850	205.7	6800	35-135	ATAS	Level flight
	14,970	205.6	5600	48-131	ATAS Removed	
	14,870	205.8	7750	44-110	ATAS	Climbs at IRP[4]
	15,350	205.5	7750	50-110	ATAS Removed	
	14,870	205.8	7240	142-171	ATAS	Dives at IRP
	15,350	205.5	6950	148-175	ATAS Removed	
	14,810	205.9	6570	98	Autorotative Descents	
Static Longitudinal Stability	15,470	205.7	7350	119	Level flight trim, vary airspeed incrementally ±20 kts from trim	
Static Lateral-Directional Stability[3]	15,000	205.8	6870	121	Level flight trim, vary sideslip incrementally to ±15 degrees	
Maneuvering Stability	15,240	205.7	6030	69	Left and right turns to 60 degree bank	
	14,810	205.8	7060	120		
Dynamic Stability	15,090	205.8	6980	110-120	Level flight	
	15,310	205.7	3640	0	Hover, 15 ft wheel height	
Controllability	15,450	205.7	7050	114	Longitudinal	Axes in level flight
	14,740	205.8	6730	122	Lateral	
	15,270	205.7	6880	120	Directional	
	14,960 15,490	205.8 205.7	3360 3550	0	Lateral and directional axes, 15 ft wheel height	
Low-Speed Flight Characteristics	15,220	205.7	3380	0-45[5]	Left/right sideward	15 ft wheel height
	14,980	205.8	3280	0-45[5]	Rearward/forward	
Simulated Single-Engine Failure	15,720	205.6	6290	48	Accelerate to 60 kts after engine failure with minimum altitude loss	
Mission Maneuvering Characteristics	15,440	205.7	3160	0-80	Mission-oriented tasks and training maneuvers	

NOTES:

[1]Tests were conducted in ball-centered flight and the ATAS/8-Hellfire configuration except as noted, with digital automatic stabilization equipment ON, force trim ON, altitude hold OFF, stabilator AUTO and rotor speed at 100% (289 rpm).
[2]Center of gravities over the range of 205.5 to 205.8 are aft.
[3]Pitot-static system performance was evaluated in level flight in conjunction with control position tests and static lateral-directional stability tests.
[4]IRP: Intermediate rated power.
[5]KTAS: Knots true airspeed.

and airframe vibration levels. Abbreviations and acronyms used in this report are defined in appendix F.

RESULTS AND DISCUSSION

GENERAL

8. A Preliminary Airworthiness Evaluation (PAE) of the AH-64A equipped with Air-to-Air Stinger (ATAS) missile system was conducted at the McDonnell Douglas Helicopter Co. (MDHC) flight test facilities in Mesa, Arizona. The evaluation was conducted in two phases. The first phase was an evaluation of the effects of the ATAS installation on the handling qualities of the AH-64A. The second phase was a human factors evaluation of the installation of a fully operational preproduction ATAS system using captive flight training Stinger missiles. Handling qualities of the AH-64A with the ATAS system installed were quantitatively and qualitatively evaluated and found to be essentially the same as the basic AH-64A. Specific shortcomings associated with the ATAS system were: poor integration of the Air-to-Air Stinger missile system, which is not directly compatible with the MIL STD 1553 data bus of the AH-64; insufficient ATAS sighting symbology, which does not provide the copilot/gunner with accurate missile seeker line of sight relative to the selected sight line of sight except in FLIR wide field of view; reduction in storage space imposed by the ATAS installation in the aft storage bay; location of the repositioned chaff fire switch on the cyclic hand grip; and the manual reset feature of the ATAS missile sequencing logic. The absence of an altitude encoding feature in the installation of the AN/APX-100(V) transponder was a shortcoming not associated with the ATAS modification. Nine previously reported shortcomings were evaluated during this test and still exist. Seven recommendations specific to the ATAS installation are made.

HANDLING QUALITIES

Control Positions in Trimmed Forward Flight

9. Control positions in ball-centered, trimmed forward flight were evaluated with the DASE and TRIM ON, and the ATTITUDE HOLD OFF under the conditions presented in table 1. The tests were conducted with the ATAS launchers/missiles installed during level flight, intermediate rated power (IRP) dives, IRP climbs, and autorotative descents. Selected data points in level flight, IRP dives, and IRP climbs were repeated with the ATAS launchers/missiles removed. Data are presented in figures E-1 through E-3. In IRP dives, an aft migration of longitudinal control position occurred with increasing airspeed above 155 knots calibrated airspeed (KCAS). Control margins were adequate for all tests. For the tested flight conditions, control positions in trimmed forward flight were essentially the same with ATAS launchers/missiles installed or removed, were unchanged from previously reported results, and are satisfactory. However, control positions in IRP dives fail to meet the requirements of paragraph 10.3.3.1.2 of the AH-64 systems specification (ref 8, app A) in that longitudinal control position required for trim became increasingly aft as airspeed increased beyond 155 KCAS.

Static Longitudinal Stability

10. The collective fixed static longitudinal stability characteristics of the ATAS AH-64A were evaluated at 119 KCAS with the DASE and TRIM ON, and the ATTITUDE HOLD OFF under the conditions presented table 1. Data are presented in figure E-4. The

evaluation was conducted by trimming the aircraft in level flight at the test airspeed and then varying the airspeed incrementally to 20 knots each side of trim. The helicopter exhibited very weak positive static stability as indicated by the slightly increasing forward longitudinal stick position with increasing airspeed and slightly increasing aft longitudinal stick position with decreasing airspeed. The static longitudinal stability characteristics of the AH-64A with ATAS at 119 KCAS are unchanged from the basic helicopter and, as previously reported (ref 6), the static stability characteristics of the AH-64A are satisfactory for flight in visual meteorological conditions.

Static Lateral-Directional Stability

11. The collective fixed static lateral-directional stability characteristics of the ATAS AH-64A were evaluated in level flight at 121 KCAS with the DASE and TRIM ON and the ATTITUDE HOLD OFF under the conditions presented in table 1. Data are presented in figure E-5. The test was performed by stabilizing the aircraft in ball-centered, level flight, trimming out control forces, and then incrementally increasing the sideslip angle while maintaining a constant heading flight path. The aircraft has positive directional stability as indicated by increasing left directional control displacement with increasing right sideslip and increasing right directional control displacement with increasing left sideslip. The directional control displacement to sideslip gradient is constant. Positive effective dihedral, as indicated by increasing right lateral control displacement with increasing right sideslip and increasing left lateral control displacement with increasing left sideslip, was also present. Positive side force cues, as indicated by increasing right roll attitude with increasing right sideslip, were weak at approximately half a degree of roll attitude for each degree of sideslip. The static lateral-directional characteristics of the ATAS AH-64A at 121 KCAS are satisfactory and unchanged from the basic aircraft.

Maneuvering Stability

12. The maneuvering stability characteristics of the ATAS AH-64A were evaluated at approximately 69 and 120 KCAS with the DASE and TRIM ON and the ATTITUDE HOLD OFF under the conditions presented in table 1. Data are presented in figures E-6 and E-7. The test was performed by trimming the aircraft in level, ball-centered flight, fixing the collective and then incrementally stabilizing at increasing bank angles. The aircraft exhibited positive maneuvering stability at both tested airspeeds in that increasingly aft longitudinal control position was required with increasing load factor. The longitudinal control position to load factor gradient at 69 KCAS and at airspeeds near 120 KCAS was similar to that noted in previous tests (refs 6 and 7). As noted during the First Article Preproduction Tests (ref 6) significant control activity in pitch and roll is required to maintain airspeed and roll attitude during flight at left or right bank angles approaching 60 degrees. There were no significant variations in pitch rate or stabilator position noted in the data. Pitch rate is an input to the stabilator control units. The increasing sensitivity in pitch of the rotor system to vertical gusts or longitudinal control inputs with increasing load factor was also noted. The maneuvering stability characteristics of the ATAS AH-64A at load factors less than 1.9 are satisfactory and unchanged from the basic aircraft.

Dynamic Stability

General:

13. The dynamic stability characteristics of the ATAS equipped AH-64A were evaluated with the DASE and TRIM ON, and the ATTITUDE HOLD OFF under the conditions presented in table 1. A hand held control fixture was employed to control input size for pulses used to excite the short term response.

Longitudinal Long Term Response:

14. The longitudinal long term response characteristics were evaluated at a trim airspeed of 110 KCAS by application of aft longitudinal stick to slow the aircraft approximately 10 knots from trim airspeed. The longitudinal control was then smoothly returned to the trim position, and the resultant response observed and recorded with control positions fixed. The long term response was easily excited and dynamically unstable with a period of approximately 65 seconds. Recovery was accomplished easily, and was initiated after two cycles in order to avoid exceeding attitude and/or airspeed limits. The longitudinal long term response characteristics of the ATAS AH-64A are unchanged from the basic aircraft and are satisfactory.

Longitudinal Short Term Response:

15. The longitudinal short term response was evaluated at a trim airspeed of approximately 110 KCAS by making one-inch longitudinal pulse inputs which were held for approximately 0.5 second. Representative time history data are presented in figure E-8. The longitudinal short term response of the ATAS AH-64A was essentially deadbeat, unchanged from the basic aircraft, and satisfactory.

Lateral-Directional Response:

16. The lateral-directional dynamic stability characteristics were evaluated at a trim airspeed of approximately 120 KCAS. The evaluation was conducted by making one inch, single axis lateral and directional pulse inputs and by control releases from steady heading sideslips of 10 degrees from ball-centered flight. The centering characteristics of the force trim system were used to place the controls at trim. Representative time history data are presented in figures E-9 through E-11. The response during the lateral pulse was heavily damped, with one small overshoot in the yaw axis noted. The lateral-directional oscillation characteristics of the ATAS AH-64A are unchanged from the basic aircraft and are satisfactory.

Spiral Stability:

17. The spiral stability characteristics were evaluated at 120 KCAS by displacing the aircraft from trimmed flight to a 5 degree left or right roll attitude, then smoothly returning all controls to the trim positions. The controls were then fixed at the trim position and the resultant response observed and recorded. The aircraft exhibited neutral spiral stability, in that roll attitudes showed no variation in a left or right turn over a 20 second period. The spiral stability characteristics of the ATAS AH-64A are unchanged from the basic aircraft and are satisfactory.

Adverse Yaw:

18. The adverse yaw characteristics were evaluated at 120 KCAS by turns initiated with lateral cyclic only. A representative time history performed at a trim airspeed of 119 KCAS is presented in figure E-12. The aircraft exhibited no adverse or proverse yaw, as indicated by the absence of observed transient yaw response during the rapid lateral cyclic inputs. The adverse yaw characteristics of the ATAS AH-64A are unchanged from the basic aircraft and are satisfactory.

Gust Response:

19. The gust response characteristics were evaluated during the course of the PAE at various flight conditions and airspeeds, and in calm and lightly turbulent atmospheric conditions. Specific tests used for this evaluation were: collective pulse inputs of 0.5 second duration, and the techniques used to evaluate the short term response evaluation described in paragraph 15. The response was generally heavily damped with one exception. During IRP diving flight in light turbulent atmospheric conditions, it was qualitatively observed that small gust disturbances in the longitudinal axis resulted in attitude and airspeed changes from which the aircraft exhibited no tendency to return to the trim conditions. The gust response characteristics of the ATAS AH-64A in level flight are satisfactory.

Controllability

General:

20. Controllability tests were conducted with the TRIM and DASE ON at a hover and in forward flight to evaluate the control power, control response, and control sensitivity characteristics of the ATAS AH-64A. Test conditions are presented in table 1. A free-hand control fixture was used to set the step input size and permit a brisk control input. Controllability was measured in terms of aircraft attitude displacement (control power), maximum angular velocity (control response), and maximum angular acceleration (control sensitivity) about an aircraft axis following a control step input of a measured size. Data reduction techniques for the controllability tests are presented in appendix D.

Forward Flight:

21. The longitudinal controllability characteristics were evaluated at an average trim airspeed of 114 KCAS. Longitudinal controllability data are presented in figure E-13 with a representative time history at a trim airspeed of 105 KCAS presented in figure E-14. Longitudinal control power and response were similar in both forward and aft directions. The rates and accelerations were linear with respect to control input magnitudes. Longitudinal control response was predictable, although an initial slight hesitation in a change in pitch attitude was evident during control inputs in both directions. Aft step inputs caused a coupled right roll response. No control coupling was evident during forward step inputs. The longitudinal controllability characteristics of the ATAS AH-64A at 114 KCAS are unchanged from the basic aircraft and are satisfactory. The longitudinal controllability failed to meet the requirements of paragraph 10.3.4.4.2 of

the AH-64 systems specification in that the average response time to a longitudinal control input was 0.4 seconds where 0.7 was required. The shorter delay time was acceptable to the pilot.

22. The lateral controllability characteristics were evaluated at an average trim airspeed of 122 KCAS. Lateral controllability data are presented in figure E-15 with a representative time history at a trim airspeed of 120 KCAS presented in figure E-16. The high lateral control power was similar in both directions. An initial hesitation in a change in roll attitude was noticeable but not objectionable. The rates were linear with respect to control input magnitude. The lateral controllability characteristics of the ATAS AH-64A at 122 KCAS are unchanged from the basic aircraft and are satisfactory. The lateral controllability failed to meet the requirements of paragraph 10.3.5.2.1 of the AH-64 systems specification in that the average response time to a lateral control input was 0.3 seconds where 0.7 was required. The shorter delay time was acceptable to the pilot.

23. The directional controllability characteristics were evaluated at an average trim airspeed of 120 KCAS. Directional controllability data is presented in figure E-17 with a representative time history at 119 KCAS presented in figure E-18. Directional control power and response were similar in both directions. The rates were linear with respect to control input magnitude. The directional control response was predictable, with no tendency to overcontrol. Left pedal step inputs caused a coupled left roll and nose up pitch response, and right pedal step inputs similarly caused a coupled right roll and nose down pitch response. The directional controllability characteristics of the ATAS AH-64A are unchanged from the basic aircraft and are satisfactory.

Hover:

24. The lateral and directional controllability characteristics of the ATAS AH-64A were evaluated in a hover at a 15 foot wheel height. Wind conditions were less than three knots. Data are presented in figures E-19 and E-20 with a representative time history for a directional step input presented in figure E-21. Lateral controllability characteristics were generally similar to those observed in forward flight and described in paragraphs 22 and 23. The lateral control sensitivity had a more linear response at a hover. The directional control power and response were similar in both directions and were noticeably larger than in forward flight. For directional control inputs of less than approximately 3/4 inch, steady state rates were adequate and predictable. Larger directional control inputs in each direction were characterized by acceleration to a steady state, then after 1 to 2 seconds a second acceleration occurred accompanied with nose down pitch coupling. Engine torque fluctuations of up to 20 percent were noticeable during large pedal step inputs. The lateral and directional controllability characteristics of the ATAS AH-64A in a hover are satisfactory.

Low Speed Flight Characteristics

25. The low speed flight characteristics of the ATAS AH-64A were evaluated with the DASE and TRIM ON at the conditions presented in table 1. Test were performed up to 45 knots true airspeed (KTAS) in forward, rearward, and sideward flight at a wheel height of 15 feet. Data are presented in figures E-22 and E-23. Adequate control

margins (greater than 25 percent total control travel) remained in all axes over the range at airspeeds and azimuths tested, and the stabilator remained programmed at 25 degrees trailing edge down. Maintaining steady forward and right sideward flight required minimal pilot compensation and aircraft vibrations were slight. At approximately 15 knots left sideward flight, an abrupt change in yaw and pitch attitudes occurred, requiring an increase in aft cyclic and right pedal at higher airspeeds. With the exception of rearward flight and for the azimuths and airspeeds tested, the aircraft was easy to fly. During rearward flight at and above 20 knots, attitude control in all axes was significantly more difficult, requiring nearly constant cyclic and pedal corrections, and aircraft vibrations were considerably greater (VRS 5). The low speed flight characteristics of the ATAS AH-64A are satisfactory.

Mission Maneuvers

26. The mission maneuvering characteristics were evaluated to determine the effects of the ATAS installation on the handling qualities of the AH-64A. The maneuvers were performed with the DASE and TRIM ON and the stabilator in automatic mode. Test conditions are presented in table 1. The mission maneuvers used in this evaluation were: jump takeoff from light on wheels; level acceleration to 60 knots indicated airspeed (KIAS) followed by a quick stop; 40 KIAS vertical pop up using up collective or aft longitudinal stick; bob up and down, lateral acceleration left and right to 45 KTAS; level acceleration from 60 to 120 KIAS; IRP dives to never exceed airspeed (V_{NE}); and dive recoveries from shallow and moderate dive angles. Included in the mission maneuvers were pushovers to load factors of 0.5, performed at 80 and 120 KIAS. The pushovers were done from a pull up and the aircraft was stabilized on the target load factor for one second. The mission maneuvering handling qualities of the AH-64A with the ATAS installed are unchanged from the basic aircraft and satisfactory for flight during day, visual meteorological conditions.

SIMULATED SINGLE ENGINE FAILURES

27. Simulated single engine failures were evaluated over a range of gross weights from 14,580 to 15,790 lb in the eight Hellfire configuration under the conditions presented in table 1. The purpose of performing the test was to develop data for future helicopter developments with emphasis on low speed, nap of the earth (NOE), single engine failures. The tests were performed by stabilizing the aircraft in forward flight at 40 KIAS and 50 feet above ground level, simulating NOE flight, and rapidly retarding a single power lever to IDLE. The aircraft was then accelerated to the airspeed for best rate of climb (Vy) using up to contingency power on the operating engine. The pilot's task was to minimize altitude loss (10 feet maximum) during the maneuver. The test was performed with no pilot delay following the simulated engine failure and with a one second delay. A representative time history for the maneuver is presented in figure E-24. For a representative maneuver at a density altitude of 6800 ft, maneuver entry dual engine torque was 52 percent. Following the simulated single engine failure, power transients up to 114 percent torque were experienced on the operating engine and the turbine gas temperature was less than 900 degrees C. Two feet of altitude were lost as indicated on the radar altimeter. Dual engine torque settings for the entry of the maneuver were such

that sustained single engine flight was expected. The technique used after entering the maneuver was to maintain the 40 KIAS attitude and slowly increase collective to the single engine limits or until altitude began to increase. At this point, forward longitudinal cyclic was applied to increase airspeed. As the airspeed increased and power required for level flight decreased, a climb began. For the gross weights evaluated, and at the density altitudes the test was performed, the maneuver was very easily performed.

VIBRATION CHARACTERISTICS

28. The vibration characteristics of the AH-64A with the ATAS system installed were qualitatively evaluated in conjunction with all other testing. Significant fourth harmonic vibrations of the main rotor were evident to both crewmembers under the following flight conditions: IRP climbs (VRS 5), IRP dives (VRS 6), normal approach below approximately 35 knots (VRS 5), and during rearward flight above 20 knots (VRS 5). These vibration characteristics have been previously reported as an aircraft shortcoming, and are not considered to be aggravated by the ATAS installation. Observations by the test crew and by the chase crew detected no unusual vibrations of the wing tip or the ATAS launchers/missiles.

AIR-TO-AIR STINGER INSTALLATION

System Integration

29. The integration of the ATAS system on the AH-64A was qualitatively evaluated for compatibility with the fire control system and MIL STD 1553 bus of the Apache. The AH-64A ATAS was an adaptation of the General Dynamics system built for the OH-58D, and had to be "made to fit" on the AH-64A. Direct electronic connections between the ATAS interface electronics assembly (IEA) and the fire control system of the AH-64A are not possible. The signal conditioner unit (SCU) is required to permit the IEA to connect with the fire control system of the AH-64A along with the use of the DASE computer and the right forward avionics bay (FAB) multiplex remote terminal unit (MRTU). This "patch on" approach to a new system installation on the Apache will add unnecessary weight and components. The poor integration of the Air-to-Air Stinger missile system, which is not directly compatible with the MIL STD 1553 data bus of the AH-64A is a shortcoming. The production Air-to-Air Stinger missile system installation on the AH-64A should be fully integrated with the aircraft fire control system MIL STD 1553 data bus.

Missile Sighting Symbology Implementation

30. The implementation of a sighting symbology for the ATAS missile system was qualitatively evaluated for tactical utility. The sighting system consists of the lock on after launch (LOAL) and the lock on before launch (LOBL) boxes concentrically displayed on the sighting system of the crew station where ATAS is selected. The ATAS sighting symbology permits the pilot or copilot/gunner (CPG) to direct the missile seeker head to the selected line of sight (LOS). A more thorough description is presented in appendix

B. For the pilot the ATAS sighting symbology is available in either the helmet mounted display (HMD) or night vision system (NVS) positions of the SIGHT SEL switch. In the NVS position the ATAS reticle is imposed over the 30 x 40 degree field of view forward looking infrared (FLIR) image. In either the HMD or NVS positions the ATAS reticle maintains an accurate relative position in the HMD field of view for the missile seeker LOS. For the CPG an accurate relative position of the seeker LOS, as presented by the ATAS sighting symbology, is available only in FLIR wide field of view on either the optical relay tubes (ORT) displays or the CPG HMD. Should the CPG select any day television (DTV) field of view or a FLIR field of view other than WIDE, the ATAS reticle will not provide the CPG with an accurate relative position between the seeker LOS and the displayed field of view. In a tactical situation where either the pilot or CPG acquires a potential airborne threat, it may not be possible to identify the target without using a field of view which provides more than 1 power magnification. The crew could select ATAS and lock up the target, but identification would then be mandatory. To insure the target is a threat, the CPG would have to select a narrower, greater magnification, field of view. The ATAS symbology would be present in the selected field of view, however, it will not necessarily provide an accurate presentation of the seeker head LOS relative to the selected sight LOS, even when the missile is locked up on the desired target. The CPG would have to select up to the FLIR wide field of view, confirm the target is still locked up by the missile, and then fire the missile. The problem becomes much more acute should friendly and threat aircraft be present simultaneously in the FLIR wide field of view. The necessity to confirm seeker LOS and launch the missile in the FLIR wide field of view increases the engagement time of the ATAS and reduces the system effectiveness. The insufficient ATAS sighting symbology, which does not provide the copilot/gunner with accurate missile seeker line of sight relative to the selected sight line of sight except in FLIR wide field of view, is a shortcoming. The ATAS sighting symbology of the production ATAS system for the AH-64A should provide the copilot/gunner with an accurate presentation of the relative position of the missile seeker in all FLIR and day television fields of view.

Missile System Reset Feature

31. The missile reset feature of the ATAS system was evaluated for function. Located on the ATAS air-to-air (ATA) control panel in each cockpit is a RESET switch which resets the missile firing sequence back to missile #1 (lower left). In order to function properly, the SAFE/ARM switches in both cockpits must be set to SAFE. The reset switch is then held in the RESET position at which point the IEA reruns built in test (BIT) and selects the #1 missile as next to be launched. The requirement to coordinate the efforts of both crew members to activate the RESET feature detracts from more important crew duties that a tactical situation would dictate. The manual reset feature of the missile sequencing logic for the ATAS system installation on AH-64A which requires the combined efforts of both crew members is a shortcoming. The reset feature of the ATAS missile sequencing logic should be fully automated on the production ATAS for the AH-64A.

Use of Aft Storage Bay

32. The use of the aft storage bay for the installation of the electronic components of the ATAS system was evaluated for the effect such installation has on the reduction of

aircraft storage space. The aft storage bay is designed for storage of aircraft covers, tie down devices, and crewmember personal equipment. As described in appendix B (see fig. B-9) the ATAS installation requires the mounting of the IEA and SCU in the aft storage bay along with an exhaust fan and the repositioning of the power supply for the external lighting system. The ATAS installation layout negates the use of the compartment for storage in spite of the fact that the components do not physically occupy the entire volume of the bay. The only alternate storage location is the survival kit bay in the forward tail boom. The space and weight limitations of the survival kit bay combined with the total lack of storage space anywhere else on the aircraft severely limit the storage space for the flight crew. An Apache crew operating in the field requires the storage space necessary not only for survival kits but the mandatory equipment required to function semi-autonomously during field operations: field gear, chemical protection ensembles, and a minimum of personal equipment. The reduction in storage space imposed by the installation of the Air-to-Air Stinger missile system in the aft storage bay is a shortcoming. Consideration should be given to adding the necessary equipment bays to support current and future new systems installation in the AH-64A.

External Aircraft Lighting

33. The proposed relocation of the anticollision lights and the navigation lights, made necessary by the ATAS modification and described in appendix B and depicted in figure B-15, was evaluated. With the lights mounted on the engine nacelles, two areas in the flight environment of the aircraft exist that are not illuminated by either navigation or anti-collision lighting. These are the area directly to the rear of the aircraft, where lighting (except for the aft navigation light) is blocked by the stabilator, and the area forward and below the nose of the aircraft, where lighting is blocked by the wings and wing stores. The proposed external light configuration may jeopardize safe operation of the aircraft in a non-tactical night or limited visibility environment. It is recommended that the coverage of anticollision and navigation lighting systems be further evaluated during future government developmental tests. This lighting configuration failed to meet the requirements of paragraph 3.7.9.3 of the AH-64 system specification in that the field of coverage is insufficient.

HUMAN FACTORS

General

34. An evaluation of the human factors elements of the AH-64A ATAS system was conducted through an in-depth review of the proposed design and installation plan. Included in the evaluation was an in-flight assessment of the fully operational preproduction ATAS system with captive flight training missiles against an airborne target helicopter. Primary emphasis was placed on control/equipment locations, system sighting displays, switch functions, and ease of operation of system controls.

Cyclic Grip

35. The cyclic grip modifications are described in appendix B and depicted in figure B-22. Operation of the ATAS system will require use of the weapons action select

(WAS) switch at the top of the grip, the cage/uncage switch at the bottom of the grip, and the trigger switch, in addition to symbology, communications, and trim switches. A pilot with an average sized hand (glove size 9) will have difficulty in operating the switches on the cyclic and will frequently be required to reposition his hand on the cyclic grip in order to perform the necessary functions. The poor anthropometric design of the cyclic grip has been previously reported, and remains a shortcoming.

Chaff Fire Switch

36. The repositioned chaff fire switch was qualitatively evaluated for interference with the radio/intercommunications rocker switch. To accommodate the use of the WAS switch to select the ATAS system, the chaff fire switch was repositioned to the upper left inside of the cyclic grip opposite the radio rocker switch as depicted in figure B-19. The close proximity of the two switches will result in the chaff fire switch interfering with the operation of the radio rocker switch or the inadvertent firing of chaff at an inappropriate moment. The location of the repositioned chaff fire switch on the cyclic handgrip will interfere with the operation of the cyclic intercom switch, and is a shortcoming. Further consideration should be given to the overall design of the cyclic hand grip to accommodate the installation of the ATAS system.

PITOT-STATIC SYSTEMS

37. The ship pitot-static systems were evaluated to determine any effects of the system installation caused by the proximity of the launchers/missiles to the wing mounted pitot probes of the aircraft. The pilot's (right pitot probe) and copilot's (left pitot probe) airspeed data were compared against the calibrated data for the boom airspeed system. Data were collected concurrently with trimmed flight control position tests (level flight, climbs, dives, and autorotations) and static lateral-directional stability test (steady heading sideslips). Data are presented in figures E-25 through E-27. Selected data points were repeated at the same test conditions and aircraft configuration except that the ATAS launchers/missiles were removed. The ATAS installation had no effect on the right pitot system of the aircraft. However, the left system displayed a one to two knot increase in airspeed signal at all airspeeds, directly attributable to the ATAS installation. The differential in airspeed signals was sufficiently small to have no measurable effect on stabilator scheduling. Because the ejector rack fairings were not installed, it is recommended that a similar pitot-static evaluation be conducted with the fairings installed.

TRANSPONDER ALTITUDE ENCODING

38. The absence of an altitude encoding, MODE C, feature in the AN/APX-100(V) transponder installation on the AH-64A was qualitatively evaluated for degradation of flight safety and operational/training limitations. The use of an altitude encoding transponder in the National Airspace System (NAS) permits ground based radar controllers to provide accurate and timely separation information to aircraft in a given area. A requirement currently exists for MODE C capability to operate an aircraft in

much of the NAS controlled airspace, and the airspace concerned is rapidly expanding because of the increased safety margin afforded by positive air traffic control. The AH-64A is qualified for flight in instrument meteorological conditions (IMC), and operational pilots are required to demonstrate and maintain proficiency in instrument flight in accordance with the Aircrew Training Manual (ref 14). In order to meet these training requirements, aircrews necessarily interface with the civil airspace structure. The night marginal visual meteorological conditions capability of the AH-64A presents the flight crew with the unique opportunity to conduct flight training operations in conditions that may result in the loss of all external visual cues. In order to safely continue flight in IMC, aircrews again are required to interface with the civil airspace structure. Occasional ferry flights (between training areas, to/from maintenance facilities, etc) are a recognized requirement for all Army aircraft, and are necessarily conducted within civil controlled air space. A MODE C capability would allow the AH-64A to comply with an expanding requirement in the NAS structure while significantly contributing to safe aircraft operation whenever in controlled airspace. The absence of an altitude encoding feature in the installation of the AN/APX-100(V) transponder in the AH-64 is a shortcoming. Future production AH-64 aircraft should incorporate a transponder altitude encoding capability.

MISCELLANEOUS

39. The following shortcomings, which have been previously reported, were evaluated during this test and still exist. The references and paragraph numbers following each item are the original sources for the shortcoming.

a. The objectionable 4/rev (19.3 Hz) vertical vibration characteristics (ref 6, para 38).

b. The restriction to the pilot's field of view caused by window edge distortion, the overhead circuit breaker panel, canopy reflection, copilot/gunner helmet, and the Pilot Night Vision System turret (ref 11, paras 32, 45; ref 12, para 86).

c. The failure of the Heading and Attitude Reference System to consistently align with the correct magnetic heading (ref 6, para 50).

d. The insufficient indications to the pilot of a balanced fuel condition between the fore and aft fuel cells during fuel transfer/crossfeed operations (ref 6, para 41; ref 13, para 73).

e. The poor anthropometric design of the pilot cyclic grip (ref 6, para 42; ref 13, para 57).

f. The excessive accumulation of oil on the main transmission deck and in the upper fairing access area (ref 11, para 82).

g. The lack of reliable indication of parking brake status (ref 13, para 60).

h. The poor readability of the transponder code numbers (ref 6, para 47).

i. The washout of the rocket panel display, Marconi instrument indications, and caution, warning, and advisory panel segment lights in direct sunlight (ref 11, para 67).

CONCLUSIONS

GENERAL

40. The following conclusions were reached upon completion of the preliminary airworthiness evaluation of the AH-64A equipped with the Air-To-Air Stinger (ATAS) missile system: (See app D for definition of shortcoming)

a. The handling qualities were essentially the same as the AH-64A without the ATAS system installed.

b. Five shortcomings associated with the ATAS system were identified.

c. One shortcoming not associated with the ATAS was identified.

d. Nine previously reported shortcomings of the AH-64A were evaluated during this test and still exist.

e. Four items of specification noncompliance were identified.

41. The aircraft was very easily recovered from a simulated single engine failure at 40 KIAS and 50 ft above ground level by maintaining near level flight and accelerating to best rate of climb speed (Vy).

SHORTCOMINGS

42. The following shortcomings associated with installation of the ATAS missile system on the AH-64A were identified and are listed in order of relative importance.

a. The poor integration of the Air-to-Air Stinger missile system, which is not directly compatible with the MIL STD 1553 data bus of the AH-64A (para 29).

b. The insufficient ATAS sighting symbology, which does not provide the copilot/gunner with accurate missile seeker line of sight relative to the selected sight line of sight except in FLIR wide field of view (para 30).

c. The reduction in storage space imposed by the installation of the Air-to-Air Stinger missile system in the aft storage bay (para 32).

d. The location of the repositioned chaff fire switch on the cyclic hand grip will interfere with the operation of the cyclic intercom switch (para 36).

e. The manual reset feature of the missile sequencing logic for the ATAS system installation on AH-64A which requires the combined efforts of both crew members (para 31).

43. The following shortcoming of the AH-64A not associated with the ATAS system was identified: The absence of an altitude encoding feature in the installation of the AN/APX-100(V) transponder in the AH-64A (para 38).

44. The following shortcomings, which were reported during previous tests of the AH-64A, were evaluated during this test and still exist.

a. The objectionable 4/rev (19.3 Hz) vertical vibration characteristics.

b. The restriction to the pilot's field of view caused by window edge distortion, the overhead circuit breaker panel, canopy reflection, copilot/gunner helmet, and the Pilot Night Vision System turret.

c. The failure of the Heading and Attitude Reference System to consistently align with the correct magnetic heading.

d. The insufficient indications to the pilot of a balanced fuel condition between the fore and aft fuel cells during fuel transfer/crossfeed operations.

e. The poor anthropometric design of the pilot cyclic grip.

f. The excessive accumulation of oil on the main transmission deck and in the upper fairing access area.

g. The lack of reliable indication of parking brake status.

h. The poor readability of the transponder code numbers.

i. The washout of the rocket panel display, Marconi instrument indications, and caution, warning, and advisory panel segment lights in direct sunlight.

SPECIFICATION NONCOMPLIANCE

45. The AH-64A equipped with the ATAS missile system was found to be not in compliance with the following paragraphs of the AH-64 system specification (ref 8, app A). Additional specification noncompliance beyond the scope of this evaluation may exist.

a. 3.7.9.3 - the field of coverage of the external lighting configuration is insufficient (para 33).

b. 10.3.3.1.2 - longitudinal control position required for trim becomes increasingly aft as airspeed is increased beyond 155 knots calibrated airspeed (para 9).

c. 10.3.4.4.2 - the average response time to a longitudinal control input was 0.4 seconds where 0.7 seconds were required (para 21).

d. 10.3.5.2.1 - the average response time to a lateral control input was 0.3 seconds where 0.7 was required (para 22).

RECOMMENDATIONS

46. The following recommendations are made:

a. Correct the shortcomings identified in paragraph 42 prior to determination of a final production Air-to-Air Stinger design.

b. Correct the shortcomings identified in paragraph 43 and 44 as soon as practical.

c. The production Air-to-Air Stinger missile system installation on the AH-64A should be fully integrated with the aircraft fire control system MIL STD 1553 data bus (para 29).

d. The ATAS sighting symbology of the production ATAS system for the AH-64A should provide the copilot/gunner with an accurate presentation of the relative position of the missile seeker in all FLIR and day television fields of view (para 30).

e. Consideration should be given to adding the necessary equipment bays to support current and future new systems installation in the AH-64 (para 32).

f. The reset feature of the ATAS missile sequencing logic should be fully automated on the production ATAS for the AH-64A (para 31).

g. Evaluate the coverage of the anticollision and the navigation lighting systems, relocated for the Air-to-Air Stinger installation, during future government developmental tests (para 33).

h. Consideration should be given to the overall design of the cyclic hand grip to accommodate the installation of the ATAS system (para 36).

i. A pitot-static evaluation with the Air-to-Air Stinger fairings installed should be conducted (para 37).

j. Future production AH-64 aircraft should incorporate a transponder altitude encoding capability (para 38).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-8, 25 April 1988, Subject: Preliminary Airworthiness Evalution of the AH-64A Equipped with the Air-to-Air Stinger (ATAS) Missile System. (Test Request)

2. Technical Manual, TM 55-1520-238-10, *Operator's Manual for Army AH-64A Helicopter*, Headquarters Department of the Army, 28 June 1984 with change 11 dated 15 April 1988.

3. ATAS Supplement (Test Only), dtd 15 May 1988, to Technical Manual, TM 55-1520-238-10, 28 June 1984.

4. Letter, AVSCOM, AMSAV-E, 13 July 1988, Subject: Airworthiness Release for AH-64A Helicopter S/N 82-23355 (PV-01) for Preliminary Airworthiness Evaluation (PAE) of Air-to-Air Missile System.

5. Test Plan, AEFA Project No. 88-05, *Preliminary Airworthiness Evaluation (PAE) of the AH-64A Equipped with the Air-to-Air Stinger (ATAS) Missile System*, June 1988.

6. Final Report, AEFA Project No. 84-10, *First Article Preproduction Tests of the AH-64A Helicopter*, November 1984.

7. Final Report, AEFA Project No. 80-17-3, *Airworthiness and Flight Characteristics (A&FC) Test of YAH-64 Advanced Attack Helicopter, Prototype Qualification Test-Government (PQT-G), Part 3 and Production Validation Test-Government (PVT-G) for Handbook Verification*, October 1982.

8. AH-64A System Specification, DRC-S-H10000B, Part I, Appendix I, *Flying and Ground Handling Qualities Specification*, 15 April 1982.

9. Flight Test Manual, Naval Air Test Center, FTM No. 105, *Helicopter Stability and Control, Theory and Flight Test Techniques*, November 1983.

10. Field Circular, FC-1-214, *Aircrew Training Manual, Attack Helicopter, AH-64*, Headquarters, U.S. Army Aviation Center, 31 May 1986.

11. Final Report, AEFA Project No. 80-03, *Engineer Design Test 4, YAH-64 Advanced Attack Helicopter*, January 1980.

12. Final Report, AEFA Project No. 74-07-2, *Development Test I, Advanced Attack Helicopter Competitive Evaluation, Hughes YAH-64 Helicopter*, December 1976.

13. Final Report, AEFA Project No. 78-23, *Engineer Design Test 2, Hughes YAH-64 Advanced Attack Helicopter*, June 1974.

14. AH-64A Apache Stinger, Student Handout, McDonnell Douglas Helicopter Company, no date.

APPENDIX B. AIRCRAFT AND AIR-TO-AIR STINGER DESCRIPTION

INDEX

TEST AIRCRAFT

General

1. The AH-64A Advanced Attack Helicopter (fig B-1) is a tandem, two-place, twin turbine engine, single main rotor aircraft manufactured by McDonnell Douglas Helicopter Company. The principle dimensions with the Air-to-Air Stinger (ATAS) installed are presented in figure B-2. The main rotor is a four bladed fully articulated system supported by a stationary mast which transmits flight loads directly to the fuselage. The tail rotor is a dual teetering, semi-rigid, delta hinged system incorporating elastomeric flapping bearings. The rotors are driven through a conventional power train by two General Electric T700-GE-701 front drive turboshaft engines rated at 1690 shaft horsepower (sea level, standard day, uninstalled) and mounted in nacelles on either side of the main transmission. An AiResearch GTCP 35-55(H) auxiliary power unit is installed to drive the accessory section of the main transmission when the rotors are not turning, providing electrical, hydraulic, and pneumatic power for aircraft systems. All of the helicopter electrical power requirements are supplied by two AC generators, two transformer-rectifiers, and a 24 volt nickel-cadmium battery. The aircraft incorporates two independent 3000 psi hydraulic systems, backed up by an emergency hydraulic system, which simultaneously power four hydraulic servoactuators (longitudinal, lateral, collective, and directional) and provide pressure for Digital Automatic Stabilization Equipment (DASE) functions, the stores pylon system, the tail wheel lock mechanism, the 30mm cannon turret drive, and the main rotor brake. The pressurized air system provides filtered, pressure regulated, air for engine starting, the environmental control system, canopy defogging, engine cooling louver actuators, hydraulic cooling eductors, hydraulic reservoir pressurization, the nitrogen inerting system, and for fuel system components. The fuel system has two fuel cells and includes a fuel boost pump for starting and high altitude operation, a fuel transfer pump for transferring fuel between cells, a fuel crossfeed/shutoff valve, provisions for pressure and gravity fueling and defueling, and provisions for wing mounted external tanks. The aircraft can carry ordnance stores internally in the ammunition bay and externally on four wing store positions, and incorporates a 30mm cannon weapons system, a 2.75 inch aerial rocket control system, and a point target weapons system (Hellfire missile). The AH-64A is designed to operate during day, night, and marginal weather combat conditions using the Martin-Marietta Target Acquisition and Designation System (TADS)/Pilot Night Vision Sensor (PNVS) and the Integrated Helmet and Display Sight System. A multiplex MIL STD 1553 dual channel data bus provides flexible interface between mission and avionics equipment and signal routing/processing for the Fault Detection and Location System (FD/LS).

First Phase Test Aircraft

2. The first phase test aircraft, S/N 82-23355, is shown in the test configuration in figures B-3 through B-5. The weapons systems were not functional and the fire control computer was removed, its functions performed by the backup bus controller. The PNVS and the TADS were removed and the nose mounted sensors replaced with aerodynamic mockups. The wire strike protection system was not installed, and the backup control system was not operational. The optical relay tube (ORT) was removed, and the

copilot/gunner (CPG) fire control panel replaced by instrumentation and instrumentation controls. The visual display unit was functional, providing only flight symbology, and the pilot fire control panel was replaced with instrumentation. An air data boom was installed on the nose of the aircraft, and the instrumentation package was distributed between the aft storage bay and the survival kit bay. As depicted in figures B-6 through B-9, the ATAS system installation consisted of ejector racks mounted horizontally at each wing tip. A dummy launcher with two missile replicas was installed at each ejector rack. Ejector rack fairings were not available for the first phase of the evaluation. The right launcher and right upper missile were instrumented. The wing tip navigation lights and anticollision lights were removed. A jettison control panel was installed at the pilot station for future testing; however no other ATAS components were installed or cockpit modifications complied with. A listing of specific aircraft components is included in table B-1.

Second Phase Test Aircraft

3. The second phase test aircraft, USA S/N 86-8944, was a representative production AH-64A with fully functioning mission and armament subsystems. The preproduction ATAS system was fully operational. The aircraft was equipped with the AN/ASN-137 Doppler Navigation Set and the -45 software to control the MIL STD 1553 data bus. The ATAS ejector rack fairings were installed. The external lighting had been repositioned to the aft portion of the engine nacelles. A limited test instrumentation package was installed in the tail boom survival kit storage bay and consisted of a video recorder, telemetry transmitters, and associated equipment to permit real time transmission of the ATAS symbology and mission video image. High speed 16mm film camera mounts were installed on the top of the right wing tip, on the right main gear mount, the aft left side of the tail boom, and midway back on the tail boom right side. With 208 pounds of ballast installed in the main landing gear cross tube, the takeoff gross weight was 16,048 pounds, which included the ATAS system with four Stinger missiles and the instrumentation package. Longitudinal center of gravity was at fuselage station 205.8. A listing of specific aircraft components is included in table B-2. A more complete description of the aircraft and instrumentation is presented in the Apache Stinger Student Handout (ref 14, app A).

FLIGHT CONTROL SYSTEM

4. The AH-64A helicopter employs a hydromechanical irreversible flight control system which is mechanically activated with conventional cyclic, collective, and directional pedal controls at each crew station. Crew flight control inputs pass through a series of push-pull tubes attached to four airframe mounted hydraulic servoactuators. A DASE system (fig. B-10) is installed to provide rate damping, command augmentation, a hover augmentation system, attitude hold, and turn coordination. The DASE is limited to ±10 percent of control authority in roll and yaw. The longitudinal cyclic hydraulic servoactuator allows 20 percent forward and 10 percent aft control authority in the pitch axis. Linear variable differential transducers (LVDT) are incorporated in all control axes to electrically measure control positions for DASE computer inputs. A trim feel system is incorporated in the cyclic and directional controls to provide a control force gradient and

positive control centering from a selected trim position. A 3-position trim release switch located on the pilot's cyclic grip provides discrete ON/OFF or momentary interruption of the force gradient in all axes simultaneously to allow the cyclic or pedal controls to be placed in a new reference trim position.

STABILATOR

5. An electrically actuated horizontal stabilator is attached to the lower aft portion of the vertical stabilizer. Movement of the stabilator can be controlled either manually or automatically. A dual series electromechanical actuator allows incidence changes of 35 degrees trailing edge down to 10 degrees trailing edge up of travel. The stabilator is controlled in the automatic mode by two stabilator control units (SCUs). Each SCU controls one side of the dual actuator. Both SCUs receive collective control position information from LVDTs in the collective control linkage, pitch rate information from independent pitch rate gyros, and airspeed information from the air data processor. Additionally, the left-hand pitot-static system provides airspeed for one SCU and the right-hand system provides airspeed to the other SCU. Both SCUs receive stabilator position information from both sides of the dual actuator.

PITOT-STATIC SYSTEM

6. The pitot-static system (fig. B-11) is comprised of two semi separate individual subsystems, one for each crew station. Each subsystem consists of a barometric (pressure) altimeter, vertical speed indicator, airspeed indicator, airspeed transducer, electrically heated pitot tube, common static ports, and associated system tubing and drains. The left-hand pitot tube, mounted on the left wing, routes ram air to the No. 1 airspeed transducer and the CPG airspeed indicator. The right-hand pitot tube, mounted on the right wing, routes ram air to the No. 2 airspeed transducer and the pilot airspeed indicator. Static pressure for the pilot and CPG instruments, the No. 1 and No. 2 airspeed transducers, and the air data processor is provided through interconnected flush mounted static ports on the left and right right side of the fuselage. Static pressure routed to the air data processor is changed internally to electrical impulses to provide control input information to the stabilator and DASE.

AIR-TO-AIR STINGER SYSTEM

General

7. The AH-64A ATAS system is a lightweight, supersonic, fire-and-forget, air-to-air guided missile system that employs passive infrared (IR) homing (heat seeking). One jettisonable launcher mounting two Stinger missiles is mounted on each wingtip of the helicopter. The system is designed to be aimed and launched by either pilot without removing his hands from the flight controls or by the CPG using the ORT. The system employs the existing sighting systems, with integrated weapons status and firing symbology. System built-in test and reporting capability is incorporated into the FD/LS and the

caution/warning panel. The components as installed on the AH-64A are depicted in figure B-12. A block diagram of the ATAS system interface with the AH-64A fire control system is depicted in figure B-13. The total weight added to the AH-64A for a loaded ATAS system is 265 pounds. A more detailed description of the ATAS system installed on the AH-64A is presented in the ATAS Supplement to the operator's manual (ref 2) and the Student Handout (ref 9).

Line Replaceable Units

8. The ATAS system incorporates three line replaceable units, not including the missile launchers, all of which are mounted in the aft storage bay (fig. B-14). These are the interface electronics assembly (IEA), the signal conditioning unit, and an exhaust fan. The IEA provides the interface between the sighting systems, the fire controls, and the launcher assemblies. Its major functions are power distribution, data processing, signal processing, and seeker head off-axis caging. It also performs a system built-in test on activation. The signal conditioning unit is required to modify aircraft voltage for use by the ATAS system. The exhaust fan is required to provide necessary ambient cooling air for the aft storage bay.

Wing Tip Installation

9. The ATAS system installation requires modification of the wing to accommodate two mounting brackets, two access panels, and an electrical conduit (fig. B-15). The mounting brackets are fitted to hardpoints at the 20 percent and the 50 percent chord wing spar locations. Rack adaptors are bolted directly to the mounting brackets to provide support for the ejector rack and four sway braces on each wing tip. The launcher is mounted on the ejector rack. Aerodynamic fairings are installed between the wing tip and the launcher assembly. Clearances between the fully installed and loaded ATAS system and the wing mounted pitot tubes are provided in figure B-16.

10. In order to accommodate the wing tip installation of the ATAS system, the navigation lights and anti-collision lights were relocated from the wing tips to the rear outboard portions of the engine nacelles (fig. B-17). The strobe power supply was also relocated from the main transmission bay to the aft storage bay.

Launcher Assembly

11. Each launcher assembly (fig. B-18) is a self contained unit which holds two missile rounds. As depicted in figure B-19, it is comprised of four major components: the launcher structure, the launcher adapter, the launcher electronics unit (LEU), and the coolant system. The launcher structure is a monocoque box unit which houses the LEU, coolant system, cables and connectors, and two missiles. The launcher adapter is bolted to the top of the launcher, and attaches the launcher to the ejector rack using two standard lugs. The LEU, located in the forward end of the launcher, provides power distribution and signal input/output control for the missiles. The coolant assembly, inside the rear of the launcher, cools the IR detector during prelaunch conditions. It consists of a portable, rechargeable, high pressure (6200 psi) cylinder of argon gas. The argon gas cyclinder is recharged by a gas pump which transfers the argon from a standard storage cylinder. The minimum recommended pressure at take off is 4500 psi. At 3500 psi a

LOW COOL message is presented in the weapon status display. 2700 psi is the minimum recommended for system operation. The launcher assembly weighs 62 pounds.

Missile Round

12. The Stinger missile round is made up of two assemblies, the launch tube assembly and the missile. The launch tube assembly is reusable and is designed to protect the missile from the environment and provide a missile launch platform. The missile (fig. B-14) is divided into four sections: guidance, warhead, dual flight motor, and launch motor. The guidance section employs an IR seeker head, gyro stabilization, and an integral electronics package to process azimuth and elevation deviation between the line of sight (LOS) of the missile and the LOS of the seeker to zero this angle and keep the missile homing to the target on a collision course. It utilizes two wing assemblies for guidance and two wing assemblies for roll control. The warhead is approximately 0.5 pounds of high explosive which is detonated on target penetration, hard target impact, or automatic self-destruct (17 +2 seconds after missile launch and the fuze is armed). The dual thrust rocket motor provides inflight propulsion, and includes four fixed stabilizing wings. The launch motor section (fig B-21) contains an explosive charge to eject the missile from the launch tube, and provides initial spin stabilization of the missile. It separates from the missile approximately 30 feet in front of the aircraft. On separation, it activates the flight motor ignition circuits, the warhead destruct circuit, and the warhead detonating fuze. The missile is 59 inches long and weighs 22 pounds.

Crew Station Design

13. The following modifications and additions have been incorporated at the crew stations for ATAS implementation:

a. Two circuit breakers (IEA and ATAS) are added to the pilot's overhead circuit breaker panel.

b. An ATA missile control panel is added to both the pilot and CPG left-hand consoles (fig. B-22).

c. The ATAS system is wired through the MSL switch of the pilot's and CPG's fire control panels. The same switch used to enable ARM/SAFE power to the Hellfire missile system. The switch serves the same purpose for the ATAS system.

d. The electrical power panel is relocated from the pilot left-hand console to the center console (fig. B-23).

e. The pilot's jettison panel is redesigned to add wing tip stores jettison capability (fig. B-24).

f. Receiver selector switch no. 5 on both the pilot and CPG communication control panel is enabled to control missile lock on audio signals.

g. An ATA segmented caution light is added to both the pilot and CPG caution/warning panels (fig. B-25).

h. The pilot and CPG cyclic grips are modified, adding an ATA weapons action switch (WAS), an ATAS cage/uncage switch, and the chaff fire switch was repositioned from the bottom position of the WAS switch (fig. B-26).

i. The CPG anti-ice panel is modified to permit installation of the C?G ATA panel (fig. B-27).

j. An ATA position is added to the WAS and a cage/uncage sw.ch is added to the left hand grip of the ORT (fig. B-28).

ATA Control Panel

14. The ATA control panel controls the operation of ATAS system on the AH-64A. Located in the left console of each crew station, the panel has three switches: AUTO/MAN, RESET, and ADV/INVD. The AUTO/MAN switch is a mode select switch which is normally operated in the AUTO position. In the AUTO mode the missile seeker head is slaved to the selected LOS, permitting the crew member to direct the missile to the desired target. In the MAN mode the seeker is directed along the longitudinal axis of the missile until a possible target is acquired, at which time automatic tracking takes place. The MAN mode might also be used in a situation were the seeker has difficulty locking up the desired target. An undesirable characteristic of the MAN mode is that control of the seeker head is difficult when several heat sources are present in the seeker field of view. The RESET switch is a spring loaded switch that when activated resets the missile firing logic to the lower left (#1) missile and reruns the built in test (BIT). The ADV/INVN has three positions ADV, OFF, and INVN. ADV sequences the system to the next missile to be fired, except in the case of the upper right (#4) when the RESET switch must be used. The INVN position presents a missile inventory in the WEAPON STATUS of the high action display.

ATAS Sighting Symbology

15. The ATAS sighting symbology consists of the lock on after launch (LOAL) and lock on before launch (LOBL) boxes used for the Hellfire missile system. Limitations imposed by the symbol generator required that existing symbology be used for the ATAS sighting. As depicted in figures B-29, the boxes are concentrically presented to the crew member who selects the ATA position of the weapon action switch. The inner box provides the crew with an indication of the ship weapons systems armed status: a dashed line box indicates the system is SAFE, a solid line box indicates the system is ARMED. By changing from a dashed to a solid line, the outer box indicates the missile seeker is uncaged and the aircraft is within missile firing constraints. In the helmet mounted displays the center of the boxes represents the LOS of the missile seeker head. With the FLIR display selected the pilot will be presented with an accurate seeker head LOS. The CPG will only have accurate missile seeker LOS in the wide FLIR field of view, although the ATAS sighting symbology will be presented to the CPG in all other fields of view of either FLIR or day television. Horizontal and vertical tick marks on the inside of the larger box provide the crew with the optimum aircraft azimuth and pitch elevation firing position. The tick marks will flash when the AUTO mode is selected and the seeker is uncaged. They become solid when a target is acquired by the seeker. The WEAPON

CONTROL and WEAPON STATUS sections of the high action display reflect ATAS status and control. The WEAPON STATUS messages incorporated with the ATAS installation are presented in figure B-30.

General Theory of Operation

16. With the MSL switches at both crew stations ON and the SIGHT SEL switches in other than STBY, the ATAS may be selected by either crew member with the aft position (ATA) of the WAS switch. At this time the ATAS sighting symbology will be presented to the crew member selecting ATA. Should the CPG select ATA, the ATAS sighting boxes will be presented to both the CPG and the pilot, to permit the pilot to maneuver the aircraft into firing constraints. Only the pilot will see the ATAS sighting boxes when he selects ATA. When the ATA is selected, argon gas begins to cool the seeker head. The WEAPONS CONTROL section of the high action display will display which crew member has control of the ATAS system. The last crew member to select ATA has control. Placing the ARM/SAFE switches in both cockpits to ARM permits full operation of the ATAS system, causing the inner sighting box to become solid lines. In the AUTO mode of operation the missile seeker head will be slaved to the LOS of the selected sight, within the limits for seeker head movement imposed by the IEA. The crew member places the center of the sighting boxes over a target and activates the CAGE/UNCAGE switch to uncage the seeker head. If the seeker acquires the desired target a steady high pitched tone will be heard in the headset, and the sighting boxes will follow the movement of the target. The headset tone produced by a positive lock on is an important element in the firing sequence. The seeker head may not acquire the desired target and instead lock on to a hot background object, producing an oscillating tone varying in frequency. The difference in tones between a positive target lock on and a bogus lock on alerts the pilot to correct target acquisition. The missile to be fired will be presented in the WEAPON STATUS as XX RDY, the next missile selected by the IEA to be launched. Pulling the firing switch to the first detent will launch the missile if all performance and safety firing constraints are satisfied. Performance and safety firing constraints and maneuvering limits are presented in figure B-32. Pulling the firing switch to the second detent will override the performance constraints imposed by the seeker head gimble limits as determined by the IEA. The missile will launch and the next missile in sequence will be selected.

Table B-1. Test Aircraft Components
USA S/N 82-23355 (PV01)

Component	Part Number	SerialNumber
Engine, No. 1	N/A	GE-E-374433
Engine, No. 2	N/A	GE-E-374940
Fire Control Computer	Not Installed	N/A
Backup Bus Controller	7-332125021-9	0540035
Digital Automatic Stability Equipment Computer	7-211000005-15	0540027
Air Data Processor	7-31970008-7	0055
Heading and Attitude Reference System	7-314200034-11	1032
Stabilator Control Unit #1	7-211010001-11	0305143
Stabilator Control Unit #2	7-211010001-11	83110

Table B-2. Test Aircraft Components
USA S/N 86-8944 (PV314)

Component	Part Number	Serial Number
Engine, No. 1	N/A	GE-E-375069
Engine, No. 2	N/A	GE-E-375035
Fire Control Computer	7-332110074	0578
Backup Bus Controller	7-311F00002-15	0870
Digital Automatic Stability Equipment Computer	7-211D00005-19	0180504
Air Data Processor	7-319720008-11	0387
Heading and Attitude Reference System	7-314200034-15	1414
Stabilator Control Unit #1	7-211D10001-11	86062099
Stabilator Control Unit #2	7-211D10001-11	86083110

APPENDIX B. INDEX OF FIGURES

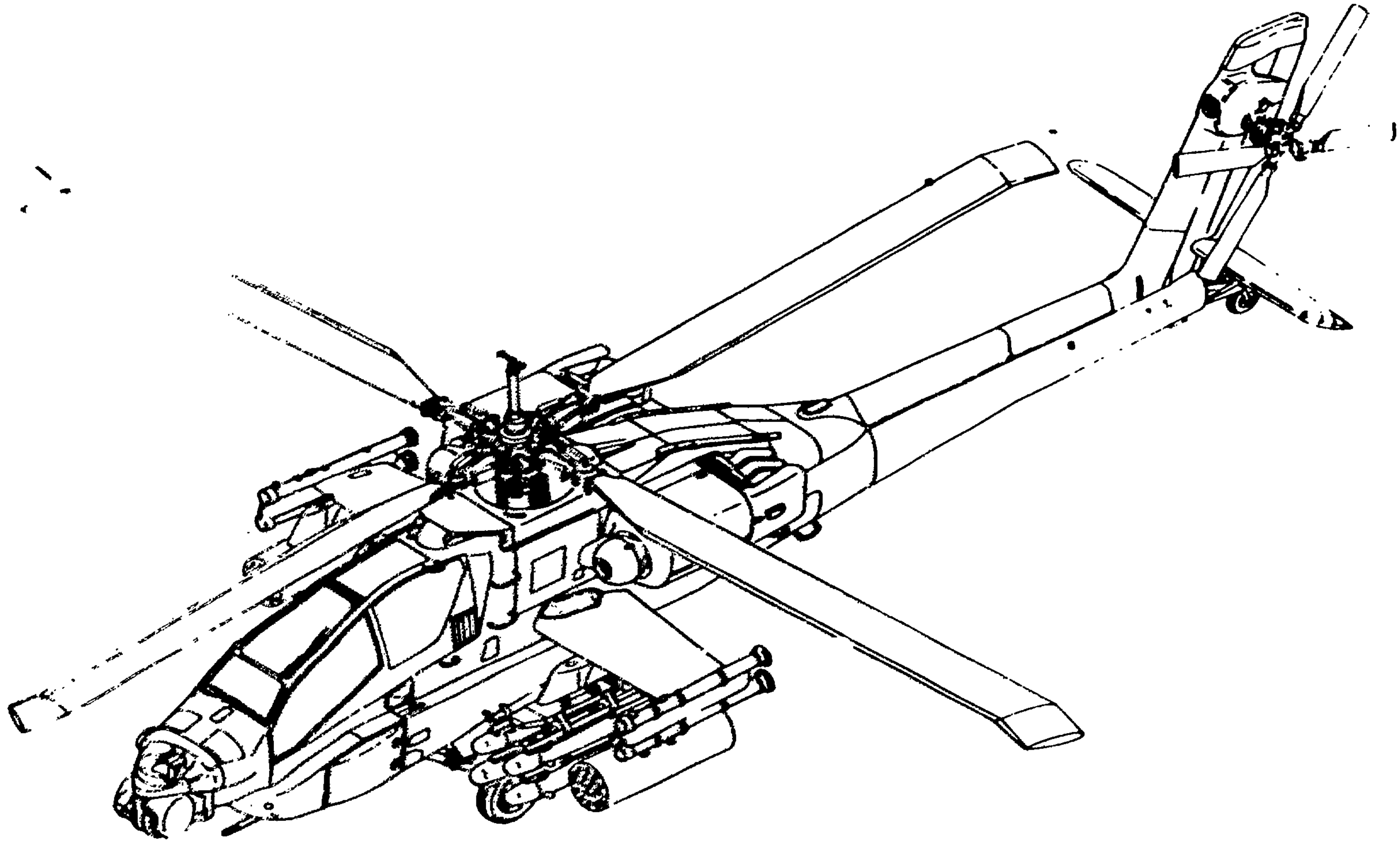


Figure B-1. Air-to-Air Stinger Configured AH-64A

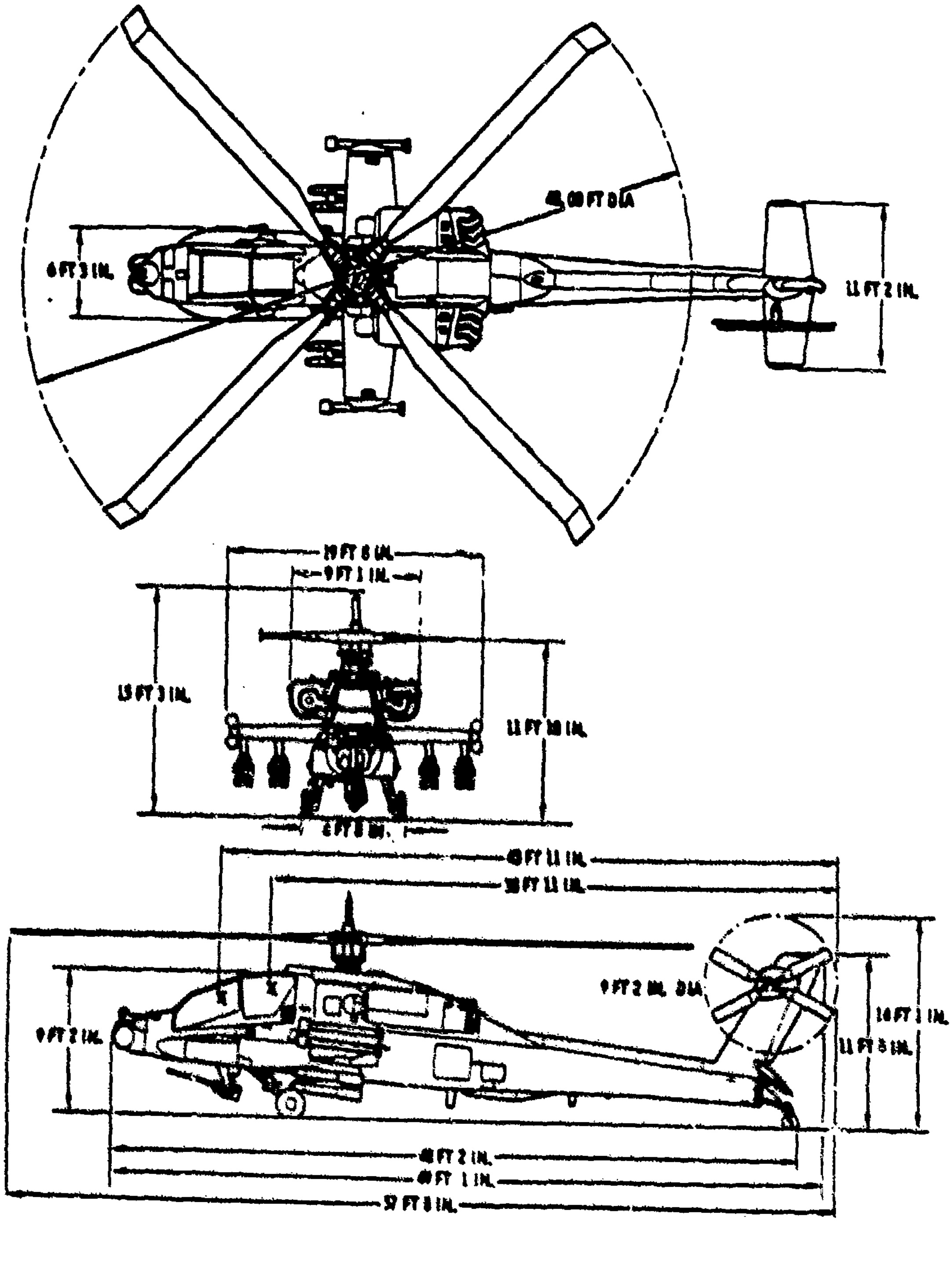


Figure B-2. Principle Dimensions

Figure B-3. Left Forward View, USA S/N 82-23355

Figure B-4. Forward View, USA S/N 82-23355

Figure B-5. Right Front View, USA S/N 82-23355

Figure B-6. Left Wing Stinger Launcher with Two Missiles
USA S/N 82-23355

Figure B-7. Left Wing Stinger Launcher with Two Missiles Ejector Fairings not Installed, USA S/N 82-23355

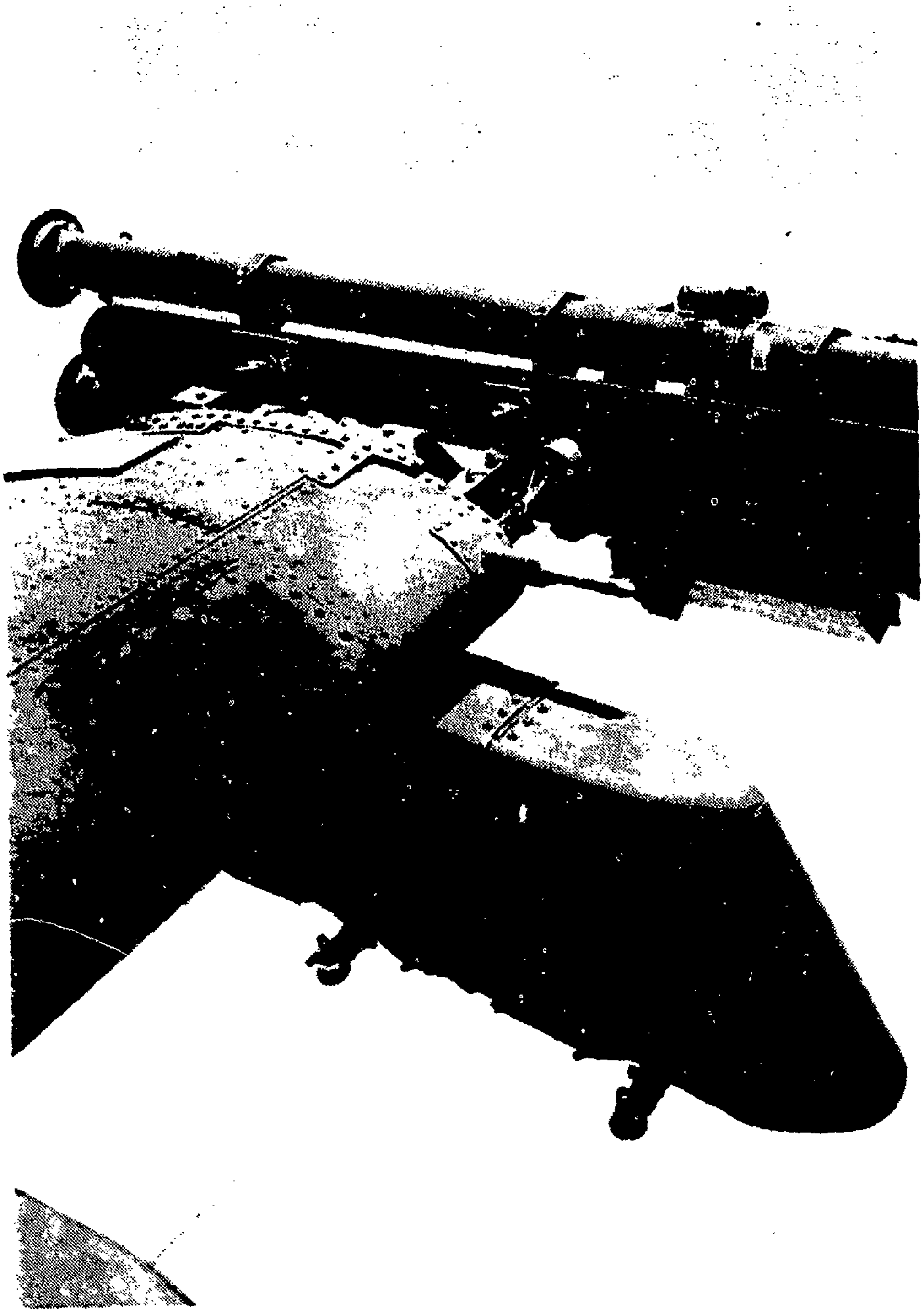


Figure B-8. Left Wing Stinger Launcher with Two Missiles Ejector Fairings not Installed. USA S/N 82-23355

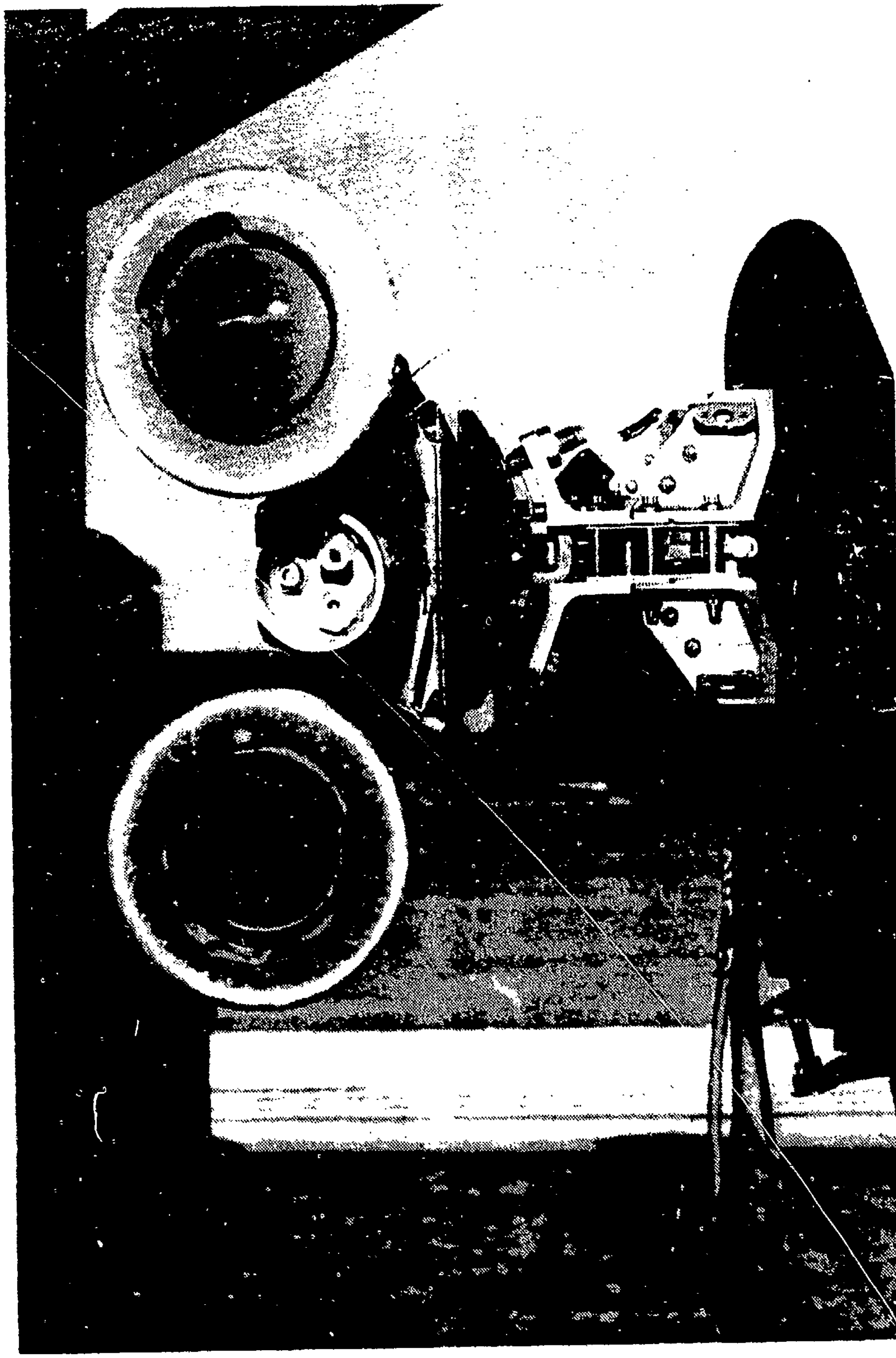


Figure B-9. Left Wing Stinger Launcher with Two Missiles
USA S/N 86-8944

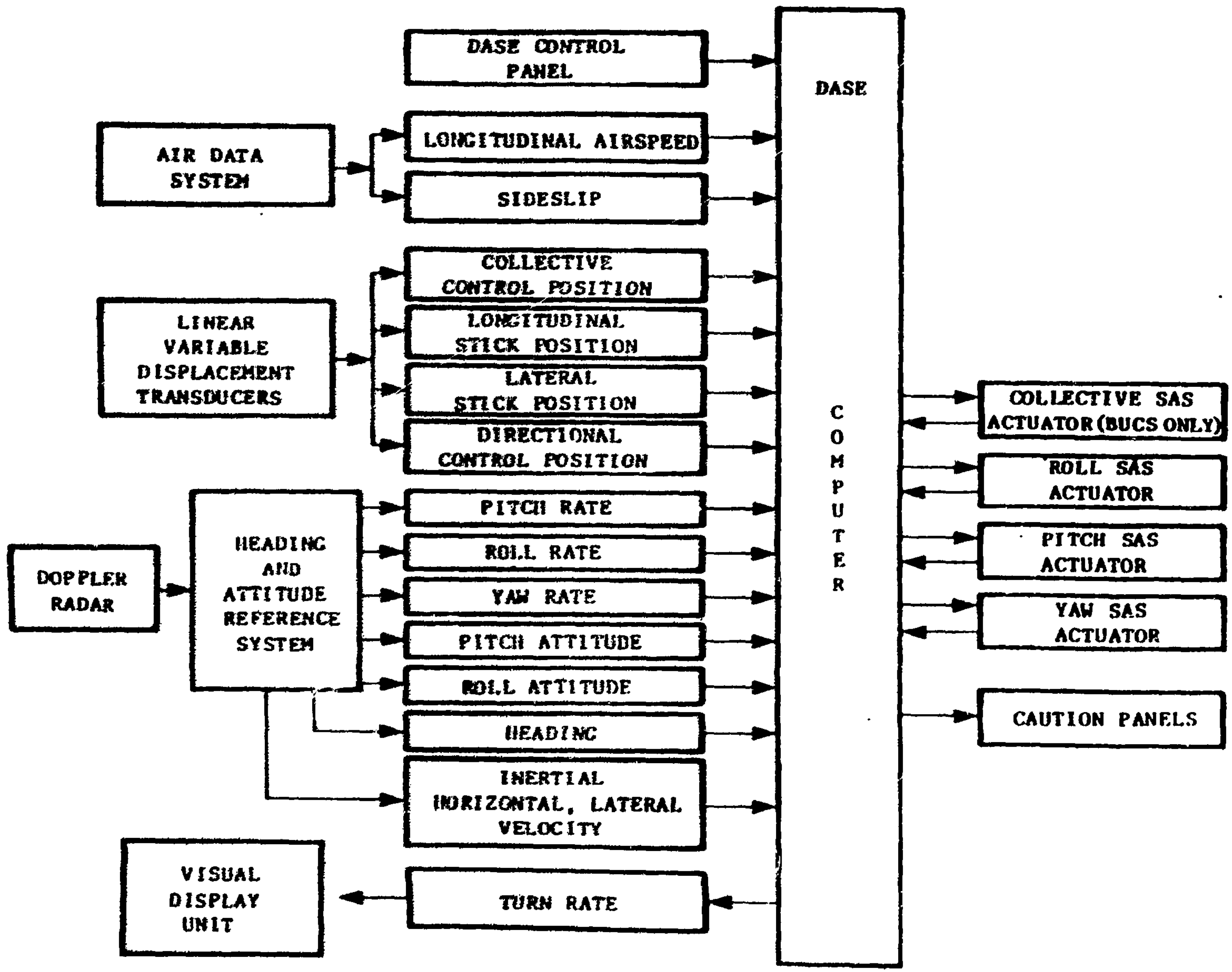


Figure B-10. Digital Automatic Stabilization Equipment

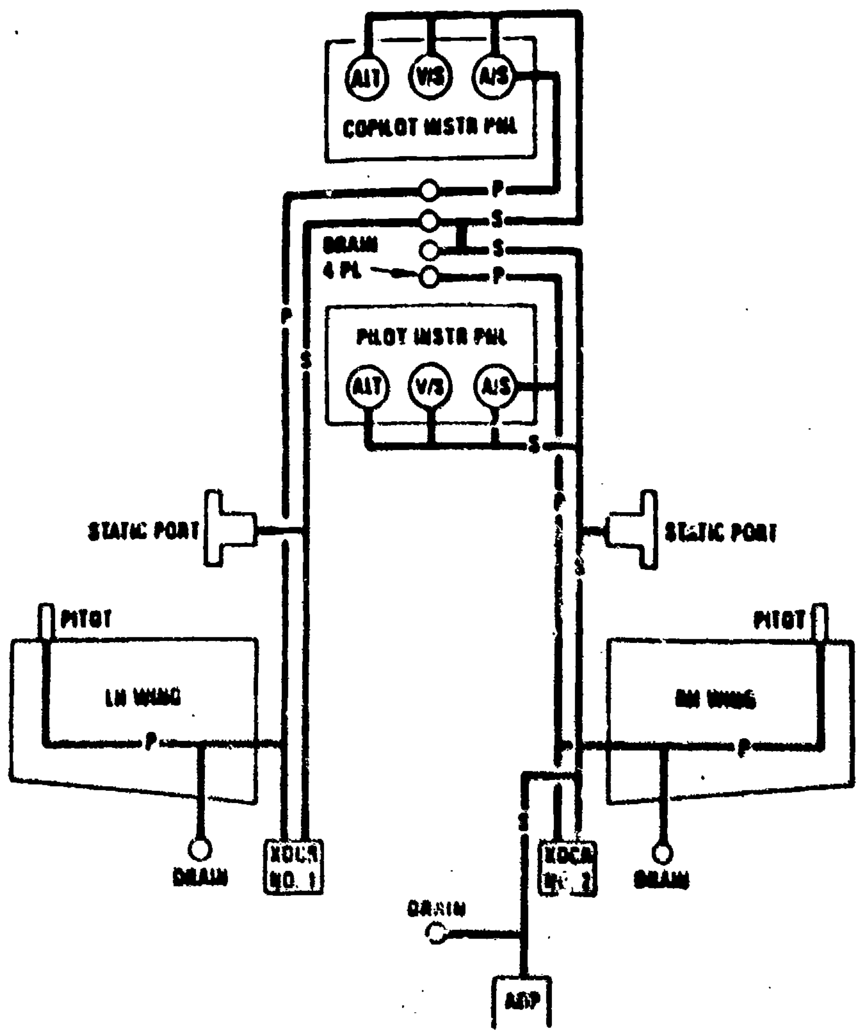


Figure B-11. Pilot-Static System

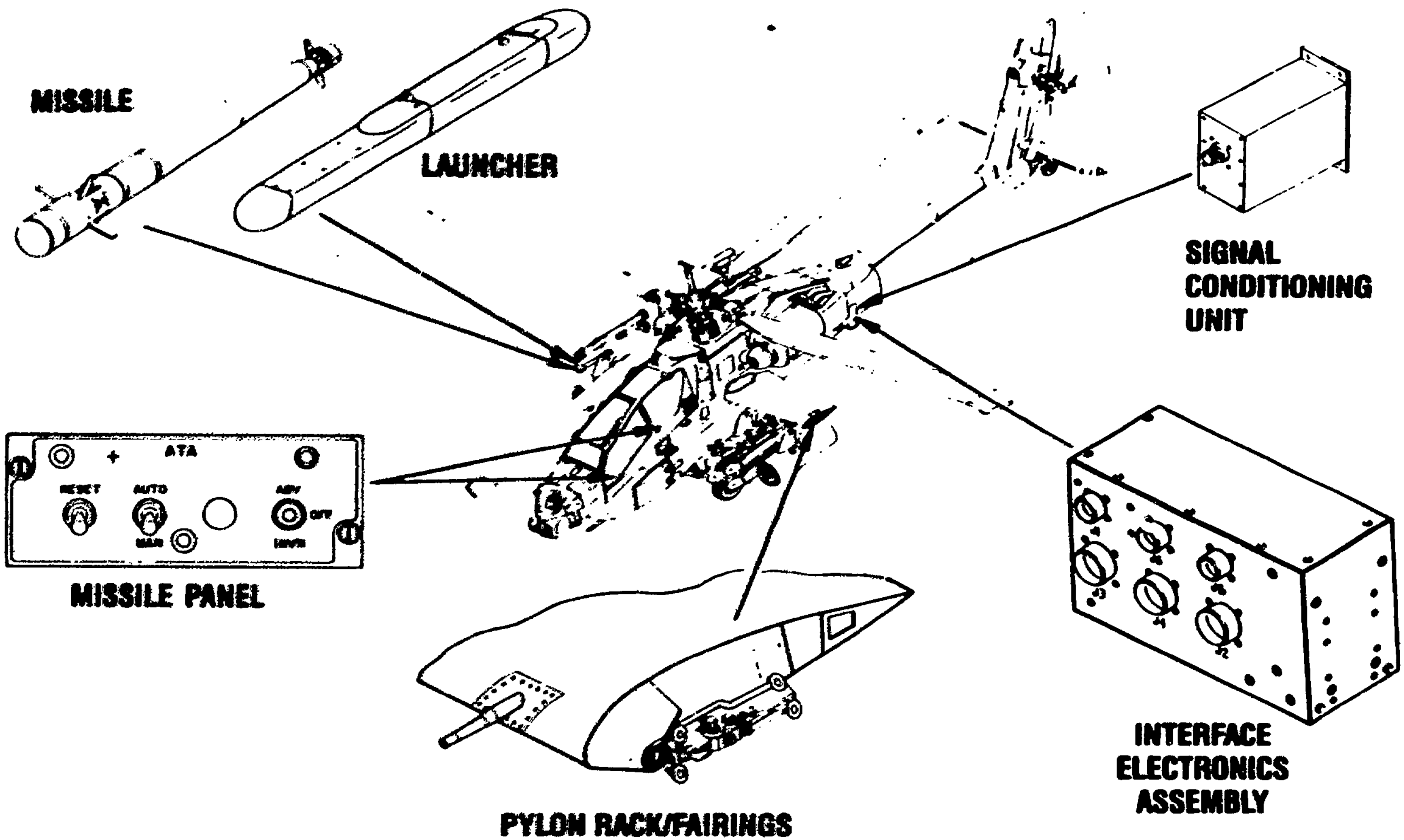


Figure B-12. Air-to-Air Stinger System Components

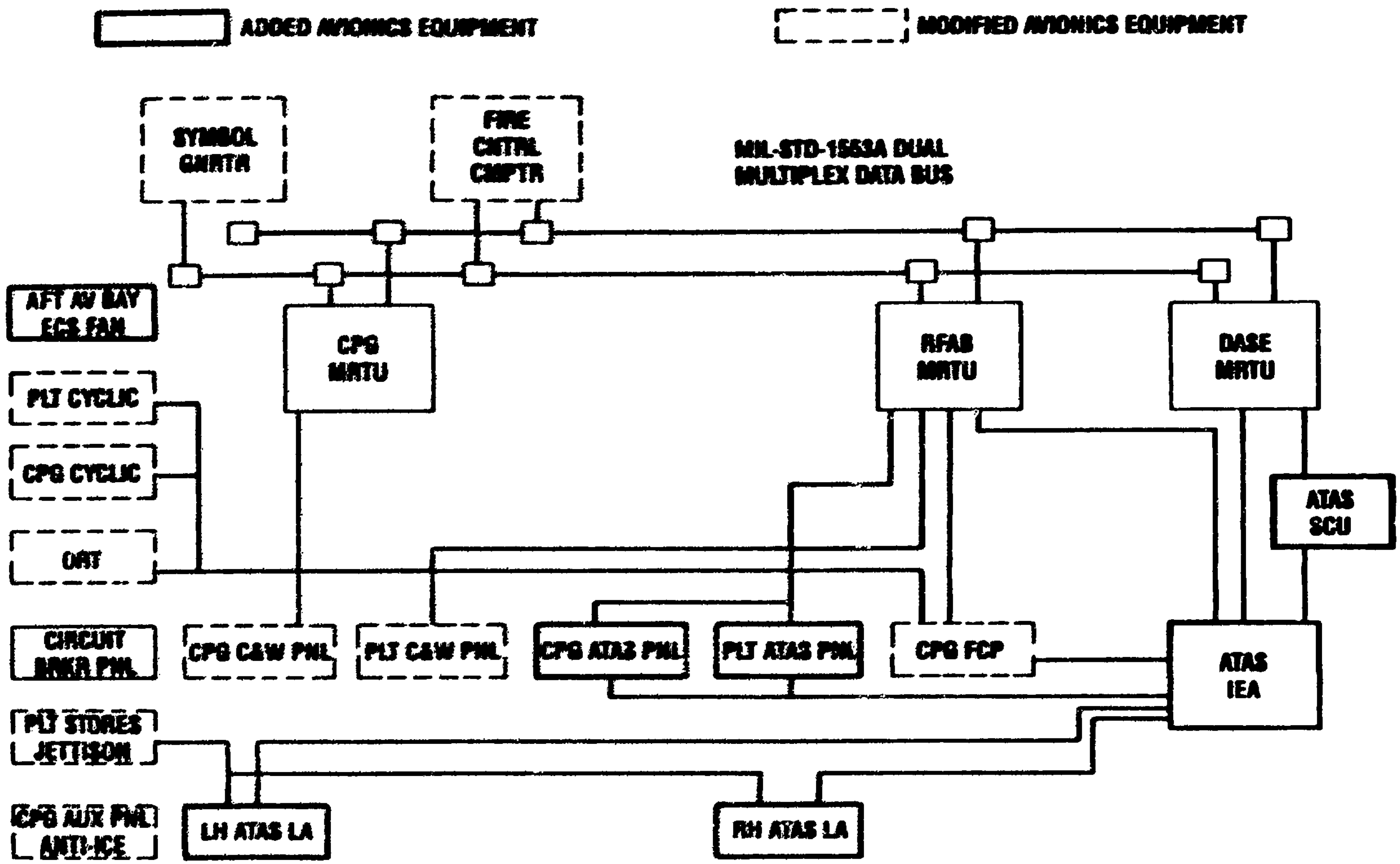


Figure B-13. Integration of Air-to-Air Stinger with AH-64A

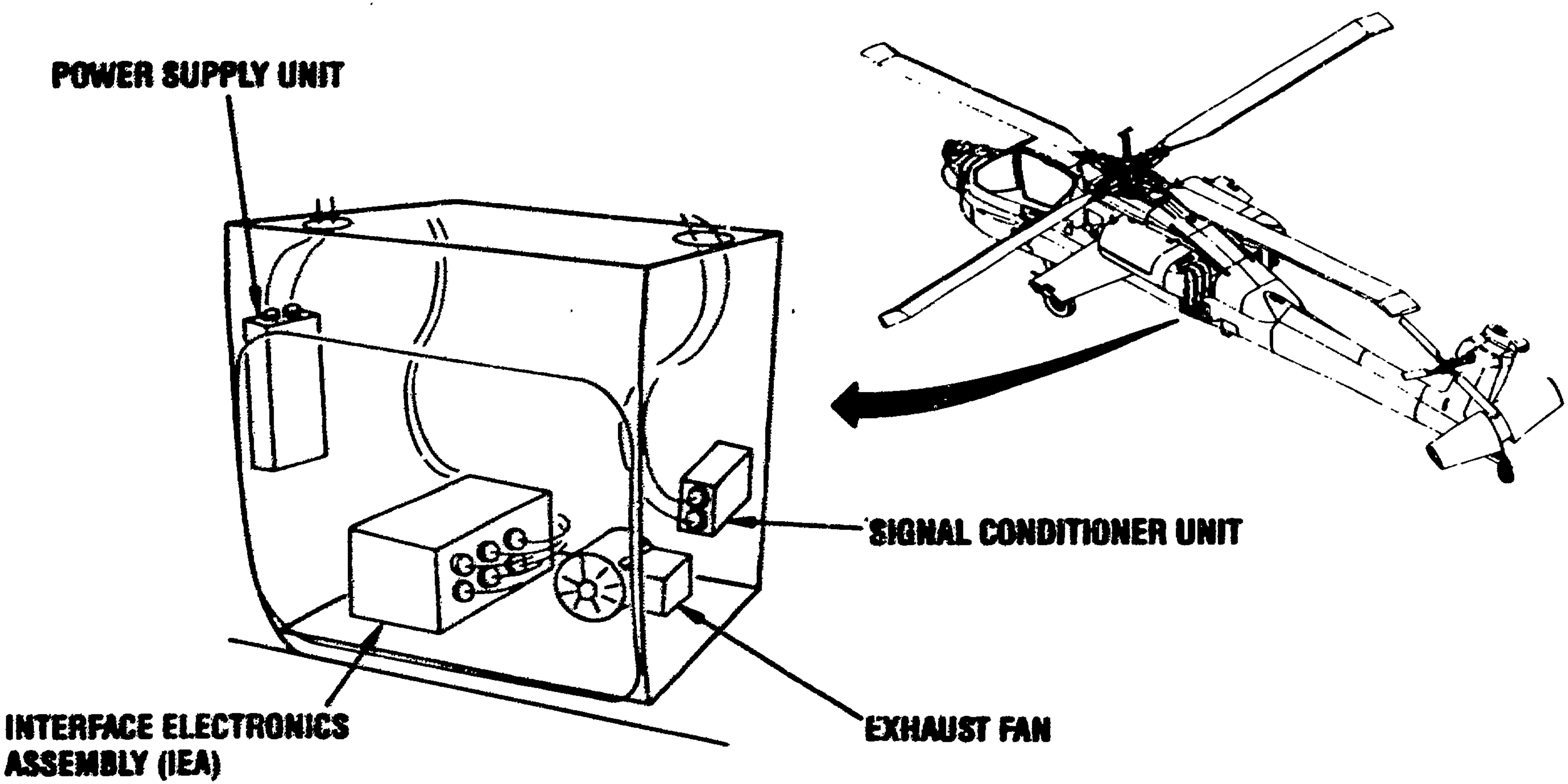


Figure B-14. Air-to-Air Stinger Modification aft Storage Bay

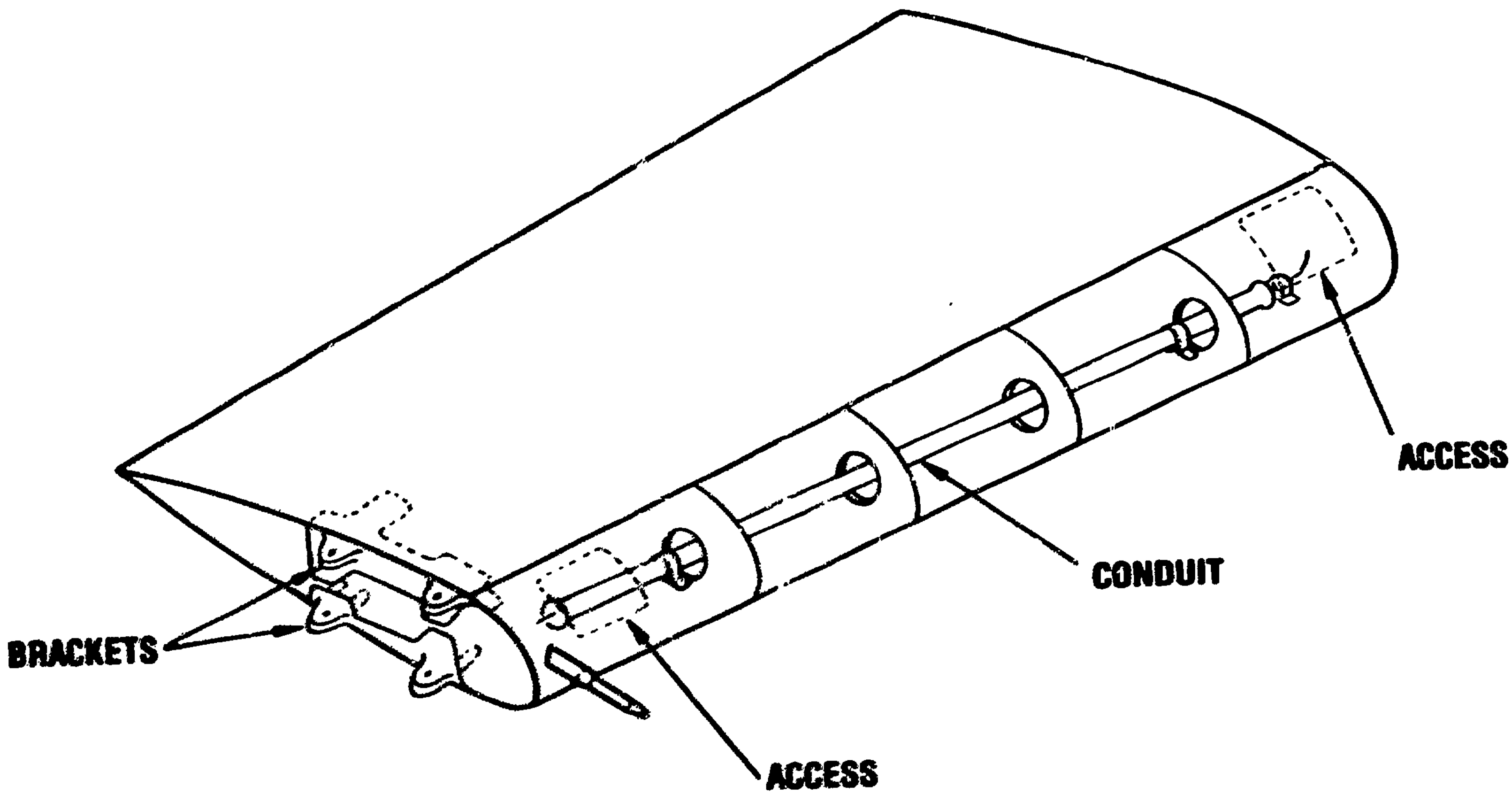


Figure B-15. Air-to-Air Stinger Modifications, Right Wing

A = 6.4 in.

B = 12.7 in.

C = 10.9 in.

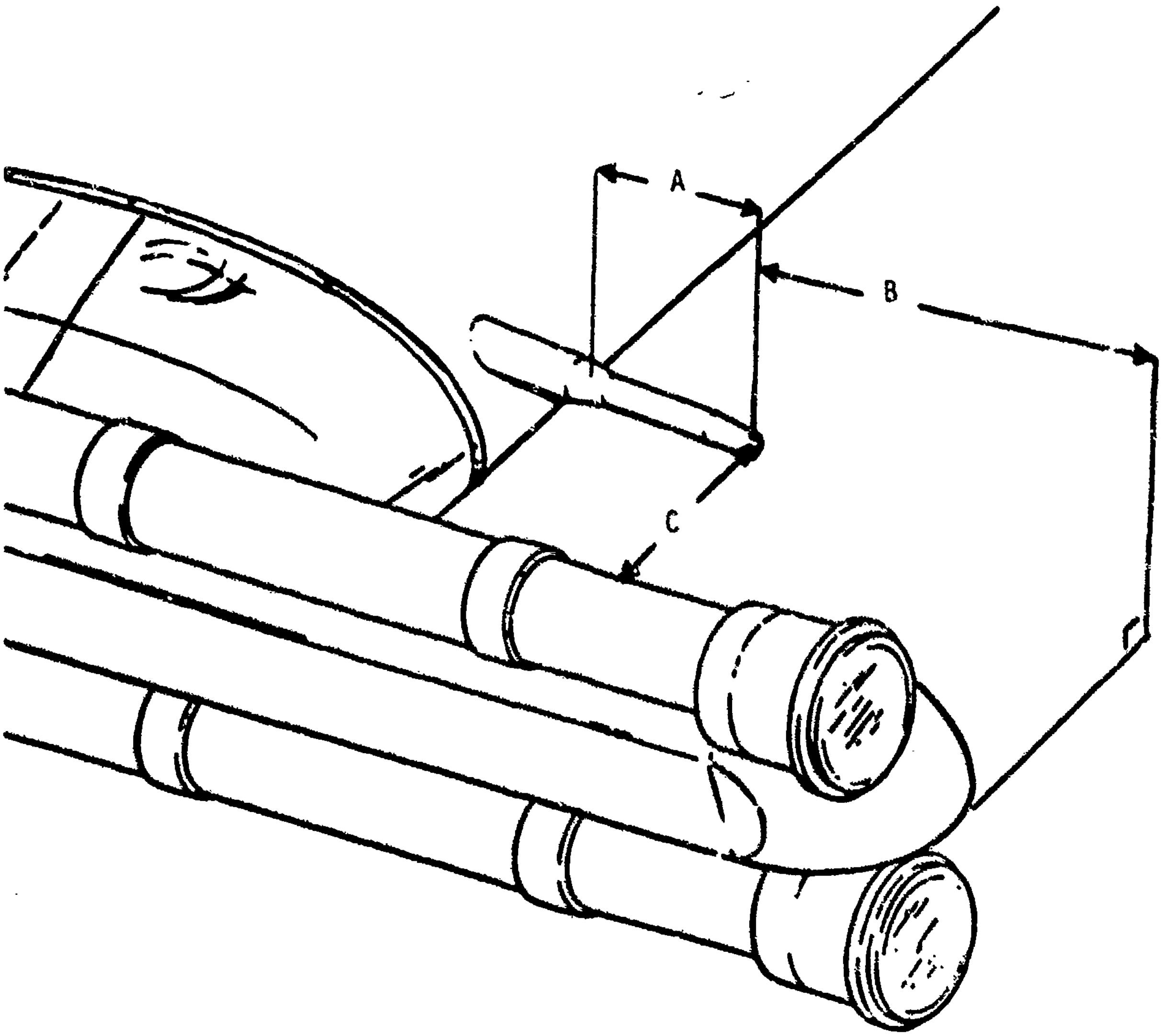


Figure B-16. Pilot Head Clearances to Launcher/Missiles

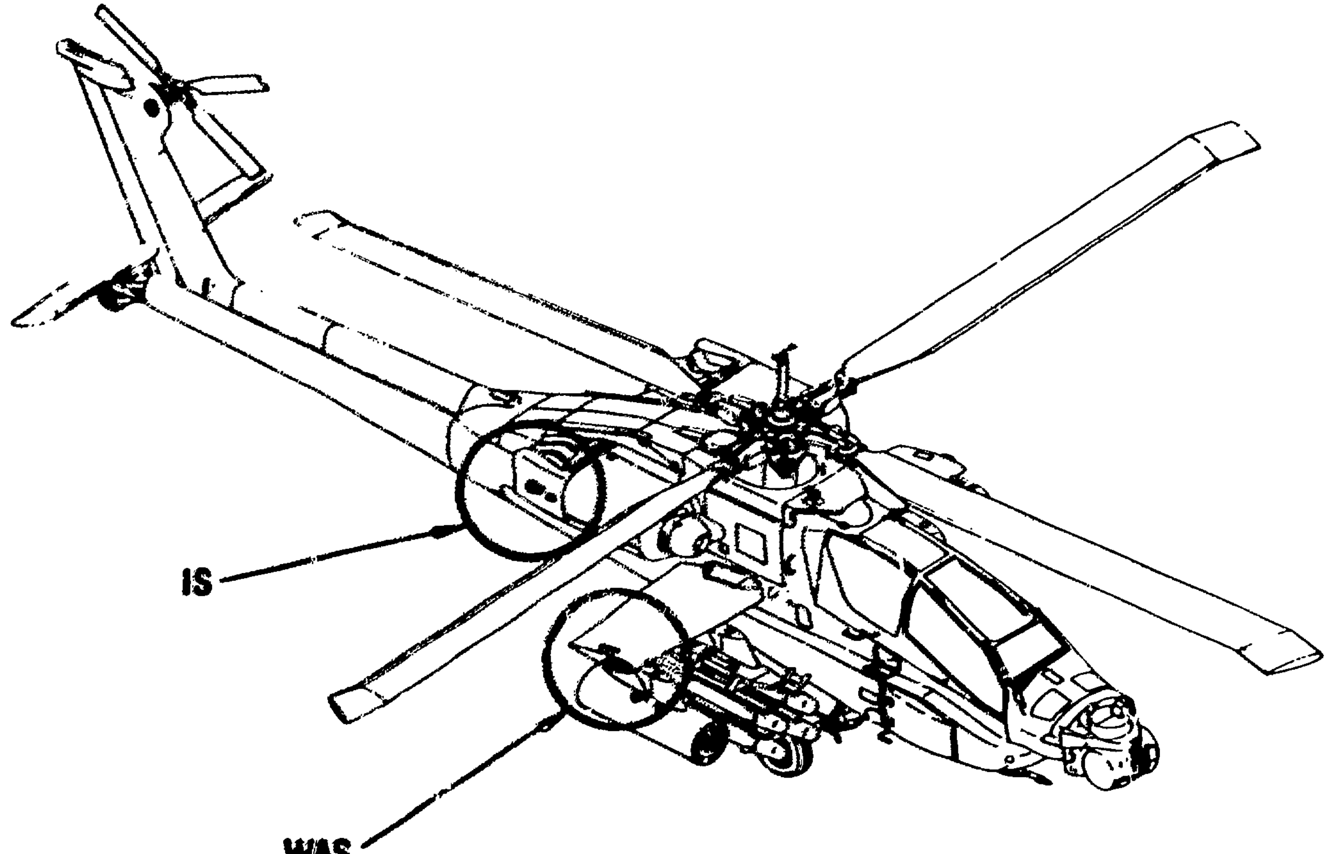


Figure B-17. Repositioned External Lighting

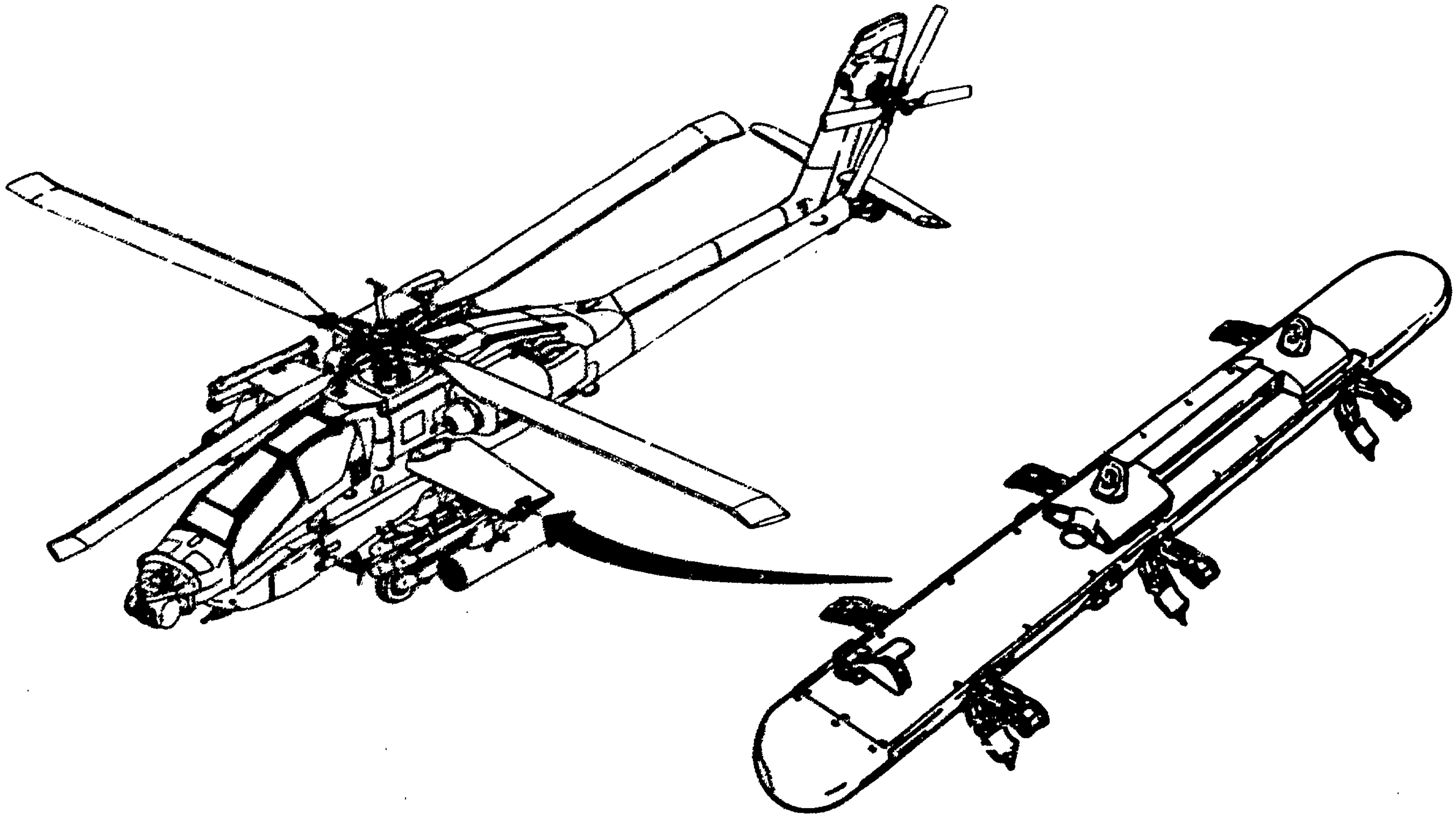


Figure B-18. Air-to-Air Stinger Launcher

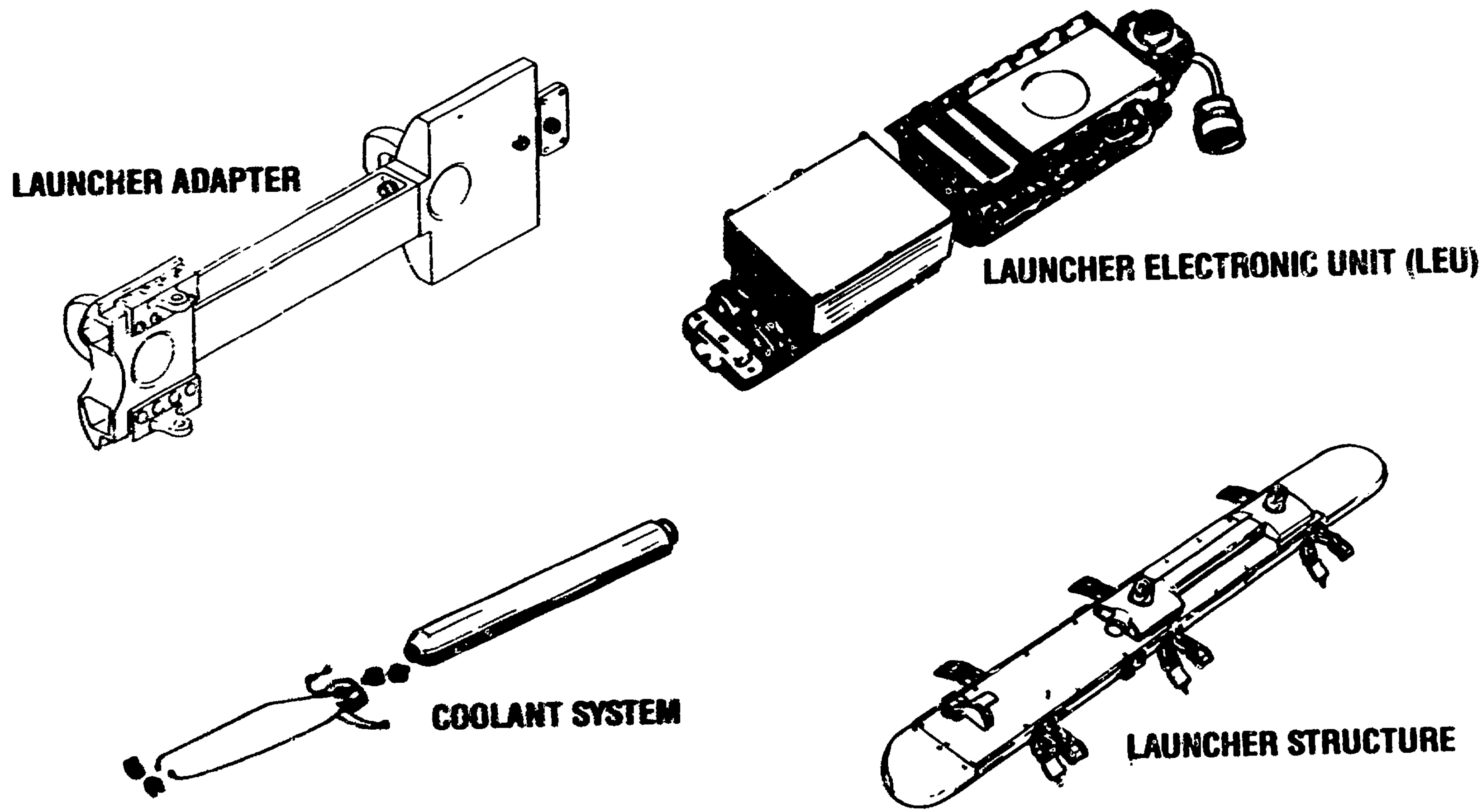


Figure B-19. Air-to-Air Stinger Launcher Components

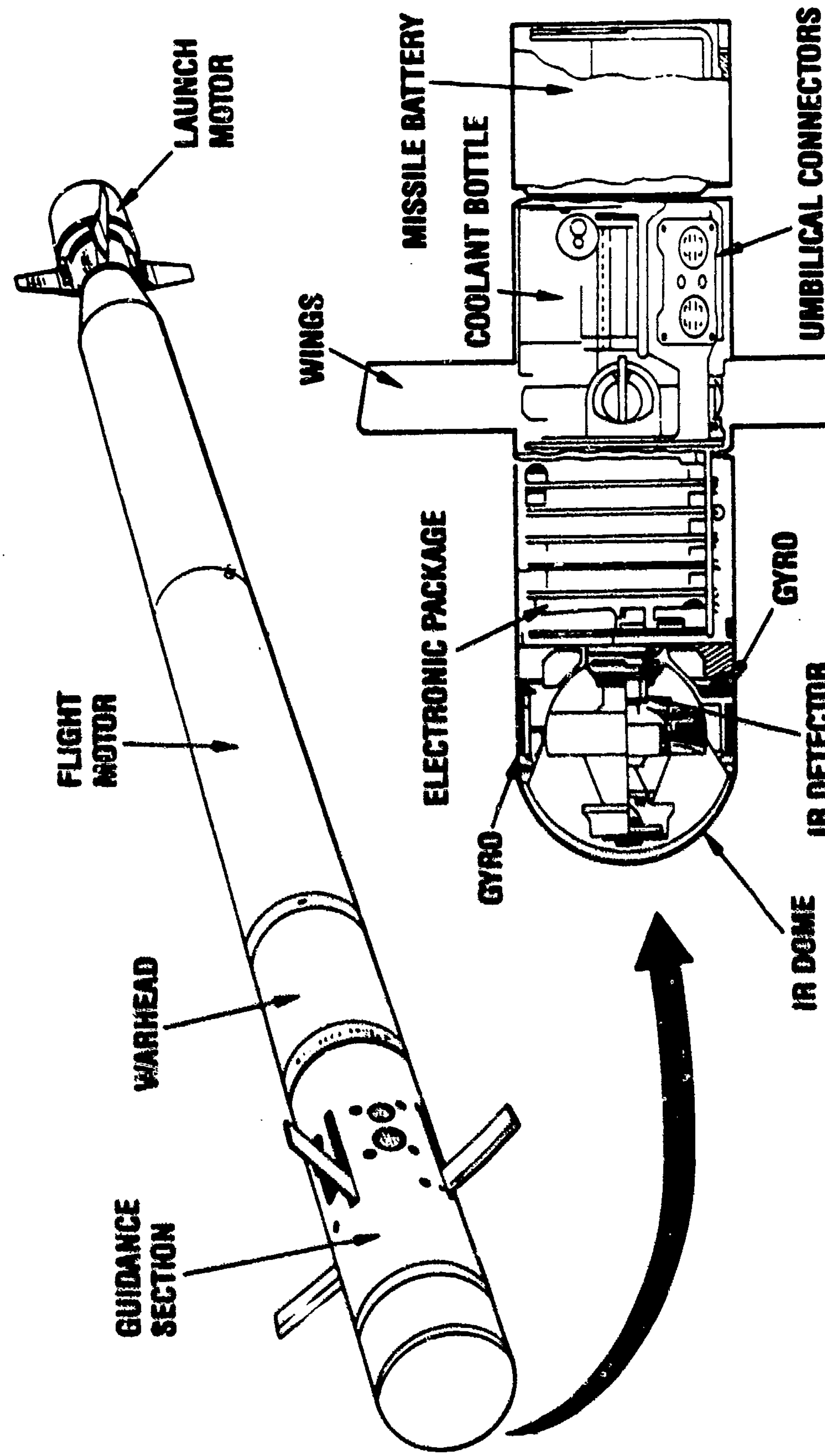


Figure B-20. Stinger Missile Guidance Head

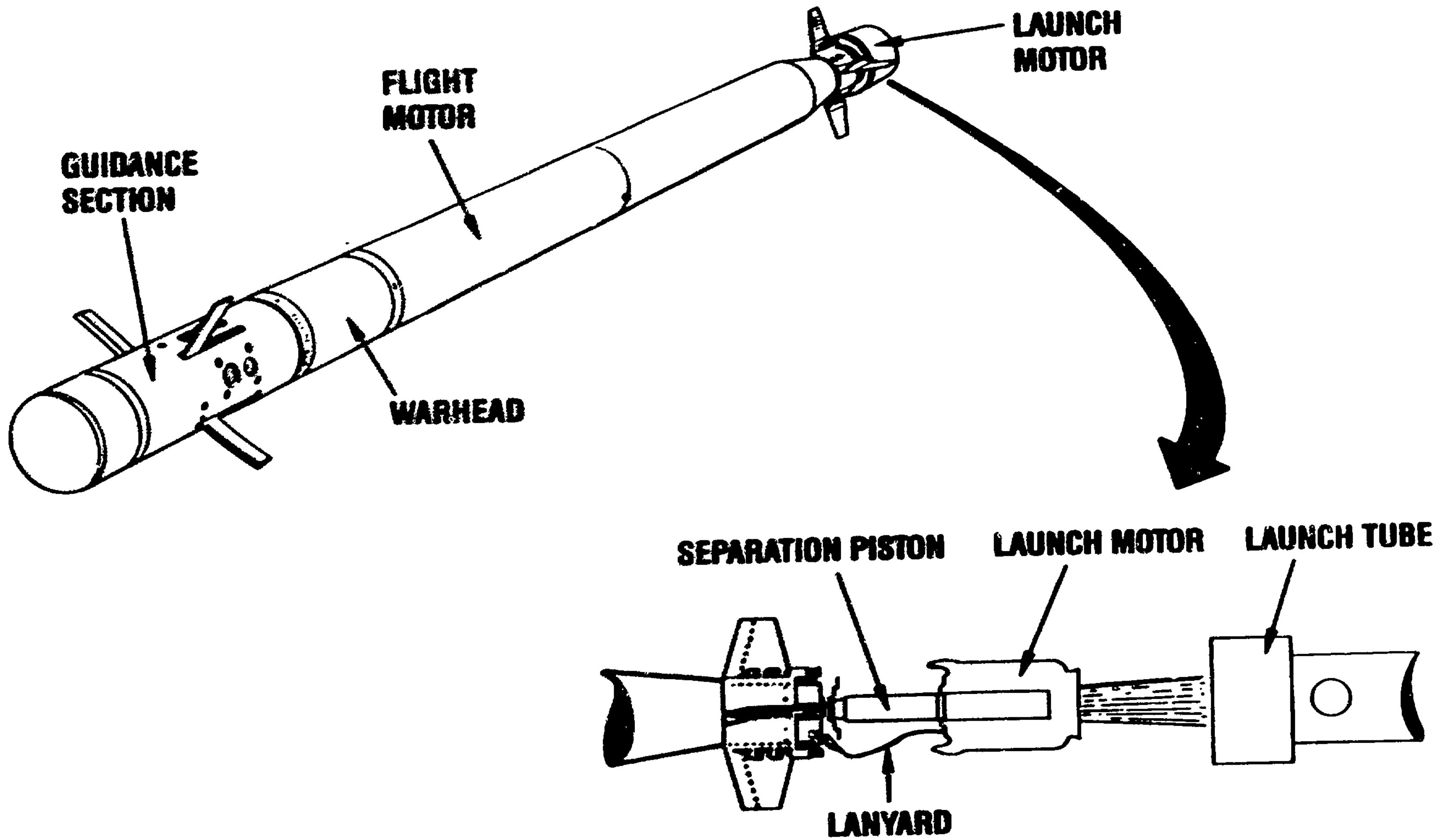


Figure B-21. Stinger Missile Launch Motor

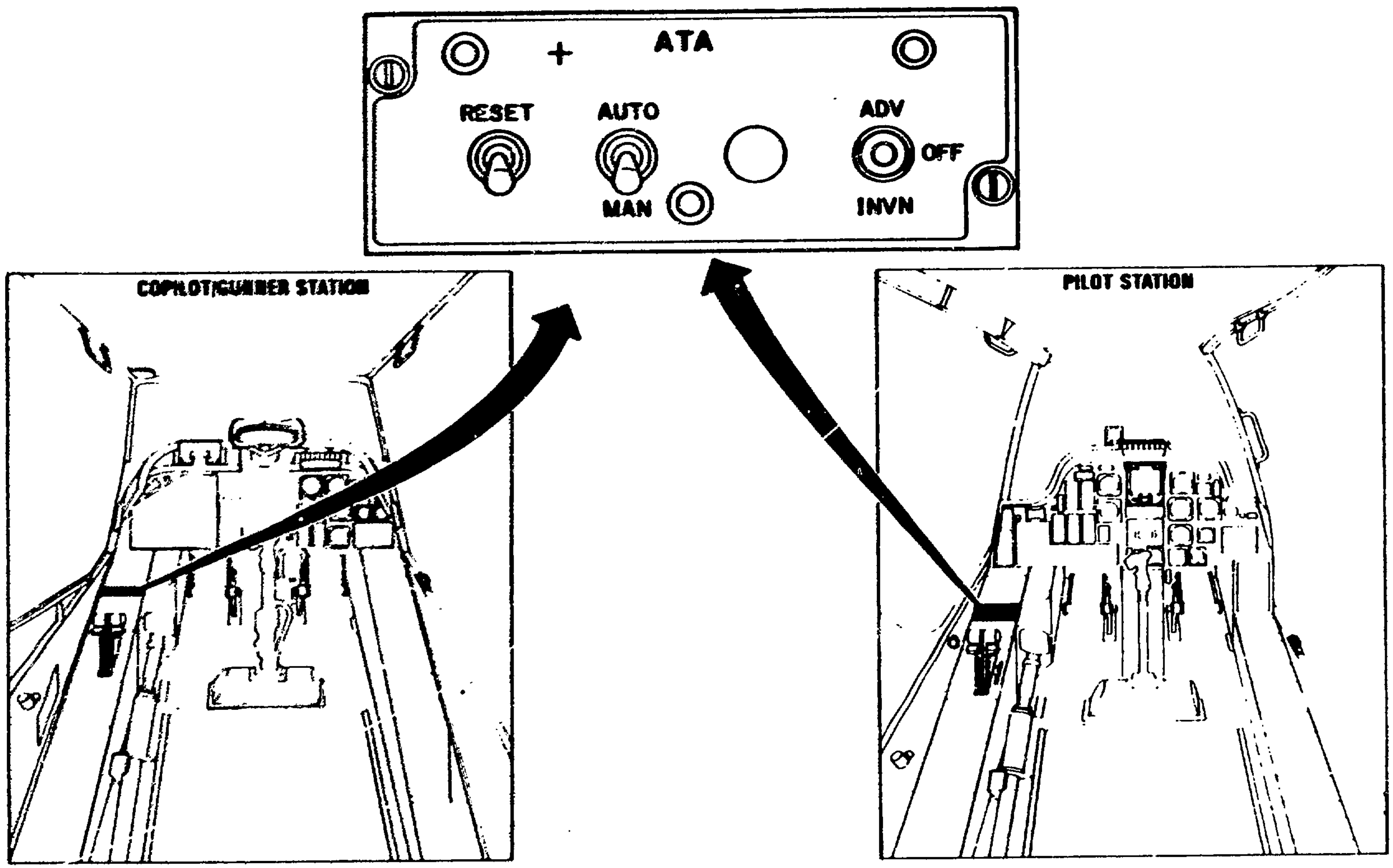


Figure B-22. Air–to–Air Control Panel

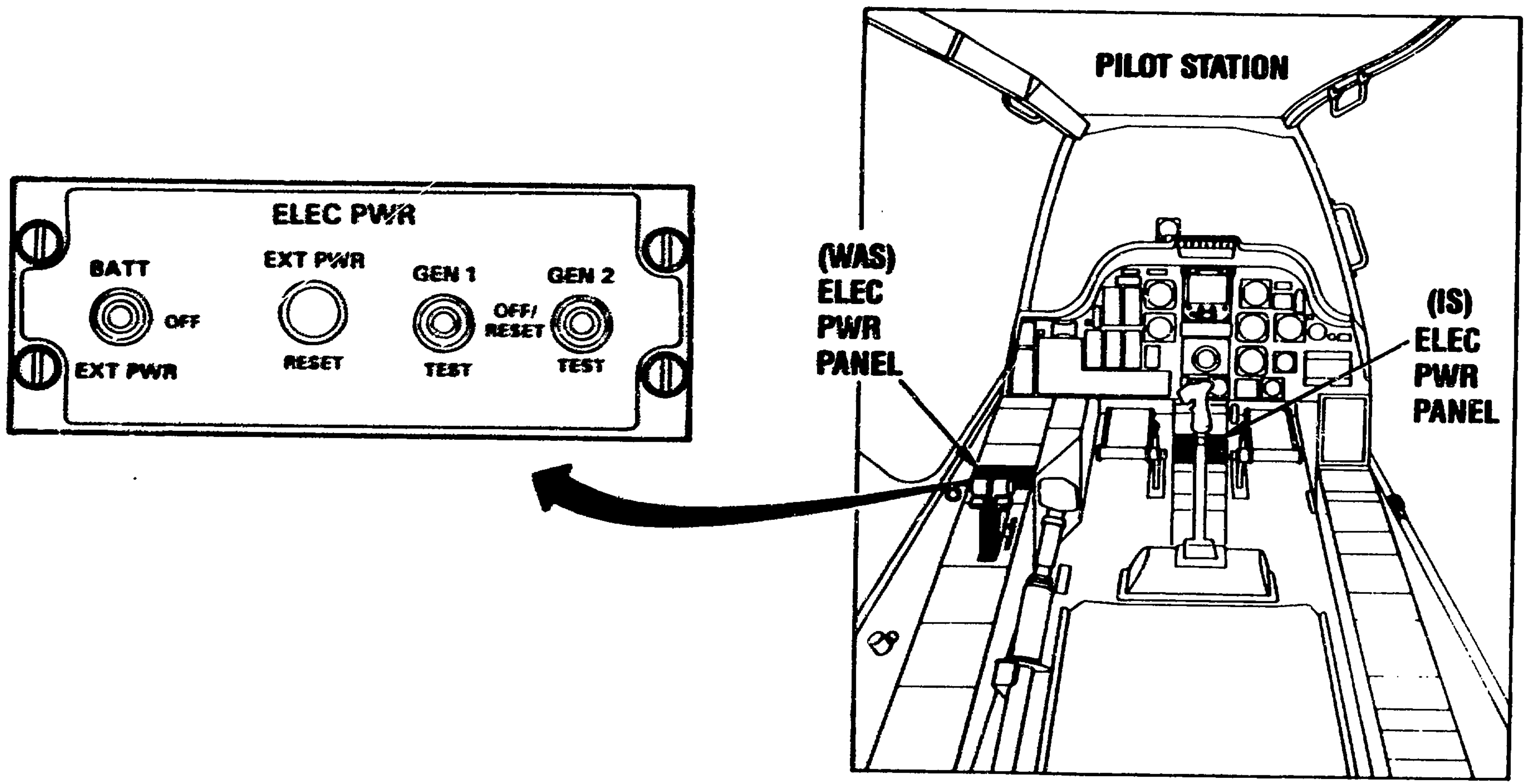


Figure B-23. Repositioned Electrical Power Panel

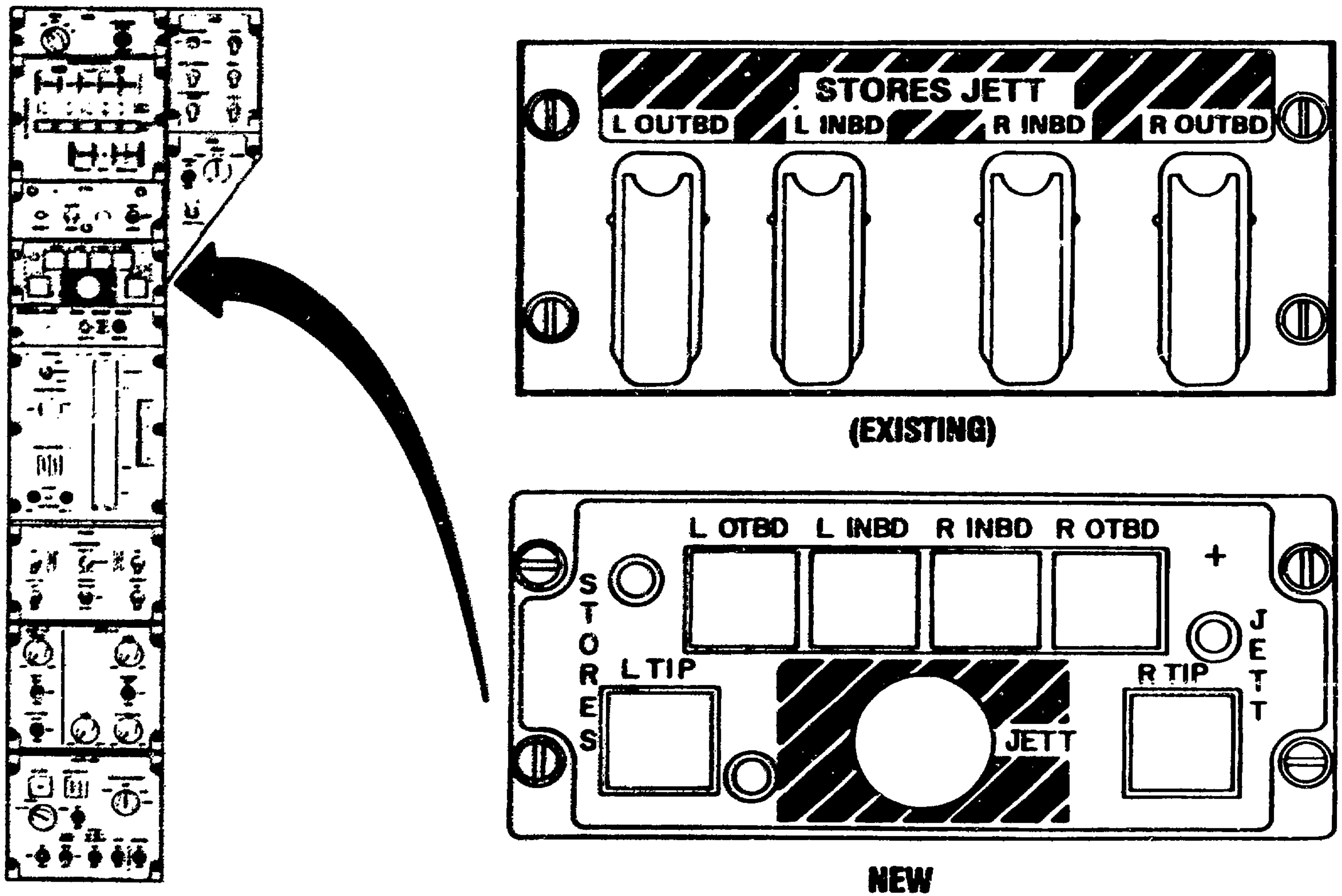


Figure B-24. Revised Wing Stores Jettison Panel

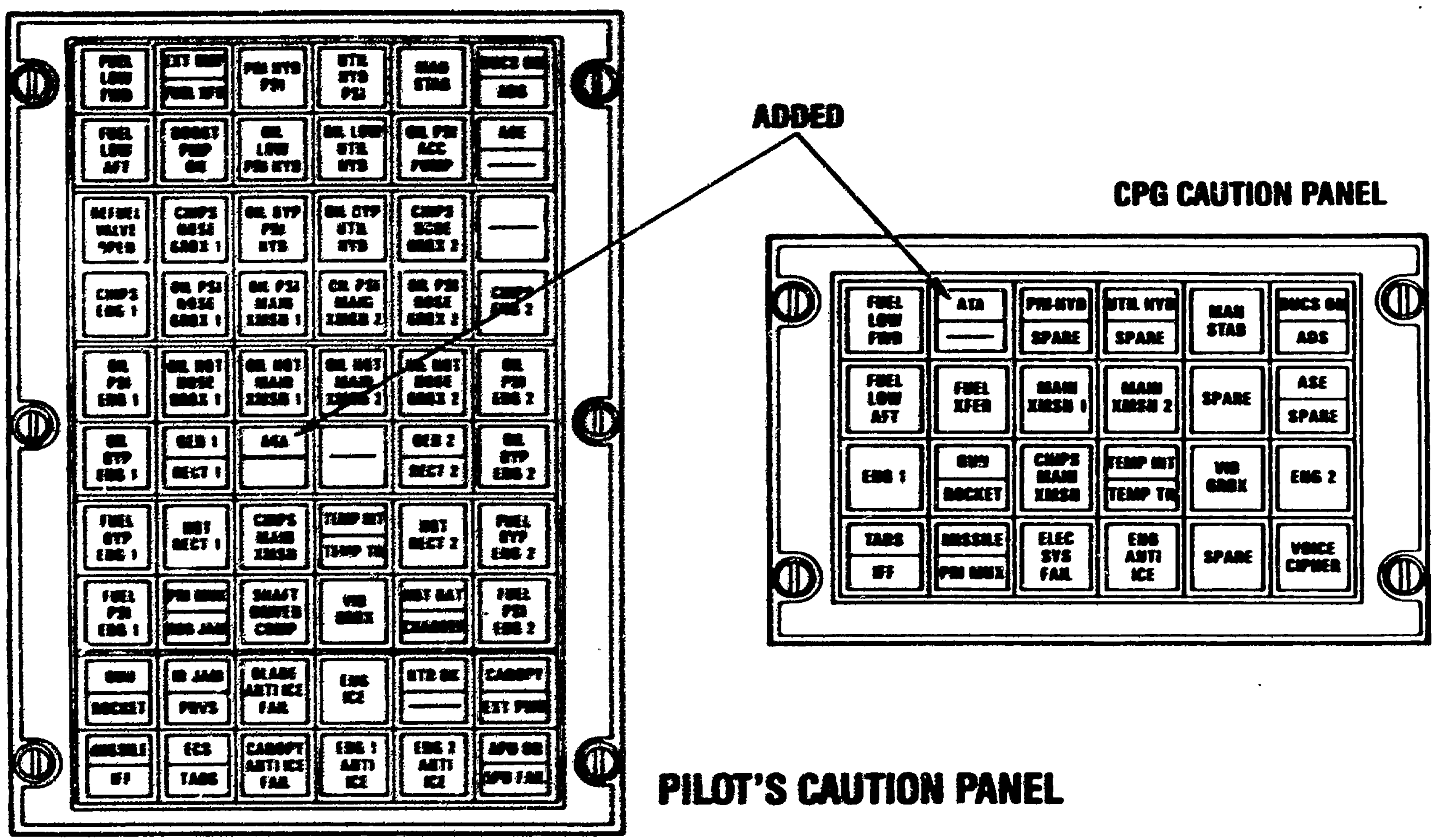


Figure B-25. Revised Caution/Warning Panels

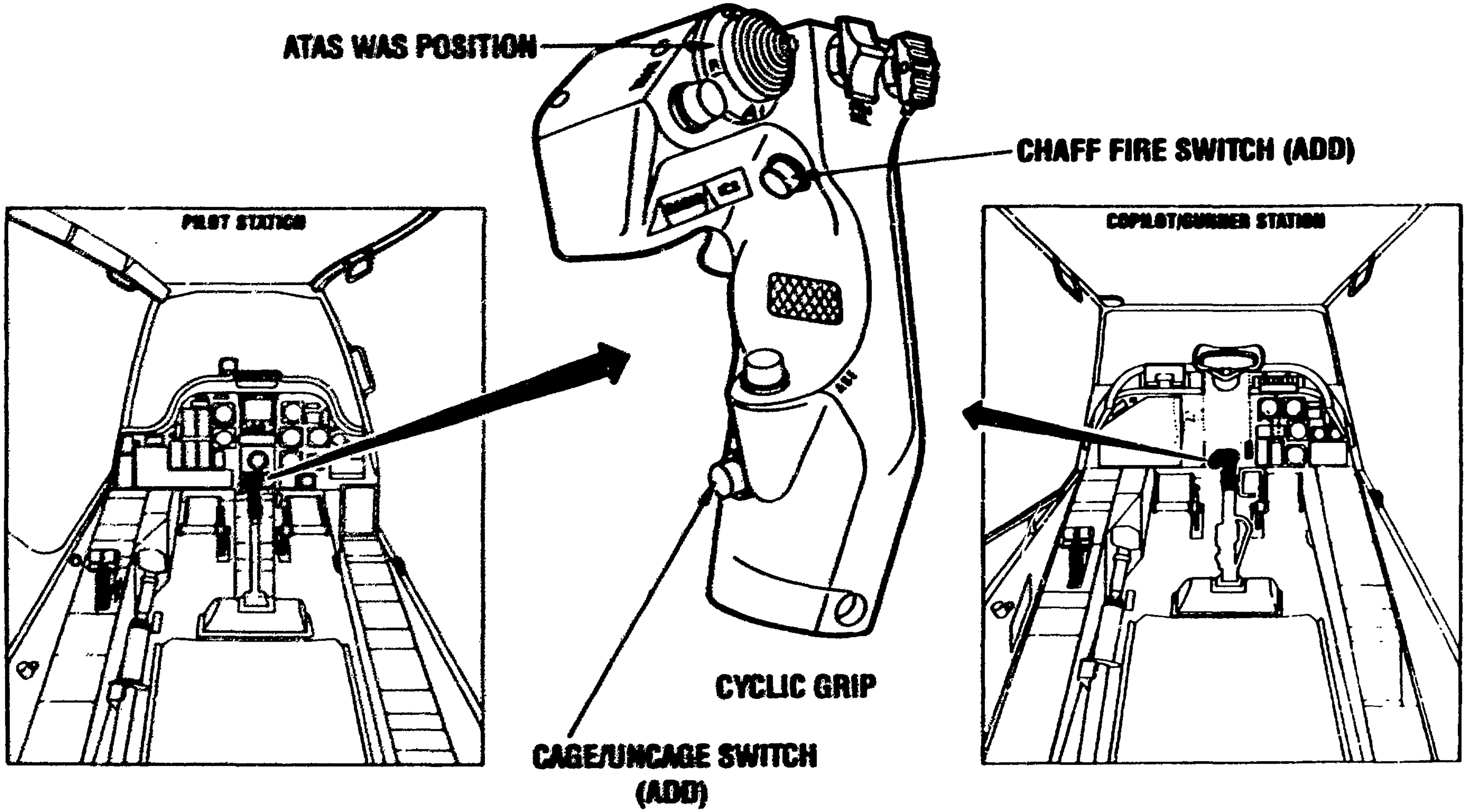


Figure B-26. Revised Cyclic Grips

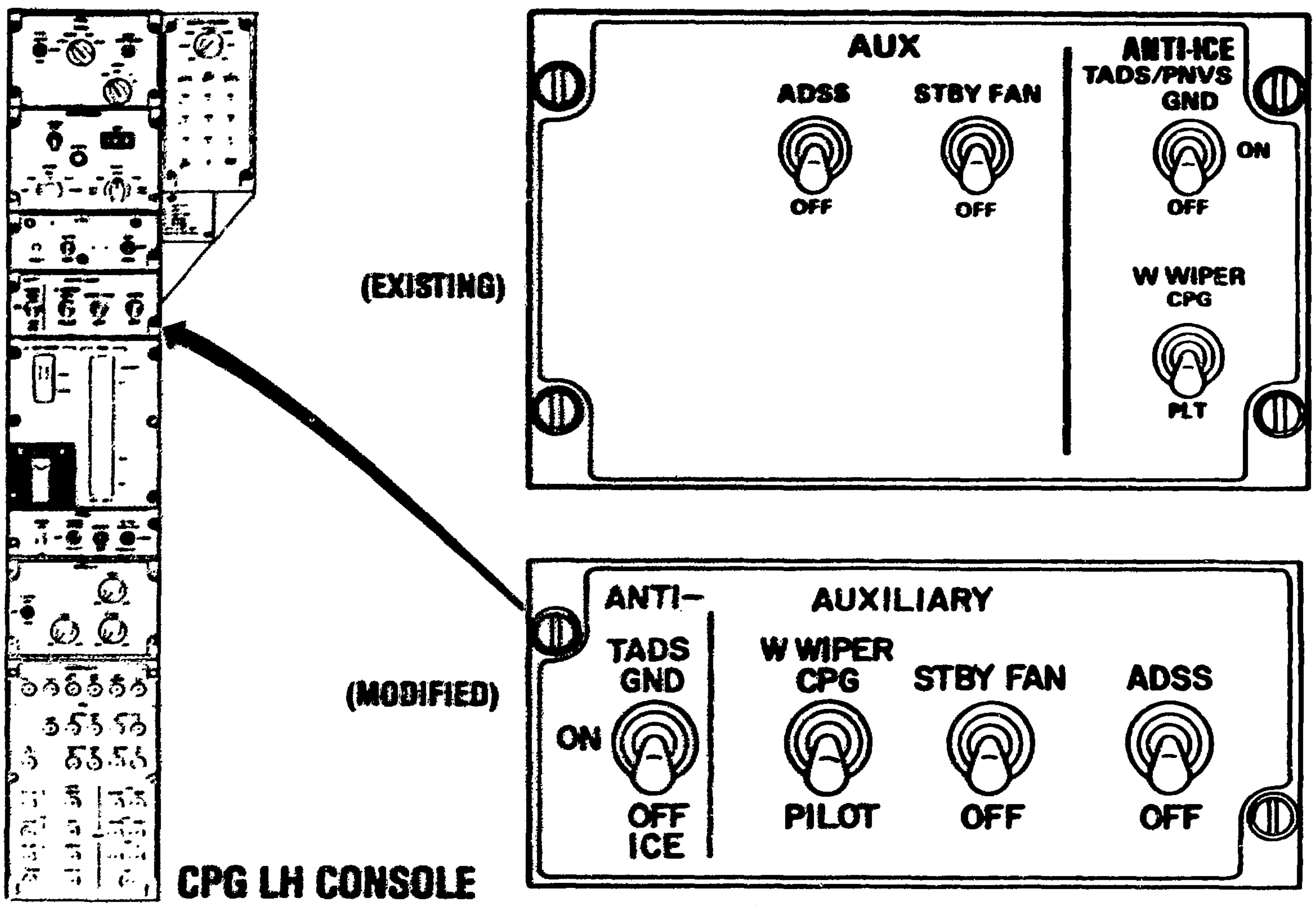


Figure B-27. Modified Anti-Ice Panel

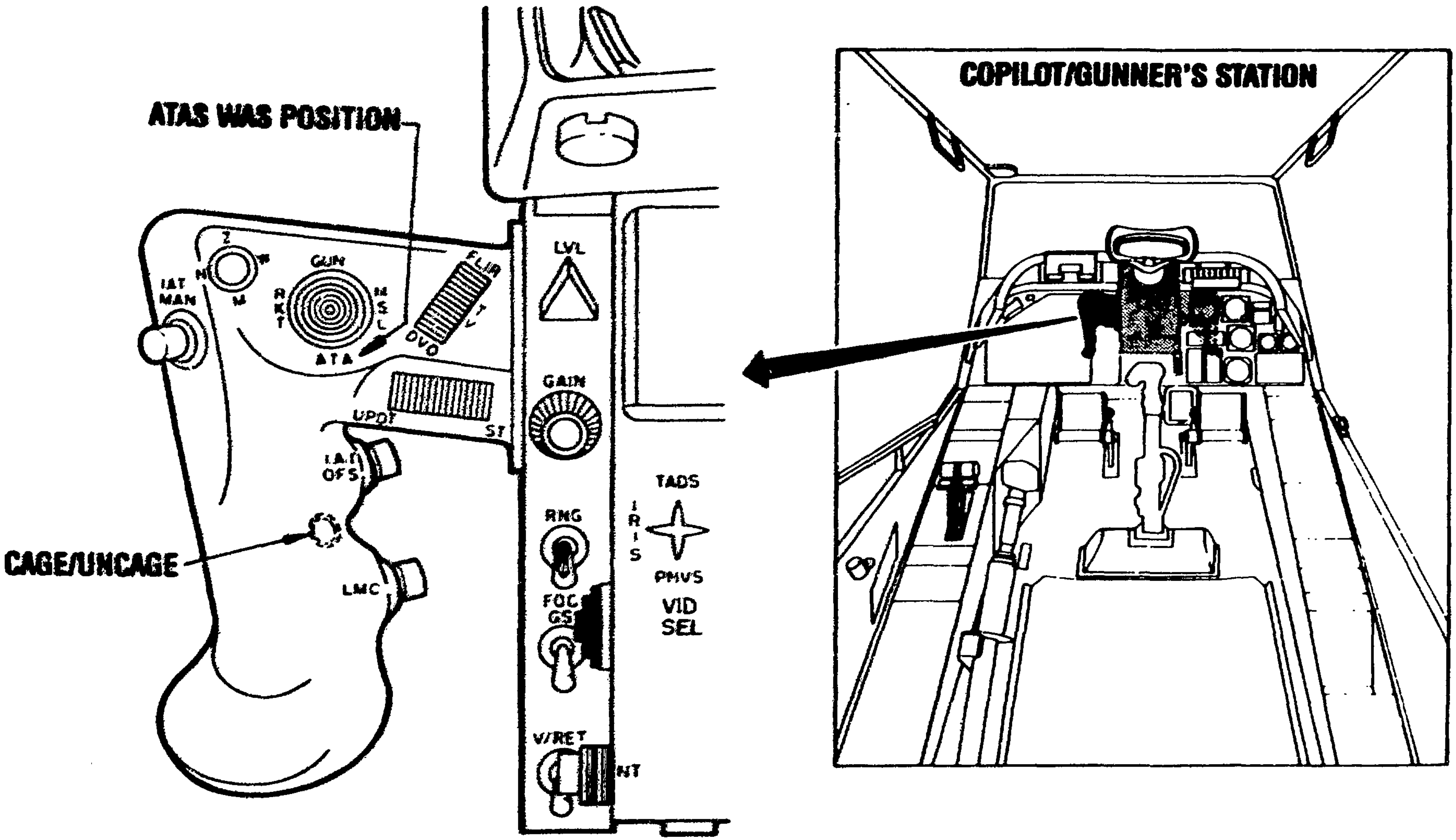
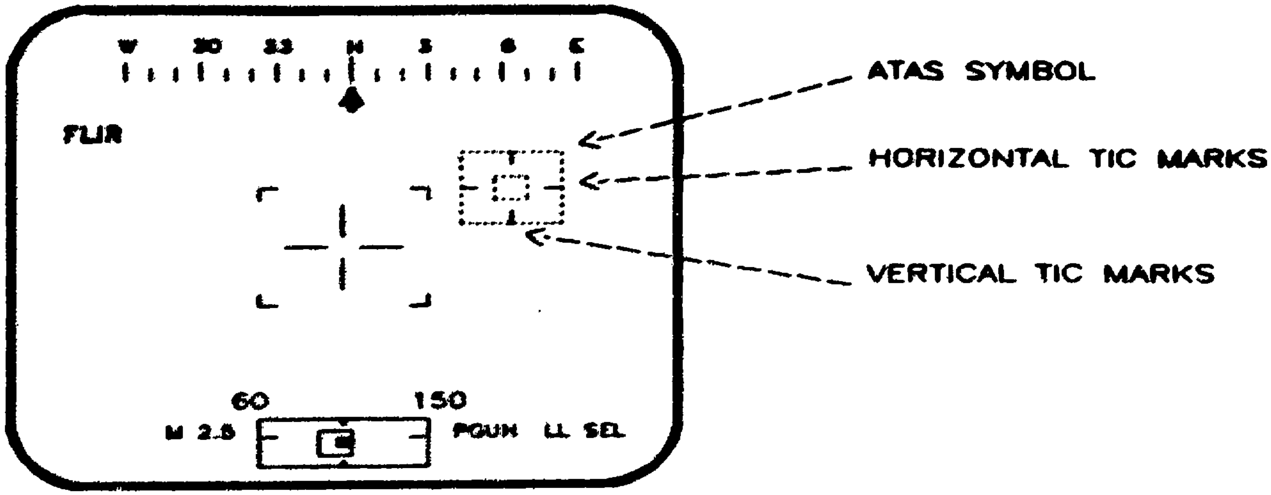


Figure B-28. Modified Optical Relay Tube Left Handgrip



- ATAS SYMBOL

  Uses HELLFIRE boxes
  - LOAL – Inner box
  - LOBL – Outer box

  Box Position
  - Sight LOS
  - Missile Seeker Position

  Coded Launch Constraints
  - Dashed outer – not in launch constraints
  - Solid outer – in launch constraints
  - Dashed inner – ATAS system not armed
  - Solid inner – ATAS system armed

- HORIZONTAL TIC MARKS

  Optimum firing position
  - Altitude
  - Missile seeker LOS
  - Fixed Range

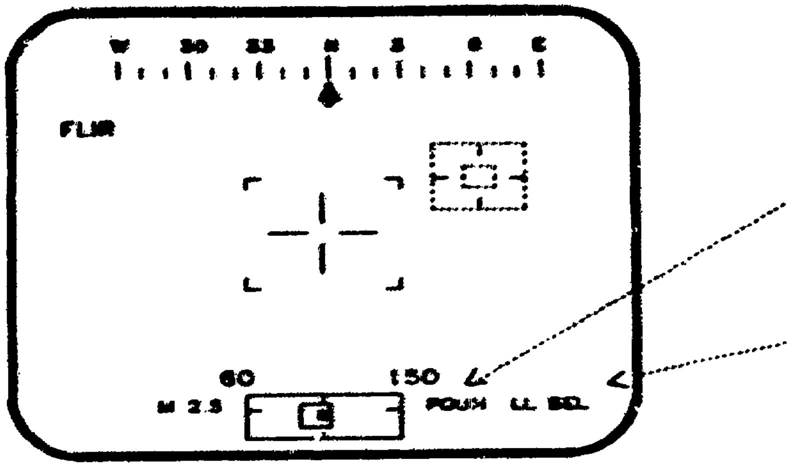
  Display range of 20 degrees

- VERTICAL TIC MARKS

  Optimum firing position
  - Missile seeker LOS
  - Fixed azimuth of 0 degrees

  Display range of 20 degrees

Figure B-29. CPG Air-to-Air Stinger Sighting Symbology



- o WEAPONS STATUS (CPG & PLT DISPLAY)

n ATA	Inventory display
SIGHT?	No sight selected
ATA LNCH	ATAS missile launch in progress
BIT IN... PROGRESS	ATAS BIT in progress
ATA FAIL	ATAS subsystem failure
xx RDY	selected missile (xx) ready
xx SEL	missile (xx) selected

n = 1 to 4 missiles
xx= LL,UL,LR,UR

- o OPPOSITE CREWSTATION WEAPON CONTROL

PATA	Pilot has ATA (CPG display only)
CATA	CPG has ATA (PLT display only)

Figure B-30. Air-to-Air Stinger Weapon Status Messages, High Action Display

ATAS MISSILE SYSTEM INHIBITS TO LAUNCH

SAFETY CONSTRAINTS

1. ARM INDICATE "IS CLEAR"
2. READY INDICATE "IS CLEAR"
3. VERIFY UNCAGE "IS CLEAR"
4. SIGHT SEL "IS IN" STBY
5. HELLFIRE MSL LAUNCH IN PROGRESS
6. ROCKET LAUNCH IN PROGRESS

PERFORMANCE CONSTRAINTS

7. MSL SEEKER EL > ±15 DEGREES
8. MSL SEEKER AZ > ±15 DEGREES

AIRCRAFT MANEUVERING LIMITS FOR ATAS LAUNCH

ANGLE	ATTITUDE	RATE
PITCH	± 30°	± 30°/ SEC
ROLL	±90°	± 60°/ SEC
YAW	—	± 50°/ SEC

FORWARD AIRSPEED ≥ 140 KNOTS
LATERAL AIRSPEED ≥ − 45, ≤ 45 KNOTS
NORMAL ACCELERATION ≤ 0.8 g
VERTICAL VELOCITY ≥ −1800, ≤ 1800 FT/MIN

Figure B-31. Safety and Performance Firing Constraints and Maneuvering Limits

APPENDIX C. INSTRUMENTATION

1. The test instrumentation system was installed, calibrated, and maintained by McDonnell Douglas Helicopter Company. An airborne data acquisition system utilizing pulse code modulation (PCM) encoding was employed during these tests. Data were obtained from calibrated instrumentation and were recorded on magnetic tape and/or displayed in the cockpit. The PCM data were telemetered to a ground station from which in-flight data was monitored. An instrumentation boom was mounted on the aircraft extending 52 inches forward of the nose. A pitot-static tube, an angle of attack sensor, and an angle of sideslip sensor were mounted on the boom. Slip ring assemblies were installed on the main and tail rotor shafts.

2. The location of instrumentation and related special equipment for aircraft USA S/N 82-23355 is presented in figure C-1. The instrumentation configuration and system block diagram for aircraft USA S/N 86-8944 are presented in figure C-1 and C-2.

3. PCM parameters recorded on magnetic tape were as follows:

Airspeed (boom system)
Altitude (boom system)
Airspeed (ship system, pilot station)
Airspeed (ship system, copilot/gunner station)
Altitude (ship system, pilot station)
Altitude (ship system, copilot/gunner station)
True airspeed
Total air temperature
Main rotor speed
Engine torque*
Engine fuel flow*
Engine gas generator speed*
Engine power turbine speed*
Engine measured gas temperature*
Main rotor drive shaft torque
Tail rotor drive shaft torque
Control positions
- Longitudinal cyclic
- Lateral cyclic
- Directional
- Collective

Angle of attack
Angle of sideslip
Aircraft attitudes
- Pitch
- Roll
- Yaw

Aircraft angular rates
- Pitch
- Roll
- Yaw

Center of gravity normal acceleration
Horizontal stabilator incidence angle

*Both engines

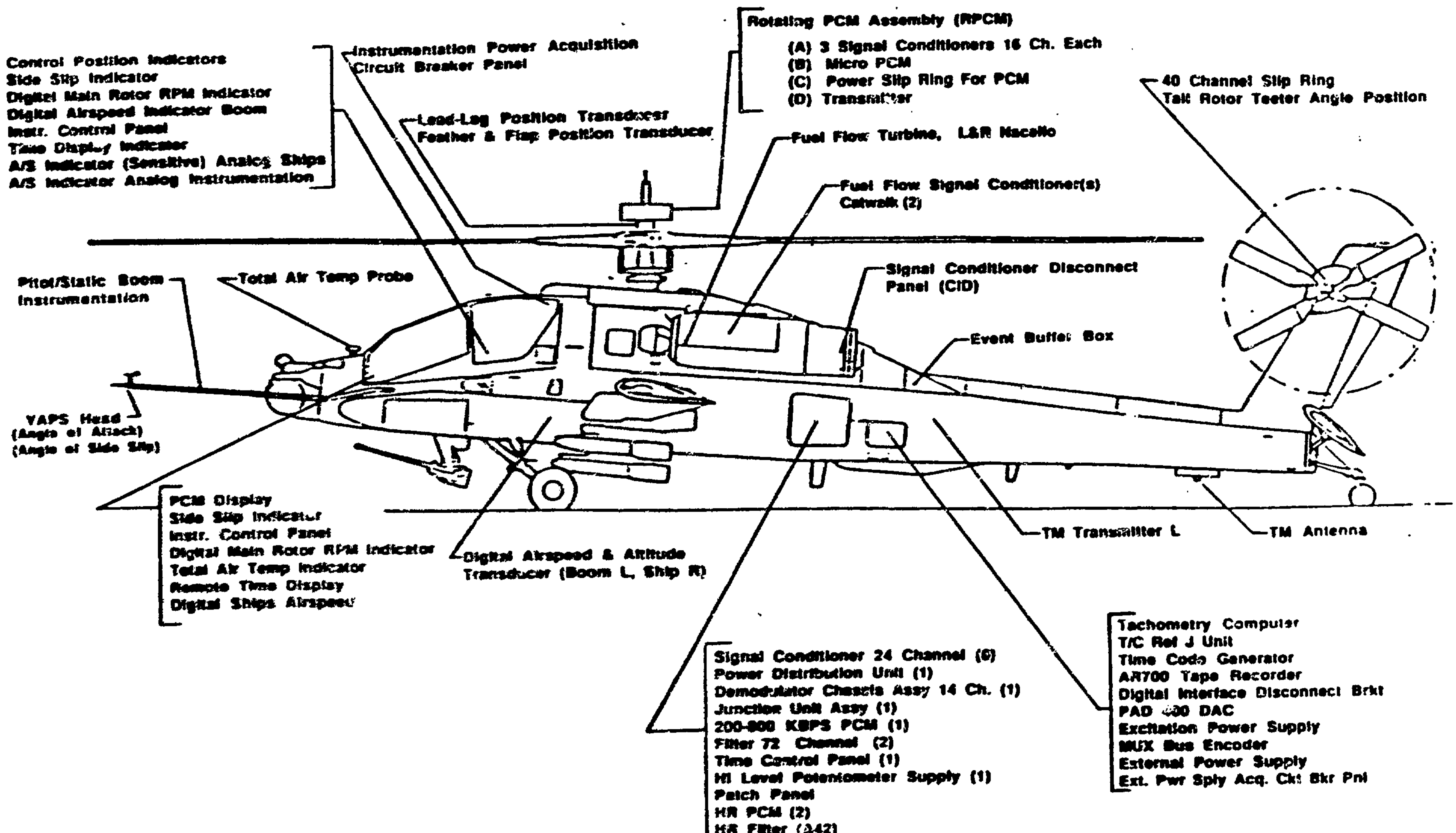


Figure C-1. Instrumentation, USA S/N 82-23355

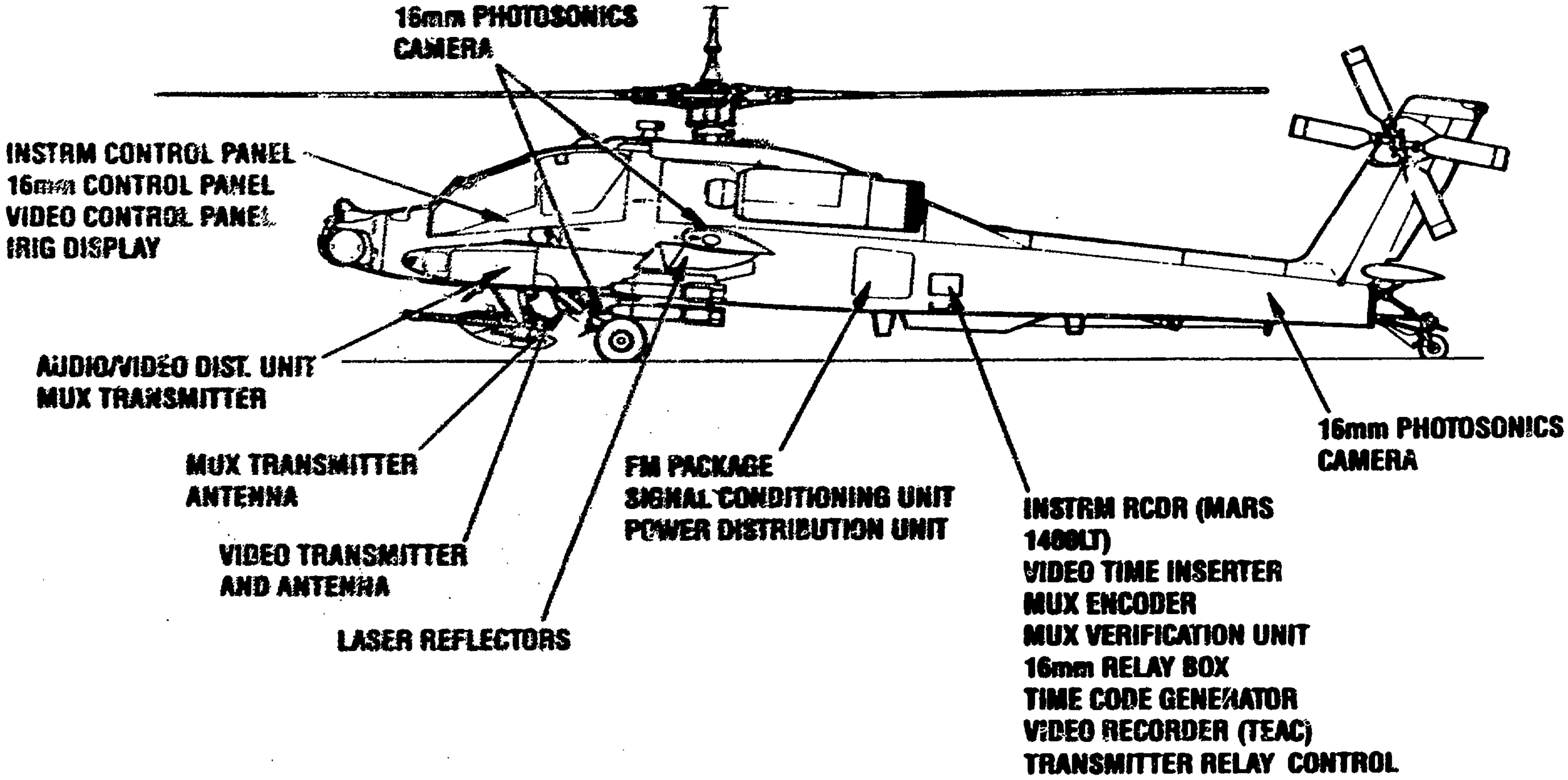


Figure C-2. Instrumentation Configuration, USA S/N 86-8944

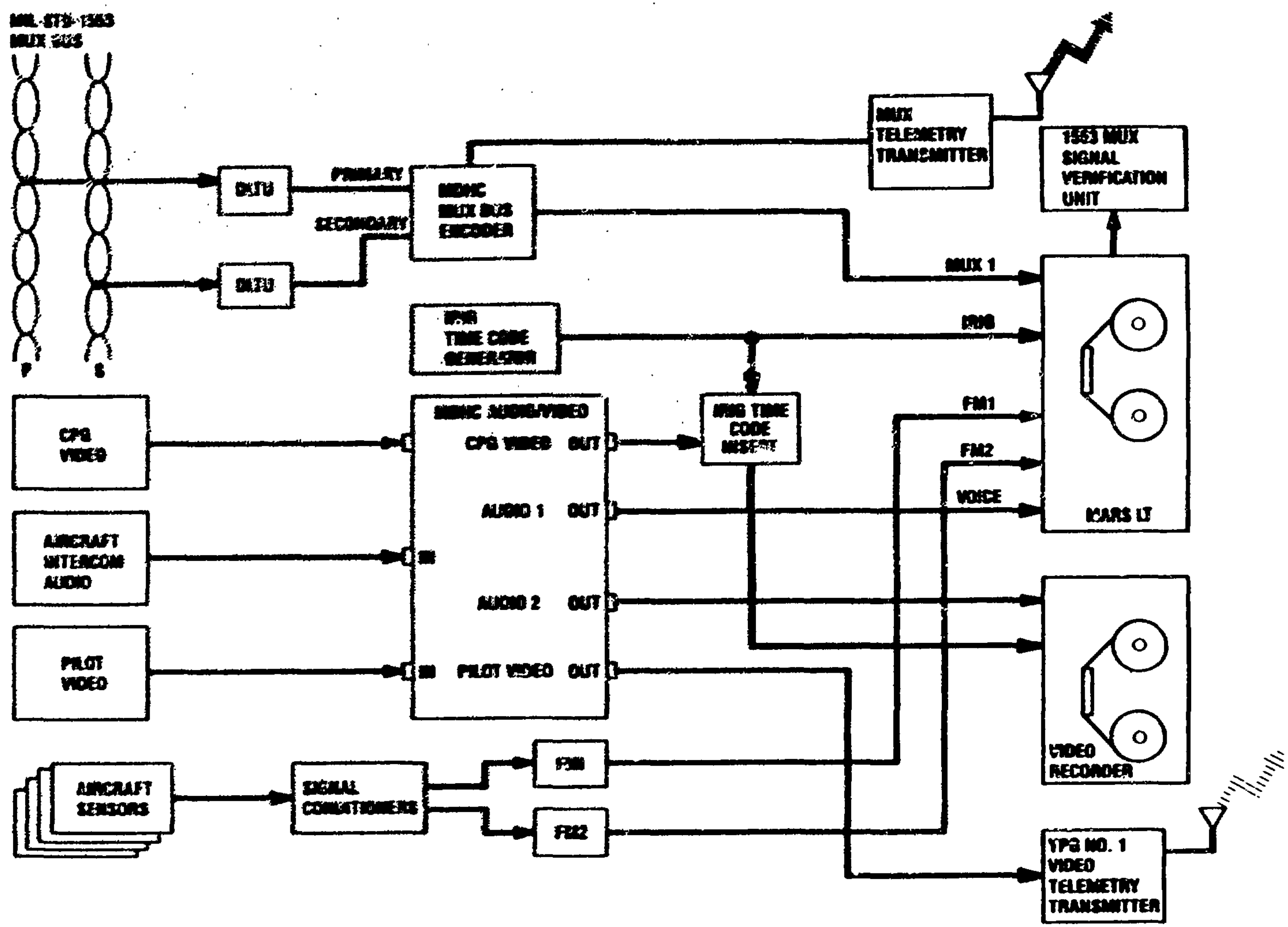


Figure C-3. Instrumentation Block Diagram, USA S/N 86-8944

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

AIRCRAFT RIGGING

1. Prior to the start of testing, a flight controls rigging check was performed by McDonnell Douglas Helicopter Company and monitored by the U.S. Army Aviation Engineering Flight Activity. The stabilator control system was also checked to ensure compliance with the production stabilator schedule.

AIRCRAFT WEIGHT AND BALANCE

2. The first phase aircraft (USA S/N 82-23355) was weighed in the Air-to-Air (ATAS)/8-Hellfire configuration, as instrumented for test, with full oil, residual fuel after draining, and ballast required for the test. In this configuration the aircraft weighed 13,530 pounds with a longitudinal center of gravity at fuselage station 209.0. The second phase aircraft (USA S/N 86-8944) had a basic weight of 13,208 pounds, which included: the ATAS system with four missiles, eight Hellfire missiles and launchers, two rocket launchers, and 208 pounds of ballast in the main landing gear cross tube to offset the weight of the aft loaded instrumentation. The longitudinal center of gravity was at fuselage station 207.7.

HANDLING QUALITIES

3. Handling qualities data were evaluated using standard test methods described in Naval Air Test Center Flight Test Manual, FTM No. 105 (ref 9). A Handling Qualities Rating Scale (fig. D-1) was used to augment pilot comments relative to aircraft handling qualities. Low speed flight tests were conducted using a ground pace vehicle as an airspeed reference.

CONTROLLABILITY

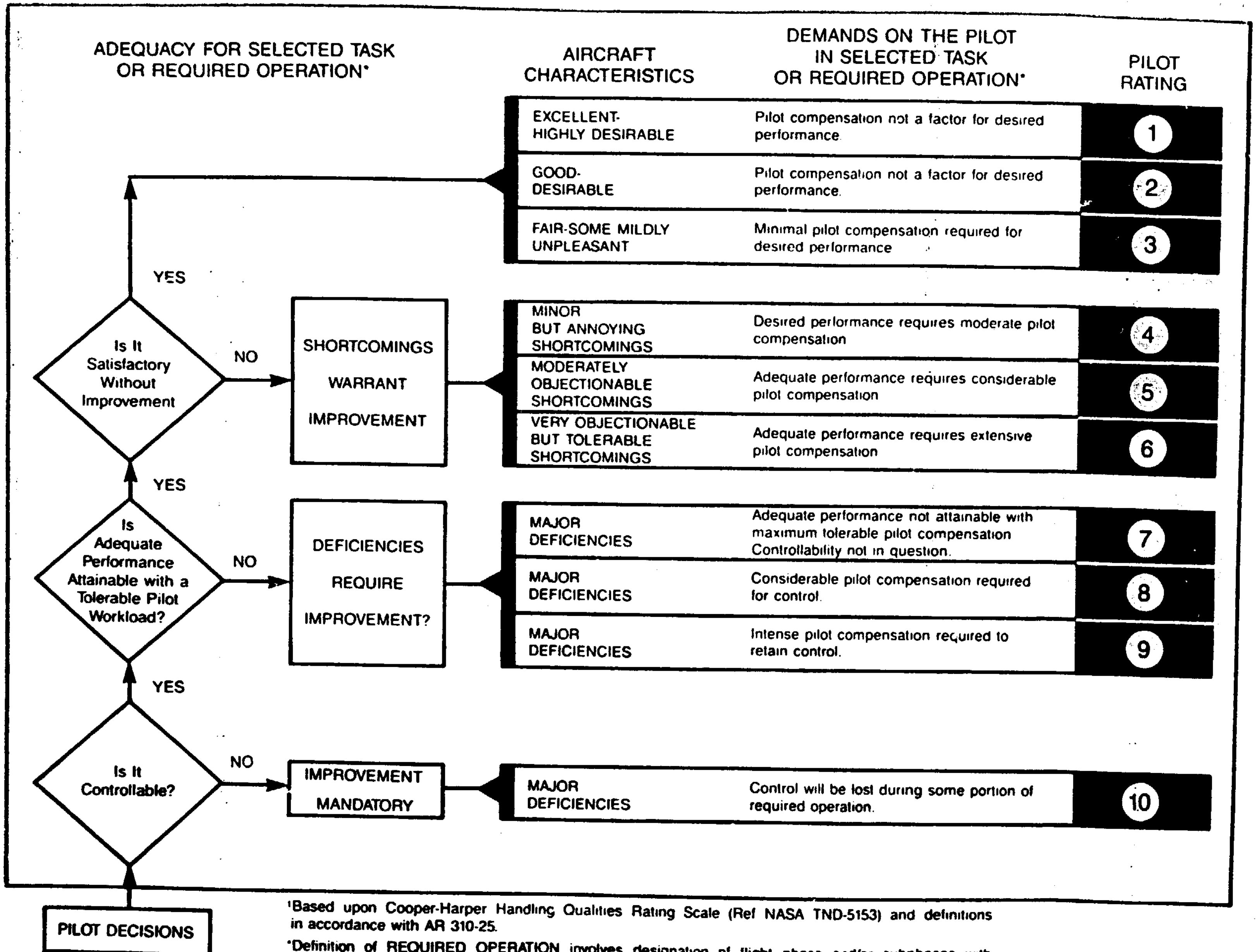
4. Controllability data were evaluated by graphical analysis of aircraft attitude, angular rate and acceleration time histories in each axis (fig. D-2). The initial time reference for all step inputs was the start of the control input for measuring the attitude change after one second (0.5 second in the lateral axis) and the time to maximum acceleration. The time to 63 percent maximum rate, however, was measured from the initial moment that the rate began to change as a result of the step input. It is because of this offset in the initial time reference that the time to 63 percent maximum rate is usually less than the time to maximum acceleration instead of longer, as would be expected if the initial time reference was the same.

VIBRATIONS

5. A Vibration Rating Scale (fig. D-3) was used to augment pilot comments relative to aircraft vibrations.

DEFINITION

6. **Shortcoming:** An imperfection or malfunction occurring during the life cycle of equipment which must be reported and which should be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the material or end product.



[1]Based upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) and definitions in accordance with AR 310-25.

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.

Figure D-1. Handling Qualities Rating

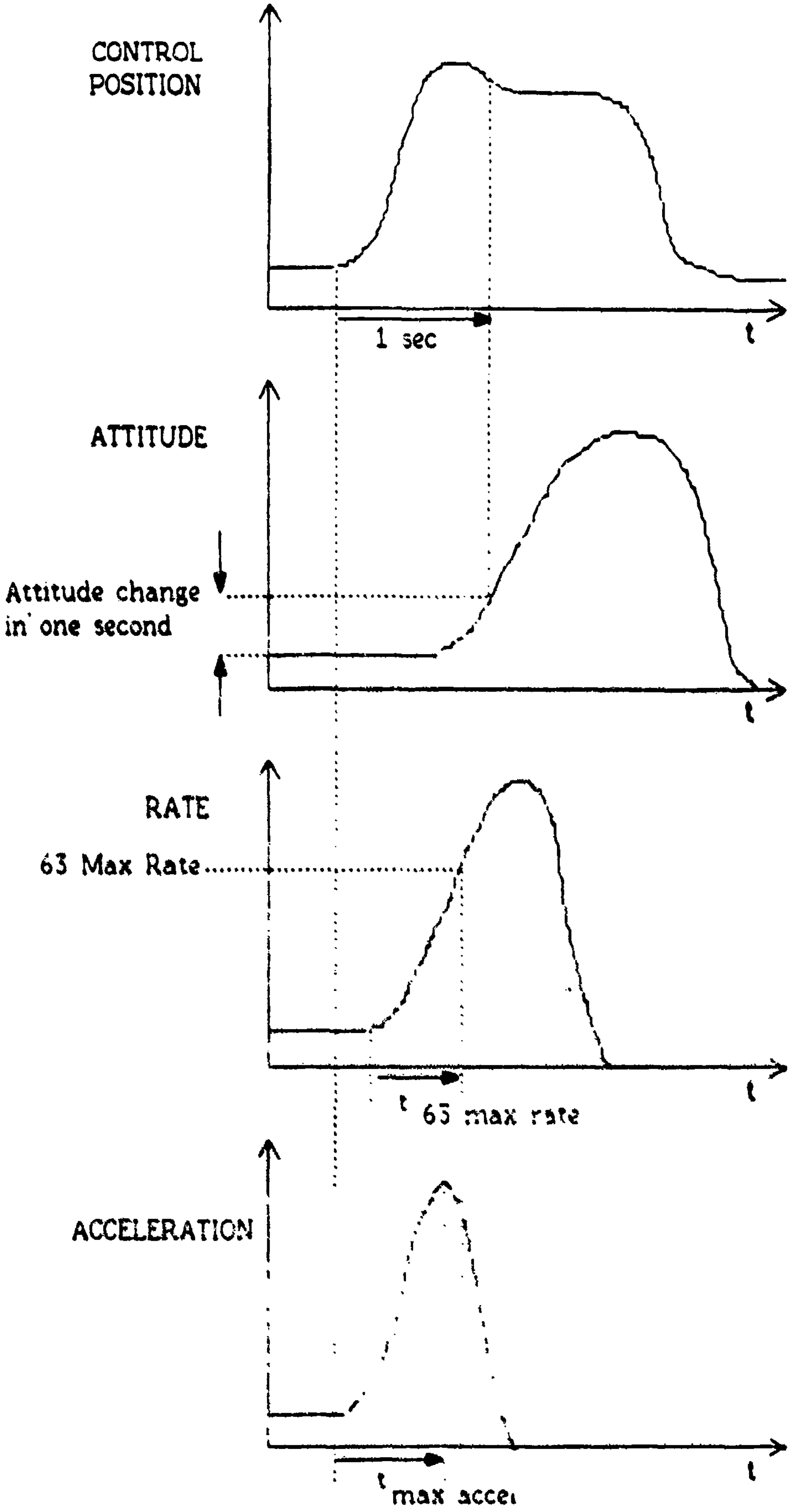


Figure D-2. Techniques for Determining Elements of Controllability

DEGREE OF VIBRATION	DESCRIPTION[1]	PILOT RATING
No vibration		0
Slight	Not apparent to experienced aircrew fully occupied by their tasks, but noticeable if their attention is directed to it or if not otherwise occupied.	1 2 3
Moderate	Experienced aircrew are aware of the vibration but it does not affect their work, at least over a short period.	4 5 6
Severe	Vibration is immediately apparent to experienced aircrew even when fully occupied. Performance of primary task is affected or tasks can only be done with difficulty.	7 8 9
Intolerable	Sole preoccupation of aircrew is to reduce vibration level.	10

[1]Based on the Subjective Vibration Assessment Scale developed by the Aeroplane and Armament Experimental Establishment, Boscombe Down, England.

Figure D-3. Vibration Rating Scale

APPENDIX E. TEST DATA

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	ATAS CONFIG
⊙	1[illegible]850	205.7 AFT	0.3 LT	6800	21.0	287	INSTLD
▲	14070	205.6 AFT	0.3 LT	5600	19.0	286	REMOVED
◆	14525	205.9 AFT	0.3 LT	6570	20.7	289	INSTLD (AUTO)

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. 8-HELLFIRE CONFIGURATION
3. FAIRED LINE REPRESENTS ATAS INSTALLED
4. AUTOROTATION PERFORMED AT 98 KCAS ONLY

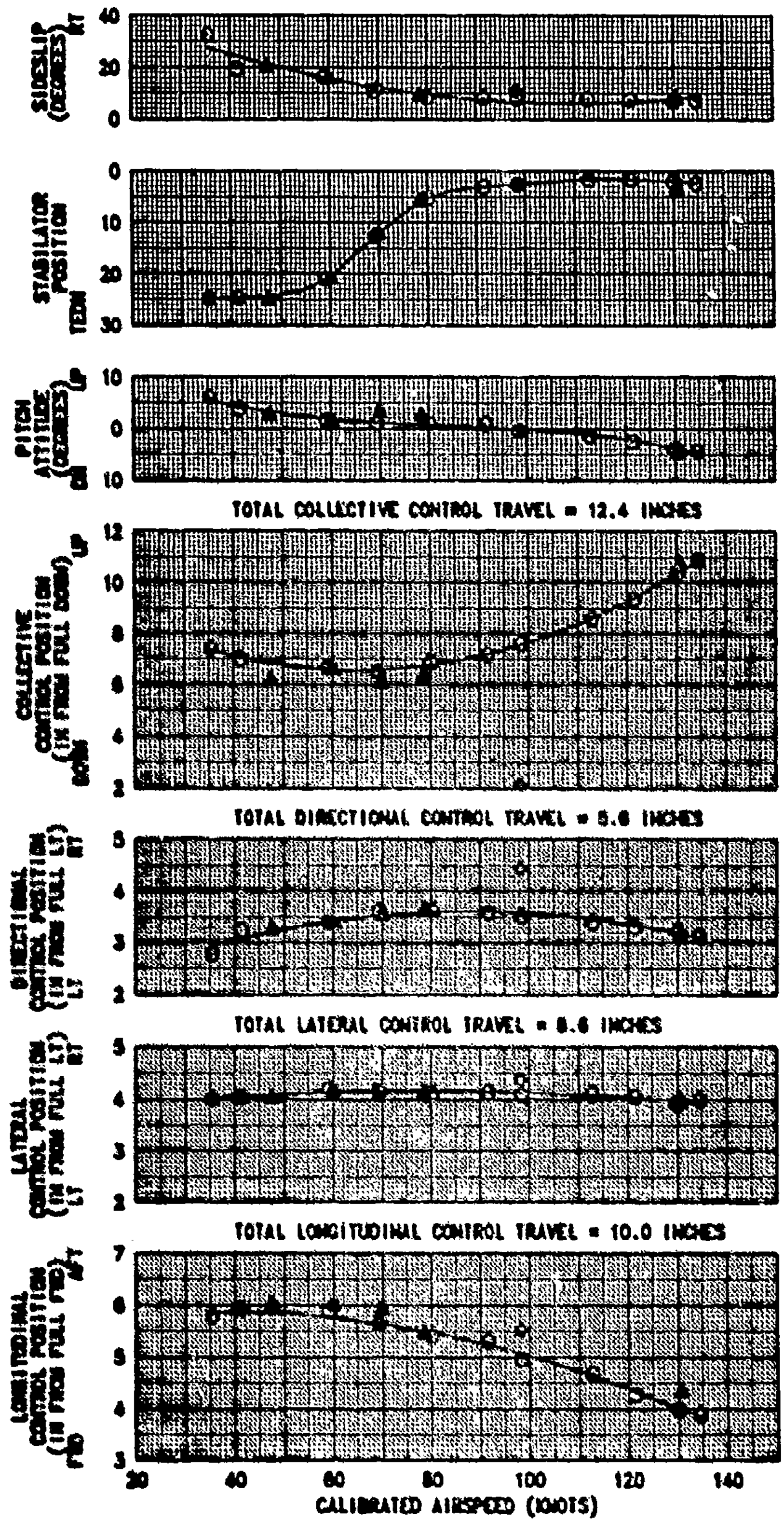


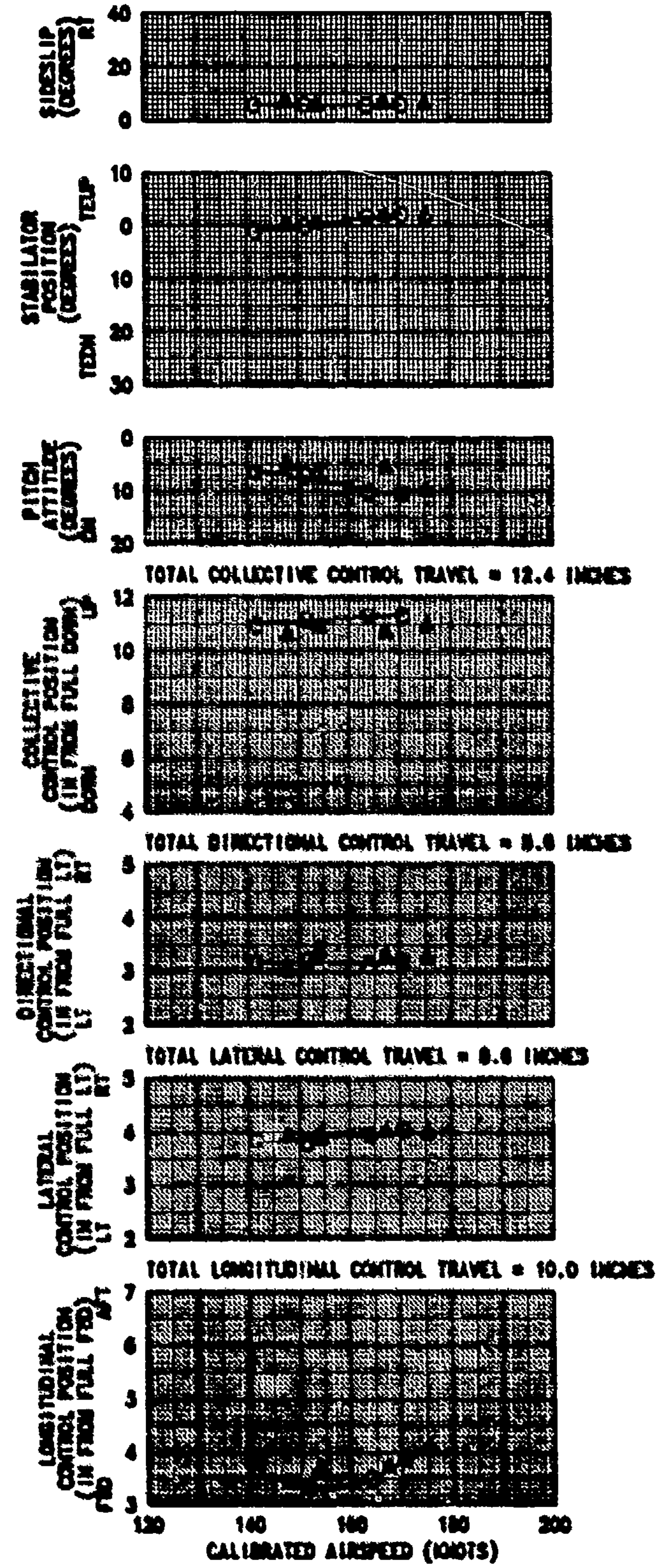
FIGURE E-2

CONTROL POSITIONS IN IRP DIVES

AH-64A USA S/N 82-23355

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	ATAS CONFIG
⊙	14870	205.8 AFT	0.3 LT	7240	19.5	287	INSTALLED
▲	15350	205.5 AFT	0.3 LT	6500	28.0	286	REMOVED

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. 8-HELLFIRE CONFIGURATION



AH-64A USA S/N 82-23355

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	ATAS CONFIG
⊙	14870	205.8 AFT	0.3 LT	7750	25.5	287	INSTALLED
▲	15350	203.5 AFT	0.3 LT	7750	28.0	286	REMOVED

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. 8-HELLFIRE CONFIGURATION

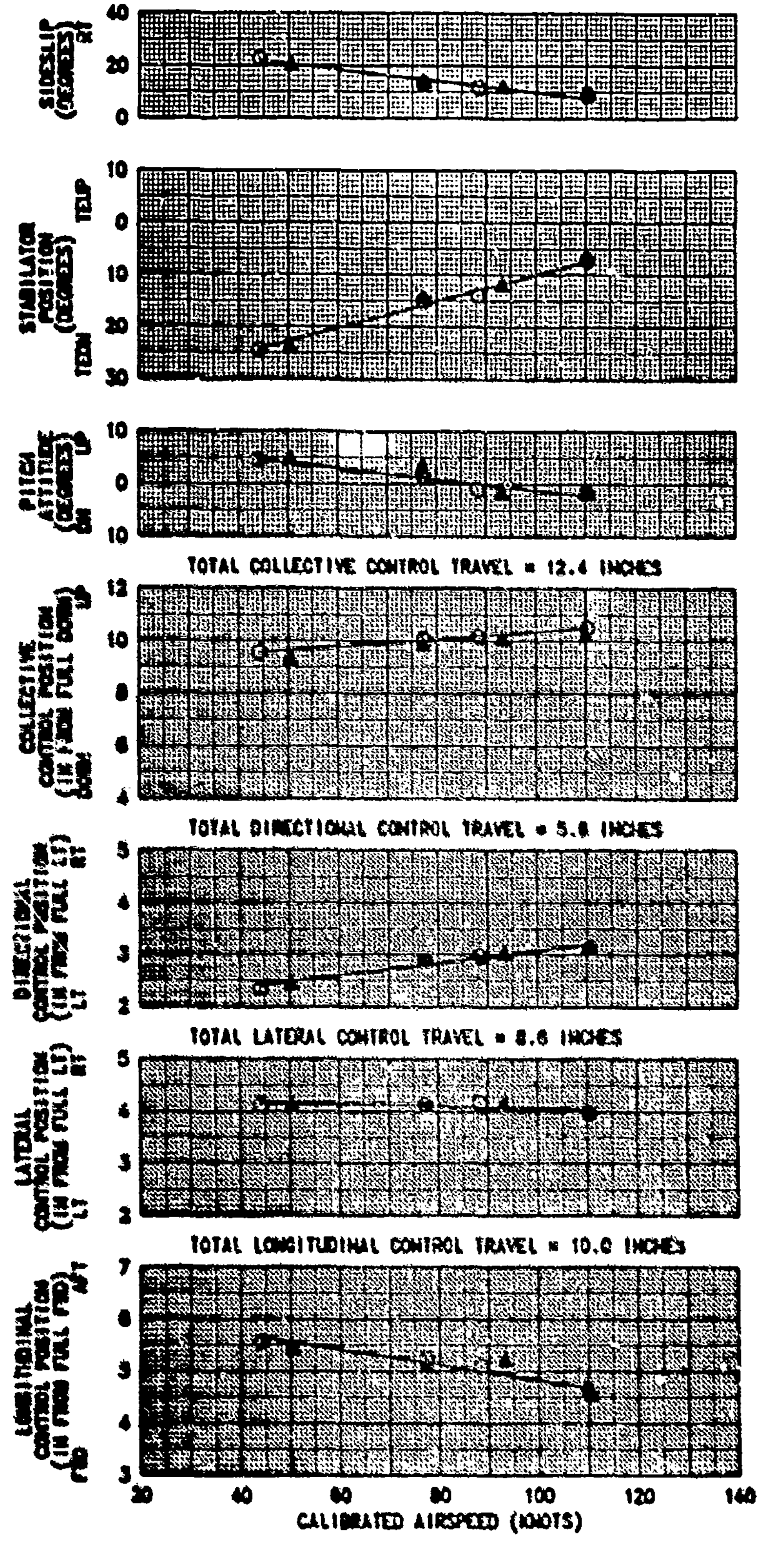


FIGURE E-4
STATIC LONGITUDINAL STABILITY
AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
15470	205.7 AFT	0.3 LT	7350	19.0	287	LEVEL

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. DASE ON, ATTITUDE HOLD OFF
3. ATAS / 8-HELLFIRE CONFIGURATION

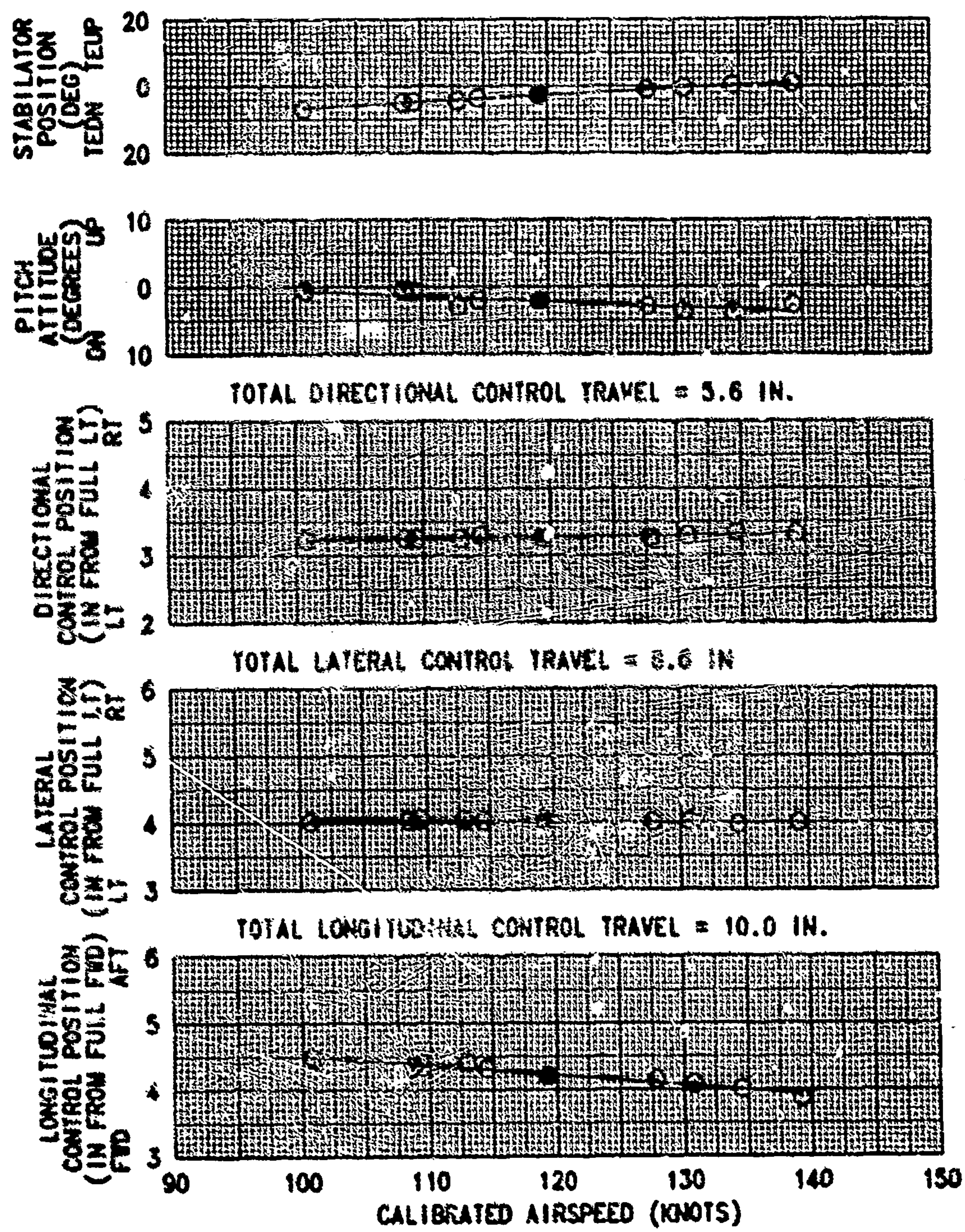


FIGURE E-5

STATIC LATERAL-DIRECTIONAL STABILITY

AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15000	205.8 AFT	0.3 LT	6870	20.0	287	121	LEVEL

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. SHADED SYMBOLS DENOTE BALL CENTERED TRIM
4. DOTTED LINE DENOTES SPECIFICATION ENVELOPE LIMIT

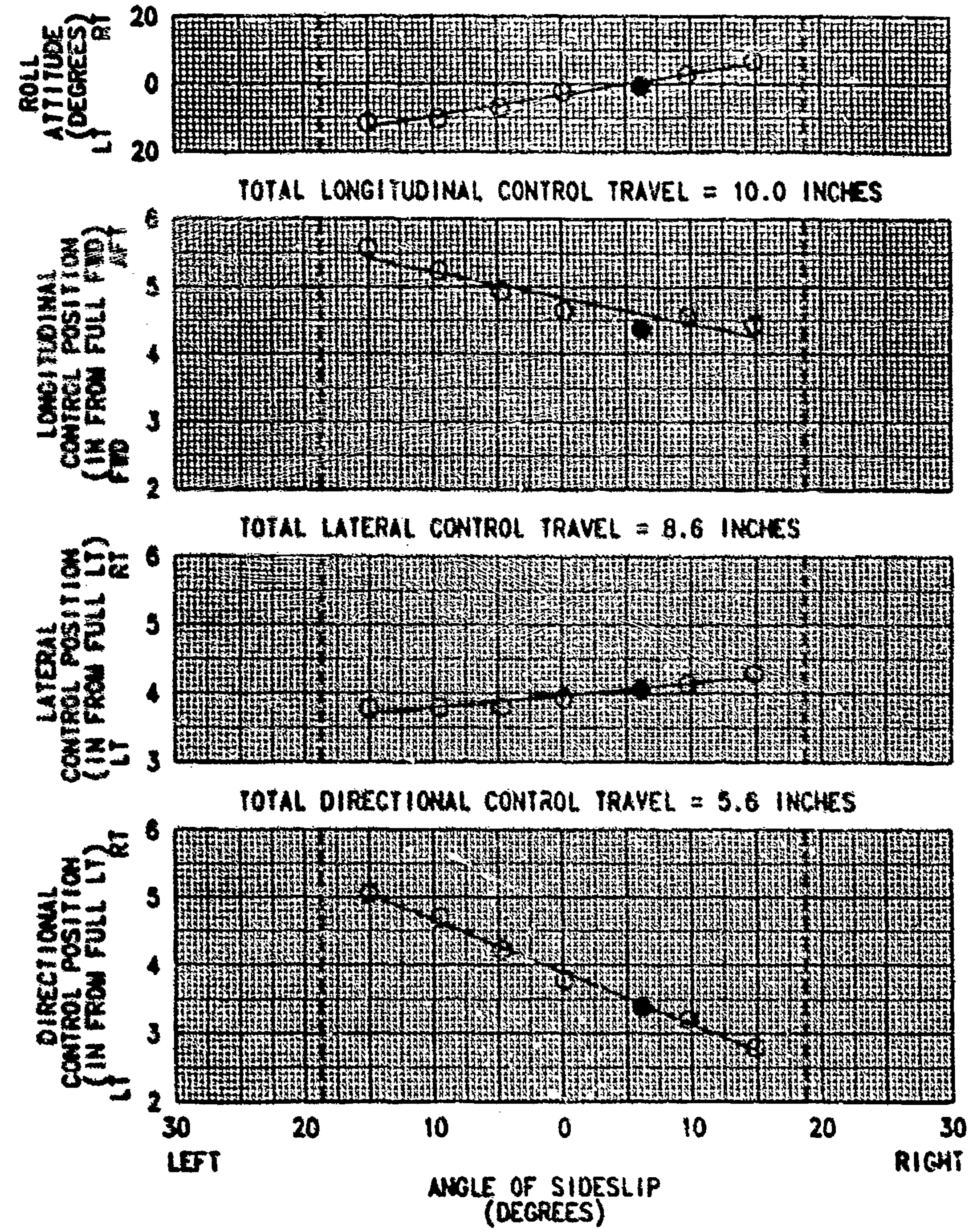


FIGURE E-6
MANEUVERING STABILITY
AH-64A USA S/N 82-23355

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KNOTS)	FLIGHT CONDITION
⊡	15380	205.7 AFT	0.3 LT	5490	22.0	287	68	RT TURN
⊙	15090	205.8 AFT	0.3 LT	6560	19.0	286	69	LT TURN

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. DASE ON, ATTITUDE HOLD OFF
3. ATAS / 8-HELLFIRE CONFIGURATION
4. LOAD FACTOR LIMITS - 0.0 TO 2.3 G

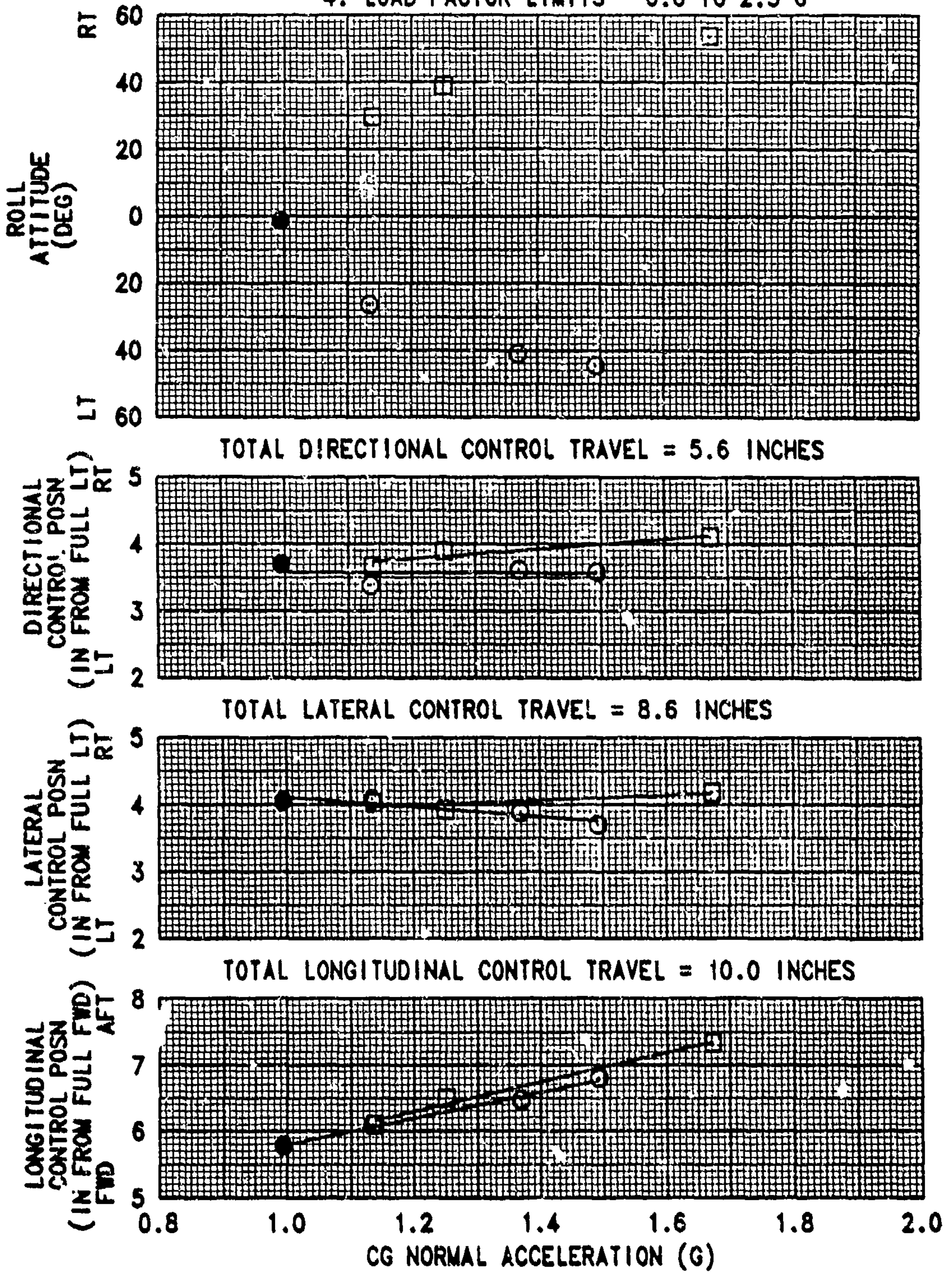


FIGURE E-7
MANEUVERING STABILITY
AH-64A USA S/N 82-23355

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KNOTS)	FLIGHT CONDITION
⊡	14900	205.8 AFT	0.3 LT	7060	17.5	287	123	RT TURN
⊙	14710	205.8 AFT	0.3 LT	7050	18.0	287	117	LT TURN

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. DASE ON, ATTITUDE HOLD OFF
3. ATAS / 8-HELLFIRE CONFIGURATION
4. LOAD FACTOR LIMITS - 0.0 TO 2.3 G

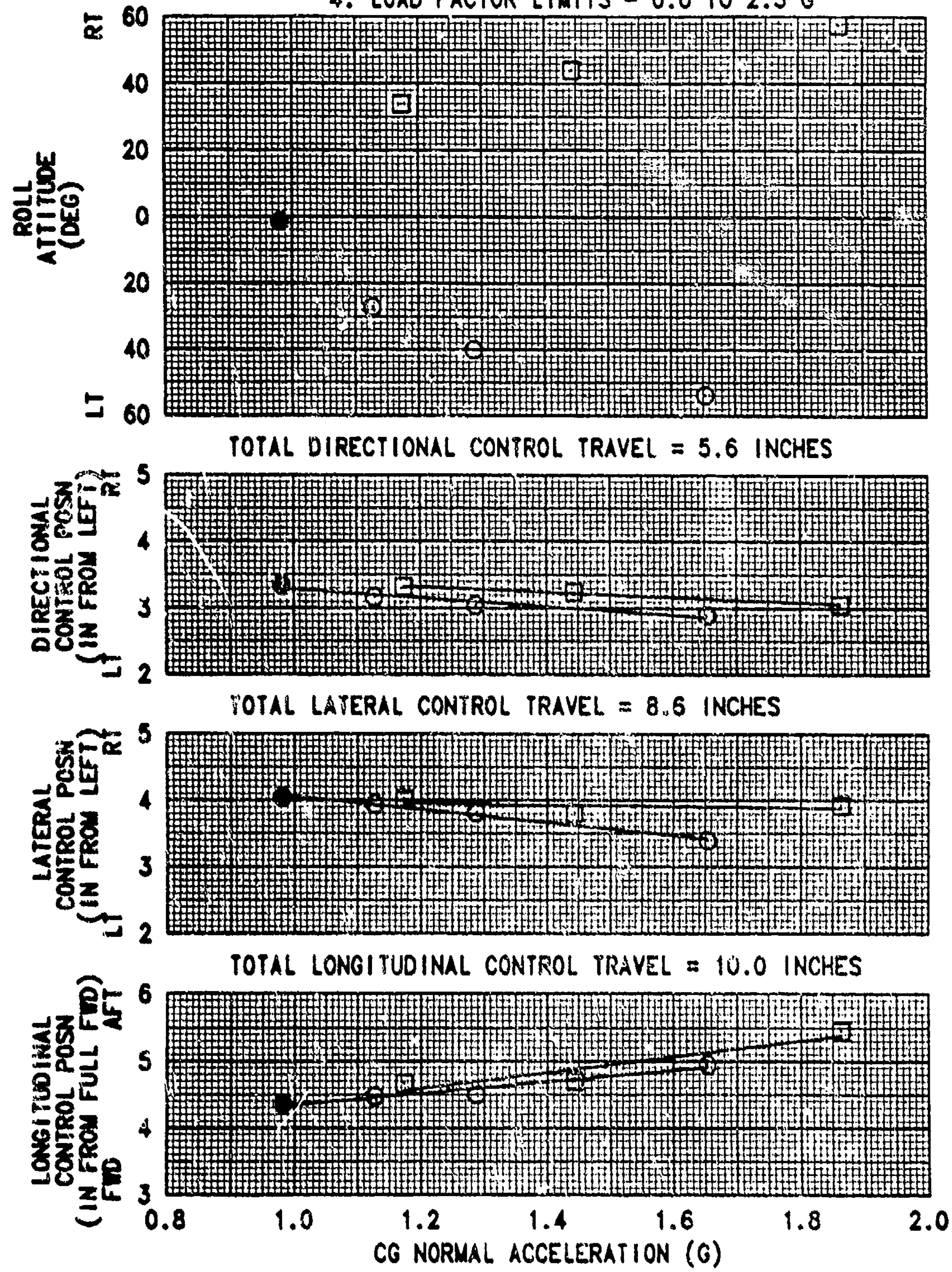


FIGURE E-8
AFT LONGITUDINAL PULSE
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15080	205.8 AFT	0.3 LT	7140	25.0	286	109	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

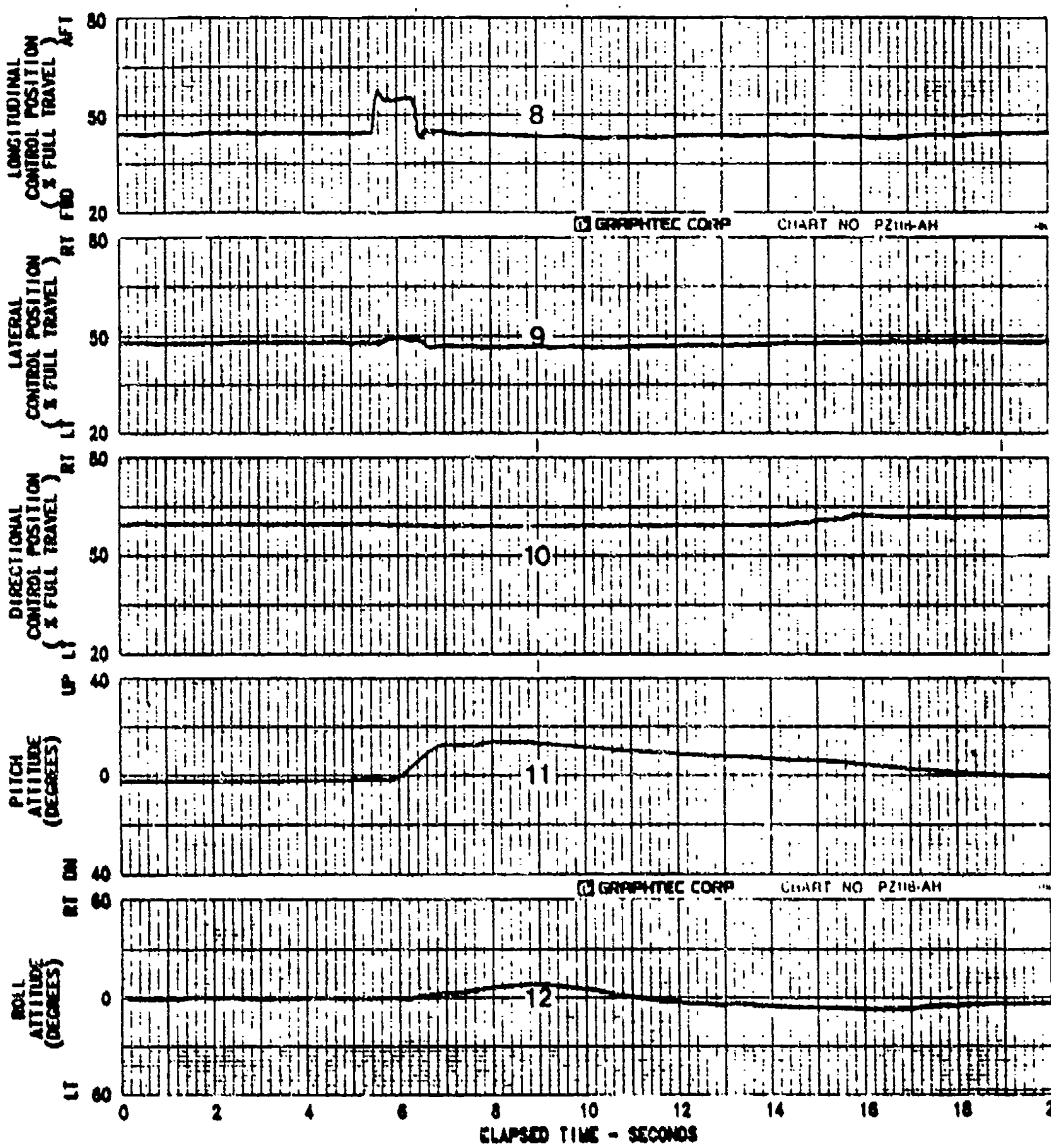


FIGURE E-8 (CONTINUED)
AFT LONGITUDINAL PULSE
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15080	205.8 AFT	0.3 LT	7140	25.0	286	109	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

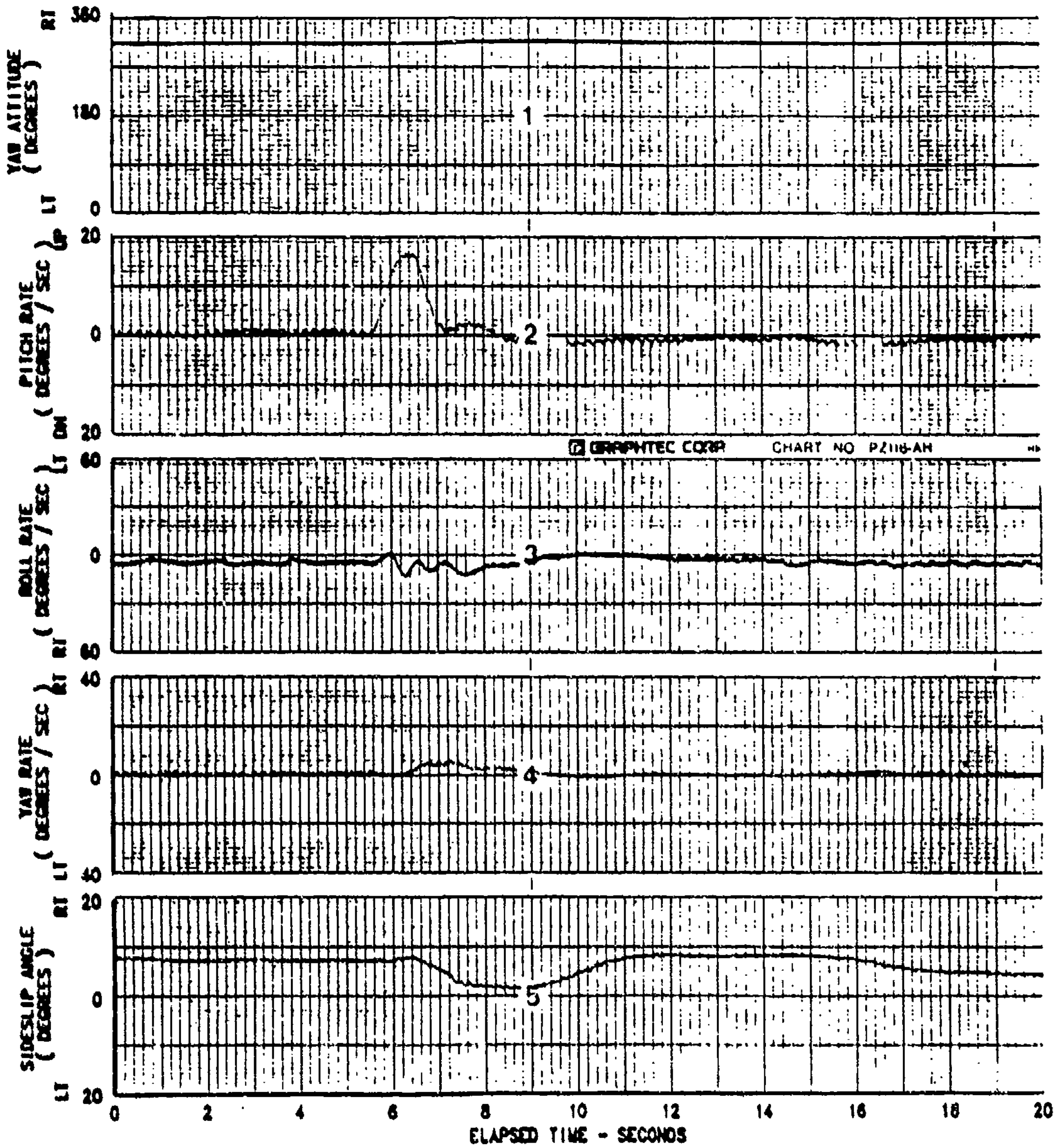


FIGURE E-9
RIGHT LATERAL PULSE
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15650	205.7 AFT	0.3 LT	6720	24.0	287	120	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

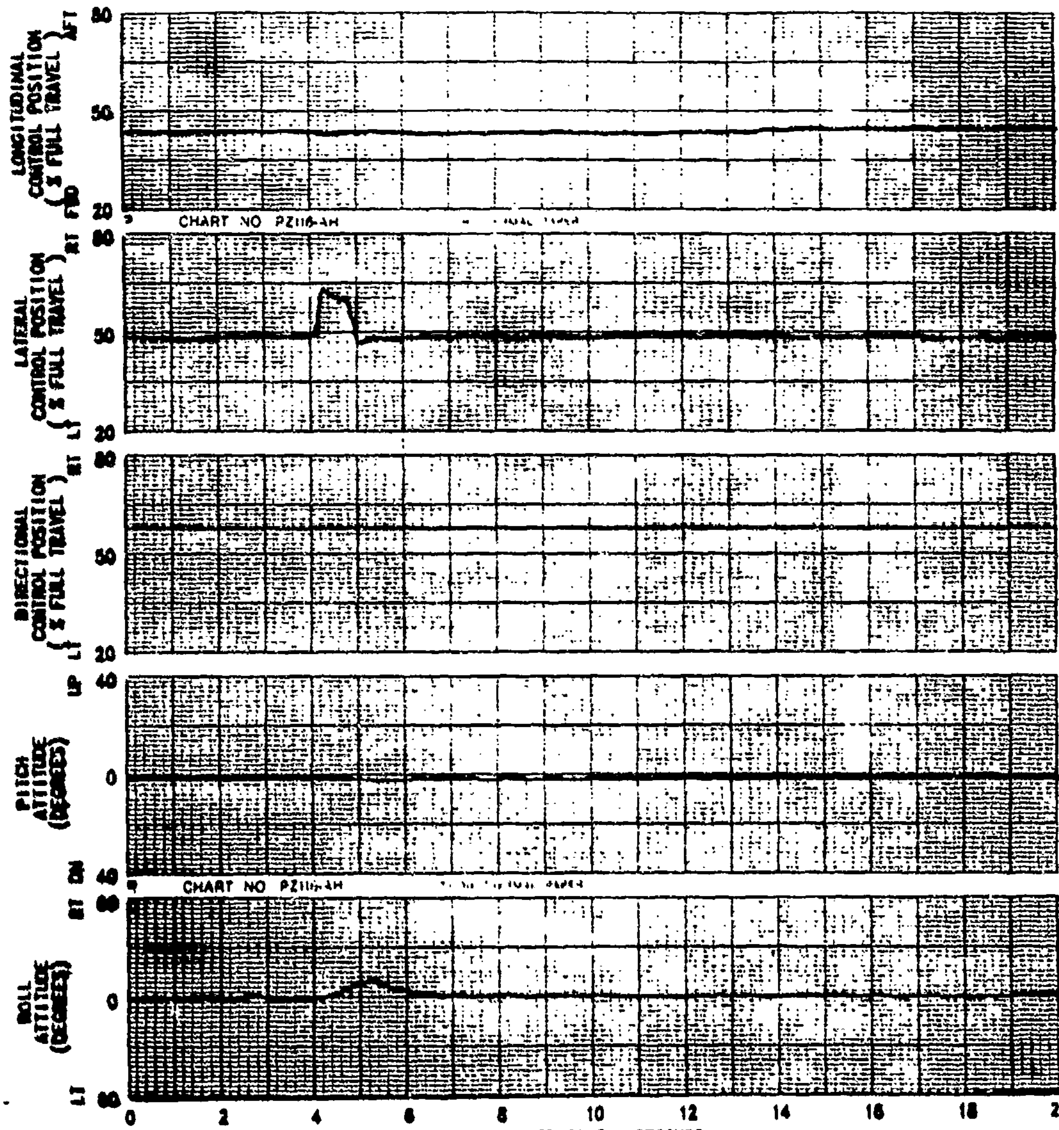


FIGURE E-9 (CONTINUED)
RIGHT LATERAL PULSE
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15656	206.7 AFT	0.3 LT	6720	24.0	287	120	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

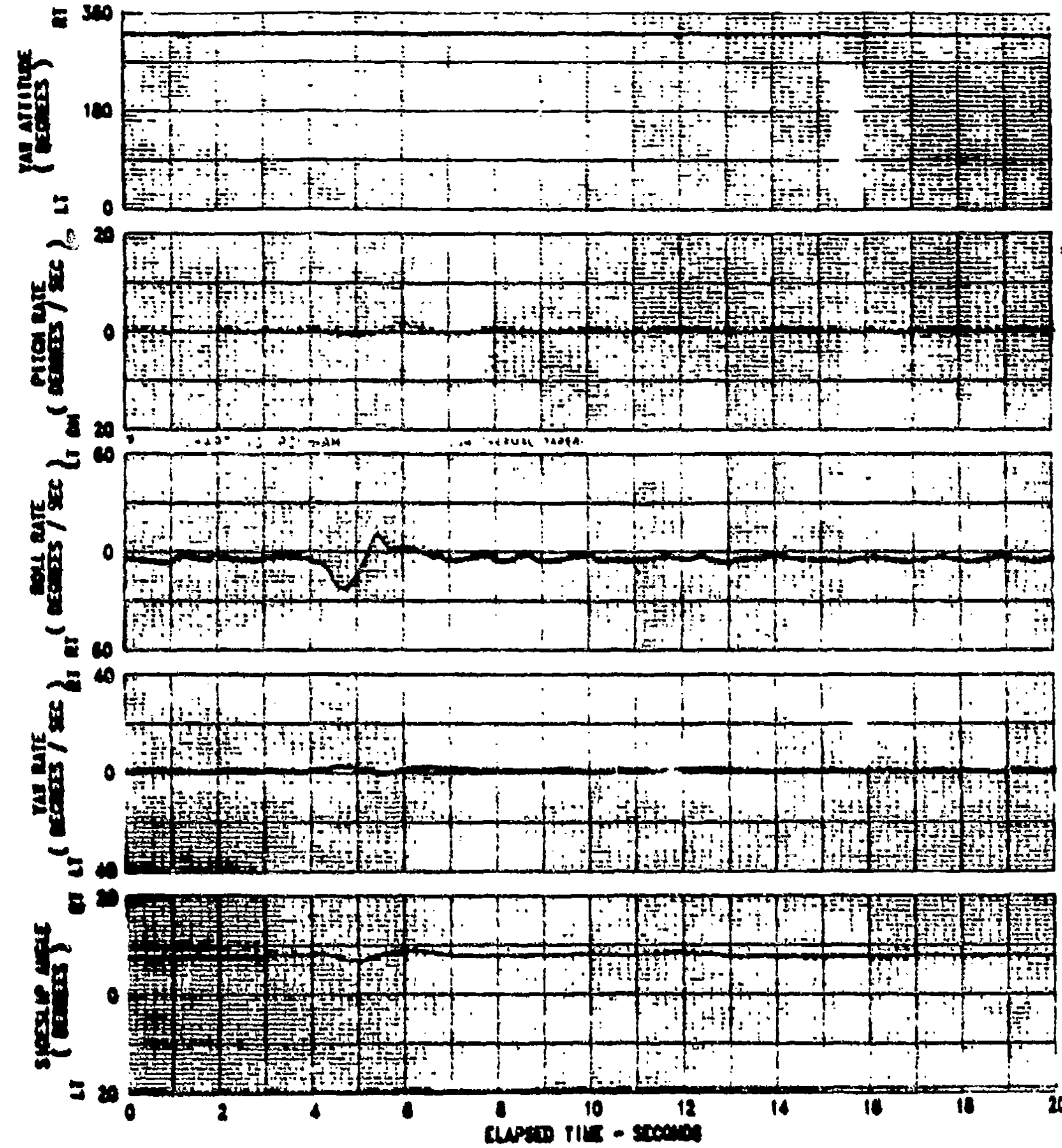


FIGURE E-10
LEFT DIRECTIONAL PULSE
AH-64A USA S/N 82-23358

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14800	205.8 AFT	0.3 LT	6980	24.0	288	118	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

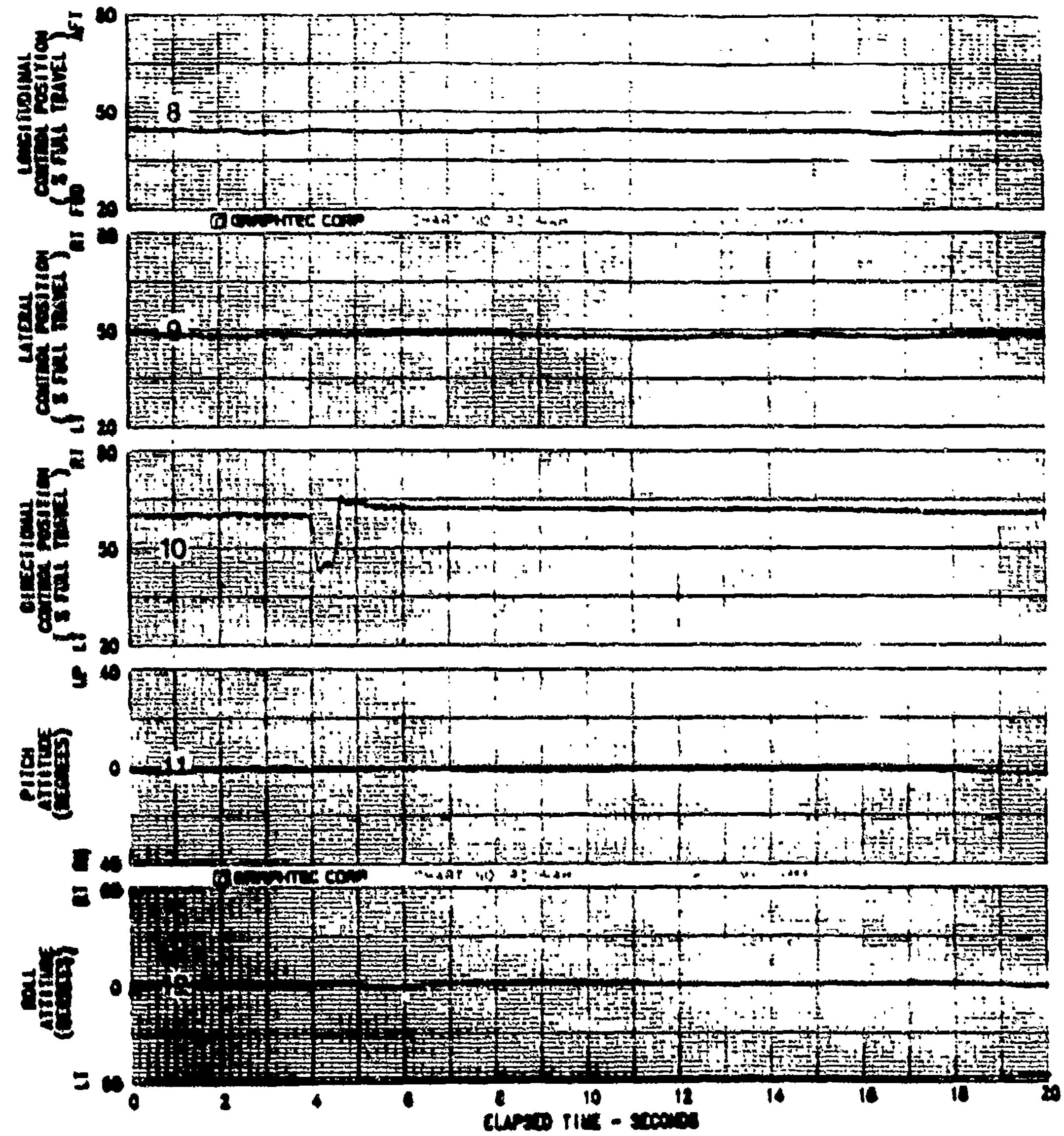


FIGURE E-10 (CONTINUED)
LEFT DIRECTIONAL PULSE
AH-64A USA S/N 82-23386

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14800	206.8 AFT	0.3 LT	6980	24.0	283	118	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

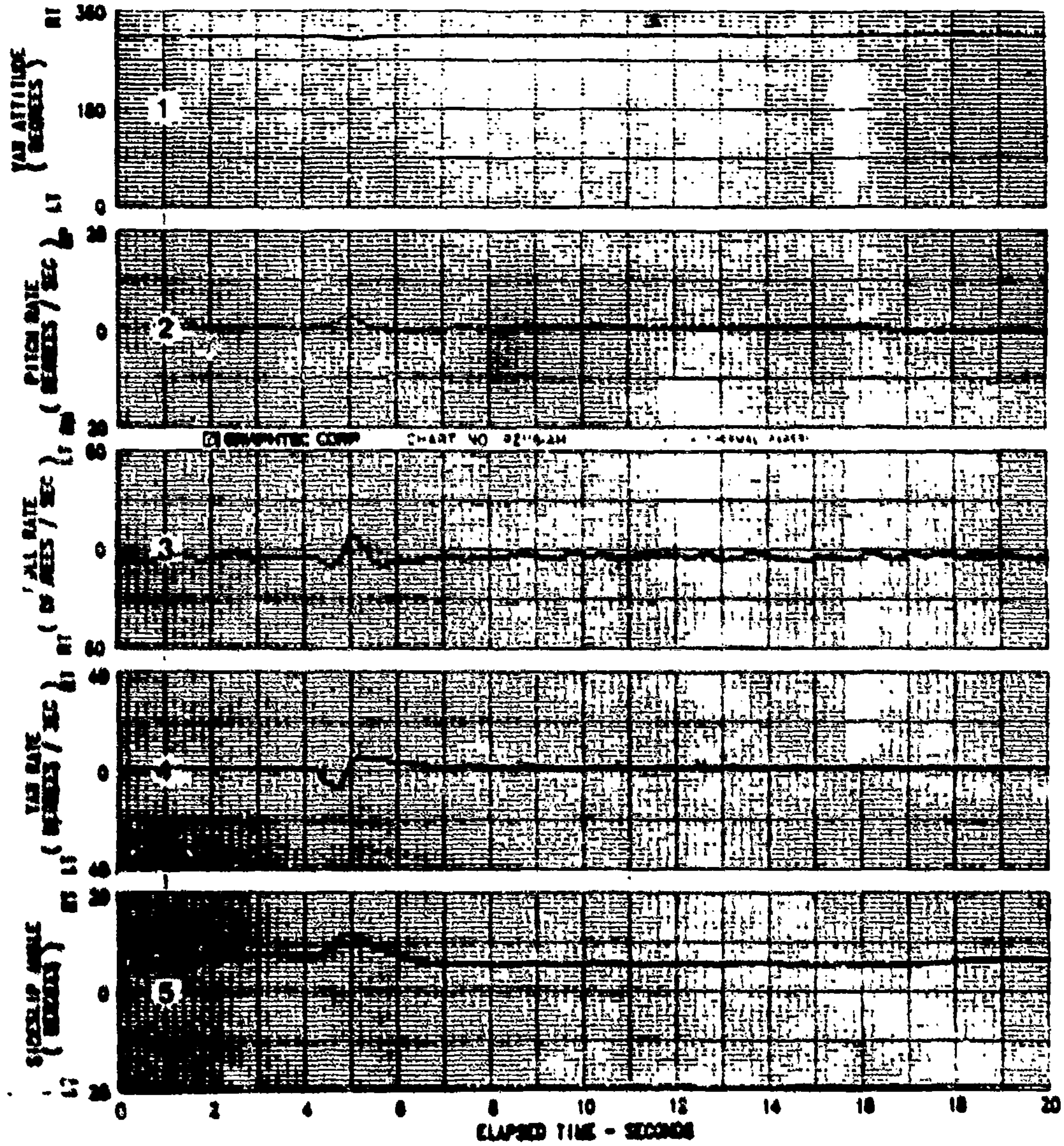


FIGURE E-11
RELEASE FROM STEADY HEADING SIDESLIP
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14650	205.8 AFT	0.3 LT	6900	24.0	288	118	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

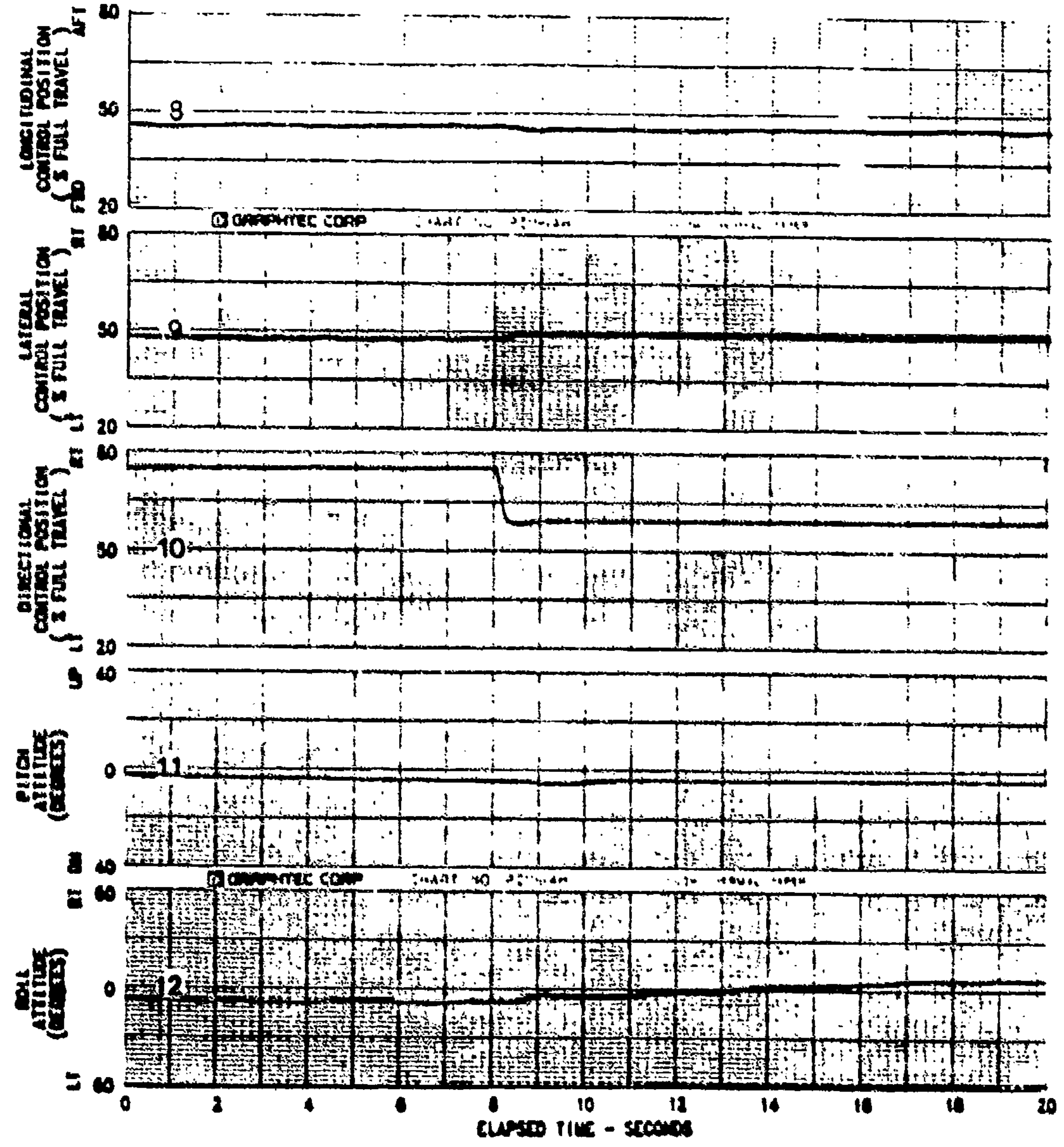


FIGURE E-11 (CONTINUED)
RELEASE FROM STEADY HEADING SIDESLIP
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14650	206.6 AFT	0.3 LT	6800	24.0	288	118	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

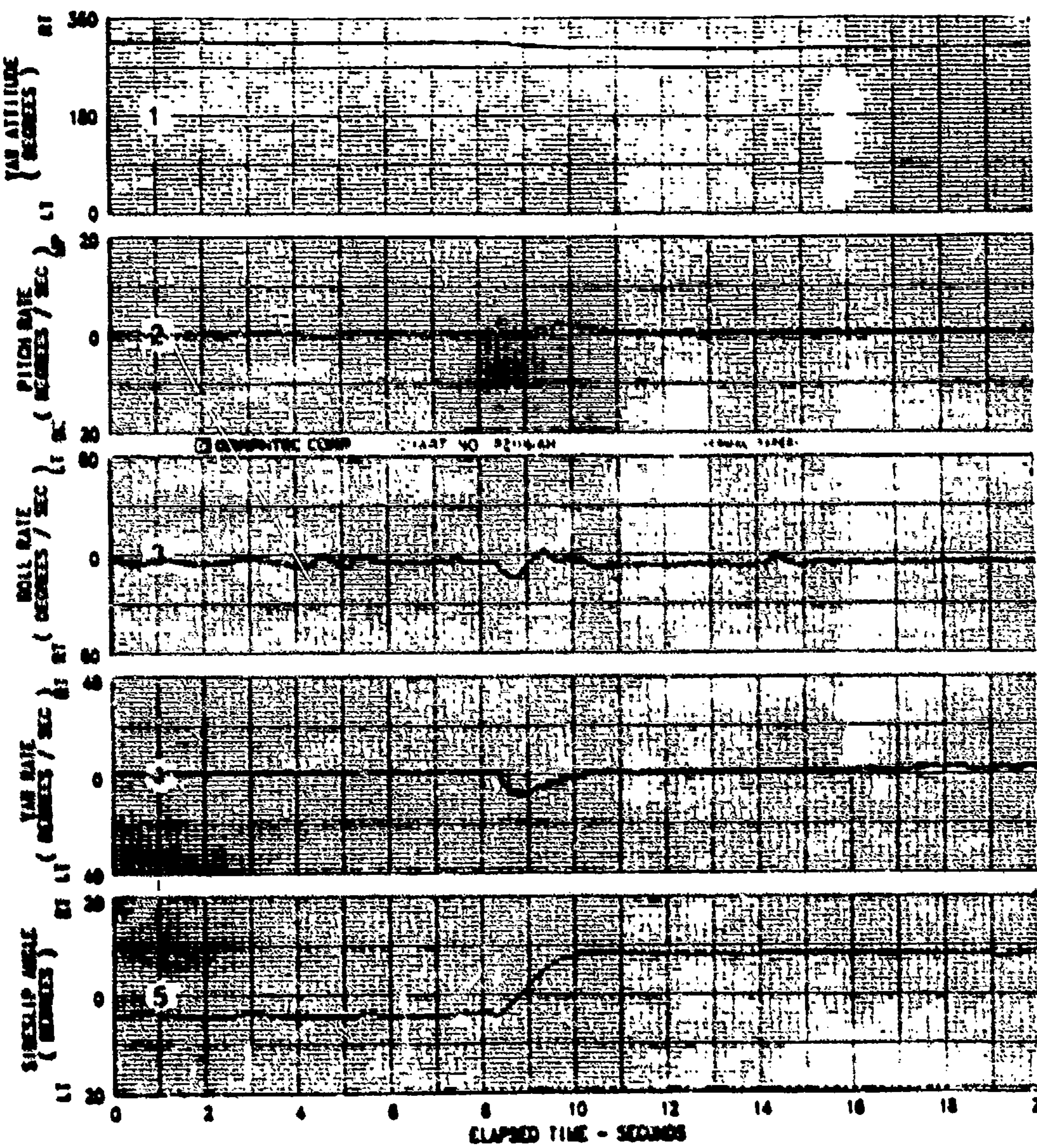


FIGURE E-12

LEFT CYCLIC ONLY TURN

AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14750	205.8 AFT	0.3 LT	6870	24.0	286	119	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

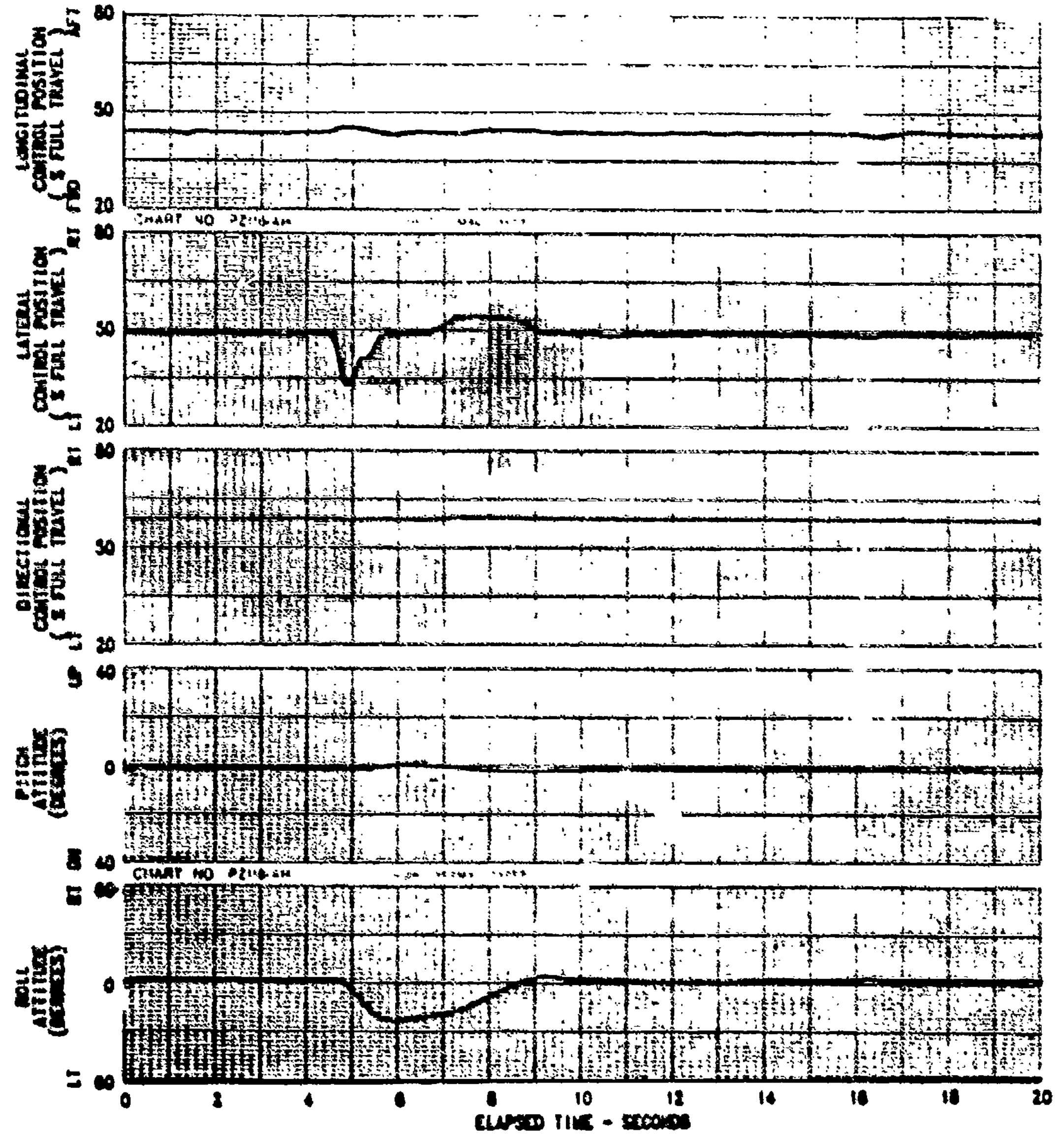


FIGURE E-12 (CONTINUED)
LEFT CYCLIC ONLY TURN
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14750	205.8 AFT	0.3 LT	4870	24.0	286	119	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

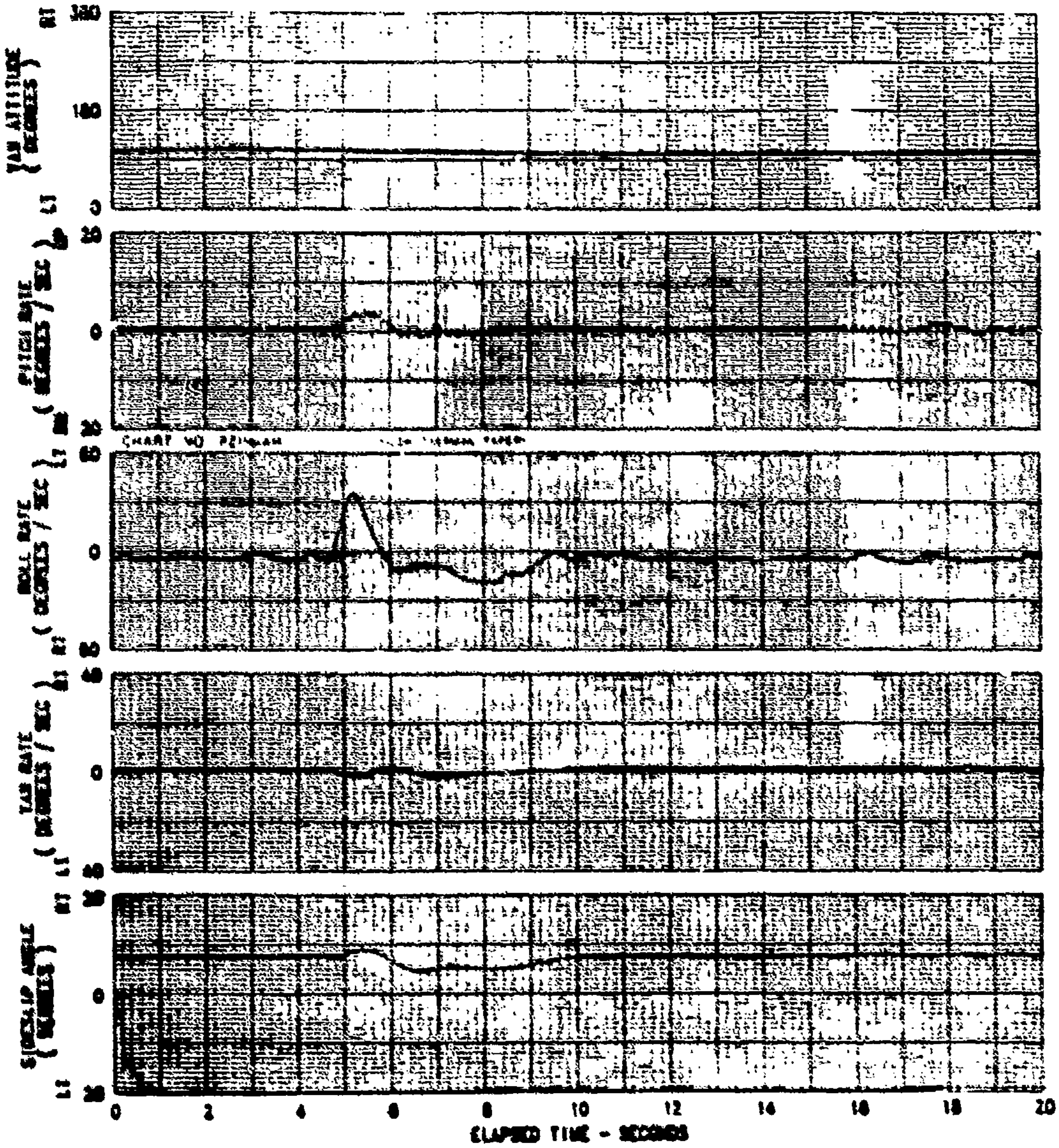


FIGURE E-13
LONGITUDINAL CONTROLLABILITY
AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KNOTS)	TRIM FLIGHT CONDITION
15450	205.7 AFT	0.3 LT	7050	25.0	286	114	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. TIME TO MAX PITCH ACCEL MEASURED FROM INITIAL CONTROL INPUT
4. TIME TO 63% MAX PITCH RATE MEASURED FROM INITIAL RATE CHANGE

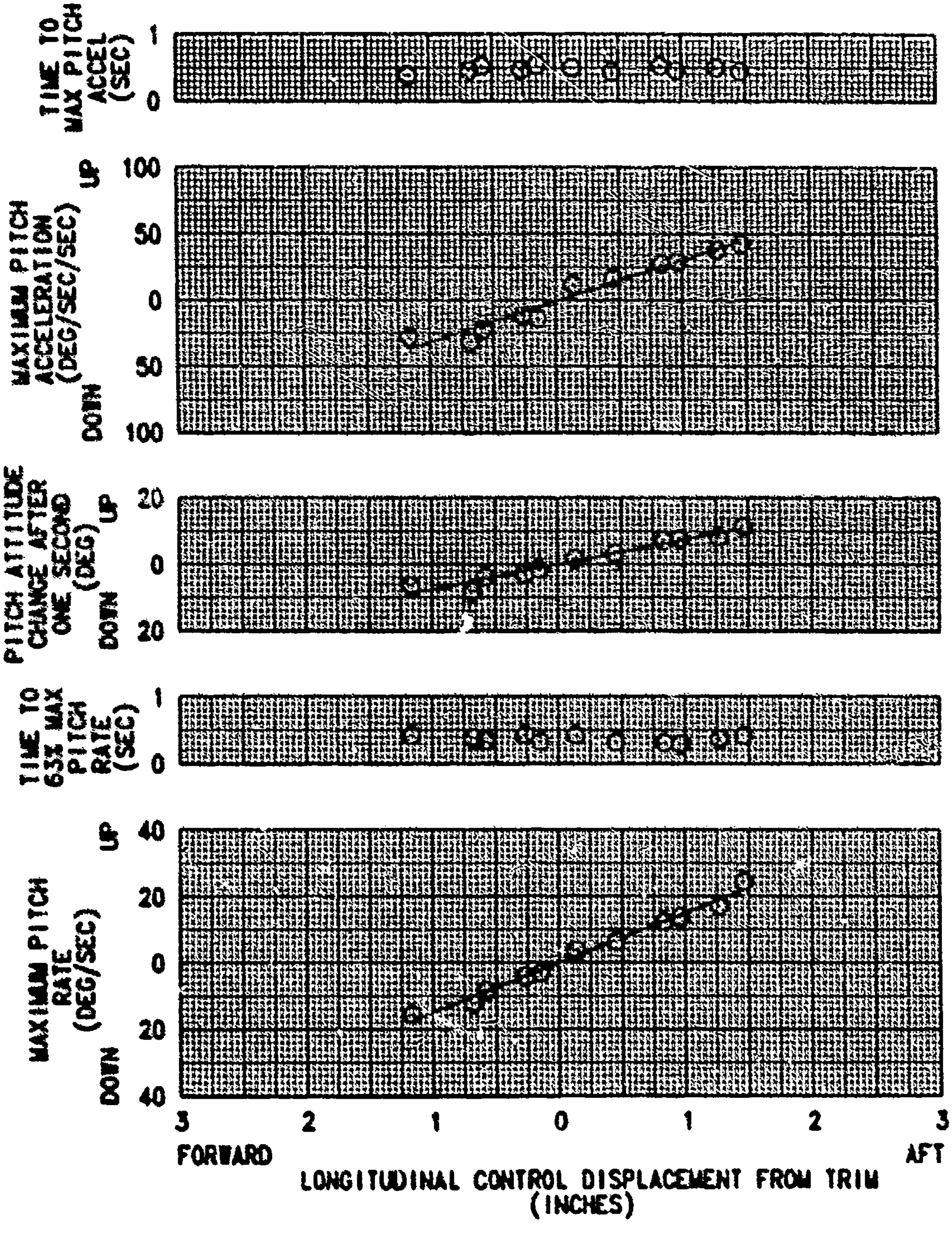


FIGURE E-14

AFT LONGITUDINAL STEP

AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15400	205.7 AFT	0.3 LT	7340	25.0	288	105	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

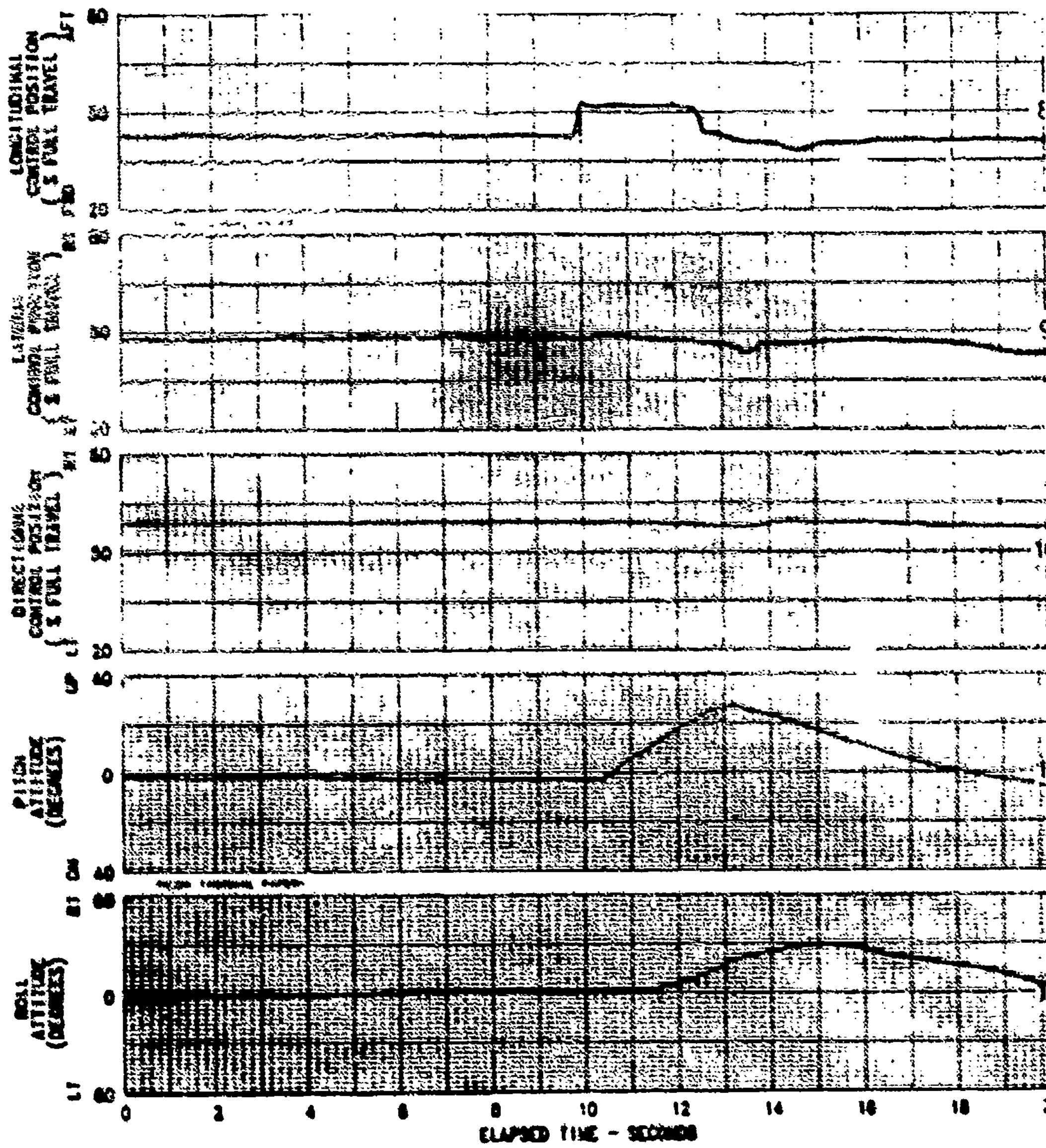


FIGURE E-14 (CONTINUED)

AFT LONGITUDINAL STEP

AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15400	205.7 AFT	0.3 LT	7340	25.0	288	105	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

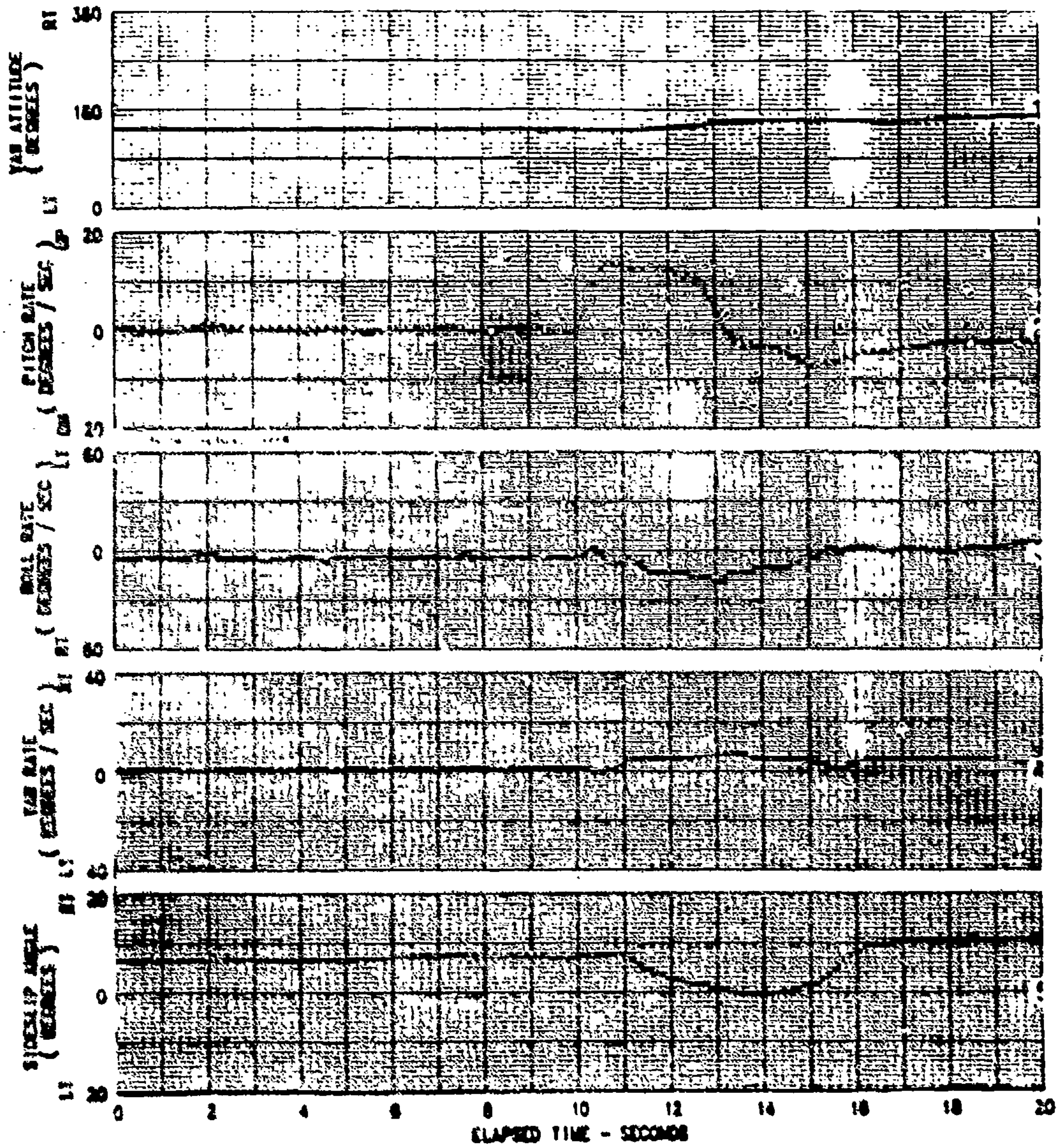


FIGURE E-15
LATERAL CONTROLLABILITY
AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KNOTS)	TRIM FLIGHT CONDITION
14740	205.8 AFT	0.3 LT	6730	25.0	286	122	LEVEL

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. TIME TO MAX ROLL ACCEL MEASURED FROM INITIAL CONTROL INPUT
4. TIME TO 63% MAX ROLL RATE MEASURED FROM INITIAL RATE CHANGE

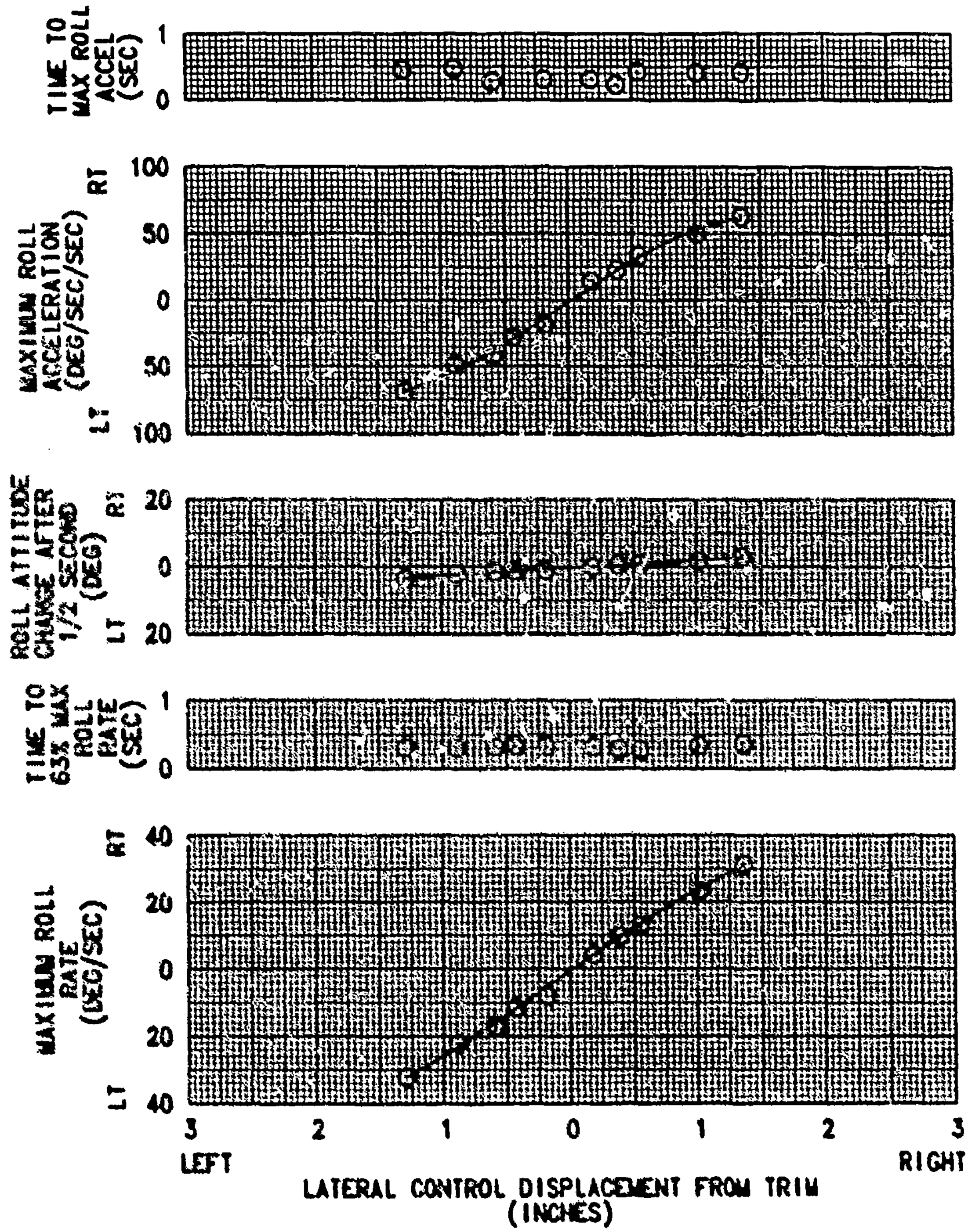


FIGURE E-16
LEFT LATERAL STEP
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14830	205.8 AFT	0.3 LT	7010	25.5	286	120	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

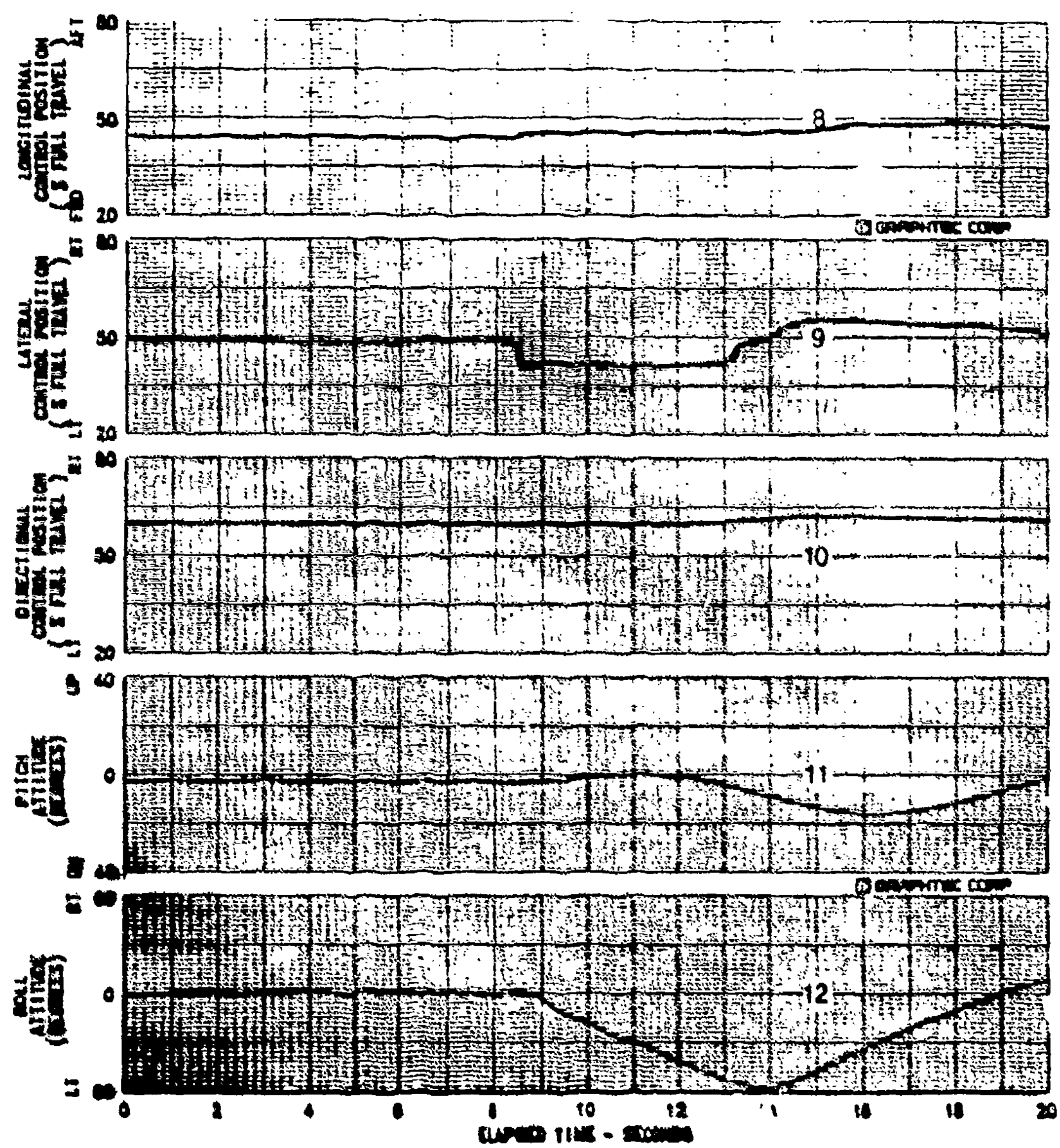


FIGURE E-18 (CONTINUED)
LEFT LATERAL STEP
AH-64A USA S/N 82-23366

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
14830	206.8 AFT	0.3 LT	7010	25.5	286	120	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

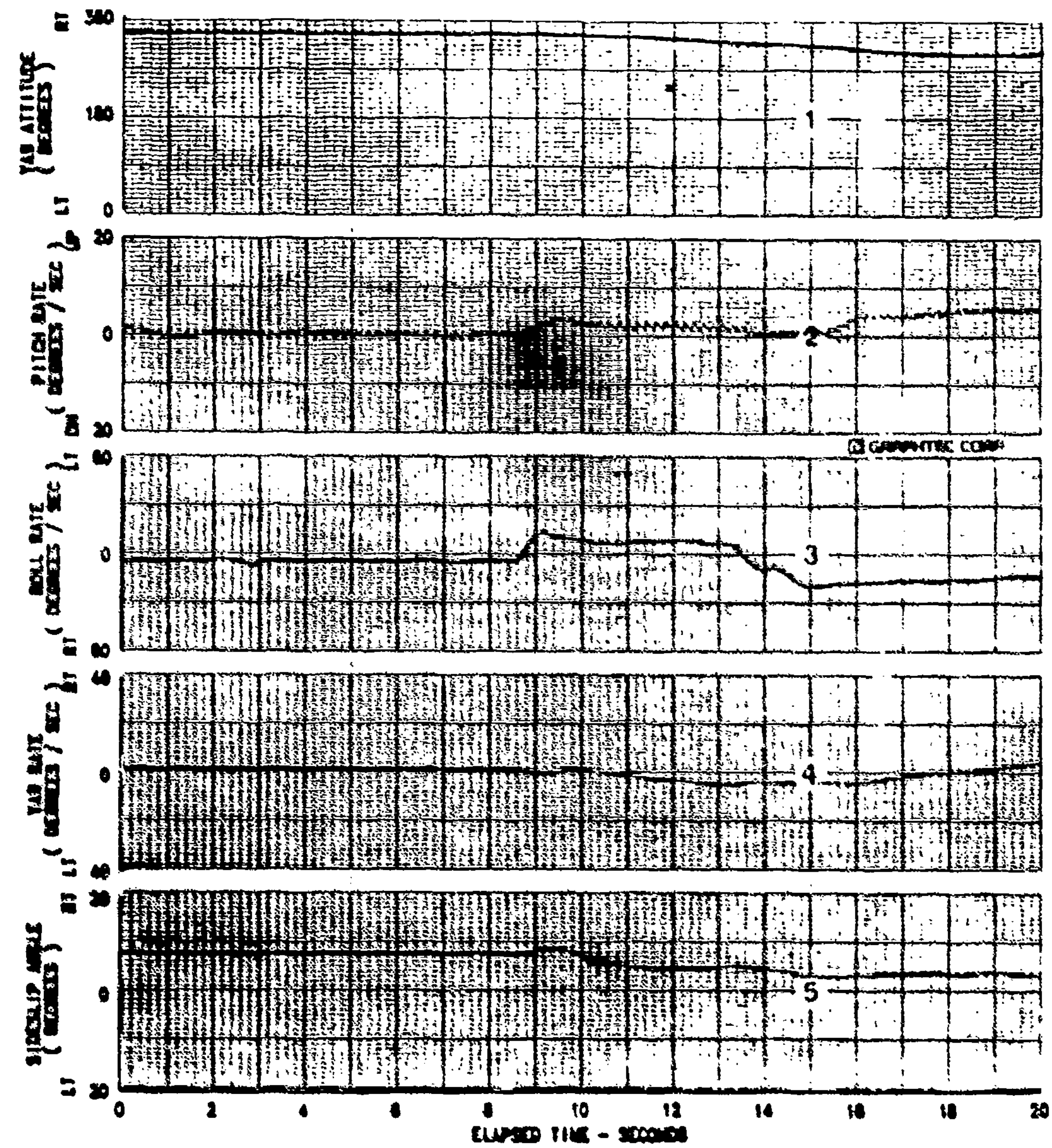


FIGURE E-17
DIRECTIONAL CONTROLLABILITY
AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KNOTS)	TRIM FLIGHT CONDITION
15270	205.7 AFT	0.3 LT	6880	24.0	286	120	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. TIME TO MAX YAW ACCEL MEASURED FROM INITIAL CONTROL INPUT
4. TIME TO 63% MAX YAW RATE MEASURED FROM INITIAL RATE CHANGE

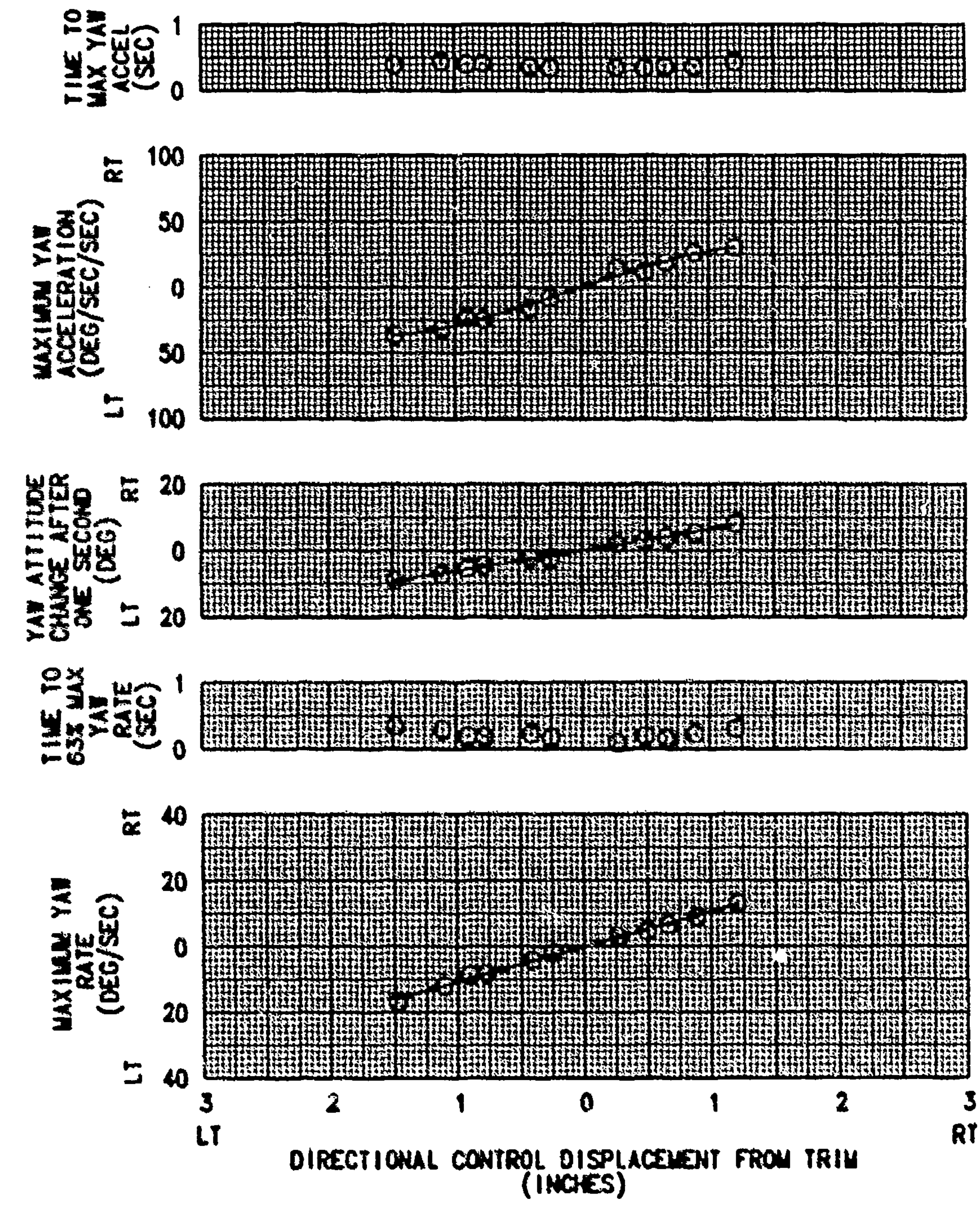


FIGURE E-18
LEFT DIRECTIONAL STEP
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15450	205.7 AFT	0.3 LT	6840	24.0	288	119	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

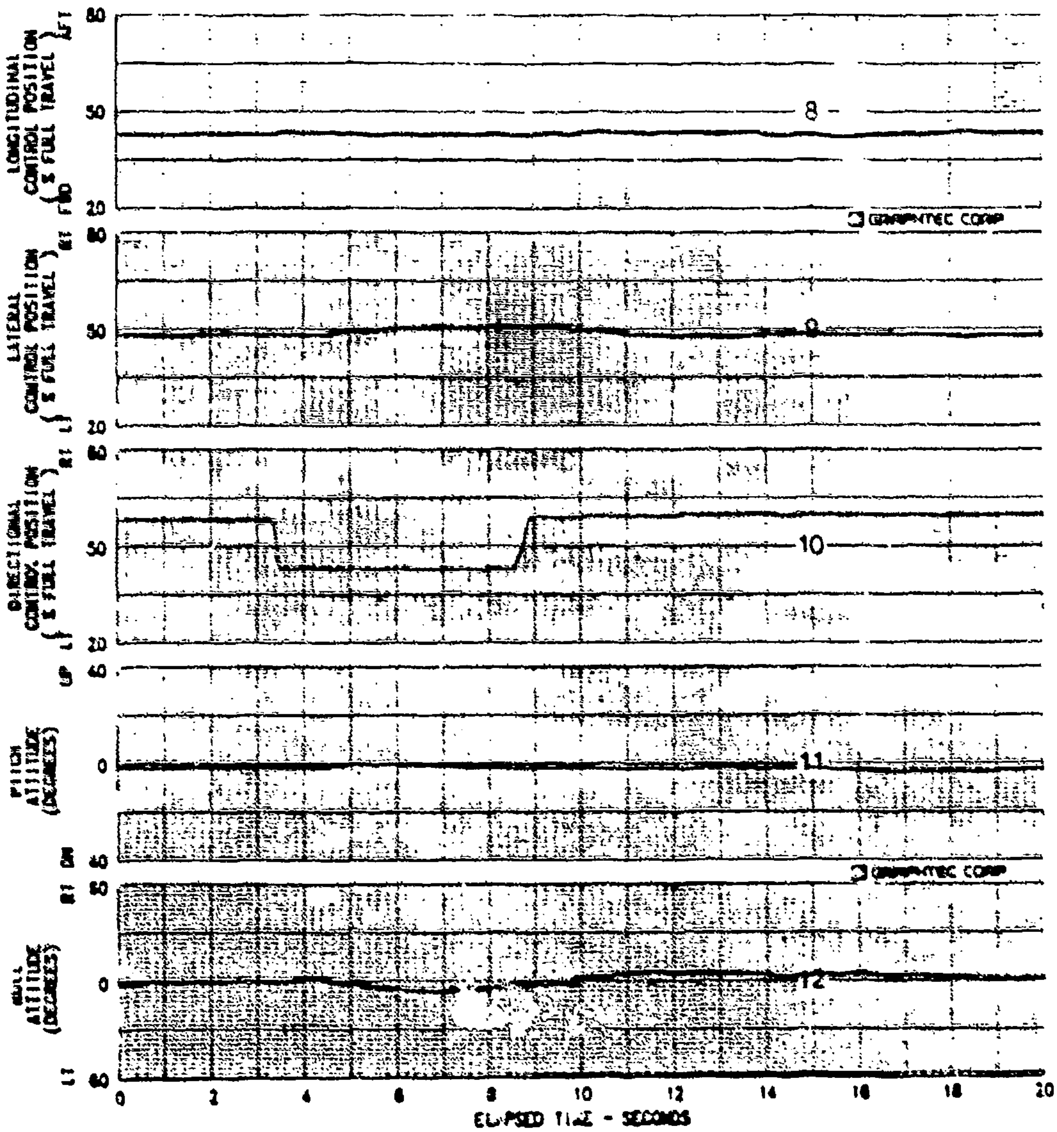


FIGURE E-18 (CONTINUED)
LEFT DIRECTIONAL STEP
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15450	205.7 AFT	0.3 LT	6840	24.0	288	119	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

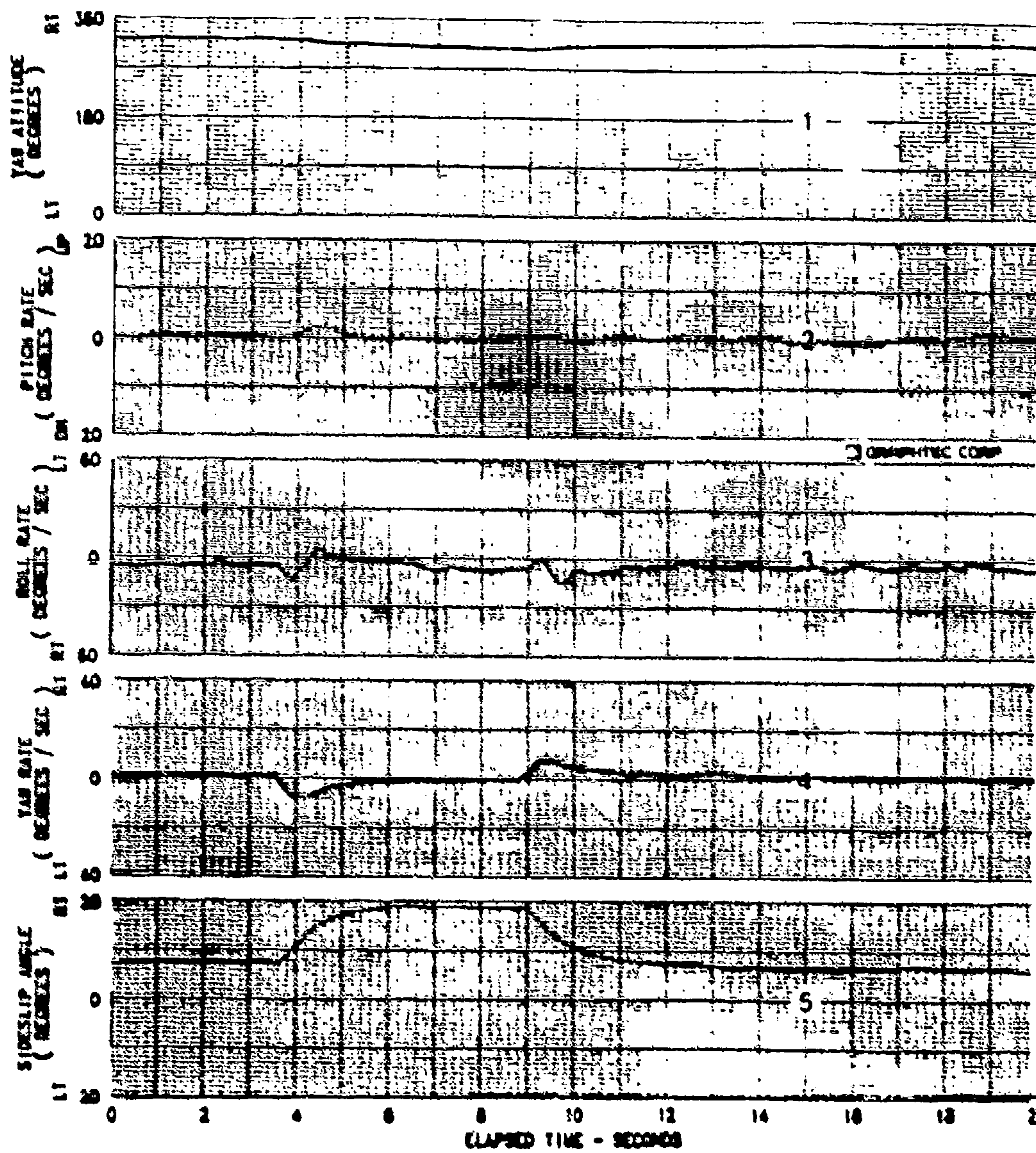


FIGURE E-19

LATERAL CONTROLLABILITY

AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
14960	205.8 AFT	0.3 LT	3360	32.0	286	HOVER

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. 15 FT. WHEEL HEIGHT
4. TIME TO MAX ROLL RATE MEASURED FROM INITIAL CONTROL INPUT
5. TIME TO 63% MAX ROLL RATE MEASURED FROM INITIAL RATE CHANGE

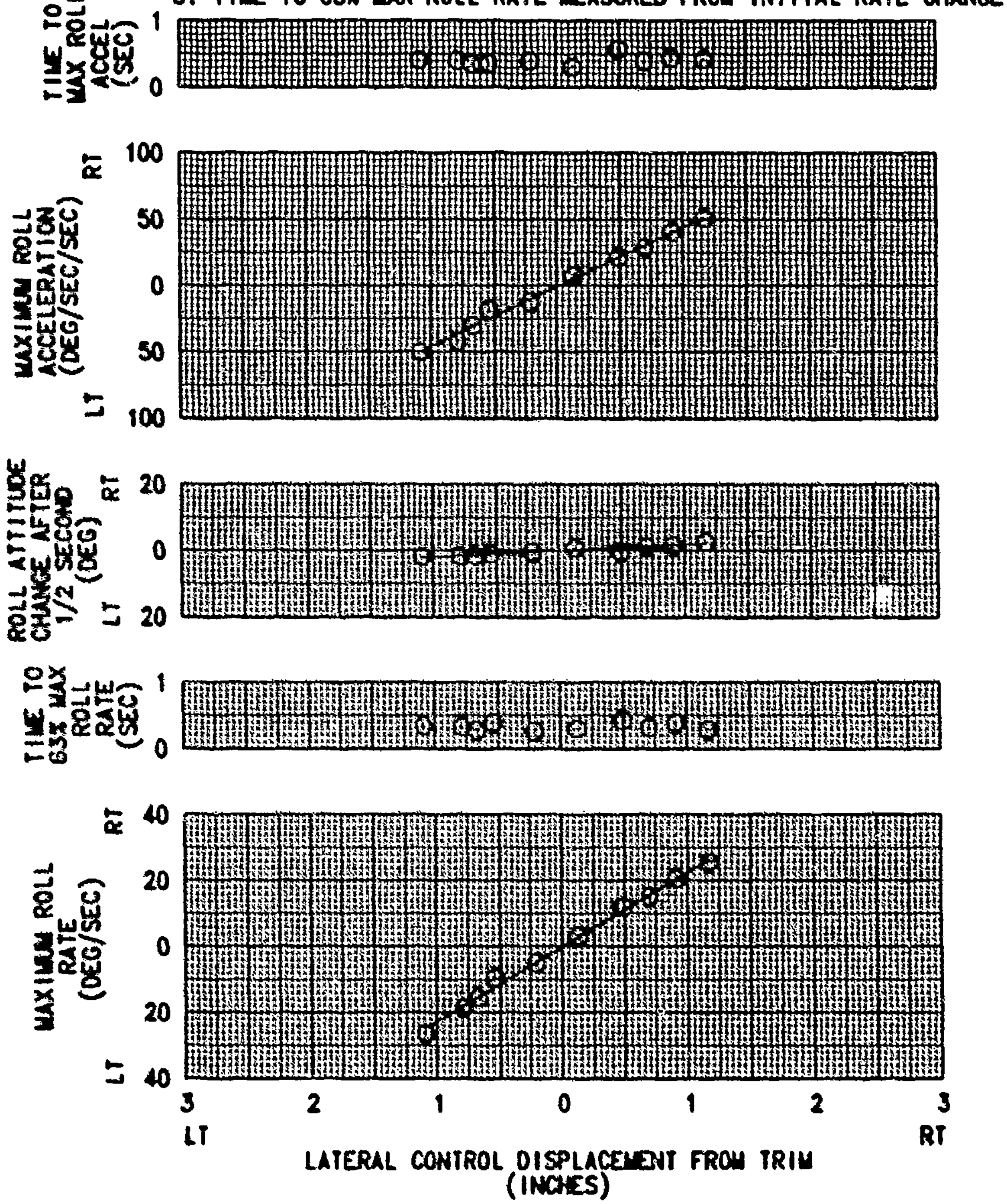


FIGURE E-20

DIRECTIONAL CONTROLLABILITY

AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
15490	205.7 AFT	0.3 LT	3550	31.0	286	HOVER

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. 15 FT. WHEEL HEIGHT
4. TIME TO MAX YAW ACCEL MEASURED FROM INITIAL CONTROL INPUT
5. YAW RATE AFTER 1 SEC MEASURED FROM RATE AT INITIAL CONTROL INPUT

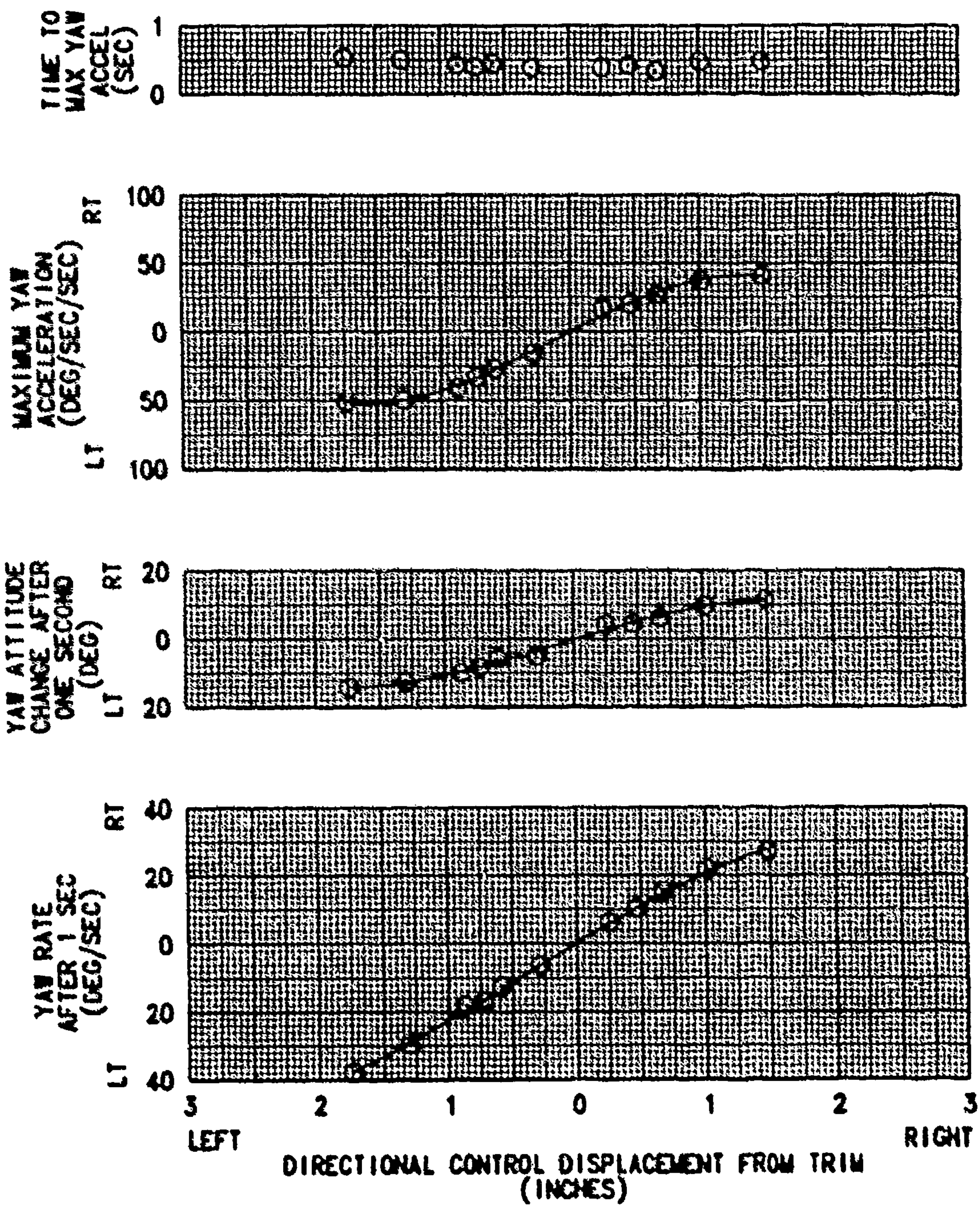


FIGURE E-21
RIGHT PEDAL STEP
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15310	205.7 AFT	0.3 LT	3840	32.0	288	HOVER	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

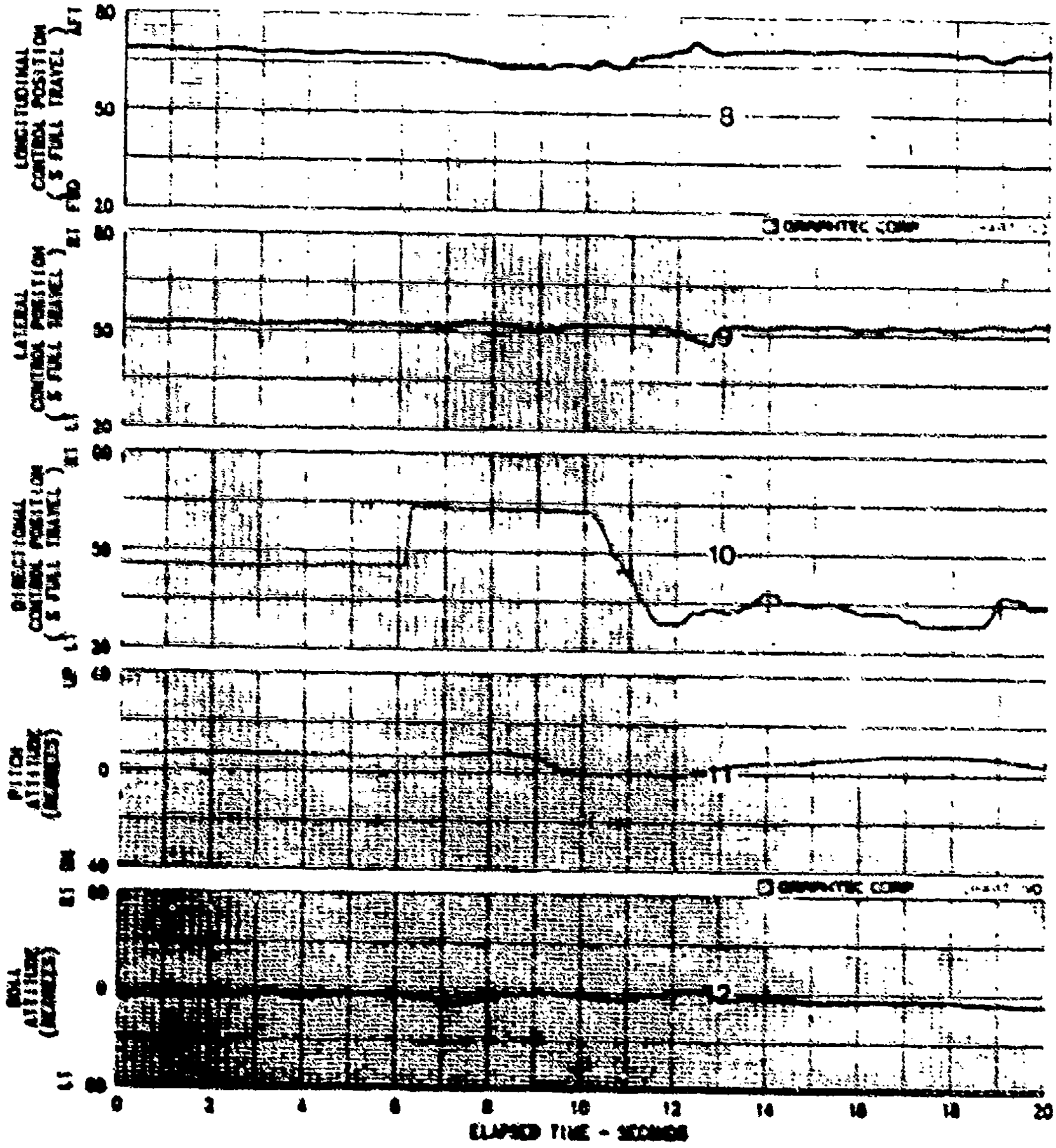


FIGURE E-21 (CONTINUED)
RIGHT PEDAL STEP
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15310	205.7 AFT	0.3 LT	3840	32.0	289	HOVER	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

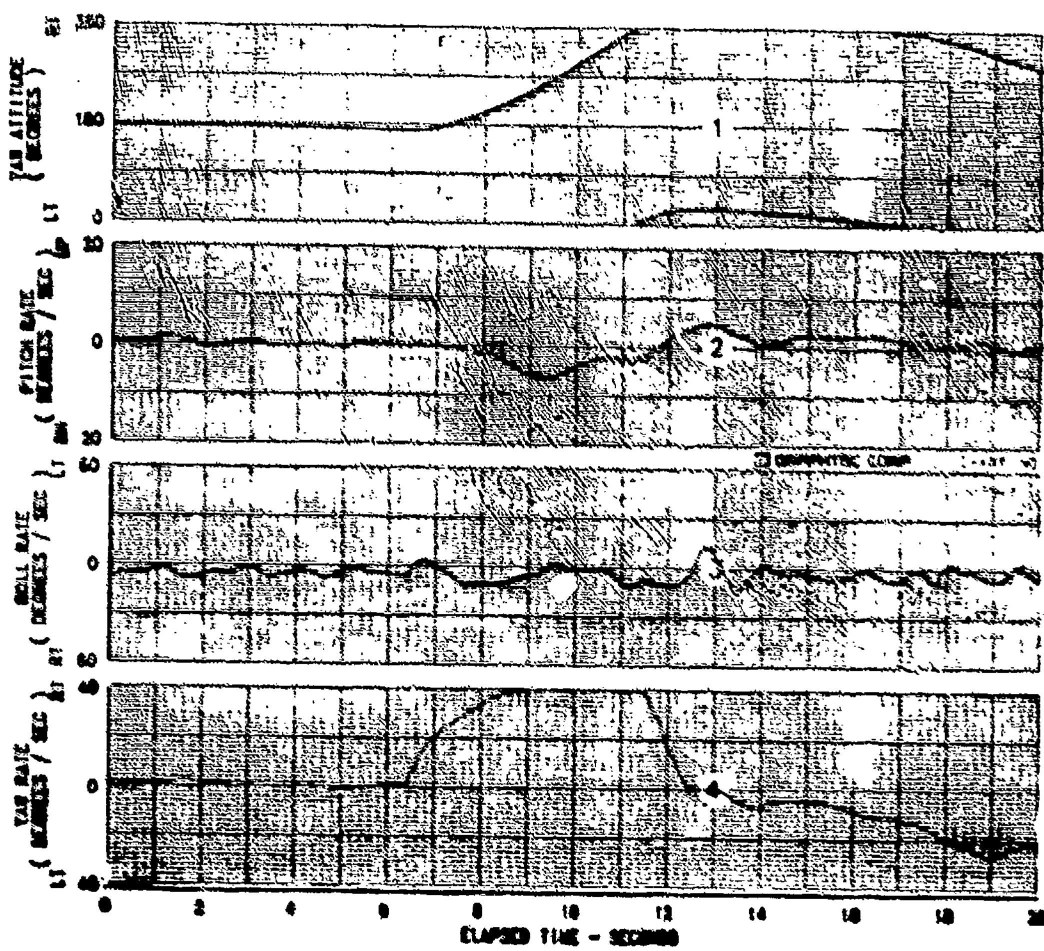


FIGURE E-22

LOW SPEED FORWARD AND REARWARD FLIGHT

AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)
14800	205.8 AFT	0.3 LT	3280	30.0	287

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. 15 FT. WHEEL HEIGHT
4. VERTICAL BARS DENOTE MAXIMUM EXCURSIONS

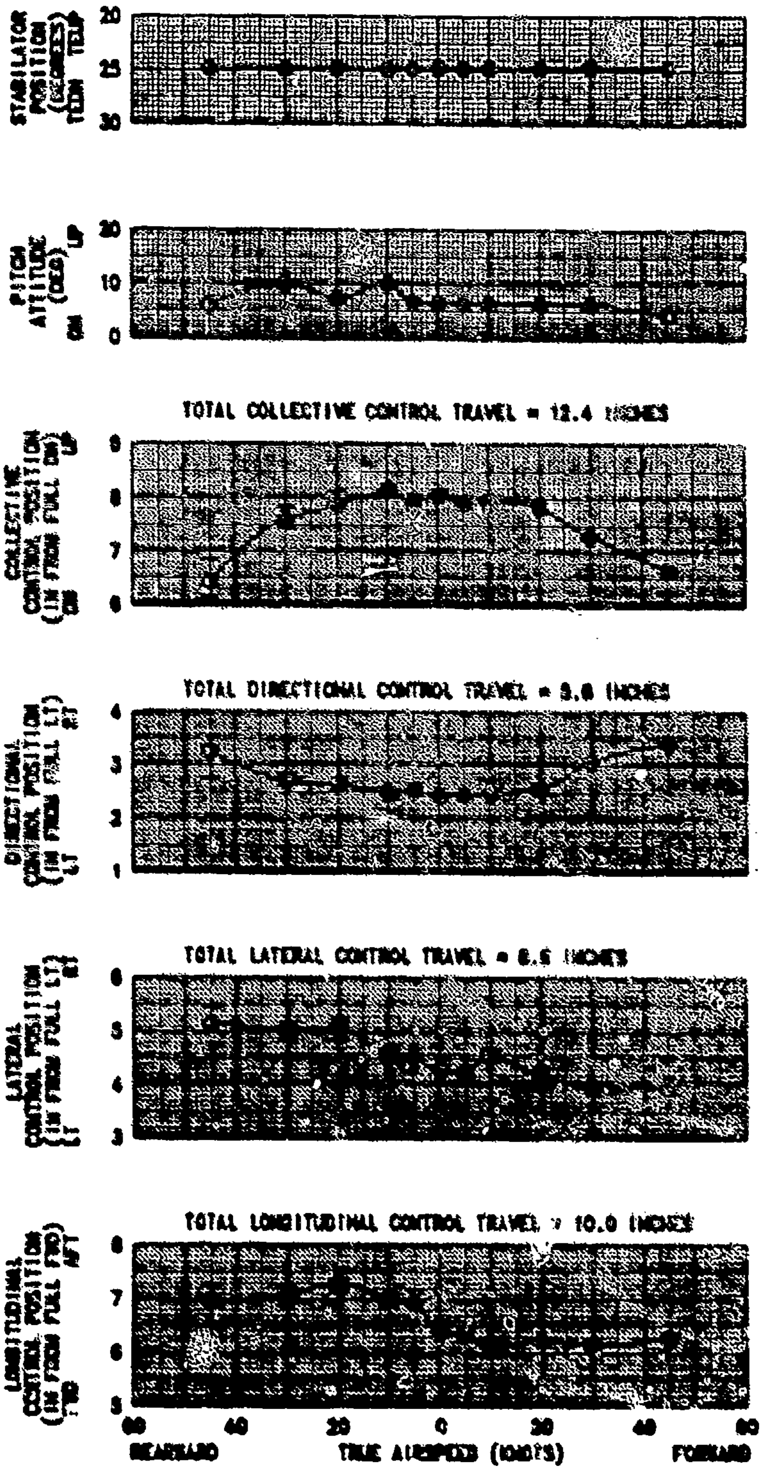


FIGURE E-23
LOW SPEED SIDEWARD FLIGHT
AH-64A USA S/N 82-23355

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)
15220	205.7 AFT	0.3 LT	3380	31.0	287

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONDITION
3. 15 FT. WHEEL HEIGHT
4. VERTICAL BARS DENOTE MAXIMUM EXCURSIONS

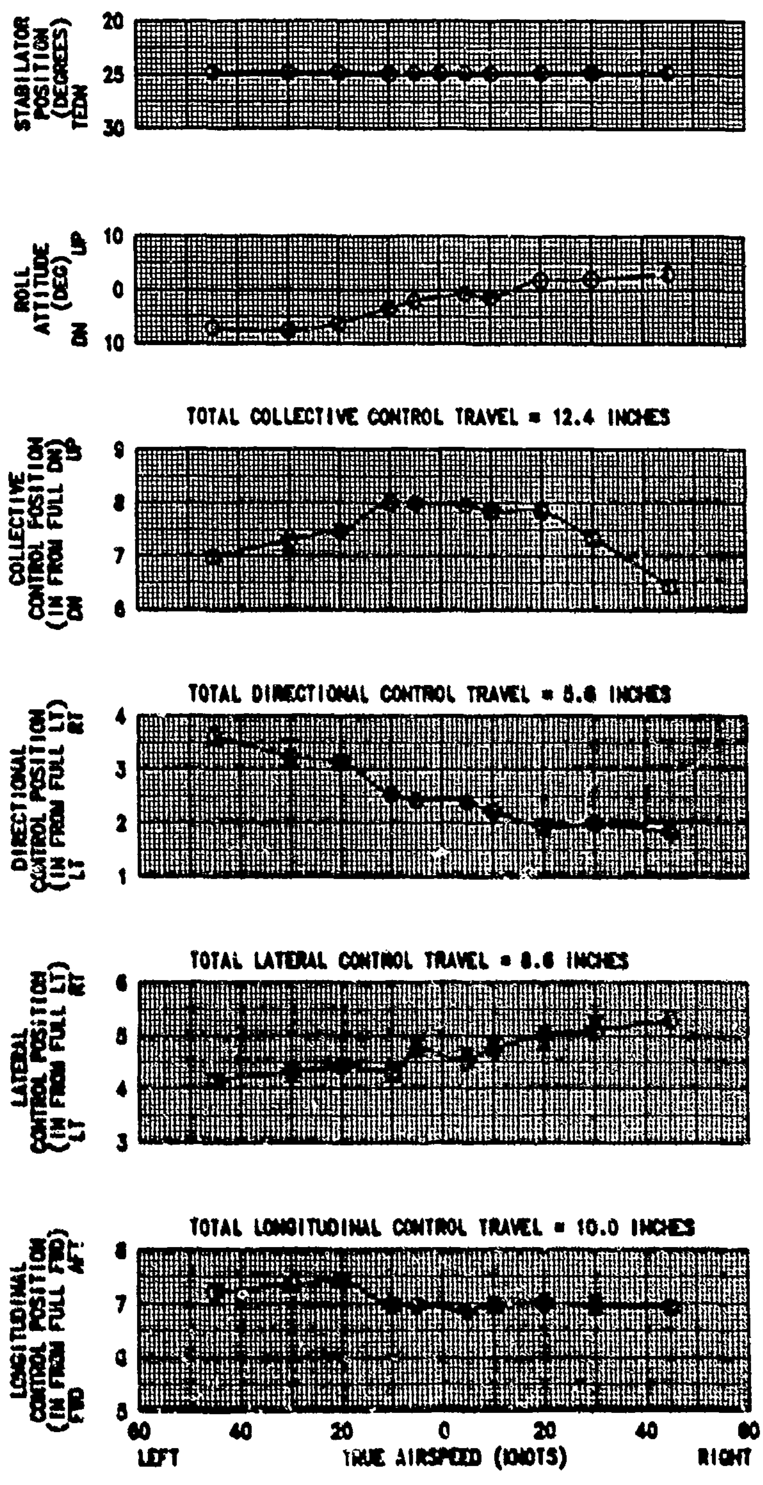


FIGURE E-24

SIMULATED LEFT ENGINE FAILURE

AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15720	205.6 AFT	0.3 LT	6290	20.0	280	48	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

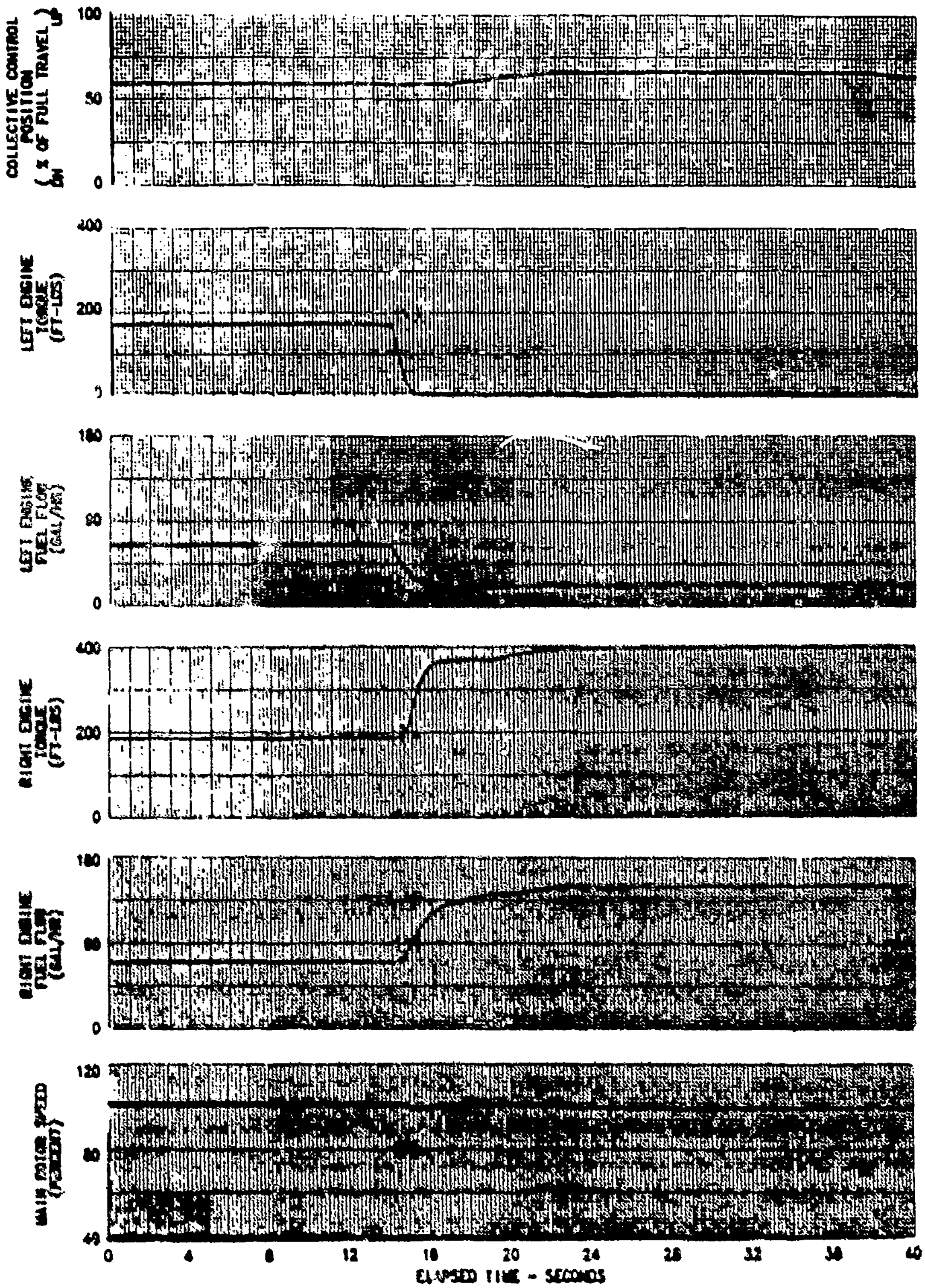


FIGURE E-24 (CONTINUED)
SIMULATED LEFT ENGINE FAILURE
AH-64A USA S/N 82-23355

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
13720	205.6 AFT	0.3 LT	6280	20.0	280	48	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

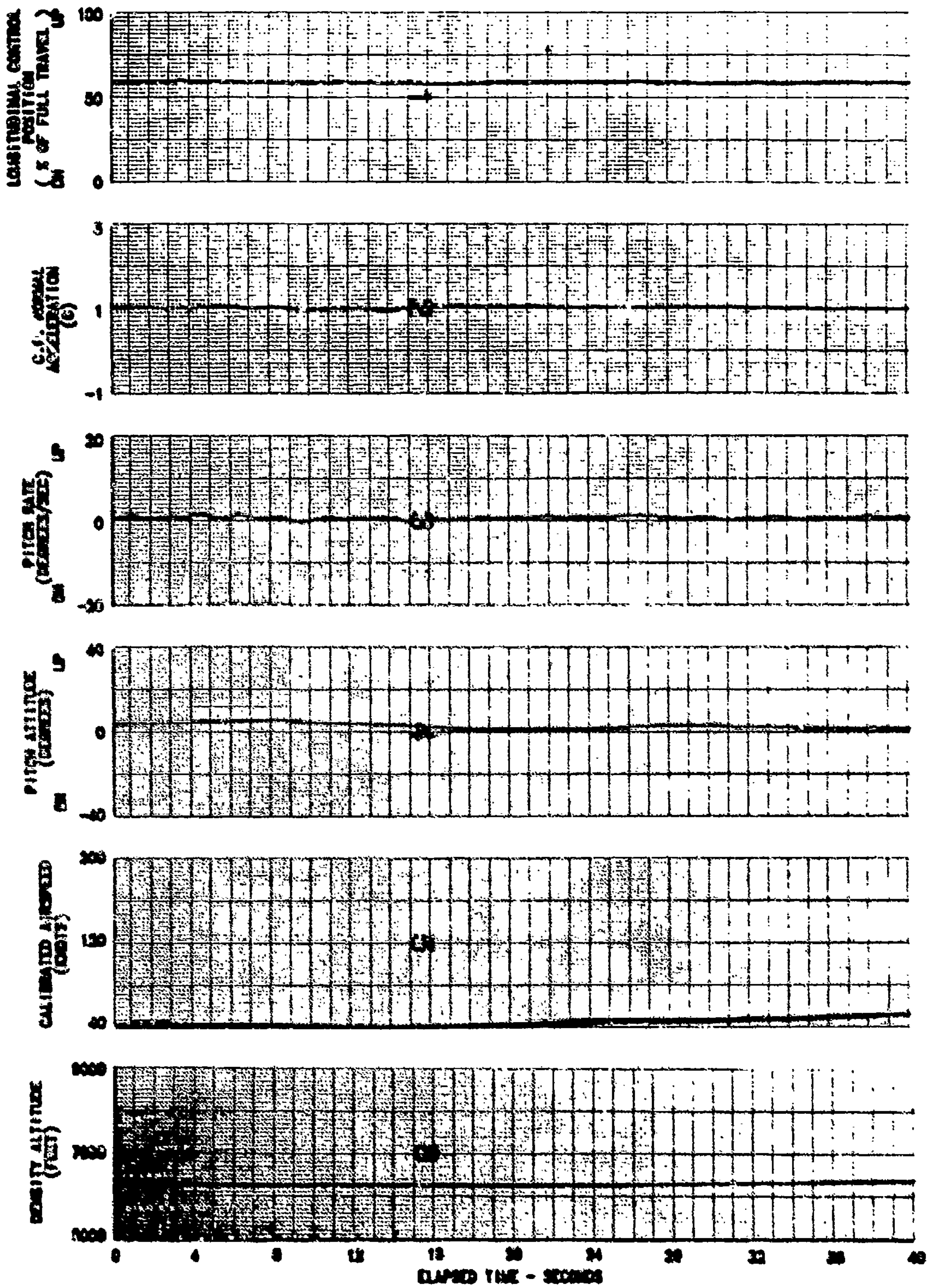


FIGURE E-24 (CONTINUED)
SIMULATED LEFT ENGINE FAILURE
AH-64A USA S/N 82-23356

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	TRIM DENSITY ALTITUDE (FT)	OAT (DEG C)	TRIM ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KTS)	TRIM FLIGHT CONDITION
15720	200.6 AFT	0.3 LT	[illegible]	20.0	280	40	LEVEL

NOTES: 1. SCAS ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION

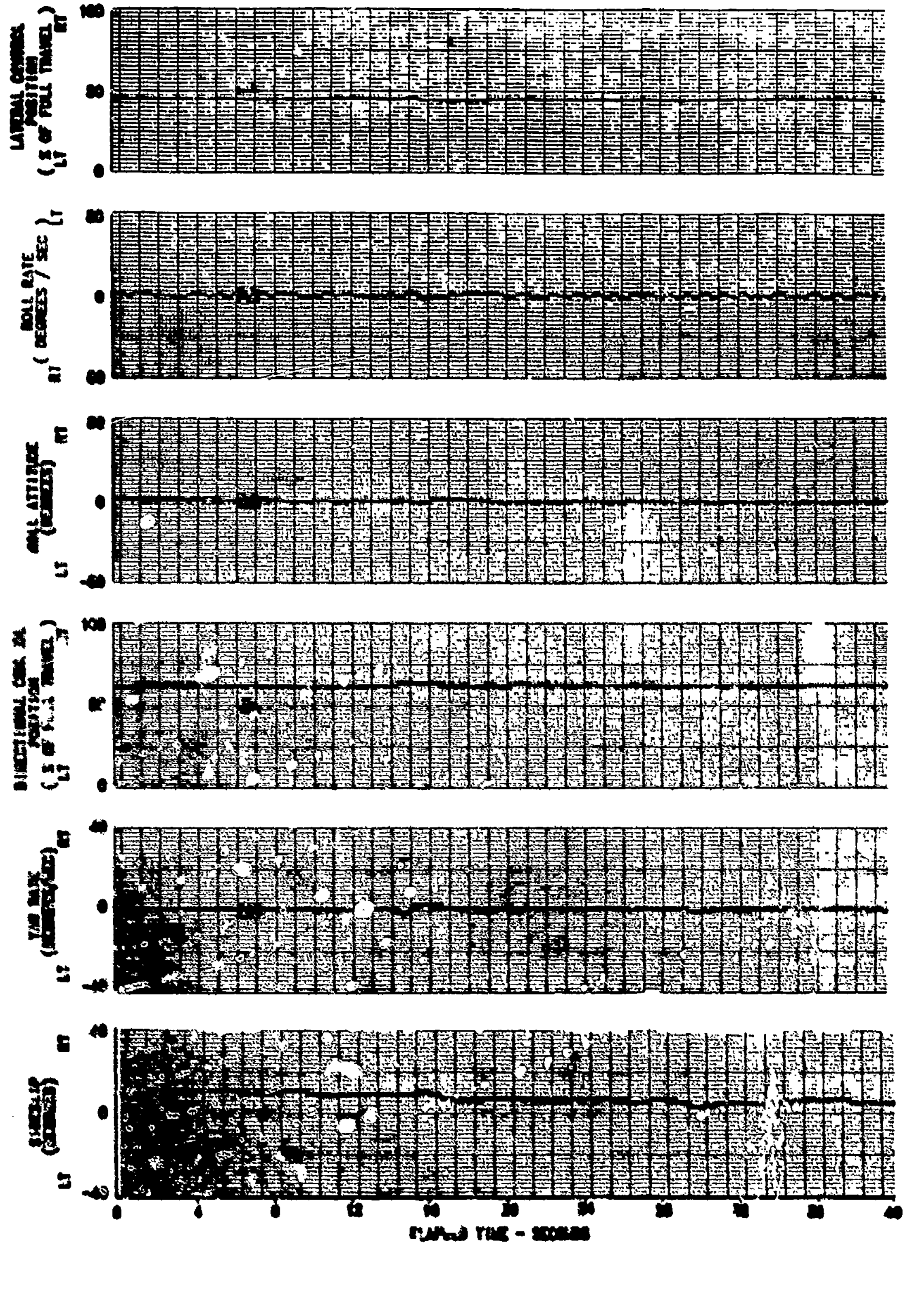


FIGURE E-25

AIRSPEED SIGNAL COMPARISON

AH-64A USA S/N 82-23355

UNCORRECTED RIGHT SIDE PITOT VS. BOOM

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	ATAS CONFIG
⊙	15360	205.7 AFT	0.3 LT	7020	21.0	287	INSTALLED
▲	15160	205.5 AFT	0.3 LT	7000	24.0	286	REMOVED

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. 8-HELLFIRE CONFIGURATION
3. RIGHT SIDE SIGNAL TO HORIZONTAL STABILATOR
4. A/S BELOW 140 KCAS (BOOM): LEVEL FLIGHT
5. A/S ABOVE 140 KCAS (BOOM): DIVING FLIGHT

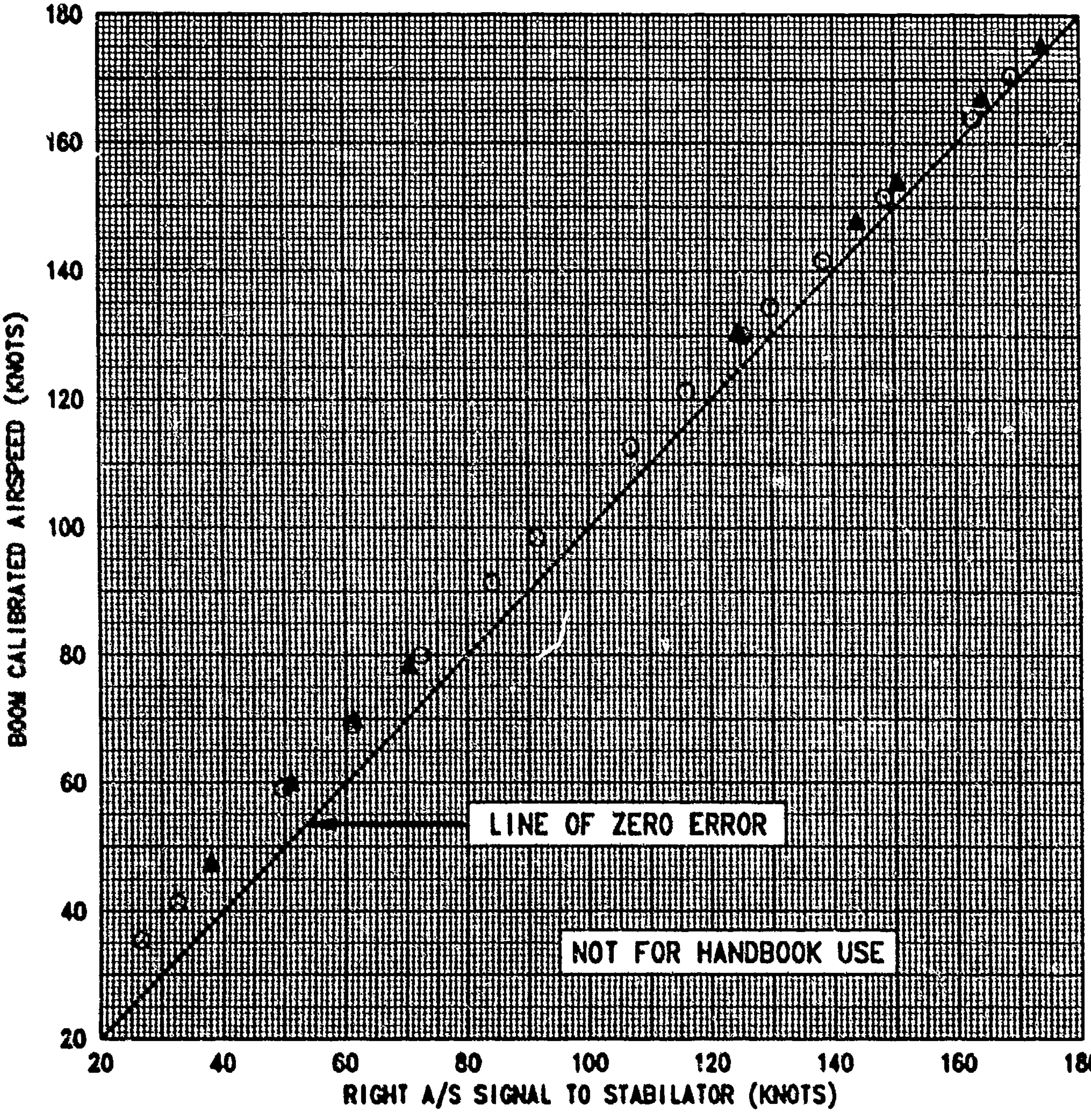


FIGURE E-26

AIRSPEED SIGNAL COMPARISON

AH-64A USA S/N 82-23355

UNCORRECTED LEFT SIDE PITOT VS. BOOM

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	ATAS CONFIG
⊙	15360	205.7 AFT	0.3 LT	7020	21.0	287	INSTALLED
▲	15160	205.5 AFT	0.3 LT	7000	24.0	286	REMOVED

NOTES:
1. DASE ON, ATTITUDE HOLD OFF
2. 8-HELLFIRE CONFIGURATION
3. LEFT SIDE SIGNAL TO HORIZONTAL STABILATOR
4. A/S BELOW 140 KCAS (BOOM): LEVEL FLIGHT
5. A/S ABOVE 140 KCAS (BOOM): DIVING FLIGHT

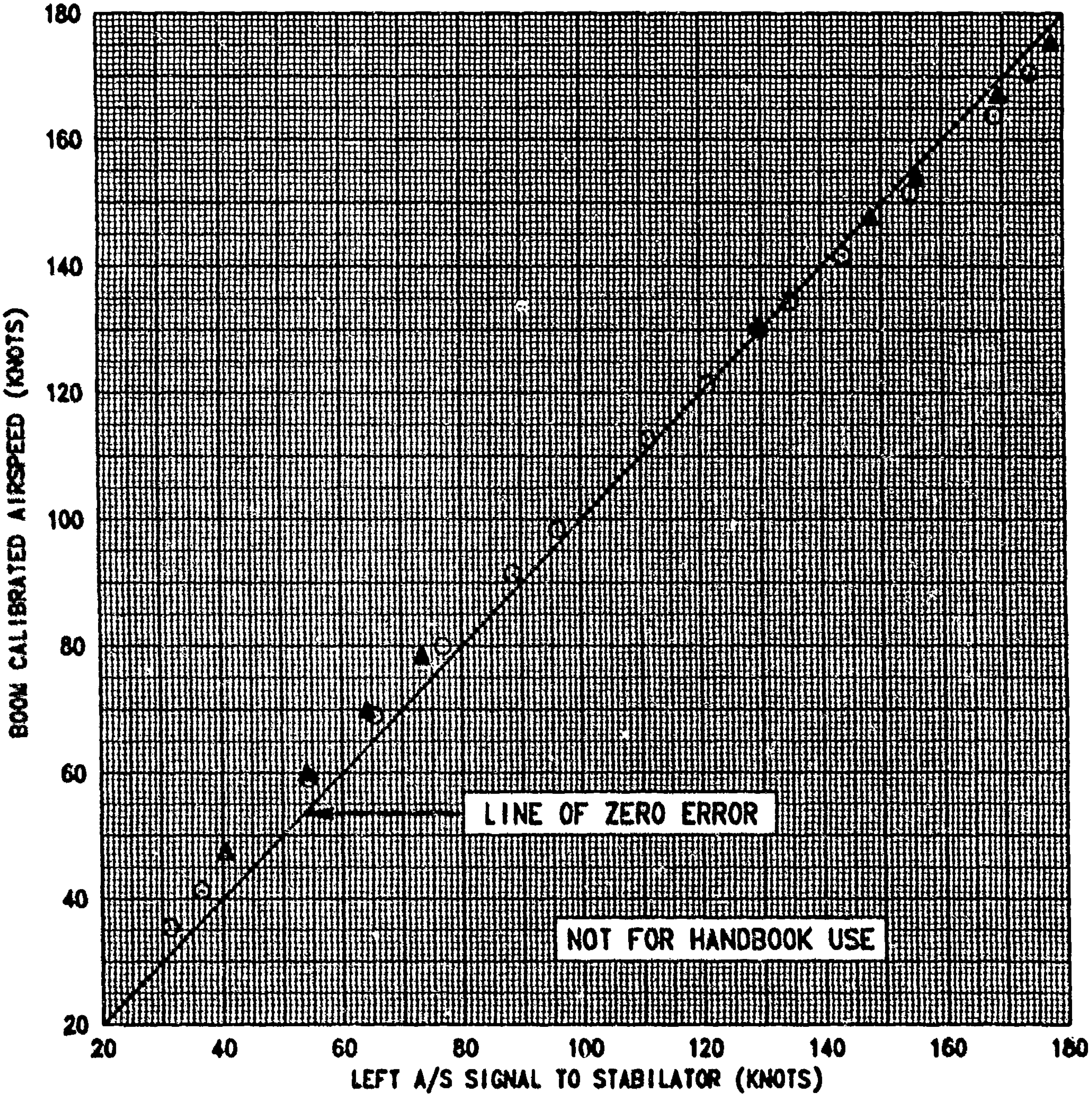
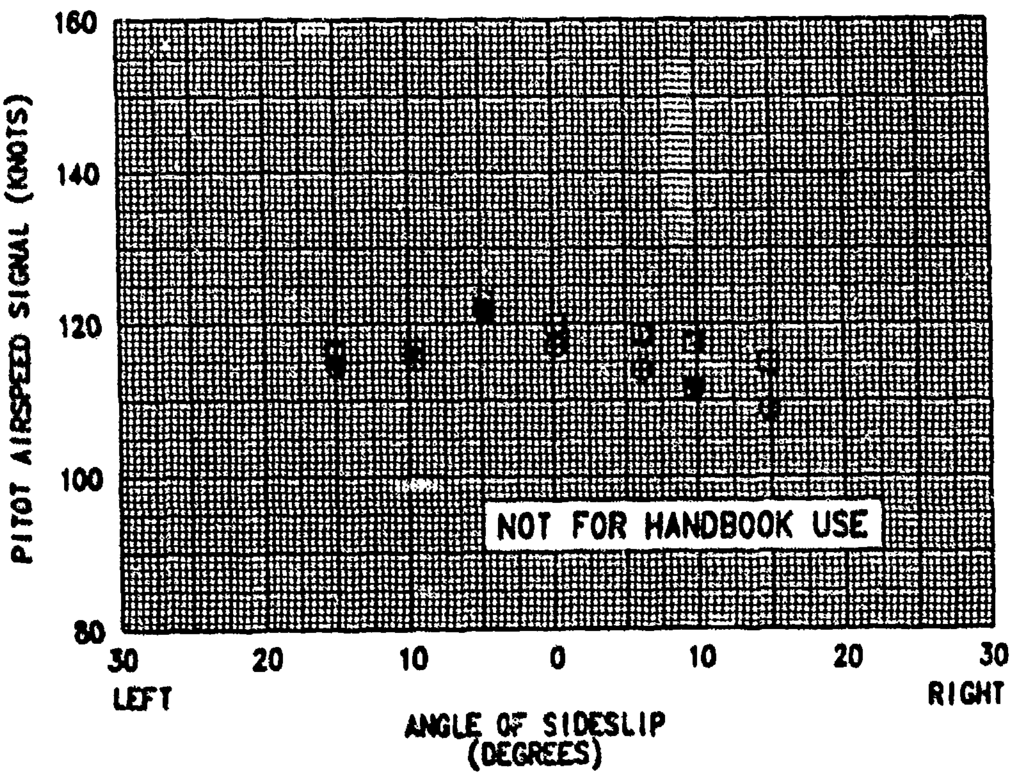


FIGURE E-27
PITOT STATIC COMPARISON
AH-64A USA S/N 82-23355
LEFT SIDE PITOT VS. RIGHT SIDE PITOT AIRSPEED SIGNALS

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION
15000	205.8 AFT	0.3 LT	6870	20.0	287	LEVEL

NOTES: 1. DASE ON, ATTITUDE HOLD OFF
2. ATAS / 8-HELLFIRE CONFIGURATION
3. ⊡ LEFT PITOT SIGNAL
4. ⊕ RIGHT PITOT SIGNAL



APPENDIX F. ABBREVIATIONS

AC	Alternating current
AEFA	U.S. Army Aviation Engineering Flight Activity
AGL	Above ground level
ATAS	Air-to-Air Stinger
AVSCOM	U.S. Army Aviation Systems Command
CPG	Copilot/gunner
DASE	Digital automatic stabilization equipment
DTV	Day television
FAB	Forward avionics bay
FD/LS	Fault detection and location system
FLIR	Forward looking infared
HQRS	Handling Qualities Rating Scale
HMD	Helmet mounted display
IEA	Interface electronics unit
IR	Infrared
IRP	Intermediate rated power
KCAS	Knots calibrated airspeed
KIAS	Knots indicated airspeed
KTAS	Knots true airspeed
LEU	Launch electronics unit
LOAL	Lock on after launch
LOBL	Lock on before launch
LOS	Line of sight
LVDT	Linear variable displacement transducer
MDHC	McDonnell Douglas Helicopter Company
MRTU	Multiplex remote terminal unit
NOE	Nap of the Earth
NVS	Night vision system
ORT	Optical relay tube
PAE	Preliminary Airworthiness Evaluation
PCM	Pulse code modulation
PNVS	Pilot's night vision system
POST	Passive optical seeker technique
PV	Production Vehicle
SCU	Signal conditioner unit
TADS	Target acquisition and designation system
TED	Trailing edge down
VRS	Vibration Rating Scale
Vy	Airspeed for best rate of climb
WAS	Weapon action select

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HQDA (DAMO-HRS)	1
HQDA (SARD-PPM-T)	1
HQDA (SARD-RA)	1
HQDA (SARD-WSA)	1
US Army Material Command (AMCDE-SA, AMCDE-P, AMCQA-SA, AMCQA-ST)	4
US Training and Doctrine Command (ATCD-T, ATCD-B)	2
US Army Aviation Systems Command (AMSAV-8, AMSAV-Q, AMSAV-MC, AMSAV-ME, AMSAV-L, AMSAV-N, AMSAV-GTD)	8
US Army Test and Evaluation Command (AMSTE-TE-V, AMSTE-TE-O)	2
US Army Logistics Evaluation Agency (DALO-LEI)	1
US Army Materiel Systems Analysis Agency (AMXSY-RV, AMXSY-MP)	8
US Army Operational Test and Evaluation Agency (CSTE-AVSD-E)	2
US Army Armor School (ATSB-CD-TE)	1
US Army Aviation Center (ATZQ-D-T, ATZQ-CDC-C, ATZQ-TSM-A, ATZQ-TSM-S, ATZQ-TSM-LH)	5
US Army Combined Arms Center (ATZL-TIE)	1
US Army Safety Center (PESC-SPA, PESC-SE)	2
US Army Cost and Economic Analysis Center (CACC-AM)	1
US Army Aviation Research and Technology Activity (AVSCOM) NASA/Ames Research Center (SAVRT-R, SAVRT-M (Library)	3

US Army Aviation Research and Technology Activity (AVSCOM) Aviation Applied Technology Directorate (SAVRT-TY-DRD, SAVRT-TY-TSC (Tech Library)	2
US Army Aviation Research and Technology Activity (AVSCOM) Aeroflightdynamics Directorate (SAVRT-AF-D)	1
US Army Aviation Research and Technology Activity (AVSCOM Propulsion Directorate (SAVRT-PN-D)	1
Defense Technical Information Center (FDAC)	2
US Military Academy, Department of Mechanics (Aero Group Director)	1
ASD/AFXT, ASD/ENF	2
US Army Aviation Development Test Activity (STEBG-CT)	2
Assistant Technical Director for Projects, Code: CT-24 (Mr. Joseph Dunn)	2
6520 Test Group (ENML)	1
Commander, Naval Air Systems Command (AIR 5115B, AIR 5301)	3
Defense Intelligence Agency (DIA-DT-2D)	1
School of Aerospace Engineering (Dr. Daniel P. Schrage)	1
Headquarters United States Army Aviation Center and Fort Rucker (ATZQ-ESO-L)	1
Commander, US Army Aviation Systems Command (AMSAV-EA)	1
Commander, US Army Aviation Systems Command (AMSAV-EIA)	1
Commander, US Army Aviation Systems Command (AMSAV-ESW)	1
Commander, US Army Aviation Systems Command (AMCPM-ATAS)	2
Commander, US Army Aviation Systems Command (AMCPM-AAH)	2