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ARMY PRELIMINARY EVALUATION YAH-1R IMPROVED COBRA AGILITY AND MANEUVERABILITY HELICOPTER

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Army Aviation Engineering Flight Activity
Edwards Air Force Base, California

May 1975

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ARMY PRELIMINARY EVALUATION
YAH-1R IMPROVED COBRA
AGILITY AND MANEUVERABILITY HELICOPTER

FINAL REPORT

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

The United States Army Aviation Engineering Flight Activity conducted an Army Preliminary Evaluation of the improved Cobra agility and maneuverability helicopter, designated the YAH-1R, serial number 70-15936, from 17 February through 7 March 1975. The helicopter was tested at the Bell Helicopter Company facility at Arlington, Texas. During the test, 17 flights were flown for a total of 20.0 flight hours, 12.9 of which were productive. Testing was limited to an

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20. Abstract

evaluation of aircraft handling qualities with emphasis on low-speed flight characteristics at gross weights of approximately 10,000 pounds. The YAH-1R helicopter was found to be a significant improvement over the AH-1G both in increased load-carrying capability and in increased low-speed directional control. The YAH-1R was capable, under test-day conditions, of hovering out of ground effect and performing lateral and longitudinal acceleration maneuvers at gross weights approximately 1000 pounds heavier than the AH-1G. Low-speed directional control margins, long a shortcoming of the AH-1G, were significantly improved. Steady-state directional control margins were 16 percent of pedal full throw or greater during all steady flight conditions, including sideward flight. At these conditions, the tail rotor power required was below the maximum continuous tail rotor transmission power limit. Tail rotor overtorque conditions and directional control application below the 10-percent left pedal margin occurred only during right lateral accelerations and during approach with the wind at the critical speed and azimuth. The one deficiency identified was the engine torque indication system, which is not sufficiently accurate to allow full utilization of the increased power. The handling qualities of the YAH-1R helicopter were similar to the AH-1G, except in the areas reflecting the improved directional control of the YAH-1R. Of the remaining five shortcomings, two minor shortcomings which resulted from the increased power and weight were (1) degradation of the dynamic stability with the stability and control augmentation system OFF in a maximum performance climb, and (2) neutral maneuvering stability above 1.35g at 120 knots calibrated airspeed and a 10,000-pound gross weight. Neither of these shortcomings will seriously degrade the handling qualities of the YAH-1R in the armed helicopter mission. Numerous recommendations are made ~~in this~~ report concerning improvement to the power management system of the YAH-1R helicopter. A total of 15 shortcomings were identified, 10 of which have been reported as shortcomings on previous models of the AH-1 helicopter.

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INTRODUCTION

BACKGROUND

1. In early 1972, development was initiated for an improved Cobra armament system (ICAS) to upgrade the AH-1G helicopter to meet the requirements for an armed helicopter in a mid- and high-intensity warfare environment by incorporation of the TOW missile system. An airworthiness and flight characteristics evaluation was conducted on a prototype ICAS helicopter, designated the AH-1Q, from April through June 1973 (ref 1, app A). Subsequent analysis of the AH-1Q mission indicated a requirement for improved Cobra agility and maneuverability (ICAM). To meet the requirements for ICAM, the Bell Helicopter Company (BHC) developed two prototype helicopters designated the YAH-1R and the YAH-1S, differing only in armament configuration. In January 1974, the United States Army Aviation Engineering Flight Activity (USAAEFA) defined test requirements for the ICAM helicopters and published the formal test plan for the Army Preliminary Evaluation (APE) in January 1975 (ref 2). In late January 1975, USAAEFA was directed by the United States Army Aviation Systems Command (AVSCOM) to conduct an APE of the YAH-1R helicopter (ref 3).

TEST OBJECTIVES

2. The objectives of the YAH-1R APE were as follows:

a. To allow early assessment of the handling qualities of the YAH-1R helicopter, with particular emphasis on increased gross weight, power, and maneuverability.

b. To provide quantitative and qualitative engineering flight test data for use in verification of the aircraft flight envelope.

c. To detect and allow for early correction of any aircraft deficiencies and shortcomings.

DESCRIPTION

3. The YAH-1R helicopter is a modified version of the AH-1G helicopter and is manufactured by BHC. The YAH-1R is a tandem, two-place, single-lifting-rotor attack helicopter equipped with a Model 212 tail rotor and is identical in appearance and overall dimensions to the AH-1G helicopter except for those dimensions pertaining to the tail rotor. A detailed description of the AH-1G helicopter and its armament systems is contained in the operator's manual (ref 4, app A). A detailed description of the Model 212 tail rotor is contained in

USAASTA Final Report No. 72-30 (ref 5). The Model 212 tail rotor used in the YAH-1R differed from that described in reference 5 only in the rigging of the maximum tail rotor blade pitch angle. The maximum blade pitch angle was larger (19.8 degrees) in the YAH-1R because of the uprated tail rotor drive train. Internal modifications applied to the AH-1G airframe to develop the YAH-1R model include the following:

a. Installation of a T53-L-703 engine with a thermodynamic rating of 1800 shaft horsepower (shp) and an engine torque limit of 1175 foot-pound (ft-lb) (1500 shp).

b. Installation of a modified AH-1J transmission rated at 1290 shp for 30 minutes and 1134 shp continuous operation.

c. Installation of a modified AH-1J tail rotor drive system allowing 187 shp continuous and up to 260 shp for 4 seconds as a transient power limit.

d. Strengthened transmission mounts and associated structures, and tail boom.

e. Installation of push-pull tubes replacing cables in the tail rotor control system.

f. An estimated empty-weight increase of 61 pounds.

g. An increase in the maximum allowable gross weight from 9500 pounds to 10,000 pounds.

4. Appendix B provides a detailed description of the modifications listed above and photos of the test helicopter (SN 70-15936).

TEST SCOPE

5. The YAH-1R APE was conducted at the BHC flight test facility at Arlington, Texas (elevation 630 feet), from 17 February through 7 March 1975. During the evaluation 17 flights were conducted for a total of 20.0 flight test hours, of which 12.9 hours were productive. All flights were conducted in the Hog configuration: four XM200 2.75-inch rocket launchers mounted on the wing stores stations (loaded with 12 28-pound inert rockets outboard and 19 28-pound inert rockets inboard), M28-A1 turret guns in the stowed position. The helicopter was evaluated as an attack helicopter against the requirements of military specification MIL-H-8501A (ref 6, app A), including applicable instrument flight requirements. The YAH-1R helicopter was evaluated to determine the effect of the modifications on the helicopter handling qualities, with particular emphasis on the high gross weight, low-airspeed maneuverability. Takeoff gross weight for all flights was 10,300 pounds in order to achieve an average flight gross weight of approximately 10,000 pounds. Testing was conducted at both forward and aft extremes of the

Table 1. Test Conditions.

Test	Average Gross Weight (lb)	Average Longitudinal Center-of-Gravity Location[1] (in.)	Calibrated Trim Airspeed (kt)	Average Density Altitude (ft)	Average Outside Air Temperature (°C)	Remarks
Control positions in trimmed forward flight	10,000	199.5 (aft)	32 to 122	5000	1.5	Level flight
	9500	199.3 (aft)	47 to 124	5100	2.5	
Static longitudinal stability	10,130	192.4 (fwd)	41	4400	17	Level flight trim
	10,080	199.5 (aft)	46	5100	2.5	Level flight trim
	9810	199.4 (aft)	151	5100	3	Dive trim
Static lateral-directional stability	9920	192.1 (fwd)	39	4000	17	Level flight trim
	10,120	199.5 (aft)	43	4900	10	Level flight trim
	9960	199.4 (aft)	151	5000	10	Dive trim
Maneuvering stability	9810	199.3 (aft)	60	5000	17	Left and right turns
	10,010	199.4 (aft)	124	5000	18	
	9870	199.4 (aft)	120	5000	18	
Low-speed flight characteristics	9940	192.2 (fwd)	[2]-35 to 40	-300	7	Forward and rearward
	9940	192.2 (fwd)	[2]-35 to 35	-300	7	Sideward
	9960	191.6 (fwd)	[2]2 to 40	-100	8	45° right relative azimuth
	9980	192.1 (fwd)	[2]-6 to 38	300	12	135° right relative azimuth
	9500	199.2 (aft)	[2]5 to 35	300	12	60° right relative azimuth
Hover in wind	9730	199.3 (aft)	[3]24	300	11	Zero to 360° in 45° increments
	9545	194.1 (fwd)	[3]20	300	11	
	9502	191.7 (fwd)	[3]22	300	10	
Control response and sensitivity	9600	191.8 (fwd)	[3]2 to 8	700	13	Longitudinal, hover OGE
	9660	191.8 (fwd)	[3]3 to 9	800	14	Lateral, hover OGE
	9440	191.6 (fwd)	[3]3 to 6	600	15	Directional, hover IGE
Dynamic stability (short-period)	9870	199.4 (aft)	45	4800	10	Pulses, doublets, all axes SCAS ON and OFF[4]
Dynamic stability (long-period)	9940	199.4 (aft)	40, 60, and 150	4800	-6	Controls fixed and pilot-suppressed lateral-directional mode
Simulated SCAS failures	9940	199.4 (aft)	40 to 60	4800	-6	Climbs at 40 to 60 knots
	9700	191.8 (fwd)	60	5000	17	Level flight at 40 to 60 knots
Mission maneuvers	9780	199.3 (aft)	Zero and 40	300	12	Lateral accelerations: Pop-up at 40 knots Bob-up - hover
Simulated engine failures	9940	199.4 (aft)	Zero	4800	-6	Hover, 40-knot level flight
	9900	199.4 (aft)	40 and 120	5000	17	40-knot climb, V_H level flight

[1]Lateral cg: -0.1 (left) for all tests.
[2]True airspeed.
[3]Wind speed.
[4]SCAS: Stability and control augmentation system.

center-of-gravity (cg) envelope (191.9 to 199.6 inches at 10,000 pounds gross weight). All tests were conducted at a main rotor speed of 324 rpm. Test conditions are shown in table 1. Flight restrictions and operating limitations were in accordance with the limitations presented in the AH-1G operator's manual as modified by the safety-of-flight release (app D) and the draft YAH-1R supplement (ref 7) to the operator's manual.

TEST METHODOLOGY

6. Established flight test methods and data reduction procedures were used during this evaluation (ref 8, app A). Test methods are briefly described in applicable sections of the Results and Discussion section of this report. Flight test data were hand-recorded from sensitive calibrated cockpit instrumentation and were automatically recorded by two oscillographs mounted in the ammunition bay of the test helicopter. A detailed listing of the test instrumentation is contained in appendix C. Aircraft space positioning data were recorded by manually operated recording optical instruments. Airspeed calibrations developed by BHC were used for this evaluation. Airspeeds for low-airspeed flight (less than 40 knots true airspeed (KTAS)) were determined by a vector sum of wind velocity and aircraft ground velocity as determined by a ground pace vehicle with a calibrated fifth wheel. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app F).

RESULTS AND DISCUSSION

GENERAL

7. An APE of the YAH-1R helicopter was performed to determine the effect of power train modifications and increased gross weight on the handling qualities of the basic AH-1G airframe and rotor system. The APE placed primary emphasis on operation in the low-airspeed heavy gross weight flight regime, including lateral agility, maneuverability, and mission-oriented tasks. The YAH-1R helicopter is a significant improvement over the AH-1G, both in increased allowable gross weight and in increased directional control capability. Under test-day conditions (a density altitude of -600 feet), the YAH-1R was able to hover out of ground effect (OGE) at 10,000 pounds gross weight with less than maximum power. It should be emphasized that this represents roughly a 1000-pound increase in OGE hover capability over the AH-1G under the conditions tested. The YAH-1R helicopter could hover and perform mission maneuvers, including pop-ups, bob-ups, and lateral accelerations, at weights which would preclude OGE hover for the AH-1G. Pedal control margin and tail rotor power-required characteristics, long a shortcoming of the AH-1G, have been significantly improved in the YAH-1R. Steady-state pedal margins were 16 percent or more in all steady flight conditions tested (including lateral flight), and tail rotor power requirements were below the maximum continuous limit in these instances. Tail rotor torque limits were exceeded on a transient basis during right lateral accelerations, large left pedal step inputs, and during an approach with the wind at the critical azimuth and speed. The 10-percent pedal margin was exceeded during this approach when full left pedal was required for approximately 1 second to arrest a yaw acceleration due to a lateral gust. One deficiency was found: the engine torque indicating system is not sufficiently accurate to allow full utilization of the increased available power. A total of 15 shortcomings were detected, 10 of which have been reported as shortcomings on previous AH-1 aircraft. Two of the remaining five shortcomings resulted from the increased power and gross weight of the YAH-1R helicopter: (1) degradation of the dynamic stability with the SCAS OFF in maximum performance climb, and (2) neutral maneuvering stability above 1.35g at 120 knots calibrated airspeed (KCAS) and a 10,000-pound gross weight. Neither of these shortcomings will seriously degrade the handling qualities of the YAH-1R in the armed helicopter mission. Correction of the deficiency should be accomplished prior to operational testing of the YAH-1R helicopter.

HANDLING QUALITIES

Control System Characteristics

8. The flight control system mechanical characteristics were evaluated on the ground with engine and rotors stopped and electrical and hydraulic power furnished by external sources. Control forces were measured on the pilot controls (aft cockpit)

Table 2. Control System Characteristics.[1]

Test		MIL-H-8501A Requirements		Test Results
		Maximum	Minimum	
Longitudinal cyclic	Breakout force (including friction)	1.5 lb[2]	0.5 lb	1.5 lb (fwd) 1.0 lb (aft)
	Gradient	2.0 lb/in.	0.5 lb/in.	1.8 lb/in.
	Full throw (fwd)[3]	8.0 lb	—	11.0 lb[4]
	Full throw (aft)[3]	8.0 lb	—	13.0 lb[4]
Lateral cyclic	Breakout force (including friction)	1.5 lb[2]	0.5 lb	1.0 lb (right) 2.0 lb (left)
	Gradient	2.0 lb/in.	0.5 lb/in.	1.7 lb
	Full throw (right)[3]	7.0 lb	—	9.0 lb[4]
	Full throw (left)[3]	7.0 lb	—	11.0 lb[4]
Directional	Breakout force (including friction)	7.0 lb	3.0 lb	3.0 lb (right) 1.0 lb (left)[4]
	Gradient	—	—	13.0 lb/in.
	Full throw (right)[3]	15.0 lb	—	28 lb[4]
	Full throw (left)[3]	15.0 lb	—	28 lb[4]

[1]Force trim ON, SCAS OFF.
[2]AH-1G contract deviation: 2.0 (±0.25) lb.
[3]Control displaced from a mid control trim position.
[4]Failed to satisfy the requirements of MIL-H-8501A or the AH-1G contract deviation. Control throw limit was not reached due to measuring system constraints.

with the force trim ON and SCAS OFF. Breakout forces (including friction) were measured by observing the stick force required to initiate first movement of the control position indicator. The cyclic control pattern is presented in figure 1, appendix E. Control system forces as a function of control position are presented in figures 2 through 4. The results of the control force evaluation are summarized in table 2. Due to the lack of precise swashplate movement indication, free play could not be determined. Cyclic control and directional control centering were positive but the accuracy of centering was a function of the friction band and the size of displacement prior to release. Cyclic and pedal dynamics were highly damped, with both controls showing only one very small overshoot in returning to trim position for control displacements of approximately 2 inches. The control system force characteristics of the YAH-1R helicopter were determined to be essentially the same as a production AH-1G. A collective stick rate limiter, installed in the YAH-1R to limit the collective stick movement rate to 9.2 inches per second, was not noticed in flight. As shown in table 2, the control system forces did not meet the requirements of paragraphs 3.2.6, 3.3.12, and 3.3.13 of MIL-H-8501A but the control force characteristics were not objectionable in flight.

Control Positions in Trimmed Forward Flight

9. Control positions in trimmed forward flight were determined in level flight at the conditions listed in table 1. The helicopter was trimmed to zero sideslip and steady heading at airspeeds ranging from 32 to 124 KCAS with the SCAS ON. The data are presented in figures 5 and 6, appendix E.

10. An increasing forward trim position of the longitudinal cyclic control was required to stabilize at each higher airspeed throughout the airspeed range tested. The gradient of forward cyclic control with increasing airspeed was essentially constant. The trim lateral cyclic control position with forward airspeed moved right with increasing airspeed to 75 KCAS, and then moved back to the left as airspeed approached V_H (maximum airspeed for level flight). This reversal was noticeable in flight but did not pose any control difficulty. The variation of directional control position with airspeed was similar to the lateral cyclic; however, this movement was not discernible to the pilot. Total variation in lateral cyclic and directional control was less than 1 inch throughout the airspeed range tested. The variation of pedal position with forward airspeed reveals a significant increase in left pedal control margin of the YAH-1R helicopter at 10,000 pounds gross weight over the AH-1G or AH-1Q aircraft at 9100 pounds gross weight. This increase in pedal margin is attributable to the installation of the Model 212 tail rotor on the YAH-1R helicopter. The trimmed control position characteristics of the YAH-1R in level flight met the applicable requirements of MIL-H-8501A and are satisfactory.

Collective-Fixed Static Longitudinal Stability

11. Collective-fixed static longitudinal stability was evaluated at the conditions shown in table 1. The helicopter was trimmed in steady-heading zero sideslip flight at the desired trim airspeed. Then, with the collective stick held fixed, the helicopter

was stabilized at incremental airspeeds greater than and less than the trim airspeed. Data were recorded at each stabilized airspeed. Test results are presented in figures 7 through 9, appendix E.

12. In low-speed flight (20 to 60 KCAS) the variation in longitudinal control position with airspeed indicated positive static stability at airspeeds greater than or less than the trim airspeed at an aft cg (199.5 inches). At the forward cg (192.4 inches), the static stability was stronger at airspeeds higher than trim airspeed but became neutral at airspeeds below 30 KCAS. Although the neutral static stability below 30 KCAS will tend to make airspeed control difficult, airspeed is generally not a prime concern since the pilot will be orienting himself to the ground speed and track. The neutral static stability below 30 KCAS makes the hover task easier, since the pilot is required to use minimal longitudinal cyclic inputs to maintain his hover position in gusty wind conditions (HQRS 3).

13. In low-speed flight (20 to 60 KCAS) the variation of pitch attitude with airspeed was essentially zero. The neutral character of the pitch attitude gradient with airspeed makes pitch attitude impossible to use for an airspeed cue; however, this lack of pitch attitude change with airspeed is helpful during hovering flight in winds. Wind gusts will not upset the hover pitch attitude; thus, minimal pilot compensation will be required to maintain hover position (HQRS 3).

14. In diving flight simulating a target engagement, the longitudinal static stability, as indicated by the variation of longitudinal cyclic position with airspeed, was positive but the stick position gradient was very shallow (0.2 inch of forward control travel from 134 to 167 KCAS). The variation of pitch attitude with airspeed was also minimal (5.0-degree nose-down pitch attitude change from 134 to 167 KCAS) but due to the excellent cockpit references, small pitch attitude changes were easily detected and provided suitable cues to airspeed changes. Airspeed changes were also easily recognizable by a change in the wind noise and vibration levels in the cockpit. The weak but positive variation of longitudinal cyclic position with airspeed provided adequate pilot cues to airspeed variations from trim and minimized the trim change due to airspeed, which simplified the diving simulated-target attack task (HQRS 2). Within the scope of this evaluation, the static longitudinal stability of the YAH-1R helicopter, as indicated by the variation of longitudinal cyclic control position with airspeed, met the requirements of MIL-H-8501A and is satisfactory.

<u>Static Lateral-Directional Stability</u>

15. Static lateral-directional stability characteristics were determined at the conditions shown in table 1. The aircraft was initially trimmed in zero sideslip level flight or in a dive at the desired airspeed. With the collective control fixed and airspeed held constant, the aircraft was stabilized at incremental sideslip angles from zero to the limit of the sideslip envelope. Test results are presented in figures 10 through 12, appendix E.

16. The static directional stability, as indicated by the variation of directional control position with sideslip, was positive up to the limit of the sideslip envelope. The effective dihedral, as indicated by the variation of lateral cyclic control with sideslip, was positive and generally linear.

17. The side-force characteristics, as indicated by the variation of bank angle with sideslip, were very weak in low-speed flight. The threshold of pilot recognition of side force is 0.1g lateral acceleration (ref 9, app A). This corresponds to a bank angle of approximately 6 degrees in hover or straight and level flight. This bank angle was not achieved within the sideslip envelope of the YAH-1R helicopter, though it was approached in left sideslip. This corresponds to the pilot qualitative observation of essentially neutral side-force characteristics at low airspeed (43 KCAS). During mission maneuvering tasks the pilot was virtually unaware of sideslip variations at low airspeeds without reference to the test sideslip indicator. The weak side forces make it impossible to obtain zero sideslip conditions or even stay within the allowable aircraft sideslip envelope, impacting the accuracy of rocket fire. Weak side-force characteristics during low-speed flight are a shortcoming.

18. During tests to evaluate the YAH-1R lateral-directional stability, a qualitative assessment of the effect of sideslip on ship's system airspeed indications was accomplished. At a 43-KCAS trim airspeed, standard airspeed system errors on the order of 20 knots indicated airspeed (KIAS) lower than the boom airspeed were observed within the sideslip envelope. This airspeed error, coupled with the weak side-force cues concerning sideslip, definitely present a problem during low-speed maneuvering. When the pilot is off of the desired airspeed, he will tend to correct with longitudinal cyclic control when the real source of error is large sideslip angles. This leads to unnecessary or even incorrect pilot compensation and significantly increases pilot workload during low-airspeed control tasks. Excessive airspeed indication error due to sideslip is a shortcoming.

19. With continued emphasis being placed on low-speed maneuvering flight and tactics requiring flight in any direction, consideration should be given to installing an airspeed system capable of giving accurate velocity information, both magnitude and direction (sideslip), throughout the rearward, sideward, and forward airspeed envelopes. Further tests should be conducted to expand the YAH-1R sideslip envelope to such an angle of sideslip that a threshold 0.1g lateral acceleration (which may be sensed by the pilot) is realized due to the sideslip. The sideslip envelope should be unrestricted below a velocity which produces 0.1g lateral acceleration.

Dynamic Stability

20. The longitudinal and lateral-directional dynamic stability of the YAH-1R helicopter was evaluated at the conditions shown in table 1 with SCAS ON and SCAS OFF. Short-term dynamic responses, simulating gust response, were evaluated by rapidly pulsing the cyclic control and pedals 1 inch for a duration of approximately 1/2 second, then returning the control to the trim position. Short-term response was further evaluated by control doublets. Time histories of representative dynamic responses are presented in figures 13 through 24, appendix E.

21. The short-term response characteristics of the YAH-1R helicopter were essentially the same as the AH-1G. With SCAS ON all responses were essentially deadbeat, while with SCAS OFF, responses were lightly damped. Aircraft responses to pulse and doublet inputs were similar at 45 and 60 KCAS in level flight. At takeoff power and 60 KCAS, the aircraft response was deadbeat with SCAS ON and exhibited two divergent modes with SCAS OFF (figs. 59 and 60, app E). These divergent modes are discussed in paragraph 79.

22. The principal response mode of the YAH-1R helicopter to external gust input was a coupled roll-yaw oscillation (Dutch roll). Time histories of this response mode are shown in figures 13 through 24, appendix E. Although this oscillation was noticeable in flight with SCAS ON, it was positively damped without pilot input and easily damped by the pilot to achieve satisfactory flight conditions to launch rockets (HQRS 3). With SCAS OFF, the lateral-directional oscillation was lightly damped and easily excited by external gusts; however, the aircraft handling qualities are acceptable for flight in this degraded mode. Maintaining an airspeed below 100 KIAS for SCAS OFF flight, as currently recommended for the AH-1G, reduces pilot effort. Qualitatively, the YAH-1R short-period dynamics are similar to the standard AH-1G at a power setting of 1100 shp or below. At power settings above 1100 shp, the SCAS-OFF divergence is more pronounced.

23. Long-period dynamic response characteristics were evaluated by slowing the helicopter with aft cyclic control to an airspeed 10 to 15 knots below the trim airspeed, then slowly returning the control to the trim position. The response was evaluated with SCAS ON and SCAS OFF by letting the aircraft respond freely about all axes and also by pilot suppression of the lateral and directional modes.

24. At an airspeed of 43 KCAS with the helicopter trimmed at zero sideslip and allowed to respond freely, the SCAS ON long-period pitch attitude was erratic but the aircraft diverged in a lateral-directional oscillation with a period of 48 seconds. At 43 KCAS with the aircraft trimmed in wings-level coordinated flight with SCAS ON, the long-period oscillation was neutrally damped with a period of 47 seconds and aerodynamically coupled in pitch, roll, and yaw. Pilot suppression of the roll and yaw oscillation resulted in a divergent pitch oscillation with a period of 38 seconds. A simulated SCAS failure while the aircraft was in a free response oscillation about the 43-KCAS trim airspeed resulted in the neutral oscillation becoming slightly convergent with a period reducing from 47 seconds to 11 seconds at the time of recovery.

25. At a trim airspeed of 61 KCAS at zero sideslip in level flight, the long-period oscillation was neutrally damped for SCAS ON and SCAS OFF conditions. Small power increases tended to increase the magnitude of the neutrally damped lateral-directional oscillation. At takeoff power and 61 KCAS, the SCAS ON long period was oscillatory divergent in pitch with a period of 39 seconds. With SCAS OFF the aircraft exhibited a divergent lateral-directional oscillation with a period of 4.7 seconds (fig. 59, app E) and an essentially aperiodic pitch and roll divergence (fig. 60). These modes will be discussed more fully in paragraph 78. Within the scope of this evaluation, the long and short-period dynamics of the

YAH-1R helicopter are acceptable for visual flight conditions. The divergent character of the SCAS OFF dynamics in a maximum performance climb is a shortcoming which will make a safe recovery extremely difficult under instrument meteorological conditions (IMC). This shortcoming will restrict recommended climb power or rate of climb in low visibility or IMC.

Maneuvering Stability

26. Maneuvering stability characteristics were evaluated at the conditions shown in table 1 with SCAS ON. Trim conditions were 120 and 124 KCAS at maximum continuous power zero sideslip level flight and 60 KCAS in a zero sideslip maximum power climb. The variation of longitudinal and lateral cyclic and pedal control positions with cg normal acceleration was determined by stabilizing the aircraft in constant-airspeed zero sideslip turns at incremental bank angles left and right. The collective control remained fixed during the maneuver and power and rotor speed varied as a function of the pitch cone coupling and the altitude variation during the turn. The quantitative results of the maneuvering stability evaluation are presented in figures 25 and 26, appendix E.

27. At 60 KCAS and maximum power, the aircraft was in a climbing spiral to about 1.2g and a descending spiral at a normal load factor in excess of 1.2g. The longitudinal stick position control variation with normal load factor shows a sharp change in slope at 1.2g. The gradient decreased but remained positive and essentially linear above 1.2g. The aircraft was easy to control during these maneuvering turns and minimal pilot compensation was required to achieve satisfactory performance in simulated rapid returns to a target at 60 KCAS and maximum power (HQRS 3). As the aircraft normal acceleration approached 1.6g, there was a noticeable buildup in the 2-per-rotor-revolution (2/rev) vibration level. The vibration level in the aft cockpit was severe enough to cause blurring of the instruments. Above 1.6g, in addition to a severe 2/rev vertical vibration, a medium-frequency vibration of increasing intensity was encountered. The maneuvering stability evaluation was terminated at 1.64g because of the high vibration level.

28. Figure 26, appendix E, shows the maneuvering stability test results for the YAH-1R helicopter at V_H with maximum continuous power. The maneuvering stability under these conditions was positive below 1.35g; however, the stick position gradient became essentially neutral above 1.35g. The aircraft was very difficult to control precisely above 1.3g due to what appeared to be a longitudinal oscillation. Although the aircraft did present control difficulty when the task was defined as precise airspeed control during maneuvering flight, the aircraft was responsive to control. The pilot could not prevent airspeed oscillations about the desired trim airspeed but there was no tendency toward a divergent pitch-up or divergent roll. No divergent tendency was noted in symmetrical pull-ups to approximately 2g. The neutral stability above 1.35g at 120 KCAS is a shortcoming which should not affect mission accomplishment. Tests should be conducted to investigate the maneuvering stability of the YAH-1R helicopter at the more severe flight conditions of higher density altitude and higher airspeed. Tests should include constant-power turns and symmetrical pull-ups.

29. During the maneuvering flight evaluation at V_H a 2/rev vertical vibration, which increased in intensity as normal load factor increased, was noted. Intermittent cyclic feedback was encountered at 1.4g, becoming steady cyclic feedback above 1.5g. The first maneuvering stability flight was terminated at 1.53g due to the severe 2/rev vertical vibration and cyclic feedback. An inspection of the aircraft after this maneuvering flight revealed low swashplate and collective sleeve friction. These frictions were adjusted and the hydraulic system was fully purged of air (para 9). The maneuvering stability flight at V_H was repeated. The 2/rev vertical vibration was still present but the severity was greatly decreased, and no cyclic feedback was encountered. The second maneuvering stability flight at V_H was terminated at 1.58g due to engine overspeed limits precluding higher stabilized normal load factors. The tendency for the engine to overspeed during collective-fixed maneuvering flight is a shortcoming.

30. Maneuvering stability tests revealed a change in the longitudinal control position gradient with normal acceleration (approximately 1.2g at 60 KCAS and 1.35g at 120 KCAS). These levels of normal acceleration occurred at the pitch rate which resulted in full extension of the longitudinal SCAS actuator in the nose-down sense. This eliminated any longitudinal stabilization by the SCAS. The shift in maneuvering stability gradient probably reflects the difference in the artificially stabilized airframe and the basic airframe characteristics. Subsequent analysis of controllability data revealed that the longitudinal SCAS actuators fully extended at approximately 10 degrees per second pitch rate. This pitch rate correlates with the longitudinal pitch rates which caused full longitudinal SCAS actuator extension during the maneuvering stability tests. The effective loss of longitudinal SCAS due to full actuator extension did not materially affect the maneuvering handling qualities at 60 KCAS; however, at 120 KCAS this effective loss of SCAS input degraded the maneuvering handling qualities, in that precise airspeed control required extensive pilot compensation during steeply banked diving turns. This conclusion was verified by attempting to hold 120 KCAS in maneuvering flight with SCAS OFF. Under these conditions, airspeed could not be satisfactorily stabilized in a turn at bank angles in excess of 15 degrees. Loss of the stabilizing influence of the longitudinal SCAS within the operational normal load factor envelope of the aircraft is a shortcoming which should be corrected as soon as practical.

Controllability

31. Controllability characteristics were evaluated in an OGE hover (longitudinal and lateral control) and in an in-ground-effect (IGE) hover (directional control) with the SCAS ON. The aircraft was trimmed in a stable hover attitude and control step inputs of varying size were applied to each axis, using a mechanical fixture to obtain the desired input size. The inputs were held until a maximum rate was established or until recovery was necessary. Test results are presented in figures 27 through 32, appendix E.

32. There were no objectionable delays in the development of angular rates in response to control displacements. Angular rates and accelerations were in the proper direction within 0.2 second after the control displacement. Aircraft responses were essentially uncoupled for cyclic control inputs. Pedal control inputs resulted in an adverse roll response (*ie*, left roll with right yaw). This roll response was damped as the yaw rate began and should provide no controllability problem in operational use.

33. Pitch attitude change in 1 second, maximum pitch acceleration, and maximum pitch rate were essentially linear functions of the longitudinal input size. The time to maximum pitch acceleration was 0.2 second or less, with 0.1 second being the median peak acceleration time. The time to maximum pitch rate was essentially independent of the input size within the accuracy of time determination.

34. Lateral step input produced responses which were linear with step size. Time to maximum roll acceleration was 0.1 second and time to maximum roll rate was nominally 1 second.

35. Yaw responses to step pedal control inputs were essentially linear for inputs of 1.3 inches, left, to 1.0 inch, right. Larger magnitude right pedal inputs produced higher yaw rates and accelerations, but the increases were nonlinear. A mean tail rotor power of 100 percent (260 shp) was noted during left pedal inputs of 1.3 inches. This input produced a transient overtorque condition of 119 percent (310 shp). Approximately 2 inches of left pedal margin were available at this hover condition. A comparison of the transient tail rotor torque during controllability step inputs to the slower inputs during hover turn arrestments (fig. 33, app E) indicates that the maximum transient torques are primarily a function of the magnitude of the input and are relatively independent of the rate of input for input times of 0.1 to 1.0 second. An oscillation was noted in both tail rotor torque and main rotor torque as a result of pedal inputs. This lightly damped torsional oscillation appears to contribute to the high peak tail rotor transient power. This torsional oscillation arises from basic relationships in the phasing of structural oscillations and should be present in all AH-1G aircraft. Since the data base for this phenomenon is not established, the effects of the modifications comprising the YAH-1R cannot be determined. Inspection of the 42- and 90-degree gearboxes and tail rotor drive output quill after completion of the APE revealed no indication of damage caused by the high transient tail rotor torque. A study should be conducted to uprate the steady-state and transient power limits of the tail rotor drive train if it is structurally feasible.

Low-Speed Flight Characteristics

36. The handling qualities of the YAH-1R helicopter during low-speed translational flight were evaluated at the conditions listed in table 1. The test aircraft was flown IGE at an approximate skid height of 5 to 10 feet above ground level. A calibrated fifth wheel mounted on a pace vehicle was used as a speed reference. Aircraft true airspeed and relative wind angle were determined by a vector sum of aircraft and wind velocity vectors. Winds during this test series were less than 7 knots.

The aircraft was stabilized at the following azimuths relative to the ground track: zero, 45 and 60 degrees (right headwind), 90 degrees (right side wind), 135 degrees (right tail wind), 180 degrees (tail wind), and 270 degrees (left side wind). For low-speed forward, rearward, and lateral flight data, only the wind velocity component along the applicable axis was considered. For other azimuth conditions, the true vector velocity of the relative wind speed was taken into account. Additionally, critical azimuth data were taken on three occasions by hovering in winds with velocities ranging from 20 to 24 KTAS. The data are presented in figures 34 through 46, appendix E.

37. At no time during steady flight or during hover in ambient winds did the directional control position fall below the 10-percent directional control margin. The least average directional control margin encountered was 16 percent with a wind speed of 25 knots from an aircraft relative azimuth of 90 degrees. At no time during this test did the mean tail rotor power exceed the continuous operation limit of 187 shp. This is a substantial improvement in the directional control margin of the YAH-1R helicopter over the AH-1G. The critical azimuth of the YAH-1R is the same as the AH-1G, a headwind approximately 60 degrees right of the longitudinal axis. During flight tests at this wind azimuth, at an aft cg and 9500 pounds gross weight, maximum control excursions were required. Transient values of control position indicated sufficient control margin at all airspeeds. The minimum transient control margin encountered was 0.6-inch left pedal; however, at this point the transient tail rotor power was at the maximum value. An airspeed between 20 and 25 KTAS at the 60-degree wind azimuth was the critical condition from an aircraft control standpoint; however, the test helicopter was maneuvered directionally through this critical condition with minimal pilot compensation required (HQRS 3).

38. The variation of control positions with true airspeed in low-speed flight shows varying gradients in all axes, depending on the direction and magnitude of the relative wind azimuth; however, these shifting gradients presented no control problems. The only apparent changes in control position gradient noticeable to the pilot were (1) longitudinal cyclic position changes passing through translational lift both in forward and rearward flight (fig. 34, app E) and (2) the shift in pedal position passing translational lift in left sideward flight (fig. 35). Handling qualities in low-speed flight simulating a hover in varying wind conditions are acceptable.

Power Management

39. Three aspects of power management degrade the handling qualities of the YAH-1R helicopter. The deficiency and shortcomings associated with power management all increased the pilot workload and therefore detracted from his ability to control and maneuver the aircraft and perform other mission-related tasks. Additionally, the deficiency and some of the shortcomings directly limited the capabilities of the aircraft, regardless of pilot workload. The three general areas are (1) automatic gas producer turbine outlet temperature limiting system, (2) rotor/engine speed control, and (3) torque indication accuracy and control.

Automatic Gas Producer Turbine Temperature Limiting System:

40. The T53-L-703 engine is the first T53-series free shaft engine to incorporate a gas producer turbine outlet temperature (T_7) measurement system, as opposed to the exhaust gas temperature (EGT) measurement used on previous versions. This is a significant improvement. The previously used EGT systems were only capable of indicating malfunctions or gross engine deterioration in normal conditions. The EGT cannot adequately indicate power level or engine condition. Therefore, this gage has minimal significance and does not need to be monitored continuously. The T_7 system accurately reflects power levels and engine deterioration. Turbine outlet temperature will limit maximum power at some conditions of pressure altitude and ambient temperature. This increases pilot workload since the pilot has an additional primary power instrument to monitor.

41. All T53-series engines have had an automatic N_1 limiting device (topping system) that is programmed as a function of pressure altitude and engine inlet temperature. The purpose of the topping system is to prevent gas producer turbine inlet temperature limits from being exceeded. In theory, each engine's topping limit (sea-level, standard-day maximum N_1) is set during the production acceptance runs to keep turbine inlet temperature below the maximum allowable. In practice, the engines are trimmed to produce slightly more than guaranteed rated power. A calculation is then made to show that the gas producer turbine inlet temperature is not exceeded. An imprecisely known temperature margin is therefore available to allow for engine deterioration. The topping system should be redesigned and initially trimmed to prevent exceeding the more accurate, measured gas producer turbine outlet temperature limits over the operational altitude and ambient temperature range. This would relieve the pilot of continuously monitoring the additional primary power instrument. It would control turbine temperatures more accurately and make available any individual engine's performance margin over rated power. A field procedure for retrimming the topping system to provide for engine deterioration should be developed and published in the appropriate manuals. The topping system should have an emergency override feature that would allow the pilot to intentionally exceed the automatic limit in an operational emergency while still retaining all governing functions.

Rotor/Engine Speed Control:

42. The static droop characteristics (difference in steady rotor speed with a change in steady power) were very good in the YAH-1R helicopter. The largest rotor speed change found within the test conditions was 3 rpm. At all conditions tested, undercompensation was observed (decrease in rotor speed with an increase in power). Dynamic droop characteristics with increasing power demand were also good. Only small short-term rotor speed decreases were noted during takeoffs or accelerations, indicating that engine acceleration characteristics are very good. The large allowable rotor/engine underspeed limits (294/6000 rpm) relative to the normal operating speed (324/6600 rpm) also minimized the impact of dynamic droop during increasing power demands.

43. The dynamic droop characteristics with decreasing power were extremely poor in the YAH-1R helicopter. They significantly increased pilot workload for all maneuvers where they were a factor and, for some maneuvers, directly limited the capabilities of the aircraft. In moderate-to-steep landing approaches (para 69) the pilot was required to decrease beep during the initial deceleration and then to increase it during the final power application to maintain rotor speed within limits. This required close monitoring of rotor/engine speed when pilot attention should be focused primarily outside the cockpit.

44. The most severe maneuver for potential overspeed was the rapid deceleration to a hover during a lateral reversal (para 57). To attain maximum deceleration without climbing, collective had to be lowered and full-decrease beep applied to maintain rotor/engine speed below maximum limits. While leveling after stopping sideward motion, increased beep had to be applied while increasing collective. In some instances, main transmission overtorques resulted while attempting to arrest aircraft settling. Both the deceleration capability and ability to recover from the maneuver were limited by the rate and amount of down-collective control applied, which in turn were limited by beep rate and rotor overspeed tendencies. This maneuver would be more severe in tactical operations where obstacles, concealment, and enemy fire must be considered. Consideration should be given to incorporating a dynamic droop anticipator or some other appropriate method to minimize transient rotor/engine speed variations during maneuvering flight. For the YAH-1R helicopter, potential transient rotor/engine overspeeds could be decreased by increasing the static compensation to a condition of slight overcompensation (3 to 4 rpm). An overcompensation of this magnitude should not be perceptible to the pilot. A study should be made to define the static droop throughout the altitude, weight, and airspeed ranges of the YAH-1R helicopter to determine the maximum overcompensation possible. A study should also be made into the feasibility of more rapid engine deceleration.

45. Another area of rotor overspeed tendencies not attributable to the dynamic droop occurred during steady-state maneuvers when a steady load factor was applied to the aircraft during a turn or pullout from a dive (para 29). "Pitch-cone coupling" reduces collective blade angle with increasing normal load factor even with the collective control lever held constant, resulting in rotor speed increases. Future designs should minimize pitch-cone coupling or provide compensation for it.

46. The normal operating rotor/engine speed is 324/6600 rpm, respectively. The maximum allowable engine speed stated in the operator's manual for all helicopters using the T53-L-13 engine is 6600 rpm. The draft supplement to the operator's manual for the YAH-1R with the T53-L-703 engine has this same limit. No power-on maximum rotor speed is stated. Maximum rotor speed for autorotation is 339 rpm (equivalent to 6910 engine rpm). To normally operate at the engine speed limit without exceeding it would require perfect control by both the aircraft power systems and the pilot. With this in mind, a study was made of the source of these limits. Supplemental notes in all of the operator's manuals indicate a maximum allowable engine speed of 6750 rpm with an N_1 below 91 percent and 6640 rpm for 3 seconds above 91 percent N_1. No source for any of these limits

could be found. A review of the T53-L-703 model specification (ref 10, app A) resulted in the following analysis. The engine specification states an engine normal rated power (NRP) of 1500 shp; operating at the YAH-1R transmission limit of 1290 shp amounts to 86 percent of NRP. Engine specifications call for a maximum steady-state power turbine speed at 86 percent NRP, which corresponds to 6784 rpm on the engine output shaft. This output shaft speed corresponds to a maximum steady-state rotor speed of 333 rpm; however, a steady-state 333-rpm rotor speed will have an impact on the fatigue life of the airframe rotating components. The maximum steady-state rotor speed should be retained at 324 rpm but the allowable engine overspeed limit should be raised to at least 6784 rpm engine output shaft speed independent of power. This figure provides a rotor speed margin which is 6 rpm below the rotor speed limit of 339 rpm. The T53-L-703 maximum transient output shaft speed of 7164 rpm, as published in the YAH-1R supplement to the operator's manual, should be deleted since using this limit results in a rotor overspeed of 12 rpm.

47. An analysis similar to that above should be made for the T53-L-13 engine, since aircraft using that engine (AH-1G and -1Q, and UH-1H and -1M) suffer from the same rotor overspeed problems as the YAH-1R. Increasing the allowable transient overspeed limit of the T53 engine to these limits will relieve the pilot of a major burden in controlling rotor speed in maneuvering flight.

Engine Torque Indication:

48. The increased power available in the YAH-1R helicopter and the increased drive train power transmission capability provide a significant increase in the load-carrying and maneuvering capability over previous AH-1 aircraft. Utilizing the aircraft to the extent of its capability will require frequent periods of operation at or near the transmission power limit. The T53-L-703 engine provides significantly more power at a given altitude or the ability to maintain limit power level to a higher altitude and/or temperature. Figure A shows a comparison of the amount of transmission overtorque it is possible to achieve in steady-state nonmaneuvering flight with the T53-L-13 and T53-L-703 engines. Since the aircraft will be operated near transmission limit to realize its increased capability, and since inadvertent overpower conditions can be more serious with the higher power available, it is essential that the pilot be acutely aware of exactly what power level he is demanding.

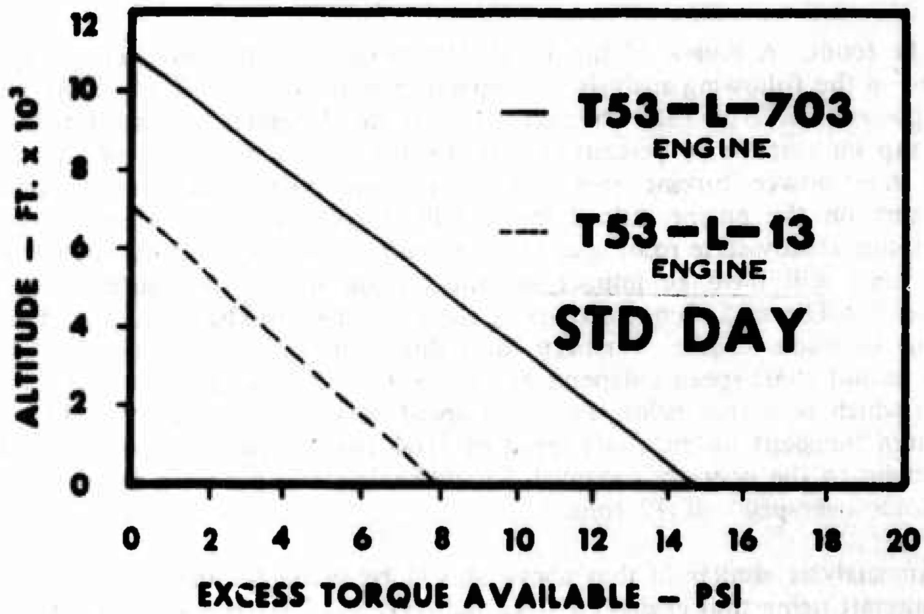


Figure A. Steady-State Overtorque Capability.

Torque System Accuracy:

49. The need for an adjustable percentile indicating torque system is evidenced by an analysis of possible system errors as presented in table 3. Using OGE hover data from tests conducted on the YAH-1R helicopter, the ratio of hover weight to hover power under sea-level, standard-day conditions was determined to be 5.7 pounds per shp. The power errors shown in table 3 indicate that under worst-case conditions where all system errors are low-side errors, an undetected overtorque of up to 8.1 psi (189 shp) is possible. Should all system errors be high-side errors, the reduction in useful load would be up to 1080 pounds (42 percent of the useful load or 137 percent of the basic mission ordnance load). Using the errors shown in table 3 to compute the error most likely to be encountered, the root mean square error yields a most likely power error of 96 shp. This translates to a most likely undetected overtorque of 4.1 psi (7.5 percent) or a most likely reduction in the useful load of 550 pounds (22 percent of the useful load or 70 percent of the basic mission ordnance load). With a suitable trimmable torque indicating system that would eliminate system errors and improve readability to 1 percent, the worst-case error would be 4 percent (52 shp) and the most likely error would be 2 percent (26 shp).

Table 3. Torque Indicating System Error Analysis at Maximum Power.[1]

Source of Error	Magnitude of Error		
	Percent	Shaft Horsepower	PSI Torque
Gage readability	±4.5% of reading (55.7 psi)	±58	±2.5
Torque sensor	±2% of reading (55.7 psi)[2]	±26	±1.1
Variation in torque constant between engines	±4.4% of normal rated power (1500 shp)[2]	±66	±2.8
Airframe sensor inaccuracy[3]	±2% of reading (55.7 psi)	±26	±1.1
Airframe sensor precision[3]	±1% of reading (55.7 psi)	±13	±0.6
Maximum error[4]	±14.6% of maximum allowable power	±189	±8.1
Root mean square error[5]	±7.5% of maximum allowable power	±96	±4.1

[1]1290 shp, 6600 engine output shaft rpm.
[2]Obtained from reference 10, appendix A.
[3]Obtained from AVSCOM.
[4]Represents a maximum undetected overtorque condition or an apparent decrease in usable power.
[5]Represents a most likely undetected overtorque condition or a most likely decrease in usable power.

50. The present engine torque indicator is poorly located low on the left side of the instrument panel adjacent to identical engine system instruments. During maneuvering tasks which demand pilot attention outside the cockpit, it is not possible to rapidly scan this instrument because of the fundamental difficulty in locating it. Markings on the face of the instrument read OIL PRESSURE and the units are in pounds per square inch (psi). The word TORQUE is placed above the instrument. The scale markings are in increments of 5 psi, giving a readability of about 2-psi accuracy. This readability is unsatisfactory to monitor limits listed as 55.7 psi (54.7 psi in the test helicopter). The limit markings are painted on the glass face cover of the instrument, obscuring a portion of the scale markings. This was particularly true of the red line indicating maximum allowable torque. During this test the limit marking made it impossible to accurately determine maximum power. Maximum power was estimated by increasing torque until the needle was visible above the red line, then reducing torque slightly so that the point of the needle was again not visible. Torque errors of up to 2 psi were common during this test when the pilot was deliberately attempting to control torque. It is reasonable to expect wide torque variation in operational situations where torque is more monitored than actively controlled. Parallax errors between the limit markings (on the glass) and the scale markings (on the instrument face) are another potential source of error. The torque indicator presently used in the YAH-1R cannot be adjusted to reflect the engine's individual torque constant, thereby introducing an error apart from sensing and readability errors. The engine torque indicating system is not sufficiently accurate to allow full utilization of the increased power available in the YAH-1R helicopter and is a deficiency. Correction of this deficiency will allow better maneuvering performance because of improved utilization of excess power available. The torque indicator used with the T53-L-13 and T53-L-703 engines has been reported as being unsatisfactory since the introduction of the T53-L-13 engine (ref 11, app A).

51. An improved torque gage should alleviate the problems listed in paragraphs 49 and 50 concerning the existing gage. A 3-inch gage graduated in percent of maximum allowable torque is recommended. The range should be zero to 150 percent of maximum allowable torque, since the possibility exists for significant overtorque conditions with the T53-L-703 engine. Scale marking should be in increments of 2 percent for a readability of 1-percent accuracy. Torque limit markings should be on the instrument face itself to avoid parallax error. The instrument could be trimmed to indicate 100 percent of the actual maximum allowable torque, similar to the manner in which EGT gages are trimmable to match the readings to calibrated values (para 41). A tattletale "bug" should be incorporated in the instrument to record and retain the maximum value of torque achieved. This bug should not be resettable by the flight crew or during the normal course of daily maintenance. A recording device to record both duration and magnitude of all overtorques should be incorporated, since the bug will only record the peak overtorque. Also, a warning light similar to the present rotor speed and fire warning light should be incorporated. This overtorque warning light would be more readily seen by the pilot as he concentrates his attention outside the aircraft during maneuvering flight.

Torque Control:

52. A torque-limiting system would significantly improve the utilization of and survivability of the YAH-1R helicopter in low-level maneuvering flight since the pilot would be free to maneuver to the limits of the aircraft capability without focusing his attention inside the aircraft to observe transmission or engine limits. Such a system should limit engine torque to a value that results in 1290 shp at the engine output quill and should be adjustable, so that field maintenance personnel can set the limit to account for the variation between engines or torque system calibration changes so as to assure the availability of maximum allowable power. Any torque-limiting system should incorporate a manual override which would allow full utilization of power available in emergency situations, while retaining engine speed governing functions.

Mission Maneuvering Characteristics

Lateral Acceleration/Deceleration:

53. The lateral acceleration handling qualities were evaluated at the conditions shown in table 1 for OGE and IGE conditions. The aircraft was stabilized at the desired hover height and the lateral acceleration was initiated by simultaneously applying lateral cyclic and increasing collective pitch to maximum power. Lateral control was used to maintain a constant height as the aircraft accelerated at maximum power. Lateral control reversals were initiated at the maximum sideward velocity by reducing power and executing a side flare maneuver while attempting to maintain a 324-rpm rotor speed and minimum altitude change. Time histories of these lateral accelerations are presented in figures 47 through 50, appendix E.

54. Lateral accelerations were conducted at mission gross weights of 10,000 pounds IGE and 9900 pounds OGE. That lateral accelerations were possible at these gross weights indicates a significant increase in the capability of the YAH-1R helicopter as compared to the AH-1G. Comparison with lateral accelerations of previous AH-1 aircraft at equivalent useful loads was not possible. In both OGE lateral accelerations (figs. 47 and 48, app E), the power required to hover was in excess of the maximum transmission power of the AH-1G, yet the YAH-1R had excess power to be used to accelerate laterally. Qualitatively, the lateral acceleration capability of the YAH-1R helicopter was dependent on both the power margin available and the pilot's ability to control this excess power to reach maximum power as soon as possible. Control of the excess power to prevent transmission overtorque was the difficult task, due to the inadequate torque instrument in the cockpit (HQRS 7). The inadequate cockpit display of engine torque is a major contribution to an overall deficiency previously defined as an insufficiently accurate torque indicating system. Correction of this deficiency should be accomplished prior to operational testing of the YAH-1R helicopter.

55. Aircraft handling qualities during lateral acceleration maneuvers were good except for the power management difficulty previously mentioned. In both IGE and OGE lateral accelerations, the performance of the aircraft in left lateral acceleration was significantly greater than to the right. The mean bank angle for lateral acceleration to the left, IGE, was 21 degrees while the right acceleration bank angle was 15 degrees. In the OGE case, the bank angle in left accelerating maneuvers increased throughout the maneuver, while in right sideward accelerations a mean bank angle of 8 degrees was established. Sideward velocity was very difficult to judge during lateral acceleration maneuvers. Table 4 is a comparison of the left and right OGE lateral accelerations depicted in the time histories in figures 47 and 48, appendix E. It should be reiterated that these lateral accelerations were complicated by the lack of a suitable torque display. Maximum acceleration will be realized by achieving maximum rotor thrust (maximum torque) in the shortest possible time to allow use of the excess thrust to establish an acceleration. In the lateral acceleration maneuver, pilot attention is focused outside the aircraft; therefore, to prevent overtorque, the pilot must rapidly scan the power instruments and quickly interpret their indications. The torque instrument location and readability make this very difficult in the YAH-1R and AH-1G aircraft. This is evident from the slow collective application rate shown in figures 49 and 50. Lateral acceleration capability may be as much a function of the ability to control the available power as it is a function of the amount of excess power available.

Table 4. Lateral Acceleration (OGE).[1]

Velocity (kt)	Left		Right	
	Time (sec)	Distance (ft)	Time (sec)	Distance (ft)
5	1.1	13	1.9	12
10	2.2	30	3.8	38
15	3.4	55	5.7	78
20	4.5	85	7.4	128
25	5.9	136	9.1	194
30	7.2	195	11.2	293

[1]Test conditions:
Gross weight: 9780 pounds. Center-of-gravity location: FS 199.3 (aft). Density altitude: 250 feet. Outside air temperature: 10°C. Rotor speed: 324 rpm. Configuration: Hog.

56. Peak sideward velocities of 45 to 50 KTAS were measured during these tests (based on radar ground speed and measured wind speed). The aircraft has a limit (35 knots in sideward flight) which cannot be observed by the pilot. An omnidirectional airspeed system should be installed to give the pilot adequate information concerning the magnitude and direction of the airspeed vector. No adverse handling qualities were observed at sideward airspeeds in excess of 35 knots. This observation, coupled with the increasing emphasis on lateral flight as a tactical maneuver, suggests that the sideward velocity envelope of the YAH-1R helicopter should be expanded. It is recommended that the sideward velocity envelope of the YAH-1R be expanded to the limit of control authority unless a structural limit is encountered prior to the control limit. Lateral acceleration tests on the YAH-1R indicate that the maximum continuous tail rotor power limits will be exceeded in right lateral acceleration (left pedal control required); however, sideward steady-state flight was not attempted above a 35-knot sideward velocity. Sideward flight tests show relatively little variation of tail rotor power with right sideward velocity above 30 knots and a decreasing engine torque requirement.

57. Lateral control reversals were performed to decelerate the helicopter from the peak velocities obtained during the lateral accelerations. Altitude and rotor speed control were extremely difficult during any rapid deceleration (HQRS 6). With the lateral control reversal initiating a side flare, the aircraft began to climb. To maintain altitude, collective control was reduced, resulting in engine overspeed conditions which were controlled by "beeping" the engine speed down to maintain an engine output speed of 6600 rpm. This places the aircraft in the position of executing a side flare with reduced power at minimum beep, which in turn results in rotor speed control difficulty when it becomes necessary to reestablish hover power as the sideward velocity approaches zero. The increased rotor speed during rapid deceleration, resulting in engine overspeed conditions (para 44), is a shortcoming.

58. During the lateral decelerations conducted during this test, there was insufficient power to arrest the lateral velocity while maintaining altitude, even though deceleration rates were relatively slow. During lateral deceleration OGE, there was a tendency for the aircraft to settle with maximum available power applied, a shortcoming which will affect the tactics employed by the YAH-1R. This phenomenon is common to all helicopters operating near a hover power limit. Since transmission torque limits would be exceeded to maintain altitude during this dynamic maneuver, recovery was accomplished by applying maximum power and allowing the aircraft to settle toward ground effect, where the rate of descent was arrested. Although ground contact was not made during any of these descents, recovery altitudes of 5 to 10 feet above the ground were common. It must be reemphasized that these maneuvers were performed near the aircraft maximum gross weight, where power margins are critical. The AH-1G helicopter could not achieve OGE hover at gross weights in excess of 9200 pounds (ref 5, app A). Under tactical conditions allowing the aircraft to settle into ground effect to arrest a sink rate may not be possible. A possible recovery procedure from sideward flight

at velocities near the limit is to pedal turn the aircraft into the direction of flight and enter the forward flight regime. This type of maneuver was performed from high sideward velocity and no adverse handling qualities were encountered (HQRS 2).

Longitudinal Acceleration/Deceleration

59. The handling qualities of the YAH-1R helicopter during longitudinal acceleration and deceleration were evaluated at the conditions shown in table 1. From a stabilized hover forward cyclic was applied as maximum power was applied. The helicopter was accelerated using longitudinal cyclic to maintain altitude. Accelerations were conducted both IGE and OGE. Table 5 is a time/velocity history of IGE and OGE longitudinal acceleration at a gross weight of approximately 9800 pounds.

Table 5. Longitudinal Acceleration Characteristics.[1]

True Airspeed (kt)	Time (sec)	
	In Ground Effect	Out of Ground Effect
10	4.4	4.8
20	6.2	6.5
30	7.5	7.9
40	8.9	9.4
50	10.3	11.0
60	11.9	12.7
70	14.0	14.8
80	16.7	17.7
90	19.5	21.5
100	23.0	25.4

[1]Test conditions:
Gross weight: 9780 pounds. Center-of-gravity location: FS 199.3 (aft). Surface density altitude: 300 feet. Outside air temperature: 12°C. Rotor speed: 324 rpm. Configuration: Hog.

60. No handling qualities difficulties were found in longitudinal acceleration (HQRS 2). In deceleration, however, control of main rotor speed to prevent an engine overspeed demanded extensive pilot compensation (HQRS 6). The tendency for engine overspeed conditions developed by poor rotor dynamic droop characteristics is a shortcoming which should be corrected in future designs. Forward field of view was obscured with the aircraft in a rapid deceleration attitude, a shortcoming common to all AH-1 helicopters. When attempting a rapid deceleration to an OGE hover, the YAH-1R tended to enter power settling, a shortcoming which has been previously reported on the AH-1Q helicopter. Power settling was avoided by decreasing the rate of deceleration prior to loss of translational lift.

Bob-Ups and Pop-Ups:

61. The bob-up maneuver was accomplished by establishing an IGE hover and then conducting a maximum power vertical climb to establish an OGE hover. This maneuver simulated a climb above a masking obstacle and engaging a target from an OGE hover. The pop-up maneuver was accomplished by establishing 40-KIAS nap-of-the-earth flight and then using cyclic climb and collective pull to maximum power to establish a climbing decelerating flight path to an OGE hover, simulating unmasking and target engagement. Time history plots of both maneuvers are presented in figures 51 and 52, appendix E. Due to the tendency for the YAH-1R helicopter to enter settling with power, recovery from high hover points was accomplished by a right circling descending turn at 40 to 60 KIAS to return to simulated masked positions. No handling qualities difficulties were encountered in these maneuvers (HQRS 2). Bob-up and pop-up maneuvers were possible at 10,000 pounds gross weight under the conditions in which this task was performed (table 1). In general, bob-up and pop-up maneuvers, deleting the vertical descent portion of the maneuver, should be possible under any condition where an OGE hover is possible. At conditions of low airspeed and high power settings, erroneous vertical speed indications of 500 to 700 feet per minute were observed. This is a shortcoming that makes the vertical speed indicator virtually useless to establish an OGE hover under night or restricted visibility conditions. A radar altimeter and accurate rate-of-climb instrument should be installed for a precision height-above-ground reference and a vertical rate cue. This would enhance the mission capability of the YAH-1R helicopter and greatly aid the pilot in detecting the sink rate conditions leading to settling with power.

Low-Level Maneuvering:

62. Maneuvering flight at altitudes of less than 100 feet above ground level was conducted throughout this test from hover to V_H. Force trim was ON during all low-level flight maneuvers. During low-level maneuvering involving turns of 30-degree bank angles or less, at airspeeds between 40 and 100 KIAS, the aircraft was quite responsive and easily controlled (HQRS 1). Under these conditions in turbulent air the helicopter was easily controlled; however, it responded to gusts with an easily excited but moderately damped lateral-directional oscillation. In cruising flight or in simulated target engagements, no handling qualities difficulties were noted (HQRS 3).

63. During more severe maneuvering conditions involving rapid lateral cyclic movements to the left, excessively high torque transients were observed. These transients were a function of the rapidity of the left cyclic input and the airspeed at the time of input, with the high airspeed rapid input being the most critical condition. Torque transients of up to 10 psi were noted in high-speed (over 100 KIAS) rapid left maneuvers. This excessive torque rise in a rapid left roll required extensive pilot compensation to prevent an overtorque condition (HQRS 6) and is a shortcoming which has been present in all AH-1 models. The tendency toward rapid torque rise in left maneuvering flight may result in main transmission transient overtorque. The present restriction of 85 KIAS maximum velocity with maximum power applied should be retained, with the added caution to avoid abrupt maneuvers at takeoff power settings. A suitable marking should be placed on the airspeed indicator to denote the limit airspeed at power settings above 49-psi torque. In order to more effectively use the aircraft's increased power to maneuver, the present main transmission transient torque limit should be reevaluated, with a view to increasing these limits if transmission analysis warrants such action.

64. As positive normal acceleration increases in a turn, the inherent pitch-cone coupling common to all AH-1 aircraft reduces the collective blade angle, resulting in main rotor speed increases. Main rotor speed control in either a high-g turn (above 1.4g) or in any low collective setting maneuver requires considerable pilot compensation to avoid main rotor/engine overspeeds (HQRS 5) and is a shortcoming.

65. Nap-of-the-earth flying may call for pushover maneuvers resulting in normal acceleration less than 1.0g. In pushover maneuvers, as the load factor and rotor thrust decrease, the YAH-1R rolls to the right. Normal pilot reaction would be to stop the right roll with left cyclic, which under low-g conditions could induce mast bumping and structural failure. The right roll tendency of the YAH-1R helicopter under conditions of reduced normal acceleration is a shortcoming of the AH-1 family of aircraft which should be avoided in future designs. Suitable warnings are presently incorporated in the AH-1G operator's manual.

Slope Landings:

66. Side-hill slope landings were conducted on a slope measured at 10 degrees. No adverse handling qualities were noted using standard slope landing techniques (HQRS 2). A summary of control margins and main rotor flapping margins is presented in table 6.

Table 6. Slope Landing Characteristics.[1]

Control	Slope[2] (skid low)	Displacement From Hover Trim (percent)	Minimum Margin (percent)
Longitudinal	Left	Zero	45 (aft)
	Right	Zero	44 (fwd)
Lateral	Left	41 (right)	23 (right)
	Right	29 (left)	12 (left)
Directional	Left	9 (right)	23 (left)
	Right	11 (right)	28 (left)
Main rotor flapping	Left	29 (increase)	24 (down), 37 (up)
	Right	51 (increase)	13 (down), 20 (up)

[1]Test conditions:
Gross weight: 10,200 pounds.
Center-of-gravity location: FS 199.3 (aft).
Surface density altitude: 300 feet.
Outside air temperature: 12°C.
Rotor speed: 324 rpm.
Configuration: Hog.
[2]Left slope with 4 knots tailwind.
Right slope with 4 knots headwind.

Confined Area Operations:

67. Under the conditions of this test, with density altitude near sea level, the YAH-1R helicopter was able to hover OGE at 10,000 pounds gross weight with a 2- to 3-psi torque margin. Confined area takeoffs could be made vertically at test conditions in light and variable winds (HQRS 1).

68. Approaches to confined areas were characterized by extremely poor forward field of view from the aft cockpit with the aircraft in a decelerating attitude. Contact with the confined area was lost almost from the moment the deceleration was begun and the pilot was forced to rely on visual cues taken from points adjacent to the landing area (HQRS 5). The poor forward field of view during a decelerating approach is a shortcoming common to the AH-1 family of aircraft, which degrades the capability of the YAH-1R helicopter to take full advantage of the cover and concealment of the terrain.

69. The droop characteristics of the engine/rotor system are excellent. Steady-state rotor droops of only 1 to 3 rpm were noted from flat pitch to hover power. However, the dynamic characteristics during decelerations tended to result in rotor overspeed. As in maneuvering flight, this overspeed tendency was a function of the severity of the maneuver. If the approach was conducted on a shallow glide slope (6 to 8 degrees) from a low power trim condition (60 KIAS), static rotor speed increased only by 2 to 3 rpm. However, if the approach was conducted on a 10- to 12-degree slope from an airspeed of 90 KIAS, moderate pilot lead compensation was required to maintain 324 rpm (HQRS 4). The poor droop characteristics with deceleration in the approach is a shortcoming which should be corrected in future designs.

70. Steep approaches into confined areas (over a 12-degree glide slope) greatly increased the possibility of entering settling with power. Onset of power settling was defined as an increased 2/rev vertical vibration with increasing collective pitch and increasing rate of descent. Reduced left pedal effectiveness was also noted. Figure 53, appendix E, is a time history of the termination phase of an approach on a glide path of approximately 8 degrees, with the wind at the critical azimuth and near the critical speed. Full pedal deflection was required for 0.7 second to arrest an increasing yaw rate. Tail rotor power peaked 0.7 second after the pedal input at a value of 278 shp and was over the tail rotor transient torque limit (260 shp) for 0.15 second. Subsequent inspection revealed no damage to the tail rotor drive train.

System Failures

Simulated Sudden Engine Failures:

71. The response of the test helicopter to a simulated sudden engine failure was evaluated at the conditions listed in table 1 with SCAS ON. Engine failure was simulated by rapidly rolling the throttle to the flight-idle position. The controls were held fixed following the simulated power loss until the pilot deemed recovery necessary to avoid unusual aircraft attitudes or a transient rotor speed of 260 rpm or less was reached. Representative time histories are presented in figures 54 through 57, appendix E.

72. Figure 54, appendix E, is a time history of a simulated engine failure in zero sideslip 41-KCAS level flight. As the throttle was rolled off, the main rotor speed decayed at a rate of approximately 20 rpm per second; however, rotor speed decay did not begin until 0.6 second after engine torque began to decrease. The primary cue to loss of power was the left yaw acceleration; however, the left yaw attitude changed by only 18 degrees prior to lowering the collective control. The aircraft entered a mild (7 degrees per second) left roll. Collective delay time was approximately 3.2 seconds. The maneuver was very mild and easily controlled during the recovery (HQRS 1). Rotor speed decay stopped immediately on lowering the collective and rotor speed control during the recovery was excellent, with no tendency to overspeed.

73. Figure 55, appendix E, is a time history of a simulated engine failure in a 40-KCAS maximum power climb. The aircraft response was similar to that in the 41-KCAS level flight condition. Rotor speed decay rate was approximately 30 rpm per second. Yaw acceleration was still the primary cue to engine failure; however, the left roll rate reached 9.5 degrees per second and was a noticeable cue. The collective control was lowered 2.4 seconds after the power loss with main rotor speed at 260 rpm. The minimum transient rotor speed was 240 rpm, occurring 1.5 seconds after initiation of down collective control. The roll attitude of the helicopter 2 seconds after the simulated power loss was 12 degrees left. Recovery controllability was excellent. Rotor speed responded to decreased collective control and no adverse handling qualities were noted (HQRS 2). The roll response of the aircraft failed to meet the requirement of paragraph 3.5.5.1 of MIL-H-8501A by 2 degrees.

74. Figure 56, appendix E, is a time history of a simulated sudden engine failure at V_H (maximum continuous power). The rotor speed decay rate was approximately 30 rpm per second. The primary cue to power loss was a rapid left roll. Recovery was initiated 1.5 seconds after the simulated power loss in response to a 27-degree per second left roll rate. Recovery was accomplished by simultaneous longitudinal, lateral, directional, and collective inputs. No adverse handling qualities were noted during the recovery under visual flight conditions (HQRS 3). As the AH-1 aircraft are qualified for flight under instrument flight conditions, the rapid left roll response to sudden engine failure becomes more critical, due to the disorienting effect of rapid roll rates without external references. The roll rate following engine failure may be more rapid with the aircraft in a clean configuration, due to the decreased roll inertia without fully loaded external stores. Trends indicate that the roll response to sudden engine failure will be more severe at higher airspeeds. The left rolling response to sudden engine failure at V_H is a shortcoming. The USAASTA Final Report No. 70-25 (ref 12, app A) lists a chart of recommended maximum torque values for varying airspeed under conditions of reduced visibility. This chart should be used when developing standard instrument flight procedures for the AH-1G or YAH-1R aircraft. The roll attitude change in response to a simulated sudden engine failure produced a roll attitude of 26 degrees, left, 2 seconds after power loss. This exceeded the maximum value allowed by paragraph 3.5.5.1 of MIL-H-8501A by 16 degrees. The YAH-1R helicopter failed to meet the requirements of paragraph 3.5.5 of MIL-H-8051A in that aircraft reactions following a simulated engine failure at V_H preclude safe autorotational entry after a 2-second collective delay.

75. Figure 57, appendix E, is a time history of a simulated sudden engine failure in an OGE hover. Main rotor speed decay rate was approximately 25 rpm per second. Aircraft responses were very mild and the prime engine failure recognition cue was yaw acceleration. Figure 57 shows inadvertent pilot inputs of 1/2 inch right pedal and 0.3 inch right cyclic control. These inputs correspond to a yaw rate of 4 degrees per second, 1 second after the input. In an OGE hover mission, the yaw acceleration and resulting yaw attitude change will be almost instantaneous cues to the loss of engine power but this cue will be lost if the aircraft is hovering in high winds. The yaw acceleration and attitude change are similar to those

expected from a strong lateral gust. A collective pitch delay time of 2.2 seconds produced a minimum transient rotor speed of 260 rpm. A minimum normal acceleration of 0.3g was reached as the collective was lowered but normal acceleration was restored to 1g 3.5 seconds after the minimum as the vertical descent rate stabilized. Recovery was accomplished by regaining airspeed and no adverse handling qualities were noted (HQRS 3). Within the scope of this evaluation, the handling qualities of the YAH-1R helicopter during simulated sudden engine failure were essentially unchanged from the AH-1G.

Simulated Stability and Control Augmentation System Failure:

76. Simulated SCAS failures were evaluated at the conditions listed in table 1 for dynamic stability. Airspeeds of 43 and 60 KCAS were established in zero sideslip flight at power conditions for level flight and at maximum power. The SCAS failure was simulated by simultaneously disengaging all three SCAS channels and allowing the SCAS actuator to seek a null position. The SCAS hardovers were not evaluated.

77. At 43 and 60 KCAS, level flight SCAS failures were very mild. In the absence of external excitation the aircraft remained very stable and dynamic response had to be initiated by control movement. Figure 58, appendix E, is a time history of a 43-KCAS level flight SCAS failure requiring a pedal doublet to initiate a response. The aircraft responded with a convergent oscillation in roll and yaw. The roll oscillation was in response to sideslip excursions initiated by the pedal control doublet. The SCAS failures in level flight at 43 and 60 KCAS present no control problems for cruising flight in visual or instrument flight conditions (HQRS 3).

78. Figures 59, 60, and 61, appendix E, are time histores of simulated SCAS failures at 43, 61, and 63 KCAS with maximum power (1290 shp). At 43 KCAS the aircraft responded to inadvertent pilot cylic control movement and diverged in an oscillatory fashion, with a period of approximately 16 seconds. During this oscillation, pitch-to-roll coupling was evident by a nose-down pitch rate causing a right roll rate. At 63 KCAS and takeoff power, two distinct types of divergence were observed. Figure 59 shows a neutral lateral-directional oscillation in a maximum power climb with the pilot supplying the damping through cyclic control movement. When the pilot decreased his damping efforts, the aircraft diverged laterally and recovery was initiated in response to sensed roll accelerations. Recovery was positive and easily controlled; however, in conditions of restricted visibility or instrument flight, the roll accelerations would be extremely disorienting. The second and primary divergence mode is shown in figure 60. This mode was an essentially aperiodic divergence in pitch and roll, resulting in a nose-down pitch and a roll to the right. A left lateral cyclic input was made in response to the roll acceleration and the aircraft was allowed to roll to a bank angle slightly in excess of 90 degrees to the right. Recovery from this attitude was easily accomplished in visual flight conditions; however, under instrument flight conditions, a safe recovery would be extremely difficult. The divergent character of the SCAS OFF dynamics of the YAH-1R helicopter in a maximum performance

climb is a shortcoming. The severity of this shortcoming may be increased with decreased wing stores loadings, since the roll moment of inertia will be decreased, allowing roll rate to develop more rapidly. Further study should be undertaken to determine a maximum safe climb power or rate of climb for use under instrument flight conditions, with emphasis on aircraft control after a SCAS failure.

Hydraulic Systems Failure:

79. Although not specifically tested during this evaluation, flight with dual hydraulic systems failure was accomplished during pilot familiarization flights. The control forces with the emergency collective accumulator OFF were judged to be very light at airspeeds above 100 KIAS and collective control was maintained down to an airspeed of approximately 40 KIAS. A review of control system loads revealed that higher oscillatory loads were present at heavy gross weight as compared to the same flight conditions at a light gross weight. Possibly these higher oscillatory control system loads were responsible for the qualitatively assessed light collective control forces. Further study should be accomplished to determine the effects of gross weight on control forces with simultaneous dual boost failure, with a view to recommending that external stores be retained to maintain the aircraft gross weight during such emergencies.

MISCELLANEOUS

Ground Handling

80. The present AH-1G ground handling weight limit of 9000 pounds gross weight also applies to the YAH-1R. At a mission gross weight of 10,000 pounds, any operation requiring ground movement of the aircraft requires off-loading of 1000 pounds of weight. The 9000-pound ground handling limit is a shortcoming which should be corrected as soon as practical.

Dual Hydraulic Boost Maintenance

81. The hydraulic boost cylinders as installed on AH-1G and YAH-1R helicopters do not actuate through the entire range of available piston travel to achieve full swashplate and collective sleeve motion. Therefore, trapped air in the hydraulic system cannot be fully bled with the controls in place. Controls should be disconnected at the swashplate and at the bell cranks to allow the hydraulic actuator system to be fully bled. This procedure should be followed routinely when bleeding air from the hydraulic actuators is necessary. Trapped air in the hydraulic system can cause control feedback during maneuvering flight. During the course of this evaluation, control force feedback was noted at 1.4g normal acceleration. After bleeding the hydraulic system as described above, the control force feedback problem was alleviated. A note should be incorporated into the maintenance manuals for the AH-1G, -1Q, -1R, and -1S, and UH-1C and -1M reflecting the proper procedure for bleeding the hydraulic system. Air may be forced into both hydraulic systems and the seals separating the systems may be damaged by either

prolonged or rapid operation of one boost system with the aircraft turning up or by pressurizing only one system to conduct ground tests. A CAUTION should be added to the AH-1G, -1Q, -1R and -1S and the UH-1C and -1M operators' manuals and maintenance manuals, as shown below. Maintenance manuals should include instructions to pressurize both hydraulic systems when using external hydraulic power, except in those instances where this procedure is in direct conflict with the purpose of the maintenance action.

CAUTION

> Avoid rapid movements or prolonged operation of the aircraft flight controls with one hydraulic boost system inoperative. Rapid or prolonged operation of the flight controls under these conditions may result in deterioration of the hydraulic system separation seals and the introduction of air into the hydraulic boost actuators.

Oil Cooler Operation

82. The oil cooler fan in the YAH-1R helicopter is operated at a higher rpm than in the AH-1G. During the course of subsequent tests, the increased oil-cooling capacity of the YAH-1R should be evaluated to determine the effectiveness of this oil cooler modification.

Wing Stores Jettison

83. The wing stores jettison system in the YAH-1R and AH-1G helicopters is controlled by two circuit breakers. The cockpit circuit breaker controls jettison power to the stores jettison selector panel to allow selective jettison of inboard or outboard stores. The circuit breaker which allows salvo jettison through automatic sequencing relays is located in the tail boom battery compartment. If this circuit breaker is open, the gunner has no jettison capability and the pilot has no salvo jettison capability. In an emergency situation demanding salvo jettison of wing stores, the pilot would select the BOTH position on the stores jettison panel and possibly fail to get any jettison at all with the open tail boom circuit breaker. Under these conditions, jettison is possible by selecting inboard and then outboard jettison independently, utilizing power from the essential bus; however, in critical situations, time may not be available. The circuit breaker controlling the salvo capability is located in the aft battery compartment protected by a panel with 8 slothead fasteners. This area is not a normal preflight inspection point due to inaccessibility and an open circuit breaker might go undetected. The poor location of this stores jettison circuit breaker is a shortcoming.

CONCLUSIONS

GENERAL

84. The YAH-1R helicopter is a significant improvement over the AH-1G helicopter, both in the increased useful load and in the increased directional control capability. Two minor shortcomings were attributable to the increased power and gross weight of the YAH-1R. The measurement of gas producer turbine outlet temperature is a significant improvement over the measurement of EGT on previous versions of the T53 engine. The torque measuring system coupled with the allowable differences between engines can result in overtorque of up to 8.1 psi (189 shp) or in the loss of up to 1080 pounds of useful load. The most likely values (root mean square error) for these errors are 4.1 psi overtorque or loss of 550 pounds of useful load.

85. One deficiency and 15 shortcomings were found during this evaluation. Of the 15 shortcomings, 10 have been previously reported as shortcomings on AH-1 helicopters.

DEFICIENCY AND SHORTCOMINGS

86. The one deficiency identified during this evaluation was that the engine torque indicating system is not sufficiently accurate to allow full utilization of the increased power available (paras 50 and 54).

87. The shortcomings listed below were identified. Those shortcomings marked with an asterisk represent shortcomings identified in previous reports.

*a. Weak side-force characteristics during low-speed flight (para 14).

*b. Excessive airspeed error due to sideslip in the low-speed flight regime (para 18).

*c. Divergent characteristics of the SCAS OFF helicopter dynamics in a maximum performance climb (paras 25 and 78).

d. Neutral maneuvering stability gradient above 1.35g at 120 KCAS (para 28).

*e. The tendency for engine overspeed during collective-fixed maneuvering flight (para 29).

f. Loss of the stabilizing influence of the longitudinal SCAS within the operational normal load factor envelope of the aircraft (para 30).

*g. The increased rotor speed during rapid decelerations resulting in engine overspeed conditions (paras 57, 60, and 69).

*h. The tendency for the aircraft to settle with maximum available power applied during lateral and longitudinal decelerations OGE (paras 58 and 60).

*i. Forward field of view was obscured with the aircraft in a rapid deceleration attitude (para 60).

j. Excessive vertical speed indicator errors in low-airspeed flight (para 61).

*k. Excessive torque rise in rapid left rolling flight (para 63).

*l. The right roll tendency of the aircraft during conditions of reduced normal acceleration (para 65).

*m. The left rolling response to sudden engine failure at V_H (para 74).

n. The 9000-pound ground handling weight limit for a helicopter with a 10,000-pound allowable gross weight (para 80).

o. The inaccessible location of the stores jettison circuit breaker controlling salvo jettison capability (para 83).

SPECIFICATION COMPLIANCE

88. The handling qualities of the YAH-1R helicopter met the requirements of MIL-H-8501A against which they were tested except as listed below.

*a. Paragraph 3.2.6 - The limit longitudinal cyclic control force exceeded the minimum values by 3 pounds forward and 5 pounds aft (para 8).

*b. Paragraph 3.3.12 - The limit control force of the directional control system exceeded the maximum allowable value by 20 pounds (right) and 25 pounds (left) (para 8).

*c. Paragraph 3.3.13 - The directional breakout forces (including friction) failed to meet the minimum allowable value by 2 pounds (left) (para 8).

*d. Paragraph 3.5.5.1 - The roll attitude change following simulated sudden engine failure exceeded the 10-degree limit by up to 16 degrees (160 percent) (para 74).

*e. Paragraph 3.5.5 - Aircraft reactions following a simulated sudden engine failure at V_H precluded safe autorotational entry after a 2-second collective delay (para 74).

RECOMMENDATIONS

89. Correction of the deficiency listed in paragraph 86 should be accomplished prior to operational testing of the YAH-1R helicopter (para 7).

90. Correction of the shortcomings listed in subparagraphs 87e, f, g, and o should be accomplished as soon as practical.

91. Other shortcomings should be avoided in future helicopter designs.

92. Consideration should be given to installing an airspeed system capable of giving accurate velocity information, both magnitude and direction (sideslip), throughout the rearward, forward, and sideward airspeed envelopes (para 19).

93. Further testing should be conducted to expand the YAH-1R sideslip envelope to such an angle that a threshold 0.1g lateral acceleration is realized due to the sideslip. The sideslip envelope should be unrestricted below a velocity which produces 0.1g lateral acceleration (para 19).

94. Tests should be conducted to investigate the maneuvering stability of the YAH-1R helicopter at the more severe flight conditions of higher density altitude and higher airspeed. Tests should include both symmetrical pullups and constant-power turns (para 28).

95. A study should be conducted to uprate the steady-state and transient power limits of the tail rotor drive train if it is structurally feasible (para 35).

96. The engine topping system should be redesigned and initially trimmed to prevent exceeding the more accurate, measured gas producer turbine outlet temperature limit over the operational altitude and ambient temperature range (para 41).

97. The engine topping system should be adjustable in the field to compensate for engine deterioration (para 41).

98. The engine topping system should have an emergency override feature to allow intentionally exceeding temperature limits under emergency situations, while still retaining rotor speed governing functions (para 41).

99. Consideration should be given to the following possible solutions to the main rotor/engine overspeed problem: (1) incorporate a dynamic droop anticipator or some other appropriate method to minimize transient rotor/engine speed variations; (2) rotor speeds could be decreased by increasing the static compensation to a condition of slight overcompensation (3 to 4 rpm); (3) study the feasibility of a more rapid engine deceleration (para 44).

100. Future designs should minimize or provide compensation for pitch-cone coupling (para 45).

101. The maximum steady-state rotor speed should be retained at 324 rpm, but the allowable engine overspeed limit for the T53-L-703 engine should be raised to at least 6784 engine output shaft rpm independent of power (para 46).

102. The reference to a maximum transient engine output shaft speed of 7164 rpm should be deleted from the proposed YAH-1R supplement to the AH-1G operator's manual (para 46).

103. A study should be undertaken to reevaluate the engine overspeed criteria for other T53-series engines (para 47).

104. The present torque gage should be replaced with a gage having the following features (para 51):

a. Three-inch gage.

b. Percent maximum torque indication scaled from zero to 150-percent torque in increments of 2 percent.

c. Limit markings on the gage face rather than on the glass cover plate.

d. A compensating network to allow any electrical signal-producing torque sensor system to drive the needle to 100 percent at the maximum torque output voltage or current.

e. A tattletale bug to record the maximum overtorque condition. Such a bug not to be resettable by the flight crew or during the normal course of daily maintenance.

f. A recording device to record the duration and magnitude of all overtorques.

105. An overtorque warning light should be installed (para 51).

106. A torque limiting system should be installed to limit engine output shaft power to 1290 shp. Such a system should be adjustable to account for torque constant variation between individual engines, and should have an emergency override system that allows retention of engine speed governing features (para 52).

107. The sideward velocity envelope of the YAH-1R helicopter should be expanded to the limit of control authority unless a structural limit is encountered prior to the control limit (para 56).

108. A radar altimeter and a compensated rate-of-climb instrument should be installed for a precision height-above-ground reference and a vertical rate cue (para 61).

109. The present restriction of 85 KIAS maximum velocity with maximum power applied should be retained, with the added caution to avoid abrupt maneuvers at maximum power settings. A suitable marking should be placed on the airspeed indicator to denote this limit airspeed at power settings above 49-psi torque (para 63).

110. The present main transmission transient overtorque limit should be reevaluated with a view to increasing the limit if transmission analysis warrants such action (para 63).

111. Data contained in USAASTA Final Report No. 70-25 should be used in defining recommended maximum torque for a given airspeed to minimize control difficulty during instrument flight engine failure (para 74).

112. Further study should be undertaken to determine a maximum safe climb power or rate of climb for use under instrument flight conditions, with emphasis on aircraft control after a SCAS failure (para 78).

113. Further study should be accomplished to determine the effects of gross weight on control forces with a simultaneous dual boost failure, with a view to recommending that external stores be retained to maintain gross weight during such an emergency (para 79).

114. A note should be placed in maintenance manuals for AH-1G, -1Q, -1R, and -1S and the UH-1C and -1M helicopters detailing the procedure for disconnecting the control linkages from the swashplate and bell cranks to allow the hydraulic system to be fully bled (para 81).

115. Maintenance manuals should include instructions to pressurize both hydraulic systems when using external hydraulic power, except in those cases where this procedure is in direct conflict with the purpose of the maintenance action (para 81).

116. A CAUTION should be added to the AH-1G, -1Q, -1R, and -1S and the UH-1C and -1M operators' and maintenance manuals (para 81) as shown below.

CAUTION

Avoid rapid control movement or prolonged operation of the aircraft flight controls with one hydraulic boost system inoperative. Rapid or prolonged operation of the flight controls under these conditions may result in deterioration of hydraulic system separation seals and the introduction of air into the hydraulic boost actuators.

117. During the course of subsequent tests, the effectiveness of the increased oil cooler capacity should be evaluated (para 82).

APPENDIX A. REFERENCES

1. Final Report, USAASTA, Project No. 74-43, *Airworthiness and Flight Characteristics Evaluation, AH-1Q Helicopter*, July 1973.

2. Test Plan, USAAEFA, Project No. 74-33, *Army Preliminary Evaluation, AH-1R Improved Cobra Agility and Maneuverability Helicopter*, January 1975.

3. Letter, AVSCOM, AMSAV-EF, 22 January 1975, subject: Test Directive No. 74-33, Army Preliminary Evaluation of the AH-1R Improved Cobra Agility and Maneuverability Helicopter.

4. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971.

5. Final Report, USAASTA, Project No. 72-30, *Engineering Flight Test, AH-1G Helicopter with Model 212 Tail Rotor, Part II, Performance and Handling Qualities*, September 1973.

6. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.

7. Technical Manual, TM 55-1520-221-10, *YAH-1R Supplement to Operator's Manual, Army Model AH-1G Helicopter*, unpublished.

8. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

9. Final Report, USAASTA, Project No. 71-03, *Study, Pilot Perceived Jettison Envelope*, June 1973.

10. Specification, AVCO Lycoming Division, Model Specification No. 104.4, "Engine, Aircraft, Turboshaft: T53-L-703 (Lycoming Model LTC1K-4G)," date unknown.

11. Interim Report, USAAVNTA, Project No. 66-04, *Engineering Flight Test of the UH-1H Helicopter, Phase D, Product Improvement Test*, August 1967.

12. Final Report, USAASTA, Project No. 70-25, *Engineering Flight Test, AH-1G (HueyCobra) Helicopter, Autorotational Entry Characteristics*, April 1971.

APPENDIX B. AIRCRAFT DESCRIPTION

FUSELAGE

1. The YAH-1R fuselage is identical in outward appearance and dimensions to the AH-1G helicopter. Internal modifications to strengthen the fuselage structure to accept the higher stresses due to increased gross weight, power, and tail rotor power include strengthened transmission mounts and associated structure and strengthened tail boom.

ENGINE

2. A T53-L-703 engine has been installed in the YAH-1R helicopter, reflecting a growth step from the T53-L-13B engine. The T53-L-703 engine is a turboshaft engine with a two-stage axial flow free power tubine; a two-stage axial flow turbine driving a combination five-stage axial one-stage centrifugal compressor having a nominal 8:1 compression ratio at the thermodynamic limit and incorporating compressor interstage air bleed; variable inlet guide vanes; and an external annular atomizing combustor. A 3.2105:1 reduction gear housed in the air inlet housing reduces power turbine speed to output shaft speed (nominally 6600 rpm output shaft speed). The engine reduction gearbox is limited to 1175 ft-lb torque for 30 minutes and 1110 ft-lb torque for continuous usage. The engine achieves this power growth over the T53-L-13B engine through increased gas producer speed and increased operating temperatures made possible by improving the air cooling of the first-stage gas producer nozzle and by incorporating air-cooled blades in the first-stage turbine. New materials are employed in the second-stage gas producer and the power turbines. A T_7 interstage turbine temperature sensor harness has been incorporated for measurement of interstage turbine temperature, giving a more accurate indication of engine internal temperature than the T_9 temperature (exhaust gas) sensed in the T53-L-13B engine. T_7 temperature is displayed in the cockpit in place of T_9. This is noticeable in the higher temperature limit on the gage and in the shorter temperature rise time on starting the engine.

Transmission and Tail Rotor Drive

3. An uprated transmission and tail rotor drive system is installed in the YAH-1R helicopter. These systems have the following limits:

a. Transmission:

(1) 1290 horsepower for 30 minutes.

(2) 1134 maximum continuous horsepower.

b. Tail rotor drive:

(1) 187 horsepower maximum continuous power.

(2) 260 horsepower for 4-second transient limit.

Engine Oil Cooler

4. The cooling capacity of the engine oil cooler has been increased by enlarging the bleed air orifice which drives the turbine oil cooler fan, allowing higher cooling fan speed and cooling air mass flow.

Control System

5. The control system of the YAH-1R is basically the same as the AH-1G; however, two new features have been incorporated. The cable controls in the AH-1G antitorque system have been replaced by push-pull tubes. A collective control rate limiter which limits the rate of collective control movement to 115 percent of full throw in 1 second has been incorporated.

Principal Dimensions

6. Principal dimensions and general data concerning the YAH-1R helicopter are as follows:

Overall Dimensions

Length, rotor turning	52 ft, 11 in.
Width, rotor turning	44 ft
Height, tail rotor vertical	13 ft, 9.5 in.
Length, rotor removed	45 ft, 2.2 in.

Main Rotor

Diameter	44 ft
Disc area	1520.5 ft^2
Solidity	0.0651
Number of blades	2
Blade chord, constant	27.0 in.
Blade twist	-0.455 deg/ft
Airfoil	9.33 percent thickness, special symmetrical section

Tail Rotor

Diameter	8 ft, 6 in.
Disc area	56.75 ft^2
Solidity	0.1436
Number of blades	2
Blade chord, constant	11.5 in.
Blade twist	0.0 deg/ft
Airfoil	NACA 0018 at the blade root, changing linearly to a special cambered section of 8.27 percent of the tip

Fuselage

Length, rotor removed	45 ft, 2.2 in.
Height:	
To tip of tail fin	10 ft, 4 in.
Ground to top of mast	11 ft, 7 in.
Ground to top of transmission fairing	10 ft, 2 in.
Ground to bottom of chin turret	1 ft, 2 in.
Width:	
Fuselage only	3 ft
Wing span	10 ft, 8.24 in.
Engine cowling	3 ft, 6 in.
Skid gear tread	7 ft, 4 in.
Elevator:	
Span	6 ft, 2 in.
Area	25.2 ft^2
Airfoil	Inverted Clark Y
Vertical fin:	
Area	18.5 ft^2
Airfoil	Special cambered
Height	5 ft, 6 in.
Wing:	
Span	10 ft, 8.24 in.
Area	27.8 ft^2
Incidence	14.0 deg
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024

WEIGHT AND BALANCE

7. The aircraft weight, longitudinal cg, and lateral cg were determined prior to testing. Two weighings were accomplished: the first with all fuel drained and the second with a full fuel loading. Both weighings included instrumentation, two XM200 rocket pods mounted on the inboard racks with 19 rockets in each pod, and a 7.62mm minigun and a 40mm grenade launcher installed in the chin turret. The first weighing (fuel drained) was 7629 pounds with the longitudinal cg located at fuselage station (FS) 199.6 and the lateral cg located 0.1 inch to the left of the aircraft center line. The second weighing (full fuel) was 9339 pounds with the longitudinal cg located at FS 199.4 and the lateral cg located 0.1 inch to the left of the aircraft center line.

8. The external stores configuration had a total of four XM200 rocket pods mounted on the wing hardpoints. Twelve 28-pound inert rockets were located in each outboard pod and nineteen 28-pound inert rockets were loaded in each inboard pod.

9. The fuel load for each test flight was determined prior to engine start and after engine shutdown. Total fuel load was determined by measuring the fuel specific gravity and temperature and by using an external sight gage on the fuel cell to determine fuel volume.

10. Ballast weights were used at several longitudinal fuselage stations in order to achieve desired cg locations.

11. Two cg locations were utilized during the test flights for evaluation. They were the forward and aft limits of the cg envelope, respectively. Tables 1 and 2 show the average takeoff loadings to achieve the two cg locations.

Table 1. Aft Center of Gravity.

Item		Weight (lb)	Fuselage Station Longitudinal (in.)	Fuselage Station Lateral (in.)
Basic aircraft (includes instrumentation and guns in turret)		8600	[1]200.5	-0.1
Fuel		1250	204.1	0.0
Pilot		175	135.0	0.0
Engineer		185	83.0	0.0
Ballast	At tail light	50	472.0	0.0
	At horizontal stabilizer	25	414.0	0.0
Total		10,285	199.5	-0.1

[1]Battery in aft compartment, station 284.

Table 2. Forward Center of Gravity.

Item		Weight (lb)	Fuselage Station Longitudinal (in.)	Fuselage Station Lateral (in.)
Basic aircraft (includes instrumentation and guns in turret)		8600	[1]199.1	-0.1
Fuel		1000	204.2	0.0
Pilot		175	135.0	0.0
Engineer		185	83.0	0.0
Ballast	At battery compartment	100	40.0	0.0
	At gun breech	100	78.0	0.0
	At ammunition bay wall	125	103.0	0.0
Total		10,285	192.5	-0.1

[1]Battery in forward compartment, station 40.

Photo 1. Left Side View, YAH-1R Helicopter.

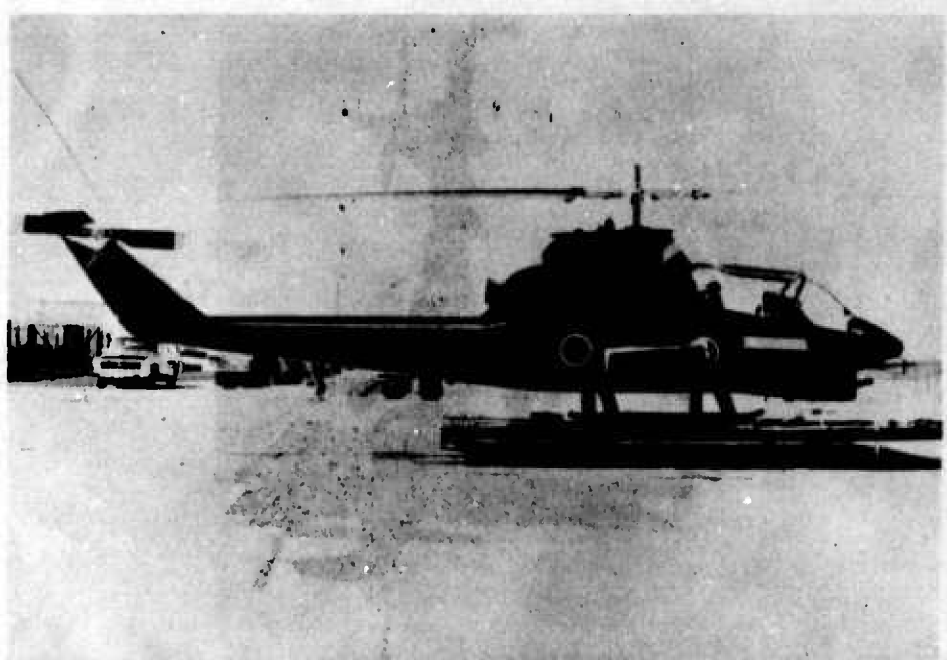


Photo 2. Right Side View, YAH-1R Helicopter.

Photo 3. Front View, YAH-1R Helicopter.

Photo 4. Rear View, YAH-1R Helicopter.

Photo 5. Right Front View, YAH-1R Helicopter.

Photo 6. Left Rear View, YAH-1R Helicopter.

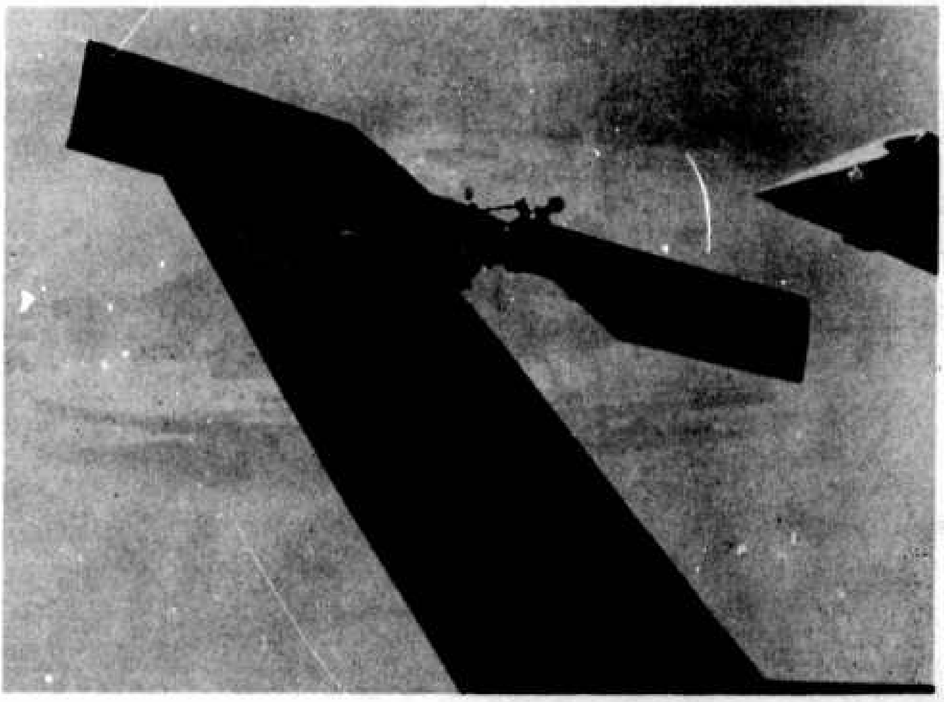


Photo 7. Model 212 Tail Rotor Installation on the YAH-1R Helicopter.

Photo 8. Detail of 90-Degree Gearbox Fairing, YAH-1R Helicopter.

APPENDIX C. INSTRUMENTATION

Instrumentation was installed in the test aircraft by BHC prior to the start of the test program and is shown in photos 1 through 6. Two oscillograph recorders were located in the ammunition bay for all testing. All instrumentation was calibrated and maintained by BHC. The following parameters were recorded:

Pilot Panel

Airspeed (sensitive boom)
Altitude (boom)
Center-of-gravity normal acceleration
Engine torque (ship's system)
Event switch
Oscillograph operate switch
Outside air temperature
Angle of sideslip
Control position indicator:
- Lateral
- Longitudinal
- Directional
- Collective

Interstage turbine temperature
Main rotor speed (sensitive and ship's system)
Vertical speed (ship's system)

Copilot/Engineer Panel

Airspeed (sensitive boom and ship's system)
Altitude (boom and ship's system)
Engine torque (ship's system)
Tail rotor torque
Event switch
Oscillograph operate switch
Angle of sideslip
Sensitive outside air temperature
Vertical speed (boom)
Interstage turbine temperature

Oscillograph

Control position:
- Longitudinal
- Lateral
- Collective
- Directional

Control force:
- Longitudinal
- Lateral
- Collective
- Directional

Longitudinal SCAS position
Lateral SCAS position
Directional SCAS position
Pitch attitude
Roll attitude
Yaw attitude
Pitch rate
Roll rate
Yaw rate
Center-of-gravity normal acceleration
Center-of-gravity longitudinal acceleration
Center-of-gravity lateral acceleration
Throttle position
Engine torque
Main rotor mast torque
Main rotor flapping angle
Main rotor linear rpm
N_2 linear rpm
Tail rotor mast torque
Tail rotor flapping angle
Main rotor/tail rotor azimuth
Tail rotor blade angle
Airspeed
Angle of attack
Angle of sideslip
Pilot/copilot event

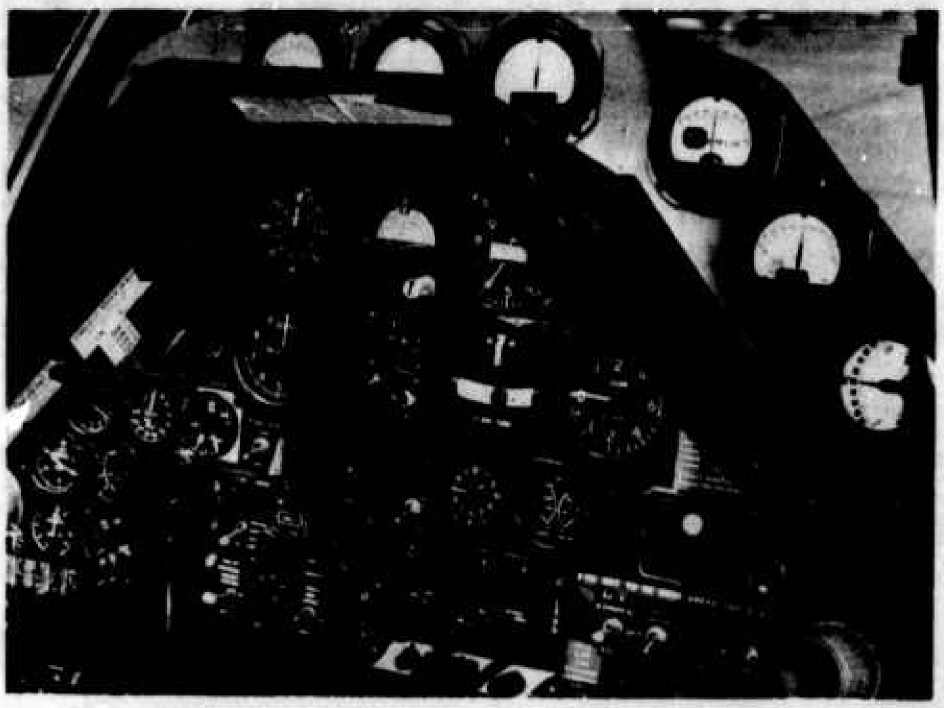


Photo 1. Pilot Instrument Panel, YAH-1R Test Aircraft.

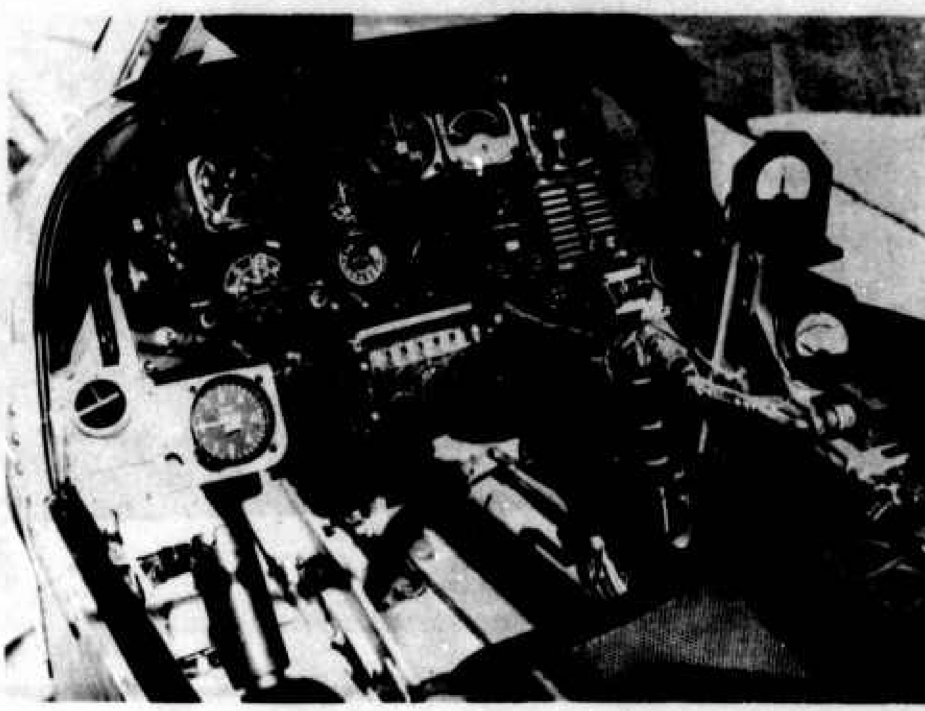


Photo 2. Engineer Panel, YAH-1R Test Aircraft.

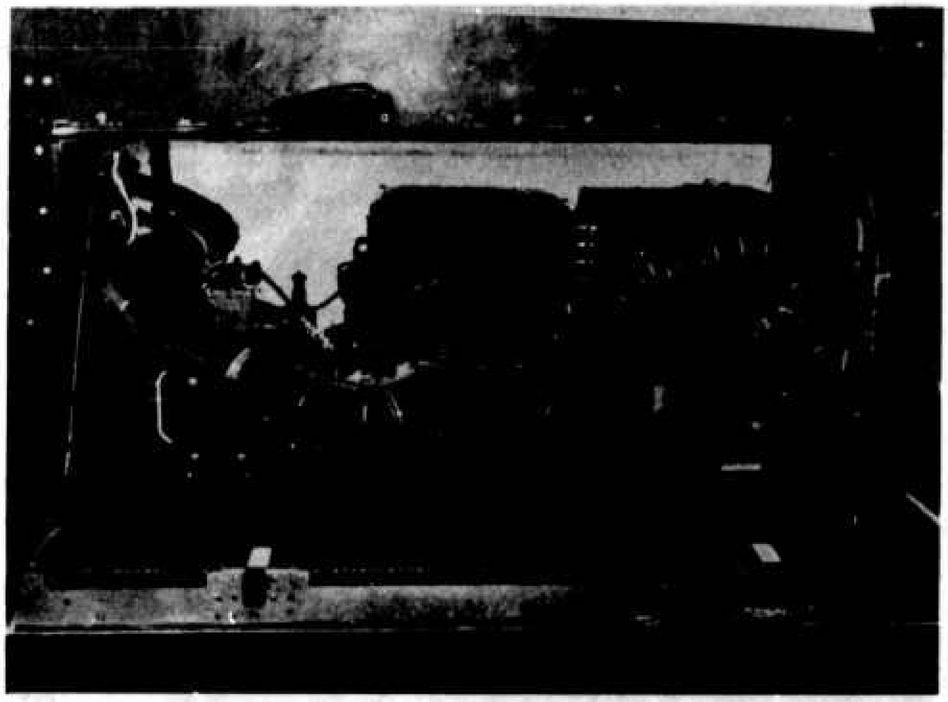


Photo 3. Oscillograph Installation in Ammunition Bay, YAH-1R Helicopter.

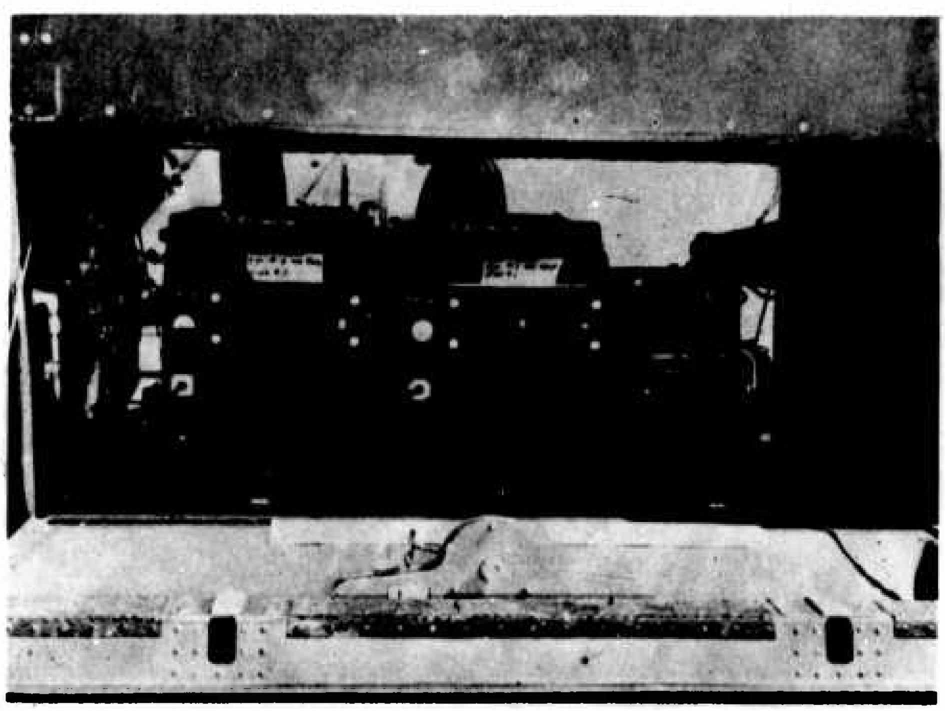


Photo 4. Oscillograph Installation in Ammunition Bay, YAH-1R Helicopter.

Photo 5. Nose-Mounted Test Instrumentation Boom, YAH-1R Test Aircraft.

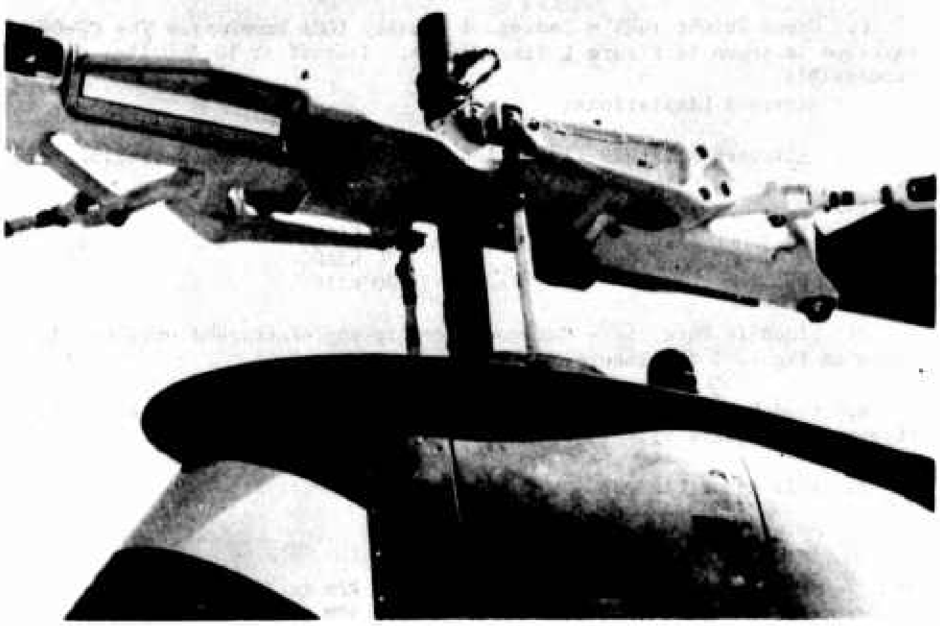


Photo 6. Main Rotor Rotating Instrumentation, YAH-1R Test Aircraft.

APPENDIX D. SAFETY-OF-FLIGHT RELEASE

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION SYSTEMS COMMAND
PO BOX 209, ST. LOUIS, MO 63166

AMSAV-EQI

SUBJECT: Safety of Flight Release for USAAVSCOM/USAAEFA Project No. 74-33

Commander
US Army Aviation
Engr Flight Activity
ATTN: SAVTE-P

1. This letter constitutes a safety of flight release (SOFR) for USAAEFA to conduct USAAVSCOM/USAAEFA Project No. 74-33, Army Preliminary Evaluation of the AH-1G ICAM (AH-1R) Helicopter.

2. The flight envelope and operating limitations to conduct USAAEFA Project No. 74-33 shall be in accordance with the following:

a. Unless specified below as unique AH-1G ICAM limitations, the limitations of the "Army Model AH-1G Helicopter" Operators Manual, TM-55-1520-221-10 shall apply.

b. Gross Weight (GW) - Center of Gravity (CG) Envelope - The CG-GW envelope is shown in Figure 1 (inclosure). Takeoff at 10,300 lbs. is permissible.

c. Airspeed Limitations:

(1) Airspeed/Altitude limitations are shown in Figure 2 (inclosure 2).

(2)

V_{NE}	190 KIAS
V_{LAT}	35 KIAS
V_{AFT}	30 KIAS
V_{AUTO}	120 KIAS

d. Sideslip Envelope - Maximum sideslip angle/airspeed envelope is shown in Figure 3 (inclosure 3).

e. Load Factor - Maximum load factor/airspeed envelope is shown in Figure 4 (inclosure 4). These are for symmetrical pull-ups.

f. Main Rotor Limits:

(1) Power On:

Forward Flight	314 RPM to 324 RPM
Hover Only	295 RPM to 324 RPM

(2) Power Off:

Maximum	339 RPM
Transient Minimum	260 RPM

g. Engine Limits (Lycoming T53-L-703):

(1)	Military (Thermo)	1800 SHP
(2)	Normal	1500 SHP
(3)	T_7 Maximum	866°C Inter Turbine
(4)	T_7 Maximum Continuous	810°C Inter Turbine
(5)	T_7 Maximum Start Or Transient Less Than Two Seconds	915°C Inter Turbine
(6)	N_1 Maximum (Red Line)	105.8%

h. Main Transmission Limits:

(1) Takeoff Power (30 minute rating limited to climb to best climb speed, hover and low speed translational flight)
1290 SHP to 85 KIAS
(55.7psi torque pressure)

(2) Maximum Continuous Power — 1130 SHP to V_H
(49 psi)

i. Tail Rotor Gearbox Power

(1) Maximum Transient (4 second max) — 260 SHP (100%)

(2) Maximum Continuous — 187 SHP

j. Maximum Dive Power — 900 SHP
(39 psi)

k. Air Starts Not Approved

l. Throttle chops approved throughout recommended flight envelope.

m. Manual fuel control operation approved. (1050 SHP maximum available at sea level - 46 psi).

n. Autorotative flight and landing approved.

o. Single boost operation approved (test only).

p. Operation of ECU above 70°F ambient is prohibited.

q. Transmission and Drive Train Inspection required same as for AH-1J when:

(1) Engine torque pressure 55.7 to 57.9 psi (torque 100% to 104%) inspect per NAVAIR 01-110HCB-6-3, card 24.

(2) Engine torque pressure is 57.9 to 62.4 psi (torque 104% to 112%) inspect per NAVAIR 01-110HCB-6-3, card 24.1.

(3) Engine torque pressure over 62.4 psi (over 112%) remove parts and inspect per NAVAIR 01-110 HCB-6-3, card 24.2.

r. The 204-040-623-1 Tail Rotor drive shaft bearings shall be replaced every 500 hours.

FOR THE COMMANDER:

Incl-4
as

CHARLES C. CRAWFORD, JR.
Chief, Sys Dev & Qual Div
Directorate for RD&E

GROSS WEIGHT - CENTER OF GRAVITY ENVELOPE

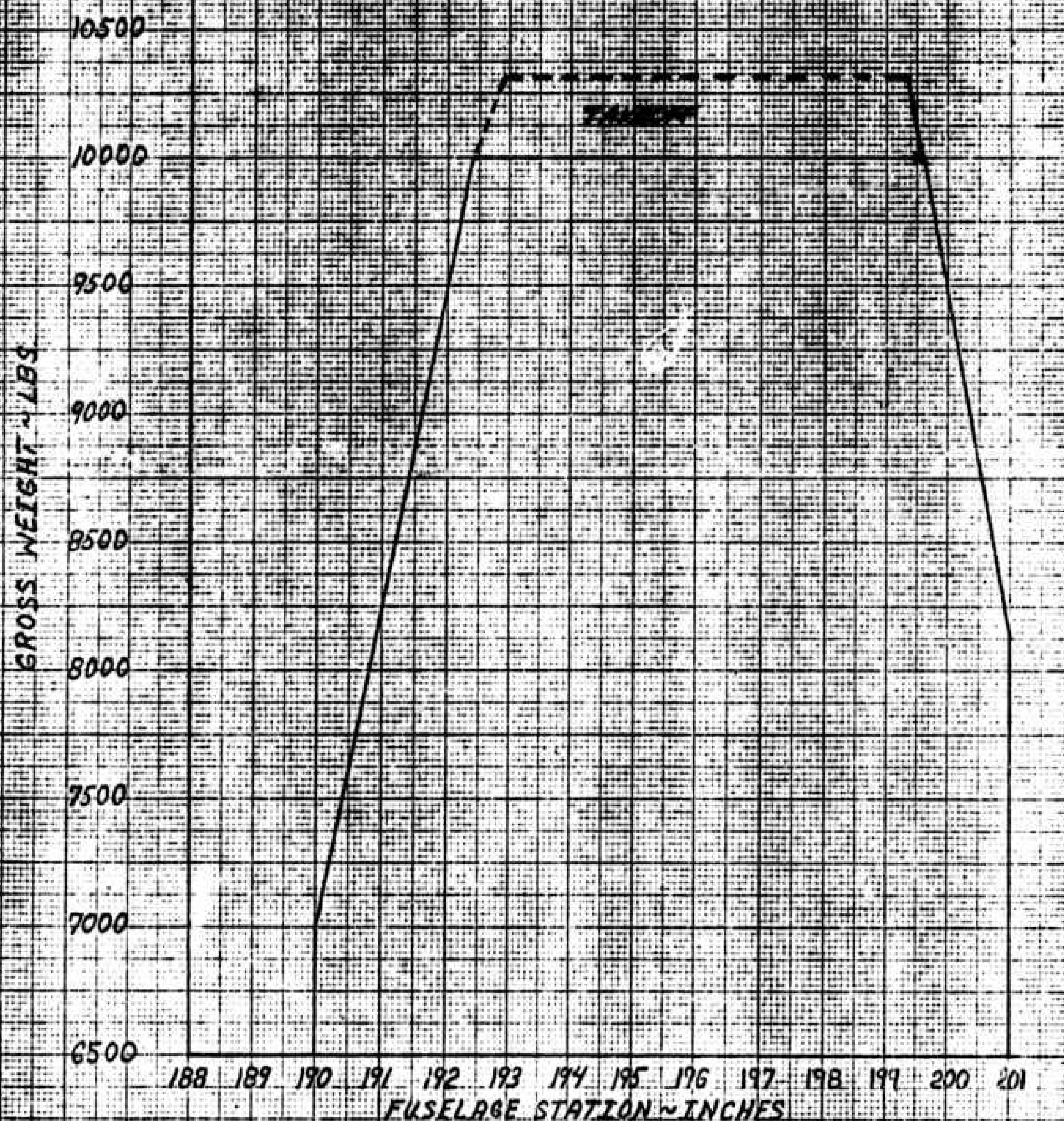


FIGURE 1

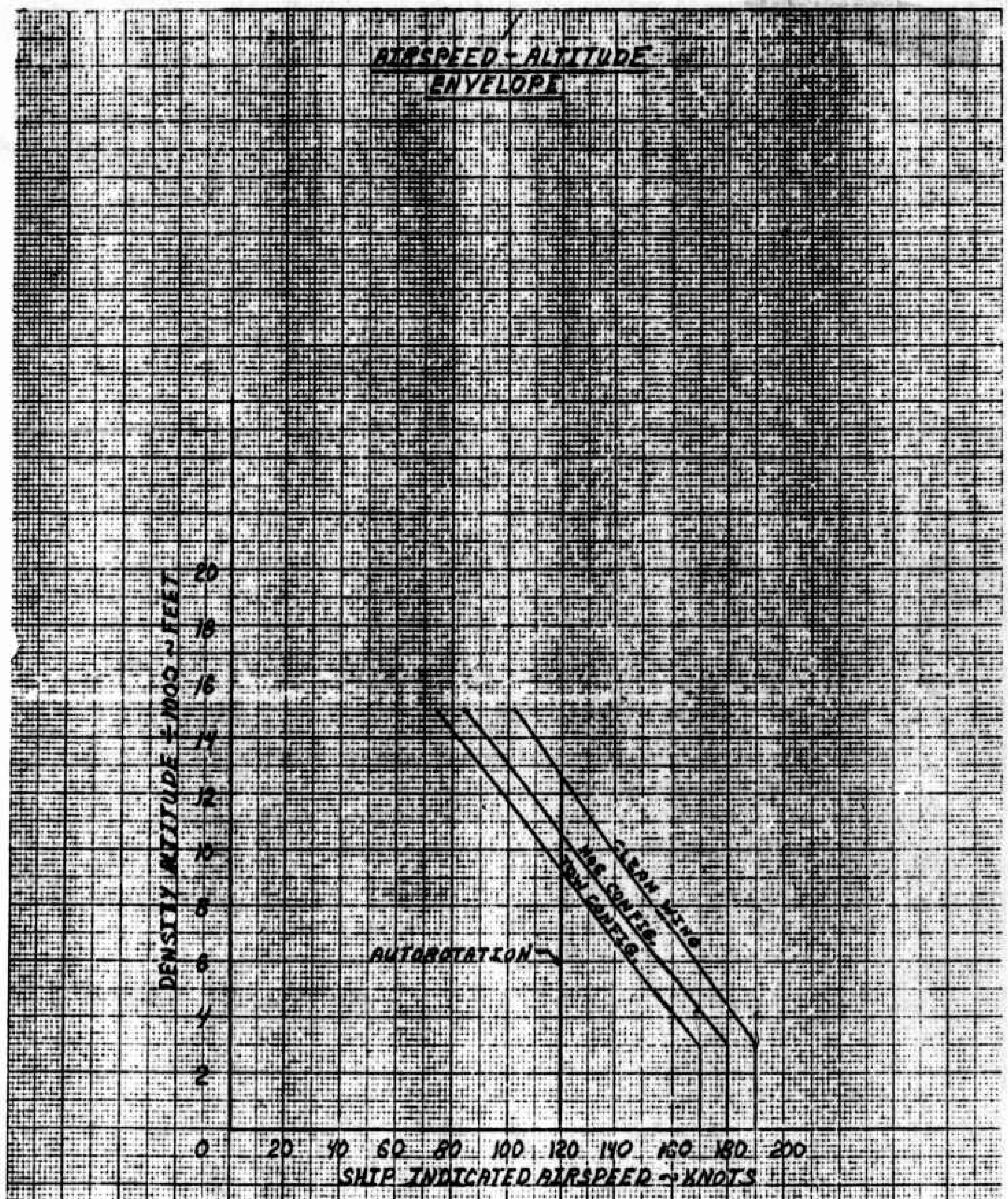

AIRSPEED - ALTITUDE
ENVELOPE
DENSITY ALTITUDE ÷ 1000 ~ FEET
20
18
16
14
12
10
8
6
4
2
0
CLEAN WING
MAG CONFIG
TOW CONFIG
AUTOROTATION
20
40
60
80
100
120
140
160
180
200
SHIP INDICATED AIRSPEED ~ KNOTS

FIGURE 2

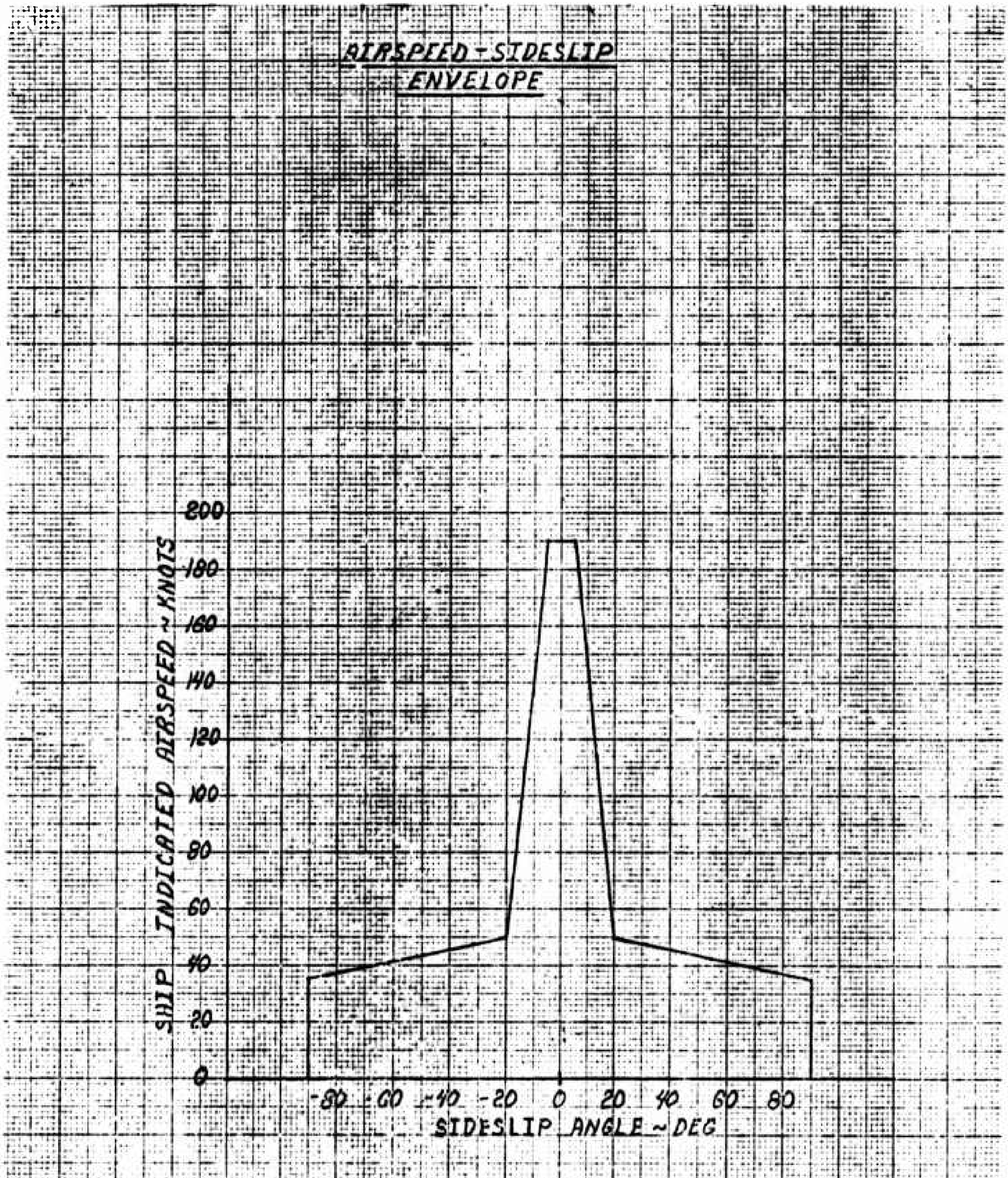

AIRSPEED - SIDESLIP ENVELOPE
SHIP INDICATED AIRSPEED ~ KNOTS
200
180
160
140
120
100
80
60
40
20
0
-80 -60 -40 -20 0 20 40 60 80
SIDESLIP ANGLE ~ DEG

FIGURE 3

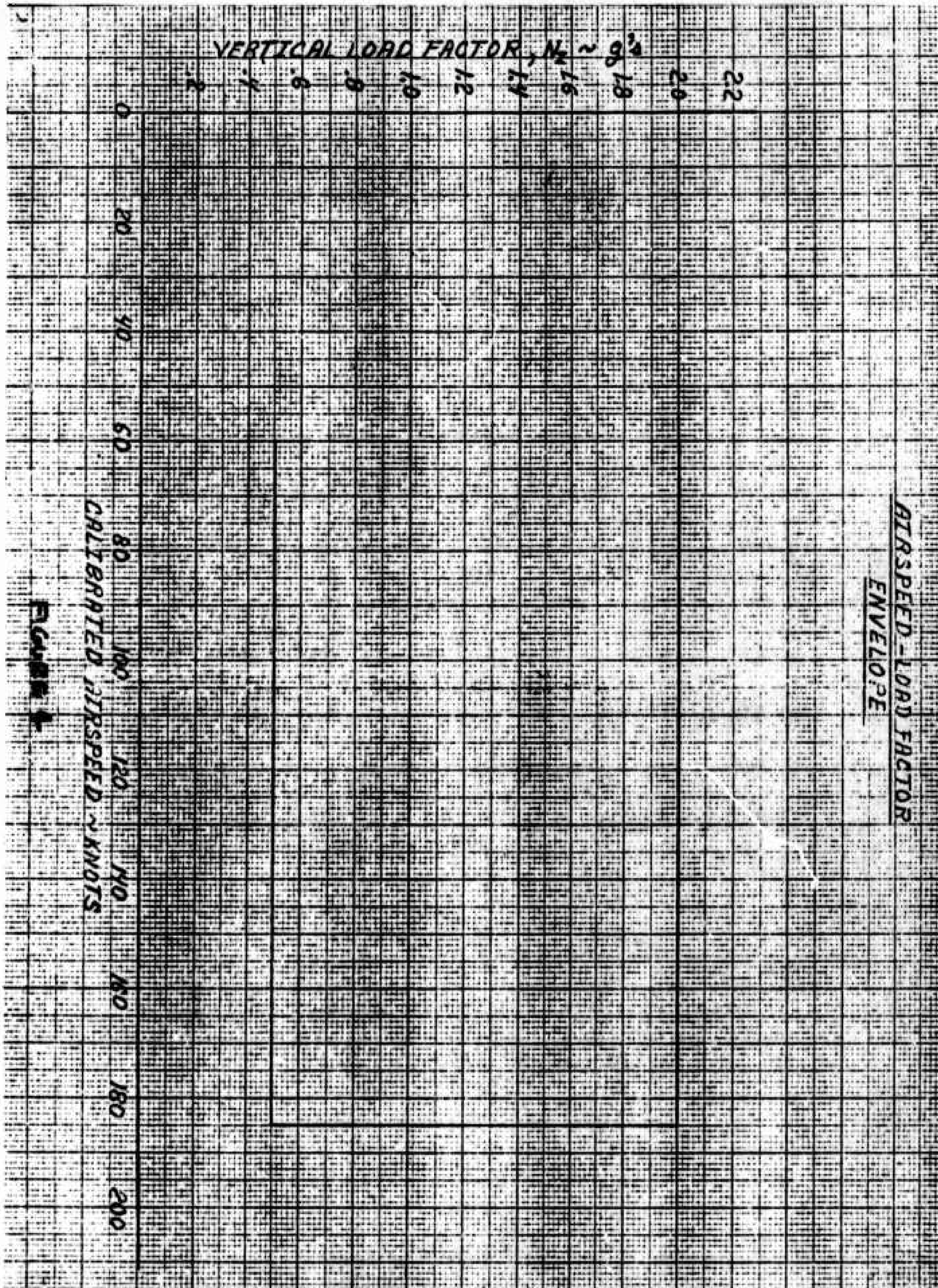

AIRSPEED-LOAD FACTOR
ENVELOPE
VERTICAL LOAD FACTOR, N_z ~ g's
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
0
20
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KNOTS

FIGURE 4

APPENDIX E. TEST DATA

INDEX

FIGURE 1
CYCLIC STICK CONTROL PATTERN
YAH-1R USA S/N 70-15936

NOTES:
1) ROTOR STATIC
2) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
3) NO. 1 AND NO. 2 BOOST SYSTEMS ON
4) TOTAL LONGITUDINAL CONTROL TRAVEL = 9.90 INCHES
5) TOTAL LATERAL CONTROL TRAVEL = 9.70 INCHES
6) COLLECTIVE CONTROL POSITION DID NOT ALTER CYCLIC MOVEMENT LIMITS
7) SCAS OFF
8) FORCE TRIM OFF

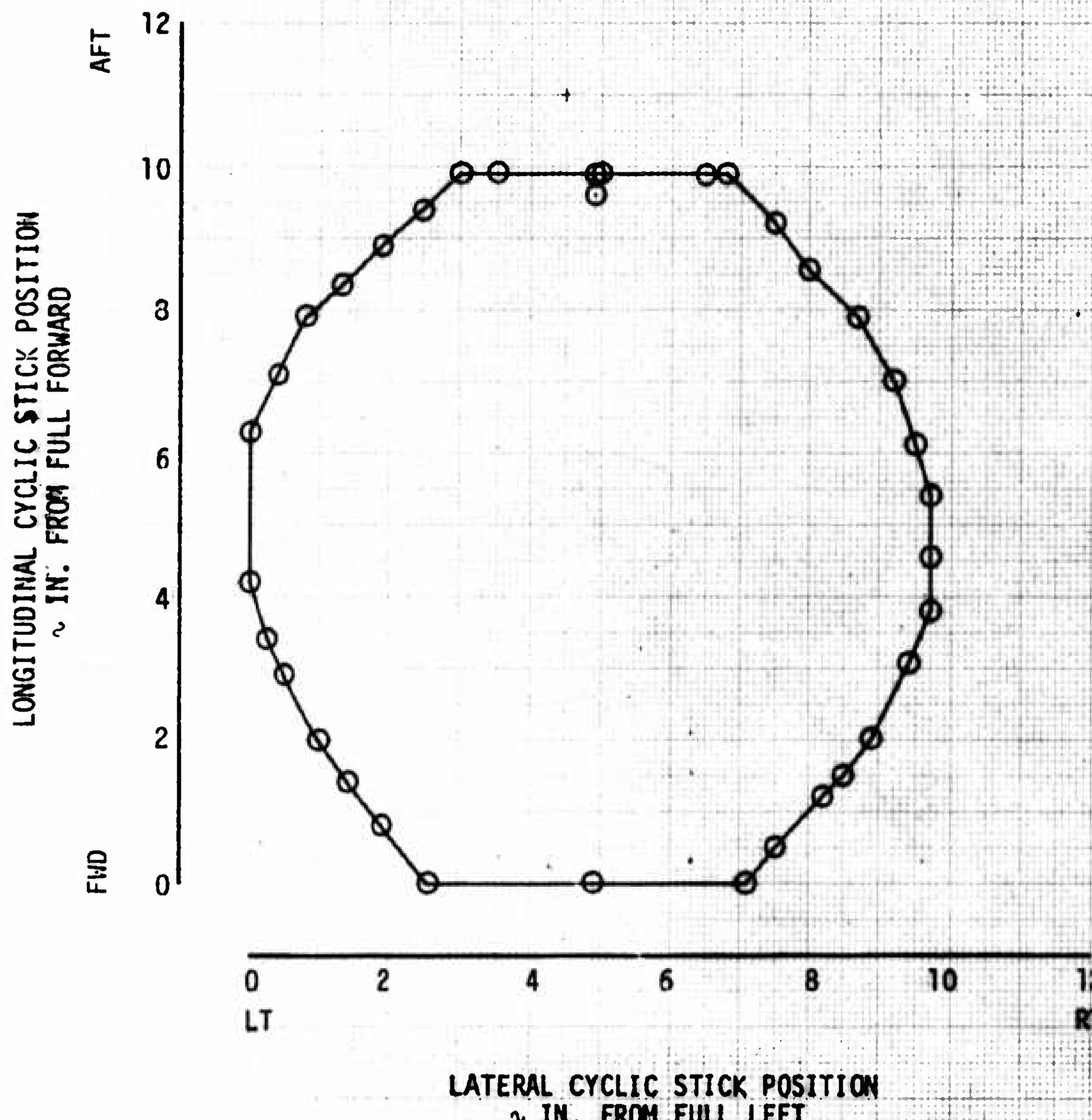


FIGURE 2
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-1R USA S/N 70-15936

NOTES:
1) ROTOR STATIC
2) FORCES MEASURED AT CENTER OF GRIP
3) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4) NO. 1 AND NO. 2 BOOST SYSTEMS ON
5) SOLID SYMBOL DENOTES TRIM POINT
6) LATERAL CONTROL POSITION [illegible] INCHES FROM FULL LEFT (CENTERED)
7) TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 9.9 INCHES
8) FORCE TRIM ON
9) SCAS OFF

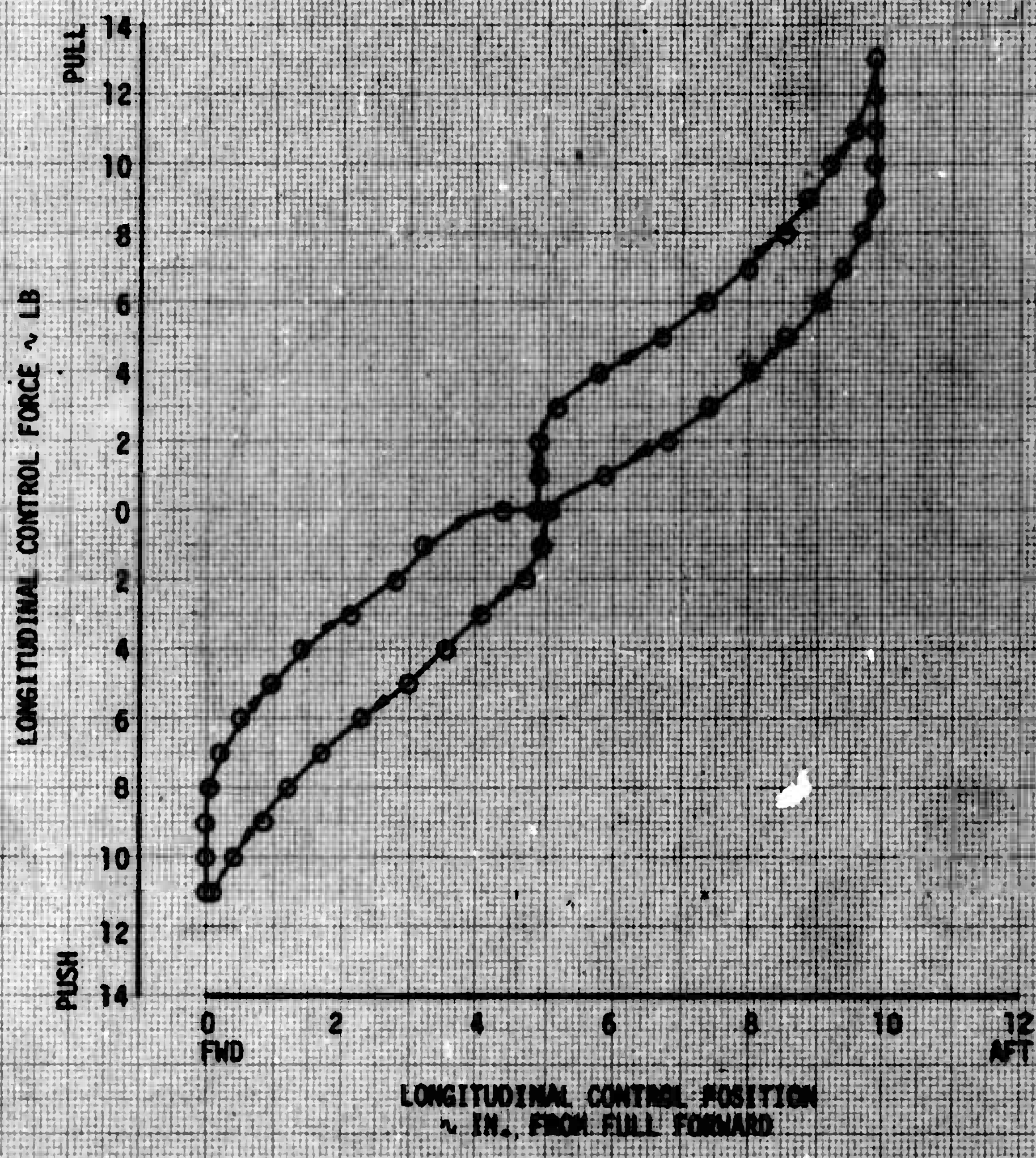


FIGURE 3
LATERAL CONTROL SYSTEM CHARACTERISTICS
YAH-1R USA S/N 70-15936

NOTES:
1) ROTOR STATIC
2) FORCES MEASURED AT CENTER OF GRIP
3) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4) NO. 1 AND NO. 2 BOOST SYSTEMS ON
5) SOLID SYMBOL DENOTES TRIM POINT
6) LONGITUDINAL CONTROL POSITION 8.9 INCHES FROM FULL FORWARD (CENTERED)
7) TOTAL LATERAL CONTROL DISPLACEMENT = 9.7 INCHES
8) FORCE TRIM ON
9) SCAS OFF

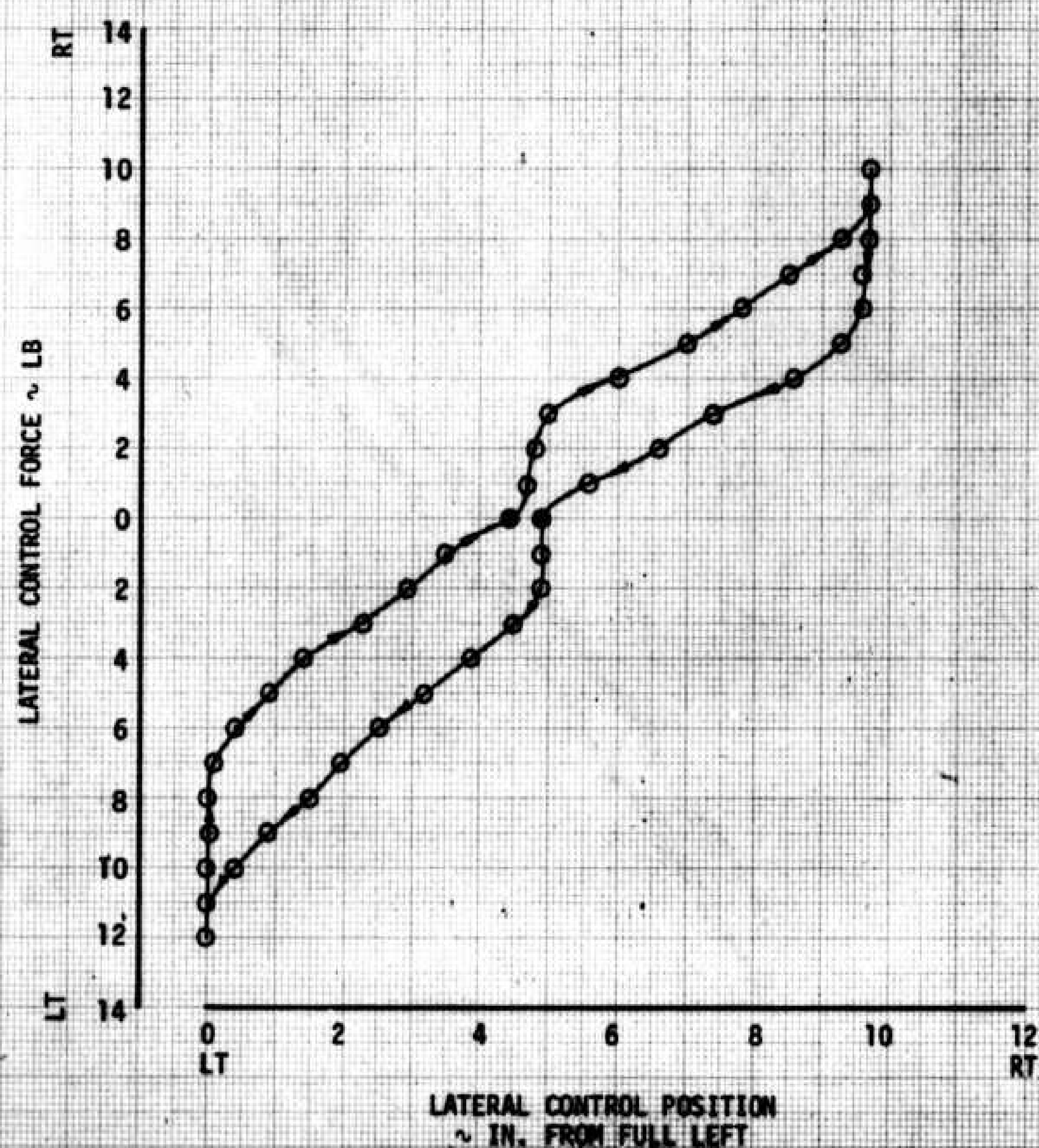


FIGURE [illegible]
DIRECTIONAL CONTROL [illegible] CHARACTERISTICS
[illegible]

NOTES:
1) ROTOR STATIC
2) FORCES MEASURED AT CENTER OF PEDAL
3) HYDRAULIC AND ELECTRICAL POWER SUPPLIED BY GROUND POWER UNITS.
4) TOTAL DIRECTIONAL CONTROL DISPLACEMENT ~ 5.45 INCHES
5) NO. 1 AND NO. 2 BOOST SYSTEMS ON
6) FORCE TRIM ON
7) SOLID SYMBOL DENOTES TRIM POINT
8) SCAS OFF
9) DIRECTIONAL CONTROL LIMITS NOT REACHED DUE TO MEASUREMENT SYSTEM CONSTRAINTS

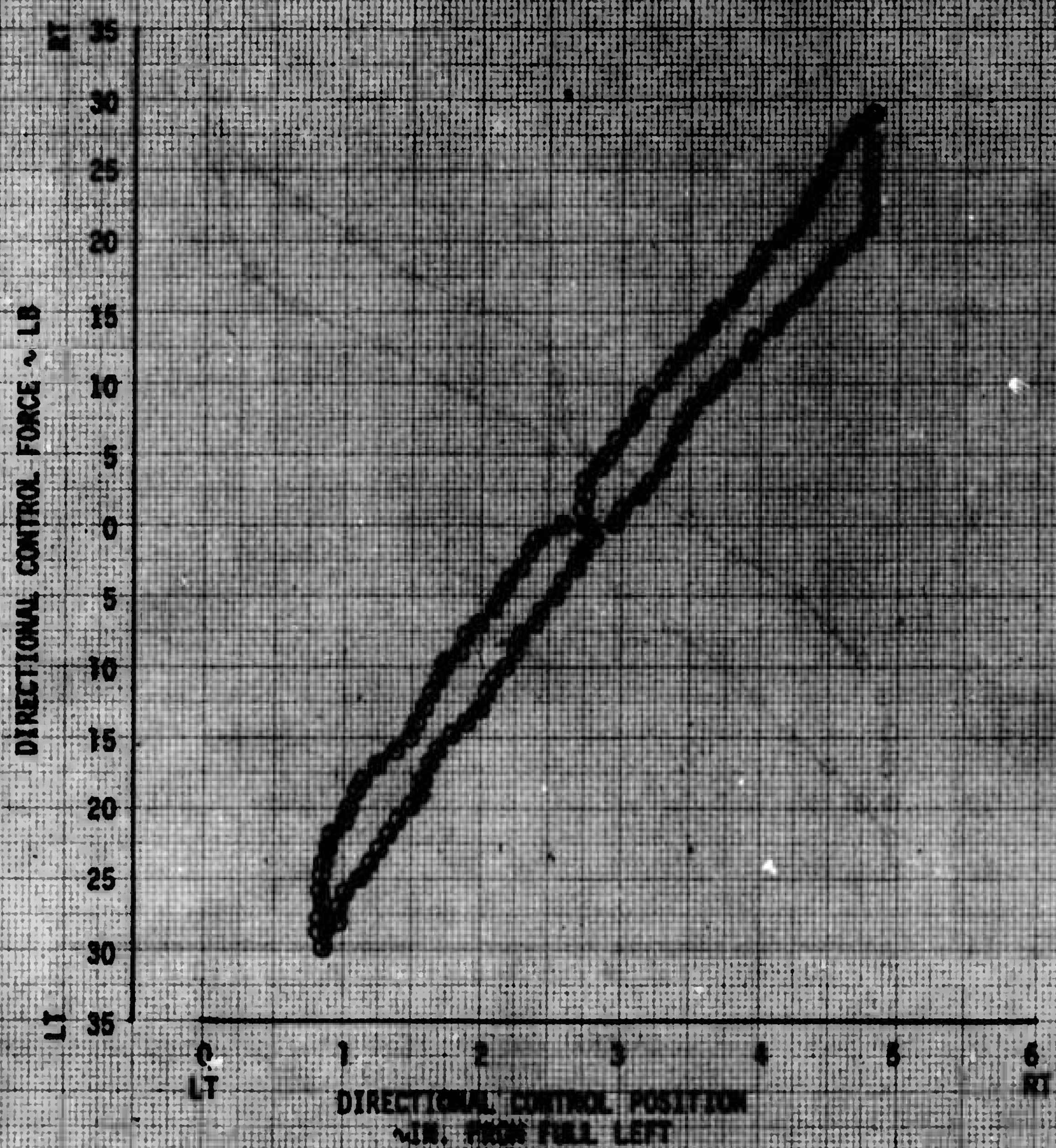
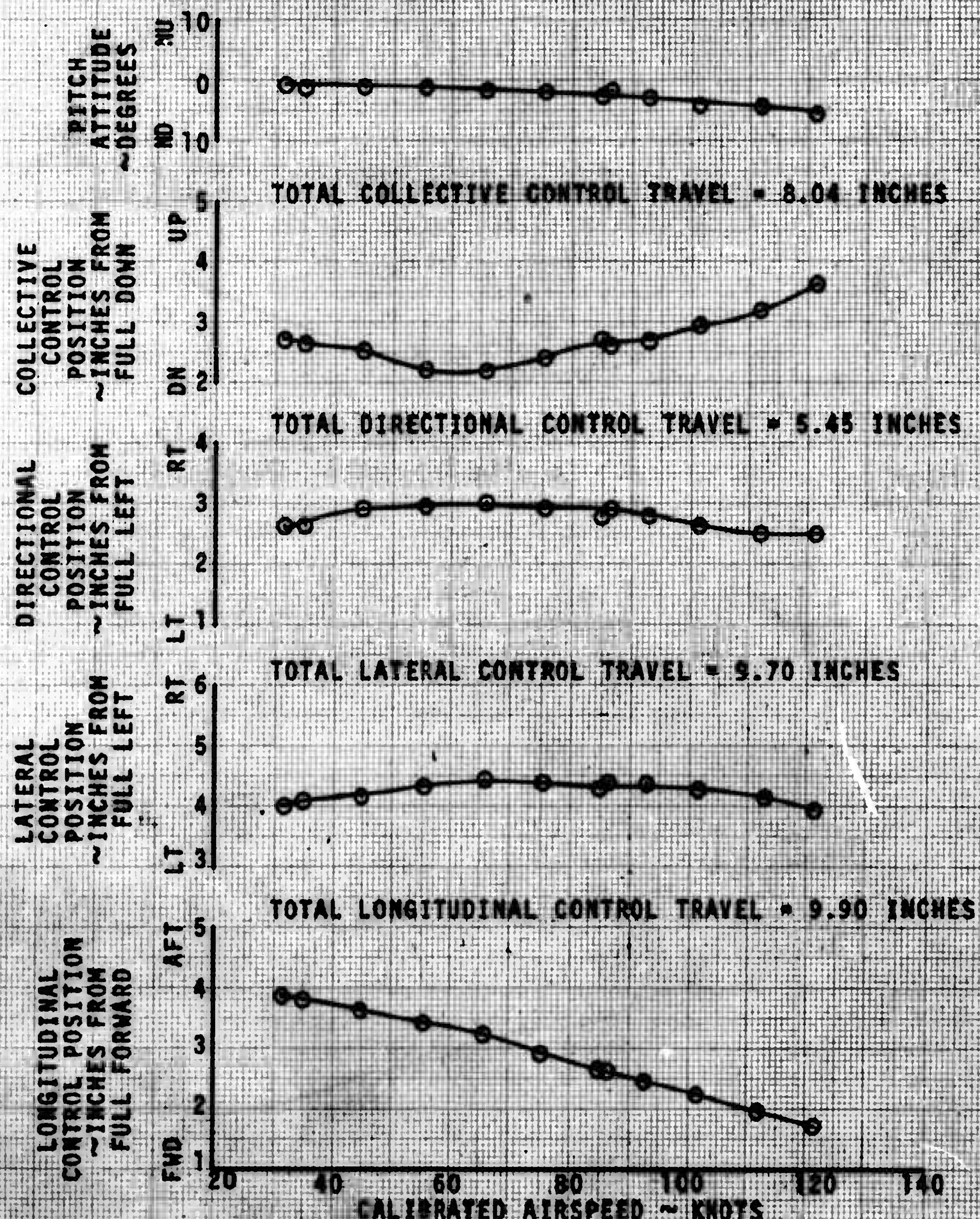


FIGURE 5
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $x10^4$	CONFIG
10,000	199.5(AFT)	-0.1(LT)	5000	1.5	324	57.63	HOG



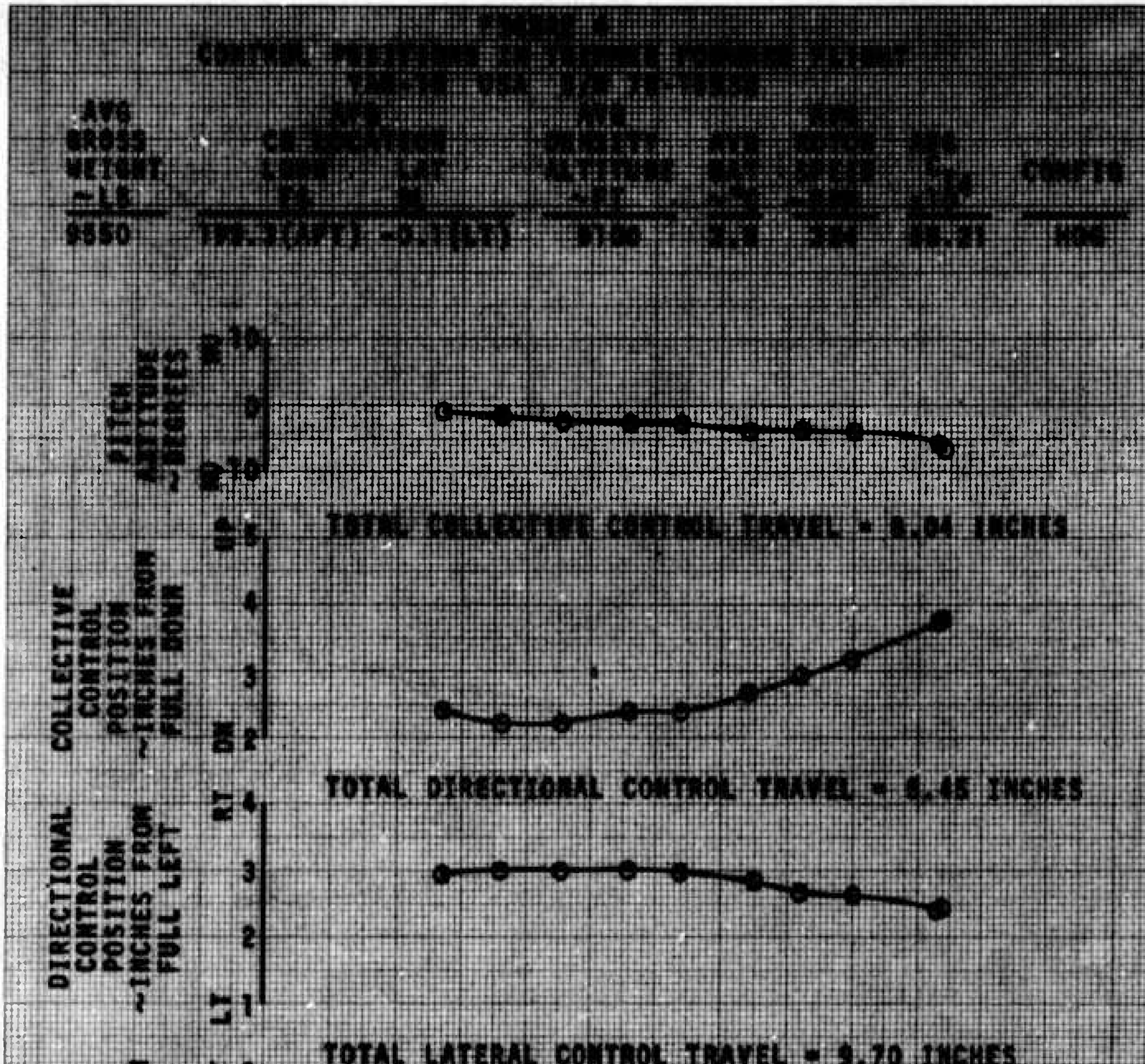

AVG GROSS WEIGHT ~LB
9550
CONFIG
PITCH ATTITUDE ~DEGREES
UP
DN
TOTAL COLLECTIVE CONTROL TRAVEL = 9.04 INCHES
COLLECTIVE CONTROL POSITION ~INCHES FROM FULL DOWN
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.45 INCHES
DIRECTIONAL CONTROL POSITION ~INCHES FROM FULL LEFT
RT
LT
TOTAL LATERAL CONTROL TRAVEL = 9.70 INCHES
LATERAL CONTROL POSITION ~INCHES FROM FULL LEFT
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.90 INCHES
LONGITUDINAL CONTROL POSITION ~INCHES FROM FULL FORWARD
AFT
FWD
CALIBRATED AIRSPEED ~ KNOTS

FIGURE 7
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $x10^4$	CONFIG	FLT COND
10,130	192.4(FWD)	-0.1(LT)	4400	17	324	57.33	HOG	LEVEL FLT

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = 2.9 INCHES FROM FULL DOWN
3) ANGLE OF SIDESLIP = ZERO DEGREES

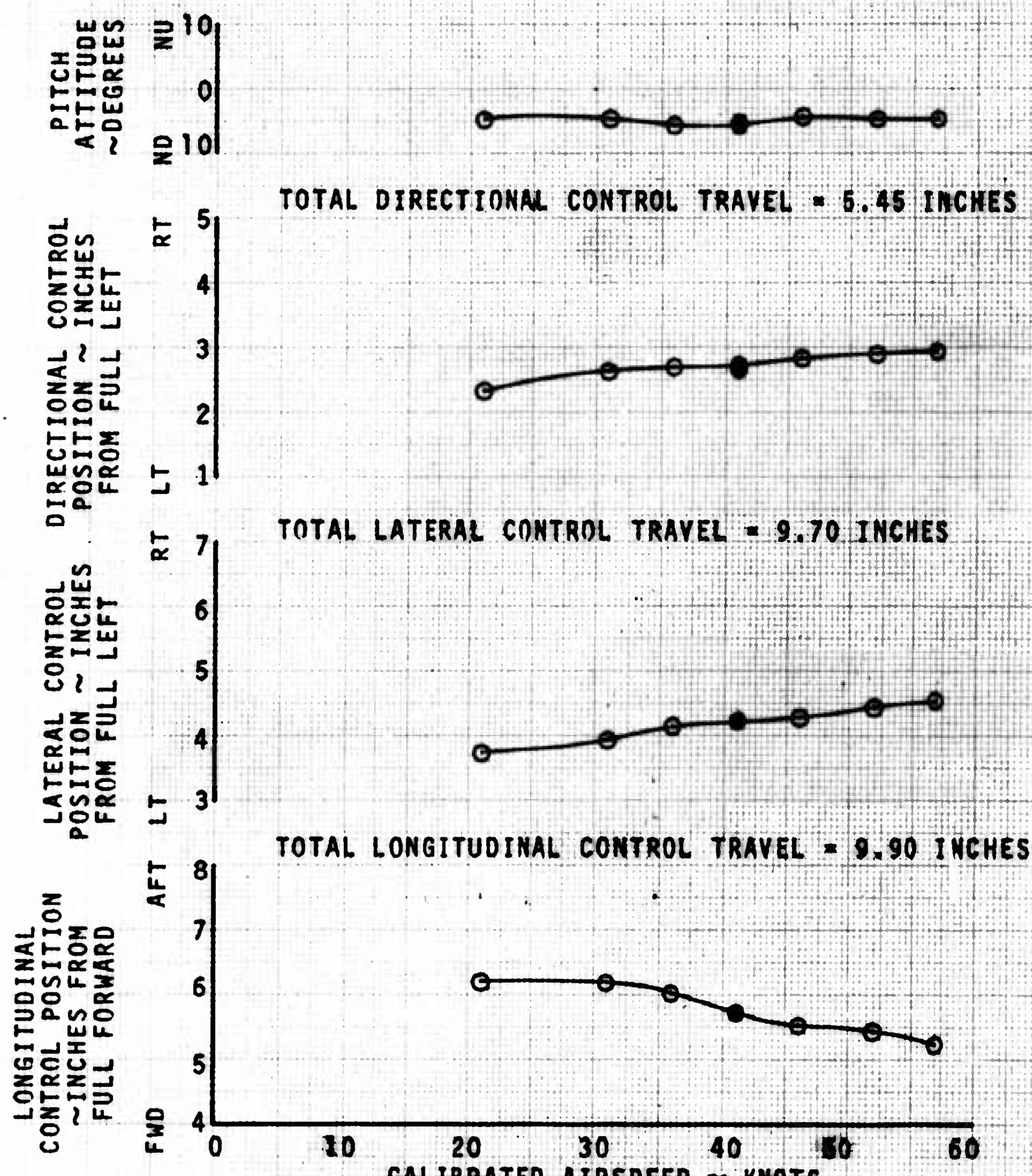


FIGURE 8
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	CONFIG	FLT COND
10,080	199.5(AFT)	-0.1(LT)	5100	2.5	324	58.27	HOG	LEVEL FLT

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = 2.5 INCHES FROM FULL DOWN
3) ANGLE OF SIDESLIP = ZERO DEGREES

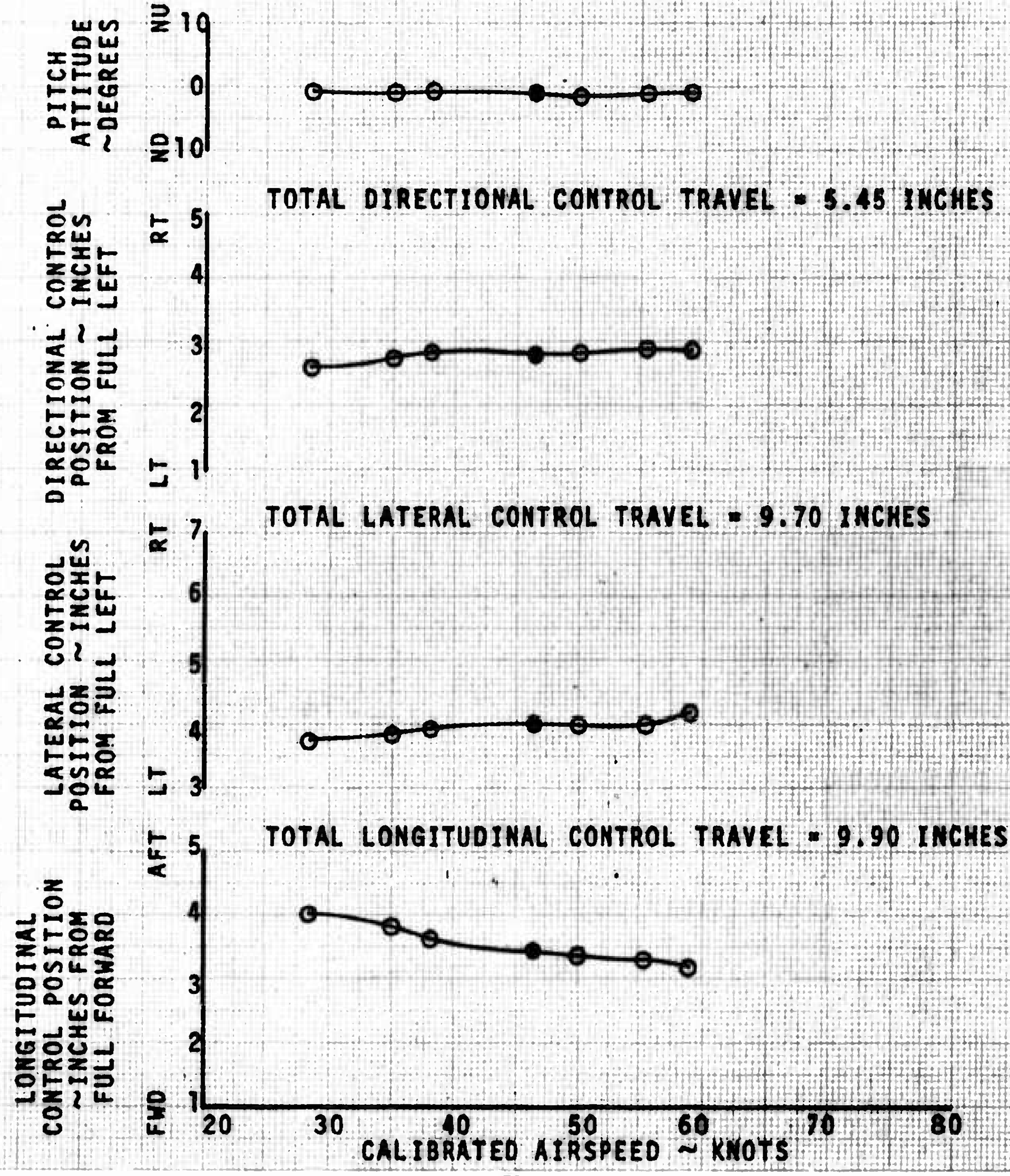


FIGURE 9
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-63 USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $x10^4$	CONFIG	FLT COND
9810	199.4(AFT)	-0.1(LT)	5100	3	324	56.71	HOG	DIVE

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = 3.2 INCHES FROM FULL DOWN
3) ANGLE OF SIDESLIP = ZERO DEGREES

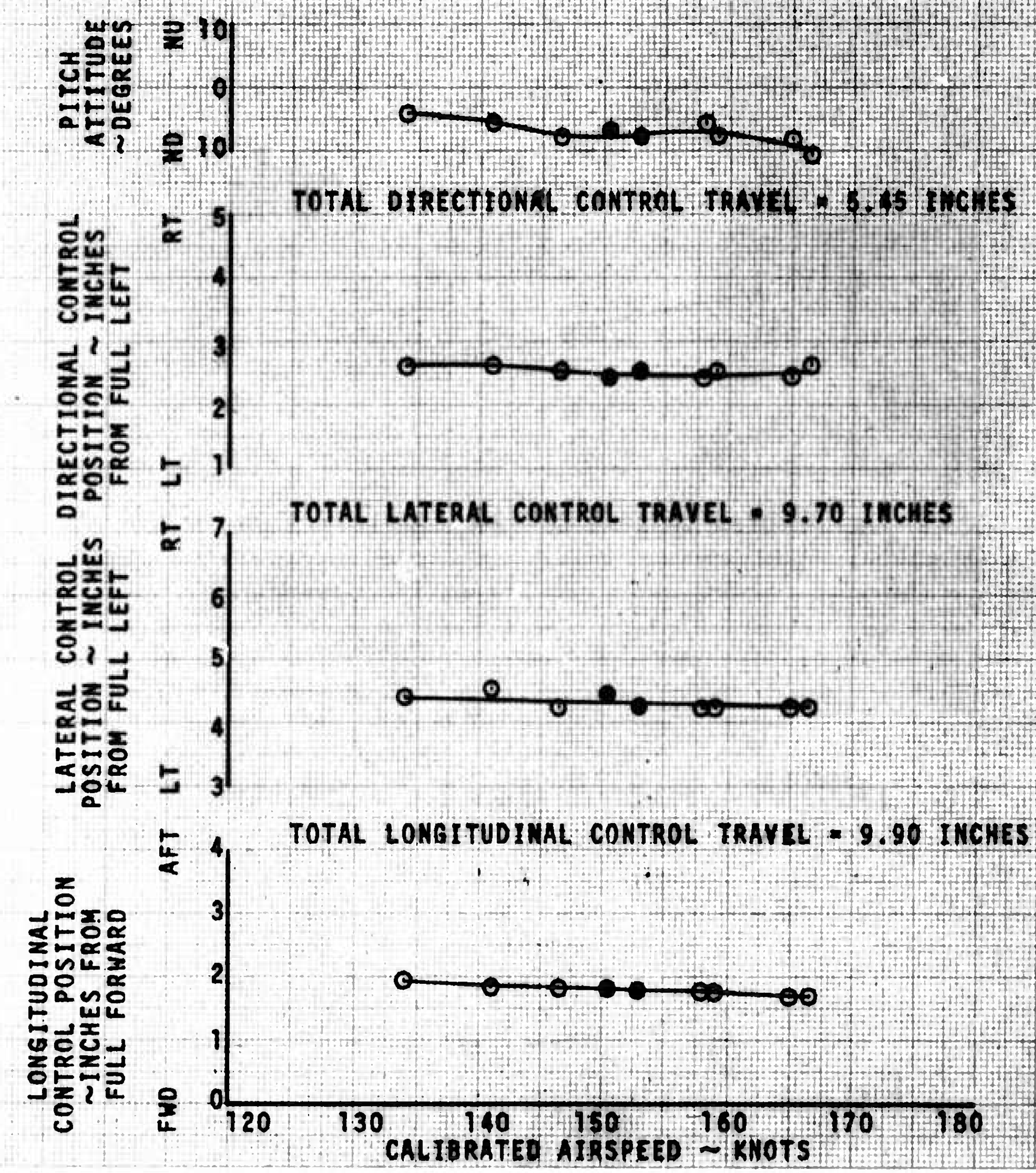


FIGURE [illegible]

STATIC LATERAL-DIRECTIONAL STABILITY

[illegible]

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	TRIM [illegible] ~KCAS	CONFIG	FLT COND
9920	192.1(FWD)	-0.1	4000	17	324	[illegible]	[illegible]	[illegible]	LEVEL FLT

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = [illegible] INCHES FROM FULL DOWN

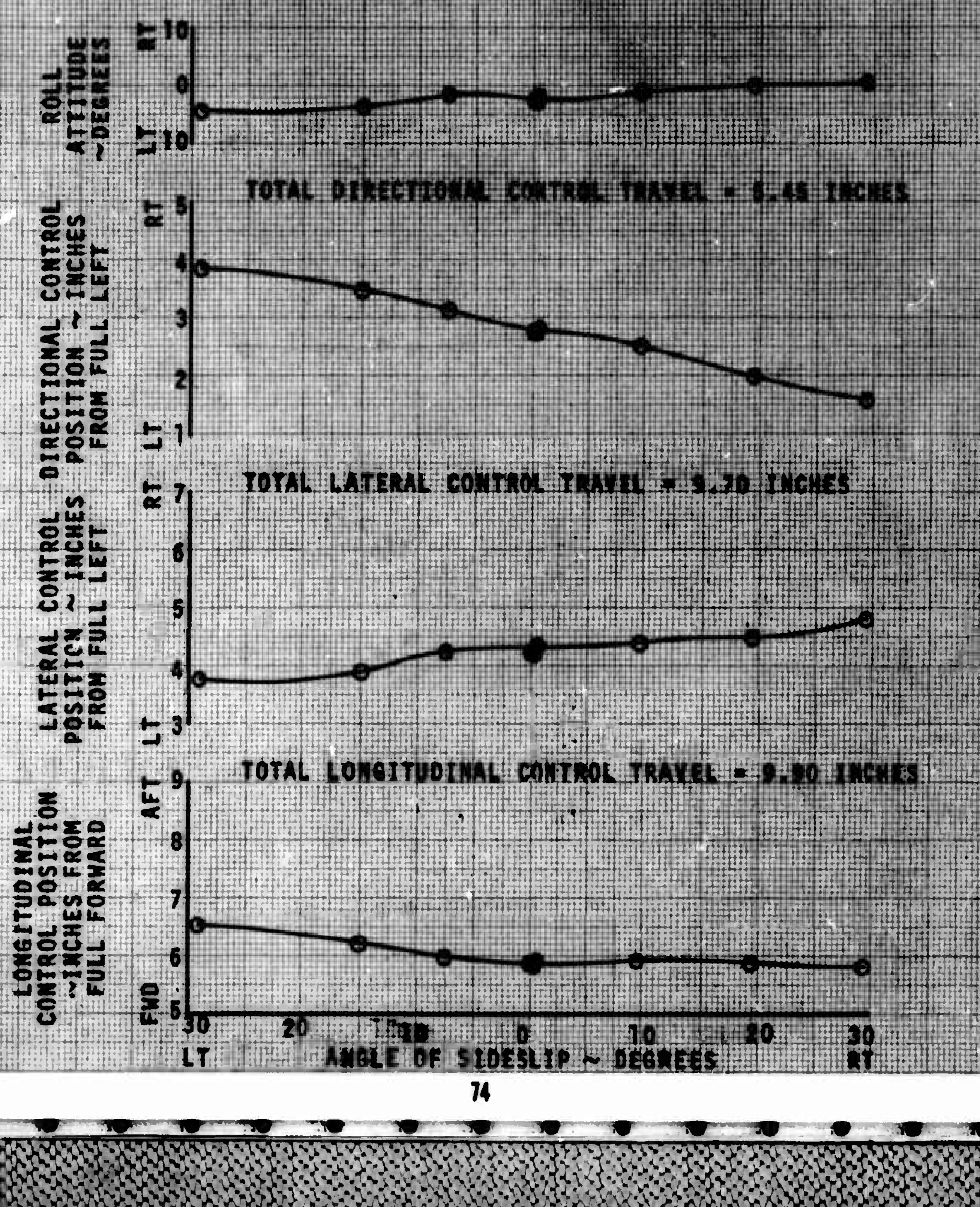


FIGURE 11
STATIC LATERAL DIRECTIONAL STABILITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $x10^4$	TRIM A/S ~KCAS	CONFIG	FLT COND
10,120	199.5(AFT)	-0.1	4900	10	324	58.15	43	HOG	LEVEL FLT

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = 2.6 INCHES FROM FULL DOWN

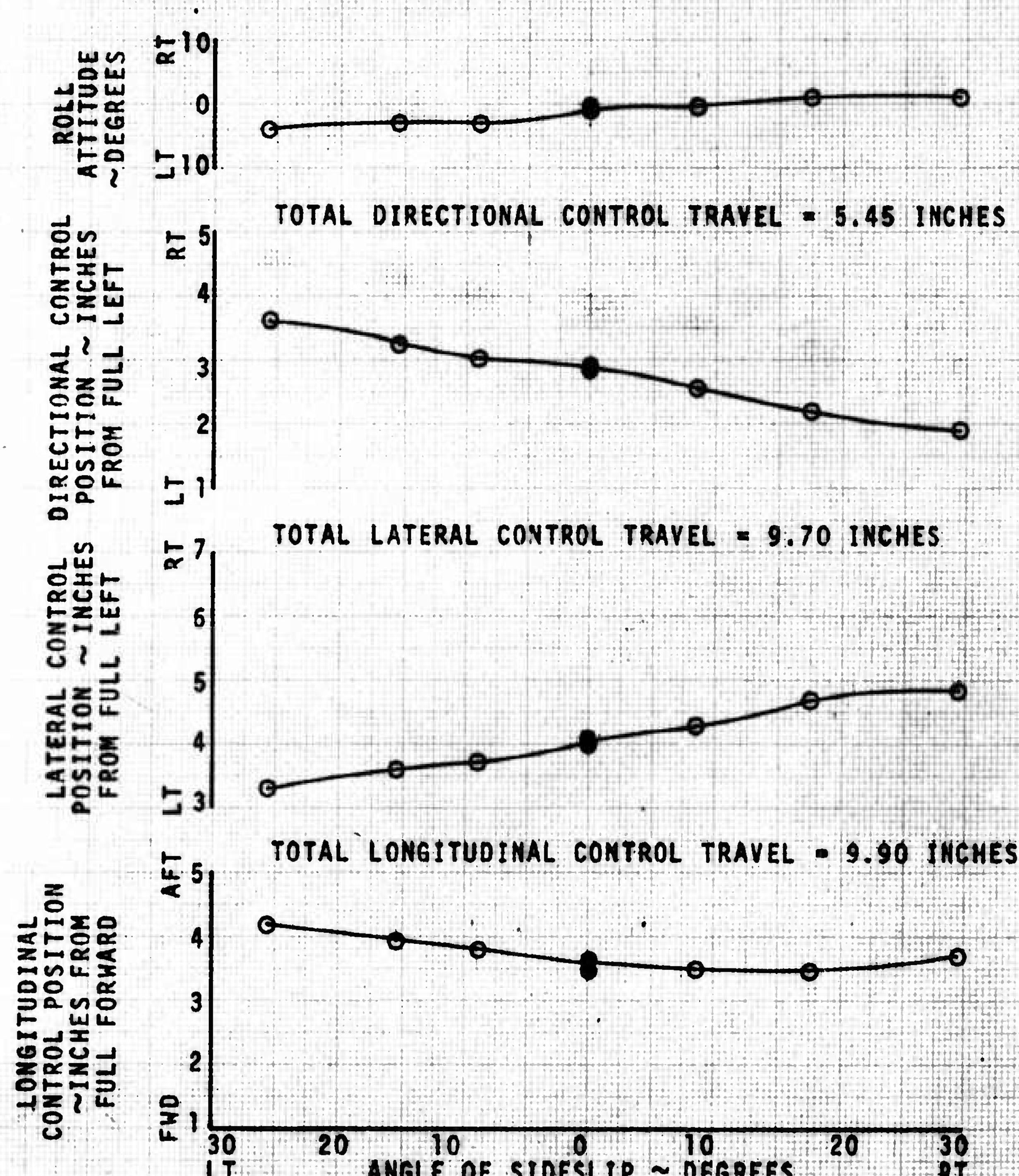


FIGURE 12
STATIC LATERAL DIRECTIONAL STABILITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	TRIM A/S ~KCAS	CONFIG	FLT COND
9960	199.4(AFT)	-0.1	5000	10	324	57.40	151	HOG	DIVE

NOTES: 1) SHADED SYMBOLS DENOTE TRIM
2) COLLECTIVE CONTROL POSITION = 3.2 INCHES FROM FULL DOWN

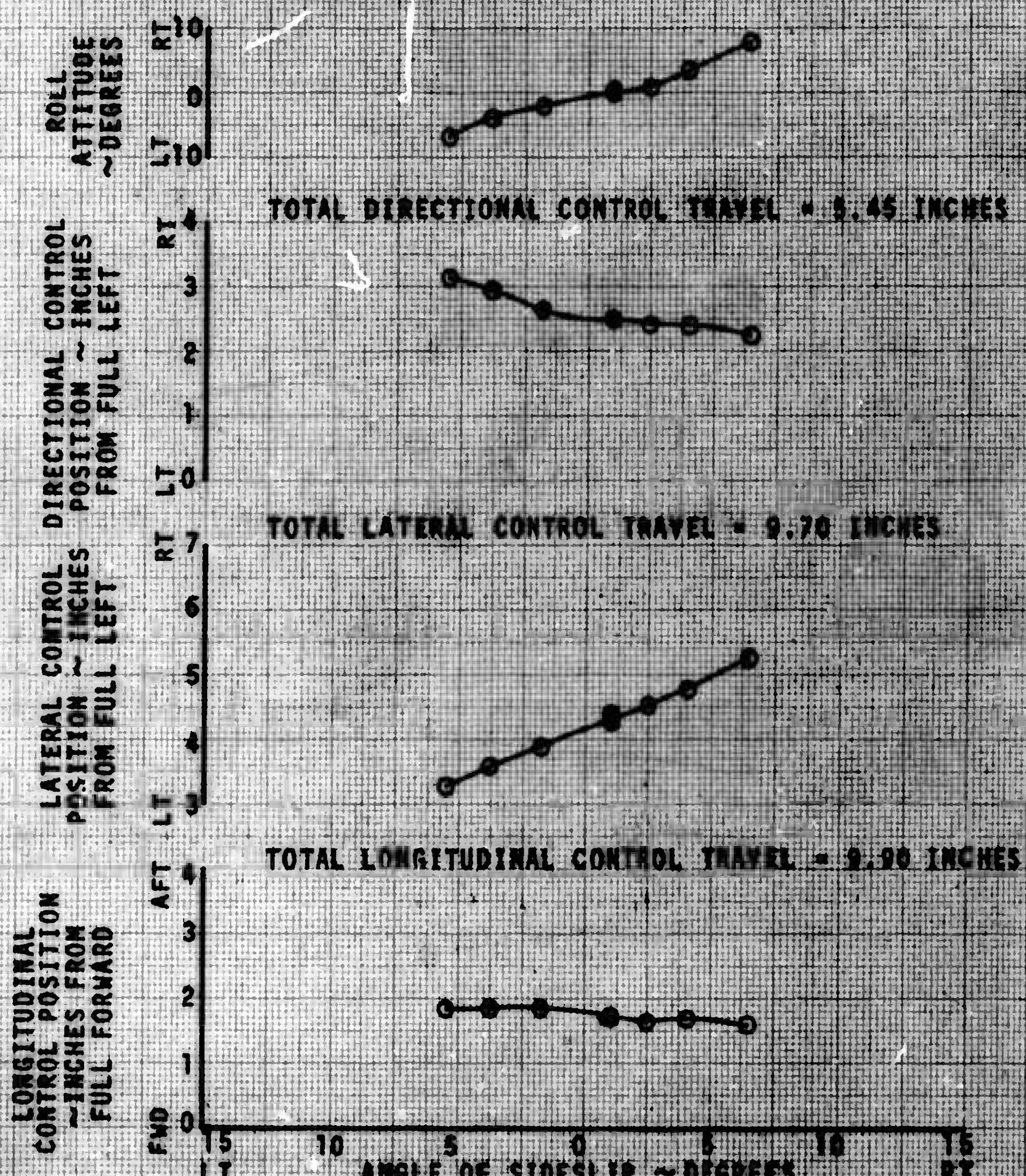


FIGURE 13
LEFT LATERAL PULSE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
10,030	199.5(AFT)	-0.1(LT)	5000	10	324	57.81	46	HOG	LEVEL FLIGHT

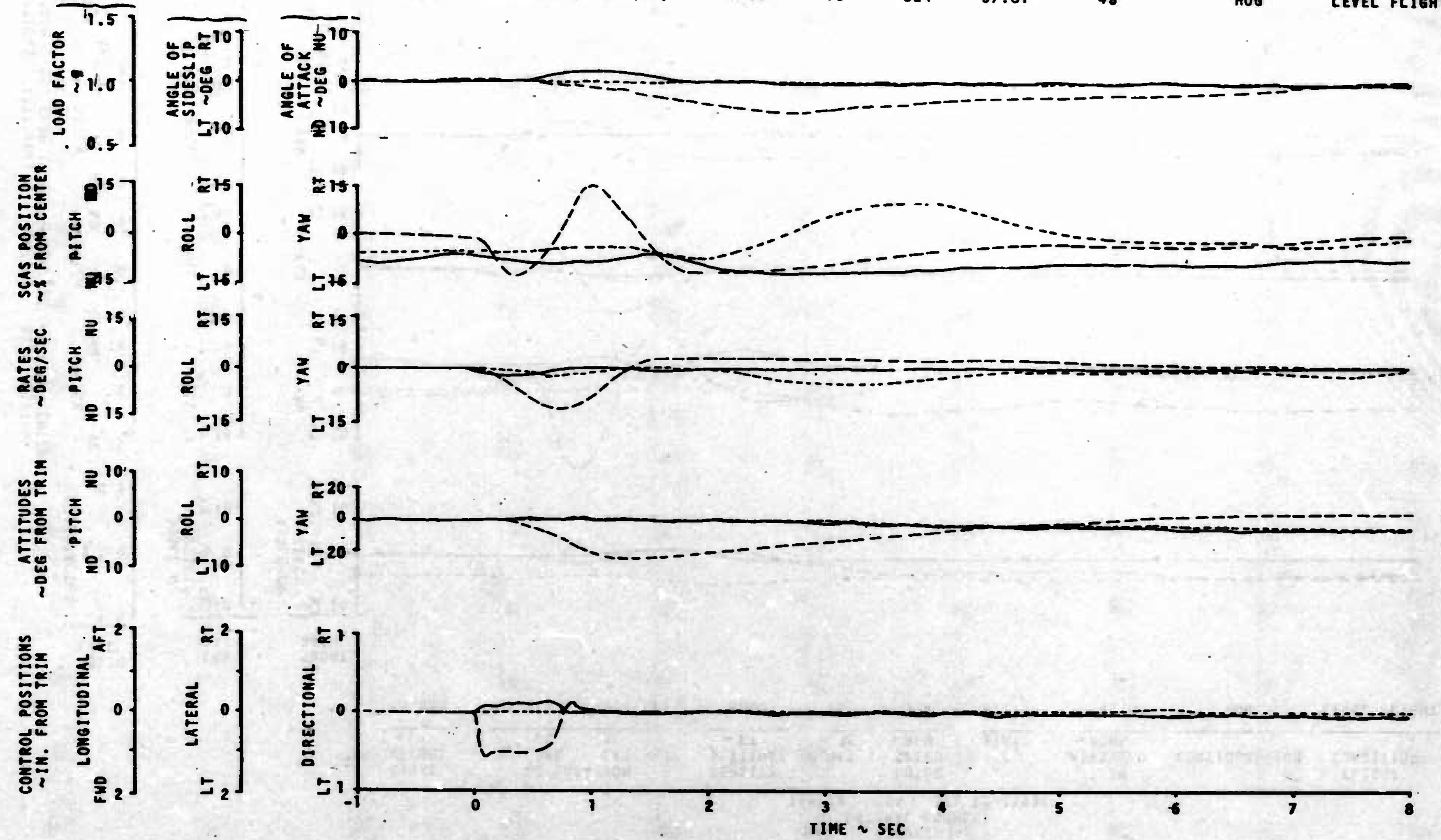


FIGURE 14
LATERAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
10,020	199.5(AFT)	-0.1(LT)	5000	10	324	57.75	45	HOG	LEVEL FLIGHT

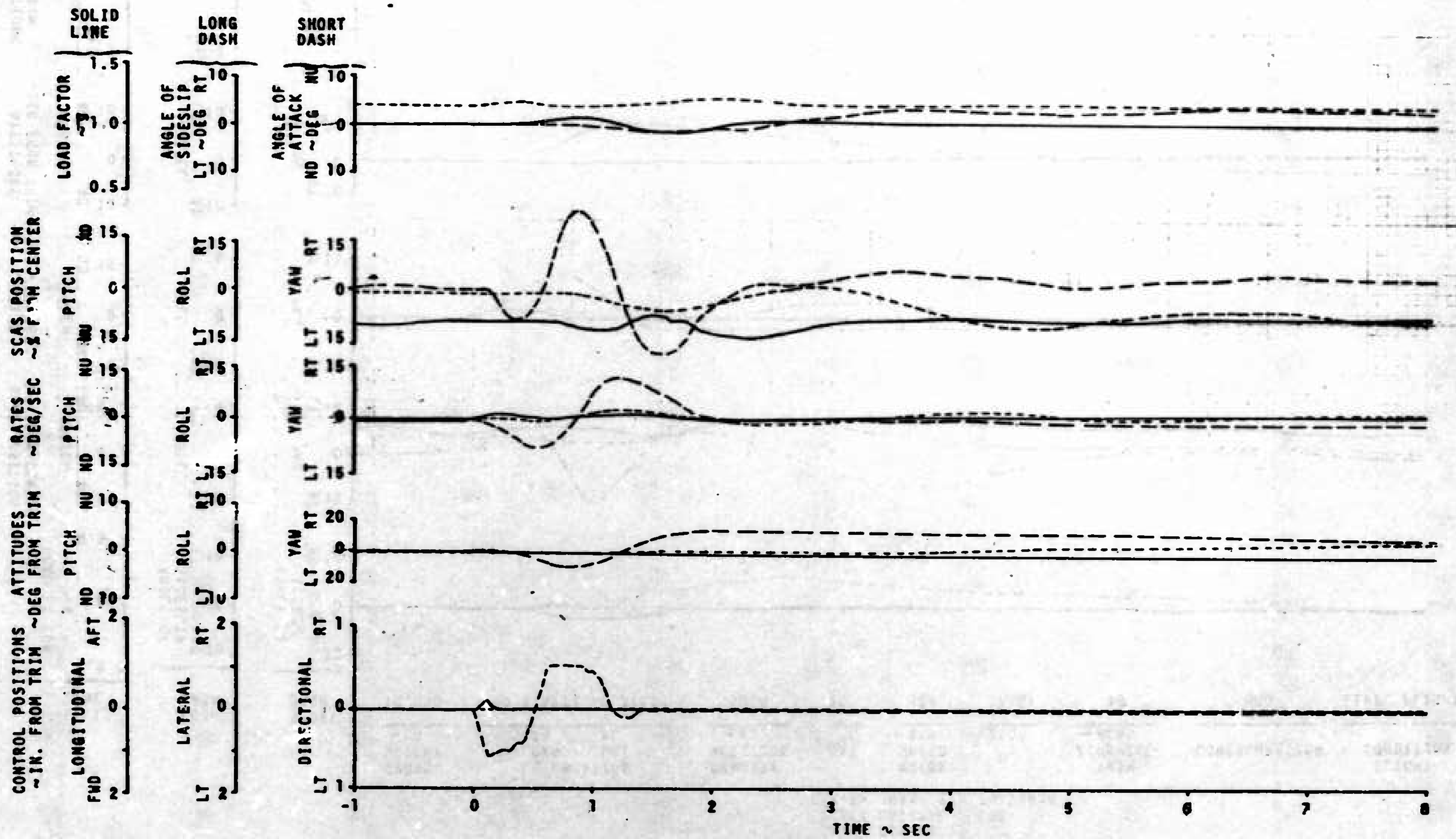


FIGURE 15
LEFT LATERAL PULSE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T $x10^4$	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9980	199.5(AFT)	-0.1(LT)	5000	10	324	57.52	45	HOG	LEVEL FLIGHT

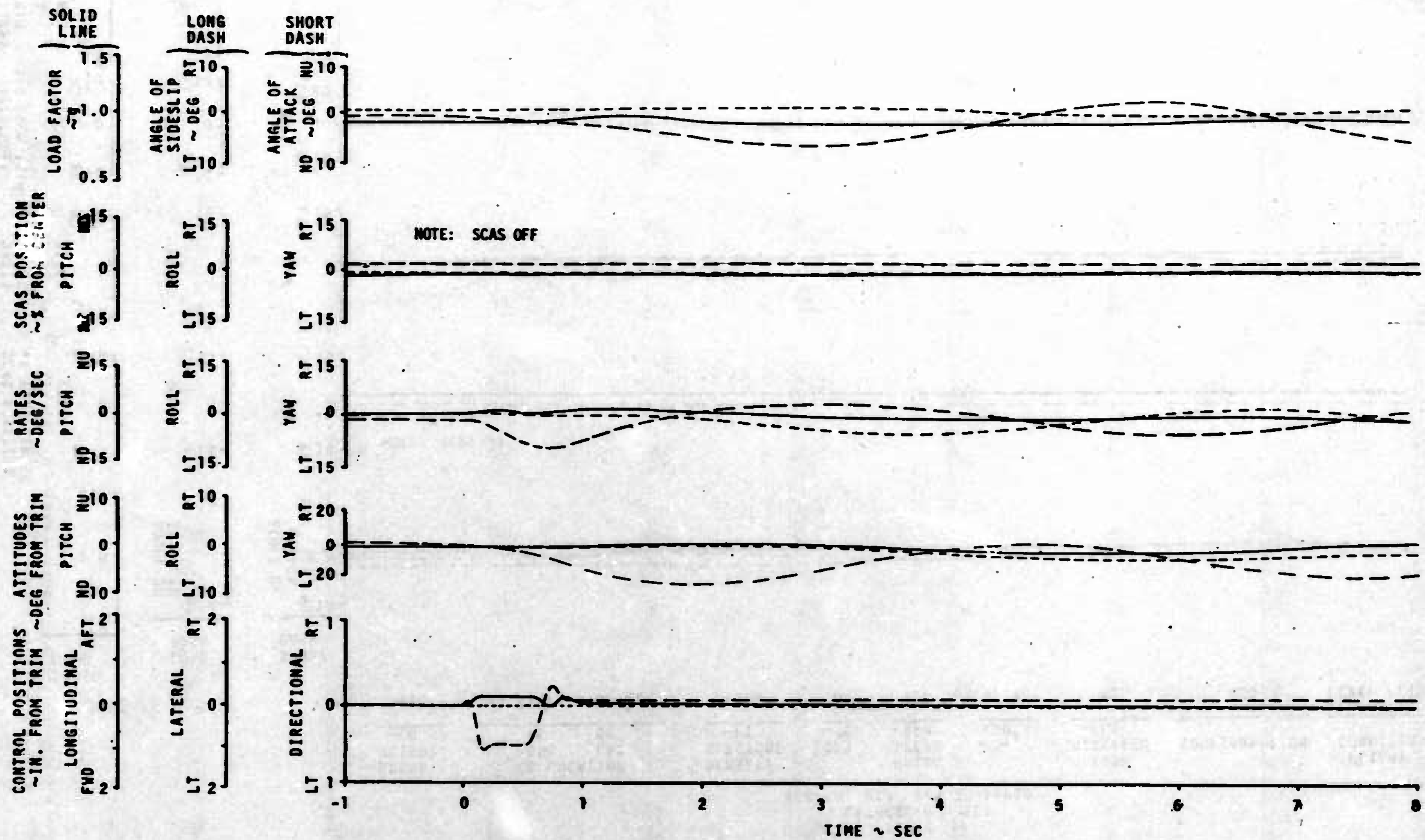


FIGURE 16
LATERAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9960	199.5(AFT)	-0.1(LT)	5000	10	324	57.40	45	HOG	LEVEL FLIGHT

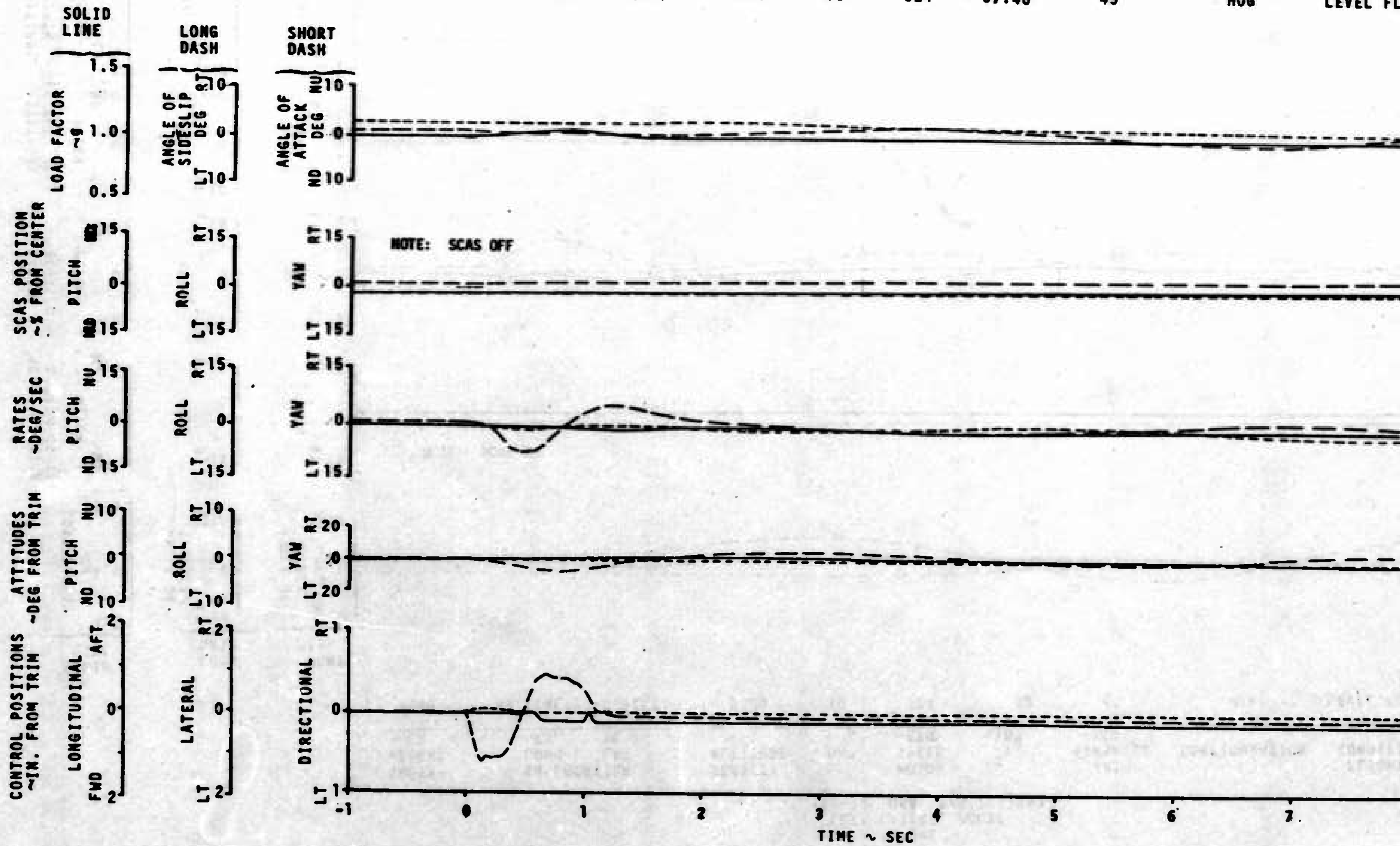


FIGURE 17
AFT LONGITUDINAL PULSE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9900	199.4(AFT)	-0.1(LT)	4700	10	324	56.54	45	HOG	LEVEL FLIGHT

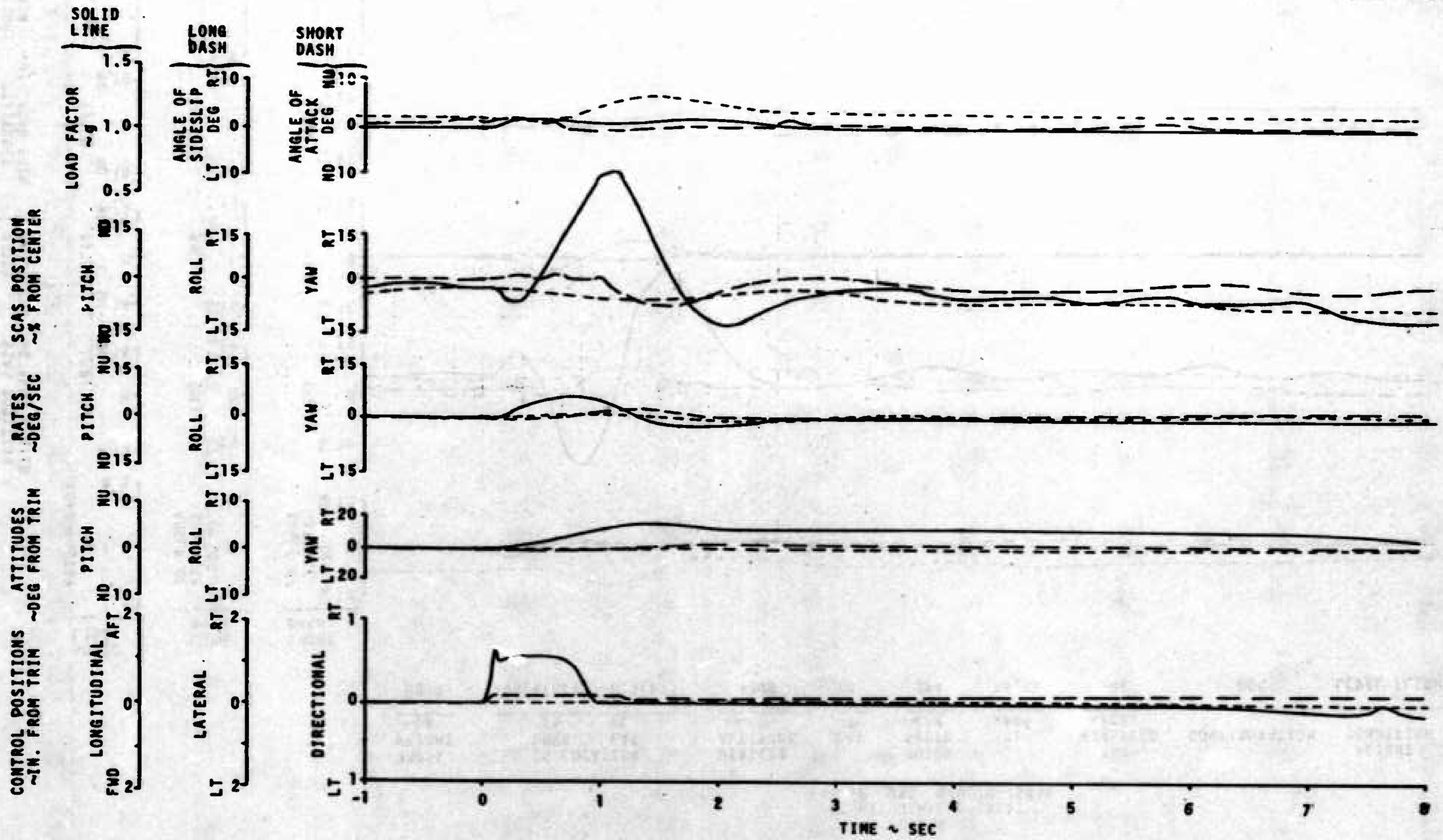


FIGURE 18
LONGITUDINAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10[4]	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9870	199.4(AFT)	-0.1(LT)	4700	10	324	56.37	45	HOG	LEVEL FLIGHT

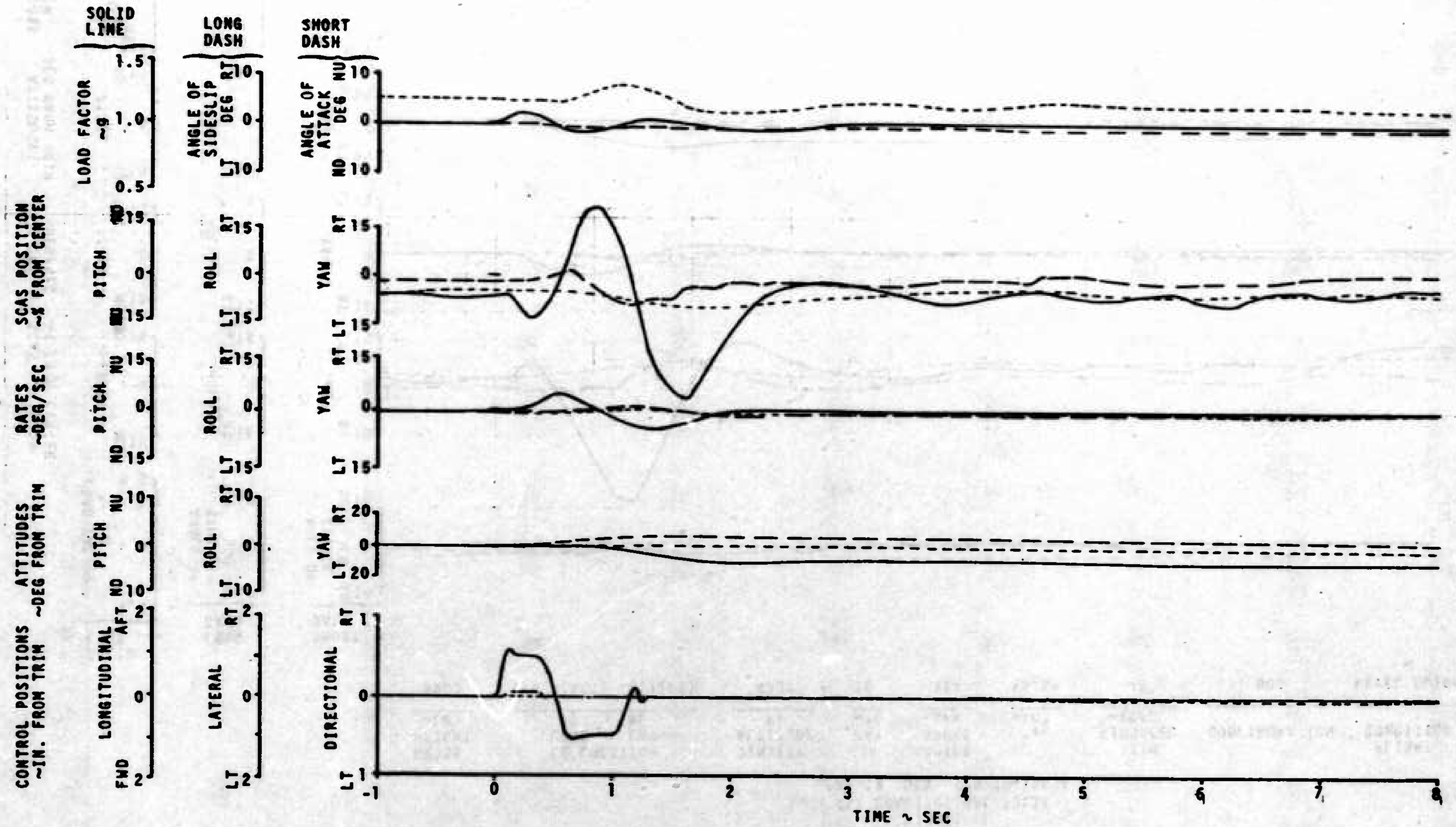


FIGURE 19
AFT LONGITUDINAL PULSE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9850	199.4(AFT)	-0.1(LT)	4700	10	324	56.26	45	HOG	LEVEL FLIGHT

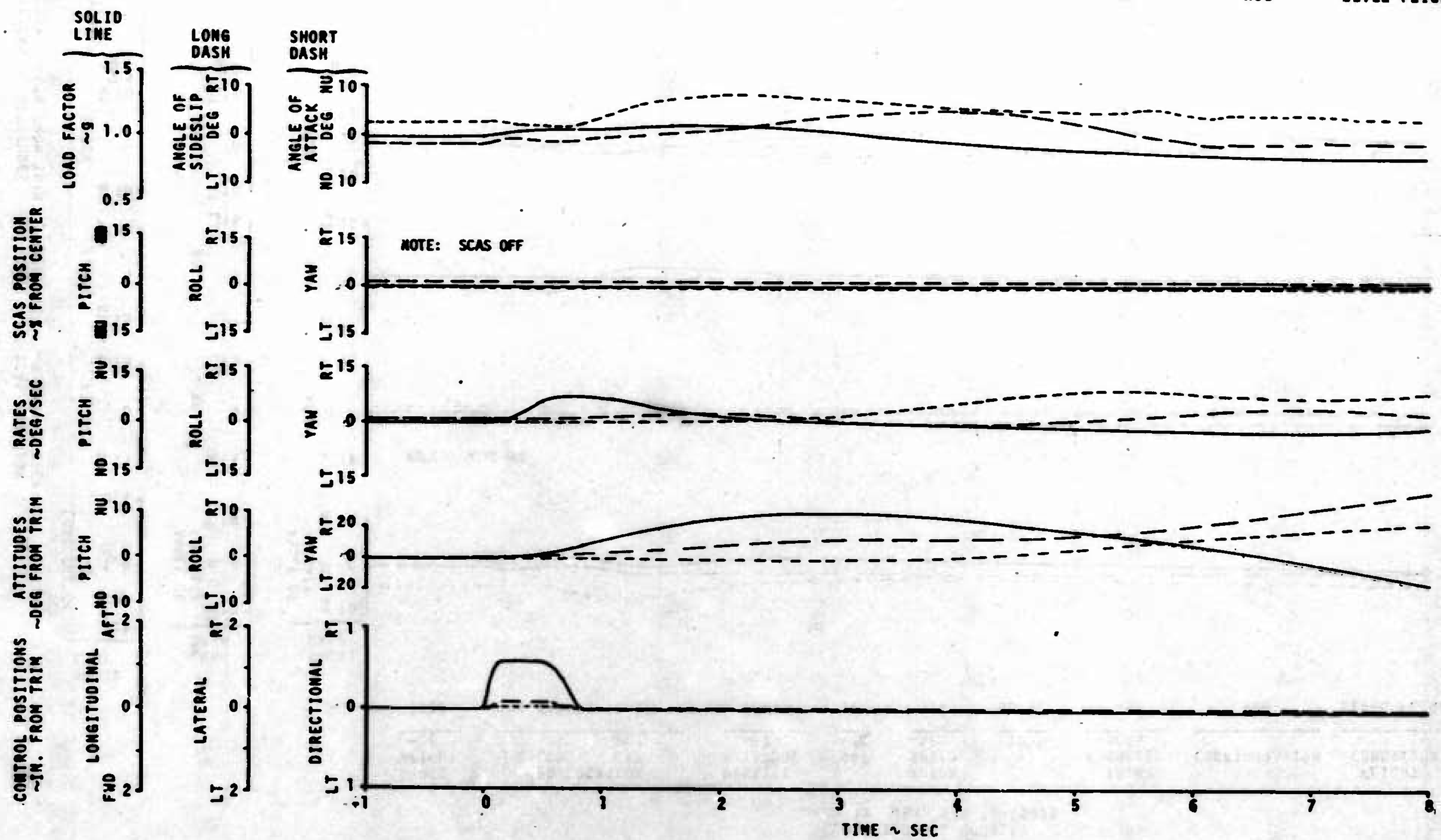


FIGURE 20
LONGITUDINAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9830	199.4(AFT)	-0.1(LT)	4700	10	324	56.14	45	HOG	LEVEL FLIGHT

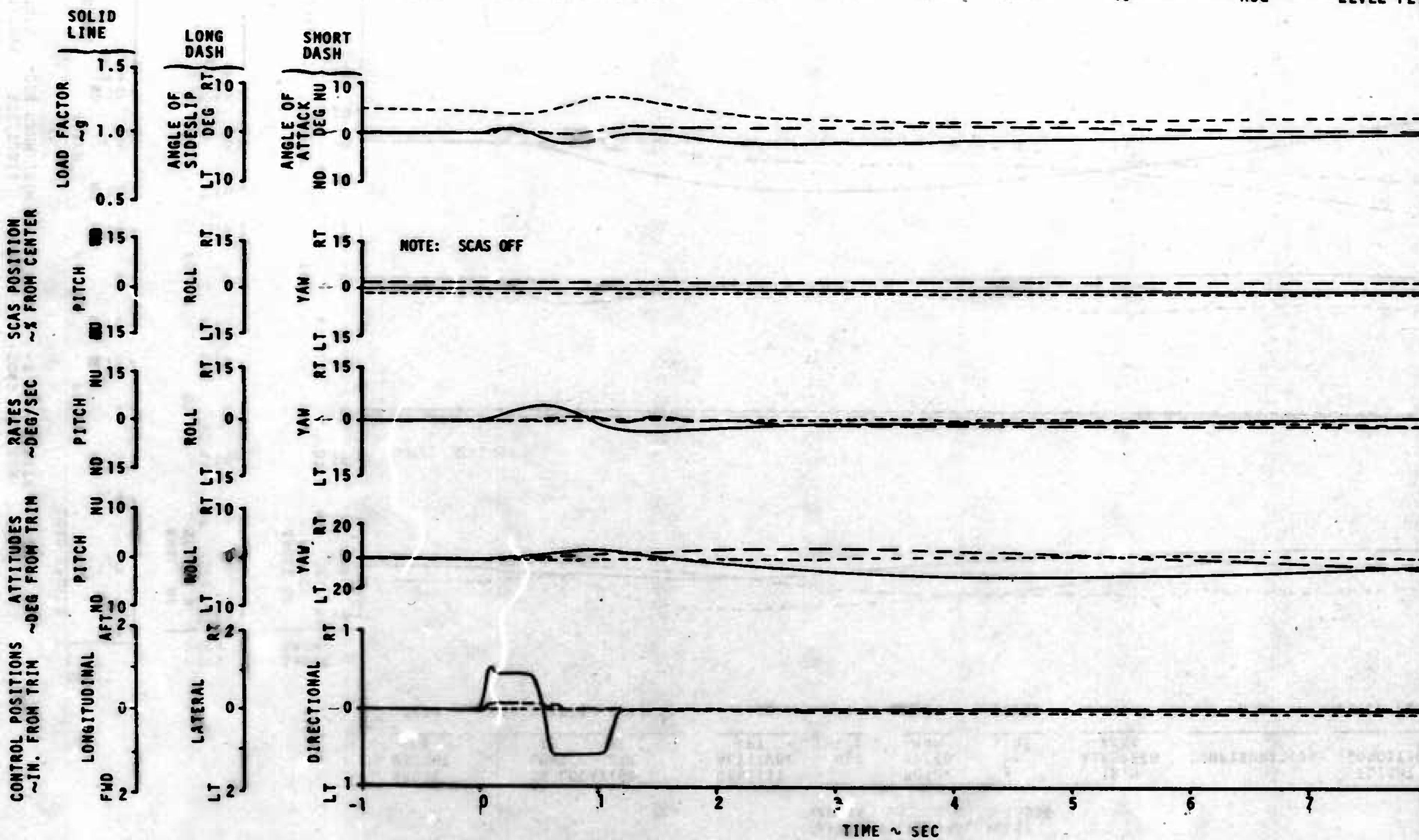


FIGURE 21
LEFT DIRECTIONAL PULSE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9780	199.3(AFT)	-0.1(LT)	4800	10	324	56.02	45	HOG	LEVEL FLIGHT

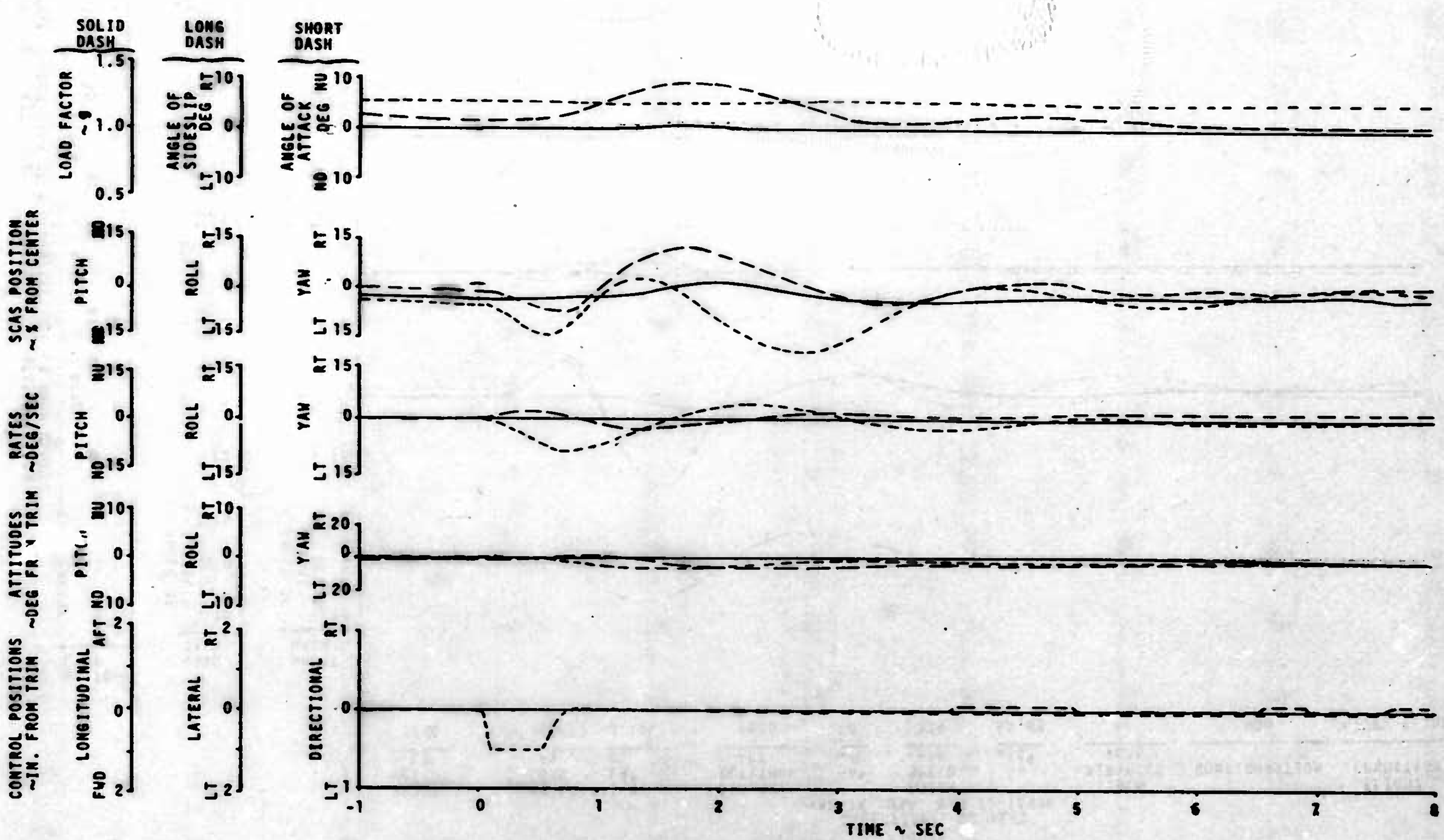


FIGURE 22
DIRECTIONAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10[4]	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9750	199.3(AFT)	-0.1(LT)	4800	10	324	55.85	45	HOG	LEVEL FLIGHT

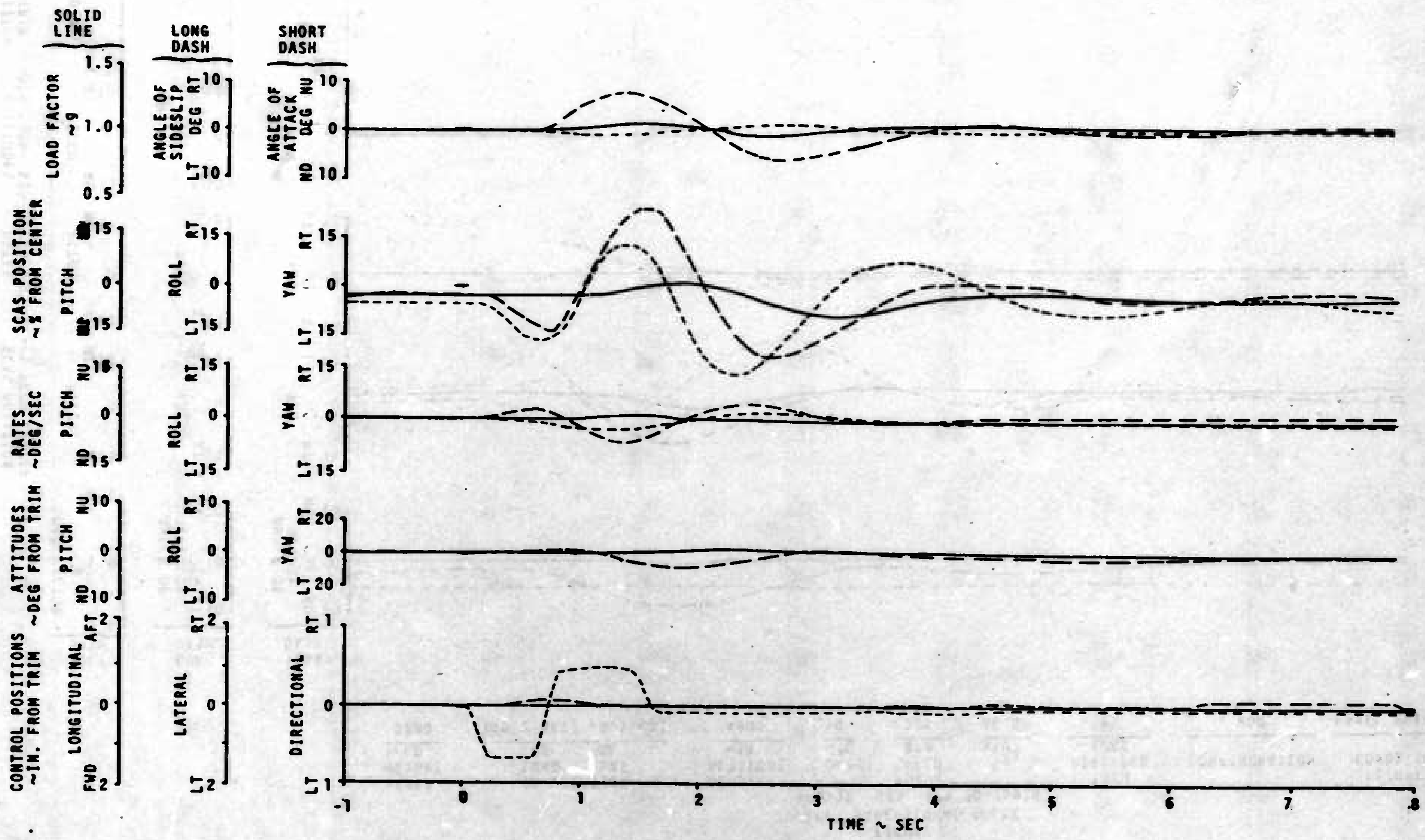


FIGURE 23
LEFT DIRECTIONAL PULSE
YAH-1R USA S/N 15936

GROSS WEIGHT ~ LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~ FT	OAT ~ °C	ROTOR SPEED ~ RPM	C_T x10^4	TRIM AIRSPEED ~ KCAS	CONFIGURATION	FLIGHT CONDITION
9720	199.3(AFT)	-0.1(LT)	4800	10	324	55.68	45	HOG	LEVEL FLIGHT

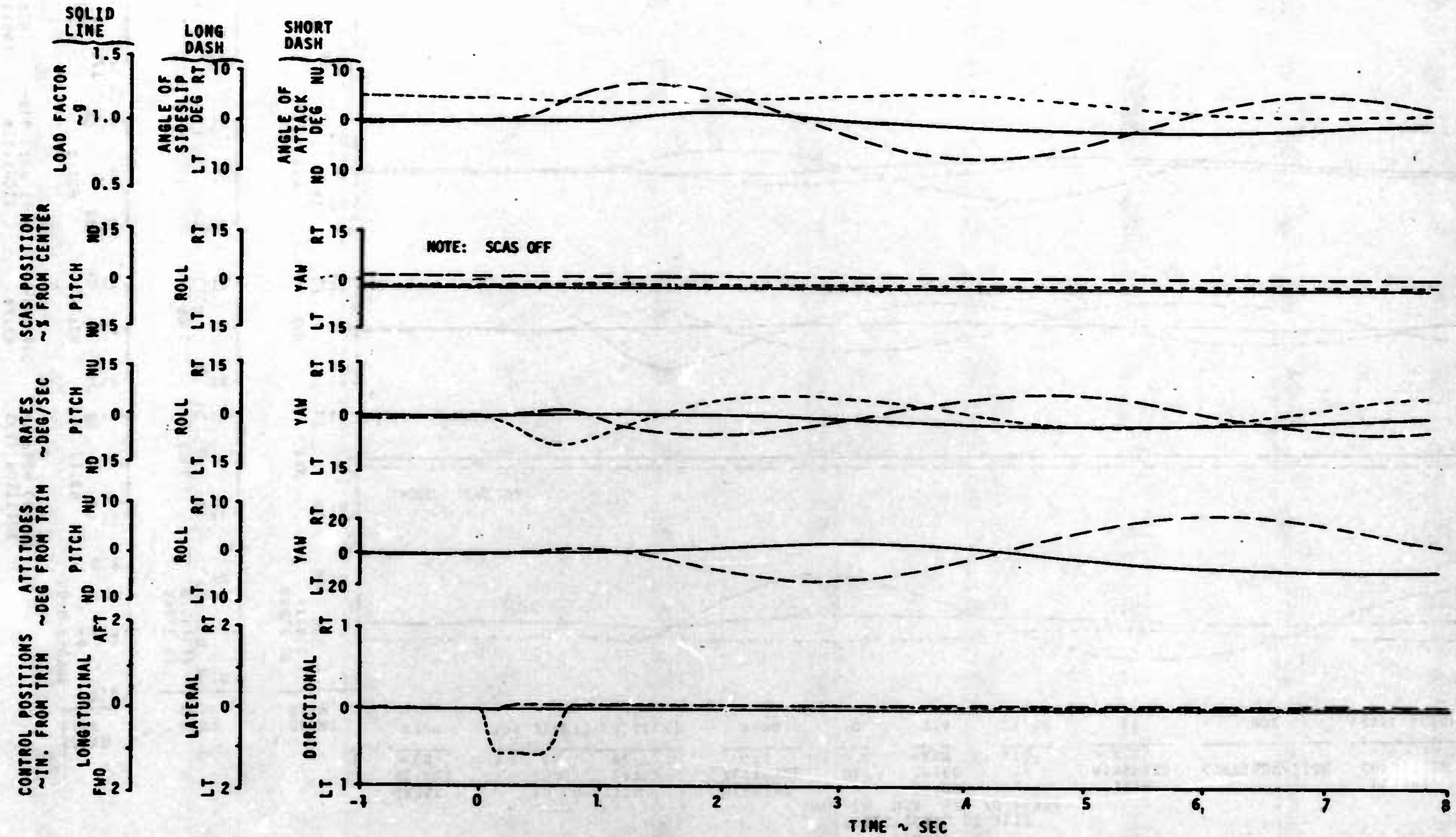


FIGURE 24
DIRECTIONAL DOUBLET
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9700	199.3(AFT)	-0.1(LT)	4800	10	324	55.56	45	HOG	LEVEL FLIGHT

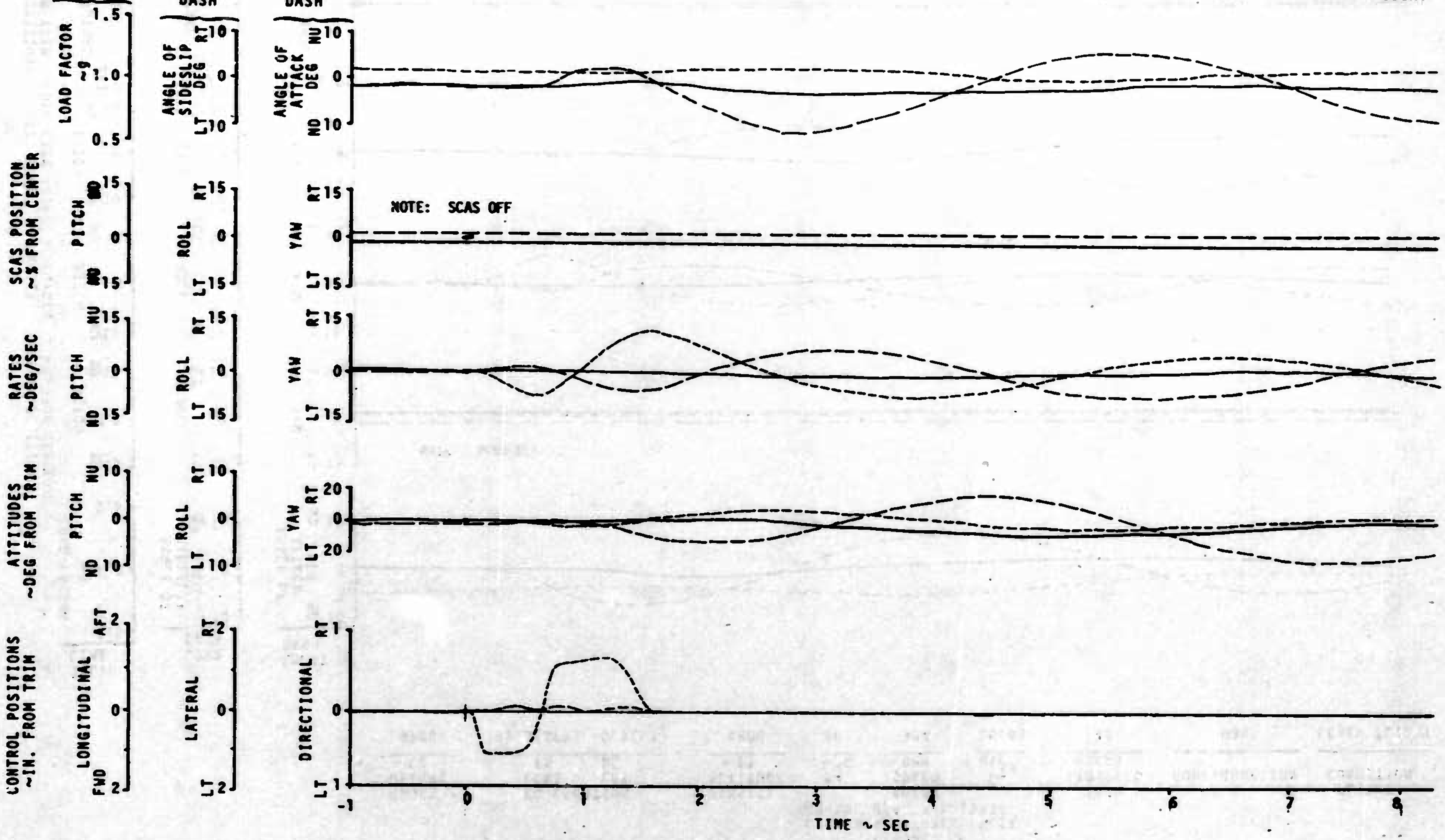


FIGURE 25
MANEUVERING STABILITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T x10^4	TRIM A/S ~KCAS	CONFIG	FLT COND
9810	199.3(AFT)	-0.1	5000	17	324	56.54	60	HOG	STEADY TURNS

NOTE:
1) SOLID SYMBOLS DENOTE TRIM POINT
2) FLAGGED SYMBOLS DENOTE LEFT TURN
3) TRIM POWER = 1160 SHP
4) SCAS ON
5) FORCE CALCULATED FROM FIGURE 2

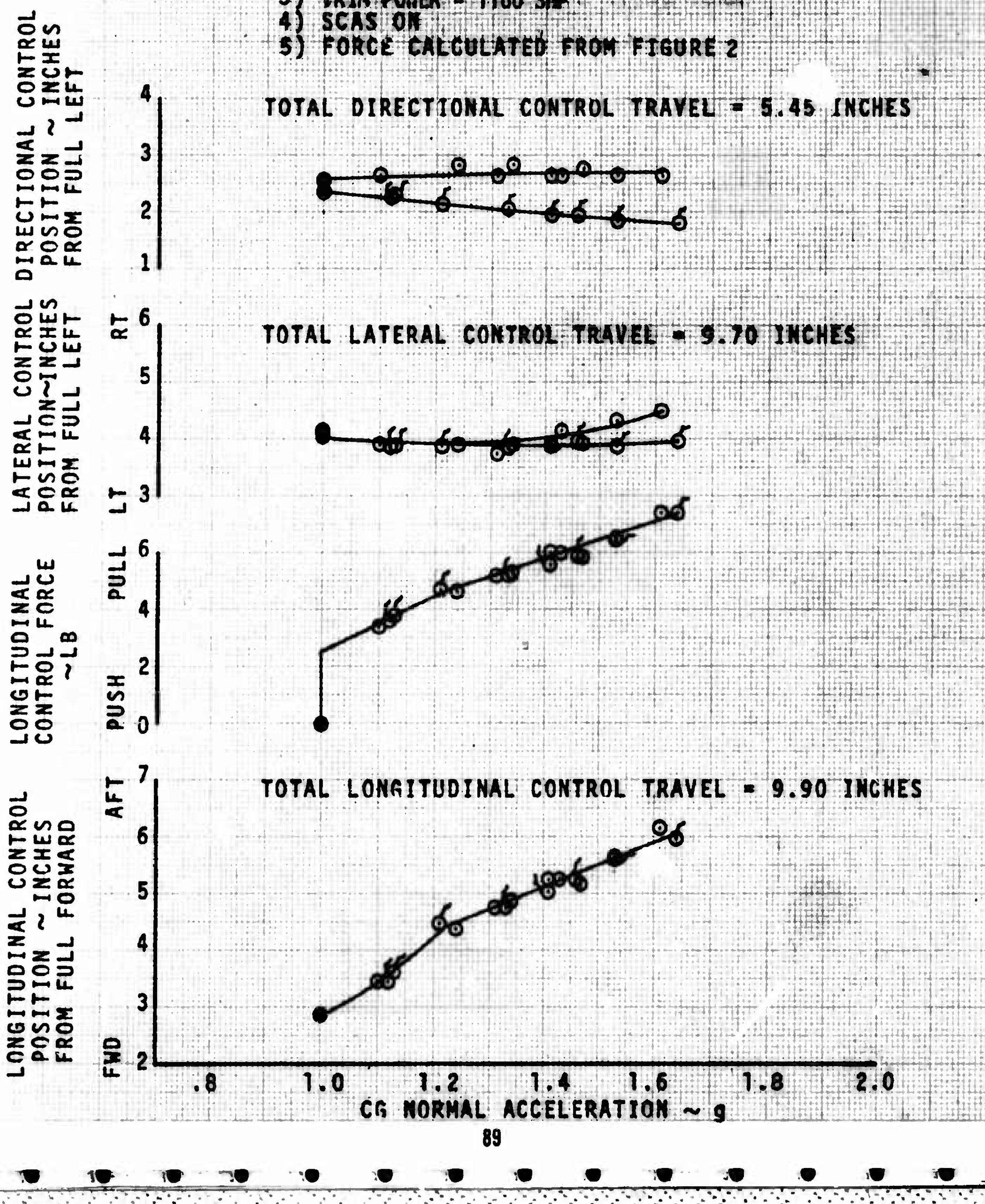


FIGURE 26
MANEUVERING STABILITY
YAH-1R USA S/N 70-15936

SYM	AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T x10^4	TRIM A/S ~KCAS	CONFIG	FLT COND
△	10,010	199.4(AFT)	-0.1	5000	18	324	57.69	124	HOG	STEADY TURNS
⊙	9870	199.4(AFT)	-0.1	5000	18	324	56.89	120	HOG	STEADY TURNS

NOTE:
1) SOLID SYMBOLS DENOTE TRIM POINT
2) FLAGGED SYMBOLS DENOTE LEFT TURN
3) TRIM POWER = 1110 SHP
4) SCAS ON
5) FORCE CALCULATED FROM FIGURE 2

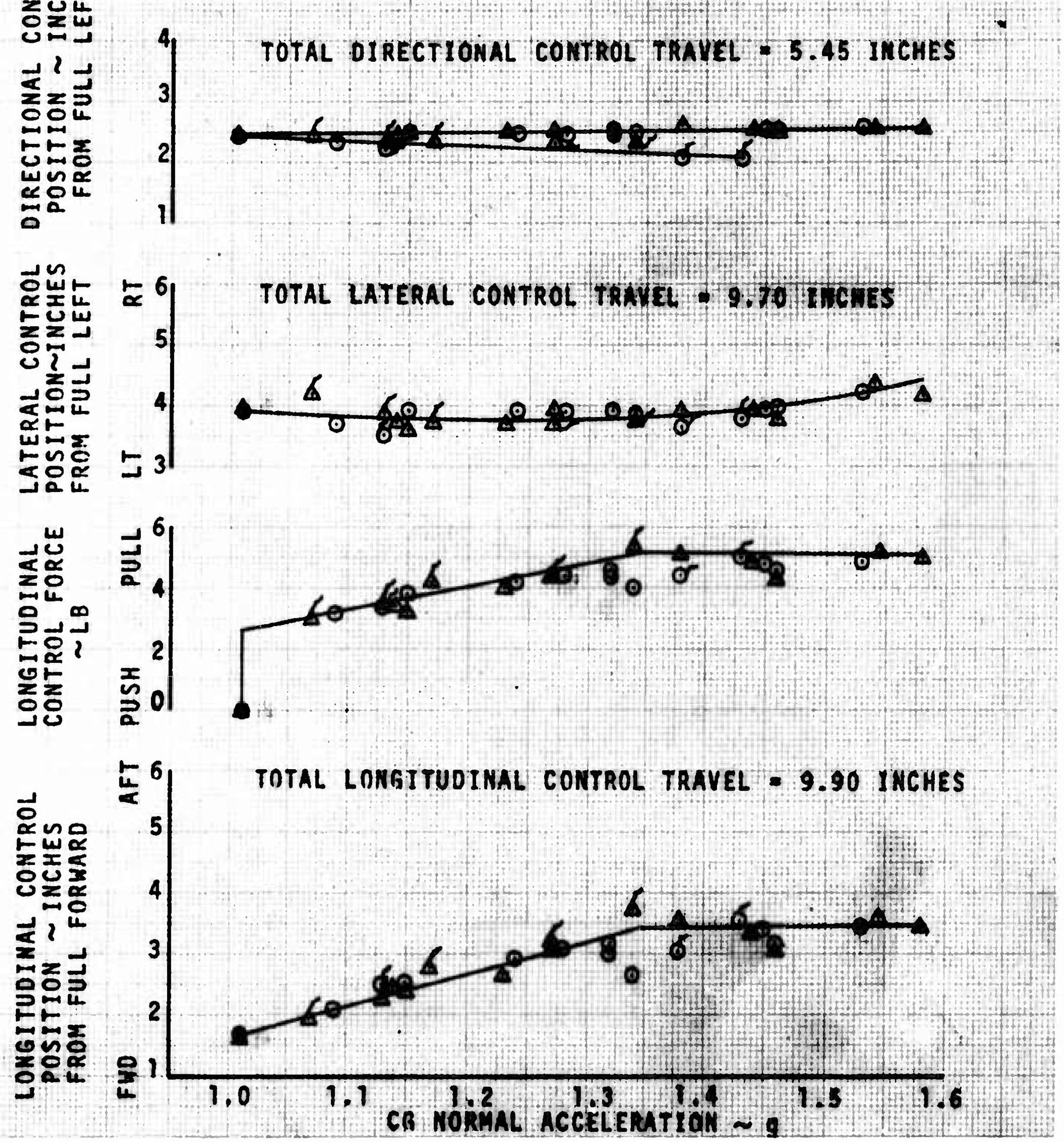
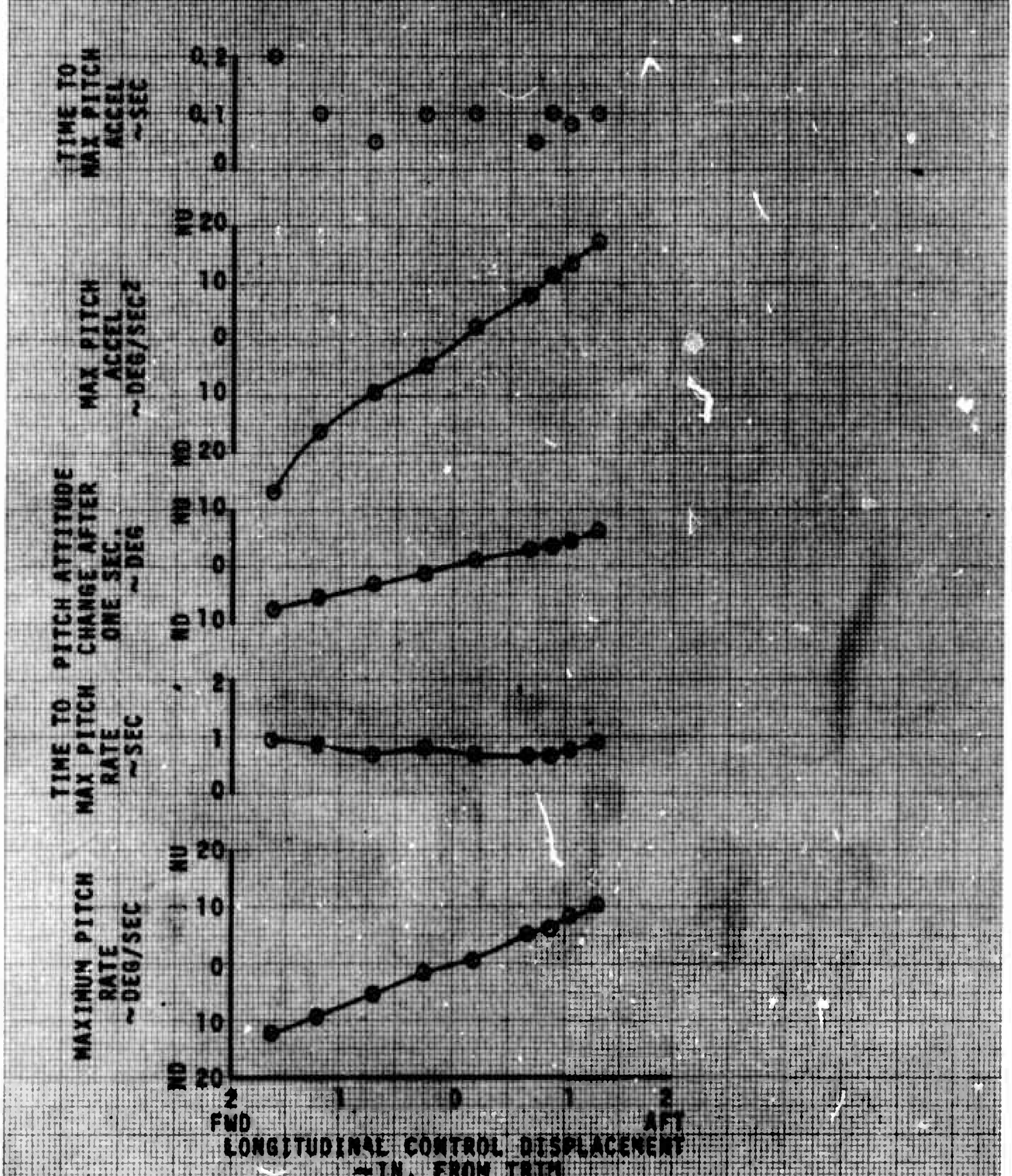


FIGURE [illegible]
LONGITUDINAL CONTROL RESPONSE AND SENSITIVITY
YAH-1R USA S/N [illegible]

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	TRIM A/S ~KCAS	SKID HEIGHT ~FT	DAMPER
9600	191.8(FWD)	-0.1	780	13	324	48.56	HOVER	208	[illegible]



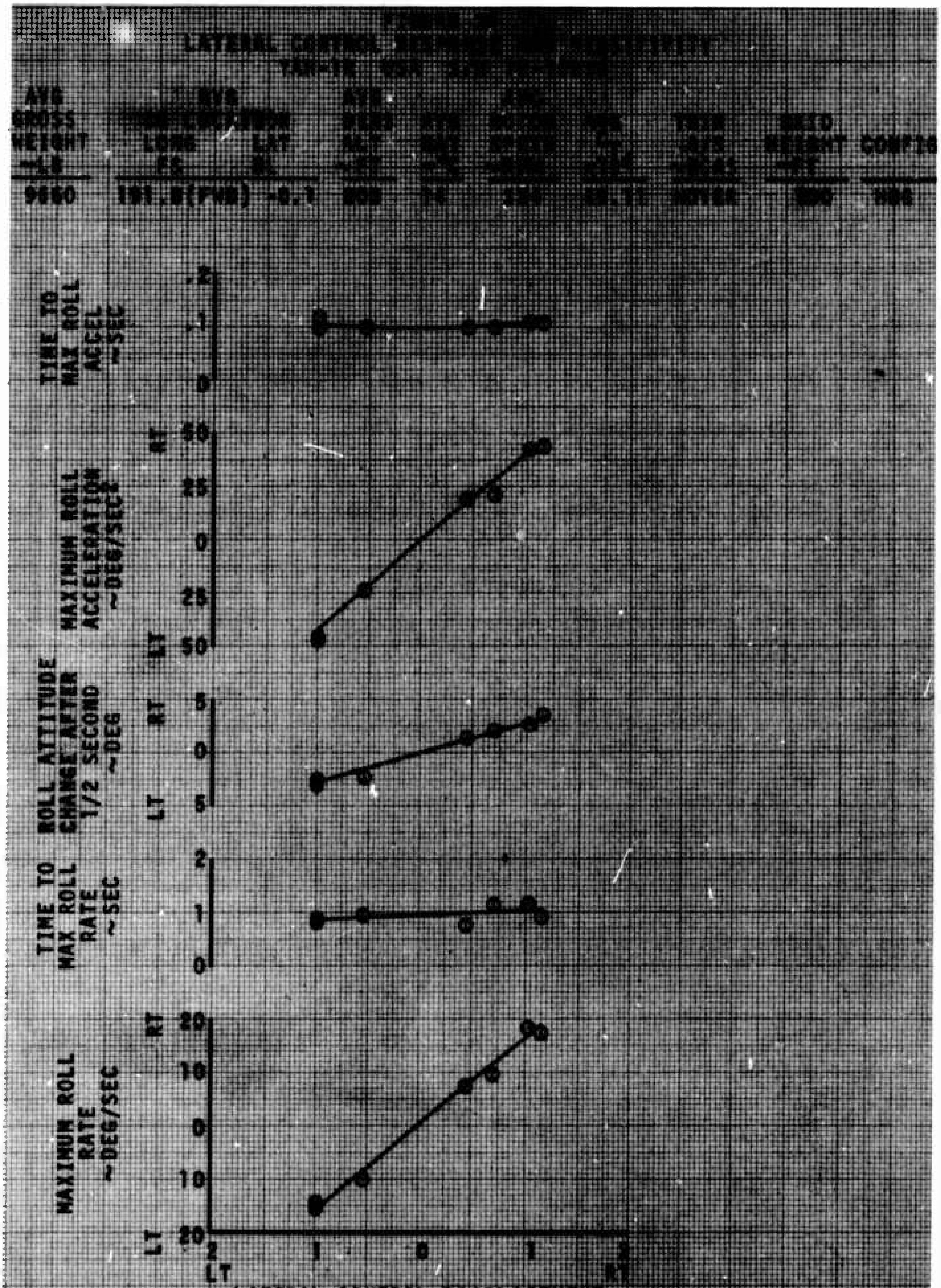

AVG
GROSS
WEIGHT
~LB
LONG
LAT
FS
BL
CONFIG
9860
TIME TO
MAX ROLL
ACCEL
~SEC
MAXIMUM ROLL
ACCELERATION
~DEG/SEC
ROLL ATTITUDE
CHANGE AFTER
1/2 SECOND
~DEG
TIME TO
MAX ROLL
RATE
~SEC
MAXIMUM ROLL
RATE
~DEG/SEC
RT
LT
LATERAL CONTROL DISPLACEMENT
~IN. FROM TRIM

FIGURE 29
DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENS ALT ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $x10^4$	TRIM A/S ~KCAS	SKID HEIGHT ~FT	CONFIG
9440	191.6(FWD)	-0.1	600	15	324	47.71	HOVER	10	HOG

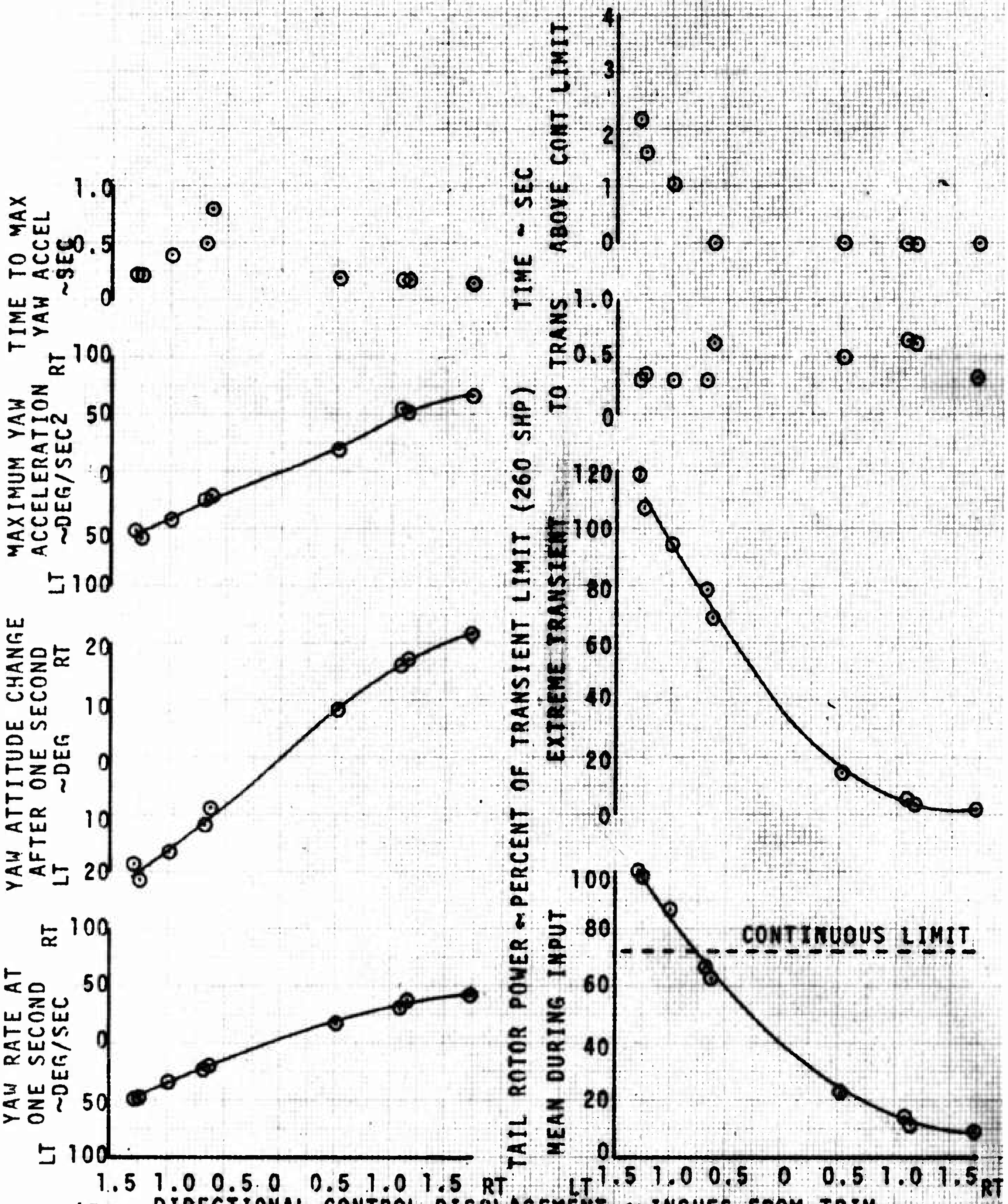


FIGURE 30
FORWARD LONGITUDINAL STEP
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED RPM	C_T x10^4	SKID HEIGHT ~ FT	CONFIGURATION	FLIGHT CONDITION
9600	131.7(FWD)	-0.1(LT)	700	13	324	48.31	200(OGE)	HOG	HOVER

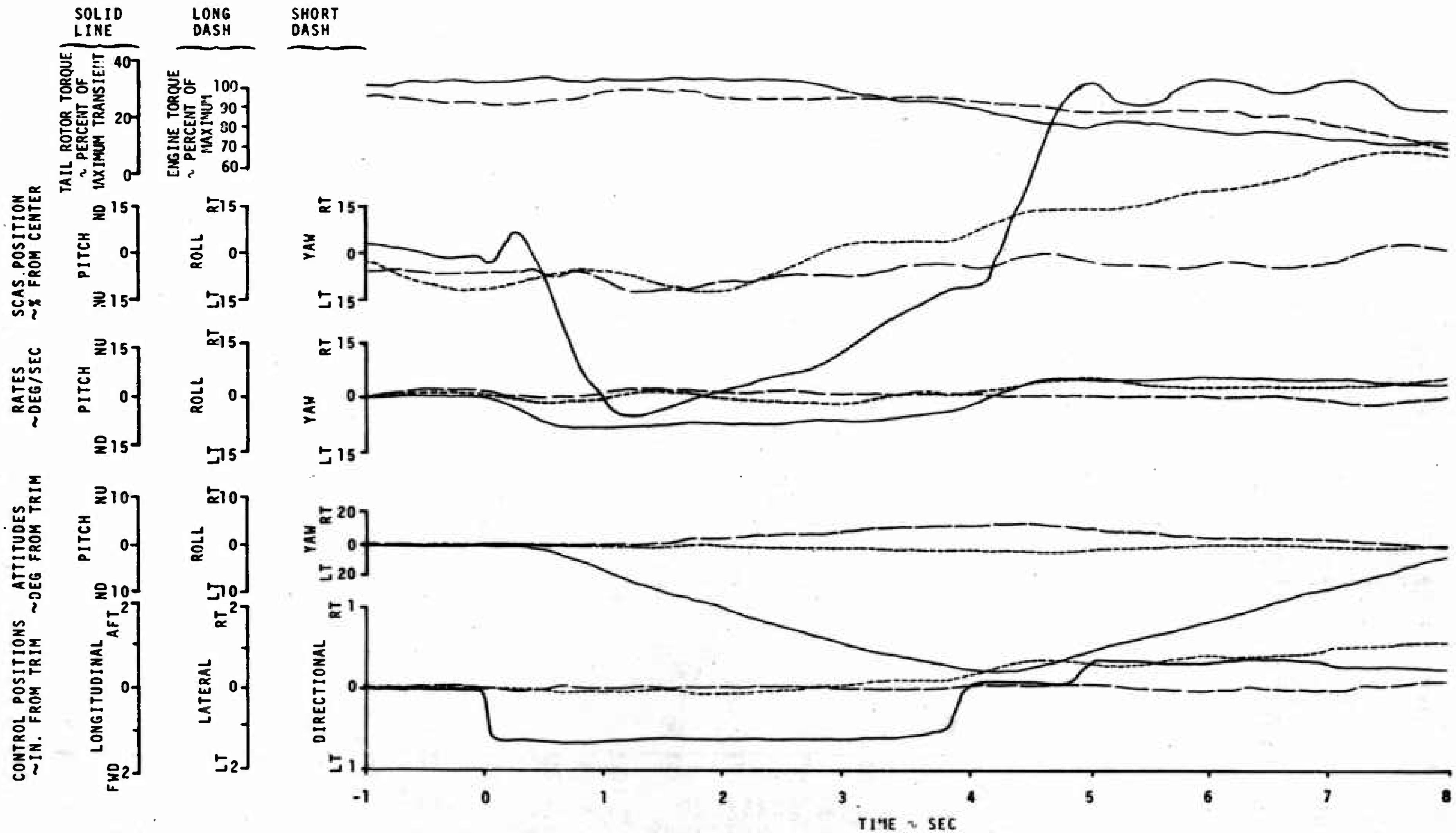


FIGURE 31
LEFT LATERAL STEP
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10⁴	SKID HEIGHT ~ FT	CONFIGURATION	FLIGHT CONDITION
9600	191.7(FWD)	-0.1(LT)	800	14	324	48.31	200(OGE)	HOG	HOVER

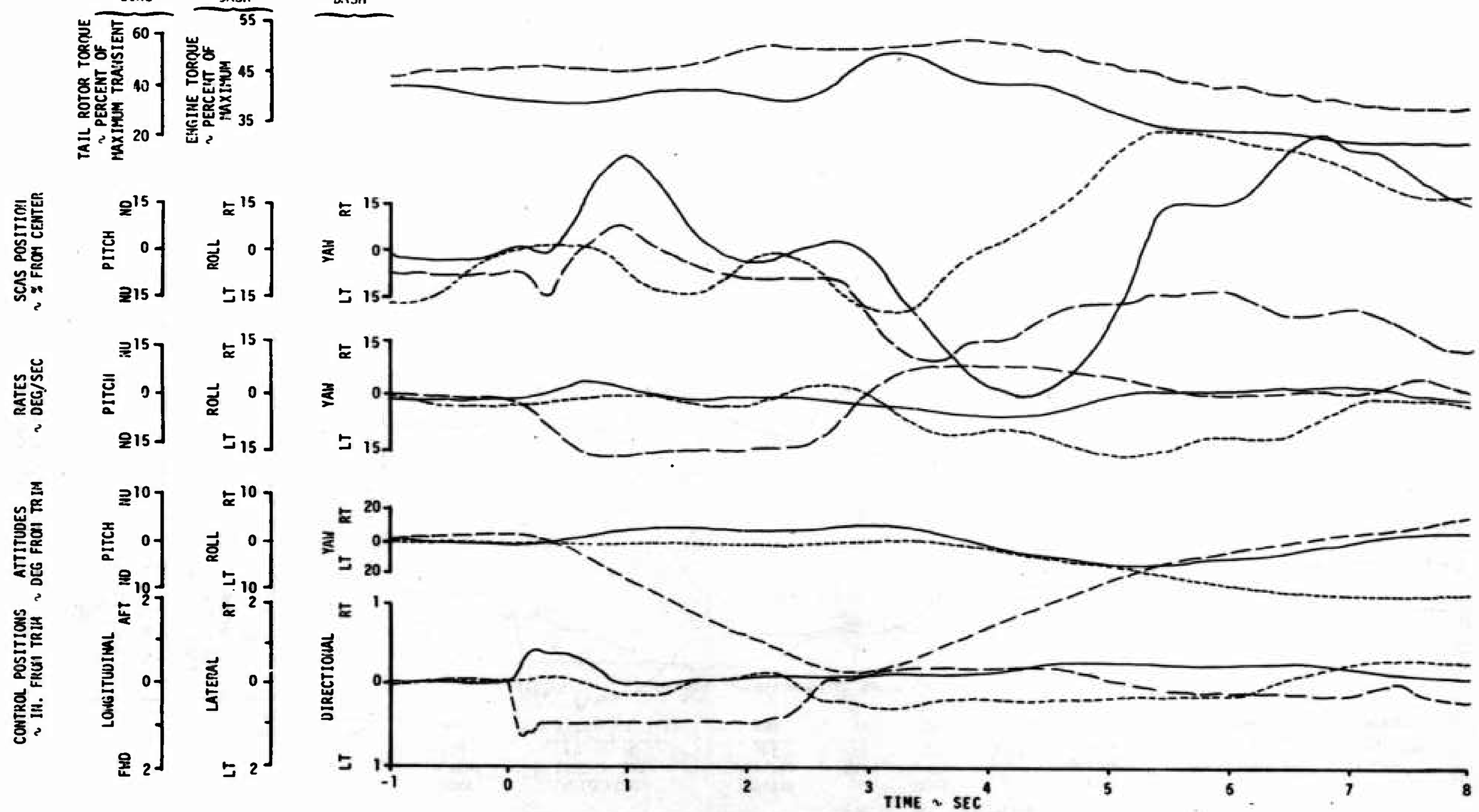


FIGURE 32
LEFT DIRECTIONAL STEP
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T $\times 10^4$	SKID HEIGHT ~FT	CONFIGURATION	FLIGHT CONDITION
9570	131.7(FWD)	-0.1(LT)	800	14	324	48.66	10(IGE)	HOG	HOVER

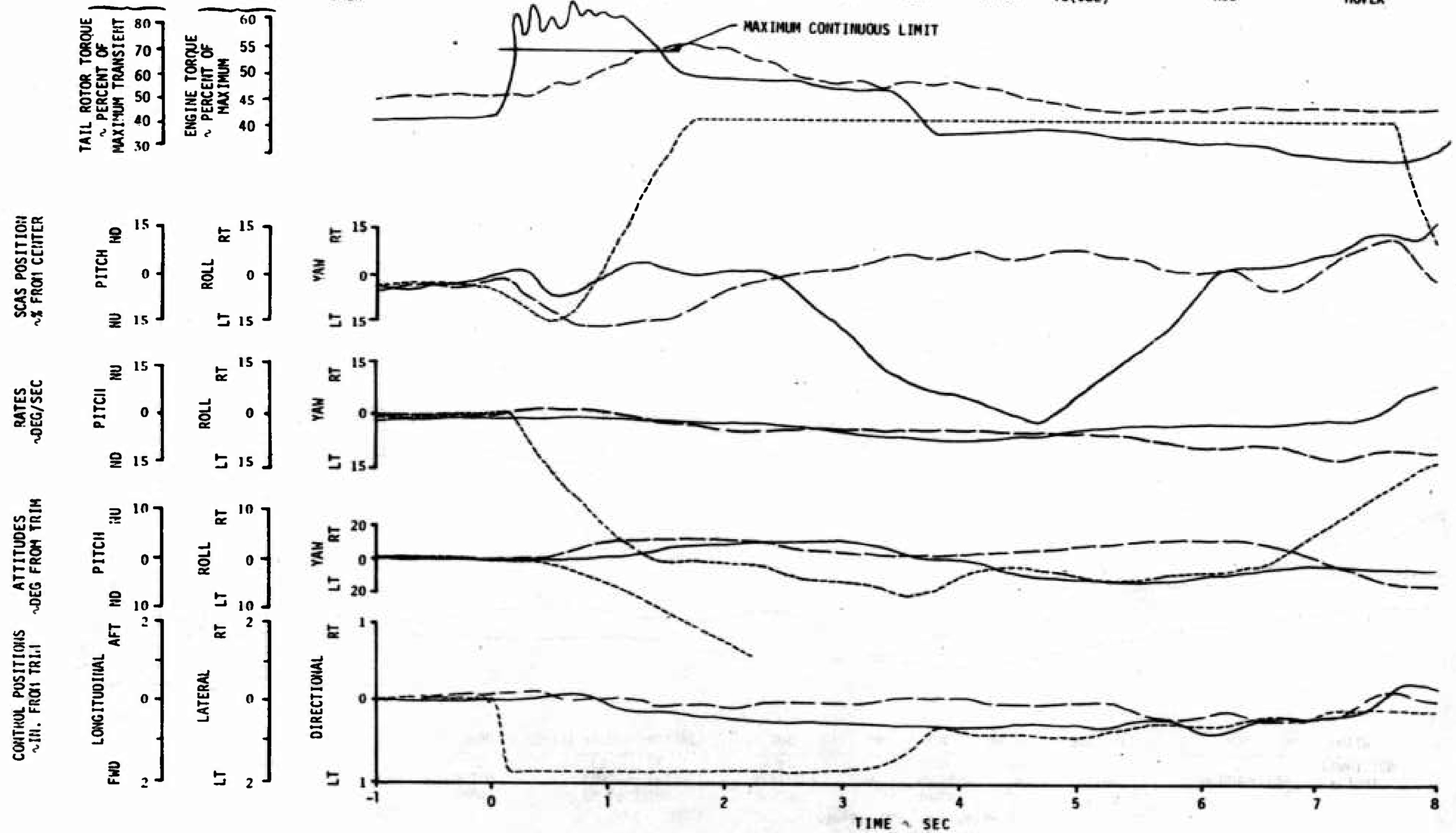


FIGURE 33
HOVER TURN ARRESTMENT
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	SKID HEIGHT ~FT	CONFIGURATION	FLIGHT CONDITION
10050	199.4(AFT)	-0.1(LT)	20	10	324	49.92	10(IGE)	HOG	HOVER

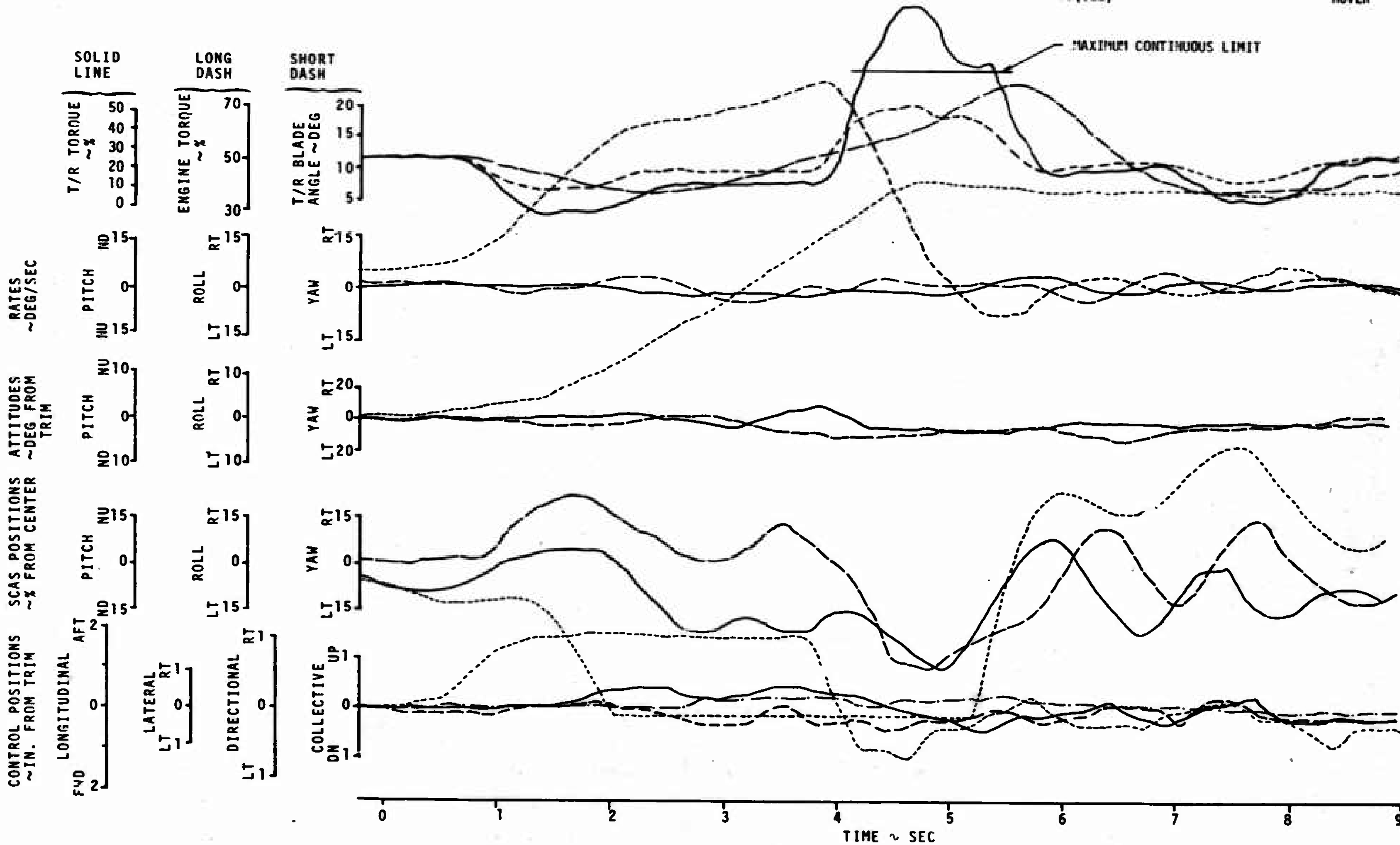


FIGURE 36
CONTROL POSITIONS IN REARWARD AND SLOW SPEED FORWARD FLIGHT
YAH-1R USA S/N 70-15936

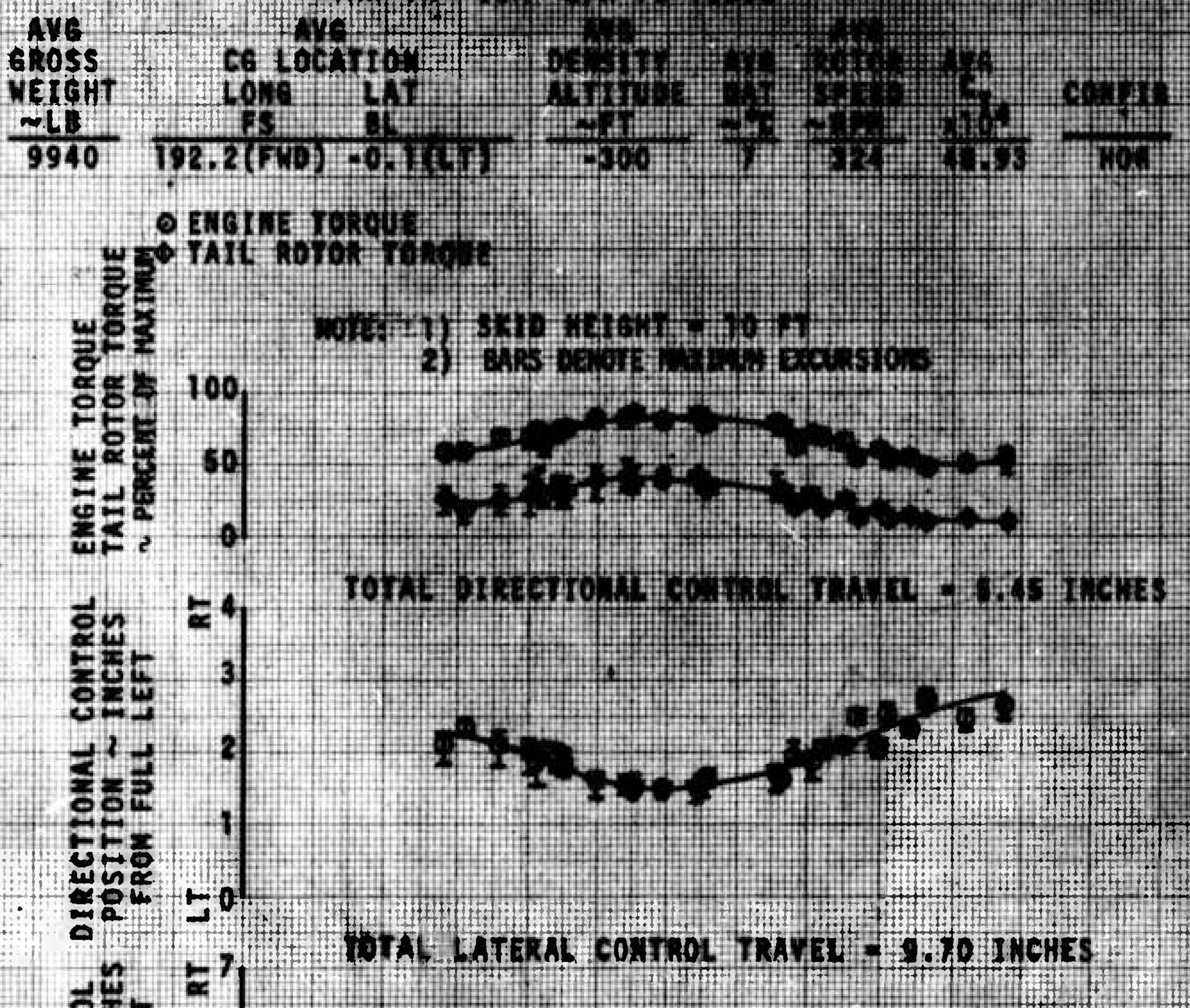


FIGURE 35
CONTROL POSITIONS IN SIDEWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T x10^4	CONFIG
9940	192.2(FWD)	-0.1(LT)	-300	7	324	48.93	HOG

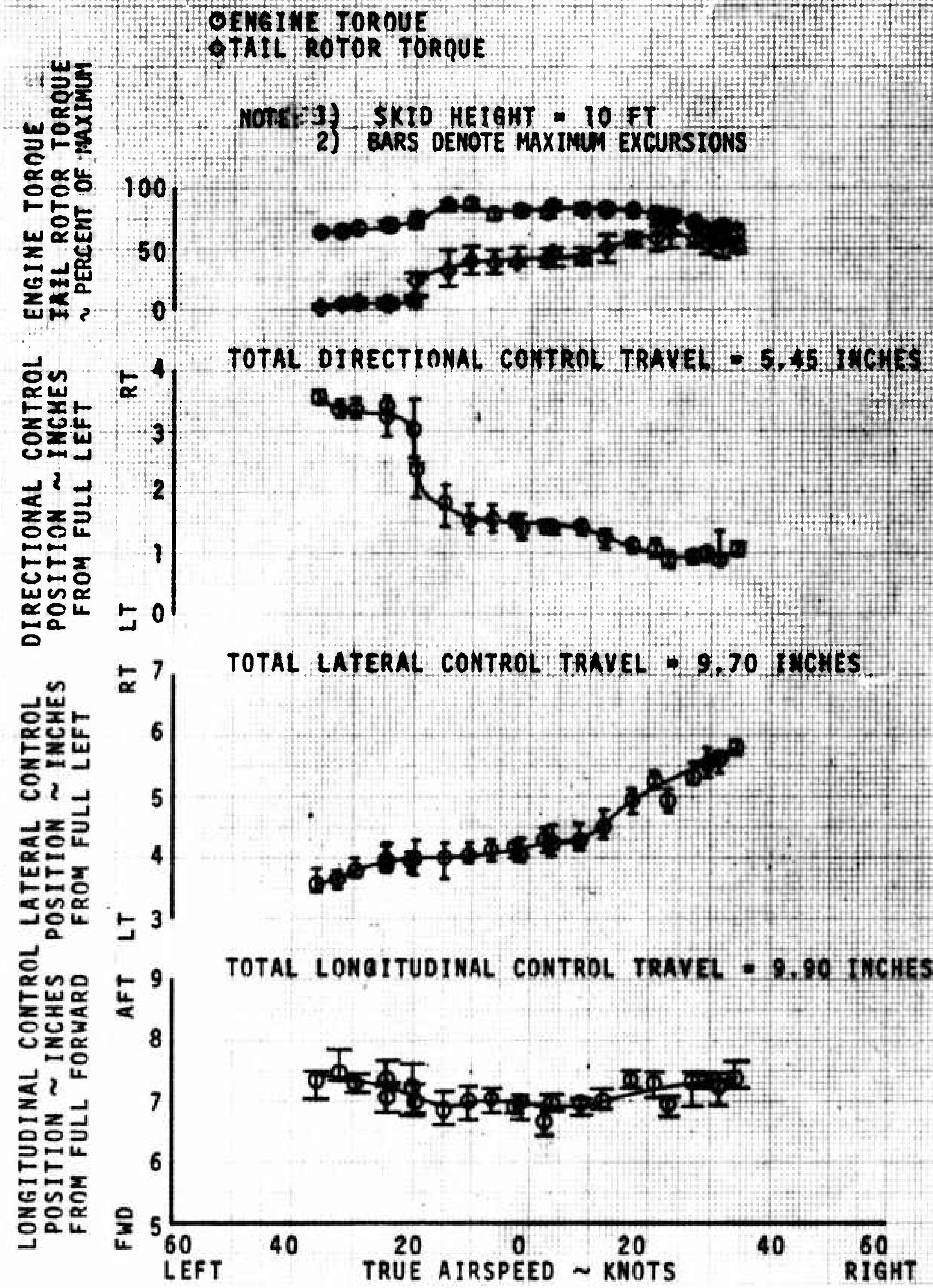


FIGURE 36
CONTROL POSITIONS IN SIDEWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	LAT BL	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	CONFIG
9960	191.6(FWD)	-0.1(LT)	-100	8	324	49.32	HOG

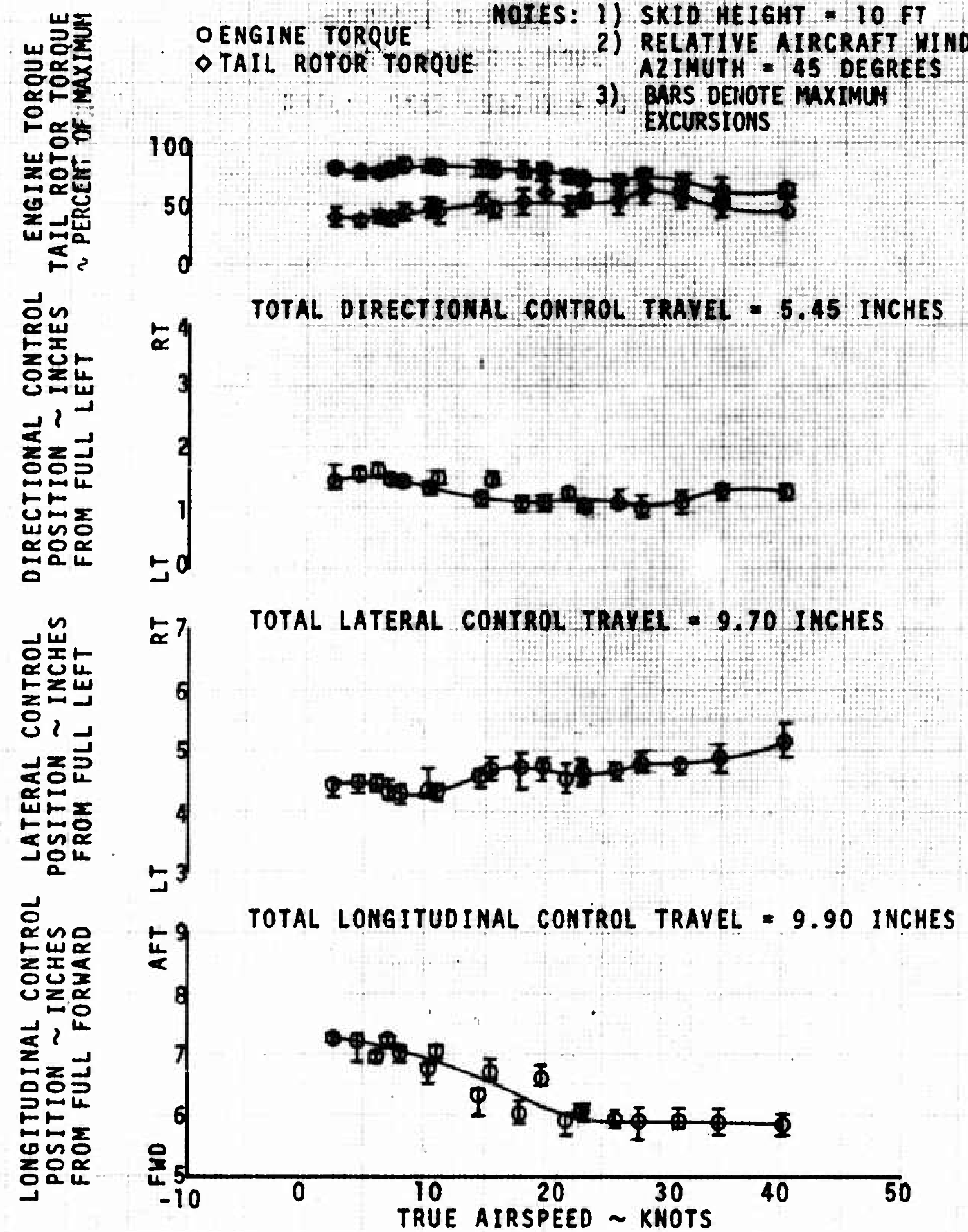


FIGURE 37
CONTROL POSITIONS IN SIDEWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	AVG C_T x10^4	CONFIG
9980	192.1(FWD)	-0.1(LT)	300	12	324	50.00	HOG

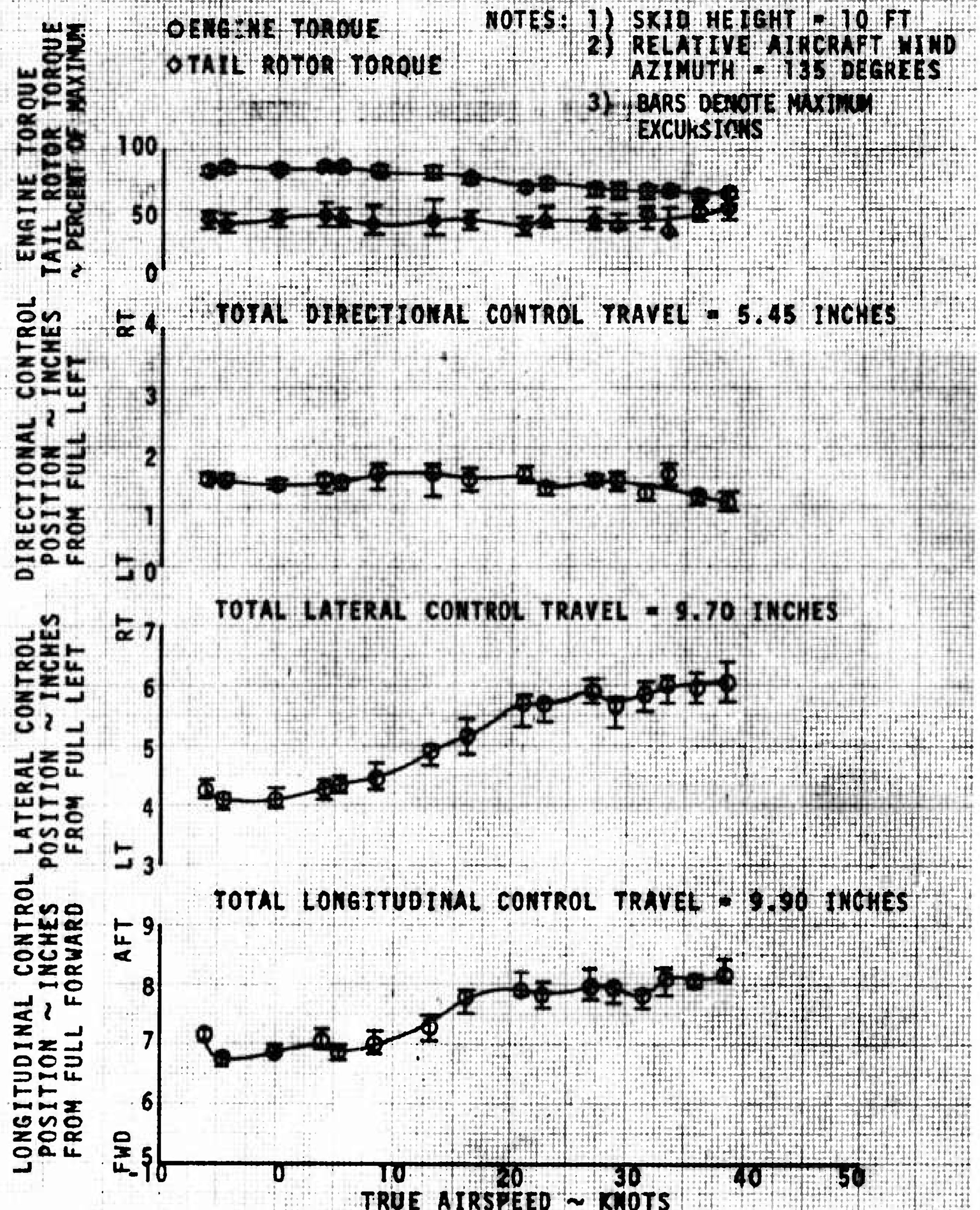
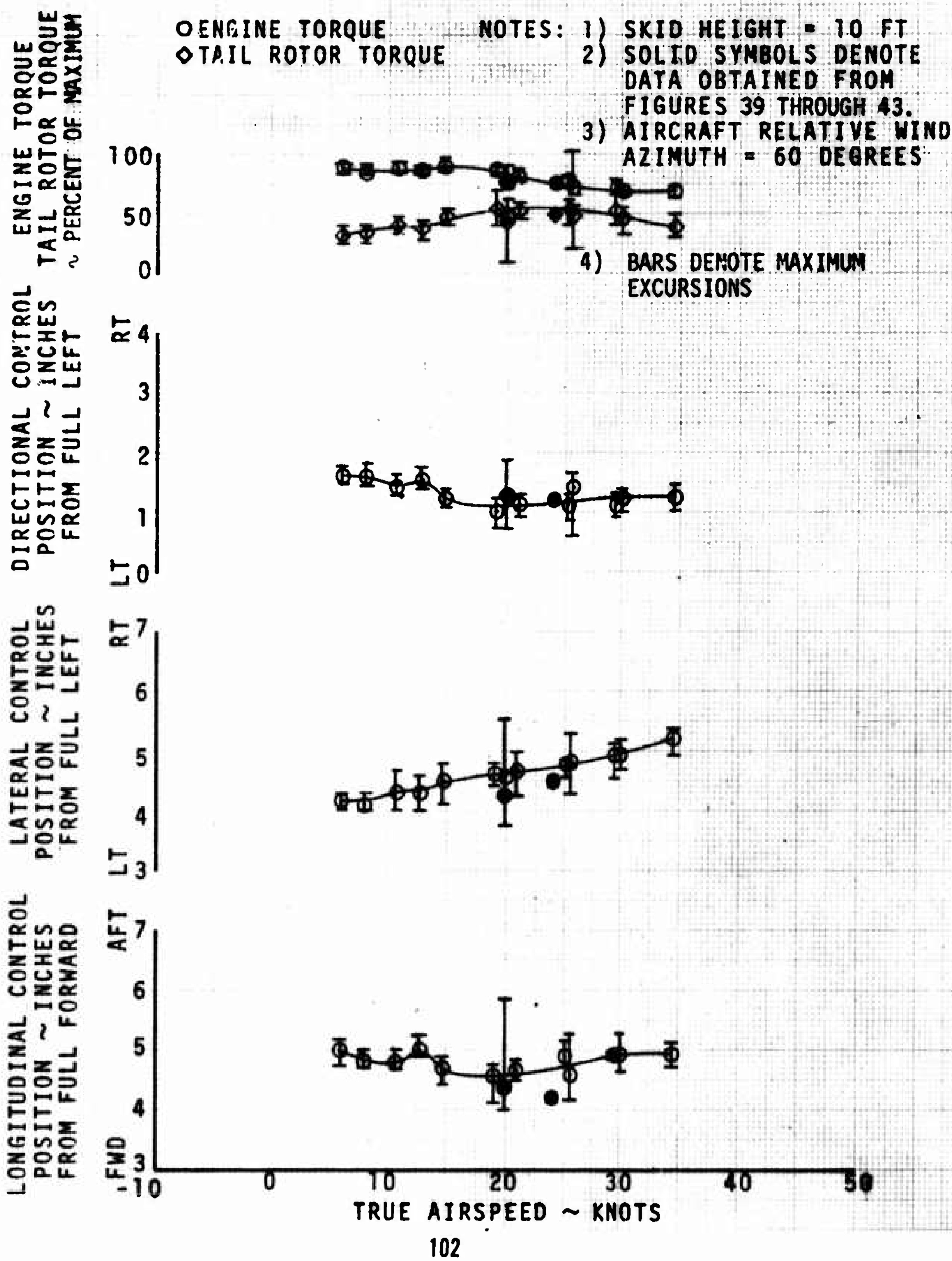
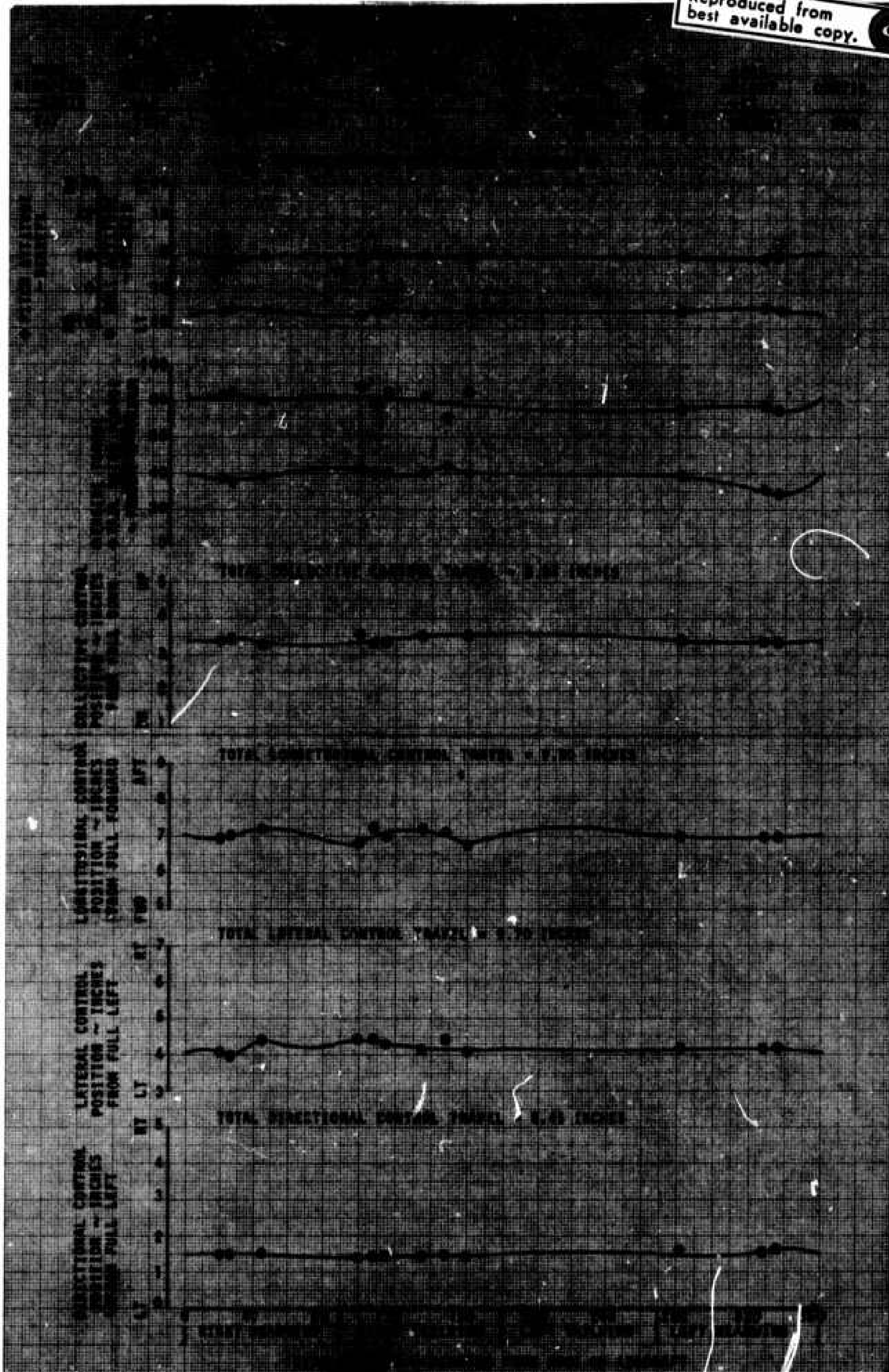
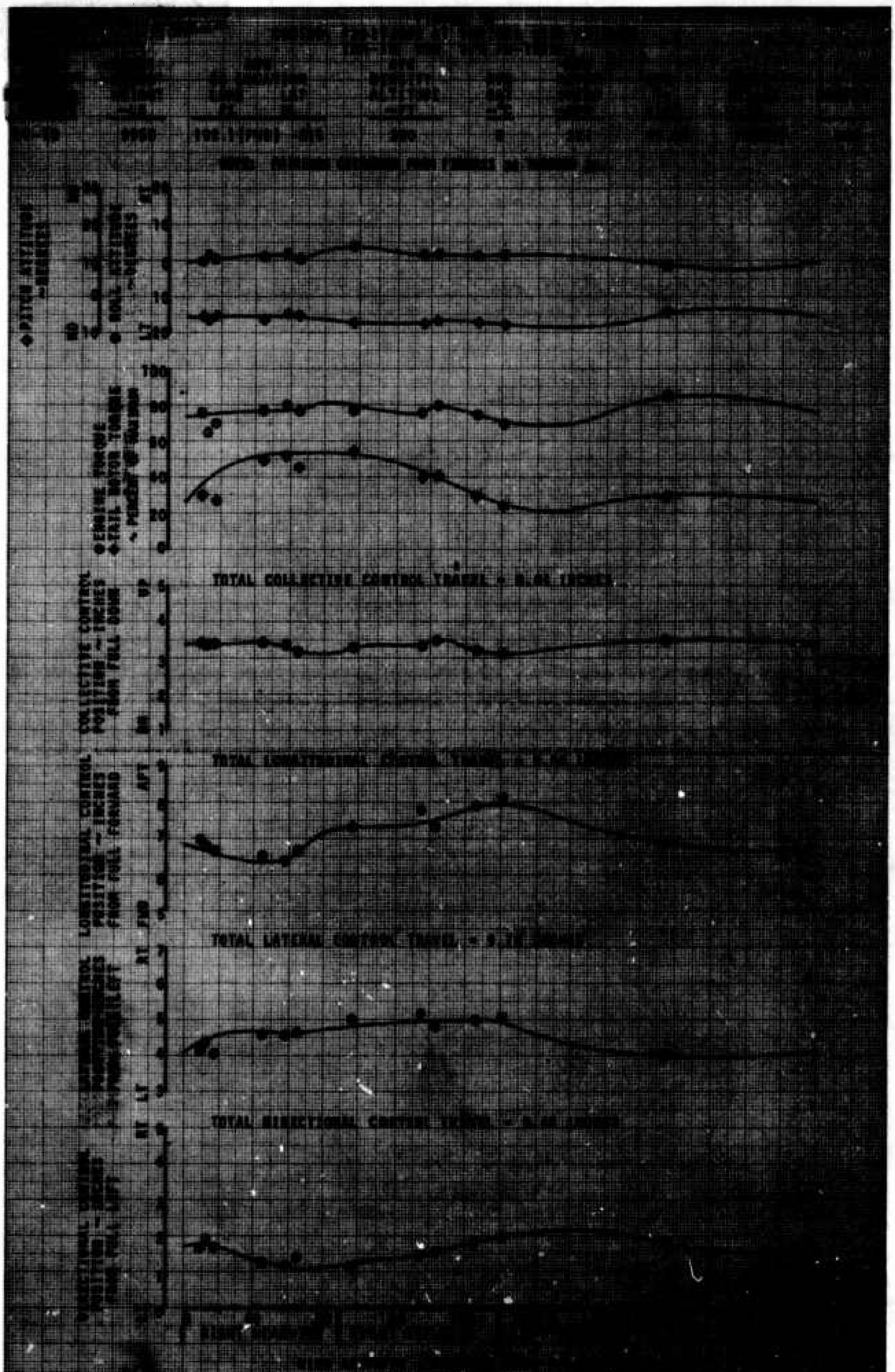


FIGURE 38
CONTROL POSITIONS IN SIDEWARD FLIGHT
YAH-1R USA S/N 70-15936

AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T x10^4	CONFIG
9500	199.2(AFT)	-0.1(LT)	300	12	324	47.59	HOG




DIRECTIONAL CONTROL
POSITION ~ INCHES
FROM FULL LEFT
LATERAL CONTROL
POSITION ~ INCHES
FROM FULL LEFT
LONGITUDINAL CONTROL
POSITION ~ INCHES
FROM FULL FORWARD
COLLECTIVE CONTROL
POSITION ~ INCHES
FROM FULL DOWN
LT
RT
FWD
AFT
DN
UP



PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ND
NU
LT
RT
ENGINE TORQUE
TAIL ROTOR TORQUE
~ PERCENT OF MAXIMUM
COLLECTIVE CONTROL POSITION ~ INCHES FROM FULL DOWN
DN
UP
TOTAL COLLECTIVE CONTROL TRAVEL
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
FWD
AFT
TOTAL LONGITUDINAL CONTROL TRAVEL
LATERAL CONTROL
TOTAL LATERAL CONTROL TRAVEL
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL

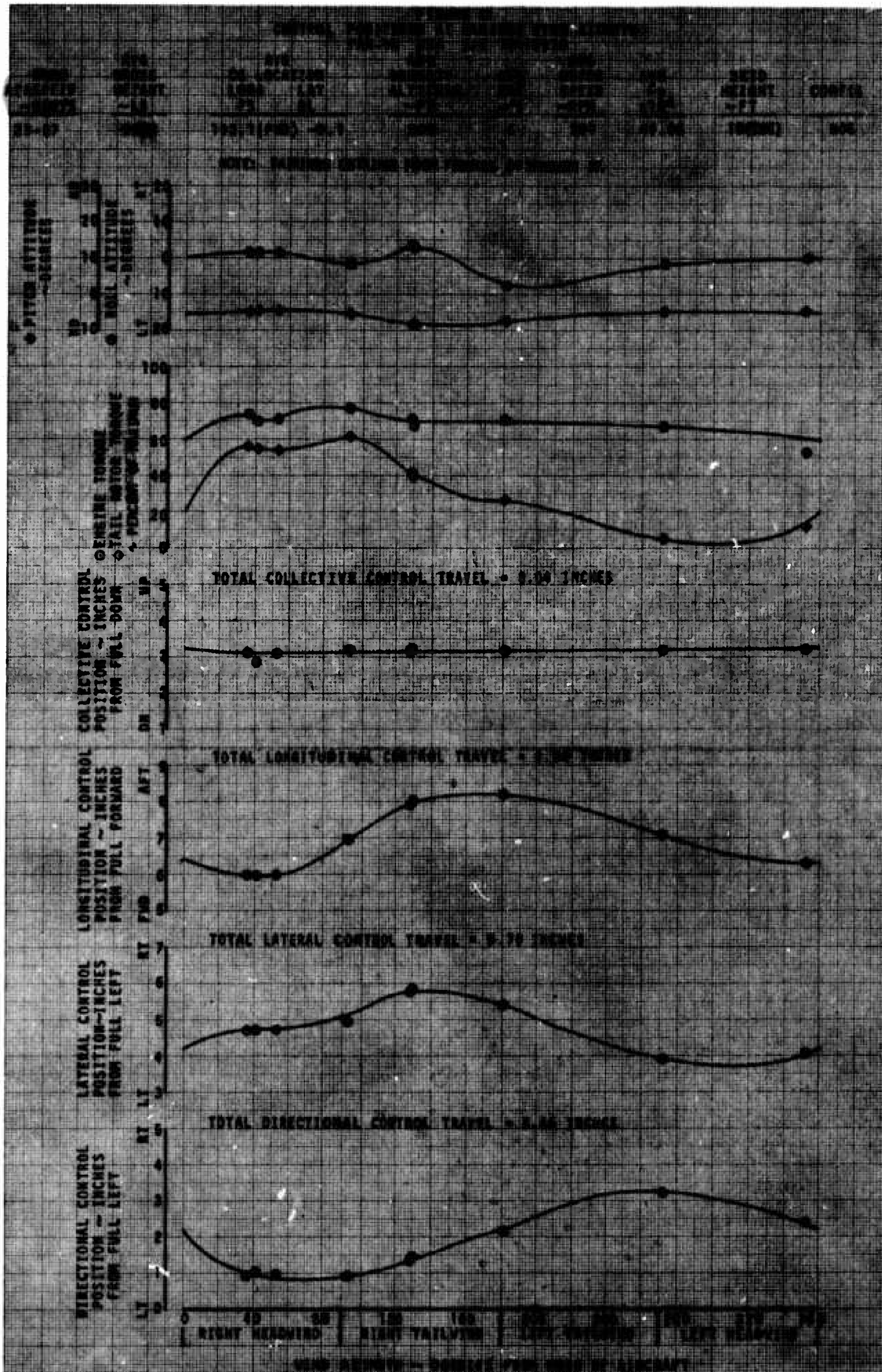
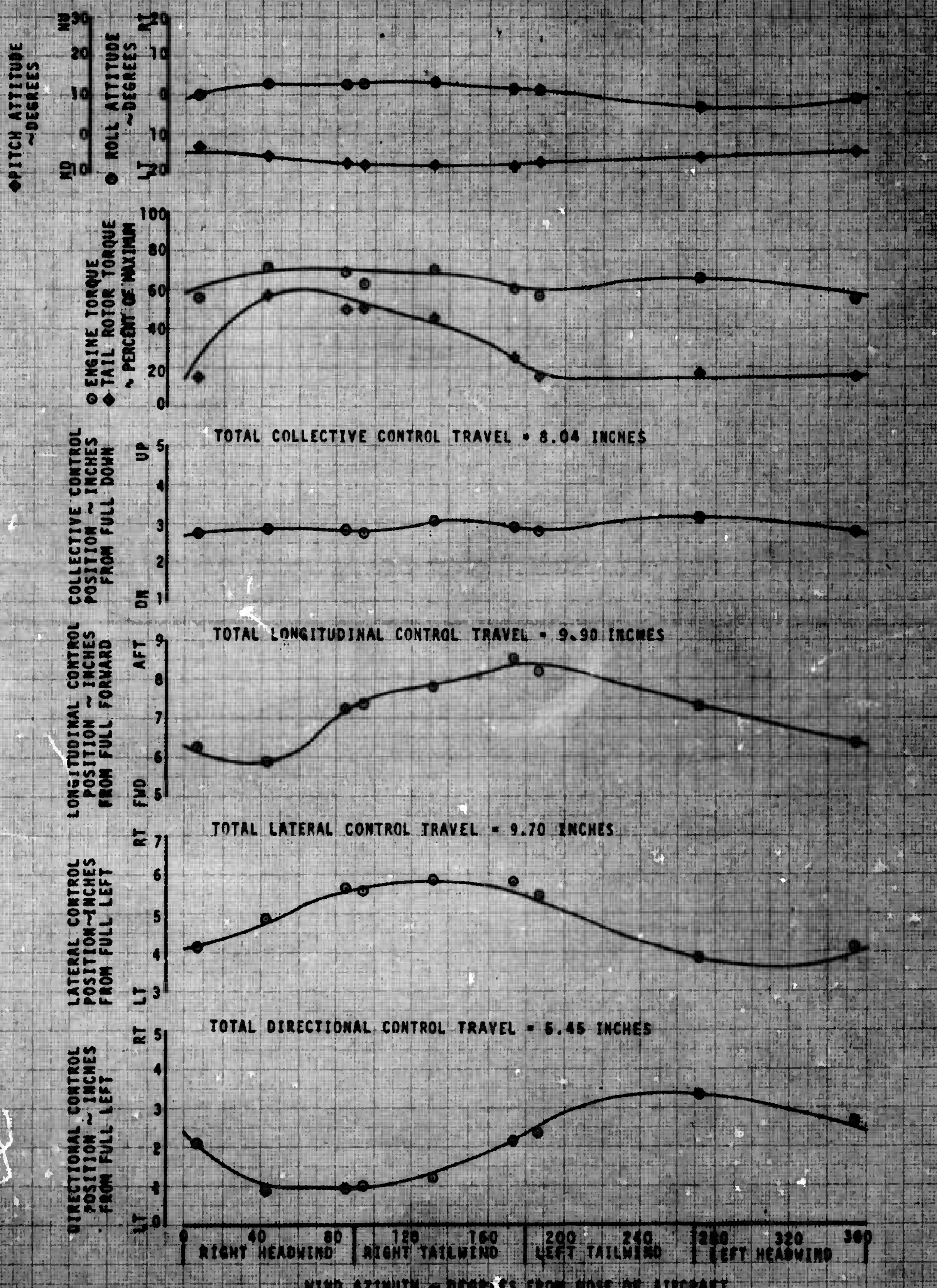
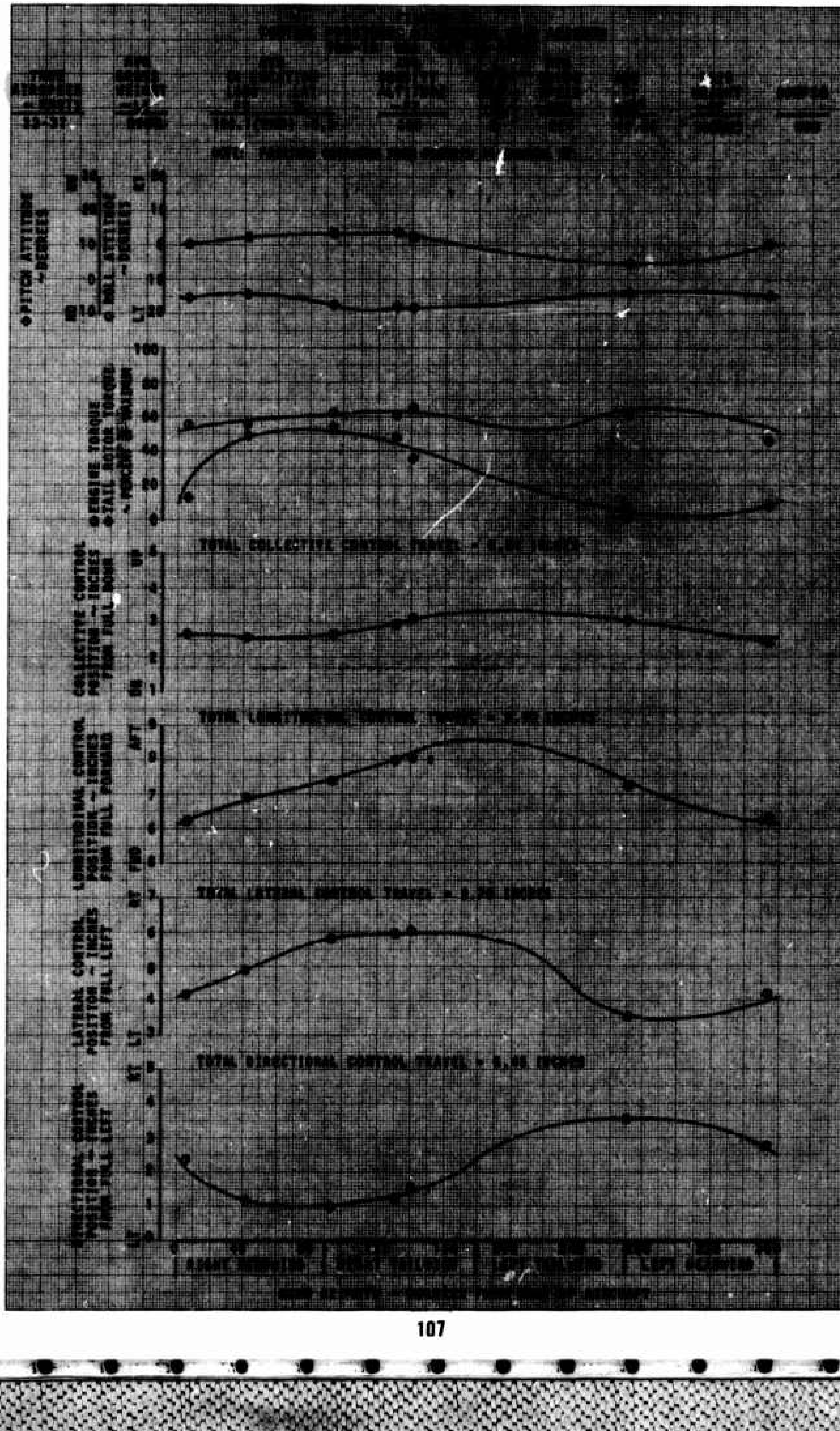

PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ENGINE TORQUE
TAIL ROTOR TORQUE
~ PERCENT OF MAXIMUM
TOTAL COLLECTIVE CONTROL TRAVEL
COLLECTIVE CONTROL POSITION ~ INCHES FROM FULL DOWN
TOTAL LONGITUDINAL CONTROL TRAVEL
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
TOTAL LATERAL CONTROL TRAVEL
LATERAL CONTROL POSITION~INCHES FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT
RIGHT HEADWIND
RIGHT TAILWIND
LEFT TAILWIND
LEFT HEADWIND

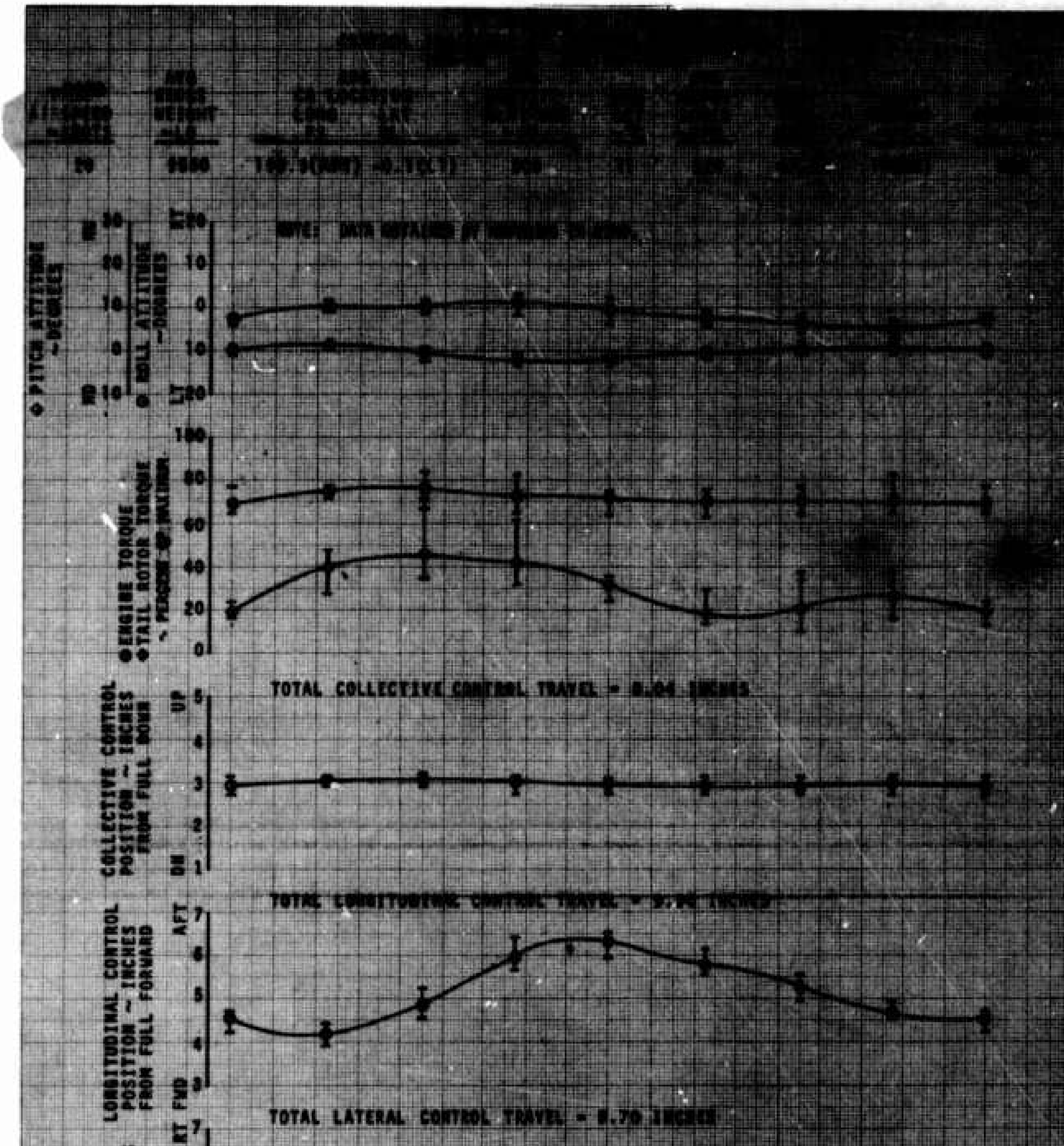
FIGURE 42
CONTROL POSITIONS AT VARIOUS WIND AZIMUTH
YAH-1R USA S/N 70-15936

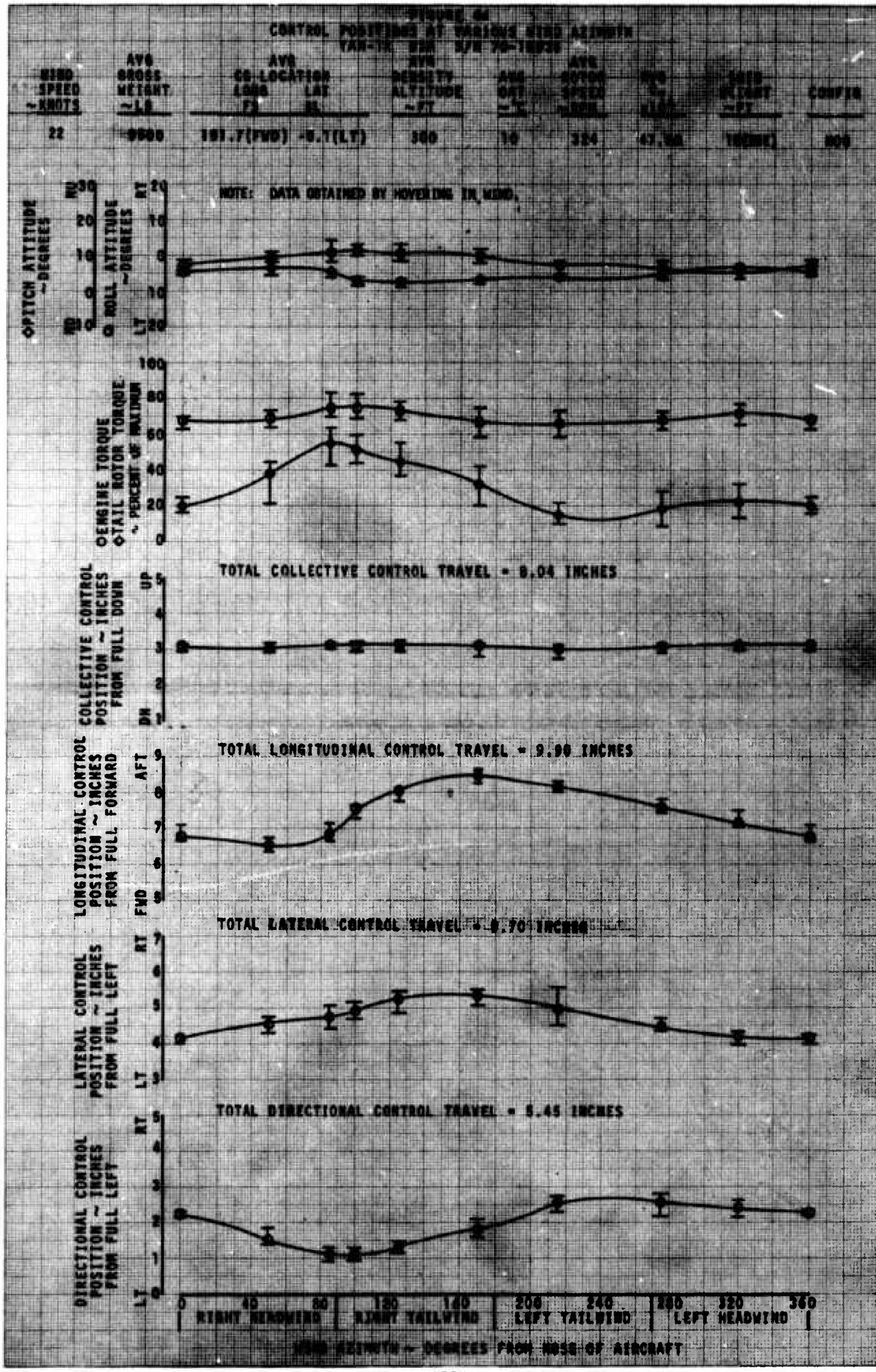
TRUE AIRSPEED ~KNOTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION LONG FS	AVG CG LOCATION LAT BL	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T $\times 10^4$	SKID HEIGHT ~FT	[illegible]
28-32	9950	192.1(FWD)	-0.1	300	6	324	49.85	[illegible]	[illegible]

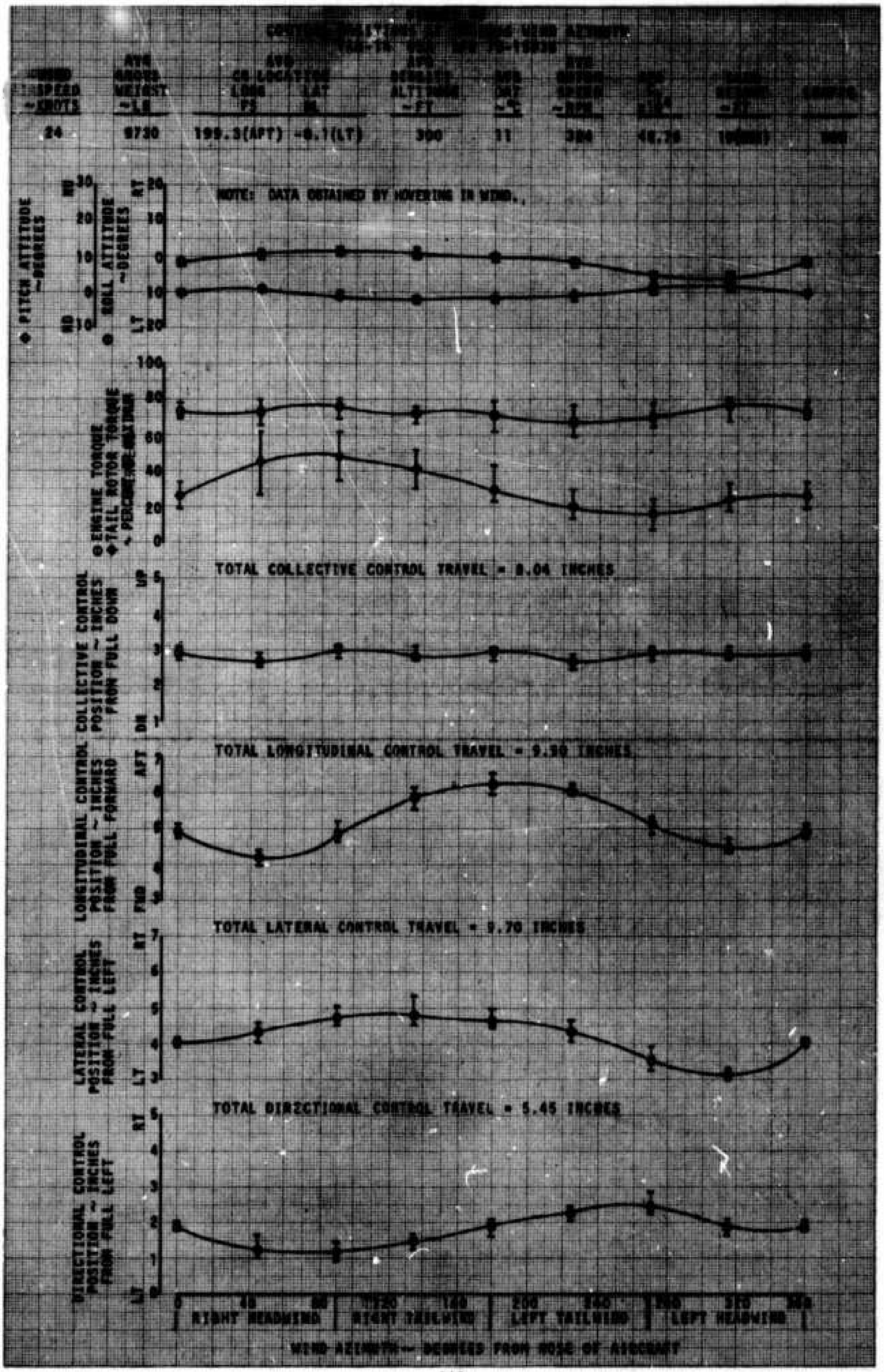
NOTE: FAIRINGS OBTAINED FROM FIGURES 36 THROUGH 37.




PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ENGINE TORQUE
TAIL ROTOR TORQUE
TOTAL COLLECTIVE CONTROL TRAVEL
TOTAL LATERAL CONTROL TRAVEL
TOTAL DIRECTIONAL CONTROL TRAVEL


NOTE: DATA OBTAINED BY AVERAGING TECHNIQUE.
PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ENGINE TORQUE
TAIL ROTOR TORQUE
~ PERCENT OF MAXIMUM
TOTAL COLLECTIVE CONTROL TRAVEL
COLLECTIVE CONTROL POSITION ~ INCHES FROM FULL DOWN
TOTAL LONGITUDINAL CONTROL TRAVEL
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
TOTAL LATERAL CONTROL TRAVEL
LATERAL CONTROL POSITION ~ INCHES FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT


CONTROL
WIND SPEED ~KNOTS
AVG GROSS WEIGHT
AVG CG LOCATION
ALTITUDE
CONFIG
22
NOTE: DATA OBTAINED BY HOVERING IN WIND.
PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ENGINE TORQUE
TAIL ROTOR TORQUE
TOTAL COLLECTIVE CONTROL TRAVEL = 9.04 INCHES
COLLECTIVE CONTROL POSITION ~ INCHES FROM FULL DOWN
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.90 INCHES
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
TOTAL LATERAL CONTROL TRAVEL
LATERAL CONTROL POSITION ~ INCHES FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45 INCHES
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT
RIGHT TAILWIND
LEFT TAILWIND
LEFT HEADWIND
DEGREES FROM NOSE OF AIRCRAFT



AVG
GROSS
WEIGHT
AVG
CG LOCATION
LONG
LAT
ALTITUDE
~FT
24
9730
199.3(AFT) -0.1(LT)
300
11
NOTE: DATA OBTAINED BY HOVERING IN WIND.
PITCH ATTITUDE ~DEGREES
ROLL ATTITUDE ~DEGREES
ENGINE TORQUE
TAIL ROTOR TORQUE
TOTAL COLLECTIVE CONTROL TRAVEL = 8.04 INCHES
COLLECTIVE CONTROL POSITION ~ INCHES FROM FULL DOWN
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.30 INCHES
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
TOTAL LATERAL CONTROL TRAVEL = 9.70 INCHES
LATERAL CONTROL POSITION ~ INCHES FROM FULL LEFT
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45 INCHES
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT
RIGHT HEADWIND
RIGHT TAILWIND
LEFT TAILWIND
LEFT HEADWIND

FIGURE 47
LEFT LATERAL ACCELERATION
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T $x10^4$	SKID HEIGHT ~FT	CONFIGURATION	FLIGHT CONDITION
9900	199.4(AFT)	-0.1(LT)	250	10	324	49.52	100(OGE)	HOG	LEVEL FLIGHT

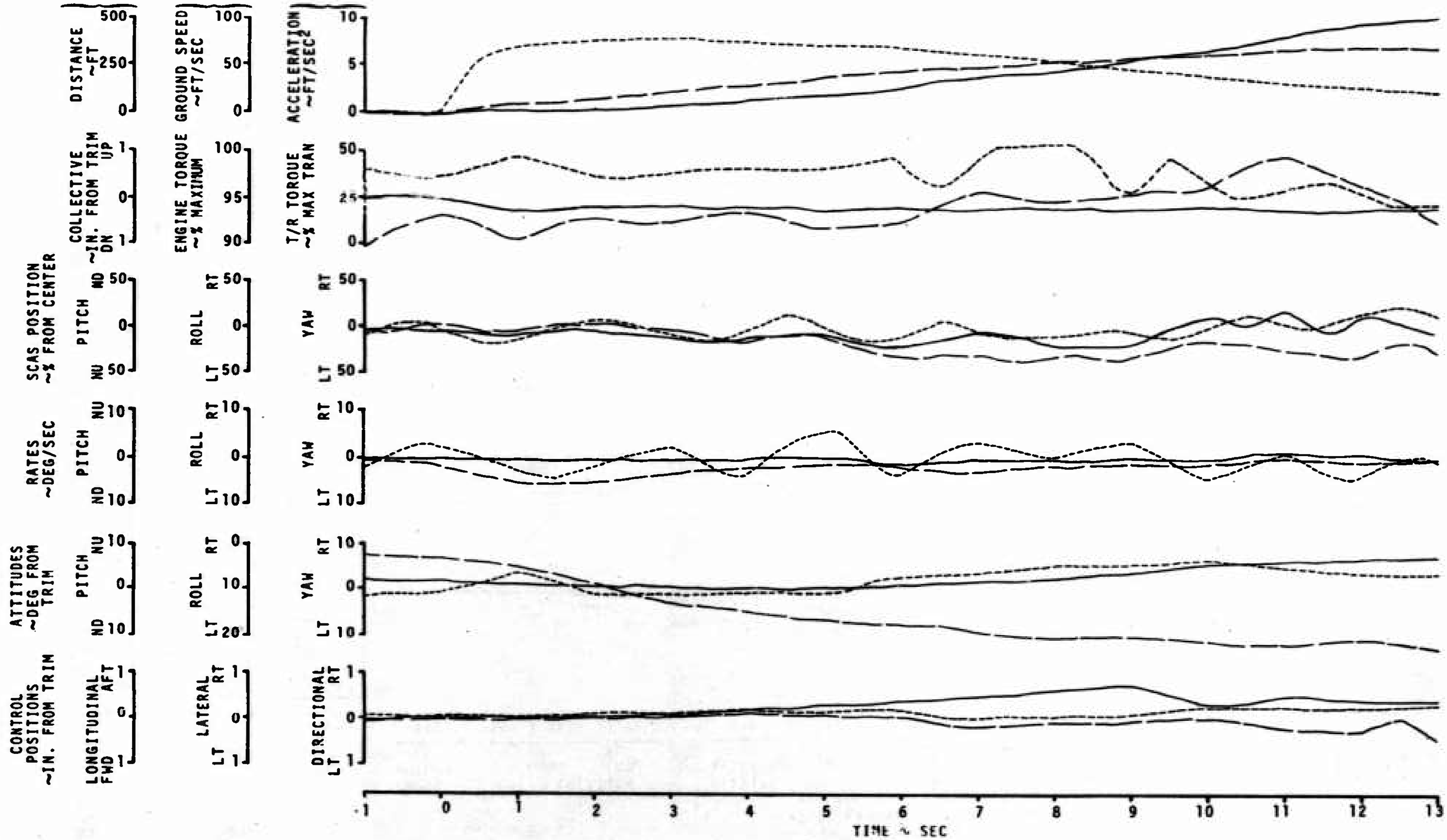


FIGURE 48
RIGHT LATERAL ACCELERATION
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	SKID HEIGHT ~FT	CONFIGURATION	FLIGHT CONDITION
9940	199.4(AFT)	-0.1(LT)	250	10	324	49.58	100(OGE)	HOG	LEVEL FLIGHT

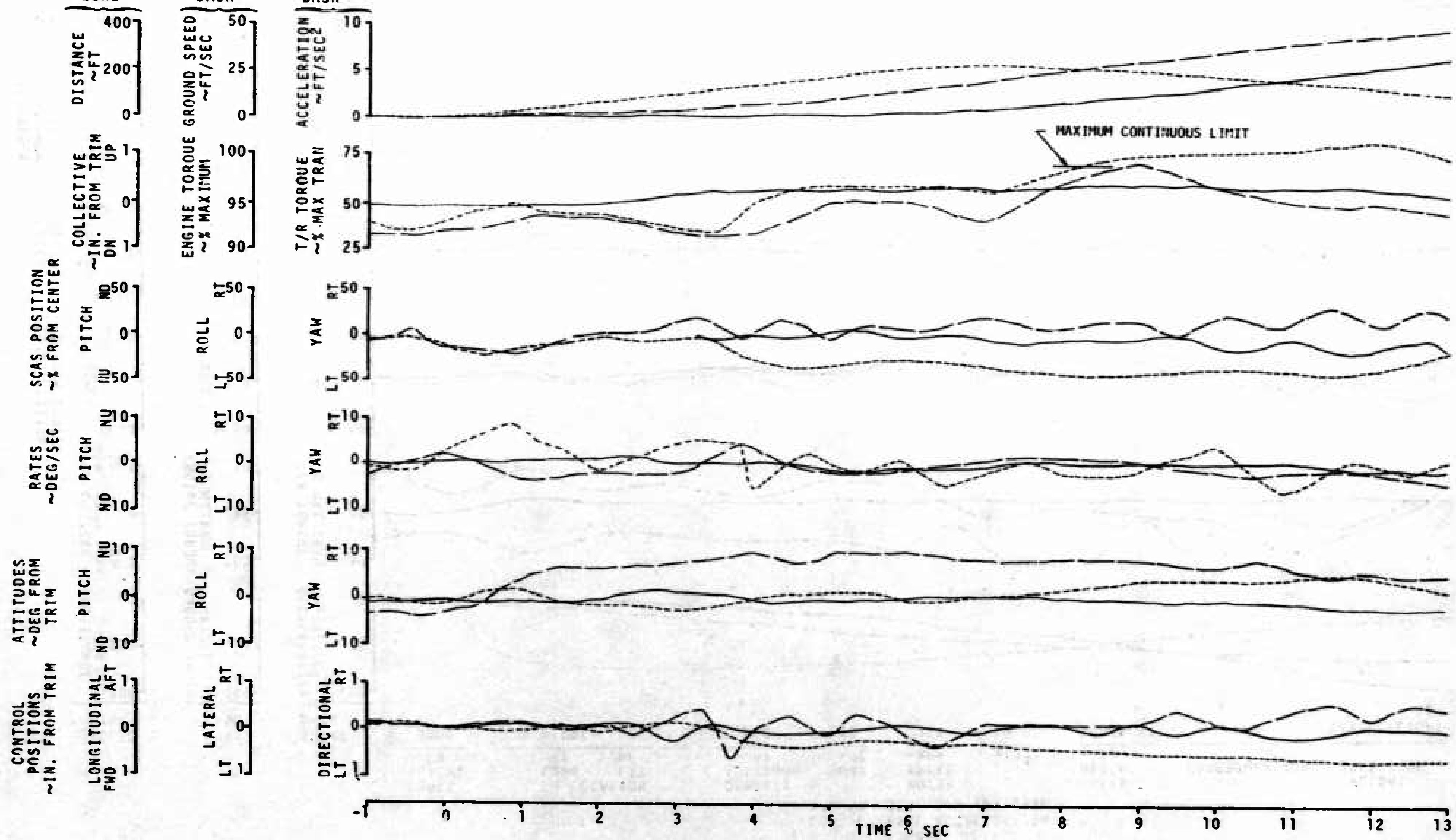


FIGURE 49
LEFT LATERAL ACCELERATION
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	$C_T \times 10^4$	SKID HEIGHT ~FT	CONFIG	FLIGHT CONDITION
10,000	192.4(AFT)	-0.1(LT)	150	10	324	49.88	10(IGE)	HOG	LEVEL FLT

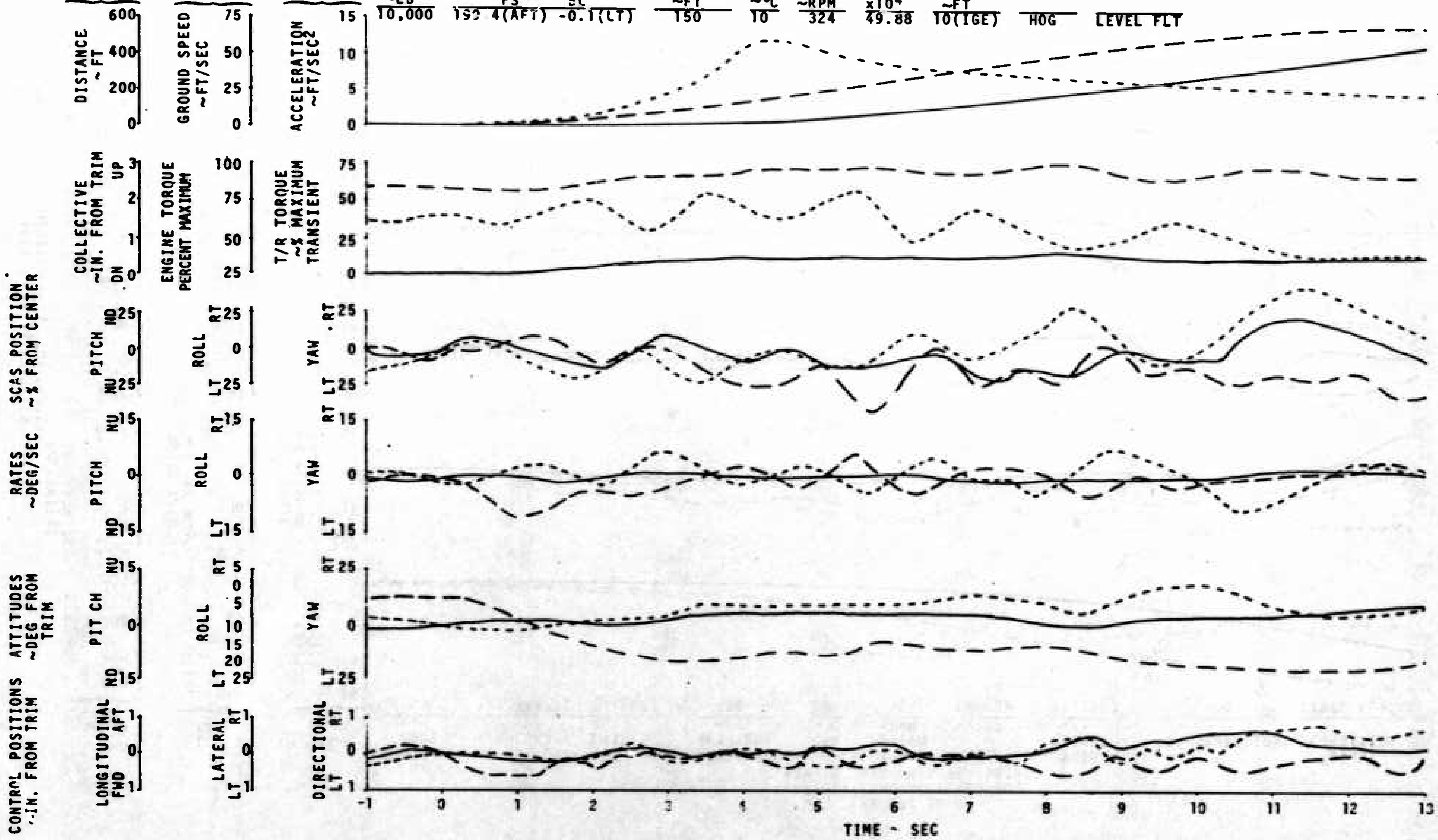


FIGURE 50
RIGHT LATERAL ACCELERATION
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	SKID HEIGHT ~FT	CONFIGURATION	FLIGHT CONDITION
9960	199.4(AFT)	-0.1(LT)	150	10	324	49.68	10(IGE)	HOG	LEVEL FLIGHT

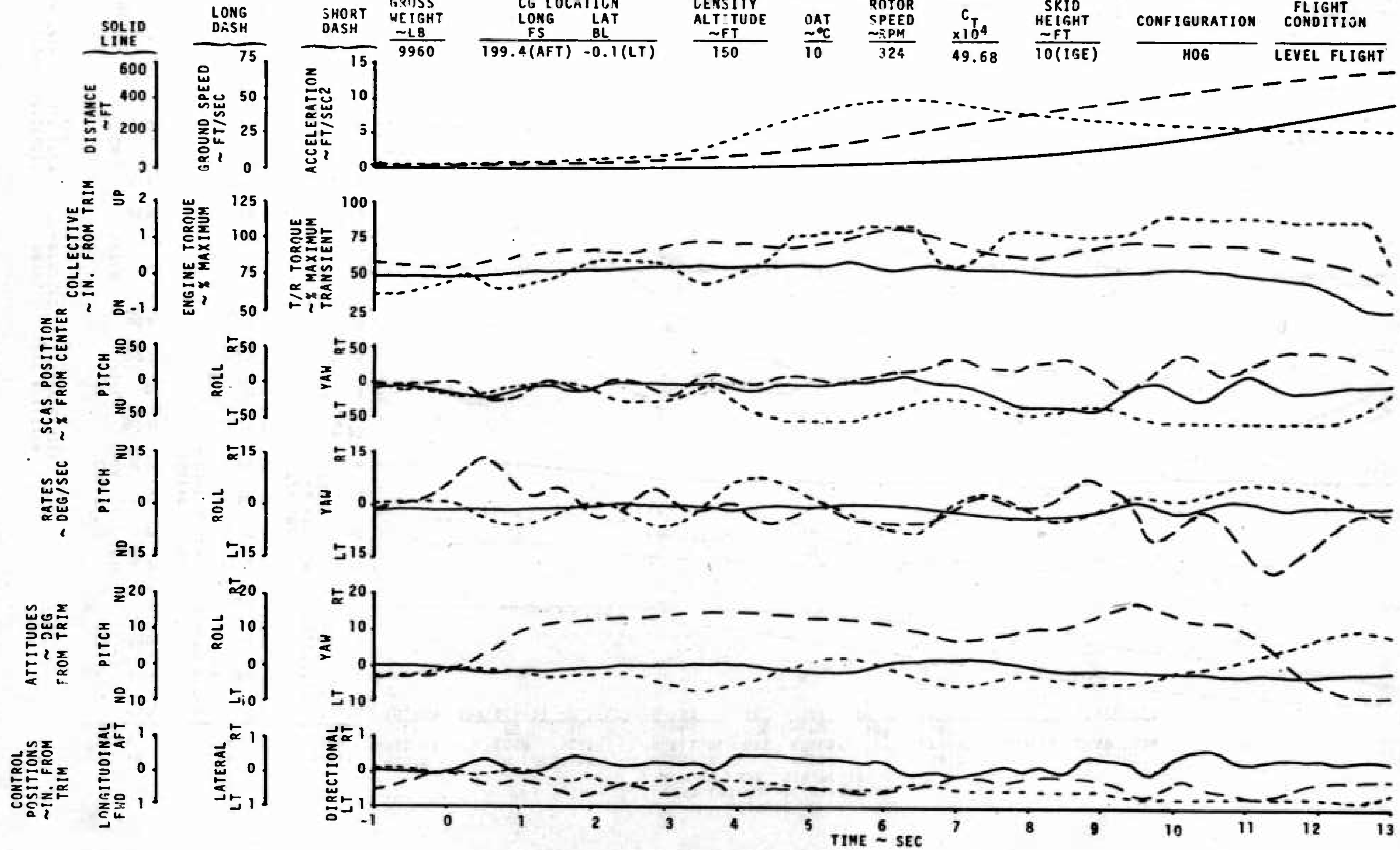


FIGURE 51
BOB UP
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_{T} x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9820	199.4(AFT)	-0.1(LT)	150	10	324	48.98	HOVER	HOG	HOVER(IGE)

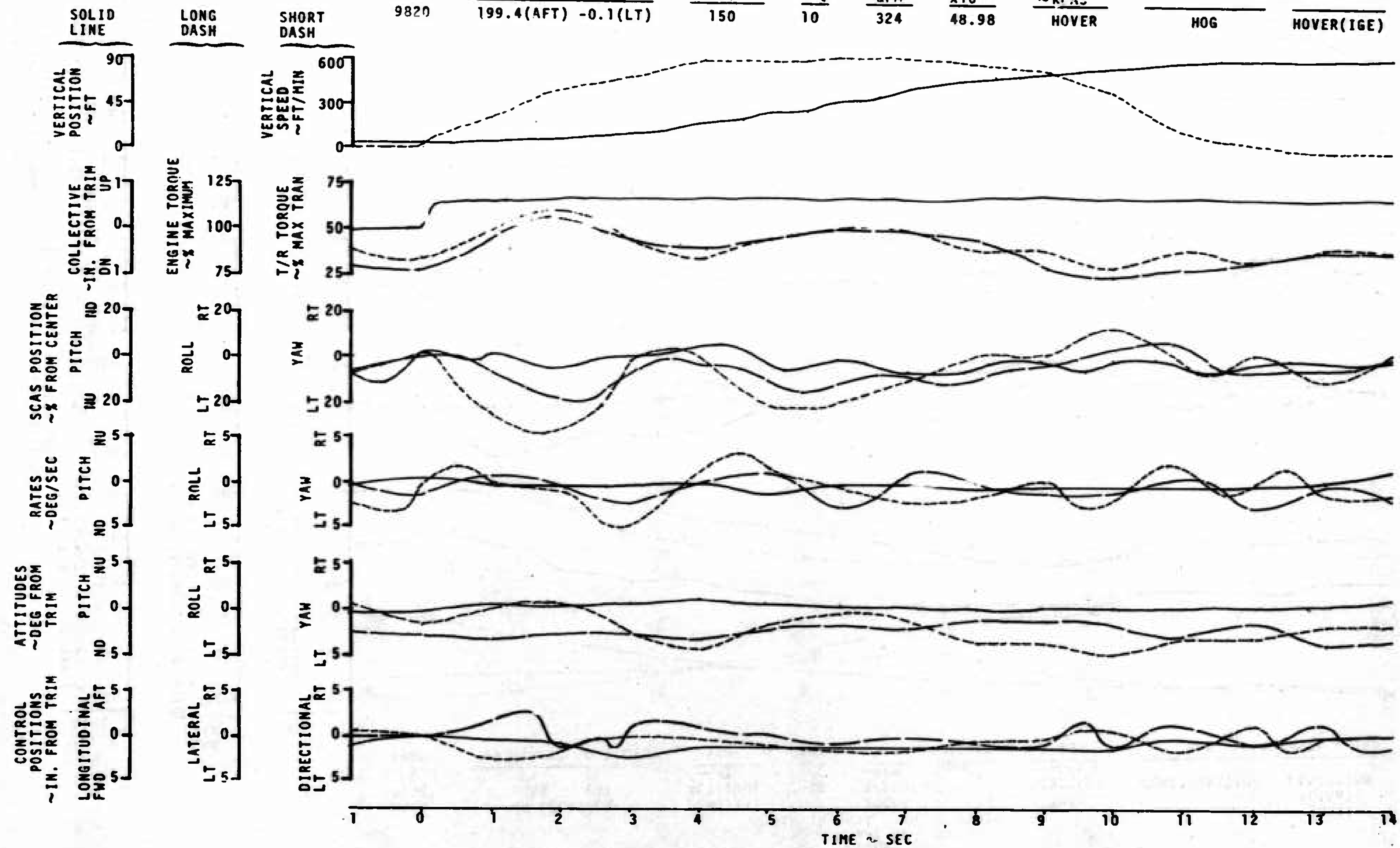


FIGURE 52
POP UP
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	ENTRY FLIGHT CONDITION
9860	199.4(AFT)	-0.1(LT)	150	10	324	49.18	43	HOG	LEVEL FLIGHT

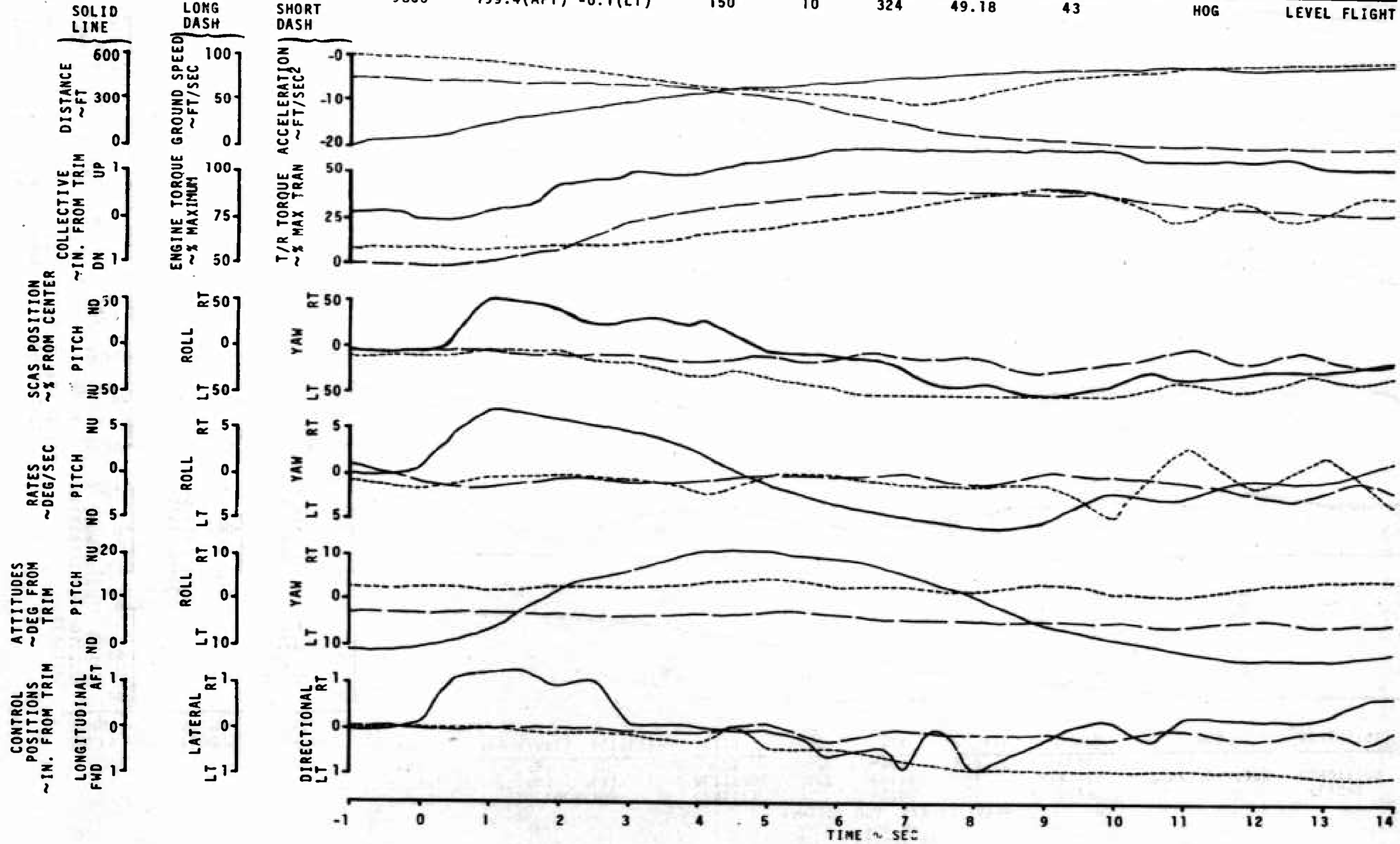


FIGURE 53
APPROACH IN WIND CONDITIONS
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10⁴	~KTS	FLIGHT CONDITION
9450	199.2(AFT)	-0.1(LT)	200	12	324	47.20		APPROACH TO IGE HOVER

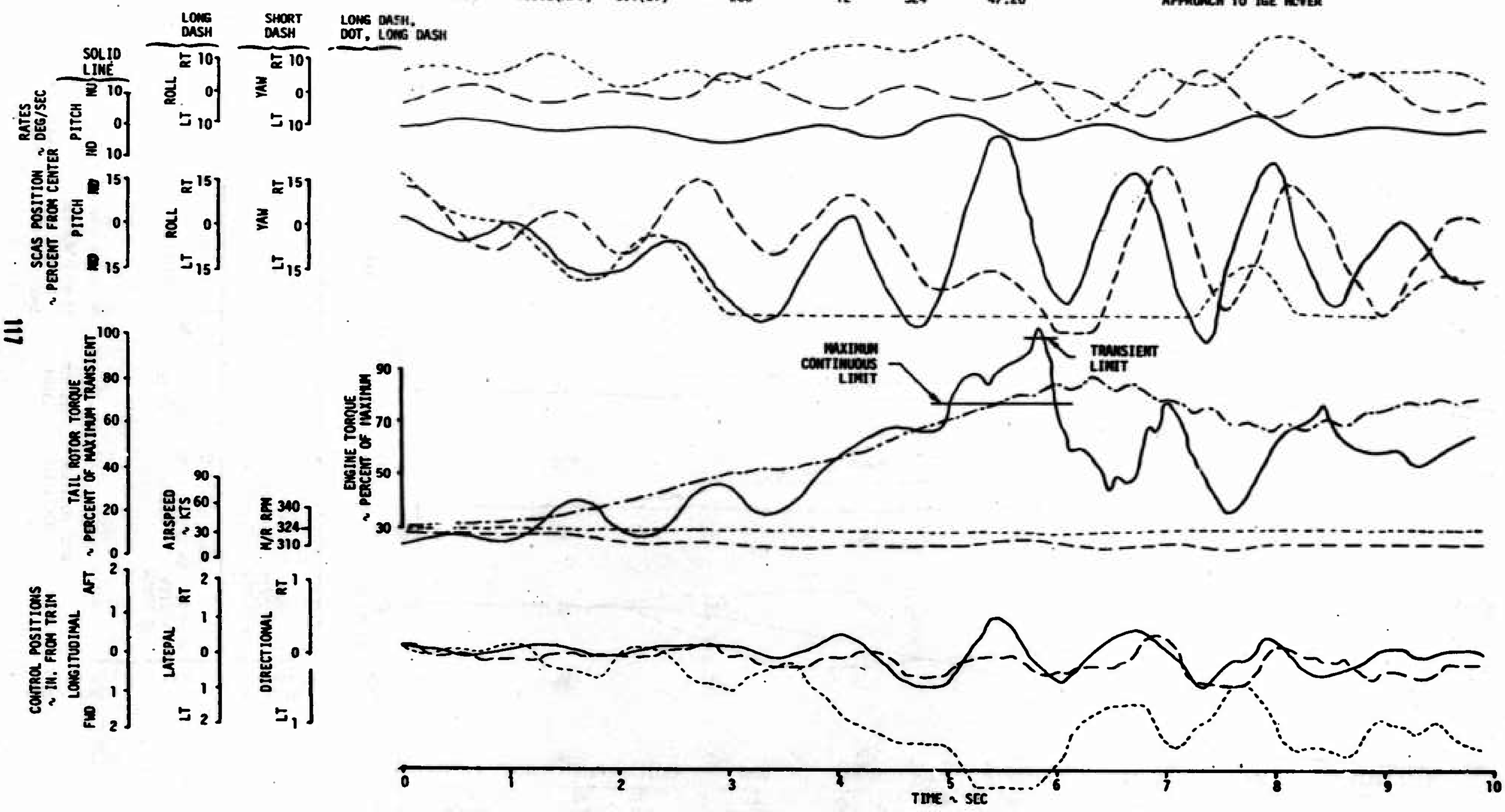


FIGURE 54
SIMULATED ENGINE FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10⁴	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9750	199.3(AFT)	-0.1(LT)	4800	16	324	55.85	41	HOG	LEVEL FLIGHT

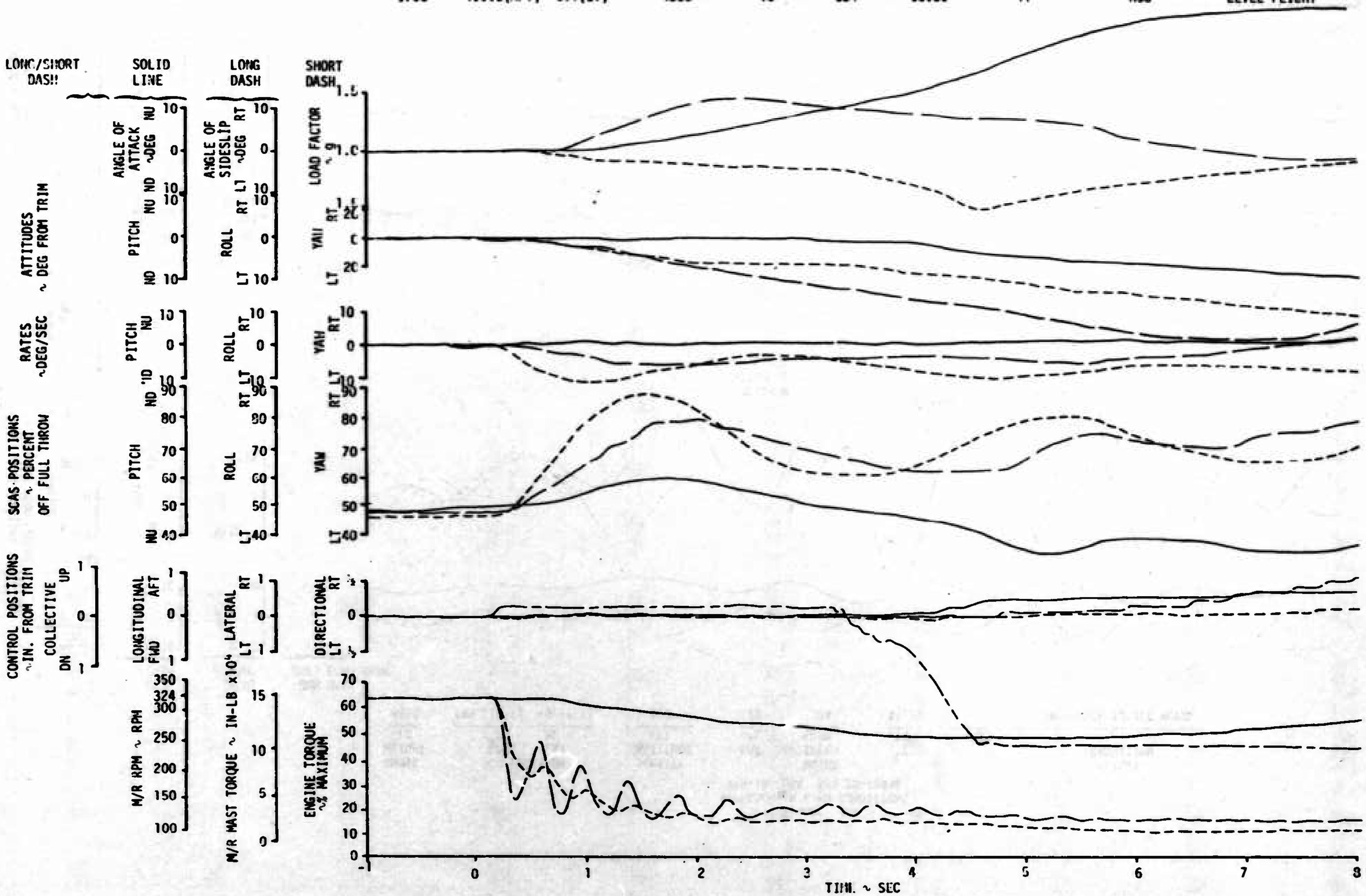


FIGURE 55
SIMULATED ENGINE FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T $x10^4$	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9600	199.3(AFT)	-0.1(LT)	4800	16	324	55.45	40	HOG	T.O. POWER CLIMB

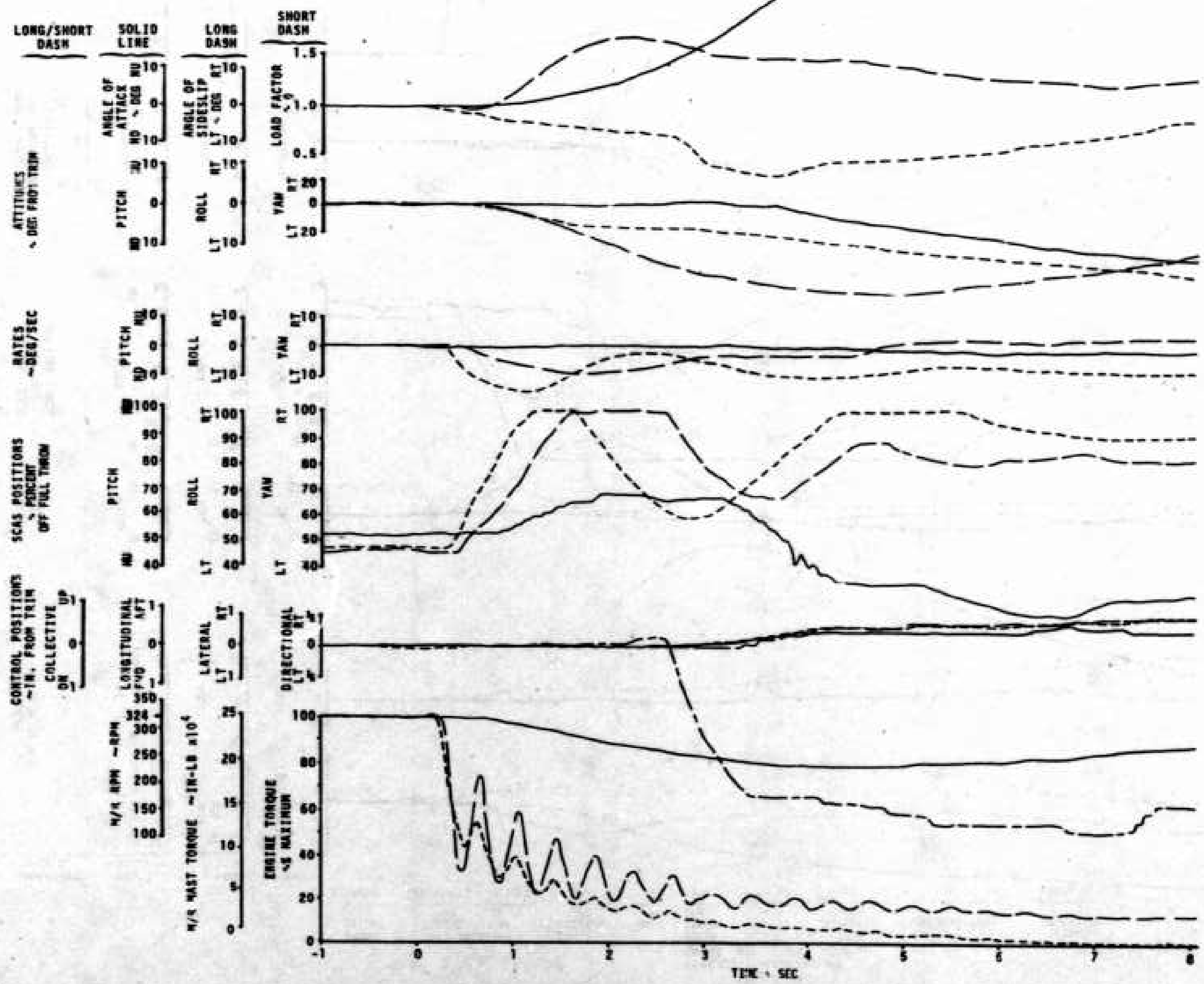


FIGURE 56
SIMULATED ENGINE FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T $\times 10^4$	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9650	199.3(AFT)	-0.1(LT)	5000	16	324	55.62	121	HOG	LEVEL FLIGHT

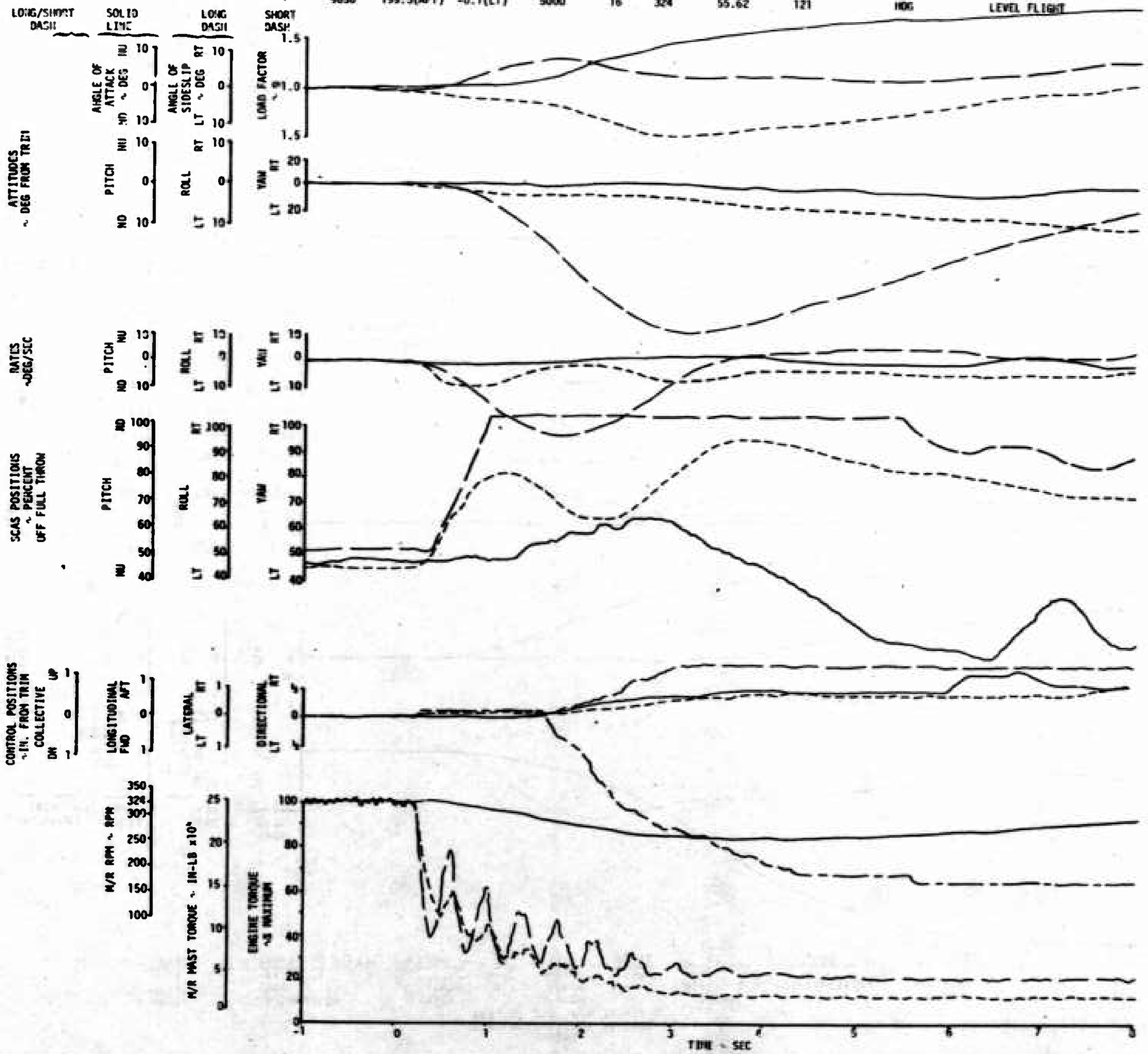


FIGURE 57
SIMULATED ENGINE FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10⁴	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9866	199.6(AFT)	-0.1(LT)	5000	-4	324	56.48	15	HOG	HOVER

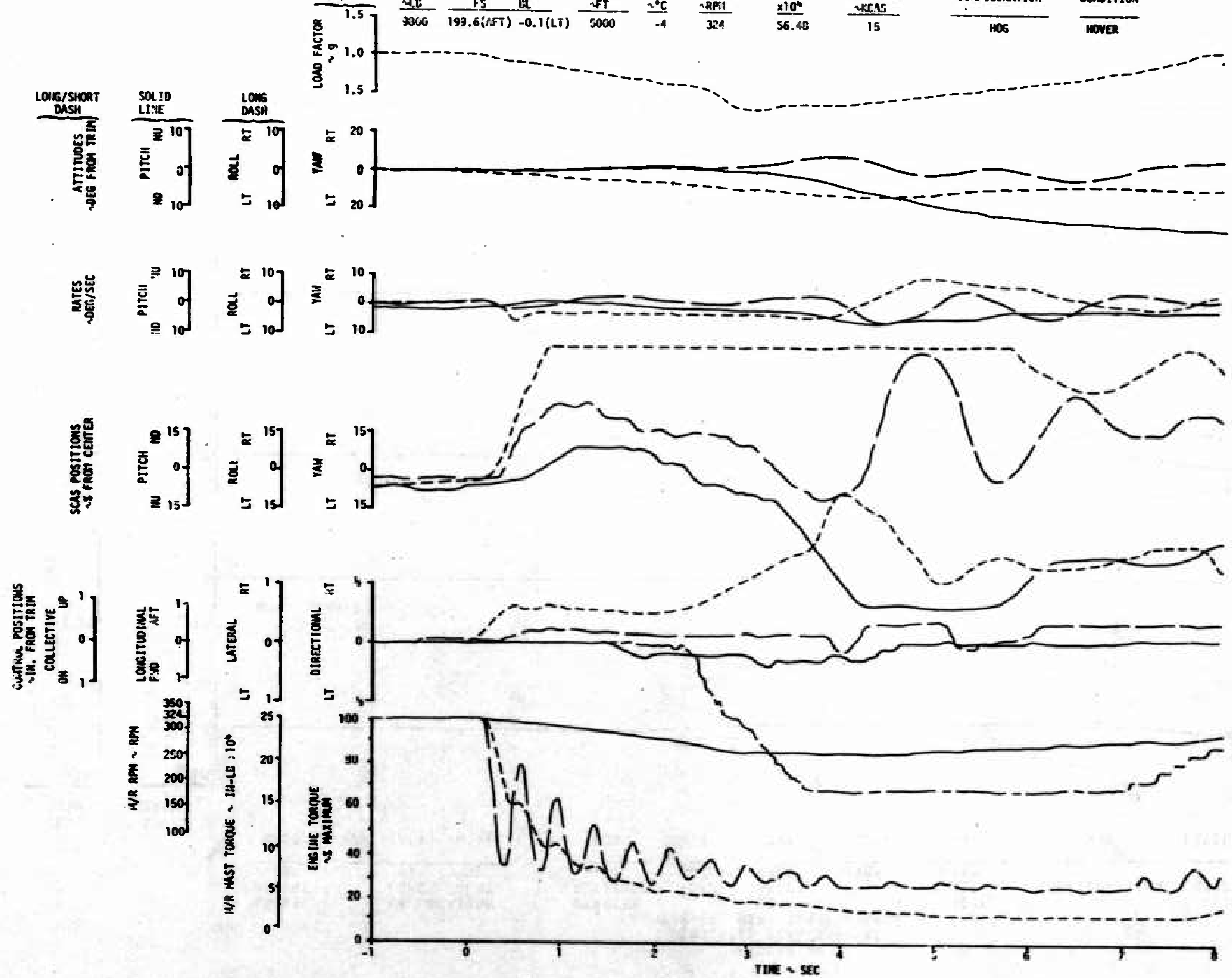


FIGURE 58
SIMULATED SCAS FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9700	199.6(AFT)	-0.1(LT)	5000	-4	324	55.91	43	HOG	LEVEL FLIGHT

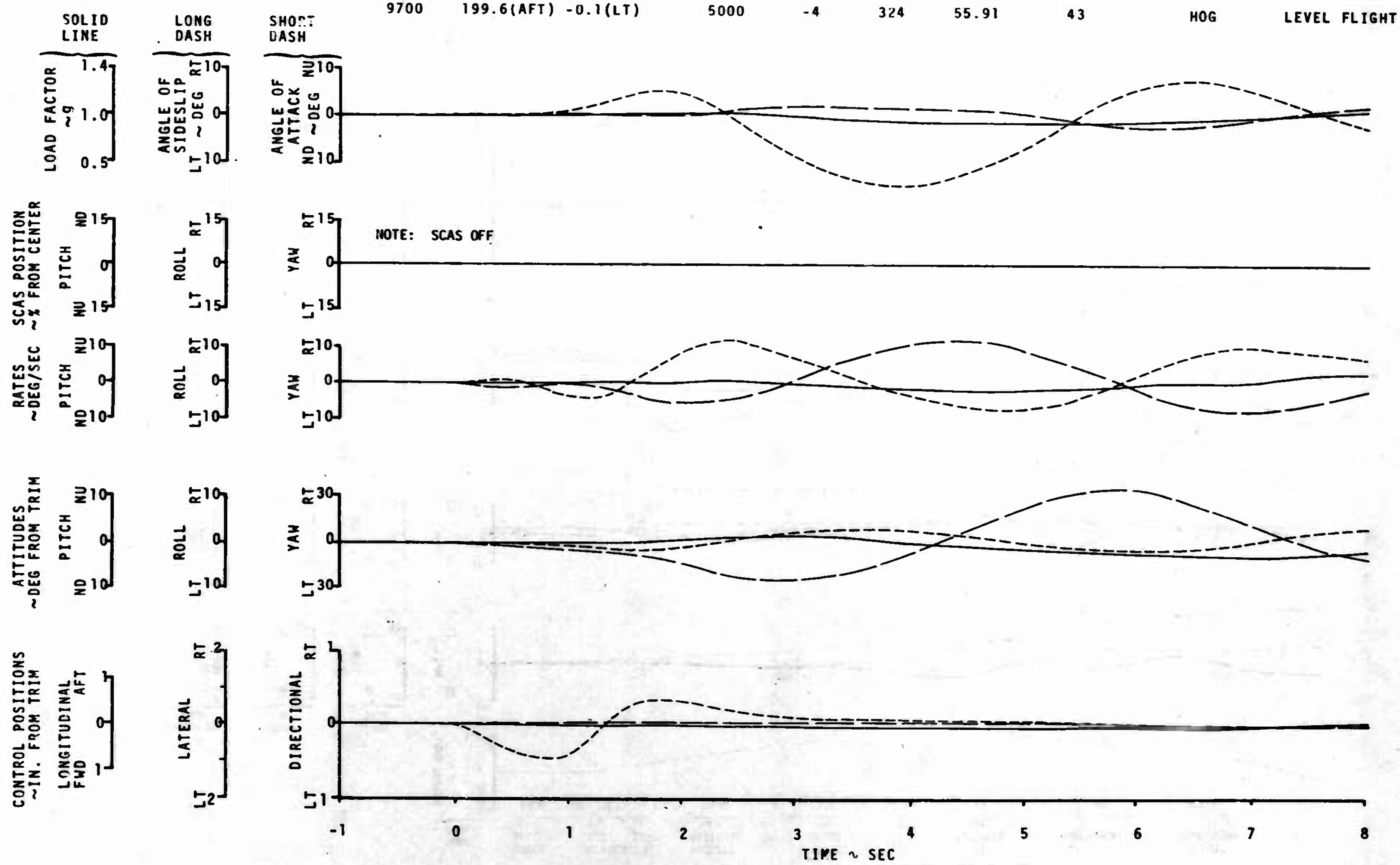


FIGURE 59
SIMULATED SCAS FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9970	199.4(AFT)	-0.1(LT)	4250	-6	324	56.17	63	HOG	CLIMB

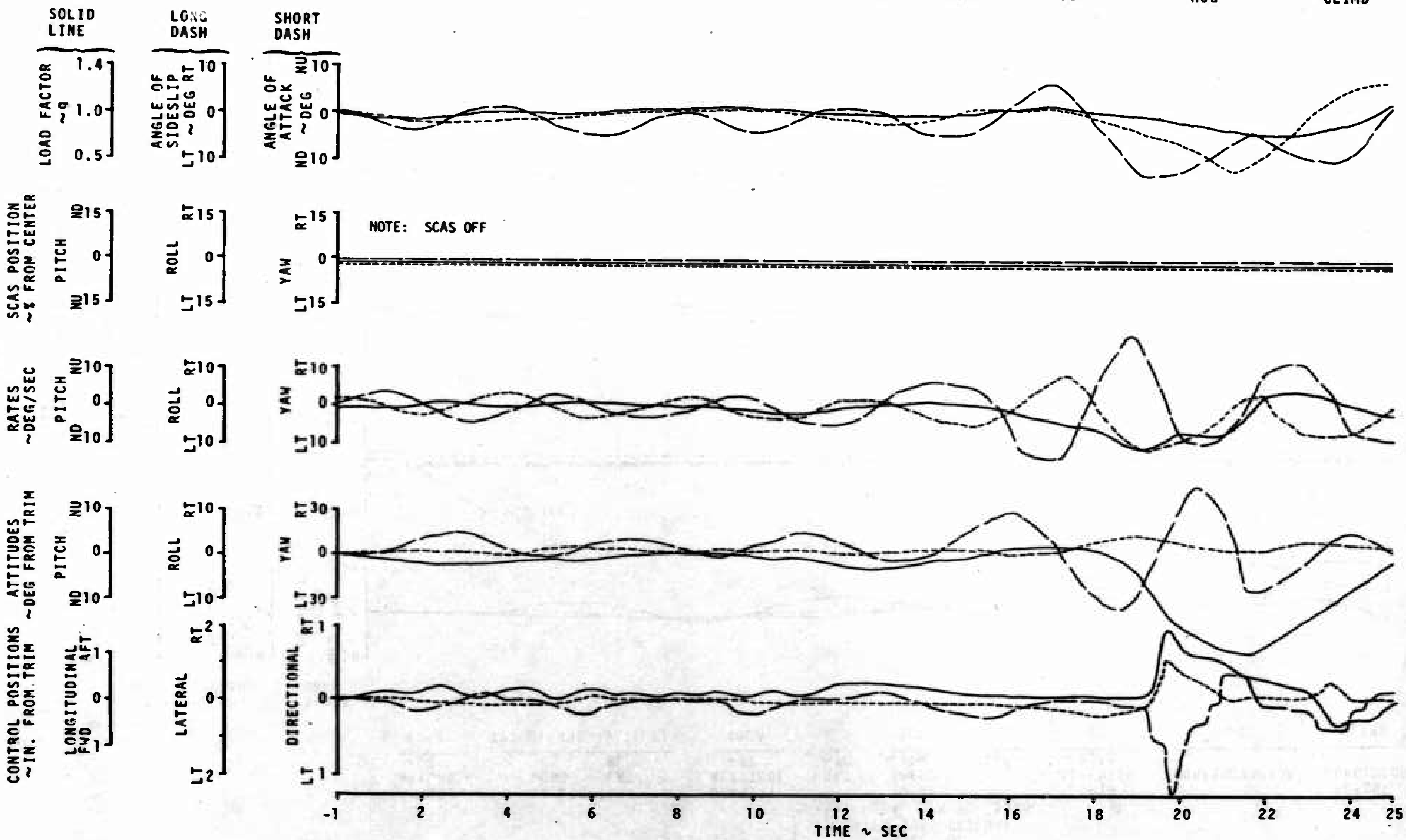


FIGURE 60
SIMULATED SCAS FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~KCAS	CONFIGURATION	FLIGHT CONDITION
9750	192.0(FWD)	-0.1(LT)	4000	17	324	54.52	61	HOG	CLIMB

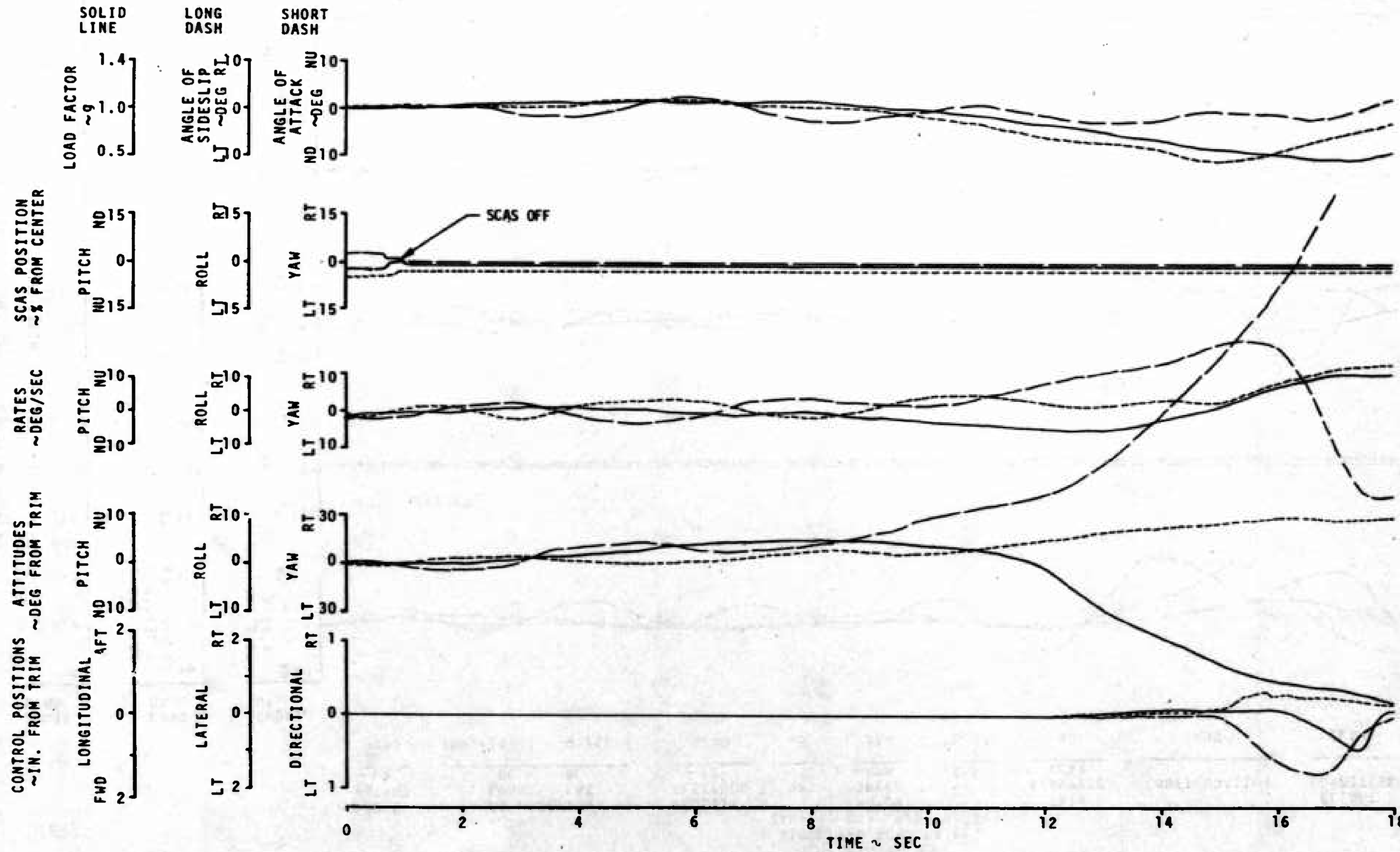
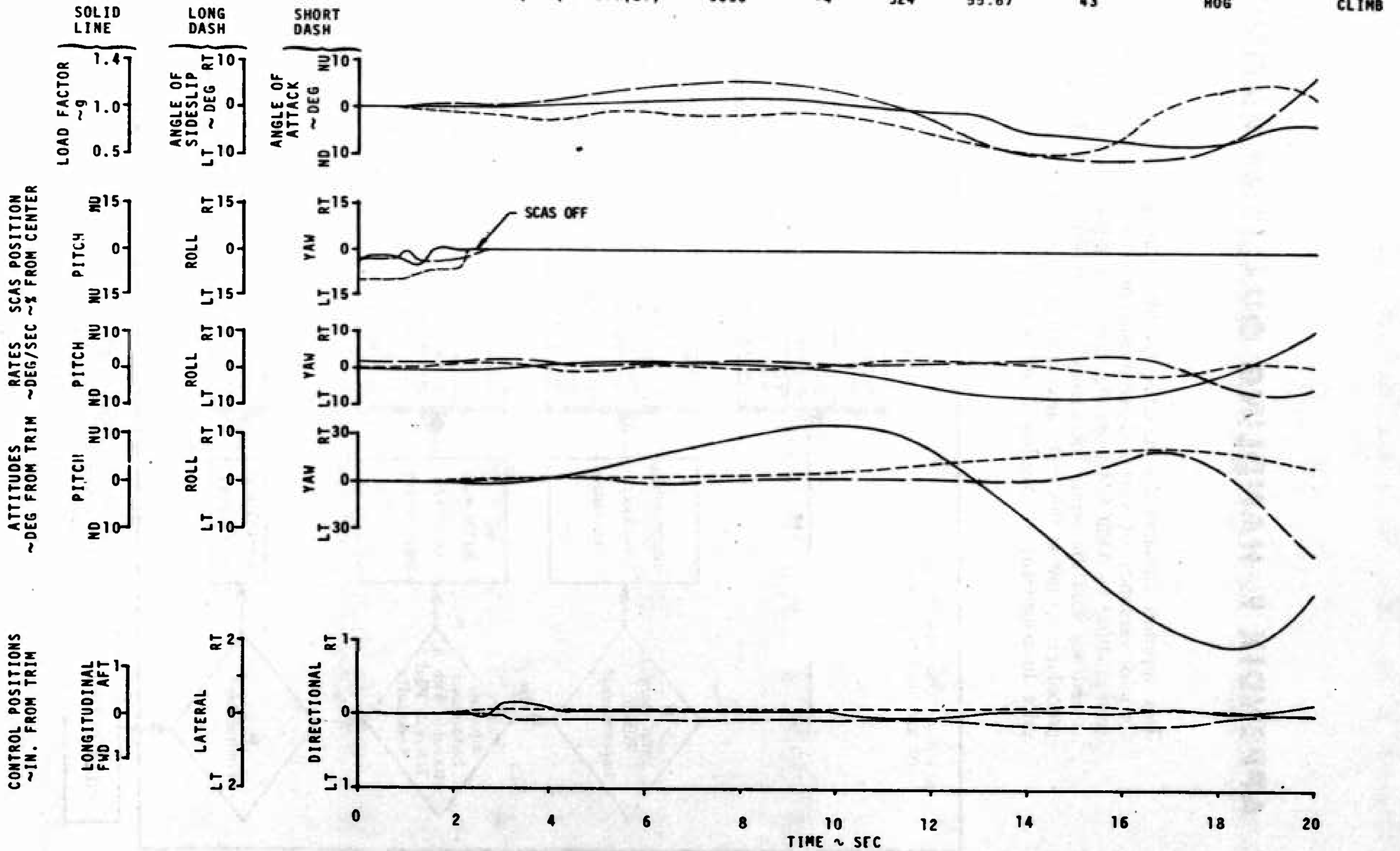


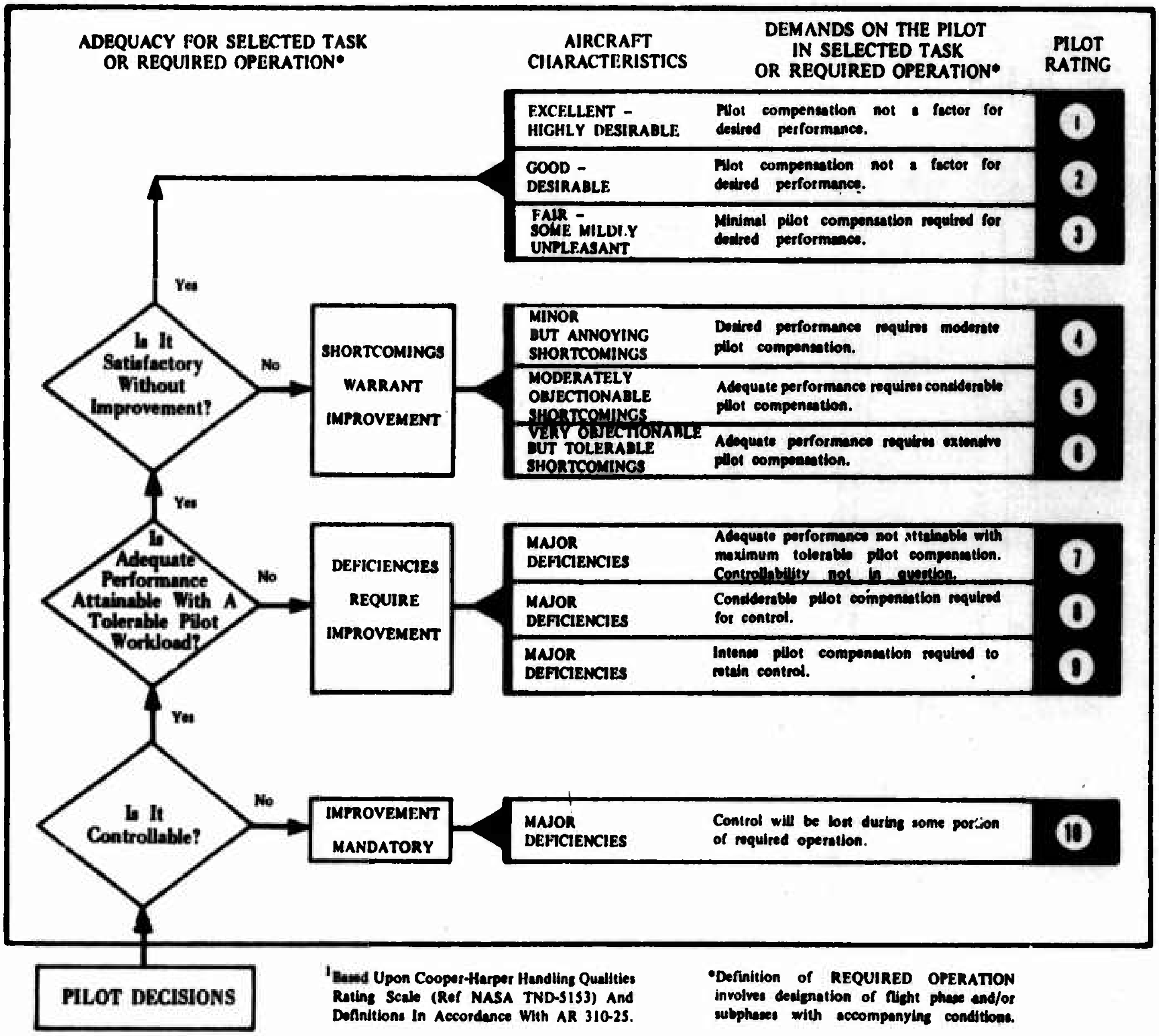
FIGURE 61
SIMULATED SCAS FAILURE
YAH-1R USA S/N 70-15936

GROSS WEIGHT ~ LB	CG LOCATION LONG FS	CG LOCATION LAT BL	DENSITY ALTITUDE ~ FT	OAT ~°C	ROTOR SPEED ~RPM	C_T x10^4	TRIM AIRSPEED ~ KCAS	CONFIGURATION	FLIGHT CONDITION
9660	199.6(AFT)	-0.1(LT)	5000	-4	324	55.67	43	HOG	CLIMB



APPENDIX F. HANDLING QUALITIES RATING SCALE

This appendix contains the Handling Qualities Rating Scale used by USAAEFA for pilot assessment of workload and mission-oriented tasks. The nomenclature has been modified by AVSCOM from that contained in NASA TN D 5153 to provide consistency with the terms "deficiency" and "shortcoming." The philosophy and procedures for use of this scale, as detailed in the NASA TN, must be understood prior to assignment of handling qualities ratings.



[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.

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US Army Test and Evaluation Command (AMSTE-BG, USMC LnO)	3
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Hq US Army Air Mobility R&D Laboratory (SAVDL-D)	2
US Army Air Mobility R&D Laboratory (SAVDL-SR)	1
Ames Directorate, US Army Air Mobility R&D Laboratory (SAVDL-AM)	2
Eustis Directorate, US Army Air Mobility R&D Laboratory (SAVDL-EU-SY)	2
Langley Directorate, US Army Air Mobility R&D Laboratory (SAVDL-LA)	2
Lewis Directorate, US Army Air Mobility R&D Laboratory (SAVDL-LE-DD)	1
US Army Aeromedical Research Laboratory	1
US Army Aviation Center (ATZQ-DI-AQ)	1
US Army Aviation School (ATST-AAP, ATST-CTD-DPS)	3
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US Army Transportation School	1
US Army Logistics Management Center	1
US Army Foreign Science and Technology Center (AMXST-CB4)	1
US Military Academy	3
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