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ARMY PRELIMINARY EVALUATION YAH-1Q HELICOPTER WITH
A FLAT-PLATE CANOPY

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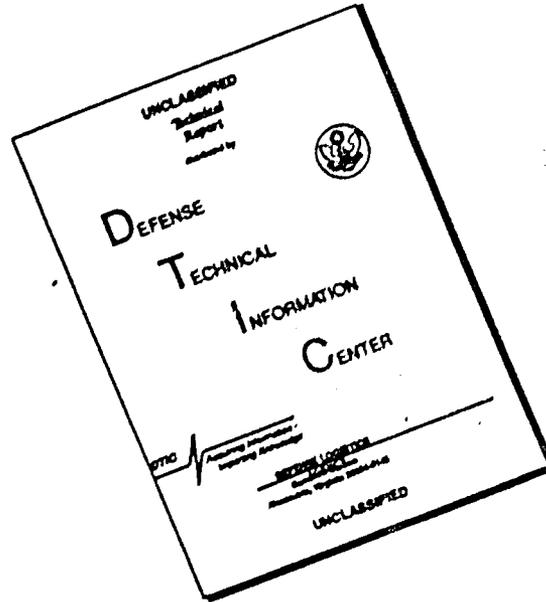
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ARMY PRELIMINARY EVALUATION YAH-1Q HELICOPTER WITH A FLAT PLATE CANOPY

FINAL REPORT

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
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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 a limited evaluation of the level flight performance and handling qualities of a YAH-1Q helicopter with a flat-plate canopy from 17 through 19 June 1975 at the Bell Helicopter Company flight test facility at Arlington, Texas. During the test program, eleven flights for a total of 4.4 productive hours were flown. A loss in maximum airspeed for level flight was determined when compared to the AH-1G (Bell (continued)		

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20. Abstract

Helicopter Company data indicate 5 to 7 knots). The primary effect of the flat-plate canopy on handling qualities was a noticeable decrease in directional stability. The one deficiency determined during the evaluation was the internal reflection from external light sources on the flat-plate canopy during night flight. Five shortcomings were noted during the evaluation. Further testing should be conducted to determine the effect of the decreased directional stability on the accuracy of rocket fire.

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INTRODUCTION

BACKGROUND

1. The Bell Helicopter Company (BHC) was tasked to conduct a feasibility flight test evaluation of an existing AH-1 series attack helicopter incorporating a flat-plate (antiglint) canopy. The purpose of the flat-plate canopy is to minimize sun reflections and thereby reduce the probability of visual detection. To meet this requirement, BHC designed, fabricated, installed, and tested a seven-plane canopy on a YAH-1Q helicopter (ref 1, app A). The United States Army Aviation Systems Command (AVSCOM) subsequently tasked the United States Army Aviation Engineering Flight Activity (USAAEFA) to conduct a limited Army Preliminary Evaluation (APE) of a YAH-1Q helicopter with a flat-plate canopy installed (ref 2).

TEST OBJECTIVE

2. The objective of this evaluation was to determine the feasibility of the flat-plate canopy installation and to determine if any adverse characteristics exist which would significantly complicate further airworthiness qualification of the system.

DESCRIPTION

3. The test helicopter, serial number 70-16019, was a production AH-1G helicopter that was modified with the improved Cobra armament system (ICAS) and redesignated the YAH-1Q. The YAH-1Q is a tandem, two-place single-lifting-rotor helicopter powered by a T53-L-13 turbine engine. Small tapered swept mid wings are provided with two hardpoint locations each for external stores. A detailed description of the AH-1G helicopter is included in the AH-1G operator's manual (ref 3, app A) and the supplement incorporating the ICAS (ref 4). The test helicopter was modified by installation of a seven-plane geometry (flat-plate) canopy. A more detailed description of the flat-plate canopy is contained in appendix B.

TEST SCOPE

4. A limited evaluation of level flight performance and handling qualities of the YAH-1Q helicopter with flat-plate canopy was conducted at the BHC flight test facility, Arlington, Texas, from 17 through 19 June 1975 by USAAEFA. Eleven test flights consisting of 6.2 total hours and 4.4 productive hours were conducted under the conditions listed in table 1. Additionally, two flights totaling 1.0 hour were flown in a standard AH-1G for comparison. Flight limitations contained in the operator's manual and the safety-of-flight release (ref 5, app A) were observed

Table 1. Test Conditions.¹

Test	Configuration ²	Average Density Altitude (ft)	Calibrated Airspeed (kt)	Remarks
Level flight performance and trim control positions	A	5250	63, 133, and 146	---
	B	4600	60, 103, and 113	---
Static longitudinal stability	A	6380	132	0.9V _H ³
	B	4960	102	
Static lateral-directional stability	A	5250	132	0.9V _H
	B	4620	102	
Maneuvering stability	A	5060	133	Turns, pull-ups, and pushovers
Dynamic stability	A	6220	132	0.9V _H
	B	4620	102	
Simulated engine failure	A	6920	106, 122, and 139	---
Field of view evaluation	A	2100	Approximately 40 to 100	NOE ⁴ , quick stops, pop-ups, deceleration and auto-rotational flares
Night visibility	Note ⁵	--	Hover to 130	---
V _{NE} ⁶ dive	A	3000	190	Buffet check
	B		170	

¹ Average rotor speed: 324 rpm; environmental control unit (ECU): OFF; stability and control augmentation system (SCAS): ON.

² Configuration A: Clean wing station; average gross weight: 7720 lb; average longitudinal center-of-gravity (cg) location: 201.5 in. (aft).

Configuration B: One M200 and four TOW missiles each wing (Hog); average gross weight: 9500 lb; average cg: 192.5 in. (fwd).

³ V_H: Maximum airspeed for level flight at maximum continuous power.

⁴ NOE: Nap of the earth.

⁵ Average gross weight: 7620 lb; average cg: 197 in. (mid).

⁶ V_{NE}: Never-exceed airspeed.

during this test. Handling qualities and simulated engine failure characteristics were evaluated with respect to the applicable requirements of military specification MIL-H-8501A (ref 6).

TEST METHODOLOGY

5. Standard engineering and flight test techniques were used during testing and data reduction (refs 7 and 8, app A). Flight test data were hand-recorded from sensitive, calibrated instrumentation and standard cockpit instruments and were recorded by two oscillographs. A detailed listing of the test instrumentation is contained in appendix C. Test methods are briefly described in applicable paragraphs of the Results and Discussion section of this report and in appendix D. Airspeed calibrations performed by BHC were used for this evaluation. A Handling Qualities Rating Scale (HQRS) (app D) was used to augment pilot comments relative to handling qualities. An AH-1G helicopter was flown for comparison of mission maneuvering characteristics. Due to insufficient data on the AH-1O (with standard canopy), test results were compared with AH-1G data (refs 9 and 10, app A).

RESULTS AND DISCUSSION

GENERAL

6. The evaluation of the YAH-1Q helicopter with a flat-plate canopy was performed to determine the effects of the canopy installation on level flight performance and handling qualities. Primary emphasis was on the high-speed flight regime to determine handling qualities and low-speed low-level flight to determine field of view. A loss in airspeed at V_H was determined when compared to the AH-1G (BHC data indicate 5 to 7 knots). The maneuvering and dynamic stability characteristics were essentially unchanged from the AH-1G. The primary effect of the flat-plate canopy (and the telescopic sight unit (TSU)) on the handling qualities was a noticeable decrease in directional stability. The one deficiency determined during the evaluation was the internal reflection from external light sources on the flat-plate canopy during night flight. Five shortcomings were noted during the evaluation.

LEVEL FLIGHT PERFORMANCE

7. Level flight performance of the YAH-1Q helicopter with a flat-plate canopy was checked in the clean and Hog configurations at the conditions listed in table 1. An AH-1G (without the TSU) was flown in similar stores configurations to determine performance degradation. The BHC data indicate airspeed reductions at V_H of 5 and 7 knots for the clean and Hog configurations, respectively. Within the limited scope of this evaluation, a reduction in V_H was confirmed. The degradation in level flight performance cannot be totally attributed to the flat-plate canopy, but rather to a combination of the flat-plate canopy and the TSU. Endurance and range degradation were not determined due to the limited scope of the evaluation.

HANDLING QUALITIES

Control Positions in Trimmed Forward Flight

8. Control positions in trimmed forward flight were investigated in conjunction with level flight performance testing. The results are presented in figures 1 and 2, appendix E, in conjunction with data obtained by BHC. In the clean configuration (fig. 1) the forward longitudinal control margin was less than 10 percent at V_H . This is a reduction of approximately 0.8 inch longitudinal control margin from the AH-1G at similar test conditions. The lack of sufficient longitudinal control margin was also evidenced during the static longitudinal and maneuvering stability tests (paras 9 and 14, respectively). The insufficient forward longitudinal control margin in the clean configuration (aft cg) at V_H is a shortcoming. The lack of

a 10-percent control margin fails to meet the requirements of paragraph 3.2.1 of MIL-H-8501A. Directional and lateral control position variation with airspeed were essentially the same as the AH-1G helicopter for both configurations.

Static Longitudinal Stability

9. Collective-fixed static longitudinal stability was evaluated for both configurations at the conditions listed in table 1. The helicopter was trimmed at a desired trim airspeed and then stabilized at slower and faster airspeeds while holding the collective control fixed. Test results are presented in figures 3 and 4, appendix E. In the clean configuration the longitudinal control margin was again noted to be less than 10 percent at the trim point of 133 knots calibrated airspeed (KCAS) ($0.9V_H$). In the clean configuration the helicopter exhibited neutral static longitudinal stability, as evidenced by the lack of variation of longitudinal control at stable airspeeds about trim. The static longitudinal stability gradient of the AH-1G is also neutral at similar test configurations, but at airspeeds in excess of 170 KCAS (ref 9, app A). In the AH-1G, the neutral static longitudinal stability was considered a shortcoming; however, during the limited evaluation of the YAH-1Q with a flat-plate canopy, the neutral static longitudinal stability was not objectionable. Airspeeds faster and slower than trim were attained and maintained without difficulty. The Hog configuration exhibited positive static longitudinal stability. The lack of positive static longitudinal stability in the clean configuration at $0.9V_H$ fails to meet the requirements of paragraph 3.2.10 of MIL-H-8501A.

Static Lateral-Directional Stability

10. Static lateral-directional stability characteristics were evaluated at the conditions listed in table 1. The tests were conducted by tracking a straight-line ground reference while stabilized at incremental sideslip angles. Control positions were recorded with the aircraft stabilized in steady-heading sideslips at the trim airspeed with the collective control fixed. Test results are presented in figures 5 and 6, appendix E.

11. For both configurations the helicopter exhibited positive directional stability (left pedal required during right sideslip). However, when the directional stability gradient of the YAH-1Q with a flat-plate canopy was compared to the AH-1G at similar test conditions, a significant loss in directional stability was evidenced (table 2). Both the flat-plate canopy and the TSU could contribute to the loss in directional stability but individual contributions cannot be determined from this test. The reduction in directional stability was qualitatively noted throughout the test, but was most noticeable in the clean configuration. During simulated attack dives in both configurations, considerable pilot compensation was required to maintain coordinated (ball-centered) flight, which is necessary for accurate delivery of 2.75-inch rockets (HQRS 5). The weak static directional stability is a shortcoming. Further testing should be conducted to determine the effect of the decreased directional stability on the accuracy of rocket fire.

Table 2. Static Directional Stability Comparison.¹

Parameter	Aircraft	Trim Calibrated Airspeed			
		51	121	132	134
$\frac{d\delta_{DIR^2}}{d\beta}$	AH-1G ³	.021	.104	.118	.120
	YAH-1Q (flat-plate canopy)	⁴ .017	⁴ .044	⁵ .060	⁴ .046

¹Clean configuration.

Cg location: 201.5 in. (aft); gross weight: 7720 lb.

²Change in pedal position (inches) per change in angle of sideslip (degrees).

³Data obtained from figure 69, USAASTA Report No. 66-06, Phase D, Part I (ref 9, app A).

⁴Data obtained from BHC Report No. 209-099-342 (ref 11).

⁵Data obtained from figure 6, appendix E.

12. The dihedral effect, as indicated by the variation of lateral control position with sideslip, was positive (left lateral control required to maintain left sideslip) and essentially linear in the Hog configuration (fig. 6, app E). In the clean configuration (fig. 5), the dihedral effect was positive with right sideslip angles and decreased to neutral with increasing left sideslip angles. The neutral dihedral effect with left sideslip angles was not objectionable. The dihedral effect of the YAH-1Q with a flat-plate canopy is essentially the same as the standard AH-1G.

13. The side-force characteristics, as indicated by the variation of bank angle with sideslip, were positive (left roll attitude required to maintain left sideslip) and essentially linear in both configurations (figs. 5 and 6, app E). The side-force characteristics of the YAH-1Q with a flat-plate canopy are essentially the same as the standard AH-1G.

Maneuvering Stability

14. Maneuvering stability characteristics were evaluated at the conditions listed in table 1. Steady turns (left and right), pushovers, and pull-ups were used to determine the variation of longitudinal control position and force with normal acceleration. The results are presented in figures 7 and 8, appendix E. The longitudinal control force characteristics were determined on the ground with rotors stopped and hydraulic and electrical power supplied by external sources. The longitudinal control force versus position characteristics about trim (fig. 9) were used in conjunction with in-flight measurement of longitudinal control positions to determine the longitudinal control forces during maneuvering stability tests. The

variation of longitudinal control position and control force with normal acceleration in the clean configuration was positive (aft control movement and pull force with increasing load factor) and essentially unchanged from the AH-1G. The change in the maneuvering stability gradient at 1.3g represents the limit of the longitudinal SCAS authority and normal accelerations above that load factor represent the basic helicopter (SCAS OFF) maneuvering stability. During pushover maneuvers to obtain normal accelerations less than 1.0g, the forward longitudinal control limit was reached. In the test configuration, insufficient forward longitudinal control margin was available to develop normal accelerations less than 0.75g. This characteristic amplifies the shortcoming discussed in paragraph 8.

Dynamic Stability

15. Longitudinal and lateral-directional dynamic stability characteristics were qualitatively evaluated at the conditions listed in table 1. Short-term dynamic characteristics, simulating gust response, were evaluated by 1-inch pulses and doublets in each control axis. The lateral-directional short-term dynamic characteristics were further evaluated by releasing the helicopter from steady-heading sideslips. The short-term dynamic characteristics for all axes were essentially deadbeat with no apparent change from the AH-1G.

16. Long-term dynamic characteristics were evaluated by returning the controls to trim after stabilizing at an airspeed 15 knots slower and 15 knots faster than the trim airspeed. The aircraft response following the return to trim was oscillatory and damped with a period of approximately 50 seconds. The YAH-1Q with a flat-plate canopy was qualitatively evaluated as being slightly less damped than the AH-1G but is satisfactory for the attack helicopter mission.

Simulated Engine Failure Characteristics

17. The response of the helicopter to a sudden engine failure was evaluated in forward flight at the conditions listed in table 1. Engine failure was simulated by rapidly rolling the throttle control to the flight-idle position. Flight controls were held fixed until (1) 2 seconds following the simulated power loss, (2) the minimum transient rotor speed (250 rpm) was reached, or (3) the pilot deemed recovery necessary. Test results for the YAH-1Q with a flat-plate canopy and data for the AH-1G at similar entry conditions are presented in table 3.

18. The test results indicate collective pitch control delay times were less than 2 seconds for entry power conditions above 34 psi. The large-magnitude roll and yaw attitude changes following the loss of power provided immediate cues which were detectable before rotor speed had approached the minimum rpm. Although the 2-second delay requirement of paragraph 3.5.5 of MIL-H-8501A could not be attained for high power conditions, they are consistent with the delay times observed for the AH-1G at similar entry conditions.

Table 3. Summary of Simulated Engine Failure Characteristics.¹

Aircraft	Entry Calibrated Airspeed (kt)	Entry Engine Torque (psi)	Recovery Delay Time ² (sec)	Yaw Rate (deg/sec)		Yaw Attitude Change at 1 Second ³ (deg)	Roll Rate at 1 Second ³ (deg/sec)
				at 1 Second ³	Maximum		
YAH-1Q (flat-plate canopy)	106	27	2.3	7.6	9.4	6.6	8.0
	122	34	1.2	8.8	10.0	8.5	14.8
	139	42	1.1	10.3	12.4	9.2	24.3
AH-1G ⁴	100	25	3.1	7.0	8.0	Note ⁵	Note ⁵
	100	30	3.0	7.2	9.4	Note ⁵	Note ⁵
	140	40	1.5	5.0	7.5	Note ⁵	19.7
	140	45	1.3	4.0	10.0	6.0	24.5

¹Clean configuration, aft cg.

²Recovery delay time: Time from power reduction until first control movement to initiate recovery.

³One second following power reduction.

⁴Data obtained from USAASTA Report No. 70-25 (ref 10, app A).

⁵Data not available.

19. A comparison of the roll and yaw characteristics following sudden loss of power for the YAH-1Q with flat-plate canopy and the AH-1G is also presented in table 3. The roll rates were similar for the two helicopters; however, the yaw rates observed during this test were higher than those noted for the AH-1G. At all airspeeds tested, the maximum yaw rates and the yaw rates at 1 second following power reduction were higher for the YAH-1Q with flat-plate canopy. This increase was more noticeable as airspeed increased. In addition to the larger peak yaw rates, the subsidence of the rates was much slower in the YAH-1Q with flat-plate canopy, resulting in larger yaw attitude changes at 1 second following power reduction. The increased yaw rates and yaw attitude changes following a sudden loss of power further substantiate the decrease in directional stability identified in paragraph 11.

FIELD OF VIEW

20. Field of view during NOE flight in the YAH-1Q with a flat-plate canopy was compared to the AH-1G. Both helicopters were flown over the same course and pilot and copilot/gunner comments were used to qualitatively evaluate the field of view. Although different canopy areas were used for the primary scan, the total field of view in the two helicopters was approximately the same. The flat-plate canopy had more areas obscured by the structural beams of the canopy, but it also provided more room for head movement, thus allowing view around the beams. During NOE flight at an aft cg (clean configuration), the location of the horizontal beam above the forward panel obscured the horizon. The area below this beam was obscured by the copilot/gunner's helmet, therefore the pilot was required to turn or sideslip the helicopter to determine the altitude necessary for obstacle clearance. Although this technique was adequate for the viewing of prominent obstacles (trees, buildings, etc.) it did not provide adequate field of view to spot less visible obstructions such as power lines. The lack of adequate forward field of view during NOE flight at an aft cg (clean configuration) is a shortcoming. For the mid and forward cg configurations, the horizontal beam was well below the horizon and the forward field of view was satisfactory.

21. Quick stops, deceleration flares, and pop-ups were performed from NOE flight to determine the field of view of the YAH-1Q with a flat-plate canopy. Compared to the AH-1G, the field of view was determined to be slightly improved during these maneuvers. Due to the expanded area for head movement, the downward field of view during flare provided improved reference for determining ground speed, aircraft attitude, and vertical descent/climb rates. Following a pop-up maneuver, the field of view was adequate to maintain a constant out-of-ground-effect (OGE) hover altitude to heights of approximately 200 feet.

22. Autorotational flares were also conducted to evaluate the field of view. As with quick stops and deceleration flares from NOE flight, the YAH-1Q flat-plate canopy provided a slightly improved downward field of view. Although the point of intended touchdown was not visible, the field of view was adequate for determining closure rate and altitude for collective pitch application.

23. A BHC-proposed alternate flat-plate canopy design, which would reduce side panel vibration by increasing the size of the lower panel structural member, was also evaluated for field of view during NOE flight, quick stops, flares, and pop-up maneuvers. For field-of-view evaluation purposes, the proposed design was simulated by installing panels over the lower portion of the pilot and copilot/gunner side panels (photos 1 and 2, app B). The reduced canopy area did not degrade field of view from the cockpit.

NIGHT VISIBILITY

24. The night visibility evaluation of the YAH-1Q helicopter with a flat-plate canopy was conducted on the ground during daylight with the canopy covered to simulate "black night" conditions and also during actual night flight. The field of view and visibility of the flat-plate canopy were compared to the standard AH-1G canopy for night operations.

25. The internal lighting and the reflections from instrument and panel lights were evaluated by covering the canopy to simulate "black night" conditions. A standard AH-1G and AH-1J were similarly covered for comparison. Although the areas where the reflections were noted differ, the overall reflection of internal lights of the YAH-1Q with a flat-plate canopy is essentially the same as the AH-1G. The only noticeable difference was that the rounded canopies caused blurred reflections whereas the flat-plate canopy caused mirror-like reflections. When compared to an AH-1J with the integral lighting system, both the AH-1G and YAH-1Q with a flat-plate canopy showed considerably more reflection of instrument and panel lights. The reflection of the instrument and panel lights in the flat-plate canopy during "black night" operations will reduce visibility and cause pilot distraction. The internal reflection of instrument and panel lights in the flat-plate canopy during night flight is a shortcoming.

26. The YAH-1Q flat-plate canopy was evaluated and compared to the AH-1G during actual night flight to determine the effects of external light sources on visibility. In areas of sparse ground lights the field of view and visibility were adequate; however, in areas of dense ground lights the mirror-like reflections in the flat-plate canopy significantly restricted visibility. The ground lights on one side of the helicopter were reflected off the opposite side panel. During level flight, the reflections restricted the pilot's and copilot/gunner's lateral visibility; however, the reflections did not significantly restrict the pilot's forward visibility through the copilot/gunner side panels. During banked turns, the reflections were visible by the pilot not only in his side panel, but also in the copilot/gunner's side panel and completely restricted visibility in the direction of turn. For example, on base leg during approaches to a lighted runway, the runway environment was consistently obscured by the reflection of external lights from the side of the helicopter opposite the runway. Additionally, the mirror-like reflections in the flat-plate canopy were easily confused with actual ground lights. During the night evaluation a moon prevented excessive reflection in the flat-plate overhead panels. However, it is anticipated that reflection of external lights in the overhead panels will further

restrict visibility during "black night" operations. In the battlefield environment, the inability of the pilot to immediately determine the source of ground lights, *ie*, ground fire, significantly reduces the survivability of the YAH-1Q with a flat-plate canopy during night operations. The internal reflection from external light sources on the flat-plate canopy during night flight is a deficiency.

CANOPY VIBRATIONS

27. The vibration characteristics of the flat-plate canopy were qualitatively evaluated throughout the test. Dives to VNE were accomplished in both configurations. During level flight and dives canopy side panel vibrations became noticeable at approximately 130 knots indicated airspeed (KIAS). The vibration of the canopy side panels increased during simulated engine failure tests and during dives to VNE. During the dives both the frequency and amplitude of vibration increased with increasing airspeed. Near VNE in the clean configuration (190 KIAS), the double amplitude of the vibrations was estimated to be 1/4 inch. The vibrations were not as pronounced in the Hog configuration at VNE (170 KIAS). No aircraft buffet was noted during the dives; however, the vibration of the canopy caused pilot distraction during precision flight tasks. The excessive vibration of the flat-plate canopy side panels at high airspeeds is a shortcoming.

ENGINE INLET DISTORTION

28. Engine inlet pressures were measured to determine inlet distortion. In the Hog configuration at VH (113 KCAS) an inlet distortion slightly in excess of the allowable 2 percent was determined. This measurement confirmed the inlet distortion found during the BHC tests. Results of the inlet pressure measurements are presented in table 4.

Table 9. Engine Inlet Pressures During Stabilized Level Flight.¹

Calibrated Airspeed (kt)	Pressure Altitude (ft)	Ambient Pressure (psi)	Differential Total Pressures Referenced to Ambient (iP) (psi)												Average iP All Probes (psi)
			Probe 1	Probe 2	Probe 3	Probe 4	Probe 5	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10	Probe 11	Probe 12	
112	3350	13.10	-0.265	-0.203	-0.223	-0.265	-0.145	-0.144	-0.330	-0.349	-0.353	-0.521	-0.279	-0.261	-0.279
2114.5	2000	13.66	-0.253	-0.198	-0.221	-0.267	-0.156	-0.138	-0.280	-0.359	-0.373	-0.474	-0.271	-0.262	-0.271
3121.5	2000	13.66	-0.278	-0.194	-0.232	-0.269	-0.177	-0.158	-0.310	-0.389	-0.320	-0.485	-0.287	-0.260	-0.280

¹Hog configuration.

Gross weight: 9500 lb.

Cg location: 92.5 in. (fwd).

Rotor speed: 324 rpm.

Density altitude: 4600 ft.

²Data obtained from BHC Report No. 209-099-342 (ref 11, app A).

CONCLUSIONS

GENERAL

29. The following conclusions were reached upon completion of the APE of the YAH-1Q helicopter with a flat-plate canopy:

a. Compared to the AH-1G, the following characteristics were noted:

(1) The V_H of the YAH-1Q with a flat-plate canopy and TSU is reduced (BHC data indicate 5 to 7 knots) (para 7).

(2) Dihedral effect is essentially unchanged (para 12).

(3) Side-force characteristics are essentially unchanged (para 13).

(4) Directional stability is reduced (paras 11 and 19).

(5) Maneuvering stability is essentially unchanged (para 14).

(6) Dynamic stability is essentially unchanged (paras 15 and 16).

(7) The downward field of view is slightly improved (para 21).

b. The field of view in the proposed alternate flat-plate canopy design is essentially the same as the basic flat-plate canopy (para 23).

c. One deficiency and five shortcomings were noted.

DEFICIENCY AND SHORTCOMINGS

30. The one deficiency identified during this evaluation was the internal reflection from external light sources on the flat-plate canopy during night flight (para 26).

31. The following shortcomings were identified:

a. Insufficient forward longitudinal control margin in the clean configuration (aft cg) at V_H (para 8).

b. Weak static directional stability (para 11).

c. Lack of adequate forward field of view during NOE flight at an aft cg lean configuration) (para 20).

d. Internal reflection of instrument and panel lights in the flat-plate canopy during night flight (para 25).

e. Excessive vibration of the flat-plate canopy side panels at high airspeeds (para 27).

SPECIFICATION COMPLIANCE

33. Within the scope of this test, the YAH-1Q helicopter with flat-plate canopy failed to meet the following requirements of MIL-H-8501A:

a. Paragraph 3.2.1 - Lack of a 10-percent forward longitudinal control margin in the clean configuration (aft cg) at V_H (paras 8 and 14).

b. Paragraph 3.2.10 - Lack of positive static longitudinal stability in the clean configuration at $0.9V_H$ (para 9).

c. Paragraph 3.5.5 - A 2-second controls-fixed delay not attained at high power settings in forward flight following a simulated engine failure (para 18).

RECOMMENDATIONS

33. The deficiency identified during this evaluation must be corrected to safely accomplish the attack helicopter mission (para 30).
34. The shortcomings should be corrected (para 31).
35. Further testing should be conducted to determine the effect of the decreased directional stability on the accuracy of rocket fire (para 11).

APPENDIX A. REFERENCES

1. Test Plan, Bell Helicopter Company, No. 209-947-255, *Model AH-1 Compensated Canopy Phase II Feasibility Flight Test Evaluation*, 16 May 1975.
2. Letter, AVSCOM, AMSAV-EQ, 14 June 1975, subject: Army Preliminary Evaluation of AH-1Q Flat Glass Canopy, USAAEFA Project No. 75-18.
3. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971.
4. Technical Manual, Supplement to, TM 55-1520-221-10, *AH-1G Operator's Manual Incorporating Improved Armament System*, 26 February 1973.
5. Letter, AVSCOM, AMSAV-EQ1, 16 June 1975, subject: Safety of Flight Release for USAAVSCOM/USAAEFA Project No. 75-18.
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. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance Testing*, 28 June 1968.
8. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.
9. Final Report, USAASTA Project No. 66-06, *Engineering Flight Test AH-1G (Hueycobra) Phase D Part I, Handling Qualities*, December 1970.
10. Final Report, USAASTA Project No. 70-25, *Engineering Flight Test AH-1G (Hueycobra) Helicopter Autorotational Entry Characteristics*, April 1971.
11. Final Report, Bell Helicopter Company Report No. 209-099-342, *Model AH-1 Compensated Canopy Flight Test Evaluation*, to be published.
12. Army Regulation, AR 310-25, *Dictionary of United States Army Terms*, March 1969.

APPENDIX B. AIRCRAFT DESCRIPTION

The test helicopter, serial number 70-16019, was a production AH-1G helicopter that was modified with an ICAS and redesignated a YAH-1Q. A detailed description of the AH-1Q is included in references 3 and 4, appendix A. The YAH-1Q was further modified by the installation of a seven-plane geometry (flat-plate) canopy. The flat-plate canopy is shown in the following figure and photographs.

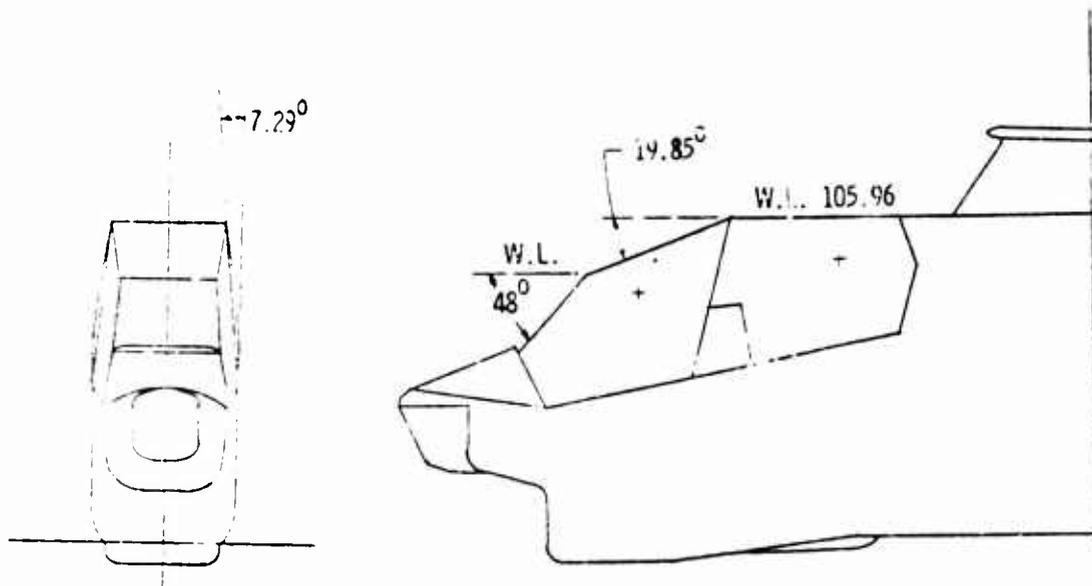


Figure 1. YAH-1Q with Seven-Plane Geometry (Flat-Plate) Canopy.



Photo 1. Right Front View, YAH-1Q Flat-Plate Canopy.
a. Alternate canopy configuration panels installed.
b. Telescopic sight unit.

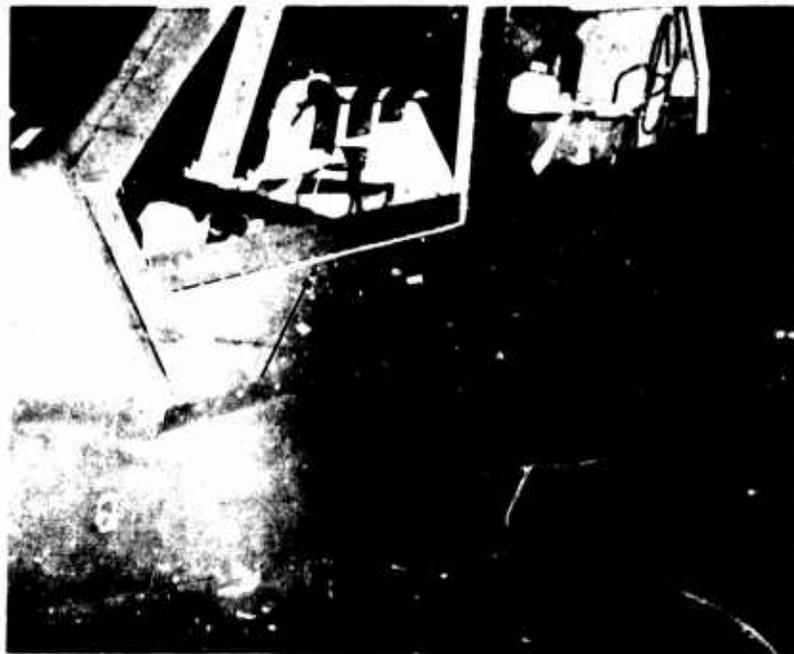


Photo 2. Left Front View, YAH-1Q Flat-Plate Canopy.
a. Alternate canopy configuration panels installed.

APPENDIX C. INSTRUMENTATION

1. The test instrumentation was installed, calibrated, and maintained by BHC. A test yaw boom connected to a sensitive sideslip indicator was installed at the nose of the aircraft. Data were obtained from calibrated instrumentation and displayed or recorded as indicated below.

Pilot Panel

Airspeed*
Altitude*
Fuel quantity*
Exhaust gas temperature*
Gas generator speed (N₁)*
Power turbine speed (N₂)*
Main rotor speed*
Main rotor speed (sensitive)
Control position:
 Longitudinal
 Lateral
 Directional
Angle of sideslip
Engine torque*

Copilot Panel

Airspeed*
Altitude*
Exhaust gas temperature*
Gas generator speed (N₁)*
Main rotor speed*
Outside air temperature (sensitive)
Engine torque*

Oscillograph No. 1

Gas generator speed (N₁)
Power turbine speed (N₂)
Main rotor speed
Engine torque
Center-of-gravity normal acceleration
Engine inlet pressure (12 probes)

*Standard ship's instrument

Oscillograph No. 2

Control position:

Longitudinal

Lateral

Directional

Collective

SCAS position:

Longitudinal

Lateral

Directional

Angle of sideslip

Attitude:

Pitch

Roll

Yaw

Rate:

Pitch

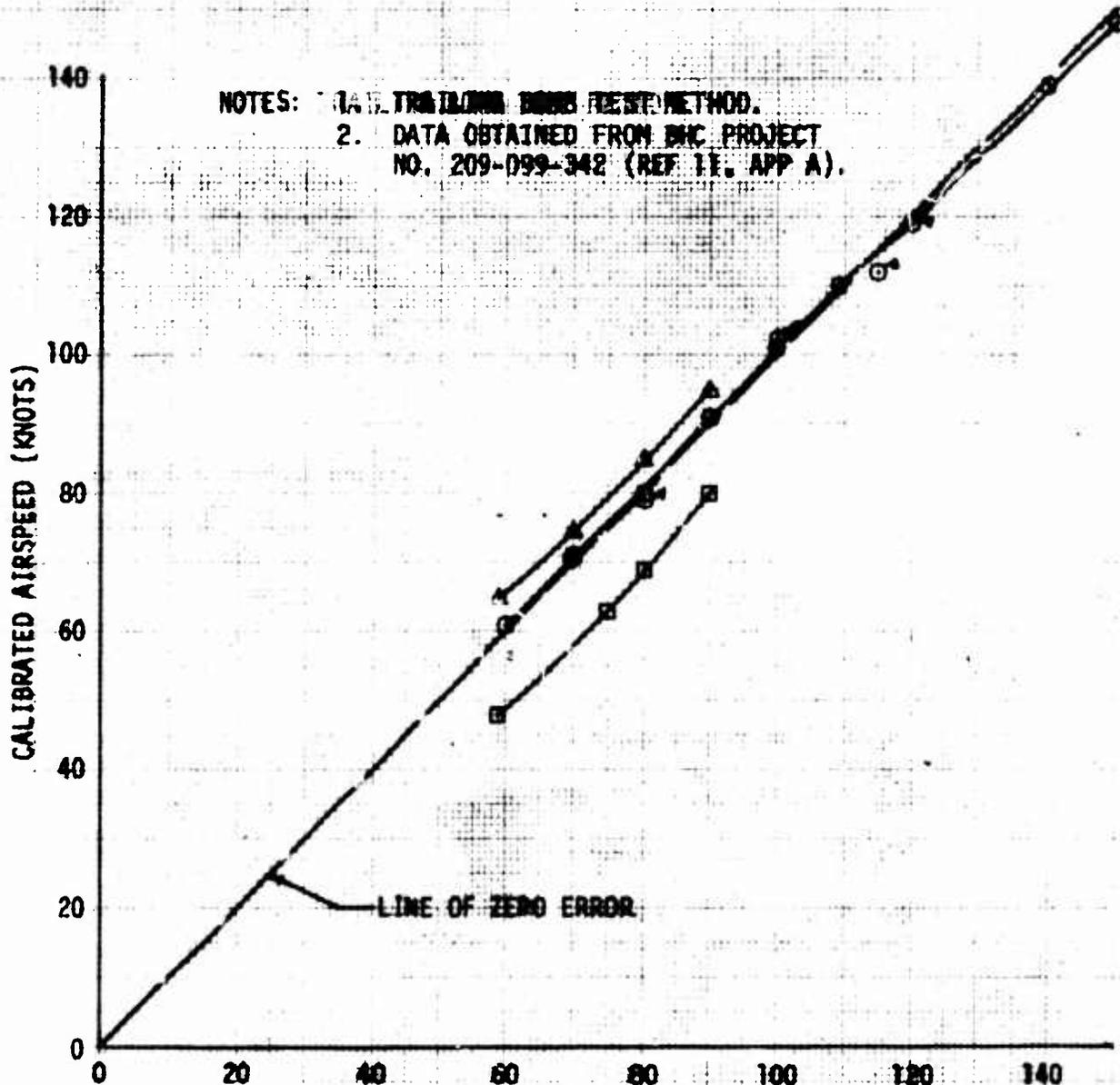
Roll

Yaw

2. The ship's standard airspeed system was calibrated by BHC using the trailing bomb method. Figure 1 presents the calibration.

FIGURE 1
AIRSPEED CALIBRATION
MM-18 USA S/N 70-10019
(FLAT-PLATE CROFT)
WEP'S STANDING SYSTEM

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION (IN.)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG MOTOR SPEED (RPM)	AVG CT	FLIGHT COND	CONFIGURATION
○	8000	201.5(AFT)	5500	18	324	0.004681	LEVEL	CLEAN
○	9500	192.5(FWD)	3000	20	324	0.004788	LEVEL	HOG
□	8000	201.5(AFT)	5500	18	324	0.004681	CLIMB	CLEAN
▲	8000	201.5(AFT)	5500	18	324	0.004681	AUTO	CLEAN



NOTES: 1. TRAILING WIRE METHOD.
 2. DATA OBTAINED FROM DMC PROJECT NO. 209-099-342 (REF 11, APP A).

INDICATED AIRSPEED CORRECTED FOR INSTRUMENT ERROR (KNOTS)

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

TEST TECHNIQUES

1. Conventional test techniques were used on both the performance and handling qualities tests. These techniques are briefly discussed in the body of this report and are outlined in more detail in references 7 and 8, appendix A.

DATA ANALYSIS METHODS

General

2. The helicopter was weighed by BHC after the installation of the test instrumentation. The fuel load for each test flight was determined prior to engine start, during flight, and following engine shutdown by hand-recording data from the standard ship's fuel quantity gage. Aircraft gross weight and cg location were controlled by ballast installed at various locations in the aircraft. An HQRS (fig. 1) was used to augment pilot comments relative to handling qualities. Definitions of deficiencies and shortcomings are as stipulated in AR 310-25 (ref 12, app A).

Level Flight Performance

3. The shaft horsepower (shp) required for level flight was determined from the following equation:

$$\text{SHIP} = \frac{N_e \times Q_E}{63025}$$

Where:

N_e = Power turbine speed (N_2) (rpm)

Q_E = Engine torque (inch-pounds)

63025 = Conversion factor

Note: Engine torque pressure indication in pounds per square inch was converted to true Q_E in inch-pounds by use of the ARADMAC engine test log.

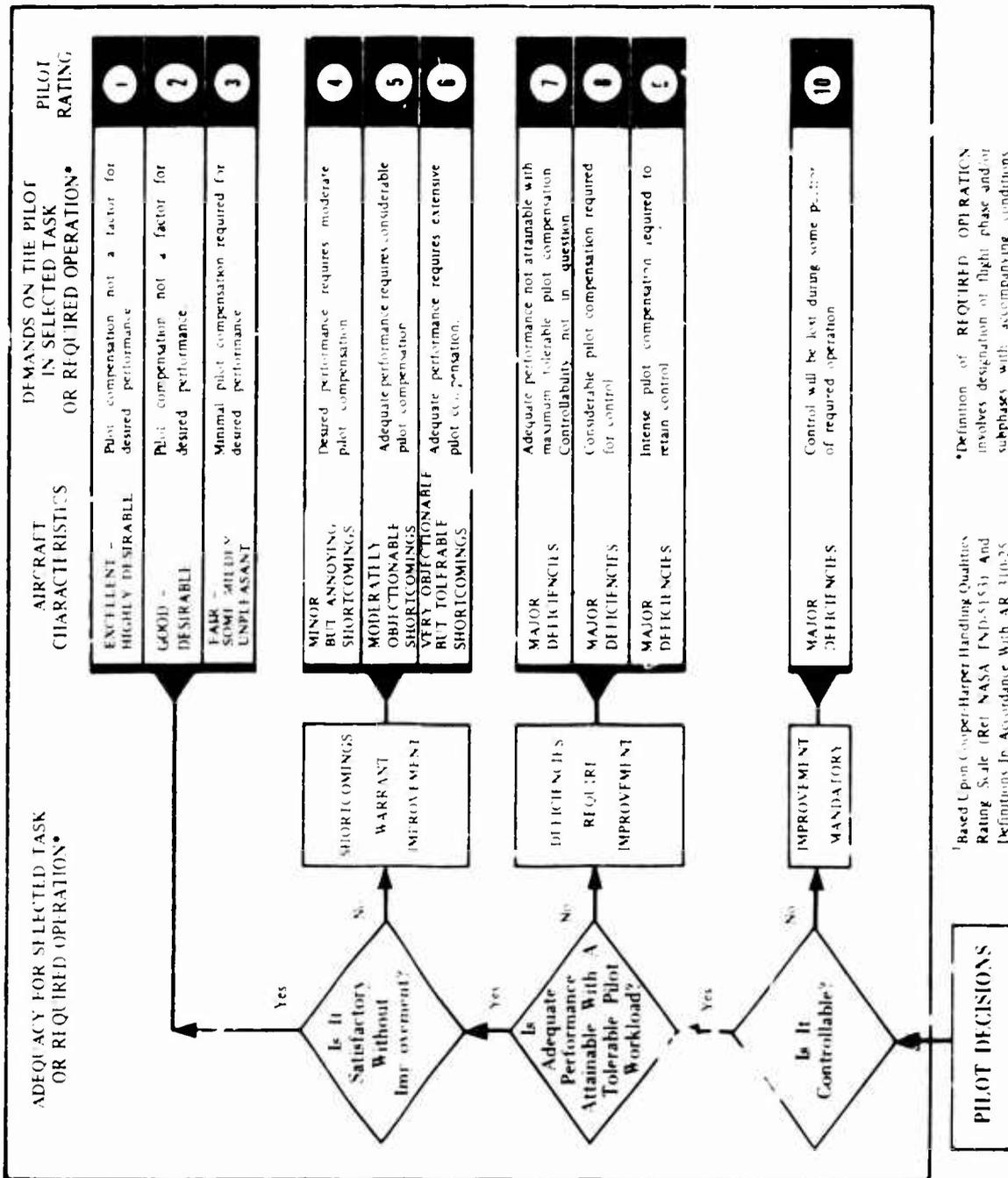


Figure 1. Handling Qualities Rating Scale.

Handling Qualities

4. Conventional data analysis techniques (ref 8, app A) were used to evaluate the aircraft handling qualities. These handling qualities data were also compared to the requirements of MIL-H-8501A and to previous AH-1G test data.

Simulated Engine Failures

5. Aircraft response to sudden engine failures was qualitatively evaluated using pilot comments. These characteristics were also quantitatively evaluated by data comparison with previous AH-1G test results and with the requirements in MIL-H-8501A.

Engine Inlet Distortion

6. The percentage distortion was determined from the ratio of the average differential pressure of all probes to the average inlet pressure. The average inlet pressure was determined by the sum of the ambient pressure and average differential pressure of all probes.

Miscellaneous

7. All other tests were qualitatively evaluated by direct comparison flights in an AH-1G and through the use of pilot comments.

APPENDIX E. TEST DATA

INDEX

<u>Figure</u>	<u>Figure Number</u>
Control Positions in Trimmed Forward Flight	1 and 2
Static Longitudinal Stability	3 and 4
Static Lateral-Directional Stability	5 and 6
Maneuvering Stability	7 and 8
Longitudinal Control System Characteristics	9

FIGURE 1
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1Q USA S/N 70-16019
(FLAT-PLATE CANOPY)

AVG. GROSS WEIGHT (LB)	AVG. C.G. LOCATION (IN)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	AVG. C_T	CONFIGURATION
7720	201.5(AFT)	5250	21.5	324	0.004483	CLEAN

NOTE: Curves obtained from Bell Helicopter Project No. 209-099-342 (ref 11, app A)

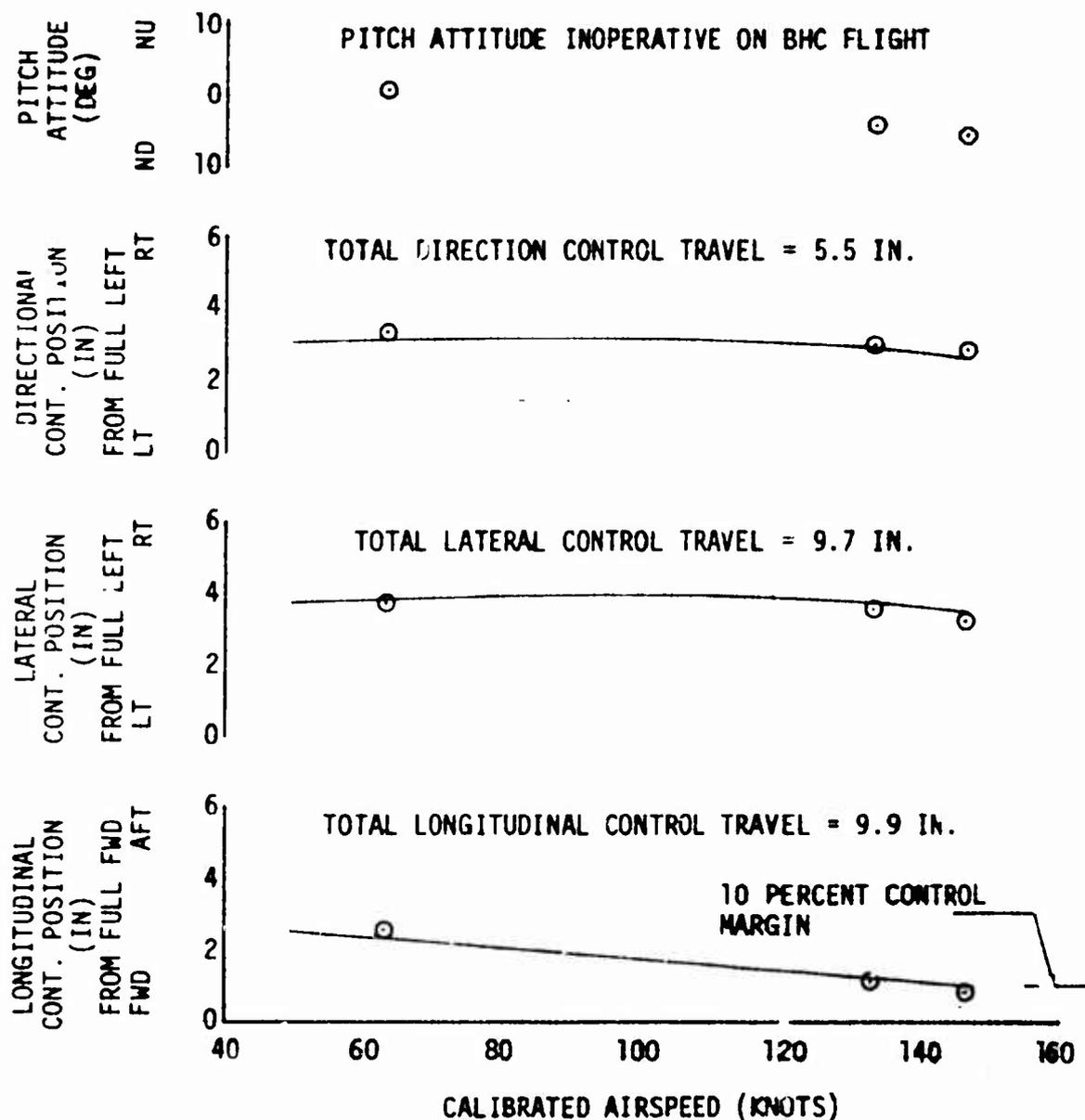
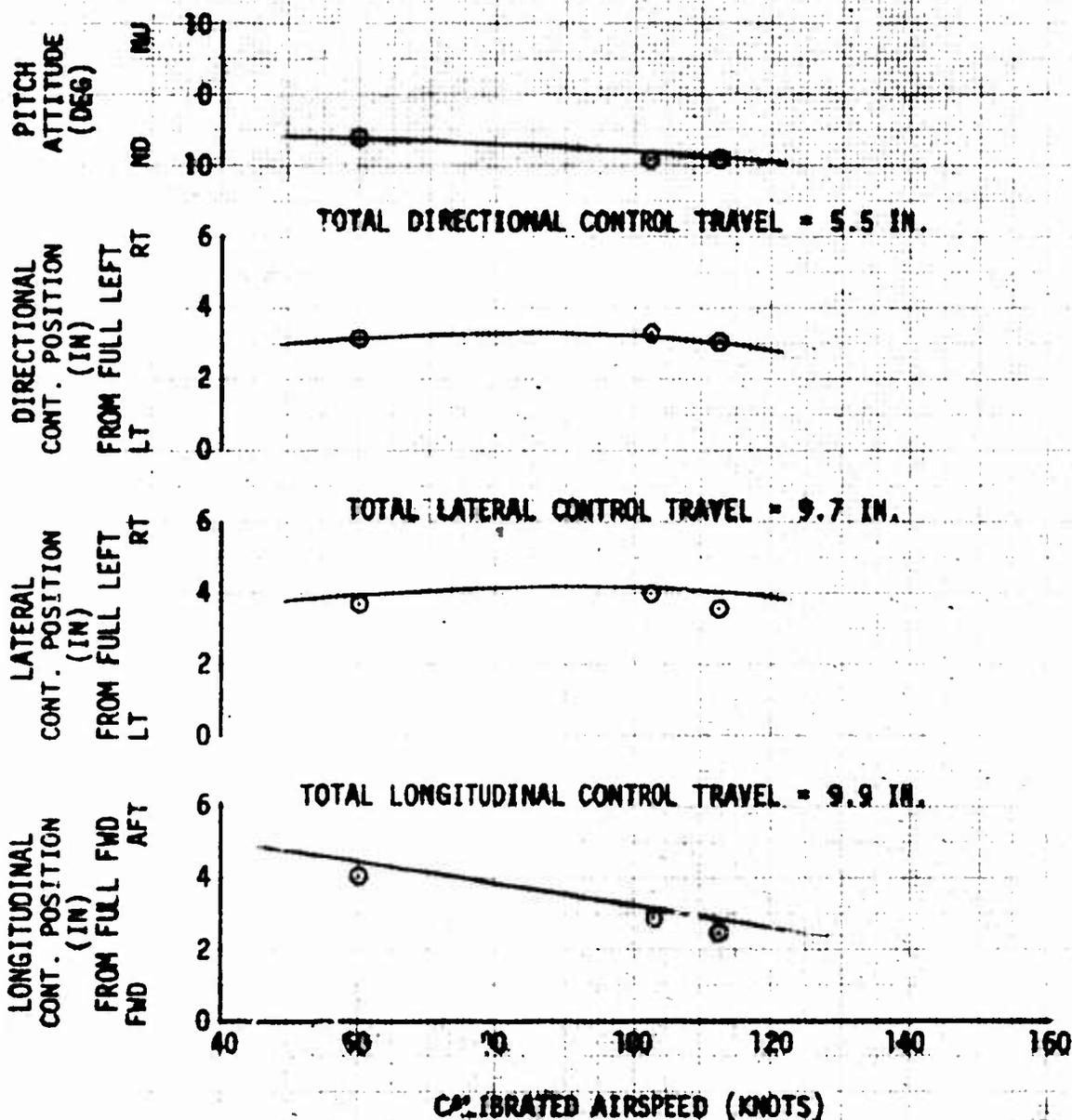


FIGURE 2
CONTROL POSITIONS IN TRAINED FORWARD FLIGHT
500-1000 RPM (100-120 KTS)
(FULL-PLANE CONTROL)

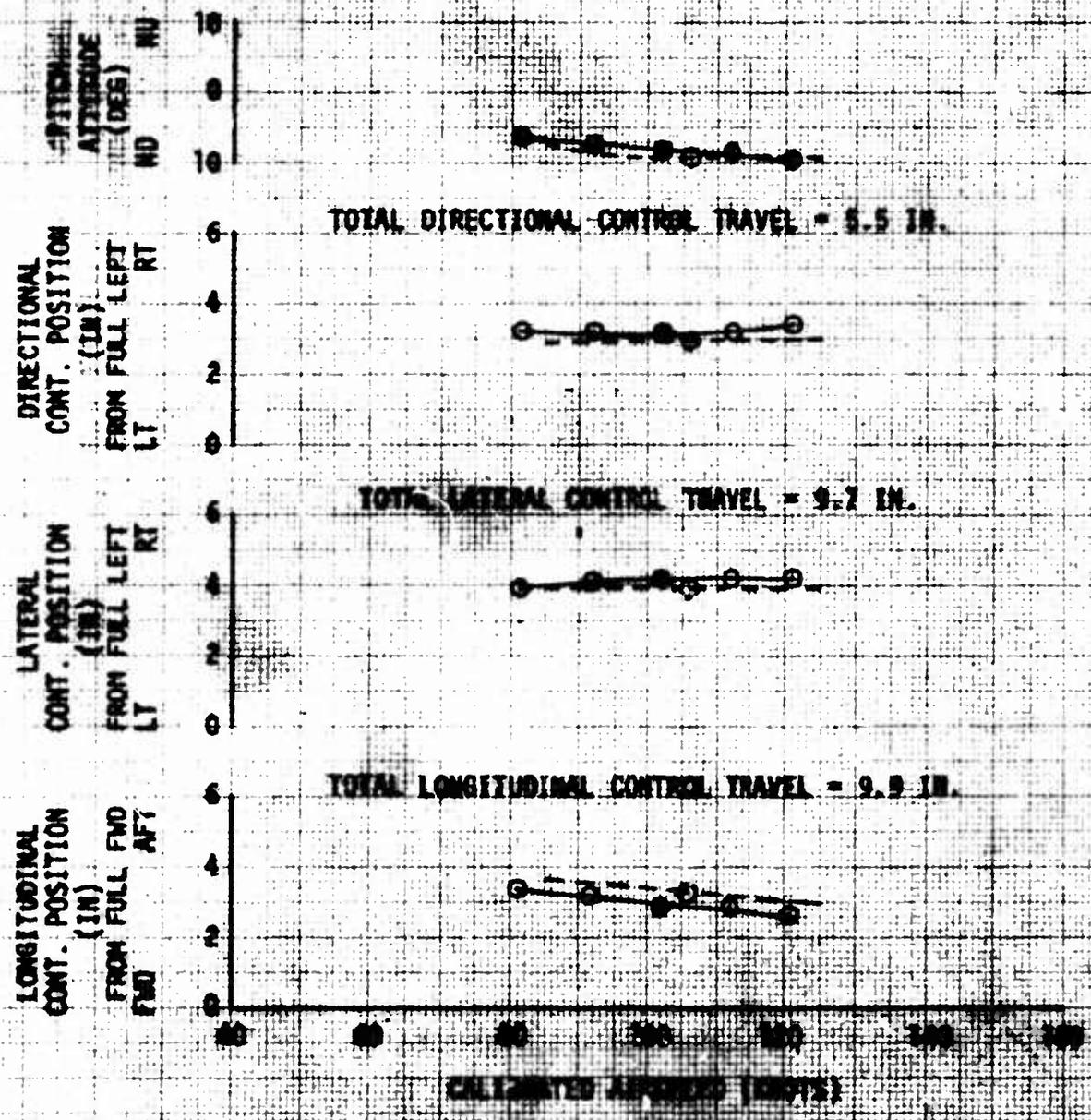
WEIGHT (LB)	AVG. C.G. LOCATION (IN)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	AVG. C_T	CONFIGURATION
95	192.8 (FWD)	4600	21.5	324	0.005886	MOS

NOTE: Curves obtained from Bell Helicopter
 Project No. 209-099-302 (ref TT, app A)



SECTION	STATION	DATE	TIME	WIND	CONDITION	REMARKS
58	192.5(100)	1960	21.5	7W	LEVEL	100

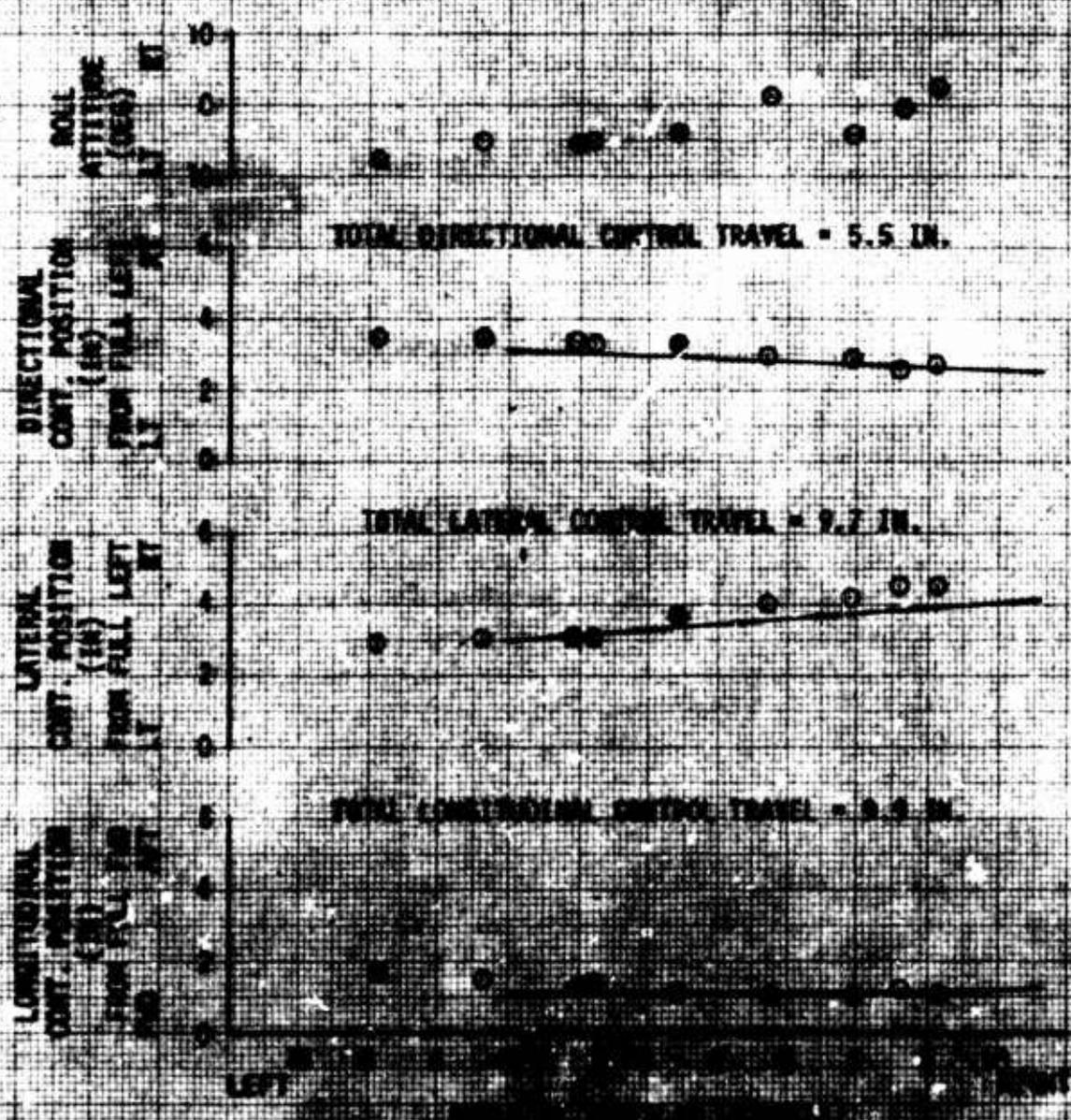
NOTE: 1) Dashed symbols denote data
 2) Dashed line and symbol denote data obtained from
 BNC Project No. 209-099-142



7750

7750

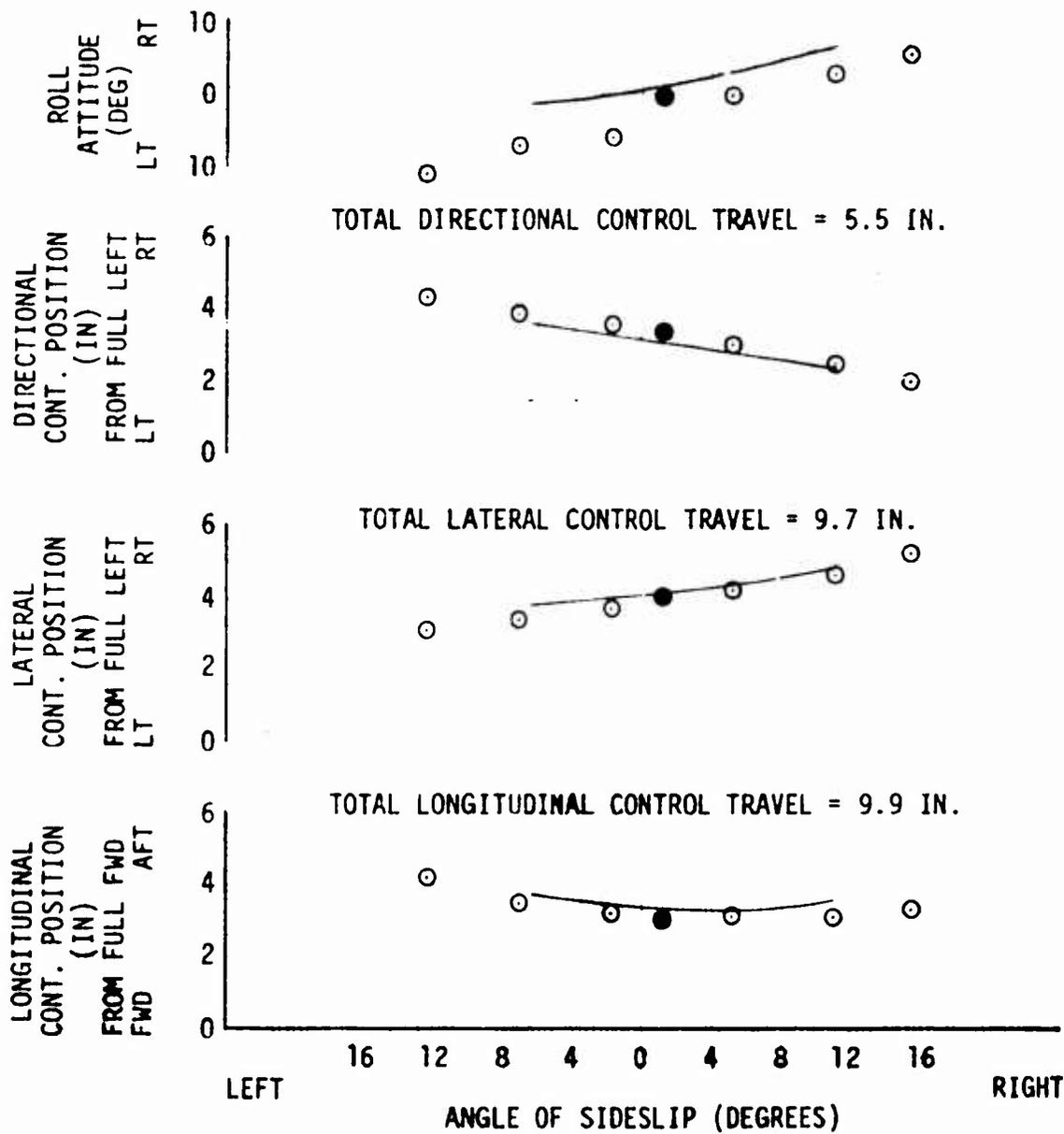
NOTE: 1) ...
2) ...



STATIC LATERAL - DIRECTION STABILITY
 YAH-1Q USA S/N 70-16019
 (FLAT-PLATE CANOPY)

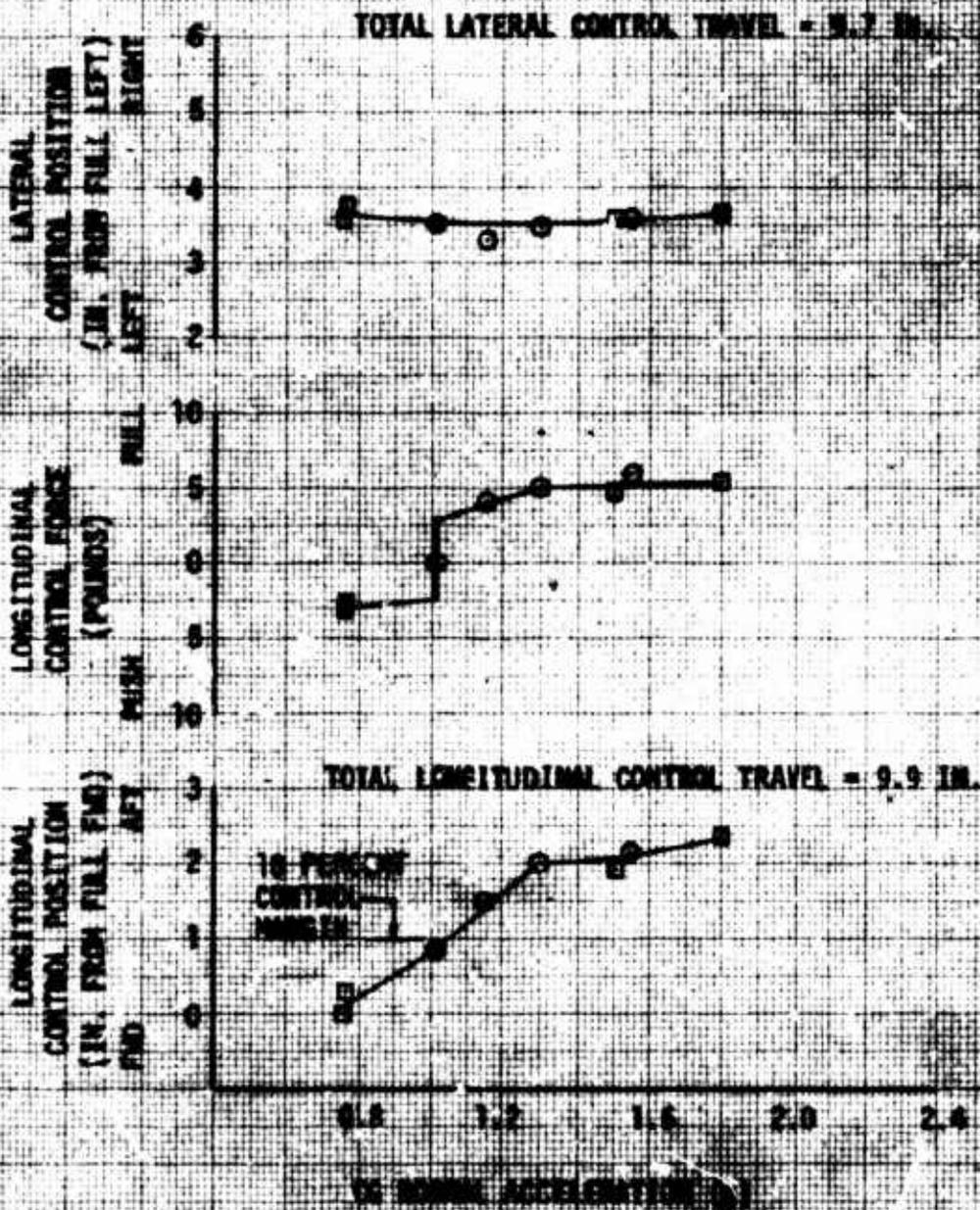
AVG. GROSS WEIGHT (LB)	AVG. C.G. LOCATION (IN)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	TRIM CALIB. A/S (KTS)	FLIGHT CONDITION	CONFIGURATION
9500	192.5(FWD)	4620	21.5	324	102	LEVEL	HOG

NOTE: 1) Shaded symbols denote trim
 2) Curves obtained from Bell Helicopter Project No. 209-099-342



AVG WEIGHT (LB)	NO OF LOCATIONS	NO OF ALTIMETER PTS	NO OF PTS	NO OF PTS	NO OF PTS	NO OF PTS	NO OF PTS
720	201.5(AFT)	8000	21.0	204	100.0	100.0	CLEAR

- NOTES:
1. SMOOED SYMBOLS DENOTE TEST
 2. LONGITUDINAL CONTROL FORCE DATA OBTAINED FROM FIGURE 9
 3. SQUARE SYMBOLS DENOTE SYMMETRICAL PUSH-OVER/PULL-UP



MANEUVERING STABILITY
YAH-1Q USA S/N 70-16019
(FLAT-PLATE CANOPY)

AVG GROSS WEIGHT (LB)	AVG CG LOCATION (IN.)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	ROTOR SPEED (RPM)	TRIM CALIB. A/S (KTS)	FLIGHT CONDITION	CONFIGURATION
7720	201.5(AFT)	5060	21.0	324	133.0	LEFT TURN	CLEAN

- NOTES: 1. SHADED SYMBOLS DENOTE TRIM
 2. LONGITUDINAL CONTROL FORCE DATA OBTAINED FROM FIGURE 9
 3. SQUARE SYMBOLS DENOTE SYMMETRICAL PUSH-OVER/PULL-UP

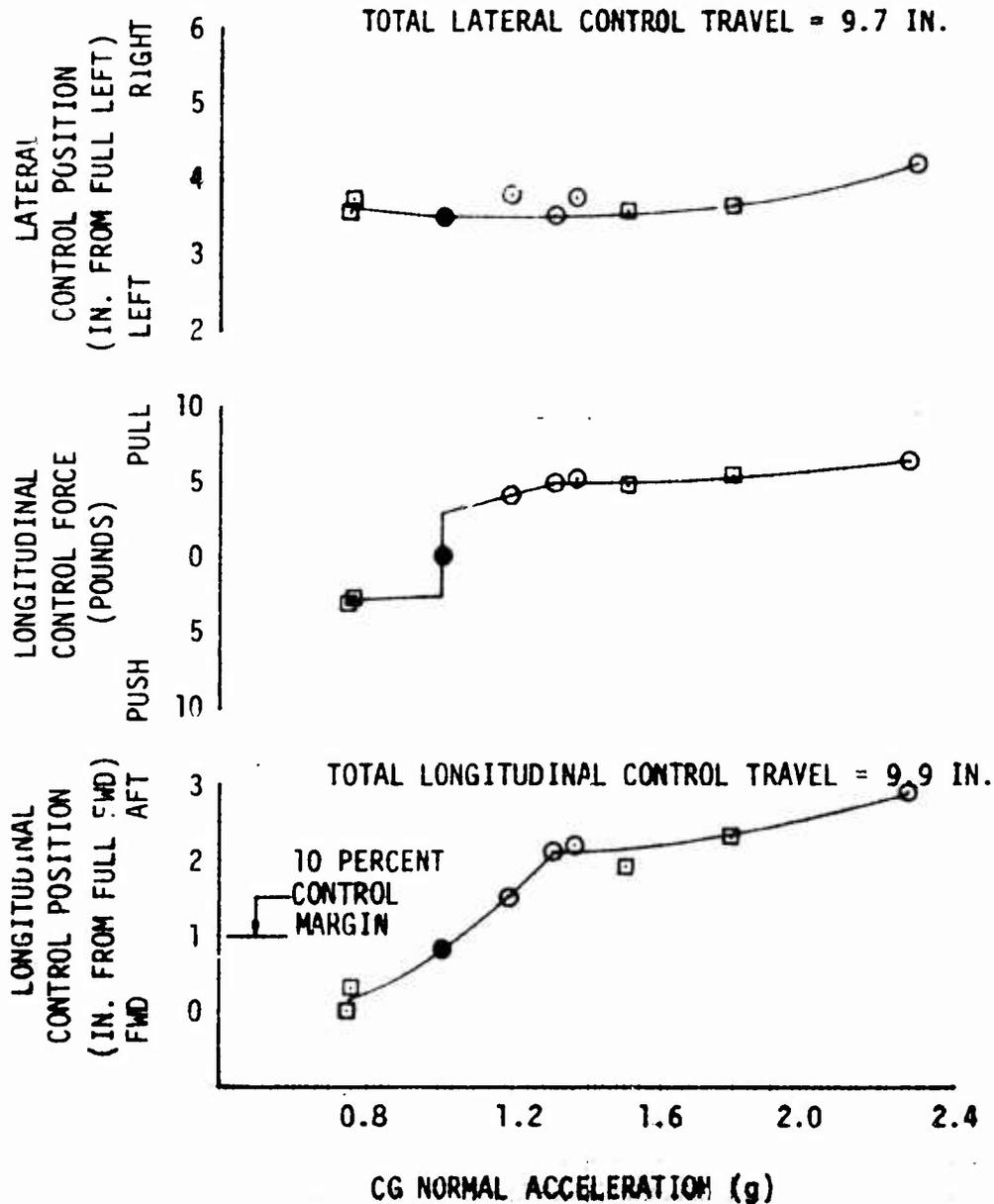


FIGURE 9
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAN-10 USA S/N 70-16019
(FLAT-PLATE CANOPY)

- 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 4.85 INCHES FROM FULL LEFT
 7. TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 9.9 INCHES
 8. FORCE TRIM ON
 9. HAND RECORDED DATA

