AD NUMBER
AD909933
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; OCT 1972. Other requests shall be referred to Army Aviation Systems Command, AMSAV-EF, PO Box 209, St. Louis, MO 63166.**
AUTHORITY
USAAVSCOM ltr, 12 Nov 1973

AD
RDTE PROJECT NO.
AVSCOM PROJECT NO. 72-12
USAASTA PROJECT NO. 72-12

ENGINEERING FLIGHT TEST
BOEING-VERTOL MODEL 347
ADVANCED TECHNOLOGY HELICOPTER

PHASE II

FINAL REPORT

ALTON G. STEINMETZ
PROJECT ENGINEER

CHARLES J. BOWERS
SP4
US ARMY
ENGINEER

ARLIN DEEL
LTC, CE
US ARMY
PROJECT OFFICER/PILOT

WILLIAM R. HORTON
MAJ, FA
US ARMY
PROJECT PILOT

OCTOBER 1972

Distribution limited to United States Government agencies only; test and evaluation, October 1972. Other requests for this document must be referred to the Commander, United States Army Aviation Systems Command, Attention: AMSAV-EF, Post Office Box 209, St. Louis, Missouri 63166.

UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

DISCLAIMER NOTICE

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

REPRODUCTION LIMITATIONS

DISPOSITION INSTRUCTIONS

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

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of the commercial hardware and software.

RDTE PROJECT NO.
AVSCOM PROJECT NO. 72-12
USAASTA PROJECT NO. 72-12

ENGINEERING FLIGHT TEST

BOEING-VERTOL MODEL 347 ADVANCED TECHNOLOGY HELICOPTER

PHASE II

FINAL REPORT

ALTON G. STEINMETZ
PROJECT ENGINEER

CHARLES J. BOWERS
SP4
US ARMY
ENGINEER

ARLIN DEEL
LTC, CE
US ARMY
PROJECT OFFICER/PILOT

WILLIAM R. HORTON
MAJ, FA
US ARMY
PROJECT PILOT

OCTOBER 1972

Distribution limited to United States Government agencies only; test and evaluation, October 1972. Other requests for this document must be referred to the Commander, United States Army Aviation Systems Command, Attention: AMSAV-EF, Post Office Box 209, St. Louis, Missouri 63166.

UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

ABSTRACT

The US Army Aviation Systems Test Activity conducted the Phase II technical evaluation of the Boeing-Vertol Model 347 winged helicopter during the period 3 through 11 April 1972. The Model 347 winged helicopter, a derivative of the CH-47 transport helicopter incorporating a variable incidence wing with normal acceleration load-sensitive flaps, was tested at the contractor's facility near Philadelphia, Pennsylvania. The evaluation was conducted to determine the improvements provided by addition of a wing system to a transport helicopter. Compliance with the provisions of military specification MIL-H-8501A was determined. Evaluations of the variable incidence wing system and the retractable landing gear system were also made. With the wing in the hover position, out-of-ground-effect hover performance of the Model 347 winged helicopter was similar to the unwinged aircraft. Both the winged and nonwinged Model 347 helicopter could hover out of ground effect using less power than could the CH-47C. Level flight performance at a heavy referred gross weight (54,000 pounds) was improved over both the nonwinged helicopter and the production CH-47C. Addition of the wing to the Model 347 helicopter did not significantly change the generally excellent handling qualities reported for the nonwinged version of the aircraft. The strong longitudinal stability exhibited by the aircraft reduced pilot workload in maintaining trim airspeed and pitch attitude. Only minimal trim changes in all control axes were required when transitioning between climbs or descents and level flight. The Model 347 winged helicopter failed to meet the requirements of five paragraphs of MIL-H-8501A. Twelve shortcomings were identified. The most significant of these shortcomings were the high pilot workload required to accomplish takeoffs and landings with the wing incidence control system functioning in the automatic mode, an excessive longitudinal oscillation in turns above 30-degrees angle of bank at 85 knots calibrated airspeed, the excessive sensitivity of rotor speed to thrust control rod position during autorotational flight, slippage of the thrust control rod at high power settings, and an excessive 8-per-revolution vibration during hover, approach to a hover, and in left sideward flight at 30 knots calibrated airspeed. The variable incidence wing and normal acceleration load-sensitive flaps installed on the Model 347 winged helicopter increased the accelerated flight capability of the aircraft. Stabilized turns in excess of a 60-degree angle of bank (2.0 load factor) were accomplished at all test airspeeds without overstressing the rotor or associated control system components. The retractable landing gear system reduced parasite drag and resulted in an airspeed increase of approximately 4 to 5 knots at indicated airspeeds above 120 knots. The advantages gained with the wing and the retractable landing gear are gained at the expense of increased weight and complexity.

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND

1. The Boeing-Vertol Model 347 helicopter is a derivative of the CH-47 helicopter used by the United States Army. The Model 347 was developed to demonstrate advanced concepts in tandem-rotor helicopter technology. The purpose of these advanced concepts was to achieve improvements in handling qualities, performance, vibration, and noise. Boeing-Vertol requested and received by bailment a CH-47A helicopter for use in this advanced technology program.

2. The technical evaluation program consisted of two phases, Phase I and Phase II, both of which were conducted by the United States Army Aviation Systems Test Activity (USAASTA) at the contractor's facility in Ridley Township, Pennsylvania. During Phase I, the basic airframe, rotor, and control system changes were incorporated, and testing was performed from 28 May to 19 June 1971. A reevaluation of the Phase I configuration was conducted 10 and 11 August 1971. The results of these tests are presented in the Phase I technical evaluation report (ref 1, app A). Following Phase I, the Model 347 was further modified with the addition of a high-mounted, variable incidence wing. Authority for the USAASTA Phase II evaluation was provided by a United States Army Aviation Systems Command (AVSCOM) test directive (ref 2). The test plan for conduct of the Phase II technical evaluation (ref 3) was prepared by USAASTA and approved by AVSCOM in March 1972.

TEST OBJECTIVE

3. The objective of this test was to evaluate the effects of a variable incidence wing on the handling qualities, performance, and vibrations of the Model 347 helicopter.

DESCRIPTION

4. The Boeing-Vertol Model 347 winged helicopter is a modified CH-47A helicopter, serial number 65-7992, manufactured by The Boeing Company, Vertol Division (Boeing-Vertol). The CH-47A is a twin-turbine-engine, tandem-rotor helicopter designed to provide air transportation of cargo and personnel. A description of the CH-47A is contained in the operator's manual (ref 4, app A). Although the basic airframe was originally a CH-47A, Boeing production tab number B-164, the aircraft had been updated to the CH-47C configuration by incorporation of all significant engineering changes applicable to the current production CH-47C. A description of the CH-47C is contained in the operator's manual (ref 5).

5. The Model 347 helicopter evaluated in Phase I incorporated major changes to the CH-47C configuration, including four-bladed rotors, a lengthened fuselage, increased aft pylon height, and retractable landing gear. The major change from the Phase I configuration is the addition of a variable incidence, high-mounted wing which incorporates full-span flaps. A general description of the Model 347 winged helicopter is contained in appendix B. Photographs of the test aircraft, including installed cockpit and cabin instrumentation, are presented in appendix C.

SCOPE OF TEST

6. The Model 347 winged helicopter was evaluated as a research vehicle to determine the effects of a wing on a large tandem-rotor transport helicopter. The evaluation of the Model 347 winged helicopter was accomplished in 12 flights for a total of 21 productive hours. Testing was conducted at the contractor's facility in Ridley Township, Pennsylvania (14-foot field elevation), and at Millville, New Jersey (87-foot field elevation), from 3 to 11 April 1972. Handling qualities, performance, and vibrations were evaluated for compliance with the applicable paragraphs of military specification MIL-H-8501A (ref 6, app A) and compared with the data obtained during Phase I testing (ref 1). Operating procedures and limitations were in accordance with the *Model 347 Demonstrator Pilot Manual* (ref 7), except as modified by the AVSCOM safety-of-flight release (ref 8). The Model 347 was tested at the conditions shown in appendix D.

7. Installation, calibration, and maintenance of the test instrumentation were performed by the contractor. Maintenance support and data reduction assistance were provided by the contractor. The test aircraft was weighed by the contractor prior to the start of the test program. Empty weight of the helicopter with all test instrumentation installed was 35,593 pounds, and the center of gravity (cg) was at fuselage station (FS) 384.5, 1.5 inches forward of the datum line between the rotors (FS 386.0).

METHODS OF TEST

8. Standard engineering flight test methods (refs 9 and 10, app A) were used to evaluate the handling qualities and performance of the Model 347 winged helicopter. These test methods are described briefly in the Results and Discussion section of this report. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app E). A detailed list of the test instrumentation used in the Model 347 winged helicopter evaluation is contained in appendix F. Details of uncommon stability and control data reduction techniques utilized are described in appendix G.

CHRONOLOGY

9. The chronology of the Phase II Model 347 winged helicopter technical evaluation is as follows:

Test directive received	10 March 1972
Test aircraft received	31 March 1972
Test started	3 April 1972
Test completed	11 April 1972
Contractor debriefed	17 April 1972

RESULTS AND DISCUSSION

GENERAL

10. Evaluations of performance, handling qualities, and vibrations were conducted to determine characteristics of the Model 347 helicopter following installation of the variable incidence wing. Results of these evaluations were compared with the characteristics of the Phase I Model 347 without wing and the CH-47C production helicopter. With the wing in the hover position, out-of-ground-effect hover performance of the Model 347 winged helicopter was similar to Phase I, and both the winged and nonwinged Model 347 helicopter could hover out of ground effect more efficiently than the CH-47C. Level flight performance at a heavy referred gross weight (54,000 pounds) was improved over both the Phase I nonwinged aircraft and the CH-47C. Addition of the wing to the Model 347 helicopter did not significantly alter the generally excellent handling qualities reported in Phase I. The strong longitudinal stability exhibited by the aircraft reduced pilot workload in maintaining trim airspeed and pitch attitude. Only minimal trim changes in all control axes were required when transitioning between climbs or descents and level flight. Longitudinal and lateral trim changes during extreme power excursions were very small. The Model 347 winged helicopter failed to meet the requirements of five paragraphs of MIL-H-8501A. Ten handling quality shortcomings were identified. The most significant of these shortcomings were the high pilot workload required to accomplish takeoffs and landings with the wing incidence control system functioning in the automatic mode, excessive longitudinal oscillation in turns above a 30-degree angle of bank at 85 knots calibrated airspeed, excessive sensitivity of rotor speed to thrust control rod position during autorotational flight, and slippage of the thrust control rod at high power settings. Two vibration shortcomings were noted. Correction of all shortcomings is desirable for improved operation and mission capability. The variable incidence wing and normal acceleration load-sensitive flaps installed on the Model 347 winged helicopter increased the accelerated flight capability of the aircraft. Stabilized turns in excess of a 60-degree angle of bank (2.0 load factor) were accomplished, both left and right, at all test airspeeds without overstress of the rotors or associated control system components. The retractable landing gear system reduced profile drag and resulted in an airspeed increase of approximately 4 to 5 knots at indicated airspeeds above 120 knots. The advantages achieved with the wing and the retractable landing gear are gained at the expense of increased weight and complexity.

PERFORMANCE

General

11. A limited evaluation of the hover, level flight, climb, and autorotational descent performance of the Model 347 winged helicopter was conducted to evaluate

the performance effects of adding the wing to the aircraft. With the wing in the hover position, out-of-ground-effect hover power requirements were similar to the Phase I test results, and both the winged and nonwinged Model 347 helicopters could hover out of ground effect more efficiently than the CH-47C production helicopter. Level flight performance at the light referred gross weight (42,000 pounds) was essentially identical to the Phase I test results. At the heavy referred gross weight (54,000 pounds), level flight performance of the Model 347 winged helicopter was superior to both the Phase I nonwinged aircraft and the CH-47C. At forward flight airspeeds above 120 knots, drag produced by the extended landing gear reduced indicated airspeed approximately 4 to 5 knots. Climb performance was slightly improved over the CH-47C production helicopter. With the wing in the autorotation position autorotational descent performance of the Model 347 winged helicopter was about the same as that determined for the CH-47C helicopter.

Hover Performance

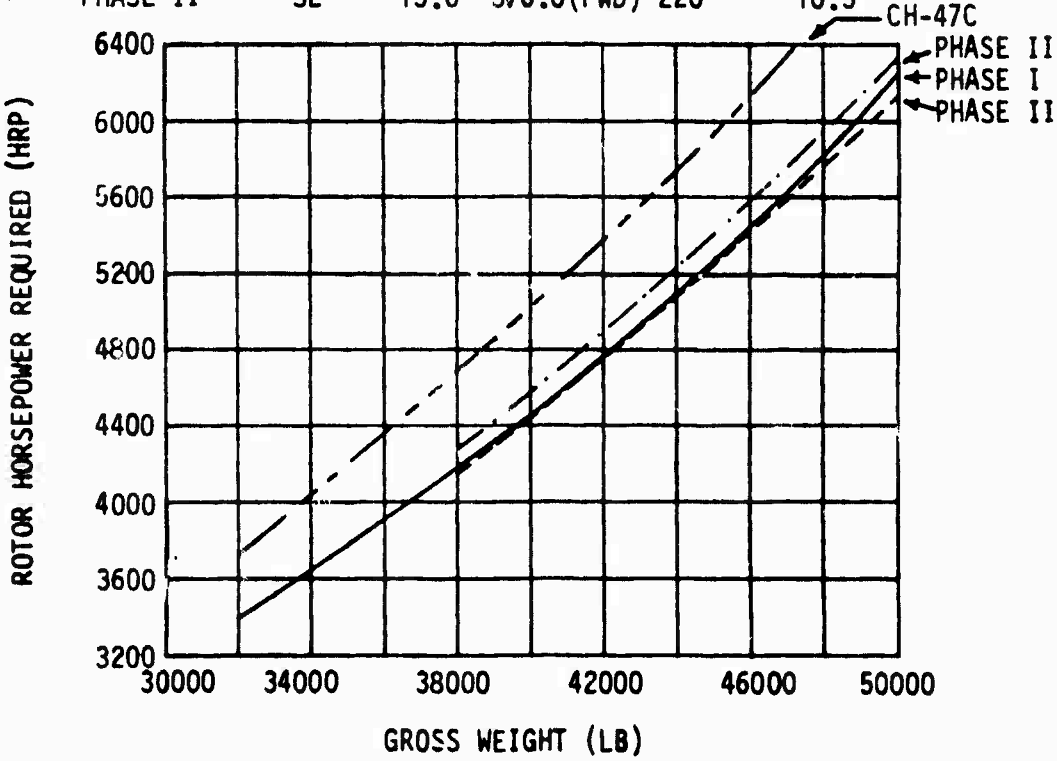
12. Out-of-ground-effect (OGE) hover testing was accomplished at the conditions listed in appendix D using a 150-foot tether line anchored to a concrete deadman. A direct-reading, calibrated load cell was used to measure cable tension. The test was conducted by stabilizing in hover at constant engine torque values up to the engine gas producer speed (N_1) limit and at a constant referred rotor speed ($N/\sqrt{\theta}$) of 220 rpm. Additional data were recorded at high and low referred rotor speeds of 235 and 216 rpm at the minimum and maximum aircraft gross weights. These tests were conducted with the wing in both the cruise (10.5-degree wing incidence) and hover (85-degree wing incidence) positions. The results of these tests are presented nondimensionally in figures 1 and 2, appendix H.

13. Figure A presents a comparison of the OGE hover performance for Phase I, Phase II, and the CH-47C (T55-L-11A engines) in terms of rotor horsepower required (shaft horsepower minus 180 horsepower for transmission and drive train losses). The OGE hover power requirements for the Phase I and Phase II Model 347 helicopter were similar. With the wing in the cruise position compared to the hover position, there was an approximate 2-percent reduction in gross weight capability. The Model 347 winged helicopter (Phase II) and the Model 347 nonwinged version (Phase I) could hover OGE at a higher gross weight than the CH-47C production helicopter. The test data indicate that with the wing in the hover position, the Model 347 winged helicopter could hover OGE at a higher gross weight than the Phase I nonwinged Model 347 at the same rotor horsepower (rhp). There was no reason determined for this unexpected characteristic.

FIGURE A

OUT-OF-GROUND EFFECT HOVER PERFORMANCE COMPARISON

LEGEND	DENSITY ALTITUDE (FT)	OAT (°C)	CG (IN.)	STANDARD ROTOR SPEED (RPM)	WING INCIDENCE (DEG)
— ·· — CH-47C	SL	15.0	331.0(MID)	245	N/A
——— PHASE I	SL	15.0	363.5(FWD)	220	N/A
- - - - - PHASE II	SL	15.0	376.0(FWD)	220	85.0
—·— PHASE II	SL	15.0	376.0(FWD)	220	10.5



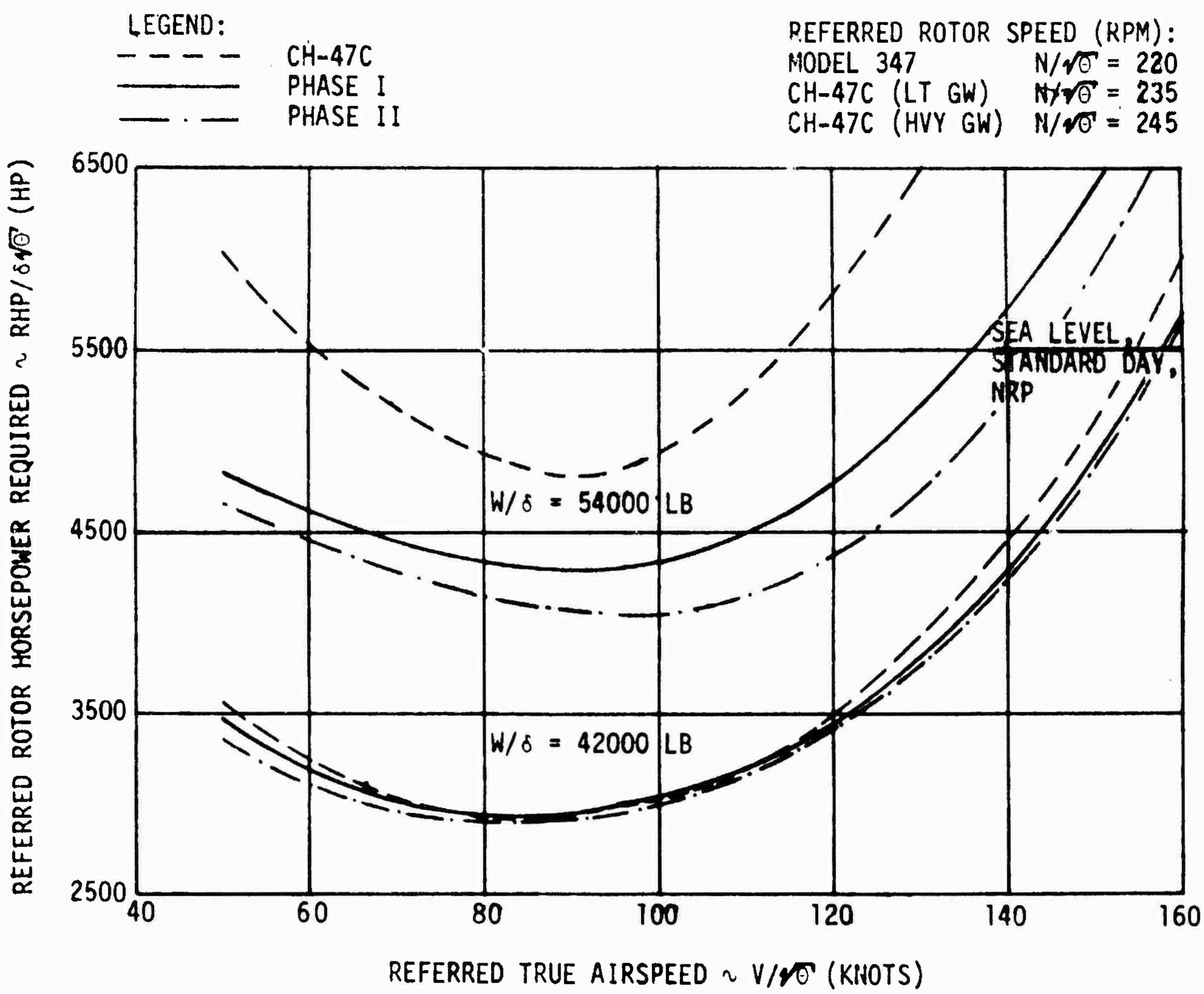
Level Flight Performance

14. Level flight performance testing was conducted in two flights at the conditions listed in appendix D. Data were obtained in stabilized level flight at approximate 10-knot speed increments while flying at a constant referred gross weight (W/δ) and rotor speed ($N_R/\sqrt{\theta}$). The results of these tests are presented in terms of generalized power required in figures 3 and 4, appendix H.

15. Figure B presents a comparison of the level flight power required at two referred gross weights (54,000 and 42,000 pounds) for Phase I, Phase II, and the CH-47C. At the lighter referred gross weight (42,000 pounds), the power-required curves for the three helicopters were similar. At forward flight referred airspeeds in excess of 110 knots true airspeed (KTAS), the power requirements for Phase I and Phase II were essentially identical. At the heavier referred gross weight (54,000 pounds), the power required for level flight varied considerably for the three helicopters. At the heavy referred gross weight and a constant 5500 rhp (normal rated power (NRP) at sea level, standard day conditions), the level flight speed of the Model 347 winged helicopter was 144 KTAS (referred), an increase of 9 knots (6.7 percent) over the 135 KTAS (referred) achieved during Phase I testing. At the heavy referred gross weight and at the level flight speed for minimum power required (90 KTAS for Phase I and 96 KTAS for Phase II), the Model 347 winged helicopter required 4040 rhp compared to 4280 rhp required during Phase I. This was a decrease of 240 rhp (5.6 percent). At the heavy referred gross weight (54,000 pounds), the Model 347 winged helicopter required less power to attain a desired airspeed than either the Phase I Model 347 or the CH-47C.

FIGURE B

LEVEL FLIGHT PERFORMANCE COMPARISON



16. The Model 347 winged helicopter incorporated a retractable forward landing gear to reduce parasite drag. The additional components and hardware required for this modification increased the basic aircraft gross weight by approximately 400 pounds compared to the standard fixed gear configuration. Quantitative tests of the drag effects of the landing gear were not accomplished during the test, but qualitative comparisons of performance were made with the landing gear both extended and retracted. Results of these tests indicated that at airspeeds below approximately 120 KIAS the drag effects of the extended landing gear were minimal (less than 2 KIAS reduction in forward flight airspeed at constant power). At forward flight airspeeds above 120 KIAS, the drag associated with the extended landing gear reduced indicated airspeed approximately 4 to 5 knots.

Climb Performance

17. Climb performance was evaluated through a 1000-foot altitude band at NRP (the maximum power for continuous operation of the T55-L-11 engines) under the conditions listed in appendix D. The results of this test are presented in figure 5, appendix H. The airspeed for maximum rate of climb was 89 knots calibrated airspeed (KCAS) at a density altitude of 5000 feet and 5°C. This airspeed corresponds to the airspeed for minimum power required in level flight. Climb performance was not evaluated during Phase I testing of the Model 347. The limited climb performance evaluation of the Model 347 winged helicopter indicated slightly improved climb performance characteristics over the CH-47C.

Autorotational Descent Performance

18. Autorotational descent performance was evaluated at the conditions listed in appendix D. Data were obtained in stabilized autorotational flight through a 1000-foot altitude band. The results of this test are shown in figure 6, appendix H.

19. At the test conditions listed in appendix D, the airspeed for maximum glide distance was 115 KCAS. Rate of descent was relatively insensitive to changes in airspeed about the airspeed for minimum rate of descent (87 KCAS). A change of ±16 knots resulted in a rate-of-descent increase of less than 100 feet per minute (ft/min). The autorotational rate of descent was recorded at 100 KCAS with the wing in the cruise position. The rate of descent was 2770 ft/min, a 20.9-percent (480-ft/min) increase over the 2290-ft/min rate of descent at the same airspeed with the wing in the autorotation position. Autorotational descent performance was not evaluated in Phase I. Autorotational descent performance of the Model 347 winged helicopter with the wing in the autorotation position was essentially the same as that determined for the CH-47C helicopter, however, the airspeed for minimum rate of descent is approximately 15 KCAS higher for the Model 347.

HANDLING QUALITIES

General

20. Addition of the wing to the Model 347 helicopter did not significantly change

the generally excellent handling qualities reported in Phase I. The strong longitudinal stability exhibited by the aircraft is a very desirable quality and reduced pilot workload in maintaining trim airspeed and pitch attitude. Only minimal trim changes were required when transitioning from climbs or descents to level flight or from level flight to climbs or descents. Longitudinal and lateral trim changes with power variation were very small throughout the flight envelope and enhanced the handling qualities of the aircraft, particularly during instrument flight or accomplishment of precision tasks under visual flight conditions. Lateral trim shifts during rearward and slow-speed forward flight were very small and considerably improved over Phase I. The handling qualities of the Model 347 winged helicopter failed to meet the requirements of three paragraphs of MIL-H-8501A. Ten handling qualities shortcomings were identified during the evaluation. The most significant of these shortcomings were the high pilot workload required to accomplish takeoffs and landings with the wing incidence control system functioning in the automatic mode, excessive longitudinal oscillation in turns above 30 degrees angle of bank at 85 KCAS, excessive sensitivity of rotor speed to thrust control rod position during autorotational flight, and slippage of the thrust control rod at high power settings. The handling qualities of the Model 347 winged helicopter are acceptable.

<u>Control System Characteristics</u>

21. The mechanical characteristics of the control system were evaluated on the ground with the rotors and engines stopped. Hydraulic and electrical power were provided by external sources. Control forces were measured by use of a hand-held force gage applied at the center of the cyclic control grip, thrust control rod (collective control) grip, and directional pedals. Since the variable force-feel system produced increased cyclic control forces with increased airspeed, these forces were measured at zero airspeed and also with forward flight airspeed signals applied to the force-feel systems. In addition, a pitch rate signal was applied to the longitudinal system to measure the force contribution due to pitch rate. All switches and systems were set to duplicate normal in-flight conditions. A complete evaluation of the mechanical characteristics of the longitudinal, directional, and thrust control systems was not accomplished since no modifications had been made to those systems subsequent to Phase I testing. Addition of the wing necessitated some modification of the lateral control system; therefore, it was fully investigated. The longitudinal, directional, and thrust control rod force characteristics were the same as reported during Phase I testing and are satisfactory.

22. The lateral control force characteristics are presented in figures 7 through 9, appendix H, and are summarized in table 1. The lateral control force characteristics were essentially the same as those determined during the Phase I reevaluation. Free play in the lateral control system was negligible (less than 1/8 inch), and breakout including friction was approximately 1 pound. The lateral force gradient varied from 0.6 pound per inch (lb/in.) at hover to 1.0 lb/in. at 170 knots indicated airspeed (KIAS). The lateral force gradient, coupled with the narrow trim control displacement band (0.1 inch), provided positive control centering. The lateral control force characteristics of the Model 347 winged helicopter are satisfactory.

Table 1. Lateral Control System Characteristics.[1]

Free Play	Less than 1/8 inch
Trim control displacement band	Hover ∿ 0.1 inch
	100 KIAS ∿ 0.1 inch
	170 KIAS ∿ 0.1 inch
Breakout including friction	Hover ∿ ±1.0 pound
	100 KIAS ∿ ±1.0 pound
	170 KIAS ∿ ±1.0 pound
Average friction band	Hover ∿ 0.8 pound
	100 KIAS ∿ 0.8 pound
	170 KIAS ∿ 1.0 pound
Average force gradient	Hover ∿ 0.6 lb/in.
	100 KIAS ∿ 0.8 lb/in.
	170 KIAS ∿ 1.0 lb/in.

[1]Ground test data. Systems energized by external electrical and hydraulic power sources. Engines and rotors stopped.

Trimmability

23. Within the normal operating envelope, all control forces could be trimmed to zero by use of the magnetic brake release switch or the beep trim switches. The variable force-feel system permitted trimming of the longitudinal, lateral, and directional controls only within the center two-thirds of the full control travel, but this trim range was adequate for all steady-state flight conditions. The change in longitudinal trim position when transitioning from climb at NRP to autorotation at 80 KIAS was 0.1 inch, aft. The required lateral trim change under the same conditions was 0.3 inch, left. These small longitudinal and lateral trim changes with power are representative of those noted at all test flight conditions. The minimal longitudinal and lateral trim changes with power variation reduced pilot workload during transition from one flight regime to another and enhanced mission accomplishment during simulated instrument flight conditions or precision tasks under visual flight conditions (HQRS 2). Except as noted in paragraphs 24 to 26, beeper trim rates and general trimmability characteristics of the Model 347 winged helicopter were essentially identical to the Phase I test results and acceptable.

24. Operation of the lateral beep trim was inconsistent throughout the test program. Roll response following activation of the lateral beep trim varied from a rapid, jerky response in the selected direction, to a smooth response in the selected direction, to no response at all. When the lateral beep trim functioned properly,

the pilot could achieve precise lateral trim changes. However, due to the inconsistent operation of the lateral beep trim, most lateral trim changes were made with the magnetic-brake release switch which also disrupted the longitudinal and directional trim references and required the pilot to reestablish precise control position for trim in all three control axes. During precision flying tasks such as sling load operations or flight in instrument conditions, desired performance would require moderate pilot compensation (HQRS 4). The erratic operation of the lateral beep trim is a shortcoming, correction of which is desirable.

25. The directional beep trim was much more sensitive to the right than to the left. Directional control (pedal) movement using the beep trim was 0.25 inch per second (in./sec) to the right and 0.07 in./sec to the left. This rate variance did not seriously affect the directional trimmability tasks in flight, and only minimal pilot compensation was required for desired performance (HQRS 3). The directional control pedals exhibited a mild recentering "jump" upon release of the magnetic brake with the pedals displaced from trim. The degree of "jump" was proportional to the pedal force being held. This characteristic required only minimal pilot compensation during directional trim tasks (HQRS 3). The directional trimmability characteristics of the Model 347 winged helicopter are satisfactory.

26. Thrust control rod slippage occurred both in flight and during ground measurement of the control system mechanical characteristics. At thrust control rod positions above approximately 87 percent of travel, coincident with a torque setting of approximately 87 percent, the thrust control rod slipped approximately 2 percent. To attain a torque setting above 87 percent, the thrust control rod was positioned approximately 2 percent above the desired level, the magnetic-brake trigger was released, and the control force was then relaxed. The thrust control rod then slipped to the desired setting (an approximate 2-percent droop). During operations requiring maximum power, the pilot cannot position the thrust control rod at the maximum power limit using the magnetic-brake system without exceeding the limit to allow for slippage. The alternative is for the pilot to attain the desired power setting and maintain it by continued control force, which is undesirable. This thrust control rod slippage failed to meet the requirements of paragraph 3.4.2 of MIL-H-8501A. Considerable pilot compensation was required to attain and maintain maximum (limit) torque settings (HQRS 5). Slippage of the thrust control rod at high power settings is a shortcoming, correction of which is desired.

Sideward, Rearward, and Slow-Speed Forward Flight Characteristics

27. Trimmed control position characteristics were evaluated from 30 KCAS in rearward flight to 40 KCAS in slow-speed forward flight and to 30 KCAS in sideward flight at a heavy gross weight with a forward cg. The tests were conducted using a ground pace vehicle equipped with a calibrated anemometer. Trimmed control positions were recorded in stabilized flight while tracking the pace vehicle at the desired airspeed. Test-day wind conditions were variable from 6 to 14 knots. All tests were done while tracking parallel to the wind direction. A constant aft landing gear height of 10 feet was maintained by reference to the radar altimeter.

The tests were conducted at 5-knot increments from 30 KCAS, rearward, to 40 KCAS, forward, and to 30 KCAS, sideward, with the wing in the hover position. Representative comparison data points were recorded with the wing in the cruise position.

28. The results of the slow-speed forward and rearward flight tests are presented in figure 10, appendix H. Increasing forward longitudinal control position was required with increasing forward airspeed from 30 KCAS, rearward, to 40 KCAS, forward. The total longitudinal control travel over the 70-knot airspeed range was approximately 0.8 inch and essentially identical to the Phase I test results. Directional control travel over this airspeed range was approximately 0.5 inch with a requirement for right pedal as forward airspeed was increased above 10 KCAS. Lateral control position variation over the test airspeed range was approximately 0.25 inch. This small lateral trim shift with increasing forward airspeed was not noticeable to the pilot and was a considerable improvement over the lateral trim shift characteristics noted during Phase I testing. Test results with the wing in the cruise mode were very similar to those recorded with the wing in the hover mode. The minor trim position differences reflected in the test data were not detectable in flight. Desired trim airspeeds in the range from 30 KCAS, rearward, to 40 KCAS, forward, were easily attained and maintained (HQRS 2). The trimmed control position characteristics of the Model 347 winged helicopter in rearward and slow-speed forward flight are satisfactory.

29. Control trim positions and roll attitude in sideward flight are shown in figure 11, appendix H. Increasing lateral control displacement in the direction of sideward flight was required. The longitudinal and directional control trim shifts were minimal with increasing speed in sideward flight to approximately 25 KCAS. Above 25 KCAS, directional control displacement was in the direction of sideward flight (approximately 1/2 inch of control movement required for the 5-knot increase to 30 KCAS). This discontinuity of directional control movement was not objectionable within the allowable flight envelope of this test, but this characteristic should be investigated at higher sideward airspeeds. Test results with the wing in the cruise mode were essentially identical to those recorded with the wing in the hover mode. The minor trim position differences reflected in the test data were not detectable in flight. Desired trim airspeeds to 30 KCAS in sideward flight were attained and maintained with minimal pilot compensation (HQRS 3). Within the scope of this test, the trimmed control position characteristics of the Model 347 winged helicopter in sideward flight are satisfactory.

Control Positions in Trimmed Forward Flight

30. Control position characteristics in trimmed forward flight were investigated by trimming the helicopter in coordinated level flight, climbs at NRP, and autorotational descents. Airspeed was varied incrementally, and control position data were recorded at each stabilized condition. Level flight data were recorded in approximate 10-knot increments from 54 to 161 KCAS by varying power (thrust control rod setting) to maintain altitude constant. Climb data were recorded while climbing through a 1000-foot altitude band, 500 feet either side of the target

altitude, at NRP in an airspeed band of 76 to 95 KCAS. Autorotational descent data were recorded while descending through the 1000-foot altitude band with both engines "beeped down" to provide near-zero torque. Autorotational descent data were collected from 62 to 129 KCAS.

31. Control positions in trimmed level flight at 39,880 pounds and 44,630 pounds gross weight are presented in figures 12 and 13, appendix H. The trimmed longitudinal control position requirements were essentially identical for the two gross weights. Total longitudinal control position variation with airspeed was 1.2 inches from 54 to 161 KCAS. The trimmed longitudinal control position was consistently forward with increasing airspeed and was linear throughout the test airspeed band. Lateral and directional control trim shifts in level flight were minimal for both gross weights. The lateral control variation was approximately 1/2 inch, and the directional control variation was less than 1/2 inch. During Phase I testing, lateral control migration with airspeed change was reported as excessive and objectionable. The contractor installed a low-rate parallel trim device in the lateral control system to compensate for the migration; and during Phase I reevaluation, the lateral control trim position characteristics were satisfactory. Addition of the wing to the Model 347 helicopter produced a rolling moment in opposition to and of slightly greater magnitude than the moment induced by the rotor system. By biasing the left flap (trailing edge up), these opposing roll moments were cancelled, hence the lateral parallel trim mechanism was not required and was disabled on the Model 347 winged helicopter. Pitch attitude variation with airspeed change in level flight was minimal (less than 2 degrees) from 54 to 120 KCAS. From 120 to 161 KCAS, the pitch attitude change was approximately 5 degrees, nose down. This characteristic appears virtually unchanged from Phase I testing. The control position characteristics of the Model 347 winged helicopter in trimmed level flight are satisfactory.

32. The control position characteristics during NRP climbs and autorotational descents are presented in figures 14 and 15, appendix H. Longitudinal and lateral control position variations were minimal between the power differential extremes of a NRP climb to an autorotational descent in the forward flight regime. Longitudinal control position variation was approximately 0.1 inch, and lateral control position varied less than 0.25 inch. The maximum directional control displacement required for transition from a NRP climb to autorotation was 0.1 inch.

33. Table 2 presents a comparison of trimmed control positions during level flight, NRP climbs, and autorotational descents. Longitudinal and directional trim control positions were essentially identical (less than 0.25 inch of movement) throughout the test airspeed band. The lateral control exhibited the greatest change (0.88 inch variation between level flight and a NRP climb at 76 KCAS), but this variation was not objectionable in flight. From trimmed, steady-heading, level flight conditions, the pilot could easily make altitude changes by adjusting only power (thrust control rod). During these flight condition changes, airspeed remained constant at the trim value with less than a 1-knot variation, and the aircraft remained trimmed, both laterally and directionally. This characteristic was evaluated

at several gross weight and cg conditions during the test program at nominal cruise airspeeds between 100 and 150 KIAS and was found to be consistently repeatable. During precision flight tasks, such as flight in simulated instrument conditions, pilot workload was significantly reduced. This characteristic should reduce load-induced oscillations during sling-load operations. The minimal trim changes required when transitioning from climbs or descents to level flight and from level flight to climbs or descents is a highly desirable characteristic, and pilot compensation is not a factor for desired performance (HQRS 1). The longitudinal, lateral, and directional trimmed control position characteristics of the Model 347 winged helicopter during transitions between climbs, descents, or level flight are outstanding and enhance accomplishment of the transport mission. This highly desirable characteristic should be incorporated in future helicopter designs.

Table 2. Control Positions In Trimmed Forward Flight.[1,2]

Calibrated Airspeed (kt)	Flight Condition	Longitudinal (in. from full fwd)	Control Position	
			Lateral (in. from full left)	Directional (in. from full left)
76	NRP climb	7.05	5.11	2.91
	Level flight	7.20	4.23	3.15
	Autorotational Descent[3]	7.04	4.68	2.97
85	NRP climb	6.79	5.01	2.94
	Level flight	7.06	4.30	3.18
	Autorotational Descent[3]	6.95	4.71	3.00
95	NRP climb	6.75	4.89	3.03
	Level flight	6.90	4.48	3.20
	Autorotational Descent[3]	6.83	4.79	3.03
125	NRP climb	No data	No data	No data
	Level flight	6.48	4.76	3.21
	Autorotational Descent[3]	6.28	4.80	3.27

[1]All tests performed at an average gross weight of 44,500 pounds with a forward cg (FS 375.5).
[2]Data compiled from faired curves of figures 13 through 15, appendix G.
[3]Zero torque.

Collective-Fixed Static Longitudinal Stability

34. Static longitudinal stability characteristics were evaluated at the conditions listed in appendix D in level flight, NRP climb, and autorotation. Longitudinal stability characteristics were evaluated by first trimming the aircraft at the desired trim speed. While holding collective (thrust control rod) fixed, the helicopter was then displaced from the trim speed and stabilized at incremental speeds greater and less than the trim speed. Static longitudinal stability was evaluated about trim speeds of 86, 110, and 131 KCAS in level flight and about 82 KCAS in NRP climbs and autorotational descents. Data were recorded at each stabilized airspeed and are presented in figures 16 through 20, appendix H. Contrary to the characteristics of most aircraft, the simple variation of longitudinal control position with airspeed was not a true indicator of static stability for this aircraft because of the contribution of the longitudinal control position transducer (control pick-off) to the differential airspeed-hold (DASH) actuator. A more realistic indication of static longitudinal stability in the Model 347 winged helicopter was obtained by eliminating the effects of the control pick-off contribution. Additional test results were obtained by holding the longitudinal control fixed at the trim position and increasing or decreasing airspeed by applying inputs directly to the longitudinal stability augmentation system (SAS) actuators by use of the SAS pulser box. The SAS pulser box is a test device which can be used to apply pulse or step inputs to the rotor heads through the number-one SAS. Use of the SAS pulser box to make control inputs to the rotors eliminates any influence which might be produced by the control pick-off and its associated circuitry. During the additional tests, pulser box step inputs were held until the helicopter stabilized on the new airspeed, and the results were recorded.

35. The steep gradient (heavy solid line through each trim condition on figures 16 through 18, appendix H) presents the resulting no pick-off equivalent longitudinal control variation with airspeed and is the best indicator of static longitudinal stability. The static longitudinal stability of the Model 347 winged helicopter, as indicated by the variation of equivalent longitudinal control position with airspeed, was stable and consistent under all conditions. The minimum gradient was approximately 0.071 inch of equivalent control travel per knot at a trim airspeed of 110 KCAS and a heavy weight, forward cg loading (fig. 17). The maximum gradient was approximately 0.078 inch per knot at a trim airspeed of 86 KCAS and at a heavy weight, forward cg loading (fig. 16). The variation of equivalent control position was essentially linear and constant about each trim airspeed. The static longitudinal stability of the Model 347 winged helicopter was less than reported for the Model 347 helicopter in Phase I. However, the longitudinal stability characteristics were observed to be quite powerful in correcting natural disturbances encountered in flight. The strong longitudinal stability exhibited by the Model 347 winged helicopter is a very desirable quality, and pilot compensation is not a factor in maintaining trim airspeed and pitch attitude (HQRS 2). The static longitudinal stability characteristics are satisfactory.

36. Static longitudinal stability characteristics with both DASH systems inoperative were determined mathematically by subtracting the DASH actuator motion from the control position data obtained during DASH-ON flight. The results of this computation at a heavy gross weight and forward cg loading are shown in figure 21, appendix H. A comparison with the Phase 1 Model 347 helicopter is shown on the same figure. Qualitatively, static longitudinal stability with both DASH systems inoperative was neutral to unstable at airspeeds of 35 KCAS and greater, and stable at speeds below 35 KCAS. With both DASH systems inoperative, the static longitudinal stability of the Model 347 winged helicopter was slightly degraded from Phase I. Flight with both DASH systems inoperative, considerably increased pilot workload in maintaining pitch attitude and airspeed, but safe operation of the aircraft in visual-flight-rules (VFR) conditions was possible.

Static Lateral-Directional Stability

37. Static lateral-directional stability characteristics were evaluated at the conditions listed in appendix D in level flight, NRP climb, and autorotation. The tests were conducted by trimming the aircraft in coordinated level flight at the desired airspeed and recording the control positions and bank attitude. Holding collective fixed, the aircraft was then displaced to incremental sideslip angles on either side of the trim sideslip angle and stabilized in steady-heading flight at increasing sideslip angles up to the envelope limit. The results of these tests are presented in figures 22 through 26, appendix H. A comparison of the Phase I and Phase II static directional stability characteristics in level flight is presented in figure 27.

38. Static directional stability, as indicated by the variation of directional control position with sideslip, was strongly positive to the left (right pedal, left sideslip) at all level flight conditions. The directional stability was essentially neutral at sideslips above 17 degrees to the right at 85 KCAS, but became stable as airspeed was increased. A comparison at approximately 110 KCAS, shown in figure 27, appendix H, indicated that the Model 347 winged helicopter had generally stronger static directional stability at sideslip angles greater than 10 degrees than the Model 347 without wing. The Phase I Model 347 helicopter exhibited strong directional stability up to sideslip angles of ±10 degrees from trim and was slightly less stable at greater sideslip angles. The Model 347 winged helicopter exhibited strong directional stability in level flight up to the sideslip limit except for the essentially neutral directional control position gradient in right sideslips above 17 degrees at 85 KCAS. The neutral directional stability in right sideslips above 17 degrees at 85 KCAS failed to meet the requirements of paragraph 3.3.9, MIL-H-8501A but is satisfactory.

39. The static directional stability characteristics in NRP climbs were essentially the same as those exhibited during level flight. In autorotation, the Model 347 winged helicopter exhibited weak directional stability characteristics. Compared to Phase 1, the Model 347 winged helicopter exhibited more directional stability in autorotation for left sideslip angles greater than 15 degrees, and essentially the same stability in right sideslips. A severe buffeting of the helicopter occurred in

autorotational right sideslips of approximately 25 degrees. The aircraft could not be stabilized in autorotational right sideslips above approximately 20 degrees due to this buffeting. This characteristic was not considered a shortcoming since large sideslips in autorotation are not desirable and the buffeting acted as a warning cue of excessive sideslip angle.

40. Static directional stability characteristics with all SAS systems inoperative were mathematically determined by subtracting the SAS extensible link contribution from the SAS-ON directional control position data. The results are plotted as broken lines in figures 22 through 27, appendix H. With both SAS systems inoperative, the directional stability was slightly stable to the left and essentially neutral to the right for all powered flight conditions. In autorotation, the directional stability was slightly stable in left sideslips to approximately 20 degrees. Directional instability was evidenced in left sideslips greater than 20 degrees and at all right sideslip angles. The directional stability characteristics were essentially the same as reported for the Model 347 helicopter without wing. Compared to the CH-47C, the directional stability characteristics noticeably improved the pilot's ability to conduct flight under SAS-OFF conditions.

41. Dihedral effect, as indicated by the variation of lateral control displacement with sideslip, was positive (lateral control movement in the direction of sideslip) and essentially linear at all test conditions except during NRP climb. Dihedral effect increased as airspeed increased. In left sideslips during NRP climb, the dihedral effect was neutral between sideslip angles of zero and approximately 12 degrees and slightly positive at greater sideslip angles. Except for this discontinuity during NRP climb in left sideslip, the dihedral effect of the Model 347 winged helicopter was slightly more positive than was observed in Phase I. The neutral dihedral effect in left sideslip to 12 degrees during NRP climb failed to meet the requirements of paragraph 3.3.9, MIL-H-8501A but is satisfactory.

42. Sideforce, as indicated by the variation of bank angle in steady-heading sideslips, was weak under all flight conditions, but became more positive with increasing airspeed. In powered flight, the Model 347 winged helicopter exhibited slightly stronger sideforce characteristics than the Phase I helicopter. During autorotation, sideforce characteristics were weaker than those observed in powered flight. The weak directional stability and weak sideforce in autorotation, as indicated by both directional control position and bank angle, resulted in the helicopter being trimmed at sideslip angles up to 10 degrees from trim without the pilot being aware of the condition. Trimming the helicopter within satisfactory sideslip angles required moderate pilot compensation (HQRS 4). The weak sideforce during autorotation was slightly improved with the addition of the wing, but still inadequate. The weak sideforce in autorotation is a shortcoming, correction of which is desirable.

43. Pedal-only turns of large magnitude directional control input resulted in consistent, steady-state roll displacement into the turn, however, a pedal input of sufficient magnitude to generate an approximately 1/2 standard rate turn did not

result in a change in roll attitude. These essentially flat pedal-only turns indicated neutral dihedral effect. This neutral dihedral effect during small magnitude pedal-only turns was also observed during Phase 1 testing. This characteristic does not degrade accomplishment of the transport mission and is satisfactory.

44. Cyclic-only turns were evaluated in level flight. No reversal of rolling motion was observed and turn rates were always generated in the proper direction. The degree of adverse yaw generated was a function of lateral control rate of movement. Adverse yaw was not noticeable with slow lateral stick inputs. A normal rate of input resulted in approximately 3 to 5 degrees of adverse yaw, but was not objectionable for a transport helicopter.

45. Increasing sideslip angles in either direction from trim required essentially no longitudinal control displacement under all flight conditions. This neutral pitch with sideslip characteristic is an improvement over the Phase I Model 347 helicopter. Maneuvers involving intentional sideslips, such as sideslip decelerations, require less control manipulation.

46. Within the scope of this test, the static lateral-directional stability characteristics of the Model 347 helicopter were not significantly changed from those reported in Phase 1. Except for the inadequate sideforce in autorotation (para 42), the static lateral-directional stability characteristics of the Model 347 winged helicopter are acceptable.

Maneuvering Stability

47. Maneuvering stability characteristics were evaluated at the conditions listed in appendix D. Addition of the wing and flaps to the Model 347 helicopter reduced the dynamic loads on the rotor control system and maneuvering flight at load factors to 2.0 was accomplished at all test airspeeds. The variation of longitudinal control position with normal acceleration was determined by trimming the aircraft in coordinated level flight at the desired airspeed and then establishing steady-state banked turns to the limit bank angle in each direction. The thrust control rod was fixed at the level flight trim setting and constant airspeed during the turns was maintained by varying altitude as required. After stabilizing at the desired bank angle, longitudinal control position and normal acceleration data were recorded. A pitot-static boom was not installed on the test aircraft. Airspeed was maintained by reference to the standard ship's system. The results of the maneuvering stability tests are shown in figures 28 through 30, appendix H.

48. The maneuvering stability of the Model 347 winged helicopter, as indicated by the variation of longitudinal control position with normal acceleration, was neutral at all test airspeeds. Qualitative inflight evaluation of the longitudinal control force characteristics during accelerated flight agreed with the quantitative control position data. Compared to the Phase I tests, the Model 347 winged helicopter maneuvering stability was unchanged in left turns (neutral longitudinal control position gradient) and slightly degraded in right turns (the Phase I longitudinal control position gradient in right turns was slightly positive). During steady turns

at 85 KCAS and at bank angles greater than 30 degrees, a longitudinal oscillation extensively increased pilot workload in attaining the desired airspeed. Airspeed varied ±10 knots as the pilot attempted unsuccessfully to damp the oscillation with longitudinal control. The excessive longitudinal oscillation in turns above 30 degrees angle of bank at 85 KCAS required extensive pilot compensation for adequate performance (HQRS 6) and is a shortcoming, correction of which is desirable.

49. Turns at less than 30 degrees angle of bank could be accomplished satisfactorily at all airspeeds with minimal pilot compensation (HQRS 3). At 130 and 148 KCAS, stabilized turns at greater than 30 degrees angle of bank were difficult due to the neutral maneuvering stability, but the longitudinal oscillation noted at 85 KCAS was not apparent. Desired maneuvering performance at angles of bank greater than 30 degrees at 130 and 148 KCAS required moderate pilot compensation (HQRS 4). The neutral maneuvering stability of the Model 347 helicopter during turns exceeding 30 degrees angle of bank at 130 and 148 KCAS is a shortcoming, correction of which is desirable.

Dynamic Longitudinal Stability

50. Longitudinal dynamic stability characteristics were evaluated at the conditions listed in appendix D. Long-term response characteristics were evaluated by trimming the aircraft in level flight at the desired airspeed and displacing the aircraft from trim using the SAS pulser box. A 100 percent SAS step input was held until the aircraft stabilized at an off-trim airspeed and the step input was removed. The response of the helicopter was recorded following removal of the step input. A typical result of these tests is shown in figure 31, appendix H. Gust response characteristics were investigated by applying 1/2-second pulses through the SAS pulser box. The SAS inputs were 100 percent of extensible link authority which is equivalent to approximately 0.5 inch of the mechanical motion of the longitudinal control. The response of the helicopter in returning to the trim airspeed was then recorded. The results of these tests are presented in figures 32 through 34.

51. The long term dynamic response of the Model 347 with wing was consistent and predictable under all test conditions. Return of the aircraft to the trim airspeed and pitch attitude was smooth and positive with the airspeed deadbeat to within 11 KIAS of trim. The short term gust response was oscillatory and moderately damped. The dynamic longitudinal stability characteristics of the Model 347 winged helicopter are essentially the same as reported in Phase 1 and are satisfactory.

Dynamic Lateral-Directional Stability

52. Dynamic lateral-directional stability characteristics were evaluated at the conditions listed in appendix D by introducing 1/2-second lateral and directional pulses into the SAS system with the SAS pulser box. The pulses used were

100 percent of the lateral and directional SAS authority, equivalent to approximately 0.25 inch of lateral control displacement and 0.3 inch of directional control displacement. The results of these tests are shown in figures 35 through 40, appendix H.

53. As shown in figures 35 through 37, appendix H, the aircraft response to lateral pulses was oscillatory with a very small amplitude of less than 1/2 degree. The lateral pulse did not excite any adverse directional characteristic nor cause any noticeable affect on the roll attitude of the aircraft. In the airspeed range of 83 to 129 KCAS, the variation of airspeed had no significant effect on the aircraft response to lateral pulse inputs. The response to directional pulses is shown in figures 38 through 40. Yaw and roll oscillations were of low amplitude and moderately damped. The dynamic lateral-directional stability characteristics of the Model 347 winged helicopter are satisfactory.

Controllability

54. Controllability characteristics with all SAS and DASH systems operating were evaluated at the conditions listed in appendix D. Single-axis control step inputs were applied to the longitudinal, lateral, and directional controls using mechanical fixtures to obtain the desired control input size. The step inputs were held steady while recording the subsequent aircraft angular displacement (control power) and angular rate (control response). The aircraft maximum angular acceleration (control sensitivity) was mathematically derived from the angular rate data. Three step inputs of increasing displacement in each direction were applied to each axis to establish controllability trends. The results of these tests are presented in figures 41 through 46, appendix H. The control power characteristics during OGE hover are summarized in table 3. Also shown in this table are the control power requirements of MIL-H-8501A and the results from Phase I testing of Model 347 helicopter.

55. Longitudinal angular displacement in 1 second varied from approximately 3 degrees per inch of control travel at hover to 4 degrees per inch of forward control displacement at 83 KCAS in forward flight. This was approximately the same control power as reported in Phase I. Longitudinal control response varied from 2 degrees per second (deg/sec) at 129 KCAS for a 1 inch aft control displacement to 7 deg/sec per inch of forward control travel at 129 KCAS. At hover the control response was approximately 4 deg/sec per inch of control travel and about the same as the angular rate reported in Phase I. Longitudinal control sensitivity varied from a minimum of 5 degrees per second per second (deg/sec^2) per inch of control displacement in hover to a maximum of 19 deg/sec^2 per inch of forward control displacement at 129 KCAS. In hover, this was the same sensitivity reported for Phase I testing. At higher forward flight airspeeds, longitudinal control response and sensitivity were observed to be greater for forward control inputs than for aft inputs. Except for this increased response and sensitivity at higher airspeeds, the longitudinal controllability characteristics were similiar to the Phase I test results. The longitudinal controllability characteristics of the Model 347 winged helicopter permitted smooth, precise control of the aircraft and are satisfactory.

Table 3. Out-of-Ground-Effect Hover Control Power.[1]

Axis	Military Specification		Test Results[2]	
	MIL-H-8501A Paragraph	Minimum Requirement	Phase I	Phase II
Longitudinal (deg in 1 sec)	3.2.13	1.25 (VFR)	2.1 (fwd)	3.5 (fwd)
	3.6.1.1	2.04 (IFR)	2.5 (aft)	2.8 (aft)
Lateral (deg in 1/2 sec)	3.3.18	0.75 (VFR)	2.5 (left)	1.3 (left)
	3.6.1.1	0.89 (IFR)	2.5 (right)	1.2 (right)
Directional (deg in 1 sec)	3.3.5	3.06 (VFR)	6.0 (left)	3.1 (left)
	3.6.1.1	3.06 (IFR)	5.2 (right)	3.5 (right)

[1]Average gross weight: 46,250 pounds.
[2]Attitude change produced by a 1-inch control input.

56. The average roll attitude displacement at 1/2 second (control power) was 2.0 degrees per inch of lateral control travel. Lateral control response varied from 9.5 to 12 deg/sec per inch of control travel. The average lateral sensitivity was 18 deg/sec^2 per inch of control travel in hover and approximately 20 deg/sec^2 in forward flight. The Model 347 winged helicopter exhibited a degradation in lateral controllability from Phase I testing, but the lateral controllability characteristics permitted smooth, precise control of the aircraft and are satisfactory.

57. Directional control power varied from 3.1 degrees per inch of control travel at 1 second during hover to 4.1 degrees per inch of control travel at 1 second during forward flight at 129 KCAS. Directional control response varied from 11 deg/sec per inch of control travel during hover to approximately 7.5 deg/sec per inch of control travel during forward flight. Directional control sensitivity varied from approximately 12 deg/sec^2 per inch of control displacement during hover to 10 deg/sec^2 per inch of control travel during forward flight. Directional controllability of the Model 347 winged helicopter was degraded from Phase I results, but is satisfactory.

Autorotational Characteristics

58. Autorotational flight characteristics were qualitatively evaluated with the wing in the automatic mode at the conditions listed in appendix D. Autorotational descent was entered by lowering the thrust control rod and simultaneously reducing

engine torque on both engines to near zero by use of the engine trim control switches. The flight characteristics of the helicopter during the entry and subsequent autorotational flight were excellent. There was no noticeable pitch, roll, or yaw attitude change and the transition to full autorotational flight was very smooth. Noise and vibration levels were low. Normal maneuvers were easily performed. The weak sideforce (para 42) degraded the pilot's ability to maintain precise sideslip trim in autorotational flight, but did not preclude control of sideslip within operationally satisfactory limits nor adversely affect the maneuvering characteristics of the aircraft. Rotor speed control was very difficult throughout the autorotational flight regime. Thrust control rod position, when initially lowered to enter autorotation, was critical to rotor speed reaction. Lowering the thrust control rod to the full down position resulted in a rapid rotor speed build-up that would easily exceed the upper rotor speed limit (245 rpm) unless carefully monitored by the pilot. Considerable pilot compensation was required to manipulate the thrust control rod to achieve and maintain rotor speed within acceptable limits (HQRS 5). During autorotational descent, continuous adjustment of the thrust control rod was necessary to maintain the selected rotor speed. The excessive sensitivity of rotor speed to thrust control rod position during autorotational flight and the associated rapid build-up of rotor speed during autorotation entry is a shortcoming, correction of which is desirable. The autorotational characteristics of the Model 347 winged helicopter are acceptable.

Takeoff and Landing Characteristics and Operation of Wing

59. Takeoff and landing characteristics, including operation of the variable incidence wing, were evaluated at the conditions listed in appendix D. The surface wind was steady at approximately 10 knots and all landings and takeoffs were made into the wind. In the automatic mode, wing incidence was programmed by the ship's airspeed system. During takeoff, the wing began programming from the hover position (85 degrees angle of incidence) to the cruise position (10.5 degrees angle of incidence) when the indicated airspeed reached approximately 40 knots. During deceleration for landing, the wing began programming to the hover position at an indicated airspeed of approximately 60 knots. With the automatic mode deactivated, wing incidence could be manually positioned by the pilot. Running takeoffs and landings, takeoffs from a hover, and approaches to a hover were conducted with the wing in both the automatic mode and manually positioned by the pilot, as well as with the wing fixed in the cruise position. Typical time histories of automatic activation of the wing are shown in figures 47 through 50, appendix H.

60. During a normal takeoff from a hover with the wing in the automatic mode, acceleration was very slow. The flat plate drag effect of the 340 square foot wing requires a considerable nose down attitude to attain any forward acceleration. Figure 47, appendix H, presents a time history of a normal takeoff from a hover with the wing in the automatic mode. During this takeoff, with power and pitch attitude varied to produce acceleration while maintaining altitude constant, wing activation began in approximately 42 seconds. Dynamic air pressure fluctuations during the wing programming cycle caused variations in the rate of change of wing

incidence. These variations resulted in pitch oscillations which required considerable pilot compensation to maintain constant altitude and an acceleration attitude (HQRS 5). Pitch attitude during the maneuver reached minus 9 degrees (13 degrees down from the hover attitude) and was mildly uncomfortable. In an effort to decrease the time to wing activation, a takeoff was made using a 20 degree nose down attitude and normal rated power (NRP). The pitch attitude of 20 degrees nose down was established as the maximum tolerable attitude for the test. During the acceleration, power was reduced to maintain a constant altitude. As shown in the time history of the test (fig 48), wing activation began in approximately 7 seconds and was complete in approximately 19 seconds. During this test, the pitch attitude was very uncomfortable and extensive pilot compensation was required to maintain constant altitude and an acceleration attitude (HQRS 6). Upon completion of the wing activation cycle, the subsequent climb-out during both tests was normal and desired performance standards were easily achieved (HQRS 2). Automatic activation of the wing programming cycle at 40 KIAS resulted in a very slow acceleration. The poor performance and objectionable handling qualities during takeoff with the wing incidence control system functioning in the automatic mode is a shortcoming, correction of which is desirable.

61. During normal approaches with the wing in the automatic mode, wing activation was accompanied by a rapid deceleration. A considerable power application and large excursions of longitudinal cyclic control were required to maintain an acceptable deceleration rate, landing attitude, and glide path. Figures 49 and 50, appendix H, portray time histories of landing decelerations using 14 degrees and 17 degrees nose-up pitch attitudes, respectively. The length of time required for the wing to cycle to the hover position was approximately 9 and 10 seconds, respectively. With the wing in the automatic mode, a smooth, consistent landing approach and deceleration required considerable pilot compensation ((HQRS 5). Operations with external sling loads were not conducted during this evaluation, but it is anticipated that approaches or decelerations in the automatic wing activation mode would result in severe load oscillations. The objectionable handling qualities during landings and decelerations with the wing incidence control system functioning in the automatic mode is a shortcoming, correction of which is desirable.

62. Takeoffs and landings were also accomplished with the automatic wing activation mode inoperative. Wing incidence was manually programmed by the pilot through use of a constant rate electrical switch. Takeoffs were accomplished by simultaneously programming the wing to the cruise position as the aircraft was accelerated from a hover. This mode of operation resulted in a much smoother transition to forward flight. Landing decelerations were accomplished by initiating rotation of the wing to the hover position as airspeed was reduced to approximately 70 KIAS. As was experienced in the manually programmed takeoffs, this method of deceleration was superior to the automatic mode of operation. Takeoffs and landings were easily accomplished by manually controlling wing incidence (HQRS 3). Although this mode of operation was satisfactory the rate of movement of the wing in the manual mode was too slow, particularly during acceleration for takeoff. The activation speed in the manual mode should be made variable or optimized in future designs.

63. Landings and takeoffs were accomplished with the wing fixed in the cruise position. This mode of operation proved quite satisfactory since, qualitatively, only 2 percent more power was required to hover in ground effect with the wing in the cruise position. Transition to forward flight from a hover and transition back to a hover with the wing in the cruise position was smooth and pilot compensation was not a factor for attaining desired performance (HQRS 2). The landing and takeoff characteristics of the Model 347 winged helicopter with the wing fixed in the cruise position are satisfactory.

64. Running landings and takeoffs were satisfactorily accomplished in all modes of wing operation (automatic, manual, and fixed in the cruise position). Ease of accomplishing running transitions to and from forward flight was comparable to transitions to and from a hover. Running landings and takeoffs were most easily accomplished with the wing fixed in the cruise position, followed in order of difficulty by the manual mode and the automatic mode. The same flight characteristics discussed previously (paras 60 through 62) caused the increased difficulty encountered in the manual and automatic modes of wing operation. Within the scope of this test, the running takeoff and landing characteristics of the Model 347 winged helicopter are acceptable.

Ground Operation Characteristics

65. Ground handling characteristics were evaluated on paved surfaces in winds less than 5 knots and with the wing in both the cruise and hover positions. The incorporation of centrifugal droop stops substantially improved the ground handling characteristics of the Model 347 as compared to the CH-47C. Restrictions present in the CH-47C limiting downward movement of the thrust control rod were not applicable to the Model 347, hence the thrust control rod detent mechanism was removed and the control could be fully lowered during ground operations. This feature allowed the pilot to easily control taxi speed without the use of the brakes by full downward movement of the thrust control. Taxi speed was easily controlled from zero throughout a normal taxi speed range by movement of the thrust control rod (HQRS 2). Full freedom-of-movement of the thrust control rod during ground operations is an enhancing feature which should be incorporated in future helicopter designs.

66. During ground operations a phenomenon termed "dynamic system pounding" was observed on several occasions. This characteristic appeared to the pilot as essentially similar to moderate droop stop pounding. The dynamic system pounding was apparently caused by slack in the upper thrust bearing of the forward transmission. Tear down inspections of the forward transmission have revealed no physical damage, but the dynamic system pounding during ground operations is objectionable to the pilot and is a shortcoming, correction of which is desirable.

67. Power steering "dropout" during taxi operations was observed on several occassions in the test program. This problem, which is also present in the CH-47 helicopter, was caused when the power steering mechanism released and directional control of the steerable aft gear was lost. The malfunction was attributed to

electromagnetic interference (EMI) from the intercom system which deactivated the power steering unit. This malfunction is a shortcoming, correction of which is desirable.

68. Within the scope of this test, the wing had no effect on the ground handling characteristics of the Model 347 helicopter. Except for the shortcomings noted in paragraphs 66 and 67, the ground handling characteristics of the Model 347 winged helicopter are acceptable.

SYSTEM FAILURE CHARACTERISTICS

Simulated Single-Engine Failure

69. Failure of a single engine was simulated in level flight. Failure of the number two engine was simulated in trimmed forward flight by moving the engine condition lever to the ground-idle position. All other flight controls were held fixed at the trim conditions until recovery was initiated. The helicopter response was extremely mild and required no immediate corrective action by the pilot. Following the loss of power, the remaining engine assumed the power load; a slight nose-up pitch change was observed and airspeed stabilized at approximately 10 knots below the original trim value. Rotor speed bled off and stabilized at a level approximately 7 rpm below the trim rotor speed. A single-engine landing was also evaluated and was satisfactory. The Model 347 winged helicopter single-engine failure characteristics were similar to those reported during Phase I. Within the limited scope of this evaluation, the single-engine failure characteristics of the Model 347 winged helicopter are satisfactory.

Stability Augmentation System Failure Characteristics

70. Single and dual SAS failures were evaluated throughout the tests in forward flight, hover, and during takeoffs and landings. Aircraft dynamic stability characteristics with one SAS disengaged were not noticeably different from the characteristics with both stability augmentation systems operating. With both stability augmentation systems disengaged, the dynamic stability characteristics were considerably degraded, but continued safe operation of the helicopter in visual flight rule (VFR) conditions was possible. The SAS failure characteristics of the Model 347 winged helicopter were qualitatively the same as was reported in Phase I and are satisfactory.

Control System Hydraulic Power Failure Characteristics

71. Single failures of the dual hydraulic power system were simulated in level flight by turning OFF one of the hydraulic systems. As was reported in Phase I, failure of a single system produced no adverse results. There were no aircraft or control responses to failure of either system nor were any transient responses generated when the failed system was again activated. The control system hydraulic power failure characteristics of the Model 347 winged helicopter are satisfactory.

Wing Mode Failure During Autorotation

72. Wing mode failure during autorotation was evaluated by locking the wing in the cruise position and entering autorotation at 100, 110 and 130 KIAS. Aircraft characteristics observed were: an increase in vertical vibration, a mild roll rate which increased in magnitude with airspeed, and a slow response (build-up) of rotor speed to lowered thrust control rod. Autorotation was entered at varied rates of thrust control rod downward movement. The faster the thrust control rod was lowered, the greater the roll rate generated. Failure of the wing in the cruise position during autorotation did not seriously degrade aircraft response or handling qualities. There was no significant increase in pilot workload required compared to an autorotation with the wing in the autorotational mode. Within the scope of this test, the wing mode failure characteristics of the Model 347 winged helicopter during autorotational descent are satisfactory.

SPECIAL SYSTEMS EVALUATIONS

Variable Incidence Wing

73. A wing was installed on the Model 347 helicopter to relieve rotor stress during maneuvering flight. The variable incidence wing and normal acceleration load sensitive flaps installed on the Model 347 winged helicopter increased the accelerated flight capability of the aircraft as compared to the Phase I helicopter without wing. Turns in excess of 60 degrees angle of bank were achieved to the left and right (figures 28 through 30, appendix H). These turns were accomplished without overstress of the rotor or associated control system components. Additionally, level flight performance was improved at heavy gross weights (para 15). The penalty for these gains in maneuverability and level flight performance was a weight increase of approximately 5,300 pounds and the additional complexity associated with the wing control mechanisms. The contractor estimated that a production version of the wing would require an increase of at least 3,000 pounds to the basic aircraft weight. Increased complexity of control systems in the winged helicopter is necessary to accomodate the required variable incidence capability. Historically, the transport mission has consisted of a high percentage of sling load (external load) operations. In this mode of operation. the increased accelerated flight capability would not represent a significant advantage since high angle of bank turns are not commonly employed with external loads. Within the scope of this test, the increased accelerated flight capability and improved level flight performance achieved with the addition of the wing to the Model 347 helicopter are gained at the expense of increased weight and complexity.

VIBRATION CHARACTERISTICS

74. Vibration characteristics were evaluated with all installed vibration absorbers operating. Vibration sensors were installed at the following fuselage stations: pilot and copilot heel slides (FS 50); pilot seat (FS 95); mid cabin (FS 360): and rear of cabin, immediately forward of cargo ramp hinge (FS 592). The locations of these sensors are described in further detail in appendix F. The measured vertical. lateral, and longitudinal vibration characteristics at frequencies corresponding to 4 (14.68 Hz), 8 (29.36 Hz), and 12 (44.04 Hz) cycles per rotor revolution are presented in figures 51 through 56, appendix H. These figures show the maximum and minimum amplitude which occurred over a 10-rotor-revolution data sample at each test condition. The 4 per revolution (4/rev) vertical vibration characteristics are summarized in table 4.

Table 4. Level Flight 4/Rev Vertical Vibrations.[1]

Fuselage Station	True Airspeed					
	80 knots		120 knots		146 knots	
	Maximum Value[2] (g)	Minimum Value (g)	Maximum Value[2] (g)	Minimum Value (g)	Maximum Value[2] (g)	Minimum Value (g)
50	0.10	0.07	0.10	0.07	0.11	0.06
95	0.06	0.03	0.02	0.01	0.06	0.01
360	0.10	0.08	0.11	0.08	0.06	0.03
592	0.26	0.21	0.25	0.19	0.27	0.23

[1]Accelerations measured over 10 Rotor Revolutions.
Density Altitude: 5000 feet.
Rotor Speed: 220 rpm.
4/rev vibration = 14.68 Hz
Gross Weight: 44,800 pounds
Center of gravity: 375.0 in (fwd)
[2]MIL-H-8501A Limit: Acceleration (g) between 30 knots rearward and V_{cruise} not to exceed 0.15g for frequencies up to 32 hertz (paragraph 3.7.1(b)).

75. The 4/rev vibrations in the cockpit area were less than 0.14g (figures 51 and 52, appendix H) during all level flight tests, slightly higher than the maximum 4/rev value of 0.11g from Phase 1 testing. The 8/rev vibration level for the Model 347 winged helicopter was approximately the same as Phase ' in forward level flight. The maximum value for the 8/rev vibrations (0.58g), exceeded the 0.15g and 0.20g limits of paragraph 3.7.1(b), MIL-H-8501A. During hover and approach to hover, the 8/rev vertical vibrations reached a maximum value of 0.46g and were highly objectionable to the pilot. These vibrations, which did not occur in Phase 1, would cause pilot fatigue in prolonged operations. The same high 8/rev

vibrations also occurred in left sideward flight at 30 KCAS (maximum value of 0.8g). The excessive 8/rev vibration during hover, approach to a hover, and left sideward flight at 30 KCAS is a shortcoming, correction of which is desirable.

76. The 4/rev vibration levels were significantly higher in the cabin area than in the cockpit area. The highest vibration levels occurred in the aft portion of the cabin at station 592. As shown in figure 54, appendix H, the maximum amplitude of the 4/rev vibration recorded was 0.32g at 128 KTAS. This 4/rev vertical vibration exceeded the 0.15g limit of paragraph 3.7.1(b), MIL-H-8501A for the airspeed range of 66 KTAS to 146 KTAS. Although the vertical vibrations in the rear of the cabin area exceeded the specification limit, they were greatly reduced from Phase I. The lateral vibrations around station 592, which were excessive in Phase I, were also reduced. The reduction of the vertical and lateral vibrations in the rear cabin is attributed to the fuselage structure added to support the wing. Within the scope of this test, the 4/rev vertical vibrations in the rear cabin area (FS 592) are excessive and constitute a shortcoming, correction of which is desirable.

NOISE CHARACTERISTICS

77. Interior and exterior noise characteristics were not measured during Phase II. Boeing-Vertol acoustics personnel were consulted concerning the possibility of the wing changing the exterior noise levels of the Model 347 winged helicopter. Boeing-Vertol had performed some acoustic testing of the Phase II aircraft during March 1972 and this data (figures 57 and 58, appendix H) was compared to that obtained during Phase I testing. The test conditions were as depicted in table 5. The Phase I forward flight data was recorded with the aircraft directly overhead. The Phase II forward flight data was recorded 200 feet to the right side of the aircraft's flight path. At a hover, the noise level differences were less than 4 db throughout the frequency range from 31.5 Hz to 8000 Hz. In forward flight, comparing the Phase I Model 347 helicopter at 150 KIAS and the Phase II Model 347 winged helicopter at 165 KIAS, the noise level was 5 db lower for Phase II at 63 Hz, 2 db higher at 250 Hz, and 7 db lower at 8000 Hz. Based on this limited data comparison, the wing did not substantially change the exterior noise characteristics of the Model 347 winged helicopter.

78. No changes were made in the cabin or cockpit acoustical treatment since Phase I. As reported in Phase I, the cockpit of the Model 347 winged helicopter was pleasantly quiet. The cockpit noise characteristics met the sound-level requirements of MIL-A-8806A (ref 11, app A) and are satisfactory.

Table 5. Test Conditions for Noise Survey.

Test Phase	Gross Weight (lb)	Rotor Speed (rpm)	Airspeed (kt)	Absolute Altitude (ft)
I	46,500	220	150	200[1]
	46,500	220	0	5
II[2]	45,000	220	120	200[3]
	45,000	220	165	200[3]
	45,000	235	0	5

[1]Data recorded with aircraft directly overhead.
[2]Noise survey data for Phase II furnished by Boeing-Vertol.
[3]Data recorded 200 feet to the right side of the aircraft's flight path.

CONCLUSIONS

General

79. The following conclusions were reached upon completion of the engineering flight test of the Phase II Model 347 winged helicopter:

a. Out-of-ground-effect hover power requirements for the Phase I and the Phase II Model 347 helicopters were similar (para 13).

b. Out-of-ground-effect hover with the wing in the cruise position reduced the gross weight capability of the aircraft approximately 2 percent (para 13).

c. At any constant rotor horsepower, the Phase I or Phase II Model 347 helicopter could hover OGE at a higher gross weight than the CH-47C helicopter (para 13).

d. At a light referred gross weight (42,000 pounds), level flight power requirements were similar for the Phase I and the Phase II Model 347 helicopter and the CH-47C (para 15).

e. At a heavy referred gross weight (54,000 pounds), the Phase II Model 347 winged helicopter exhibited improved level flight performance over the Phase I aircraft and the CH-47C (para 15).

f. Climb performance of the Model 347 winged helicopter was slightly improved over the CH-47C (para 17).

g. Autorotational rate of descent was increased 20.9 percent with the wing in the cruise position as compared with the wing in the autorotation position (para 19).

h. Autorotational descent performance of the Model 347 winged helicopter with the wing in the autorotation position was essentially the same as that determined for the CH-47C helicopter (para 19).

i. The control system mechanical characteristics were unchanged from Phase I (paras 21 and 22).

j. The minimal longitudinal and lateral trim changes with power variation reduced pilot workload during transition from one flight regime to another and enhanced mission accomplishment during instrument flight conditions or precision tasks under visual flight conditions (HQRS 2) (para 23).

k. Lateral trim shifts during rearward and slow-speed forward flight were very small and considerably improved over Phase I (para 28).

l. Desired trim airspeeds in the range from 30 KCAS rearward to 40 KCAS forward were easily attained and maintained (HQRS 2) (para 28).

m. The lateral parallel trim mechanism, required in Phase I to correct lateral control migration with airspeed change, was not required on the Model 347 winged helicopter (para 31).

n. The minimal trim changes required when transitioning from climbs or descents to level flight and from level flight to climbs or descents is a highly desirable characteristic (HQRS 1) (para 33).

o. The strong longitudinal stability exhibited by the Model 347 winged helicopter is a very desirable quality and reduced pilot workload in maintaining trim airspeed and pitch attitude (HQRS 2) (para 35).

p. With both DASH systems inoperative, static longitudinal stability was slightly degraded from Phase I, but safe operation of the aircraft in VFR conditions was possible (para 36).

q. Directional stability of the Model 347 winged helicopter was essentially the same as reported in Phase I (para 40).

r. Directional stability under SAS-OFF conditions was improved over the CH-47C (para 40).

s. Dihedral effect of the Model 347 winged helicopter was slightly more positive than was observed in Phase I except in left sideslips during NRP climb (para 41).

t. The neutral pitch with sideslip characteristic is an improvement over the Phase I Model 347 helicopter (para 45).

u. Maneuvering stability was unchanged in left turns and was slightly degraded in right turns (para 48).

v. Dynamic longitudinal stability characteristics were essentially the same as reported in Phase I (para 51).

w. Longitudinal controllability characteristics were similar to Phase I (para 55).

x. The Model 347 winged helicopter exhibited a degradation in lateral controllability from Phase I (para 56).

y. Directional controllability was degraded from Phase I (para 57).

z. Takeoff and landing characteristics were satisfactory with the wing fixed in the cruise position (HQRS 2) (para 63).

aa. Taxi speed was easily controlled from zero throughout a normal taxi speed range by movement of the thrust control rod (HQRS 2) (para 65).

ab. Single engine failure characteristics were similar to those reported in Phase I (para 69).

ac. SAS failure characteristics were unchanged from Phase I (para 70).

ad. Failure of the wing in the cruise position during autorotation did not seriously degrade aircraft response or handling qualities (para 72).

ae. The increased accelerated flight capability and level flight performance achieved with the addition of the wing are gained at the expense of increased weight and complexity. (para 73).

af. Lateral and vertical vibrations at FS 592 were reduced from Phase I (para 76).

ag. The wing did not substantially change the noise characteristics of the aircraft (paras 77 and 78).

ah. Twelve shortcomings were identified during the evaluation.

Shortcomings Affecting Mission Accomplishment

80. Correction of the following shortcomings is desirable. These shortcomings are listed in the order they appear in the text and not necessarily in their orders of importance.

a. Erratic operation of the lateral beep time (HQRS 4) (para 24).

b. Slippage of the thrust control rod at high power settings (HQRS 5) (para 26).

c. Weak sideforce characteristics in autorotation (HQRS 4) (para 42).

d. Excessive longitudinal oscillation in turns above 30 degrees angle of bank at 85 KCAS (HQRS 6) (para 48).

e. Neutral maneuvering stability in turns exceeding 30 degrees angle of bank at 130 and 148 KCAS (HQRS 4) (para 49).

f. The excessive sensitivity of rotor speed to thrust control rod position during autorotational flight and the associated rapid build-up of rotor speed during autorotation entry (HQRS 5) (para 58).

g. Poor performance and objectionable handling qualities during takeoff with the wing incidence control system functioning in the automatic mode (HQRS 6) (para 60).

h. Objectionable handling qualities during landings and decelerations with the wing incidence control system functioning in the automatic mode (HQRS 5) (para 61).

i. Dynamic system pounding during ground operations (para 66).

j. Power steering "dropout" during taxi (para 67).

k. Excessive 8/rev vibration during hover, approach to a hover, and in left sideward flight at 30 KCAS (para 75).

l. Excessive 4/rev vertical vibrations in the rear cabin area (para 76).

Specification Compliance

81. Within the scope of this test, the stability and control characteristics and the vibration characteristics of the Model 347 helicopter failed to meet the following requirements of military specification MIL-H-8501A:

a. Paragraph 3.4.2 - Thrust control rod slippage at high power settings (para 26).

b. Paragraph 3.3.9 - Neutral directional stability in right sideslips above 17 degrees at 85 KCAS (para 38).

c. Paragraph 3.3.9 - Neutral dihedral effect in left sideslips to 12 degrees during NRP climbs (para 41).

d. Paragraph 3.7.1(b) - Excessive 8/rev vibration level during hover, approach to a hover, and left sideward flight at 30 KCAS (para 75).

e. Paragraph 3.7.1(b) - Excessive 4/rev vertical vibration at FS 592 in the airspeed range of 66 to 146 KTAS (para 76).

RECOMMENDATIONS

82. The shortcomings should be corrected (para 80).

83. The following enhancing features should be incorporated in future helicopter designs:

a. The minimal trim changes required during transitions between climbs, descents, or level flight (HQRS 1) (para 33).

b. Full freedom-of-movement of the thrust control rod during ground operation as an aid in controlling taxi speed (HQRS 2) (para 65).

APPENDIX A. REFERENCES

1. Report, USAASTA, Project No. 70-38, *Technical Evaluation, Boeing-Vertol Model 347 Advanced Technology Helicopter, Phase I*, January 1972.

2. Letter, AVSCOM, AMSAV-EF, 8 March 1972, subject: Test Directive, Evaluation of Boeing-Vertol Model 347, Phase II.

3. Test Plan, USAASTA, Project No. 72-12, *Army Technical Evaluation Phase II, Boeing-Vertol Model 347 Winged Helicopter*, April 1972.

4. Operator's Manual, TM 55-1520-209-10, *Army Model CH-47A Helicopter*, May 1968.

5. Operator's Manual TM 55-1520-227-10, *Army Model CH-47B and CH-47C Helicopters*, 5 August 1970.

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

7. Document, The Boeing Company, Vertol Division, *Model 347 Demonstrator Pilot Manual*, May 1971, as revised, March 1972.

8. Letter, AVSCOM, AMSAV-EF, 16 March 1972, subject: Safety-of-Flight Release for Boeing-Vertol Model 347, Project No. 72-12.

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

10. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance Testing*, 28 June 1968.

11. Military Specification, MIL-A-8806A, *Acoustical Noise Level in Aircraft, General Specification For*, 11 July 1966, with Amendment 1, 12 September 1967.

APPENDIX B. DESCRIPTION OF TEST AIRCRAFT

GENERAL

1. The Boeing-Vertol Model 347 winged helicopter was derived from the Boeing-Vertol Model 347 flown in the Phase I Army technical evaluation. The Phase I Model 347 is described in appendix A, reference 1. The aircraft was powered by two up-rated T55-L-11 engines. The only major changes were the structural modifications to the fuselage and the addition of a variable incidence high mounted wing with full span flaps. Wing details are depicted in table A.

Table A. Model 347 Wing Basic Data
(Wing tip not included)

Projected wing area	339.61 ft^2
Wing area	342.54 ft^2
Aspect ratio	6.0
Taper ratio, $\frac{\text{tip chord}}{\text{root chord}}$	0.50
Trailing edge sweepback	5°
Anhedral	7.5°
Projected span	45.11 ft
True semi-span	22.75 ft
Root chord	10.04 ft
Tip chord	5.02 ft
Mean aerodynamic chord (effective)	7.42 ft
Aircraft centerline (BL 0) to M.A.C. (measured in wing reference plane)	11.85 ft
Airfoil	note[1]

[1]NACA 65A618 modified to eliminate trailing edge cusp.

FUSELAGE MODIFICATIONS

2. The following structural modifications were made to the fuselage to accommodate the wing structure pivot points and wing tilt actuator.

a. The crown and side frames from fuselage station (FS) 410 were eliminated to provide a cut-out for the wing center section. The crown frame at FS 380 was eliminated and a shear deck in the crown area from FS 370 to 410 was added to close the structure of the fuselage crown.

b. A new frame was added at FS 410 to provide structural support for the wing pivot points, wing pivot fittings were added at FS 407.8, and longitudinal beams installed between FS 388 and 410.

c. New frames were added at FS 370 and 388 with intercostal beams between these frames to provide support for the wing tilt actuator installation. Wing tilt actuator pivot fittings were provided on both sides of the fuselage at FS 370 and 388.

d. Heavier gauge skin was installed between FS 320 and 440 and the longerons from waterline (WL) zero to WL + 47.

WING CHARACTERISTICS

3. The wing is a semimonocoque structure made of an aluminum alloy. Full span, 40 percent chord, flaps are incorporated. The basic wing structure is a three spar construction with multi-element spar caps installed for fail-safe redundancy. Additional fail-safe features include: (a) auxiliary wing-to-fuselage drag links which protect against wing detachment in case of failure of the wing pivot fitting, and (b) auxiliary flap hinge points which provide redundancy for the flap hinges and flap actuators.

4. A wing tilt actuator is provided at each side of the fuselage. Each actuator is driven through interconnecting shafts from one central wing tilt power pack. In case of a single actuator failure, the remaining actuator will position the entire wing through the interconnecting shaft mechanism.

5. Each flap has three actuators located below the wing and driven by a series of interconnecting shafts from a flap power pack located in the wing center section. Also provided is a "flaperon" power pack for differential actuation of the flaps for roll control augmentation.

WING OPERATION

6. The wing has two operating modes, automatic and manual. The automatic mode requires no pilot inputs, utilizing an airspeed cue, thrust control rod position,

normal acceleration, and rotor speed to determine wing and flap position. The wing and flaps are driven by hydraulic power when the wing is operated in the automatic mode. In the manual mode, the pilot controls wing incidence with an electrical beep switch located on the thrust control rod.

7. In the automatic mode, wing incidence is automatically programmed to the positions shown in figure 1. In the hover mode, wing incidence is 85 degrees. The wing is programmed down to the cruise position (10.5 degrees) during transition into forward flight. An airspeed sensor is used to begin programming the wing at a free stream dynamic pressure of 5 pounds per square foot, approximately 40 knots airspeed at sea level conditions. Hydraulic actuators drive the wing at a nominal rate of 12 degrees per second. During ground operations, a rotor speed sensor insures that the wing is in the cruise position when the rotor speed is below 150 rpm to insure blade clearance above the wing. Above a rotor speed of 150 rpm an rpm switch interlock system automatically moves the wing to the hover position. For entry into autorotation from cruise flight, the wing programs down to a maximum angle of incidence of -10 degrees and the flaps deflect to a maximum angle of 20 degrees, trailing edge up. Programming of the wing to the autorotational position is determined by thrust control rod position and airspeed. Wing incidence is 10.5 degrees for collective positions of 70 percent or greater and is programmed linearly to -10 degrees at 21 percent of collective. The wing rotates at a nominal rate of 8 degrees per second for autorotational entry. The flaps begin to program trailing edge upward at 21 percent of collect position, obtaining a maximum deflection of 20 degrees trailing edge up at a collective position of 11 percent. The speed of flap rotation is nominally 15 degrees per second. For autorotation entry from hover, the wing remains at an incidence of 85 degrees.

8. Flap position in forward flight is controlled by the common mode and the differential mode, which can be operated simultaneously. The differential mode positions the flaps differentially in response to inputs from lateral cyclic to enhance roll control. In the differential mode, the flaps have a maximum deflection of ±1.7 degrees for the first 1.5 inches of lateral control travel. In the common mode, the flaps are independently programmed from 0 degrees to a maximum flap angle of 30 degrees trailing edge down as a function of normal acceleration. If both flap control modes are inoperable, the flaps will remain fixed in the position they were in when the flap control system failed or the system was turned off.

9. If hydraulic power fails, the wing can be driven by an electrical system. The beep switch for the electrical system is located on the thrust control rod. In the electrical or manual mode, the wing can be set at any incidence angle between 85-degrees leading edge up and 10-degrees leading edge down.

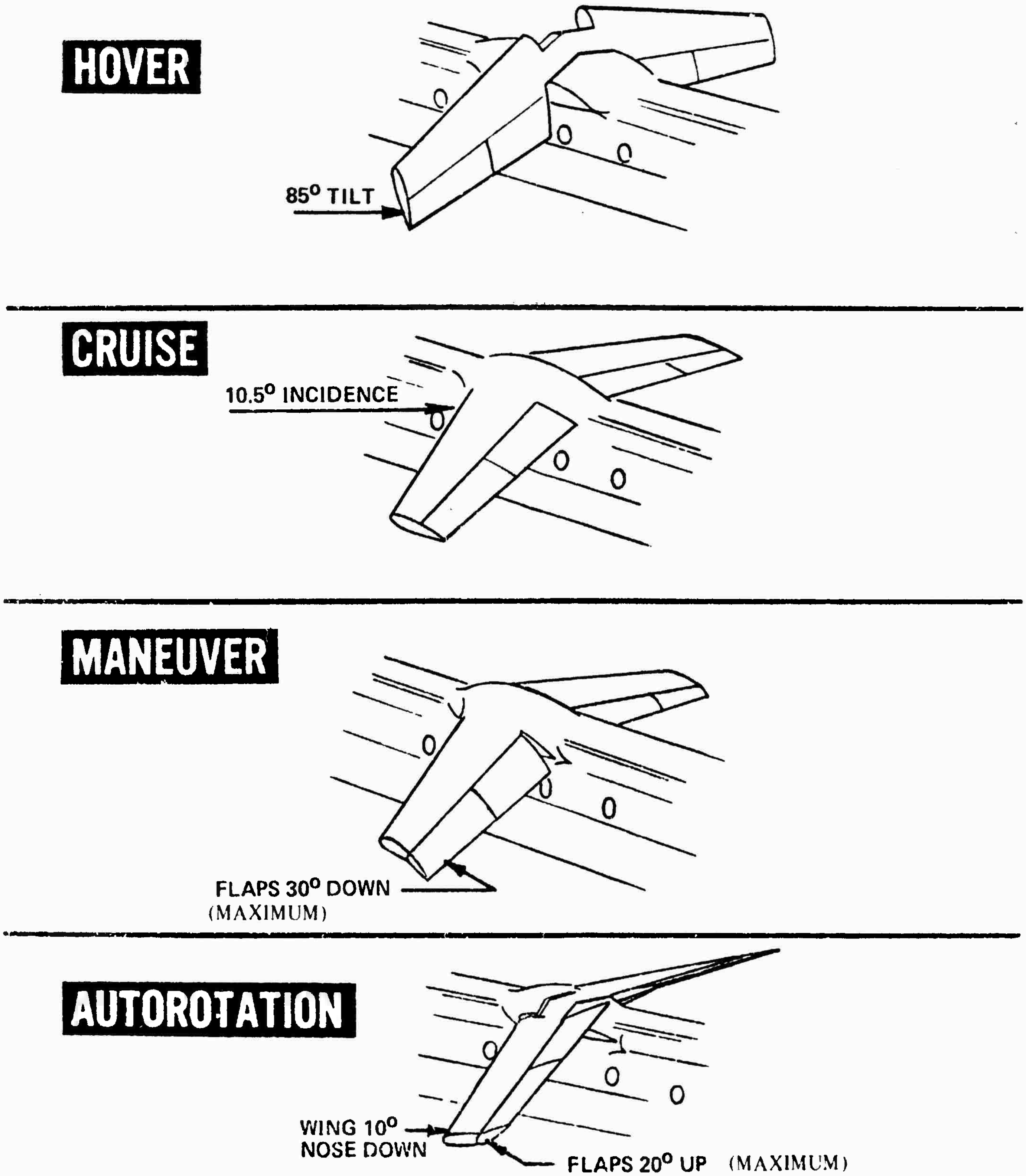


Figure 1. Model 347 Wing Flight Modes.

APPENDIX C. PHOTOGRAPHS

Photo 1. Front View - Wing in Cruise Position

Photo 2. Front View - Wing in Hover Position

Photo 3. Left Front View - Wing in Cruise Position

Photo 4. Right Front View - Wing in Cruise Position

Photo 5. Right Front View - Wing in Hover Position

Photo 6. Left Side View - Wing in Cruise Position

Photo 7. Left Side View - Wing in Hover Position

Photo 8. Right Rear View - Wing in Cruise Position

Photo 9. Right Rear View - Wing in Hover Position

Photo 10. Left Rear View - Wing in Cruise Position

Photo 11. Model 347 in Forward Flight - Wing in Cruise Position

Photo 12. Tethered OGE Hover - Wing in Hover Position

Photo 13. Tethered OGE Hover - Wing in Cruise Position

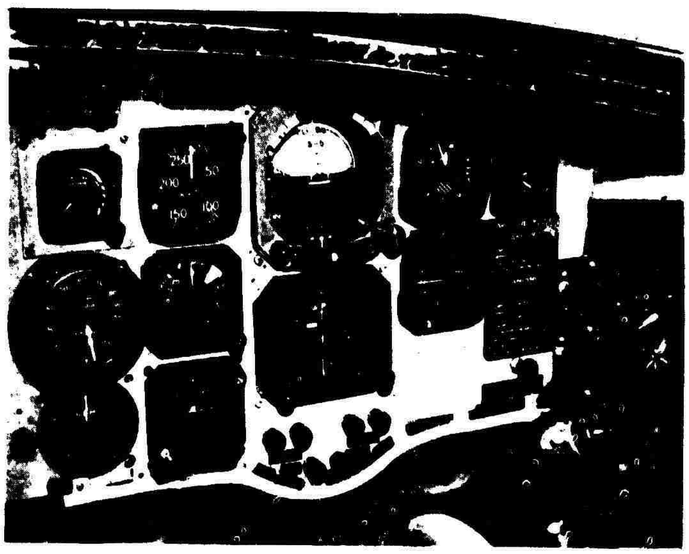


Photo 14. Pilot's Instrument Panel

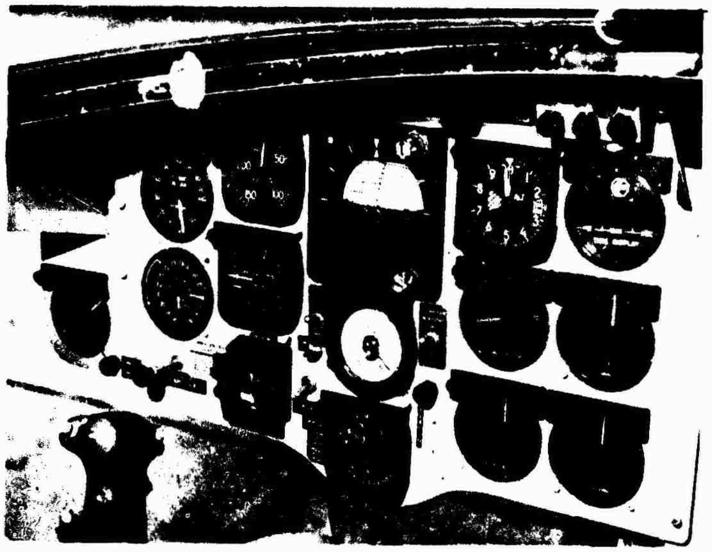


Photo 15. Co-pilot's Instrument Panel

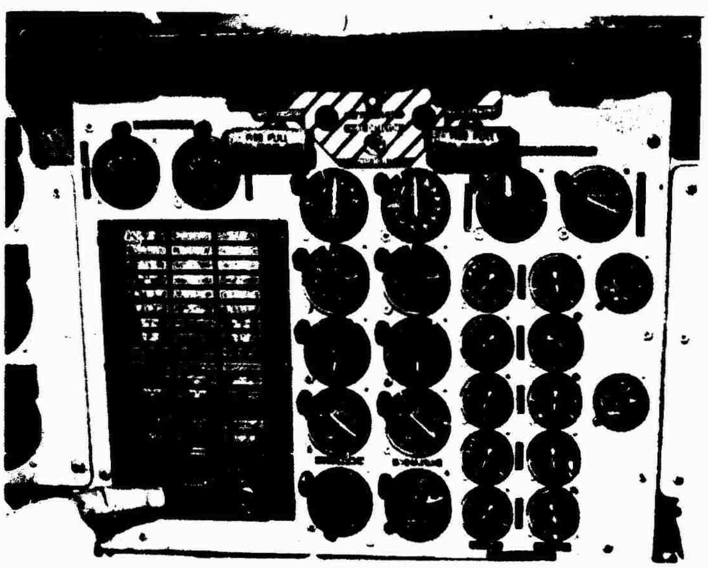


Photo 16. Center Instrument Panel

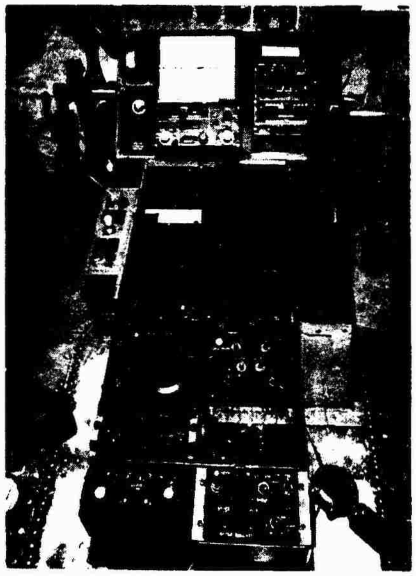


Photo 17. Center Console

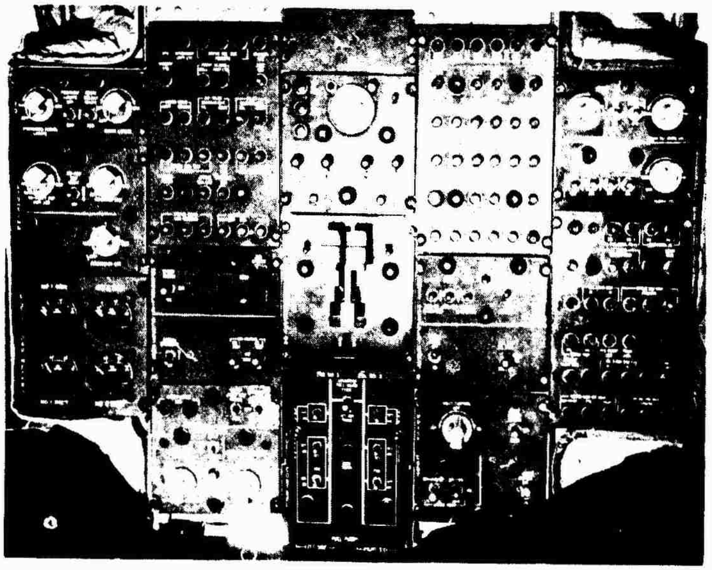


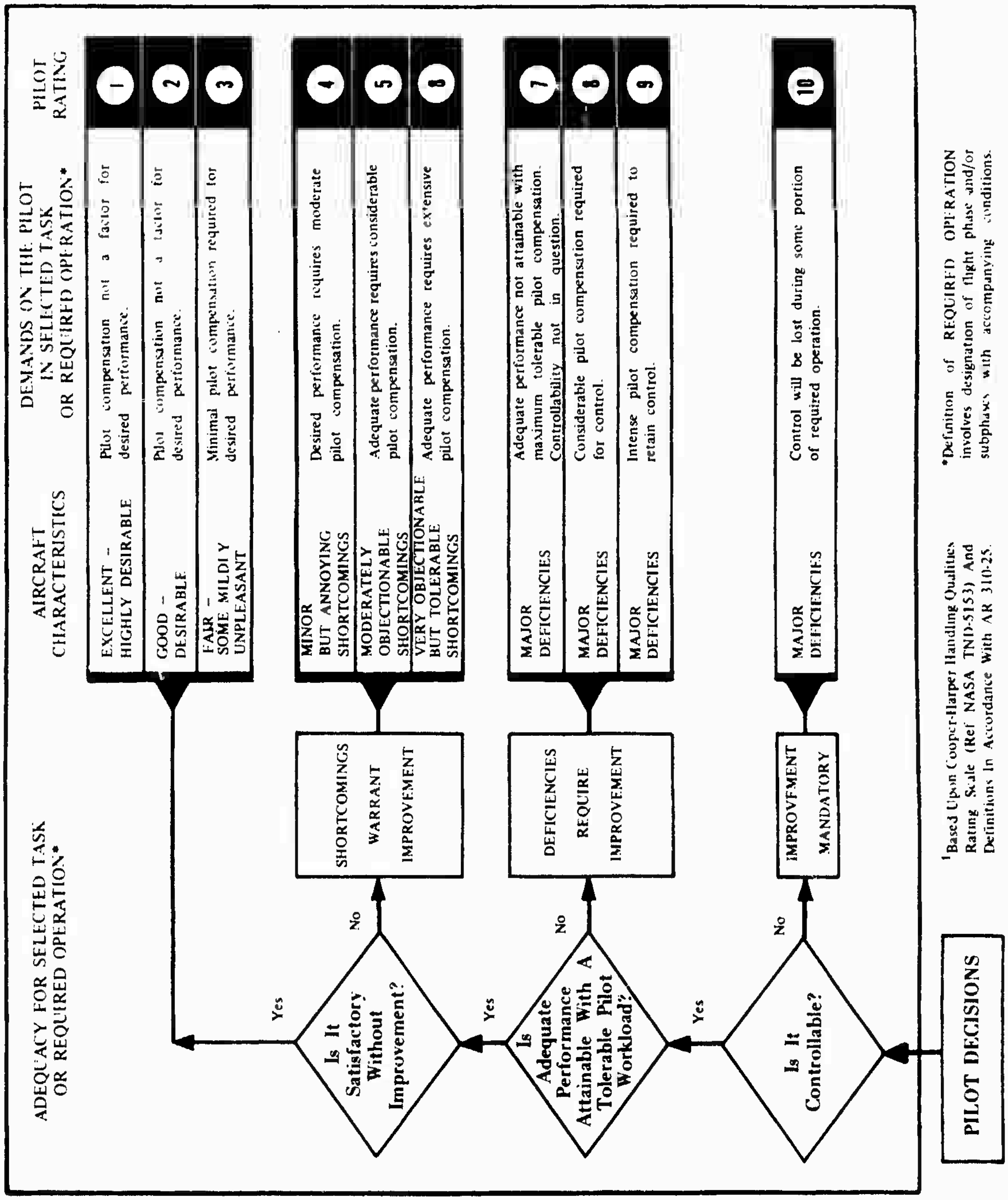
Photo 18. Overhead Console

Appendix D. Test Conditions[1,2]

Test	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Temperature (°C)	Trim Airspeed (KT)
Hover performance	40,000	-455	8.0	Zero[3]
Level flight performance	40,030	-90	1.5	53 to 163 KTAS[4]
	44,630	3500	-6.6	47 to 168 KTAS
Climb performance	44,550	5000	5.0	76 to 95 KCAS[5]
Autorotation performance	44,550	5000	5.0	65 to 129 KCAS
Slow-speed forward and rearward flight	44,250	-200	12.0	Note[6]
Sideward flight	46,000	-200	12.0	Note[7]
Control positions in trimmed forward flight (level)	40,030	-90	1.5	54 to 160 KCAS
	44,630	3500	-6.6	61 to 152 KCAS
Control positions in trimmed climb at NRP	44,550	5000	5.0	76, 86, and 95 KCAS
Control positions in trimmed autorotational descent	44,550	5000	5.0	65, 85, 97, 100, 102, 110, and 129 KCAS
Collective-fixed static longitudinal stability	43,400 to 46,300	5000	-2.0 to -7.0	82, 83, 86 110, 131 KCAS
Static lateral-directional stability	43,400 to 46,000	5000	-1.5	85, 112, 129 KCAS
Maneuvering stability	44,700 to 45,870	5000	-3.0 to -4.0	85, 130, 148 KCAS
Dynamic stability	43,950 to 45,150	-930 to 5000	3.5 to 5.0	Zero[3], 83, 112, 129 KCAS
Controllability	43,950 to 46,250	-1100 to 5000	3.5 to 14.5	Zero[3], 83, 112, 129 KCAS
Autorotational characteristics	44,550	5000	5.0	71 to 142 KCAS
Takeoff and landing and wing operation	43,100	-550	9.5	Zero to 100 KIAS[8]

[1]Doors, windows, and ramp closed. Rotor speed: 220 referred rpm for all tests except hover performance where referred rpm was 217, 235, and 220.
[2]Midpoint between rotors is at fuselage station (FS) 386. Longitudinal center of gravity range: FS 375.5 to 376.5 (fwd).
[3]Out-of-ground-effect hover (150 foot aft wheel height).
[4]Referred knots true airspeed (KTAS).
[5]Knots calibrated airspeed (KCAS).
[6]Zero to 30 KCAS rearward and 40 KCAS forward (10-foot aft wheel height, in-ground-effect).
[7]Zero to 30 KCAS sideward (10-foot aft wheel height, in-ground-effect).
[8]Knots indicated airspeed (KIAS).

APPENDIX E. HANDLING QUALITIES RATING SCALE



APPENDIX F. TEST INSTRUMENTATION

GENERAL

1. All test instrumentation was installed, calibrated, and maintained by the contractor at the test site.

TEST PARAMETERS RECORDED

2. Quantitative data were obtained from both cockpit displays and from a magnetic tape recorder installed in the forward area of the cabin. The following test paraemters were recorded:

Parameter	Magnetic Tape	Cockpit
Airspeed (ship's system)	X	X
Altitude (ship's system)	X	X
Outside air temperature	X	X
Time of day	X	X
Angle of sideslip	X	X
Rotor speed	X	X
#1 engine fuel-flow rate	X	
#2 engine fuel-flow rate	X	
#1 engine fuel temperature	X	
#2 engine fuel temperature	X	
#1 engine gas producer speed	X	X
#2 engine gas producer speed	X	X
#1 engine torque		X
#2 engine torque		X
Fuel quantity indicator		X
#1 engine fuel totalizer	X	
#2 engine fuel totalizer	X	
Forward rotor shaft torque	X	
Aft rotor shaft torque	X	
Event marker	X	X
Record counter	X	X
Longitudinal control position	X	X
Lateral control position	X	X
Directional control position	X	X
Thrust lever position	X	X
Pitch attitude	X	
Roll attitude	X	
Yaw attitude	X	
Pitch angular rate	X	
Roll angular rate	X	

Yaw angular rate	X	
Center-of-gravity normal acceleration	X	X
DASH system actuator position (upper)	X	
DASH system actuator position (lower)	X	
Wing tilt position	X	X
Left wing flap position	X	X
Right wing flap position	X	X
Longitudinal cyclic speed trim position (forward)	X	
Longitudinal cyclic speed trim position (aft)	X	
#1 yaw SAS extensible link position	X	
#2 yaw SAS extensible link position	X	
Swiveling actuator position (forward and aft head)	X	
Pivoting actuator position (forward and aft head)	X	
Vertical vibration, FS 50, BL 35L, WL -15	X	
Lateral vibration, FS 50, BL 35L, WL -15	X	
Vertical vibration, FS 50, BL 35R, WL -15	X	
Lateral vibration, FS 95, BL 0, WL -15	X	
Vertical vibration, FS 95, BL 0, WL -15	X	
Longitudinal vibration, FS 95, BL 0, WL -15	X	
Vertical vibration, FS 360, BL 49L, WL -30	X	
Vertical vibration, FS 360, BL 49R, WL -30	X	
Lateral vibration, FS 360, BL 49R, WL -30	X	
Vertical vibration, FS 592, BL 49L, WL -30	X	
Vertical vibration, FS 592, BL 49R, WL -30	X	
Lateral vibration, FS 592, BL 49R, WL -30	X	

NOTE: Vibration sensors were mounted to airframe as follows:

FS 50 On canted deck immediately forward of heel slide. Canted deck is the extreme forward portion of floor where floor is connected to skin structure.

FS 95 On floor panel, immediately aft of pedestal.

FS 360 On floor panel, between floor outer tiedown and aircraft outer skin.

FS 592 On floor panel, between floor outer tiedown and aircraft outer skin.

APPENDIX G. DATA REDUCTION AND ANALYSIS PROCEDURES

GENERAL

1. Nonstandard data reduction and analysis procedures were required in certain test areas, due to the unique characteristics of the Model 347 control system. The use of control position transducer (stick pick-off) inputs to modify the output of the augmentation systems, and the use of various augmentation devices to enhance static stability characteristics precluded the direct use of control position data to indicate static longitudinal, lateral, and directional stability, and static longitudinal trim characteristics.

STATIC LONGITUDINAL STABILITY CHARACTERISTICS

2. A dual DASH actuator system is located in the longitudinal control mechanical linkage. Airspeed and pitch attitude signals are fed into this series actuator to provide a high degree of stick-fixed speed and pitch attitude stability. The airspeed and attitude gains are such that, unless modified, the DASH system would require excessively large longitudinal control motions to change airspeed and attitude. A control position transducer signal is, therefore, added to the airspeed and attitude signals to oppose the high static stability characteristics of the DASH system.

3. In order to present the static longitudinal stability in a manner which better indicates the true restoring moment existing at any off–trim airspeed, the stick pick-off contribution must be removed from the summation of control position factors. This is accomplished by use of the SAS pulser box to produce control inputs that eliminate any influence of the control pick-off. When a control input is produced by the SAS pulser box, the change in DASH input will be a function only of the pitch attitude and airspeed contributions. When this change in DASH input in inches of equivalent control is plotted versus the change in airspeed from trim, the static longitudinal stability of the aircraft, independent of control pick-off variation is determined at the off trim airspeed.

STATIC DIRECTIONAL STABILITY CHARACTERISTICS

4. The static directional stability characteristics of the aircraft are indicated by the variation of directional control position with sideslip. The characteristic with both SAS operating is simply described by the measured control position data. In order to describe the SAS-OFF characteristics, it is necessary to mathematically remove the contribution provided by the yaw SAS actuators. The relation between yaw SAS actuator motion and directional control motion is known to be:

Equivalent directional control motion = (1.75) (yaw SAS actuator motion)

The following relationship, therefore, describes the SAS-OFF directional control position and can be used to indicate SAS-OFF directional stability:

Directional control position$_{(SAS\text{-}OFF)}$ = directional control position$_{(SAS\text{-}ON)}$

−(1.75) (yaw SAS actuator motion)

or: $\delta_{Pedal(SAS\text{-}OFF)} = \delta_{Pedal(SAS\text{-}ON)} - (1.75)\,(\delta_{SAS})$

APPENDIX H. TEST DATA DISTRIBUTION

INDEX

FIGURE 1

NON-DIMENSIONAL HOVERING PERFORMANCE.

BOEING 347 S/N 65-7992

WHEEL HEIGHT =150 FEET OGE

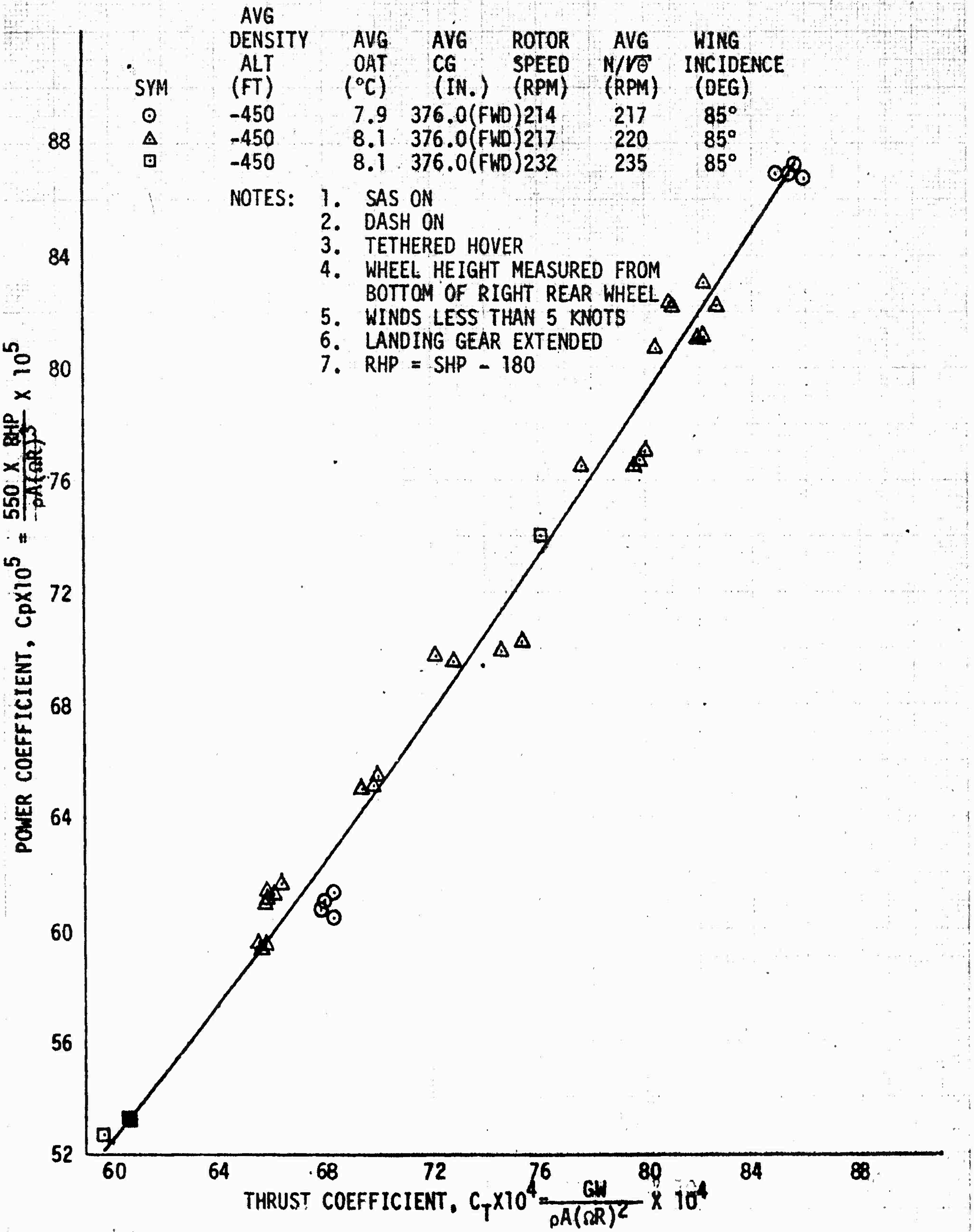


FIGURE 2

NON-DIMENSIONAL HOVERING PERFORMANCE.

BOEING 347 S/N 65-7992

WHEEL HEIGHT = 150 FEET OGE

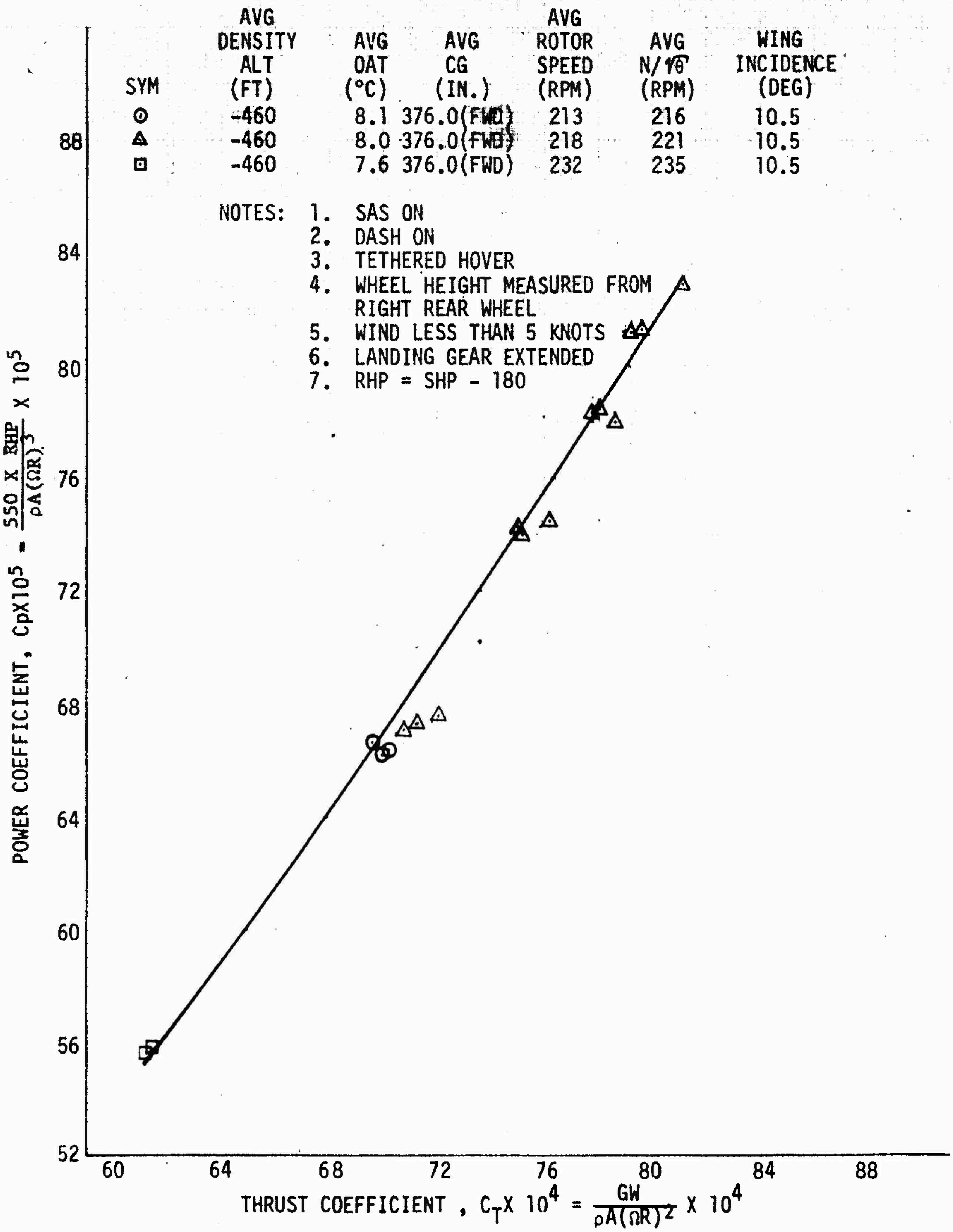


FIGURE 3
LEVEL FLIGHT PERFORMANCE
BOEING 347 S/N 65-7992

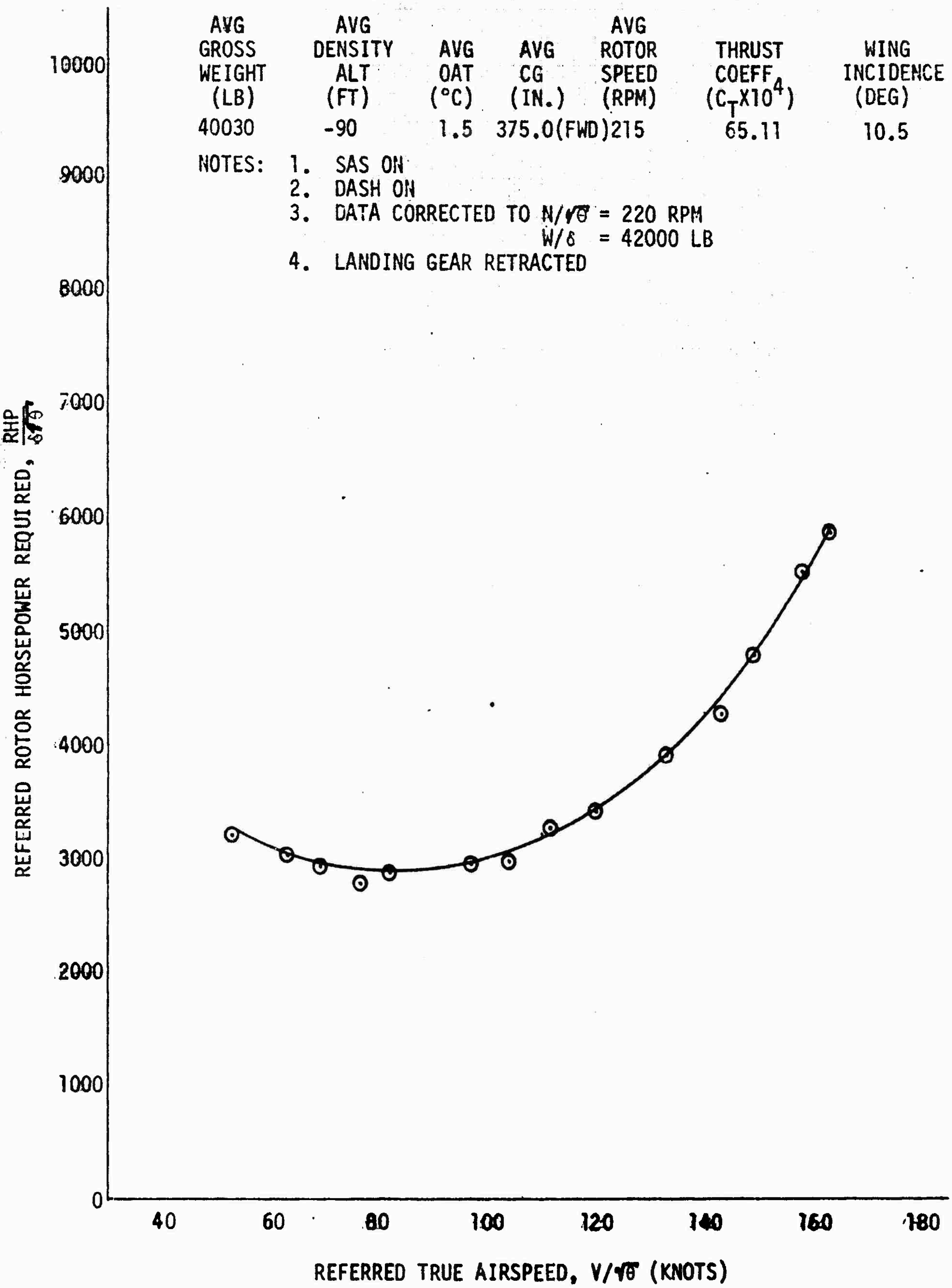


FIGURE 4
LEVEL FLIGHT PERFORMANCE
BOEING 347 S/N 65-7992

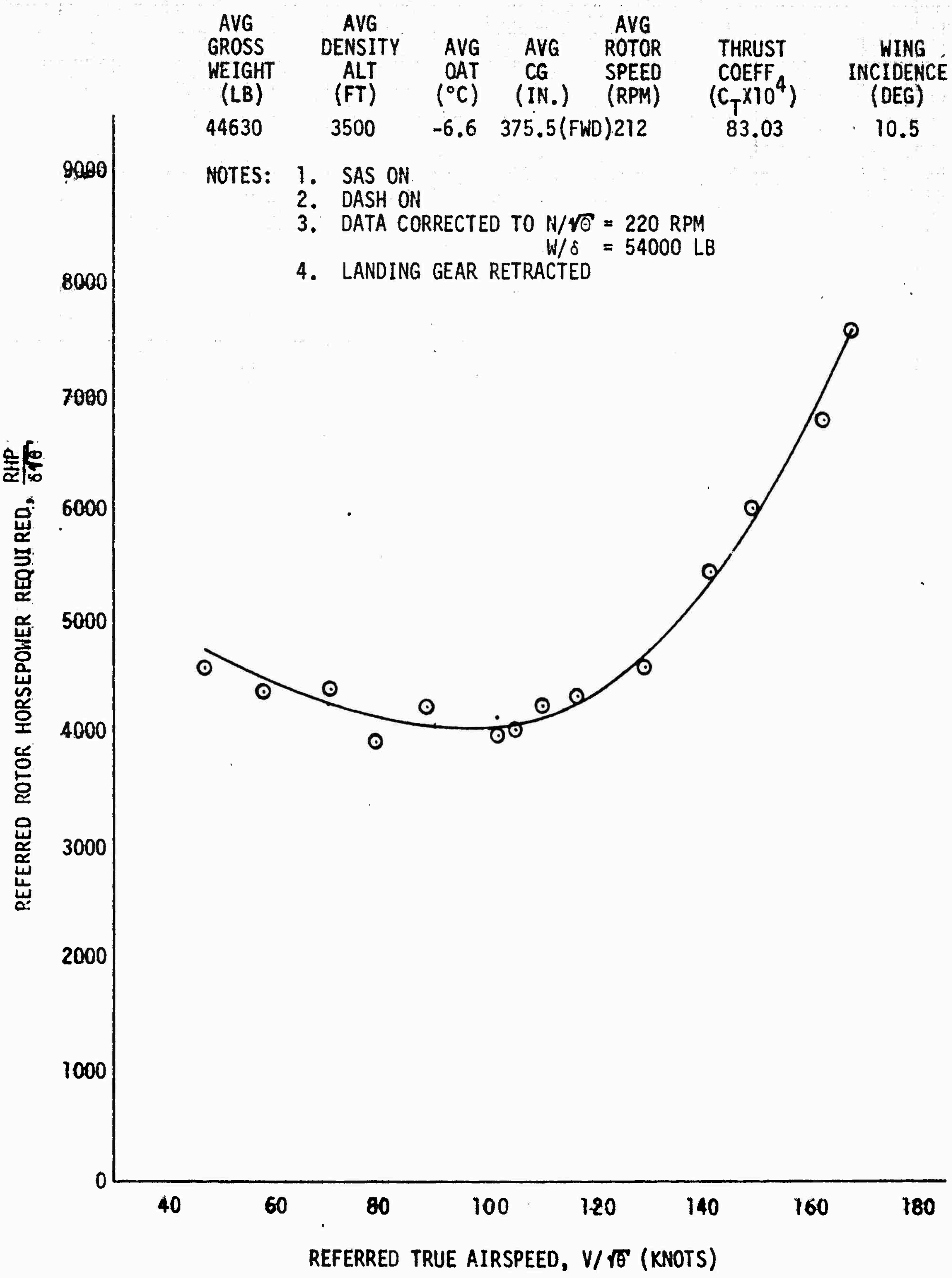


FIGURE 5

CLIMB PERFORMANCE

BOEING 347 SN 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X 10^4$)	WING INCIDENCE (DEG)
44550	5000	5.0	375.5(FWD)	216	83.52	10.5

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. CLIMBS AT NORMAL RATED POWER

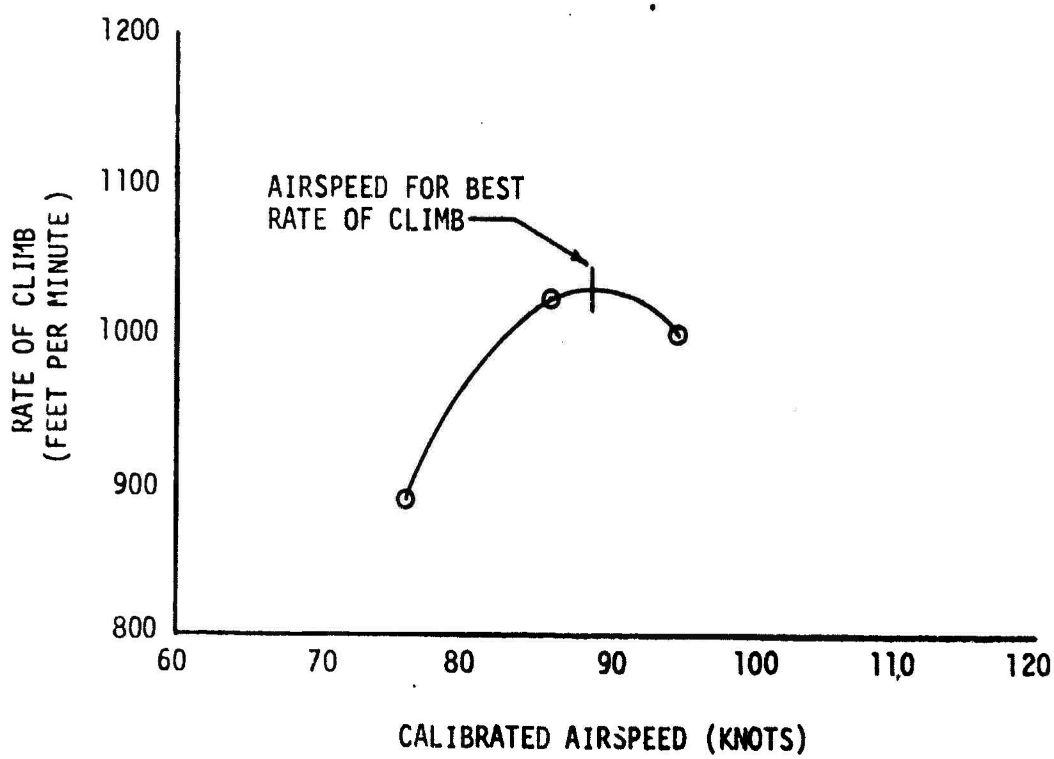


FIGURE 6

AUTOROTATIONAL DESCENT PERFORMANCE

BOEING 347 SN 65-7992

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_T X10^4)	WING INCIDENCE (DEG)
⊙	44550	5000	5.0	375.5(FWD)	216	83.52	-10.0

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. ⊡ DENOTES WING IN CRUISE MODE

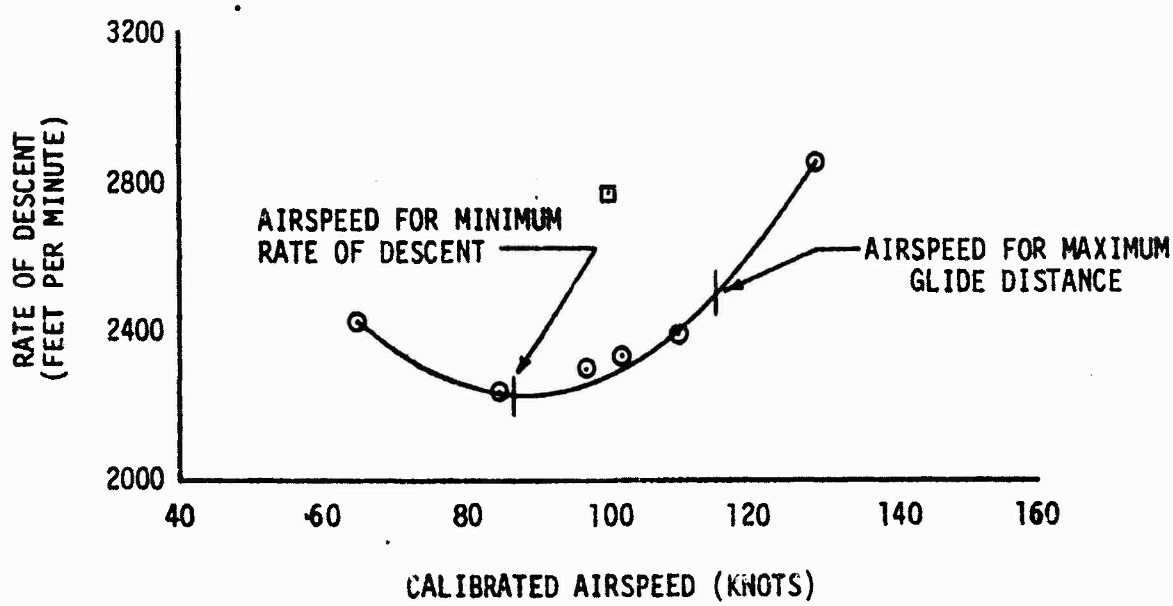


FIGURE 7

CONTROL SYSTEM CHARACTERISTICS.

BOEING 347 S/N 65-7992

AIRSPEED SIGNAL = 0 KIAS

NOTES:
1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC AND ELECTRICAL POWER
2. TOTAL LATERAL CONTROL TRAVEL = 9.25 IN.
3. SHADED SYMBOL DENOTES START POINT
4. ROTORS STATIONARY

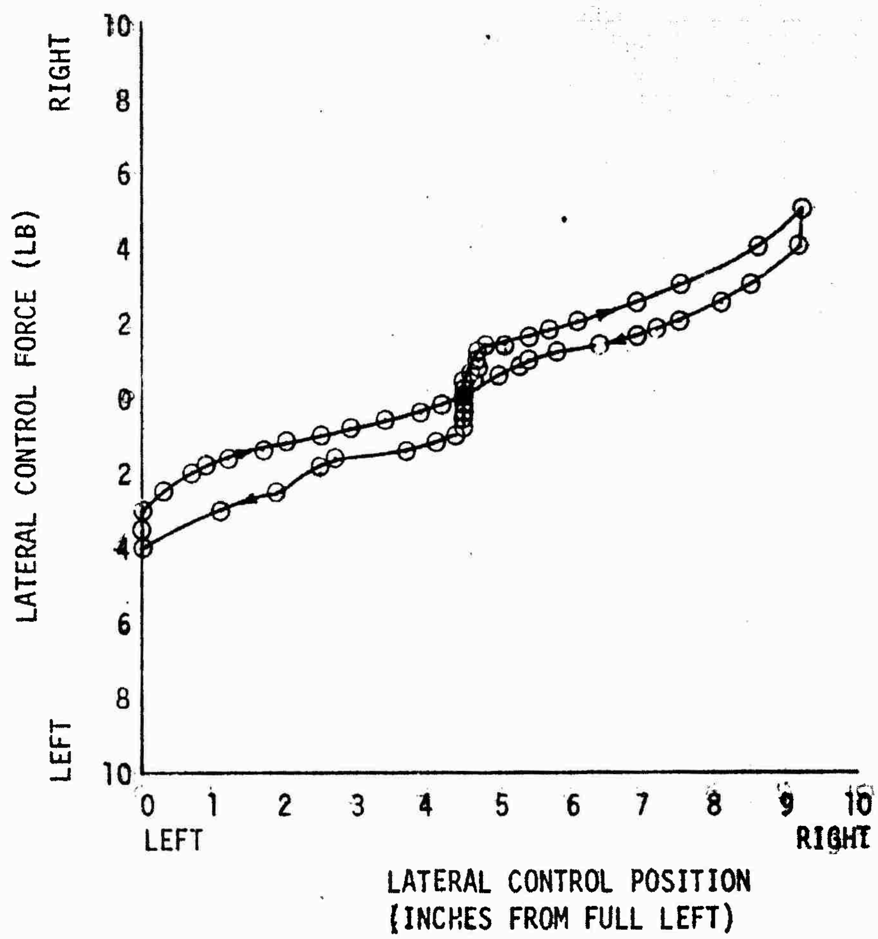


FIGURE 8

CONTROL SYSTEM CHARACTERISTICS.

BOEING 347 S/N 65-7992

AIRSPEED SIGNAL = 100 KIAS

NOTES: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC AND ELECTRICAL POWER.
2. TOTAL LATERAL CONTROL TRAVEL = 9.25 IN.
3. SHADED SYMBOL DENOTES START POINT.
4. ROTORS STATIONARY.

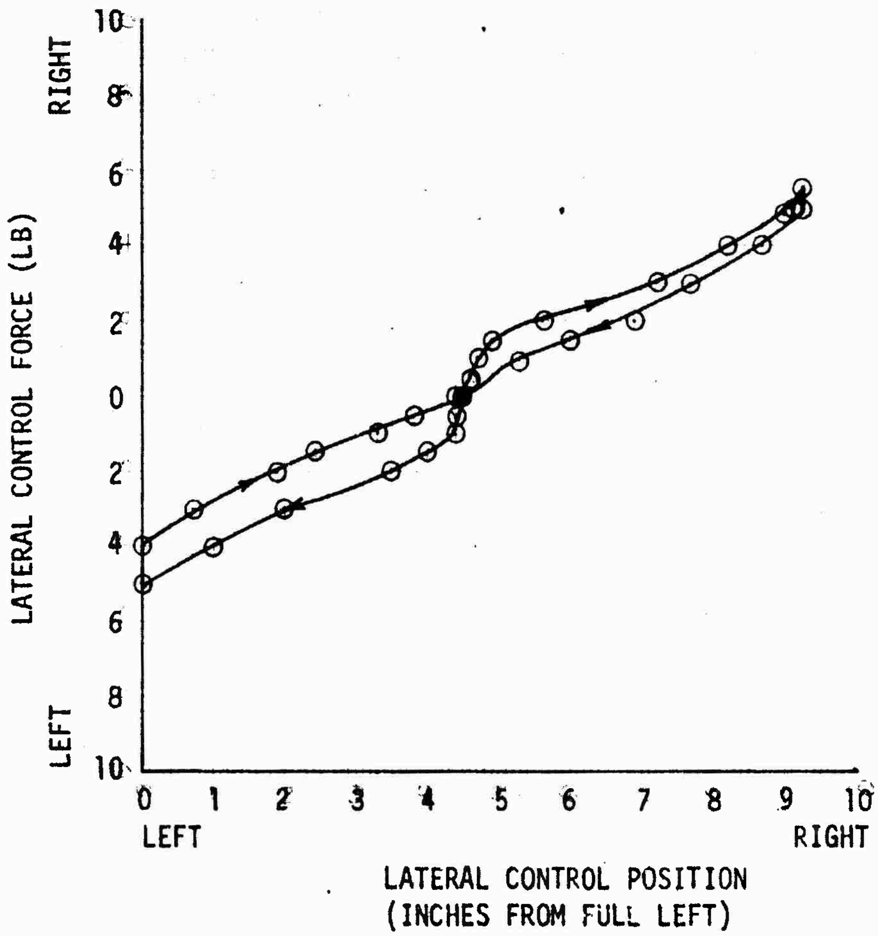


FIGURE 9

CONTROL SYSTEM CHARACTERISTICS.

BOEING 347 S/N 65-7992

AIRSPEED SIGNAL = 170 KIAS

NOTES:
1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC AND ELECTRICAL POWER.
2. TOTAL LATERAL CONTROL TRAVEL = 9.25 IN.
3. SHADED SYMBOL DENOTES START POINT.
4. ROTORS STATIONARY.

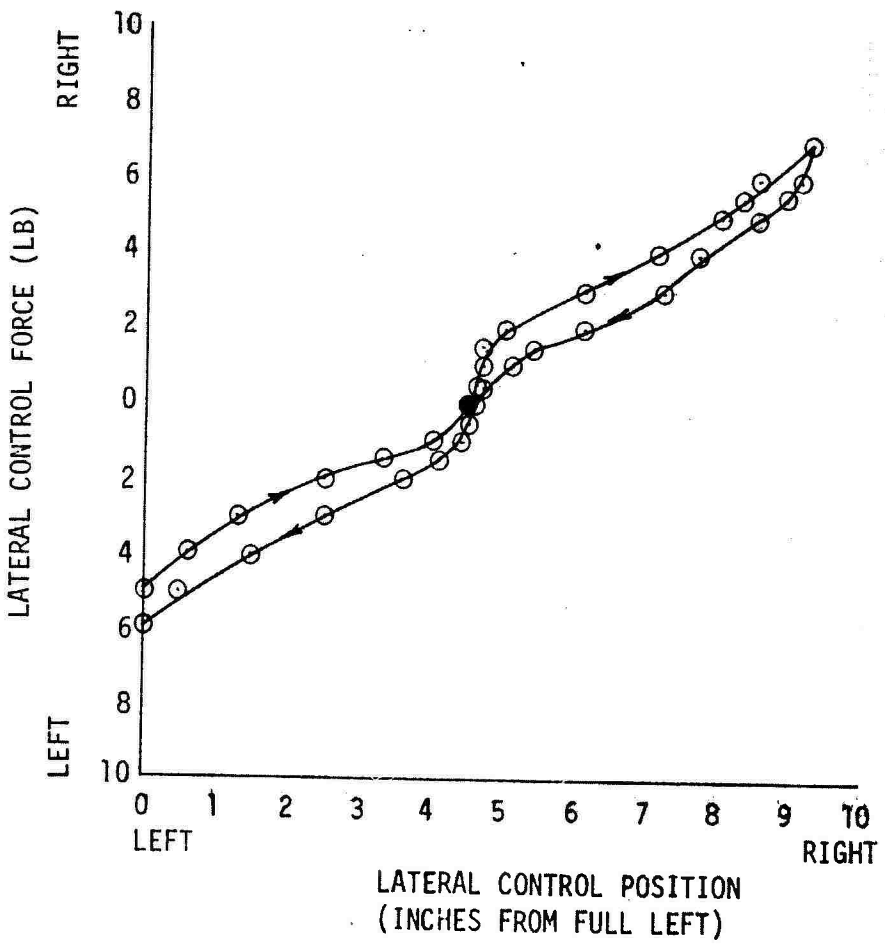


FIGURE 10
CONTROL POSITIONS IN TRIMMED SLOW-SPEED FORWARD AND REARWARD FLIGHT IGE
BOEING 347 S/N 65-7992

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	WING INCIDENCE (DEG)
⊙	44250	-200	12.0	375.5(FWD)	220	68.52	85

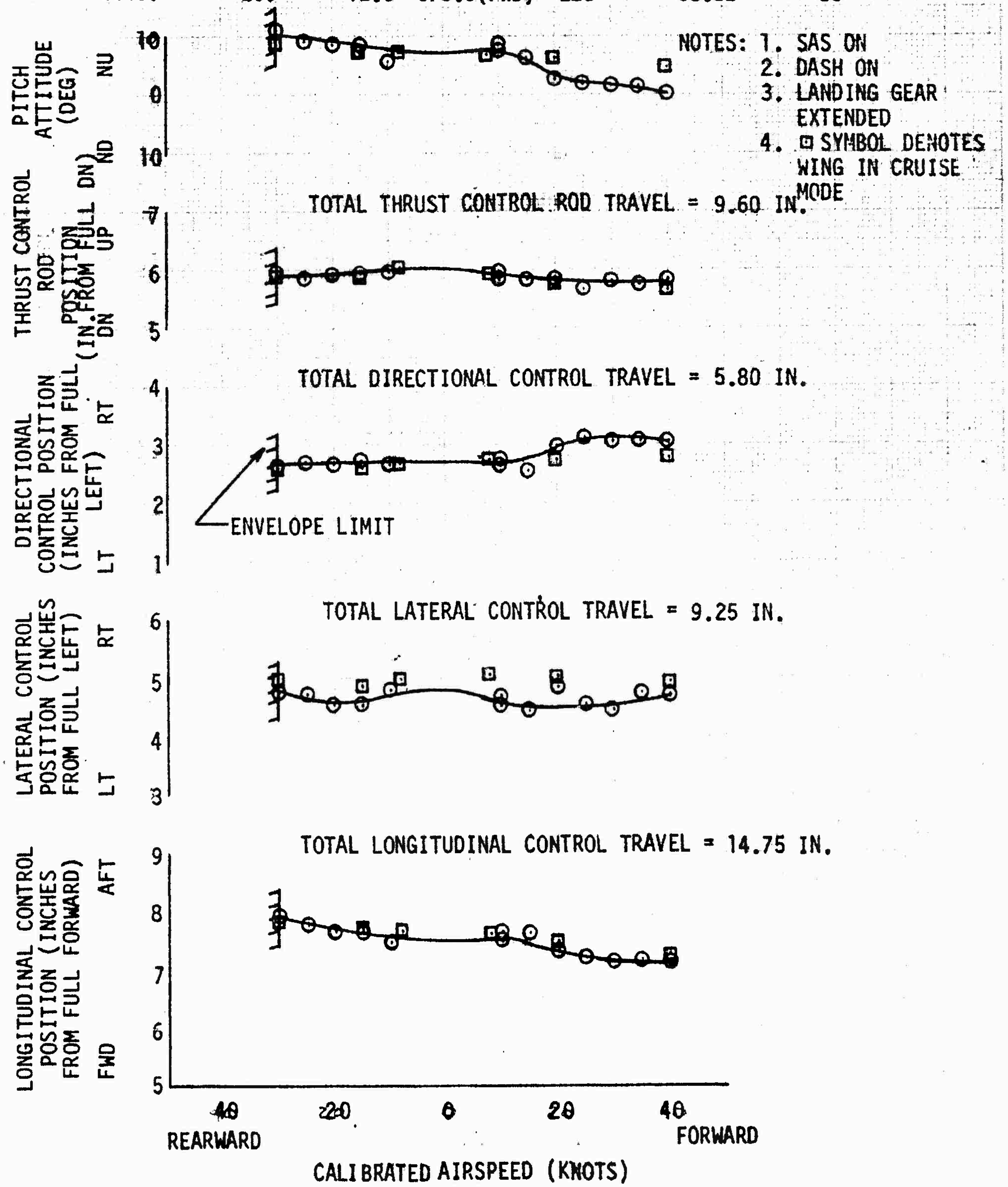


FIGURE 11
CONTROL POSITIONS IN
TRIMMED SIDEWARD FLIGHT IGE
BOEING 347 S/N 65-7992

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	WING INCIDENCE (DEG)
⊙	46000	-200	120	375.5(FWD)	220	71.23	85

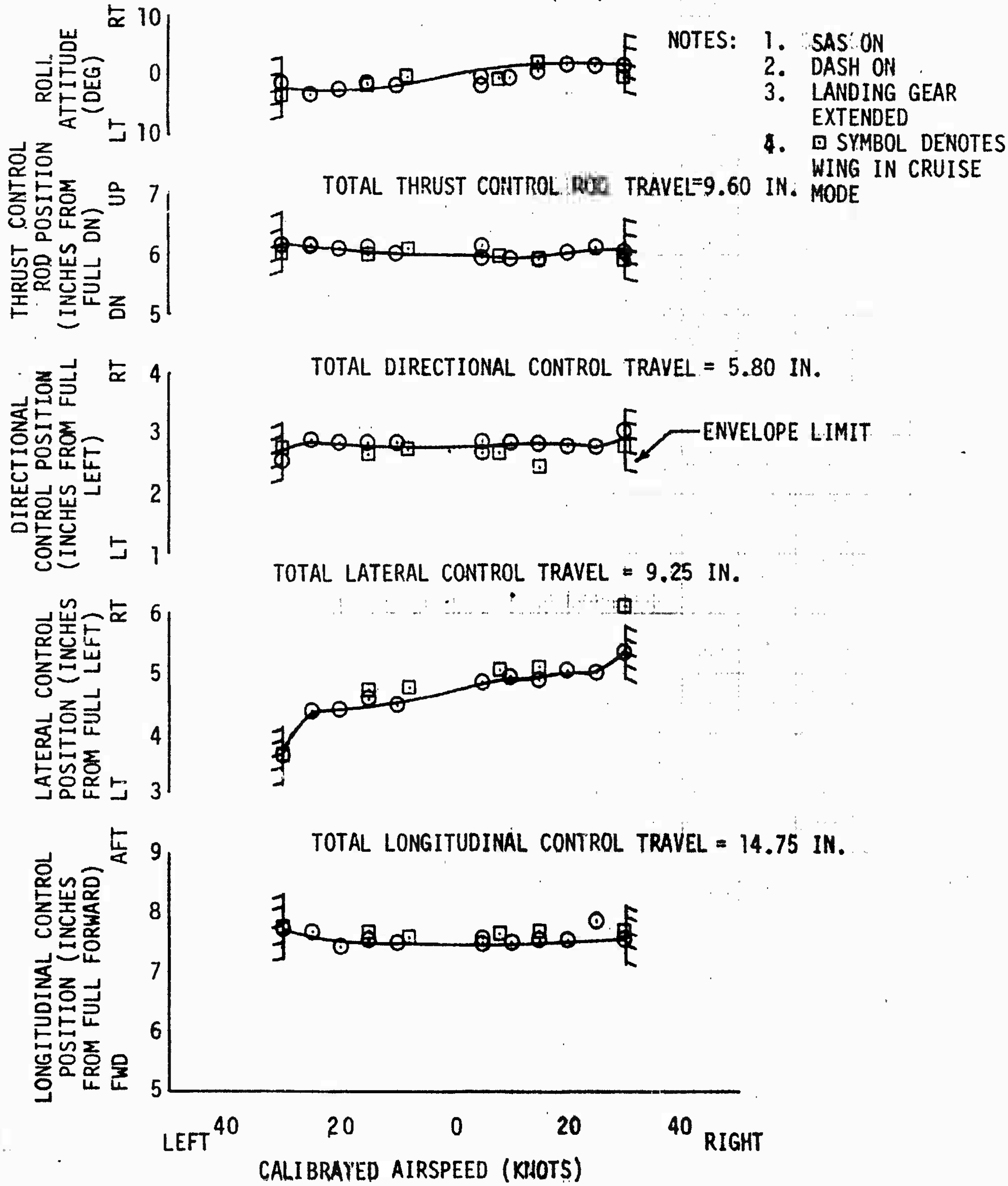


FIGURE 12

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

BOEING 347 S/N 65-7992

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T \times 10^4$)	WING INCIDENCE (DEG)
LEVEL	40030	-90	15	375.0(FWD)	215	65.11	10.5

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED

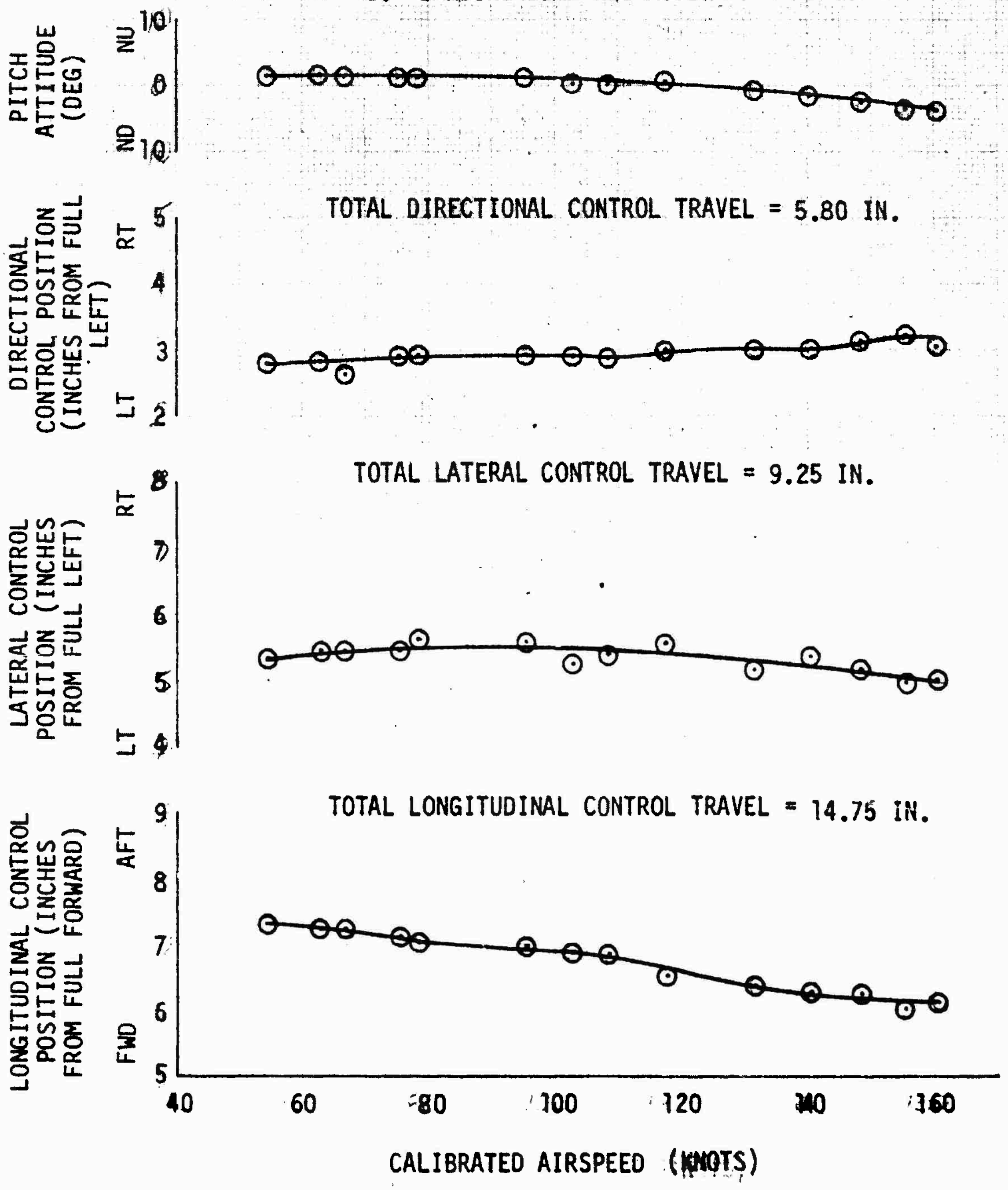


FIGURE 13

CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

BOEING 347 S/N 65-7992

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	WING INCIDENCE (DEG)
LEVEL	44630	3500	-6.6	375.5(FWD)	212	83.03	10.5

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED

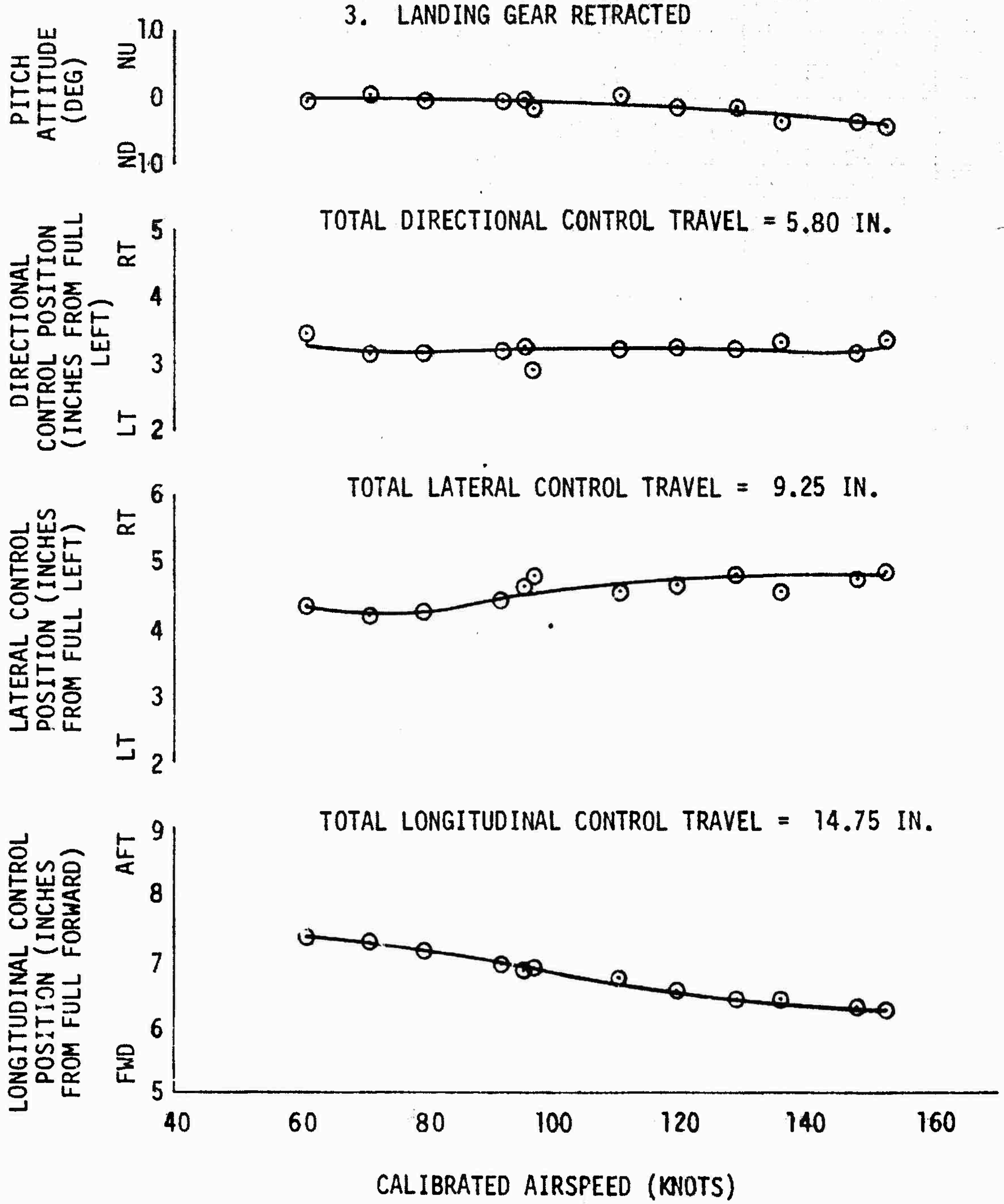


FIGURE 14

CONTROL POSITIONS IN TRIMMED CLIMB AT NRP

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	WING INCIDENCE (DEG)
44550	5000	5.0	375.5(FWD)	216	83.53	10.5

NOTES: 1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED

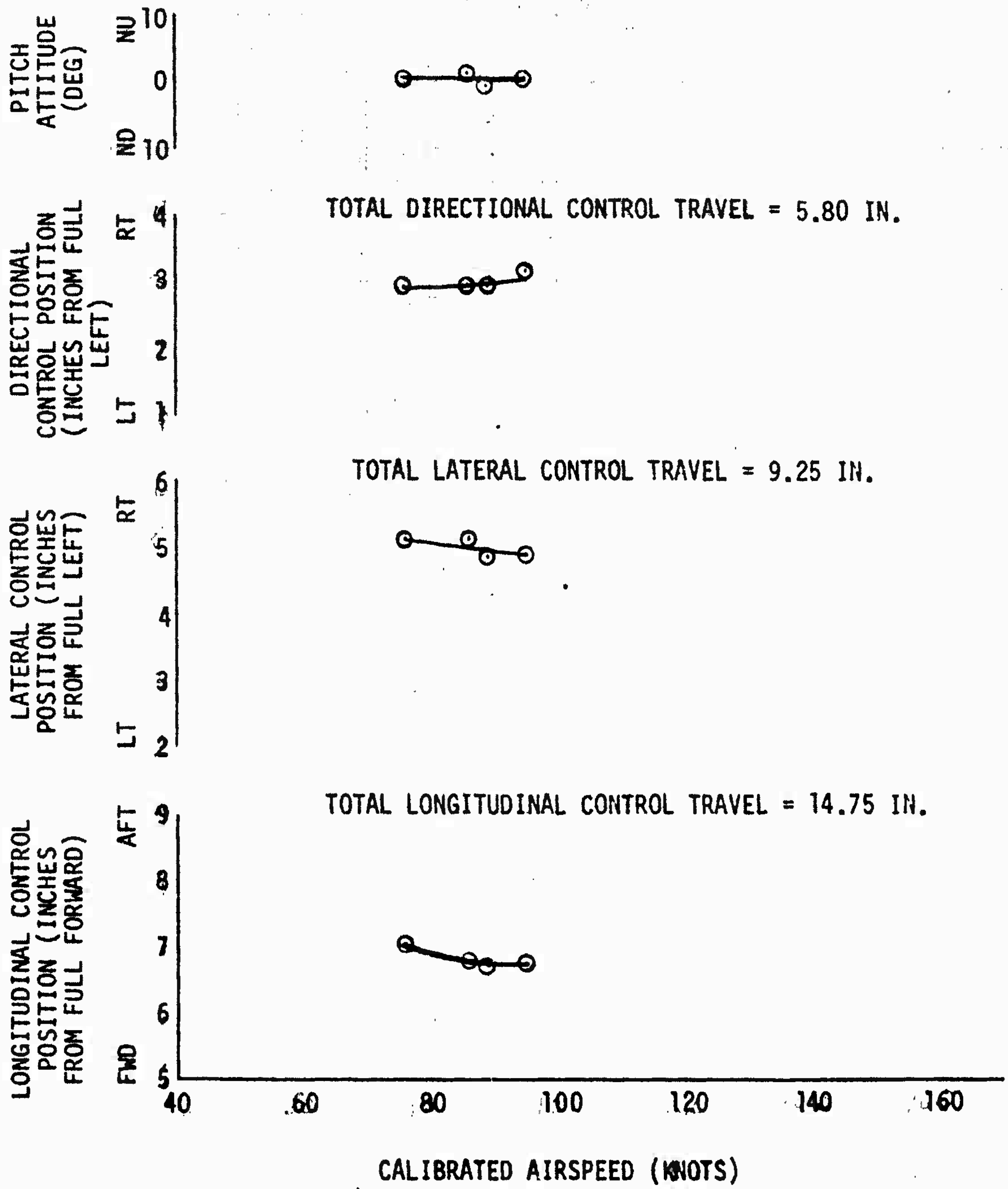


FIGURE 19

CONTROL POSITIONS IN TRIMMED AUTOROTATIVE DESCENT

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X 10^4$)	WING INCIDENCE (DEG)
44550	5000	5.0	375.5(FWD)	216	83.43	-10.0

NOTES: 1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED

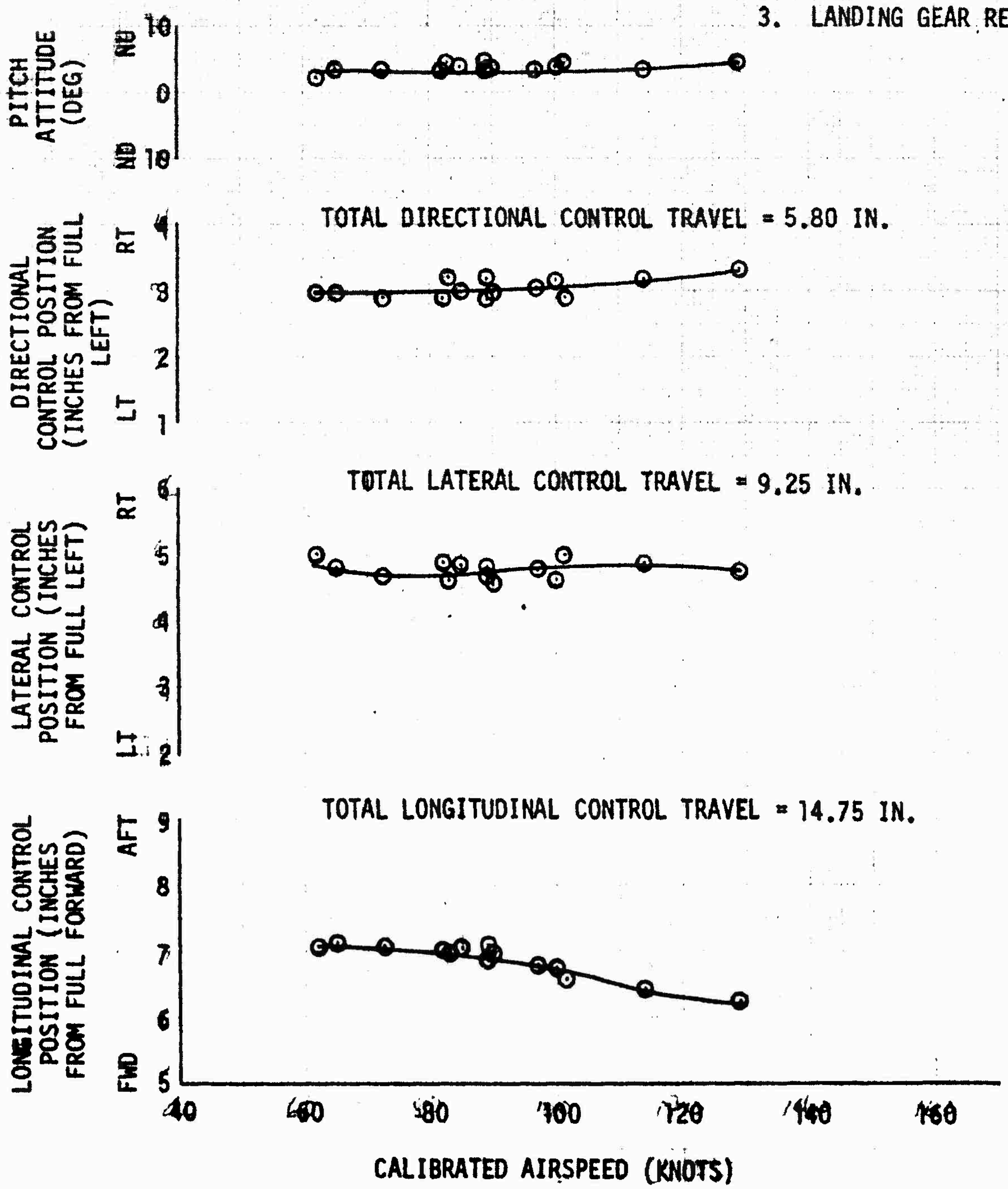


FIGURE 16

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
46300	5000	-7.0	375.0(FWD)	220	83.68	86	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. THRUST CONTROL ROD POSITION FIXED AT TRIM A/S
4. LANDING GEAR RETRACTED
5. WING INCIDENCE 10.5°
6. SHADED SYMBOLS DENOTE TRIM POINTS

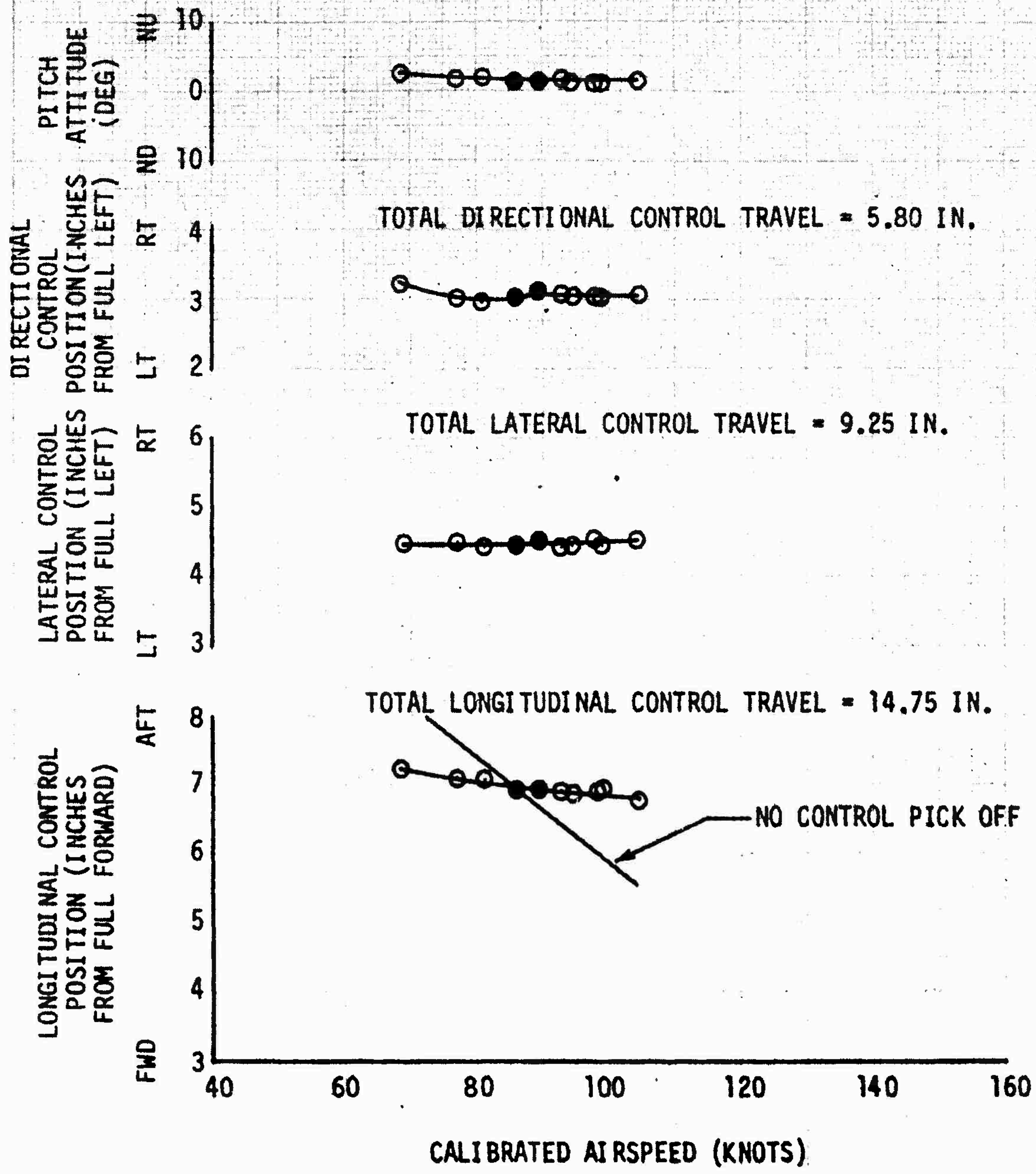


FIGURE 17

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)	FLIGHT CONDITION
45400	5000	-7.0	375.0(FWD)	220	82.06	110	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. THRUST CONTROL ROD POSITION FIXED AT TRIM A/S
4. LANDING GEAR RETRACTED
5. WING INCIDENCE 10.5°
6. SHADED SYMBOLS DENOTE TRIM POINTS

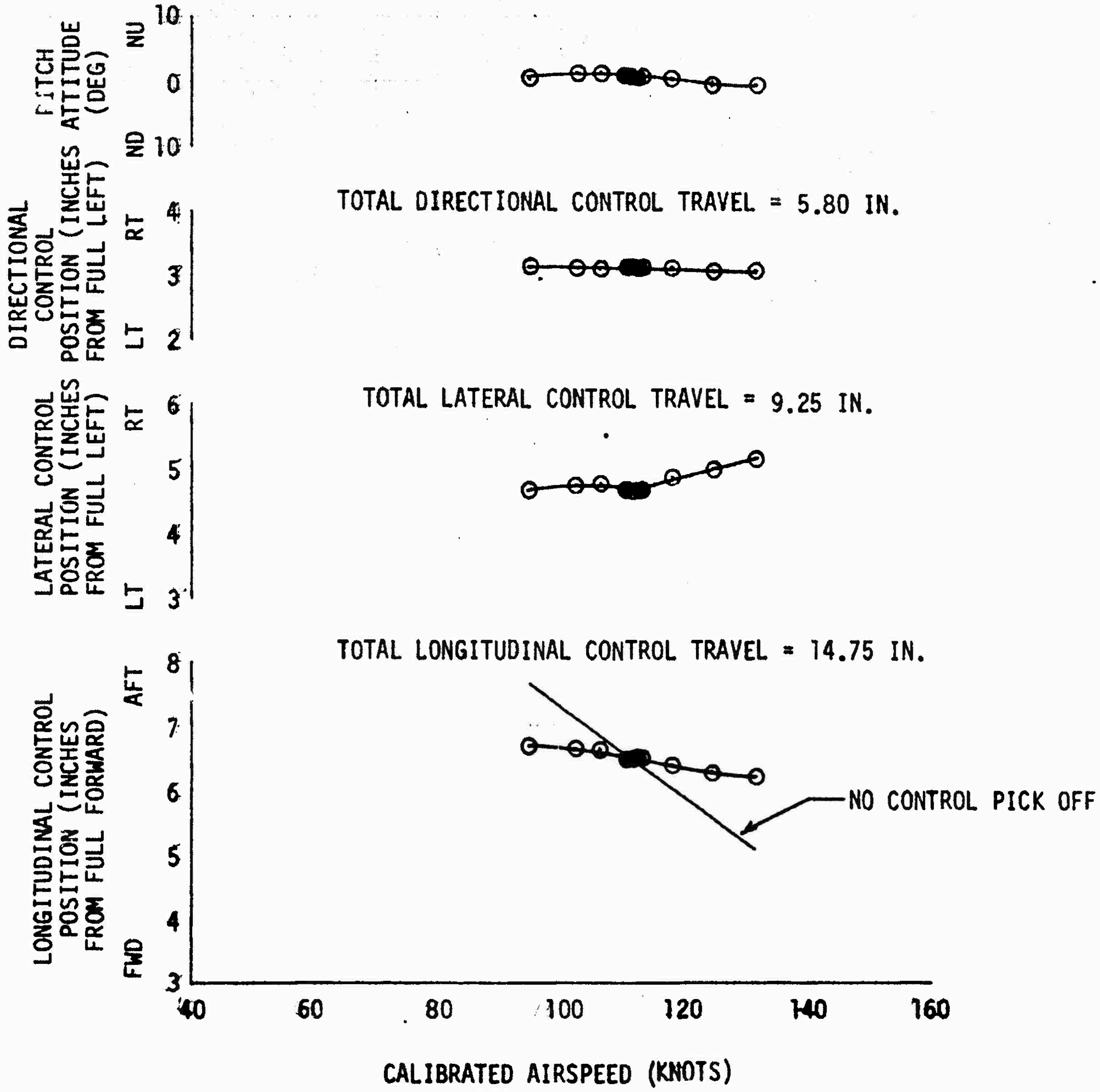


FIGURE 18

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
44500	5000	-6.0	375.0(FWD)	220	80.43	131	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. THRUST CONTROL ROD POSITION FIXED AT TRIM A/S
4. LANDING GEAR RETRACTED
5. WING INCIDENCE 10.5°
6. SHADED SYMBOLS DENOTE TRIM POINTS

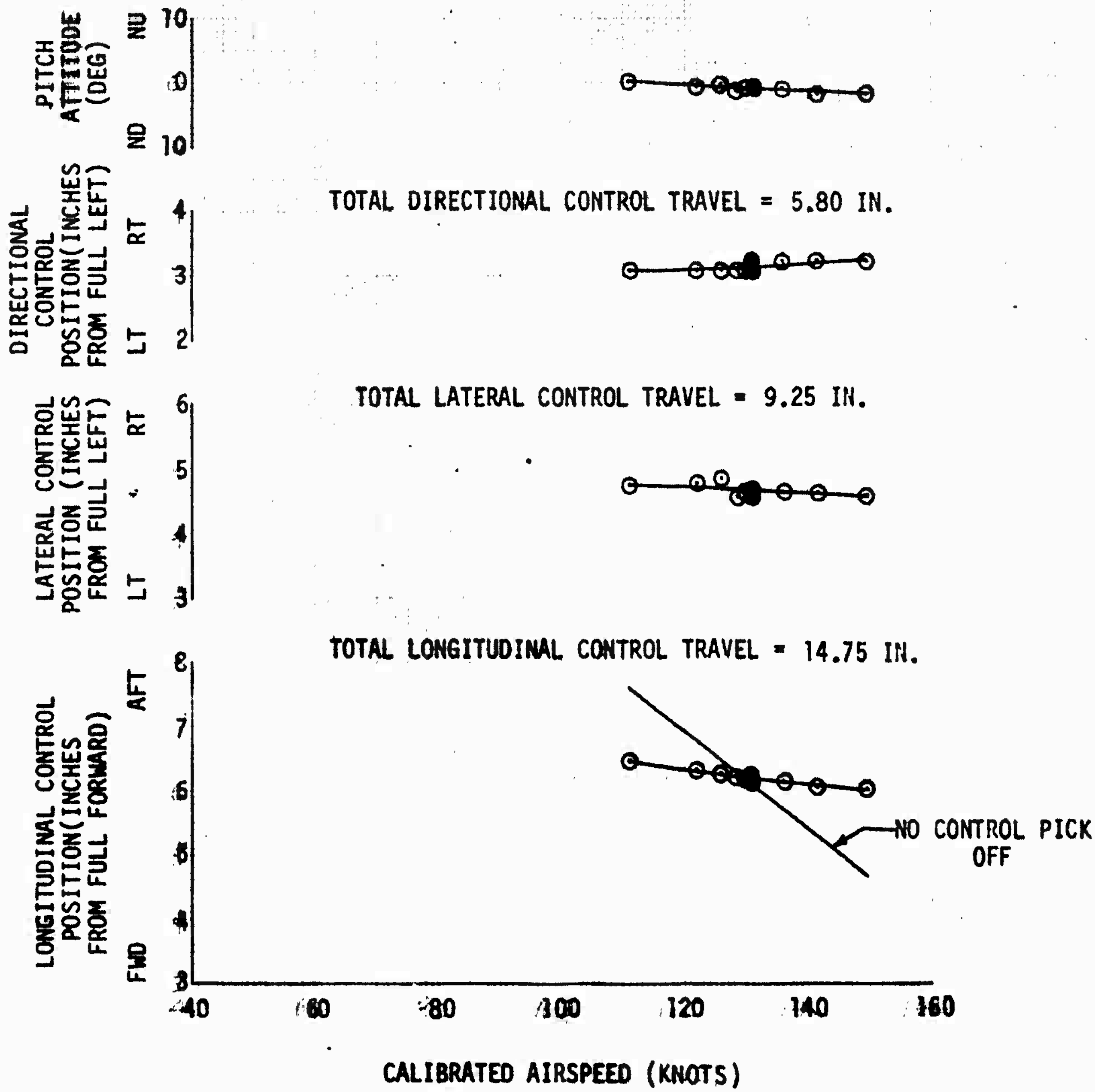


FIGURE 19

COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
43400	5000	-2.0	375.5(FWD)	220	78.44	82	CLIMB AT NRP

NOTES:
1. SAS ON
2. DASH ON
3. THRUST CONTROL ROD POSITION FIXED AT TRIM A/S
4. LANDING GEAR RETRACTED
5. WING INCIDENCE 10.5°
6. SHADED SYMBOLS DENOTE TRIM POINTS

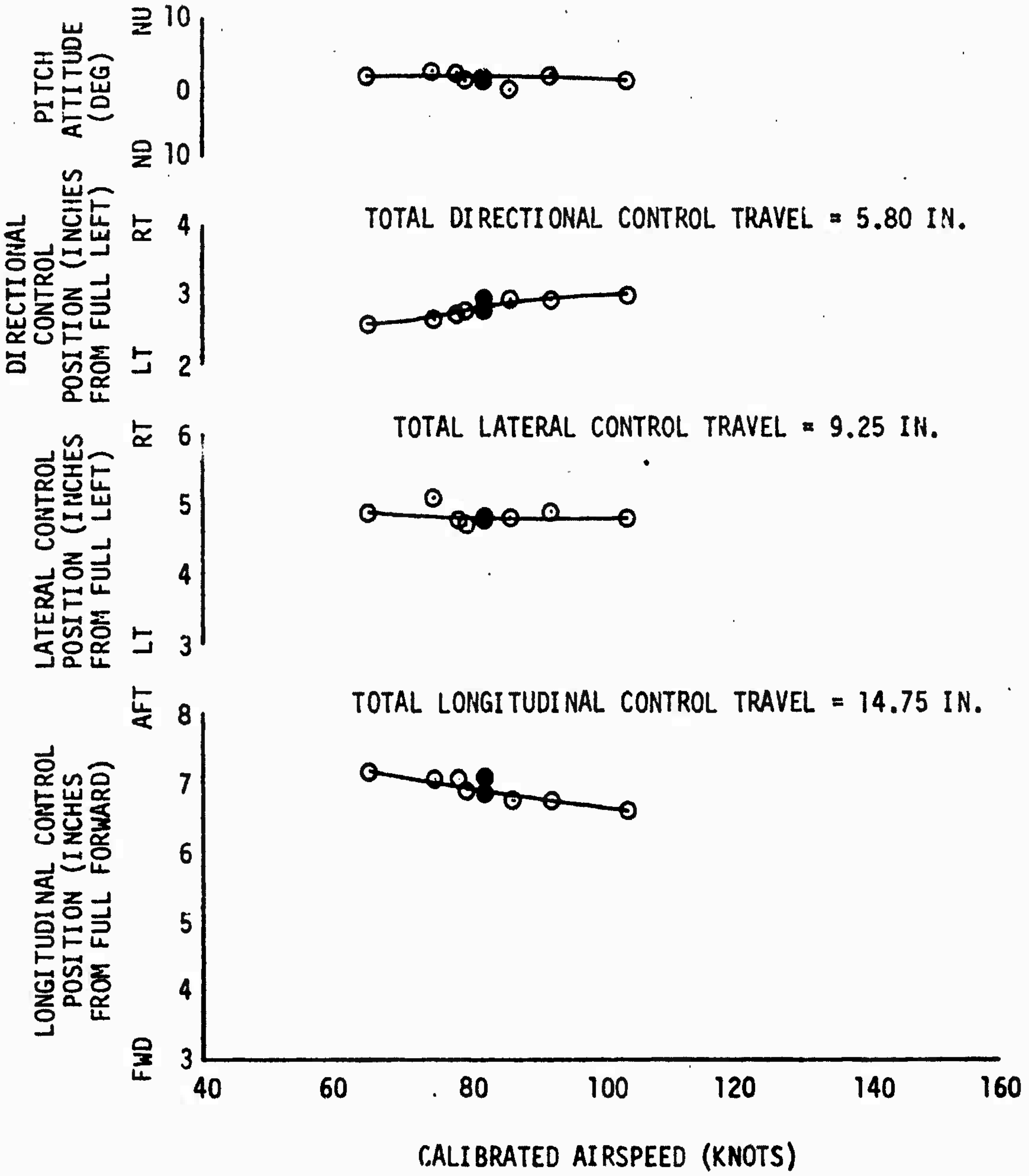


FIGURE 20

COLLECTIVE FIXED STATIC LONGITUDINAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_T X10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
43400	5000	-2.0	375.5(FWD)	220	78.44	84	AUTOROTATIVE DESCENT

NOTES:
1. SAS ON
2. DASH ON
3. THRUST CONTROL ROD POSITION FIXED AT TRIM A/S
4. LANDING GEAR RETRACTED
5. WING INCIDENCE -10°
6. SHADED SYMBOLS DENOTE TRIM POINTS

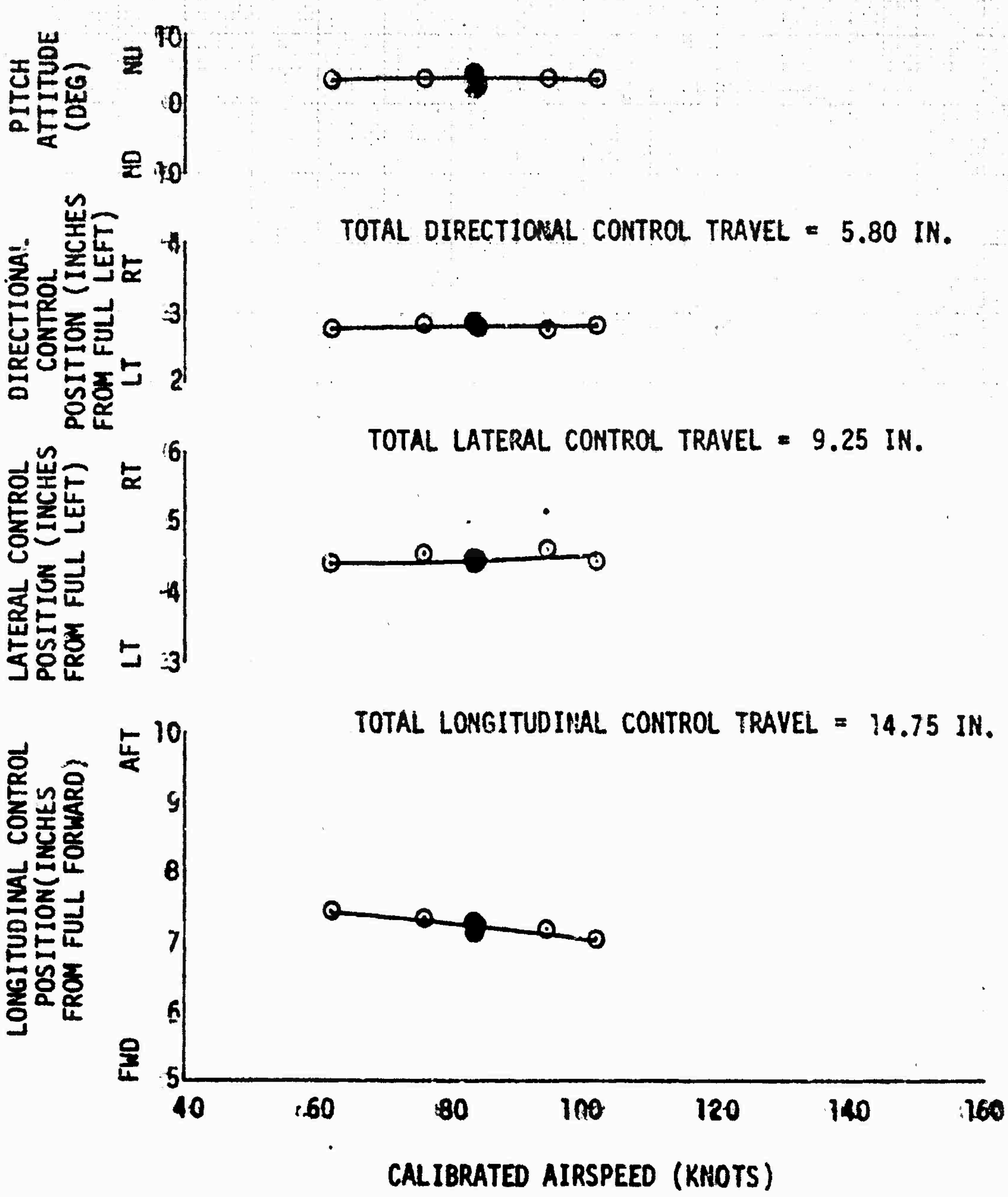


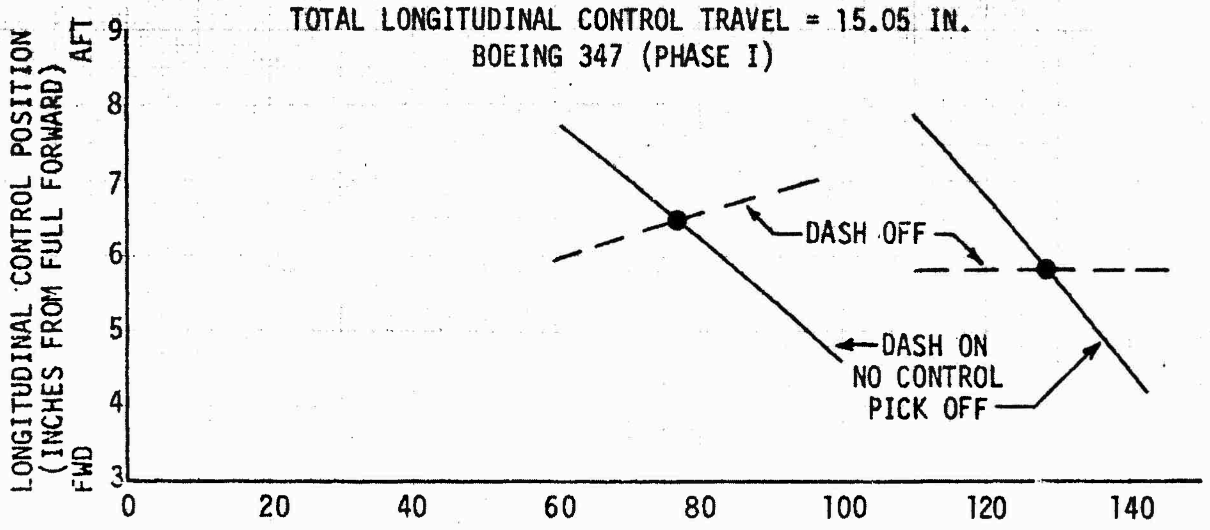
FIGURE 21

STATIC LONGITUDINAL COLLECT-FIXED STABILITY COMPARIOSN

BOEING 347 S/N 65-7992

	AVG GROSS WEIGHT (LBS)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
BOEING 347	45640	3860	16.5	394.0(AFT)	220	79.70	77	LEVEL
BOEING 347	44500	3940	17.7	398.8(AFT)	220	77.90	128	LEVEL
BOEING 347-WINGED	46300	5000	-7.0	375.0(FWD)	220	83.68	86	LEVEL
BOEING 347-WINGED	44500	5000	-6.0	375.0(FWD)	220	80.43	131	LEVEL

NOTE: 1. SHADED SYMBOLS DENOTE TRIM POINTS



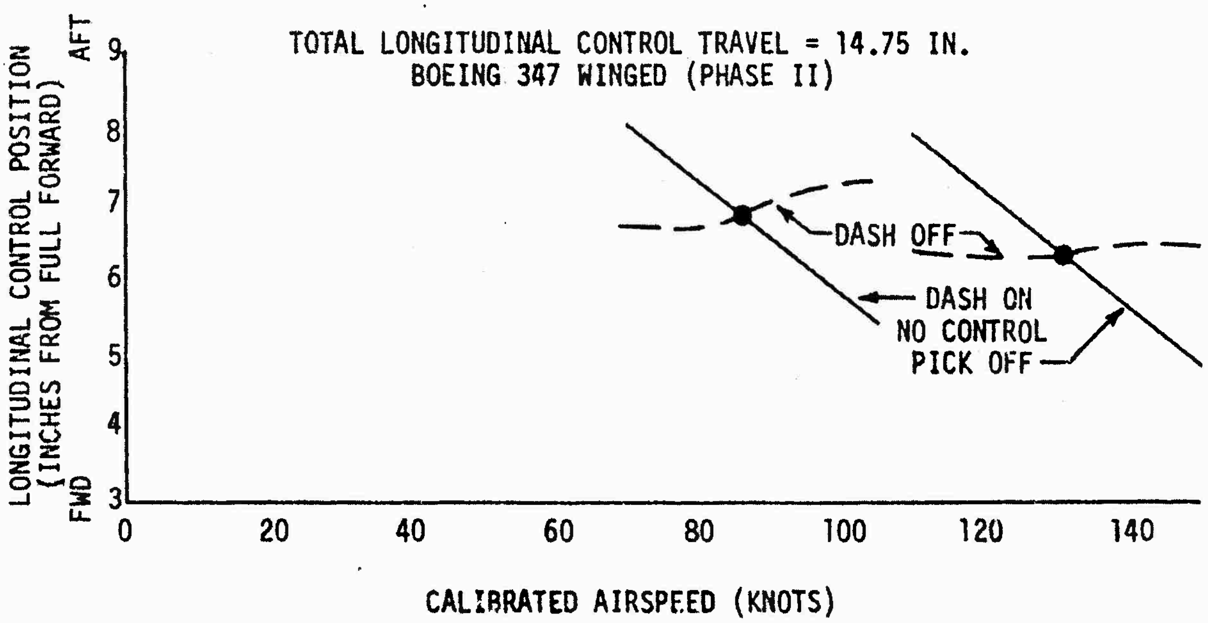


FIGURE 22

STATIC LATERAL DIRECTIONAL STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
46000	5000	-1.5	375.0(FWD)	220	83.14	85	LEVEL

NOTES: 1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. SHADED SYMBOLS DENOTE TRIM POINTS

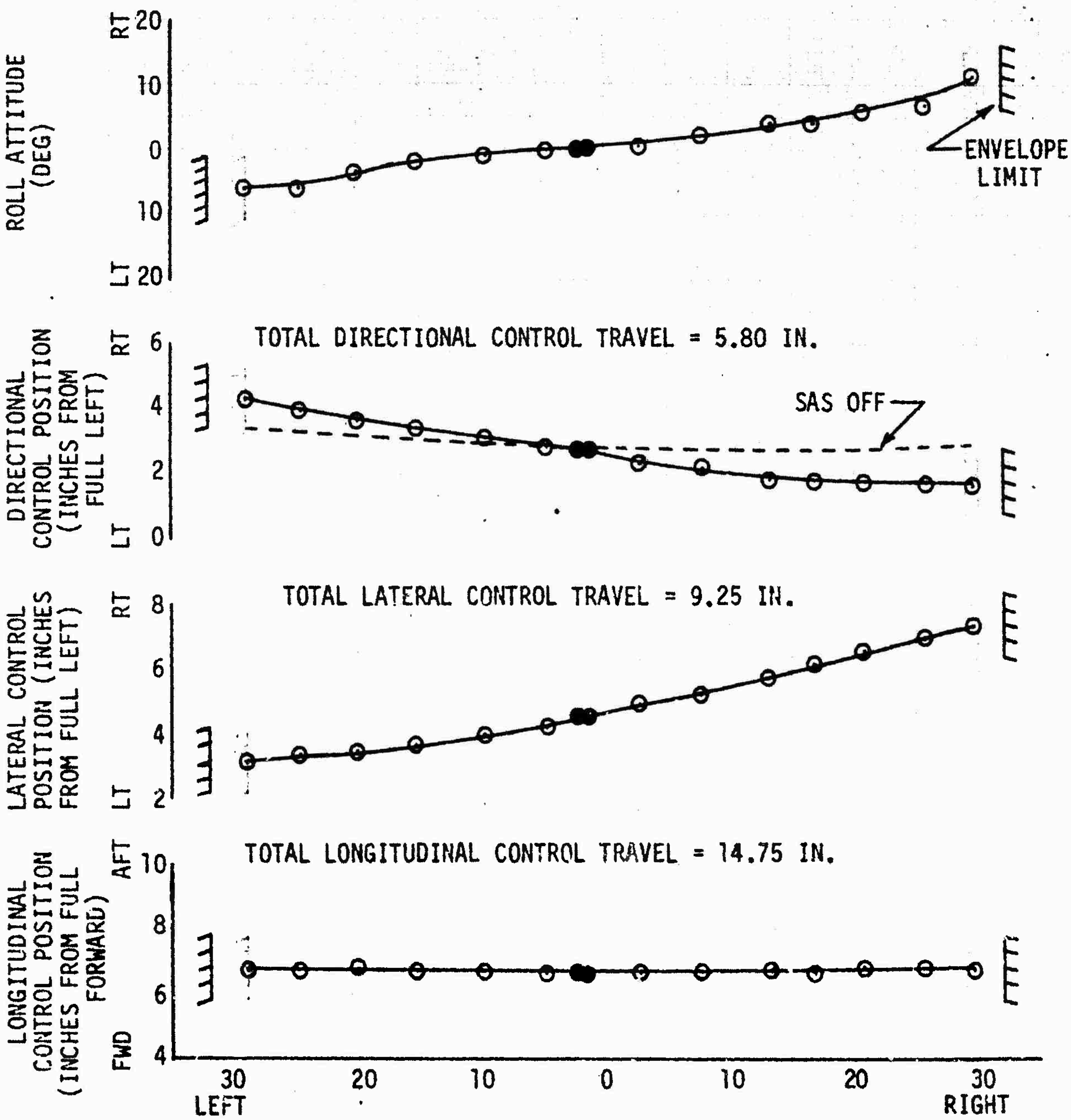


FIGURE 23
STATIC LATERAL DIRECTIONAL STABILITY.
BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
45250	5000	-1.5	375.0(FWD)	220	81.79	112	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. SHADED SYMBOLS DENOTE TRIM POINTS

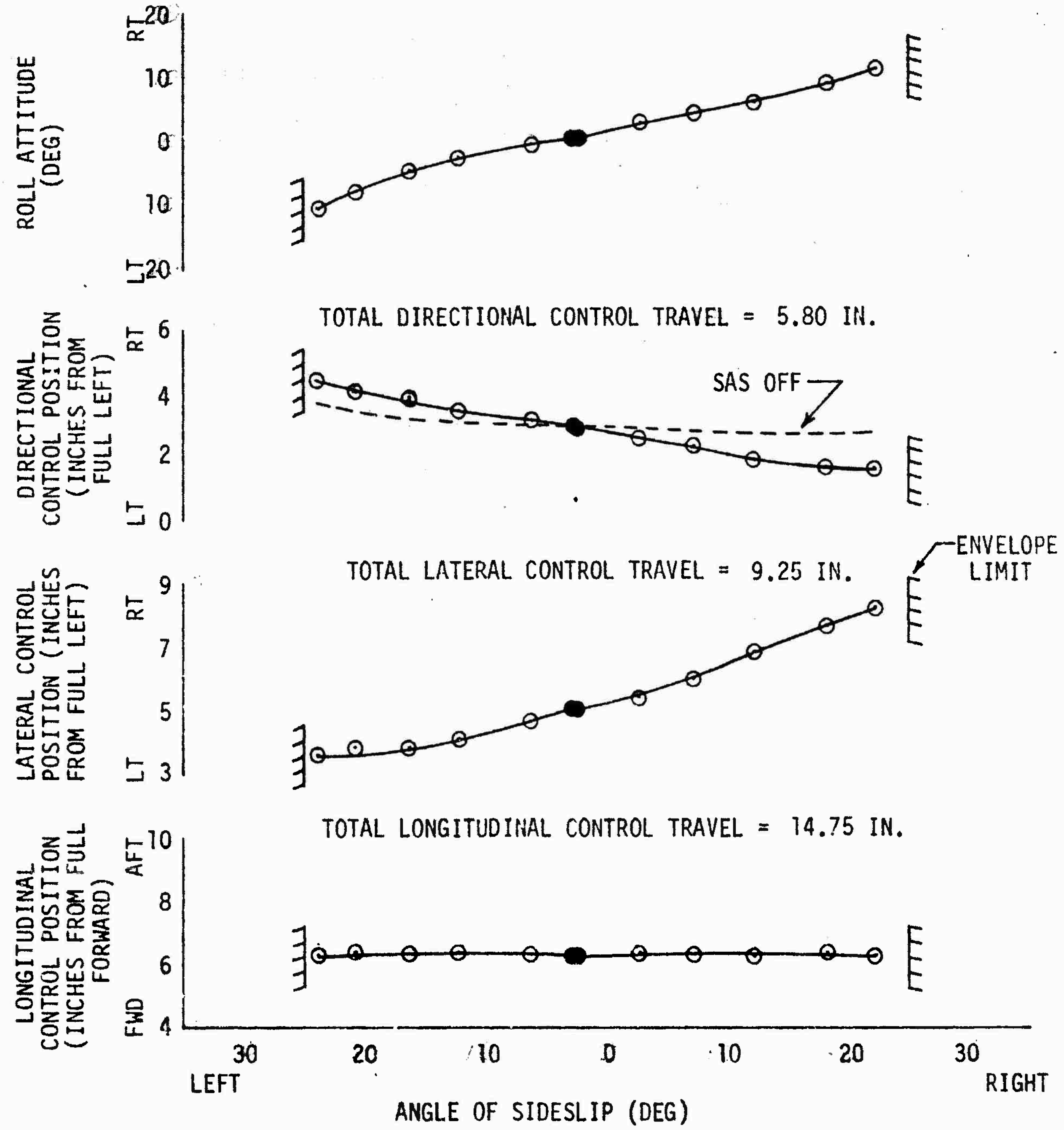


FIGURE 24

STATIC LATERAL DIRECTIONAL STABILITY.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)	FLIGHT CONDITION
44500	5000	-1.5	375.0(FWD)	220	80.43	129	LEVEL

NOTES: 1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. SHADED SYMBOLS DENOTE TRIM POINTS

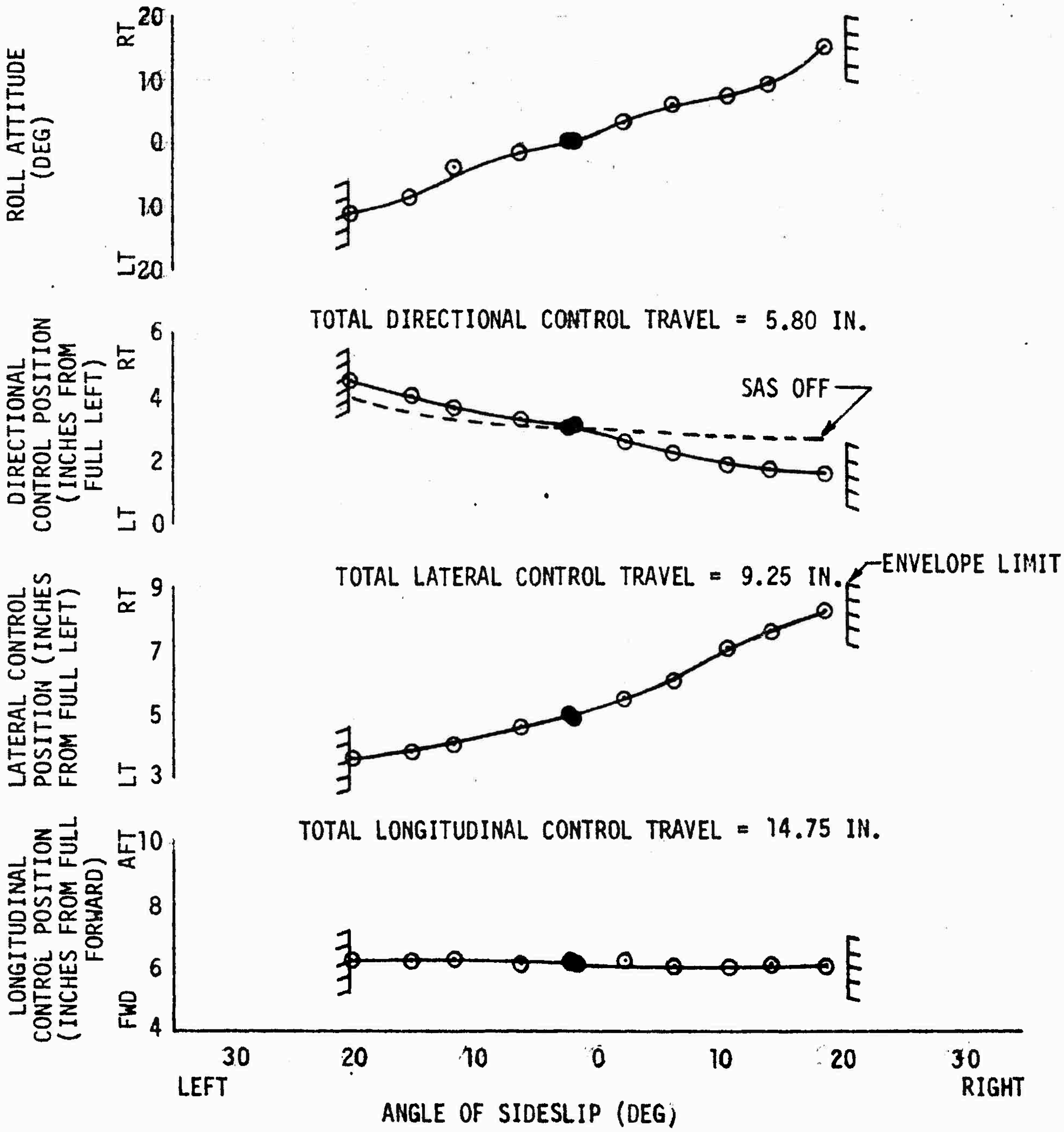


FIGURE 25

STATIC LATERAL DIRECTIONAL STABILITY.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)	FLIGHT CONDITION
43400	5000	-1.5	375.0(FWD)	220	78.44	85	CLIMB AT NRP

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. SHADED SYMBOLS DENOTE TRIM POINTS

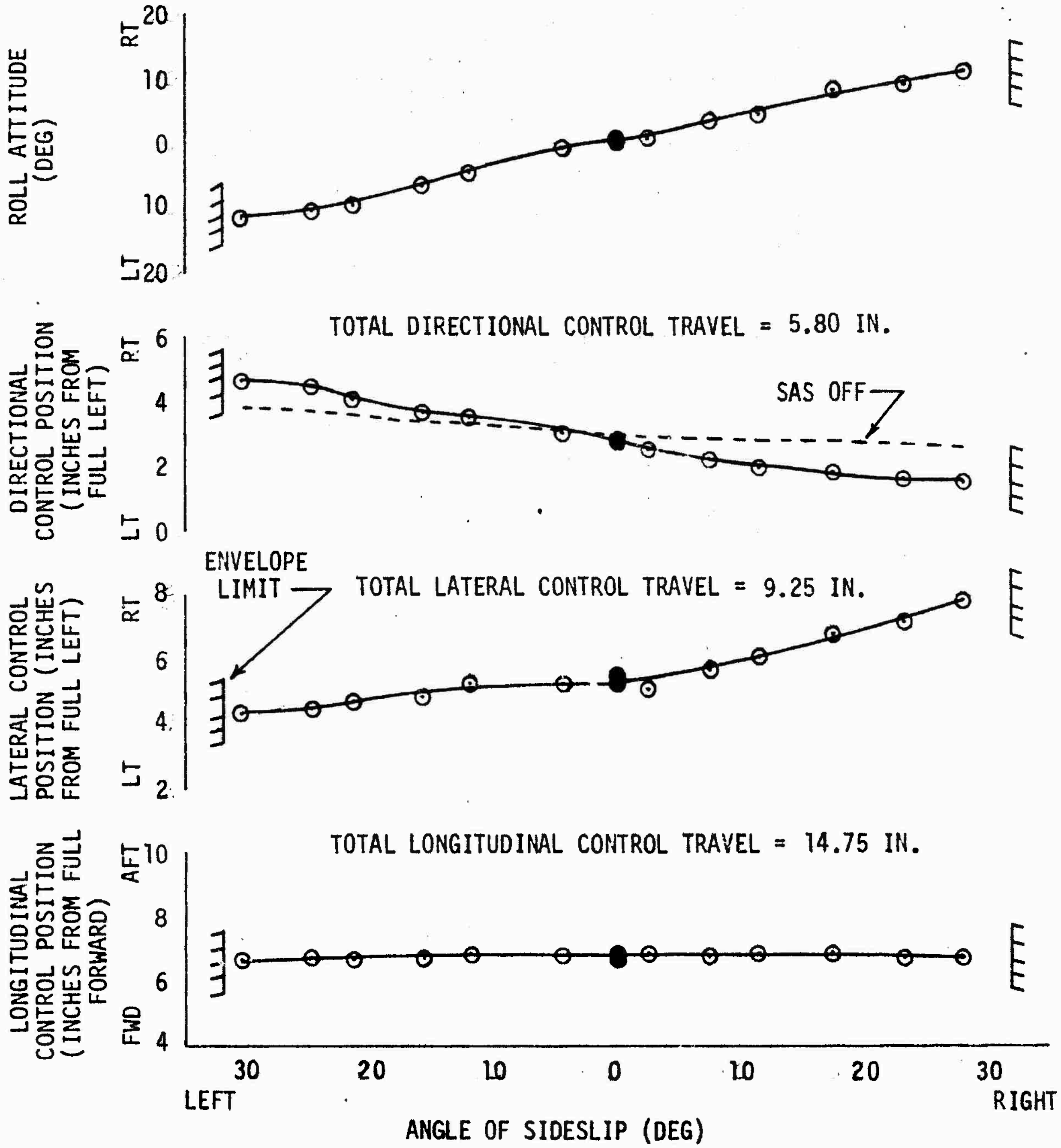


FIGURE 26
STATIC LATERAL DIRECTIONAL STABILITY
BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)	FLIGHT CONDITION
43400	5000	-1.5	375.0(FWD)	220	78.44	85	AUTOROTATIVE DESCENT

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE -10°
5. SHADED SYMBOLS DENOTE TRIM POINTS

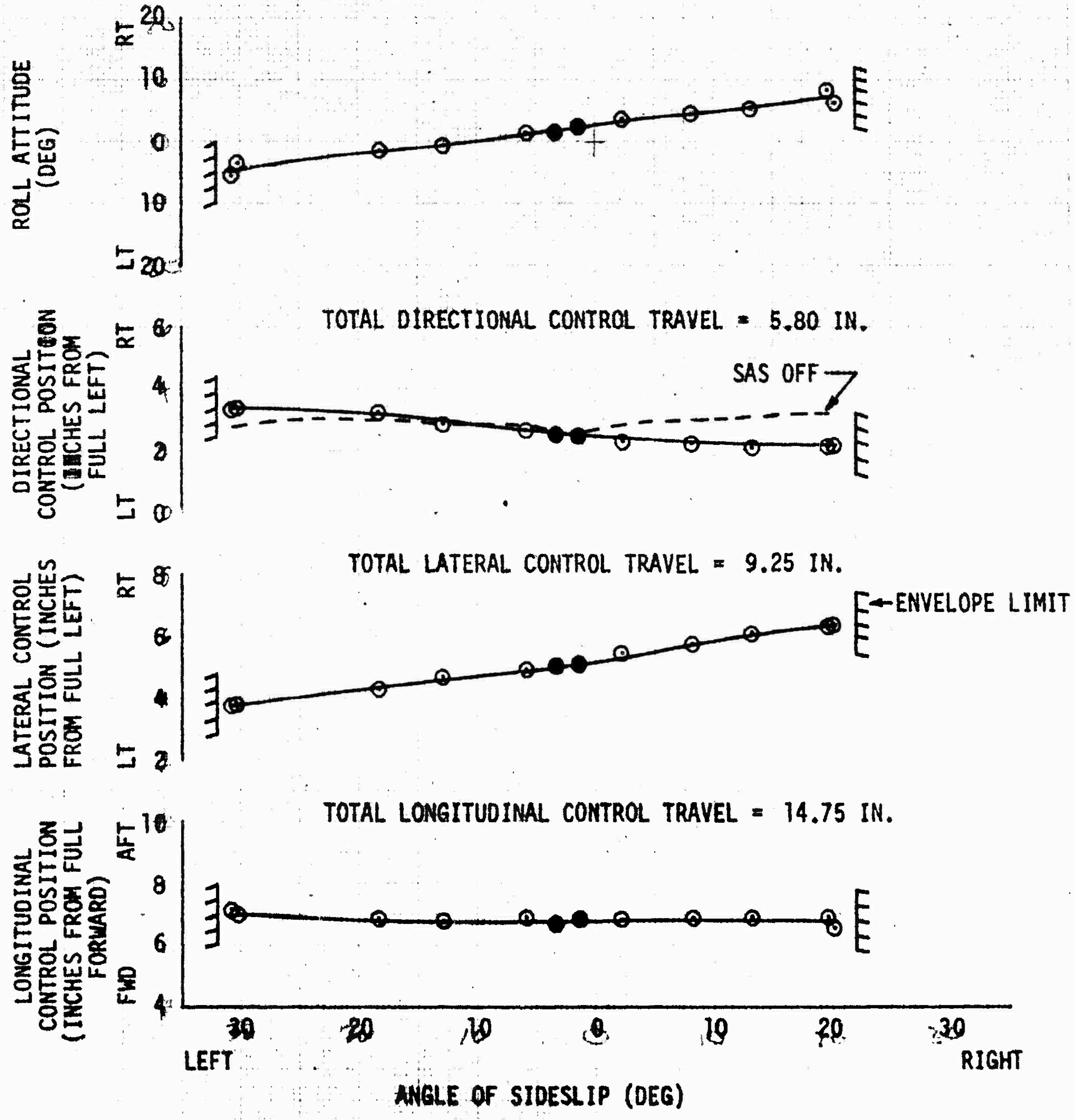
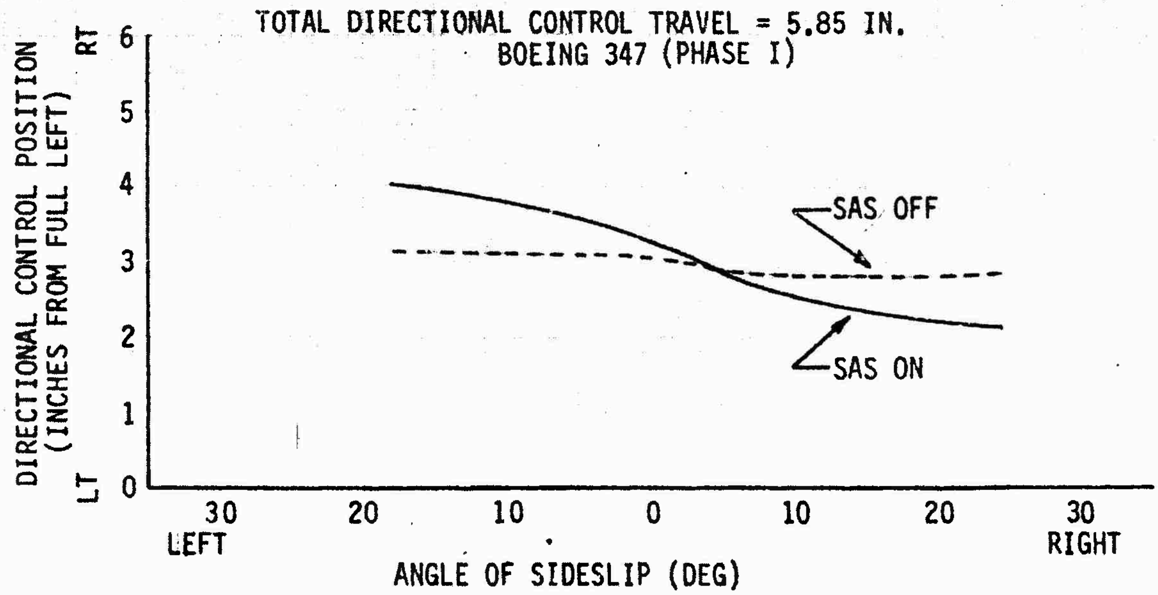


FIGURE 27

STATIC DIRECTIONAL STABILITY COMPARISON.

BOEING 347 S/N 65-7992

	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	FLIGHT CONDITION
BOEING 347	43300	4840	17.7	395.9(AFT)	220	77.89	110	LEVEL
BOEING 347-WINGED	45250	5000	-1.5	375.0(FWD)	220	81.79	112	LEVEL



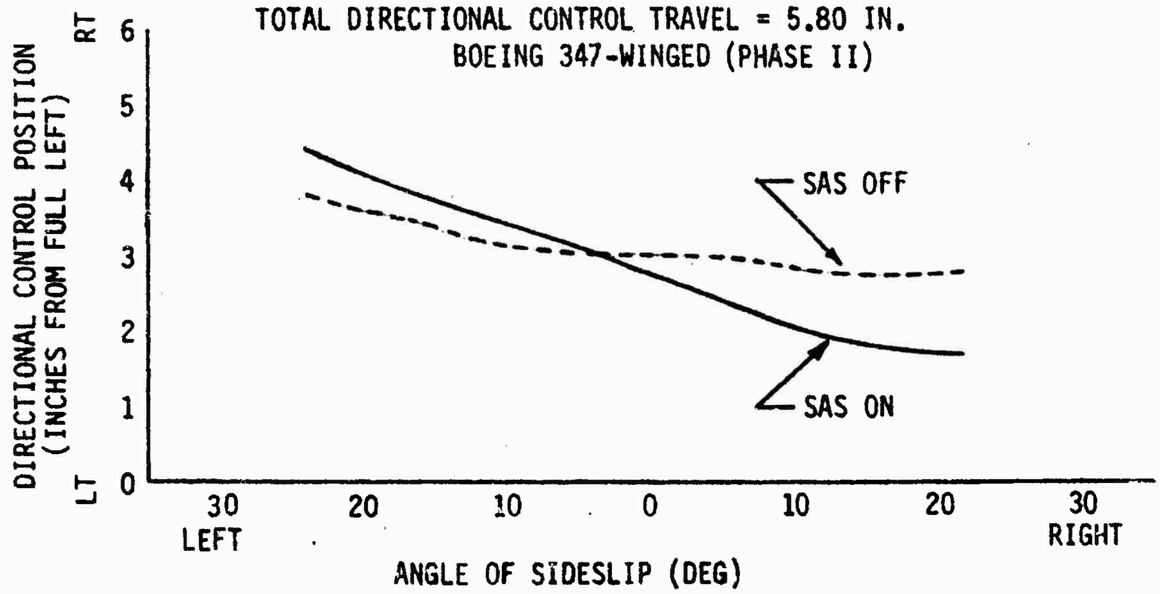


FIGURE 28

MANEUVERING STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
45860	5000	-4.0	375.5(FWD)	220	82.89	85

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. ⊙SYMBOL DENOTES LEFT TURN
6. ⊡SYMBOL DENOTES RIGHT TURN
7. SHADED SYMBOLS DENOTE TRIM

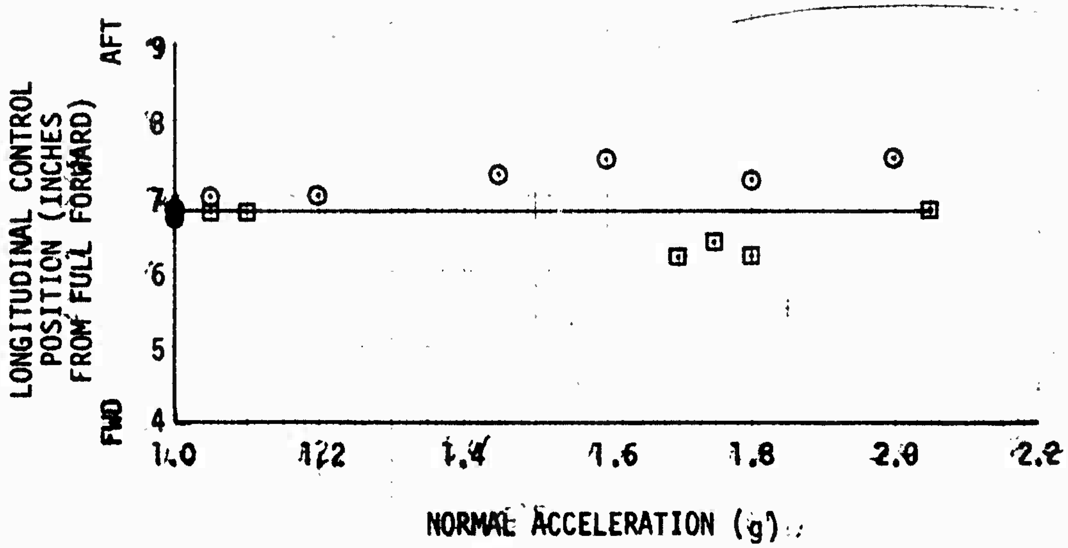


FIGURE 29

MANEUVERING STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (^{O}C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)
44880	5000	-4.0	375.5(FWD)	220	81.12	130

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. ⊙SYMBOL DENOTES LEFT TURN
6. ⊡SYMBOL DENOTES RIGHT TURN
7. SHADED SYMBOL DENOTES TRIM

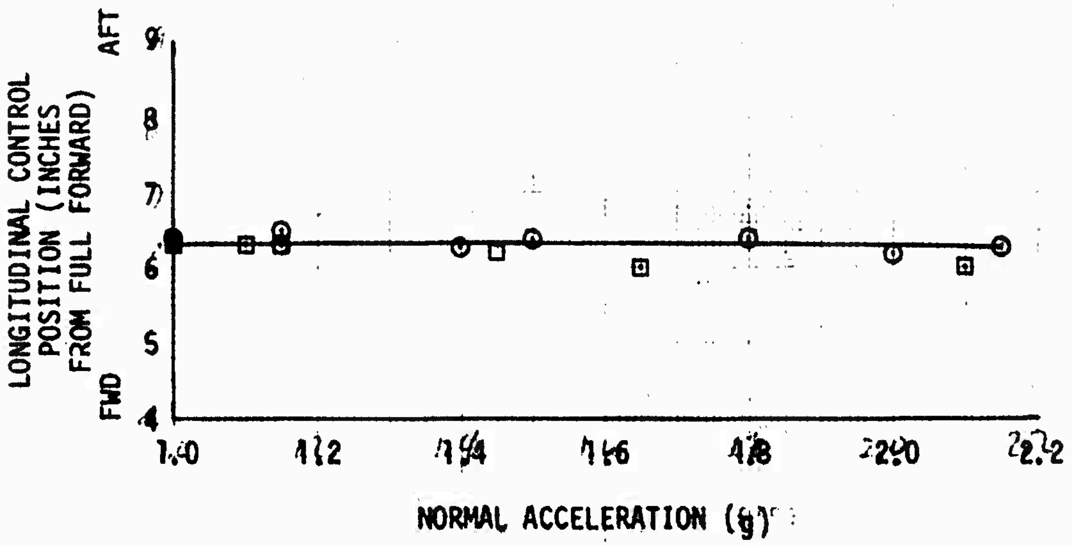


FIGURE 30

MANEUVERING STABILITY

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
44700	5000	-3.0	375.5(FWD)	220	80.79	148

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°
5. ⊙SYMBOL DENOTES LEFT TURN
6. ⊡SYMBOL DENOTES RIGHT TURN
7. SHADED SYMBOLS DENOTE TRIM

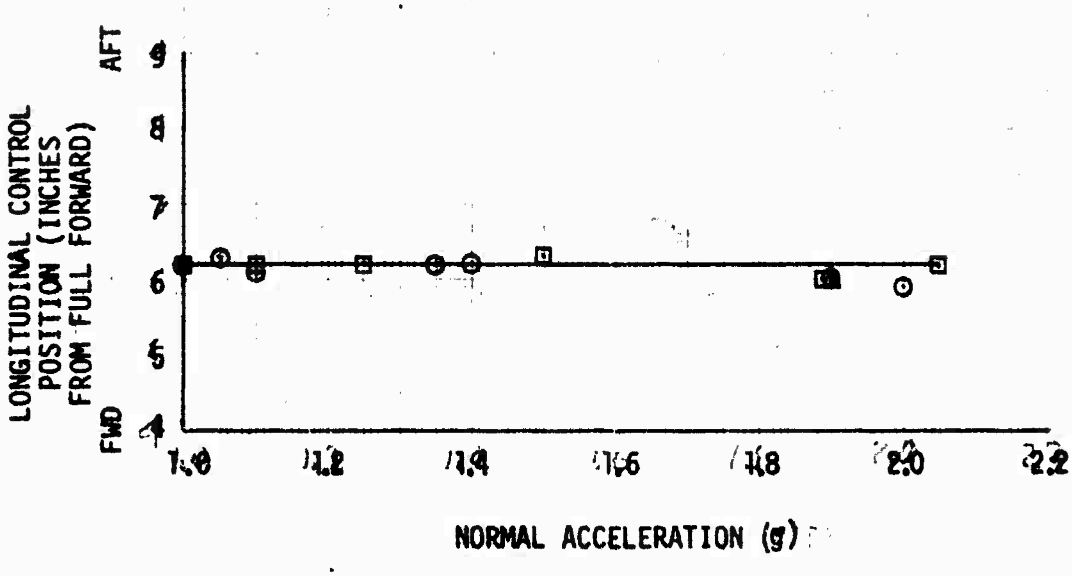


FIGURE 31
LONG TERM LONGITUDINAL RESPONSE FROM
OFF TRIM CONDITION
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
43950	5000	5.0	375.5(FWD)	220	79.44	83

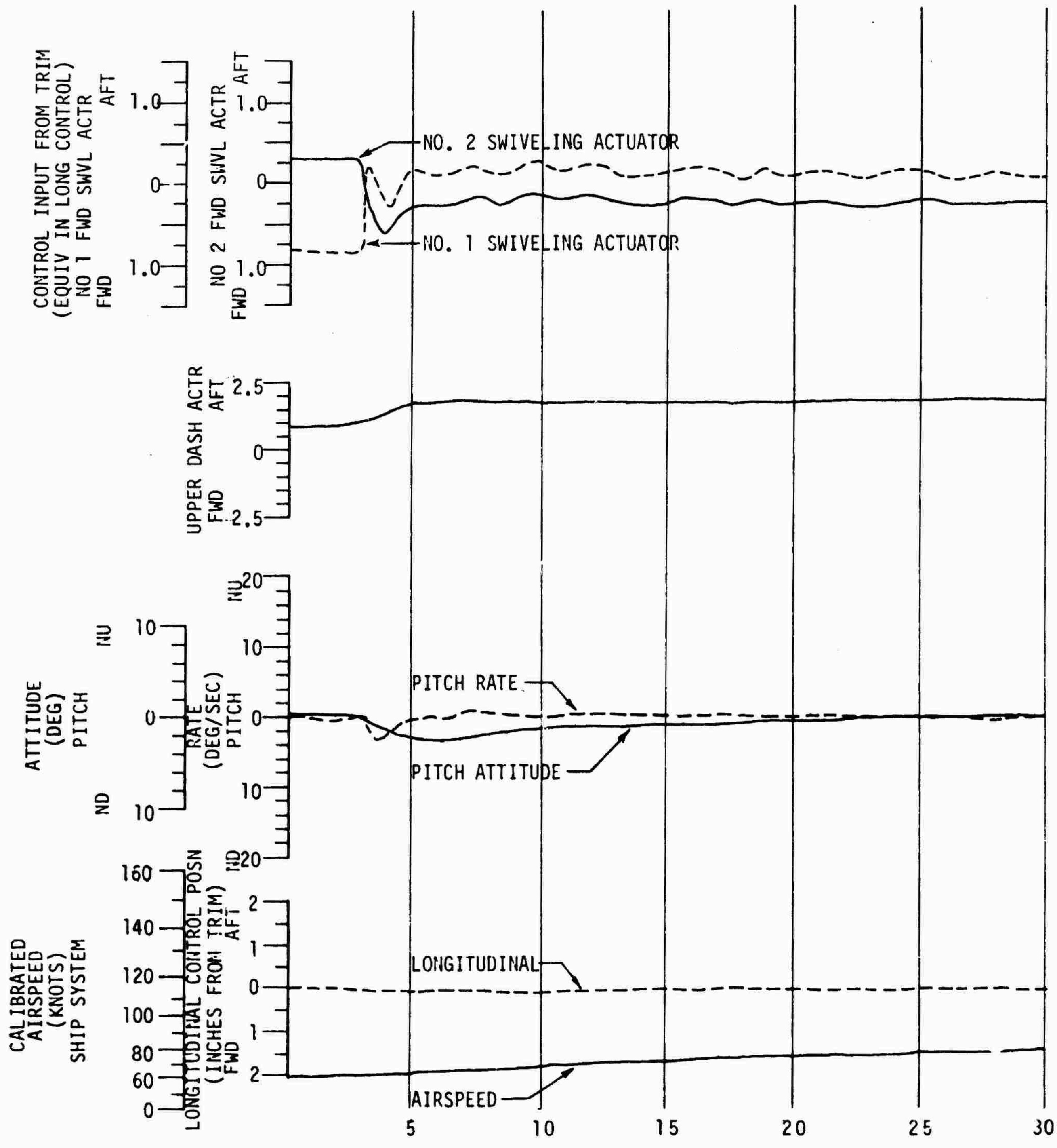


FIGURE 32
AIRCRAFT RESPONSE FOLLOWING FWD LONGITUDINAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (°C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
45050	5000	5.0	375.5(FWD)	220	81.42	83

NOTES: 1. LONGITUDINAL STICK POSITION HELD CONSTANT
2. LONGITUDINAL PULSE IS SUM OF NO. 1 AND NO. 2 SWIVEL ACTUATORS

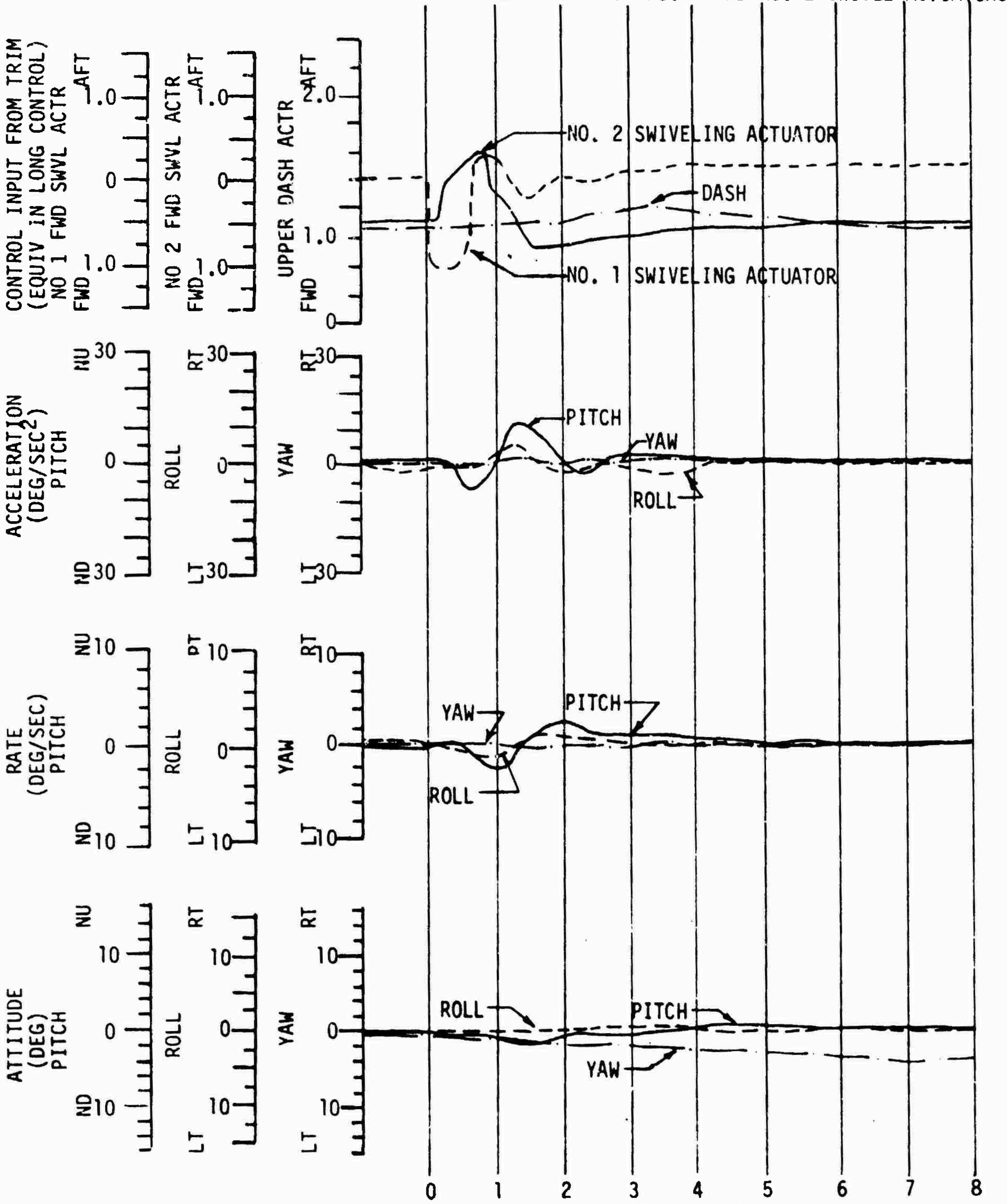


FIGURE 33
AIRCRAFT RESPONSE FOLLOWING FWD LONGITUDINAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (°C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_T X10^4)	TRIM A/S (KCAS)
43950	5000	5.0	375.5(FWD)	220	79.44	112

NOTES: 1. LONGITUDINAL CONTROL POSITION HELD CONSTANT
2. LONGITUDINAL PULSE IS SUM OF NO. 1 and NO. 2 SWIVEL ACTUATORS

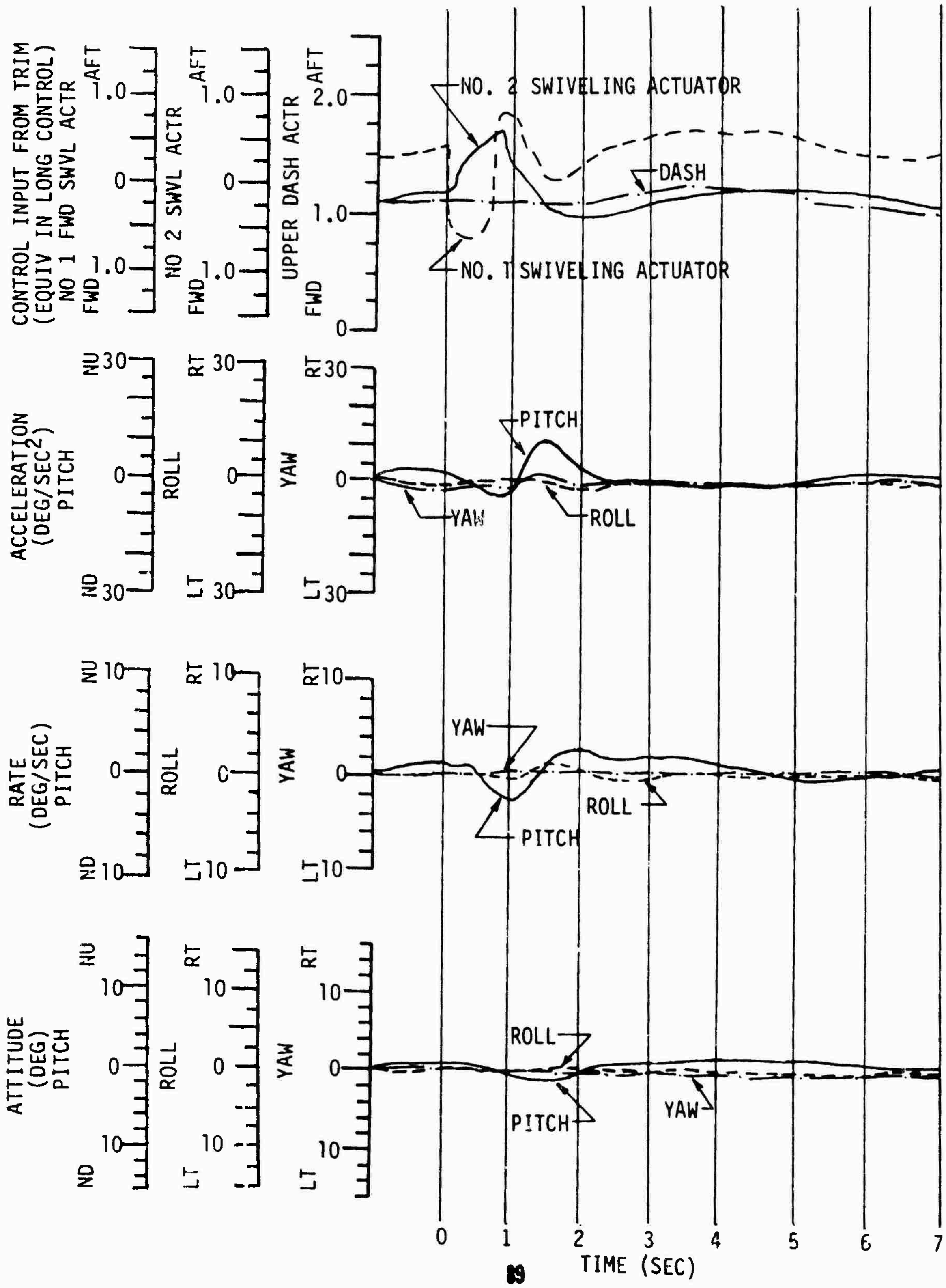


FIGURE 34
AIRCRAFT RESPONSE FOLLOWING FWD LONGITUDINAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
45150	5000	3.5	375.5(FWD)	220	81.61	129

NOTES: 1. LONGITUDINAL CONTROL POSITION HELD CONSTNAT.
2. LONGITUDINAL PULSE IS SUM OF NO. 1 AND NO. 2 SWIVEL ACTUATORS.

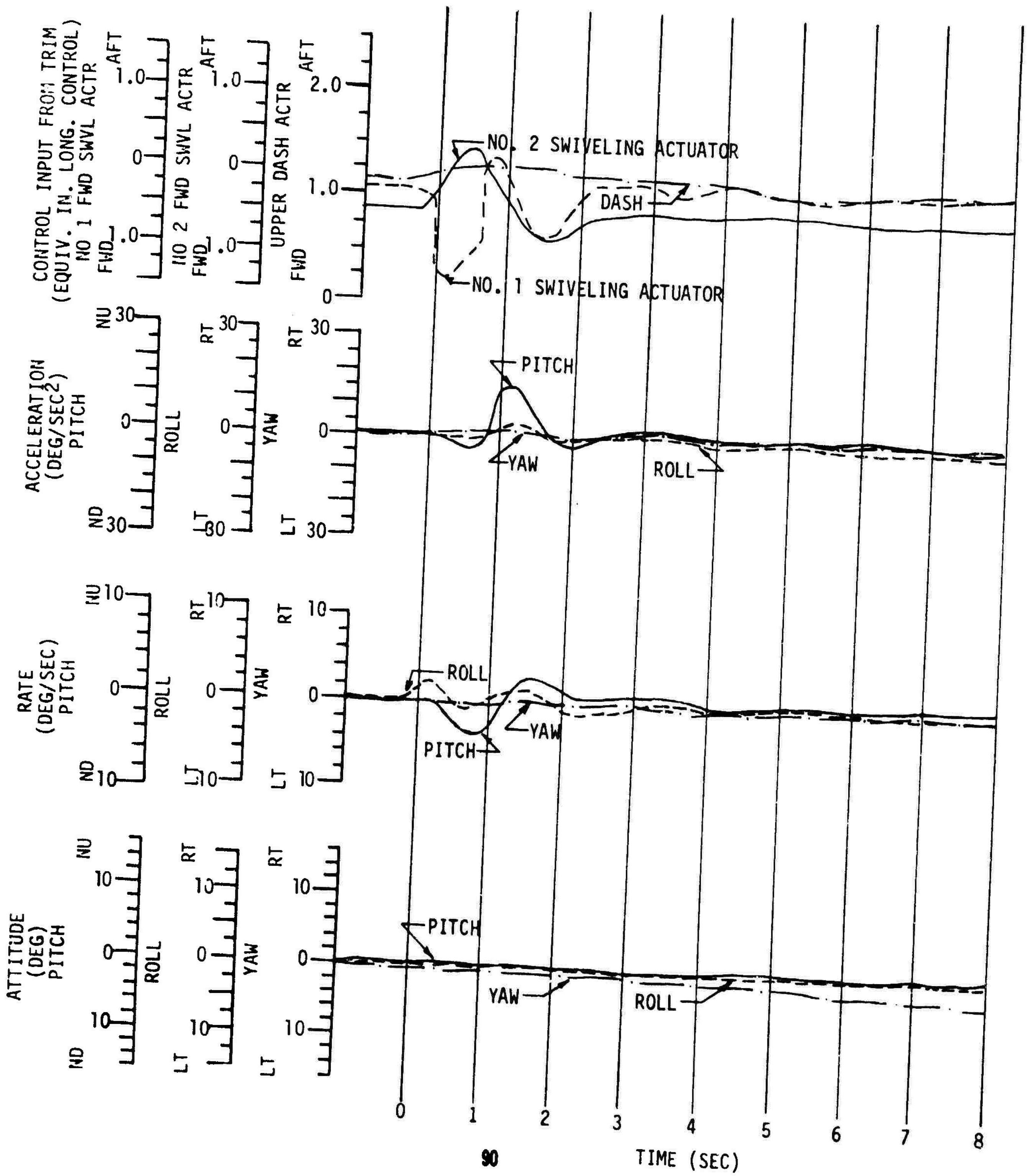


FIGURE 35
AIRCRAFT RESPONSE FOLLOWING LEFT LATERAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)
45050	5000	5.0	375.5(FWD)	220	81.42	83

NOTE: 1. LATERAL PULSE IS SUM OF NO. 1 AND NO. 2 SWIVEL ACTUATORS

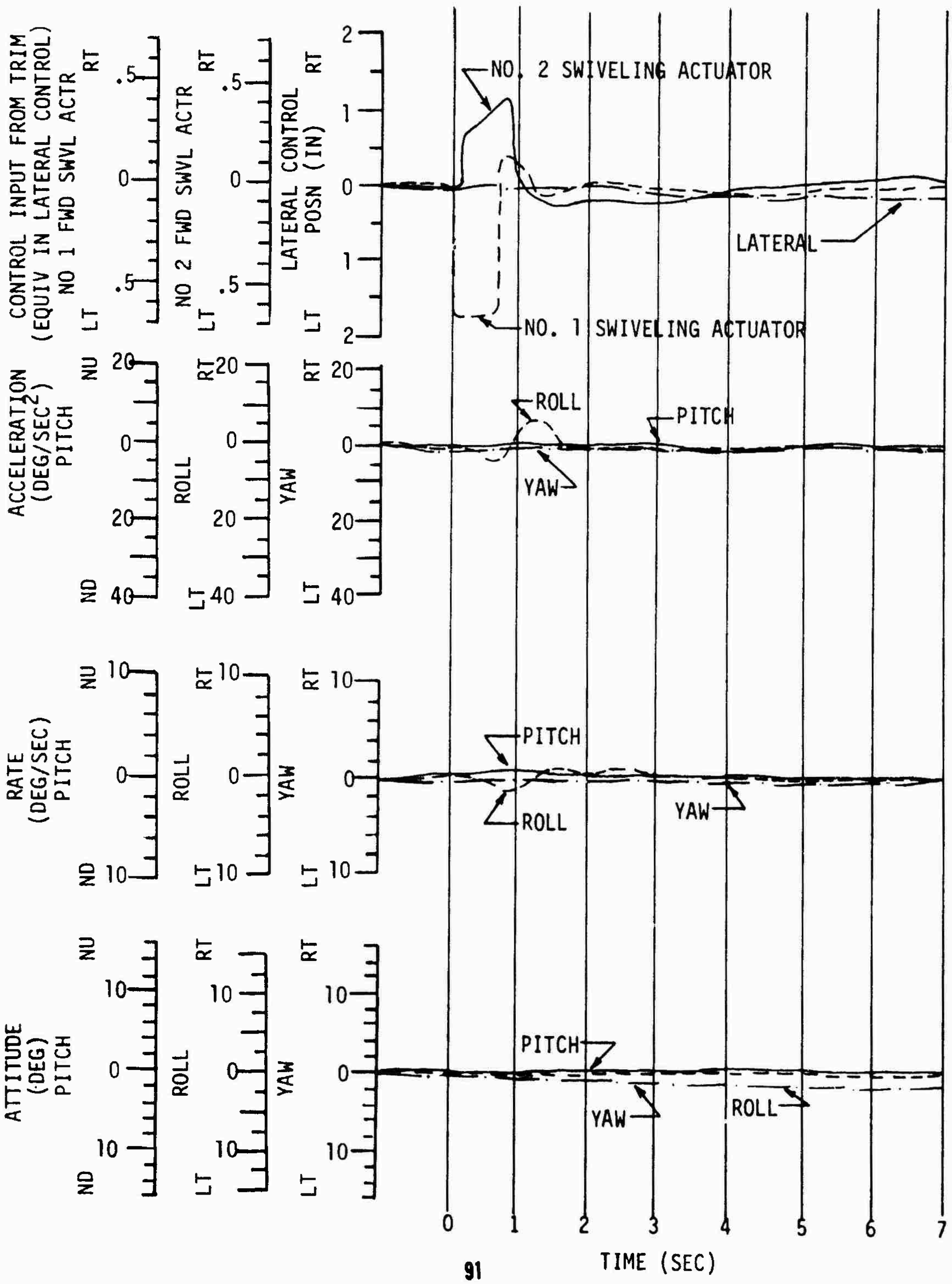


FIGURE 36

AIRCRAFT RESPONSE FOLLOWING LEFT LATERAL PULSE

BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^oC)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)
43950	5000	5.0	375.5(FWD)	220	79.44	112

NOTE: 1. LATERAL PULSE IS SUM OF NO. 1 AND NO. 2 SWIVEL ACTUATORS

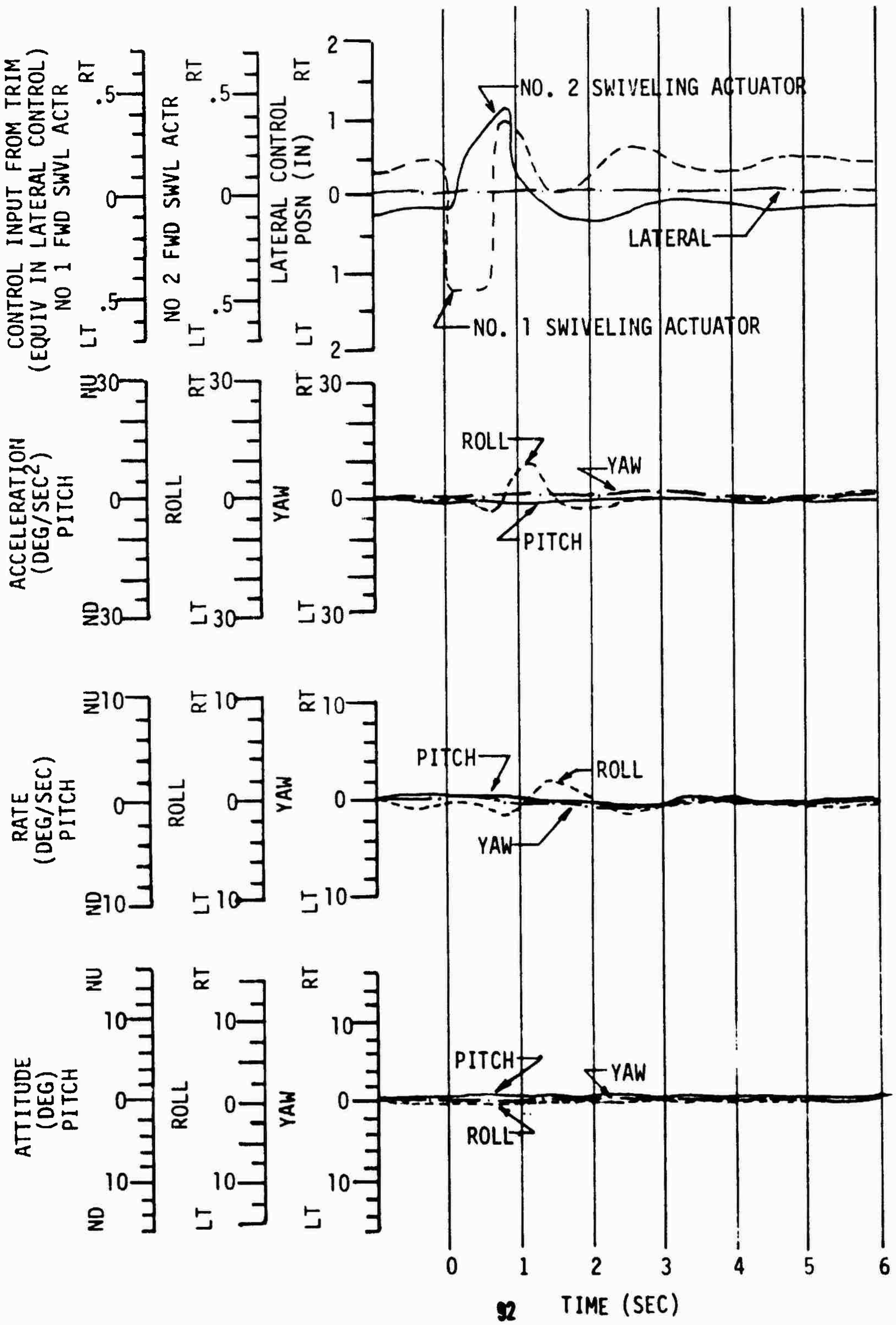


FIGURE 37
AIRCRAFT RESPONSE FOLLOWING LEFT LATERAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^oC)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
45150	5000	3.5	375.5(FWD)	220	81.61	129

NOTE: 1. LATERAL PULSE IS SUM OF NO. 1 AND NO. 2 SWIVEL ACTUATORS

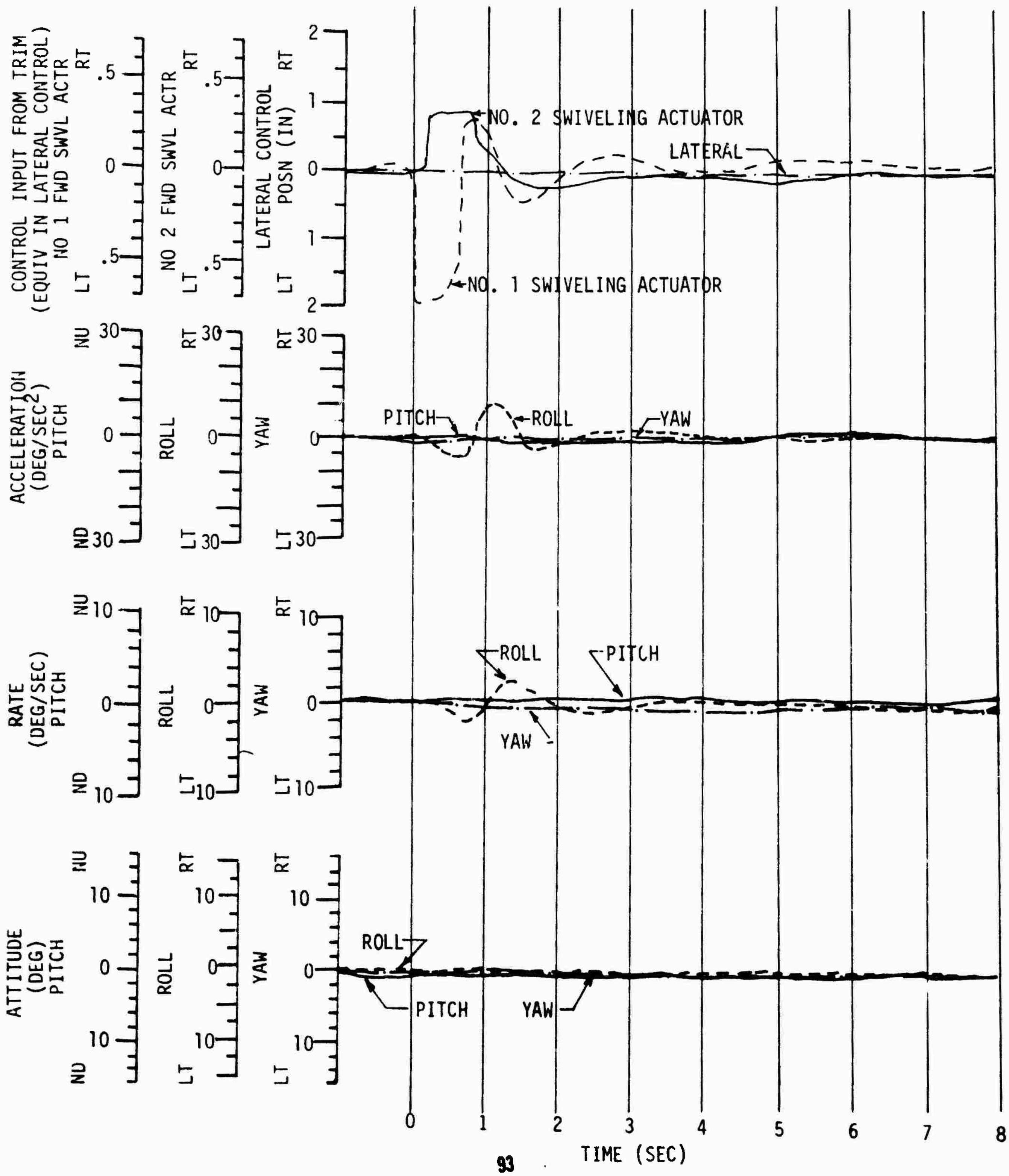


FIGURE 38
AIRCRAFT RESPONSE FOLLOWING LEFT DIRECTIONAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)
45050	5000	5.0	375.5(FWD)	220	81.42	83

NOTE: 1. DIRECTIONAL PULSE IS SUM OF NO. 1 AND NO. 2 SAS ACTUATORS

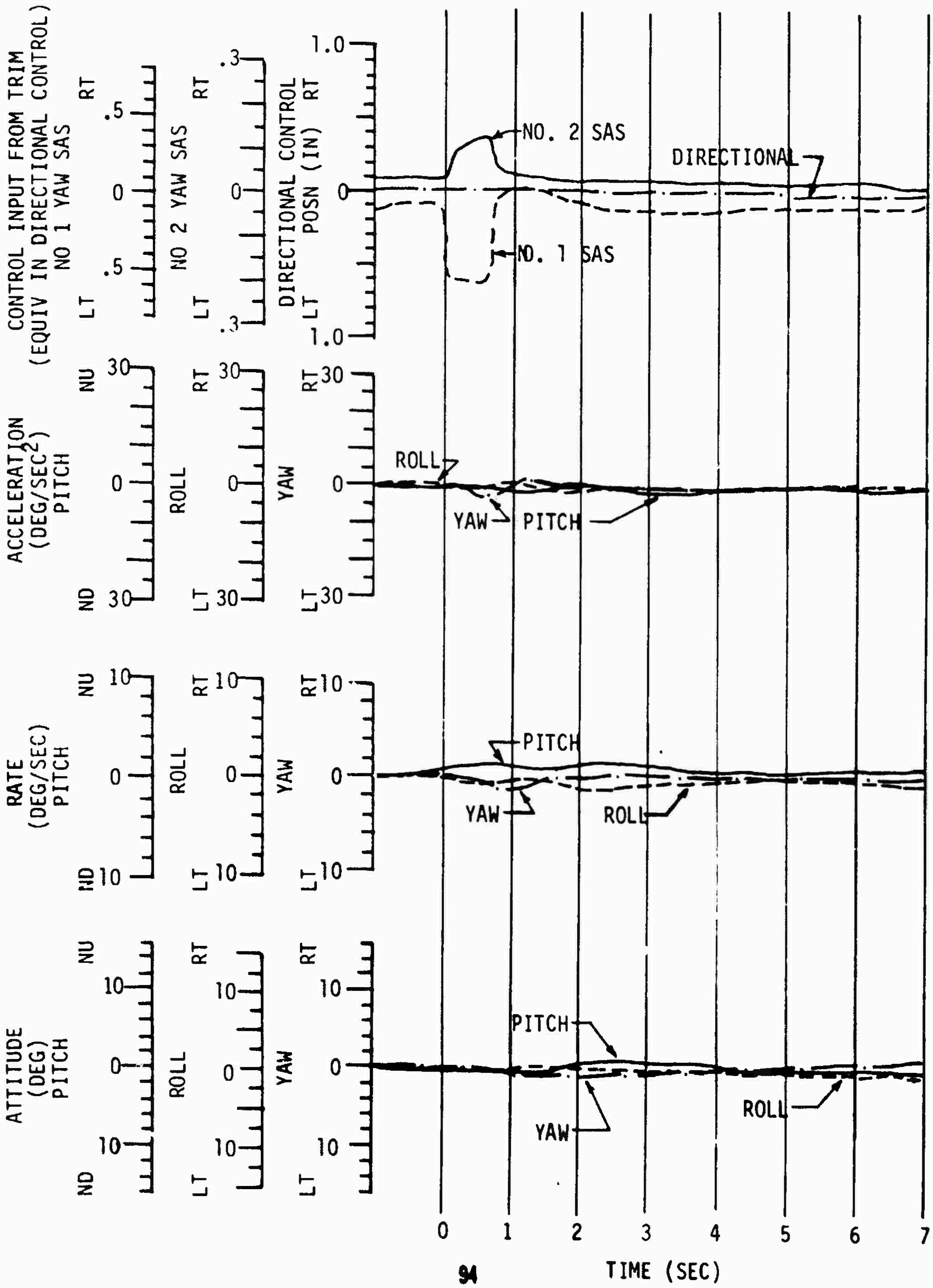


FIGURE 39
AIRCRAFT RESPONSE FOLLOWING LEFT DIRECTIONAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)
43950	5000	5.0	375.5(FWD)	220	79.44	112

NOTE: 1. DIRECTIONAL PULSE IS SUM OF NO. 1 AND NO. 2 SAS ACTUATORS

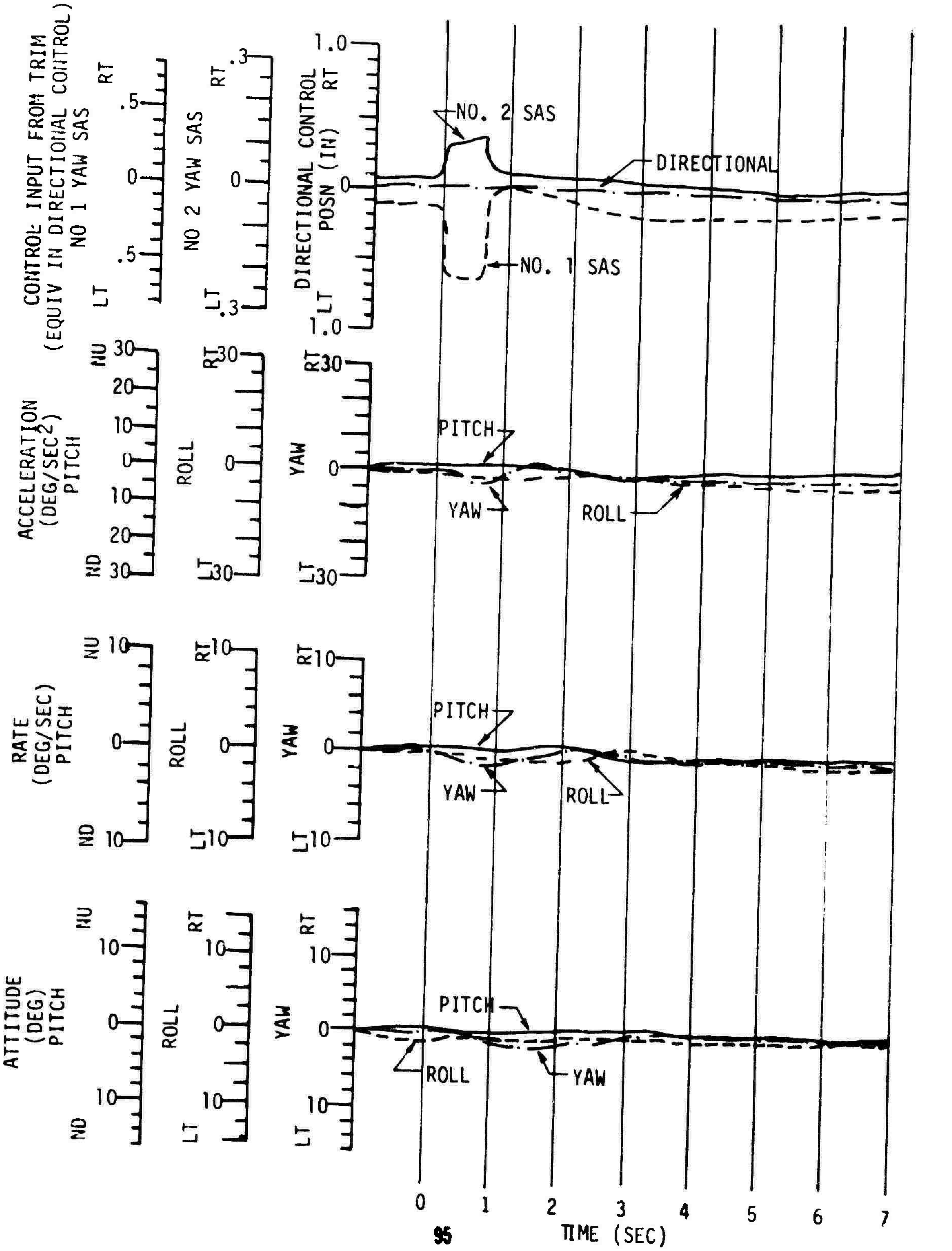


FIGURE 40
AIRCRAFT RESPONSE FOLLOWING LEFT DIRECTIONAL PULSE
BOEING 347 S/N 65-7992

GROSS WEIGHT (LB)	DENSITY ALT (FT)	OAT (^{o}C)	CG (IN)	ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)
45150	5000	5.0	375.5(FWD)	220	81.61	129

NOTE: 1. DIRECTIONAL PULSE IS SUM OF NO. 1 AND NO. 2 SAS ACTUATORS

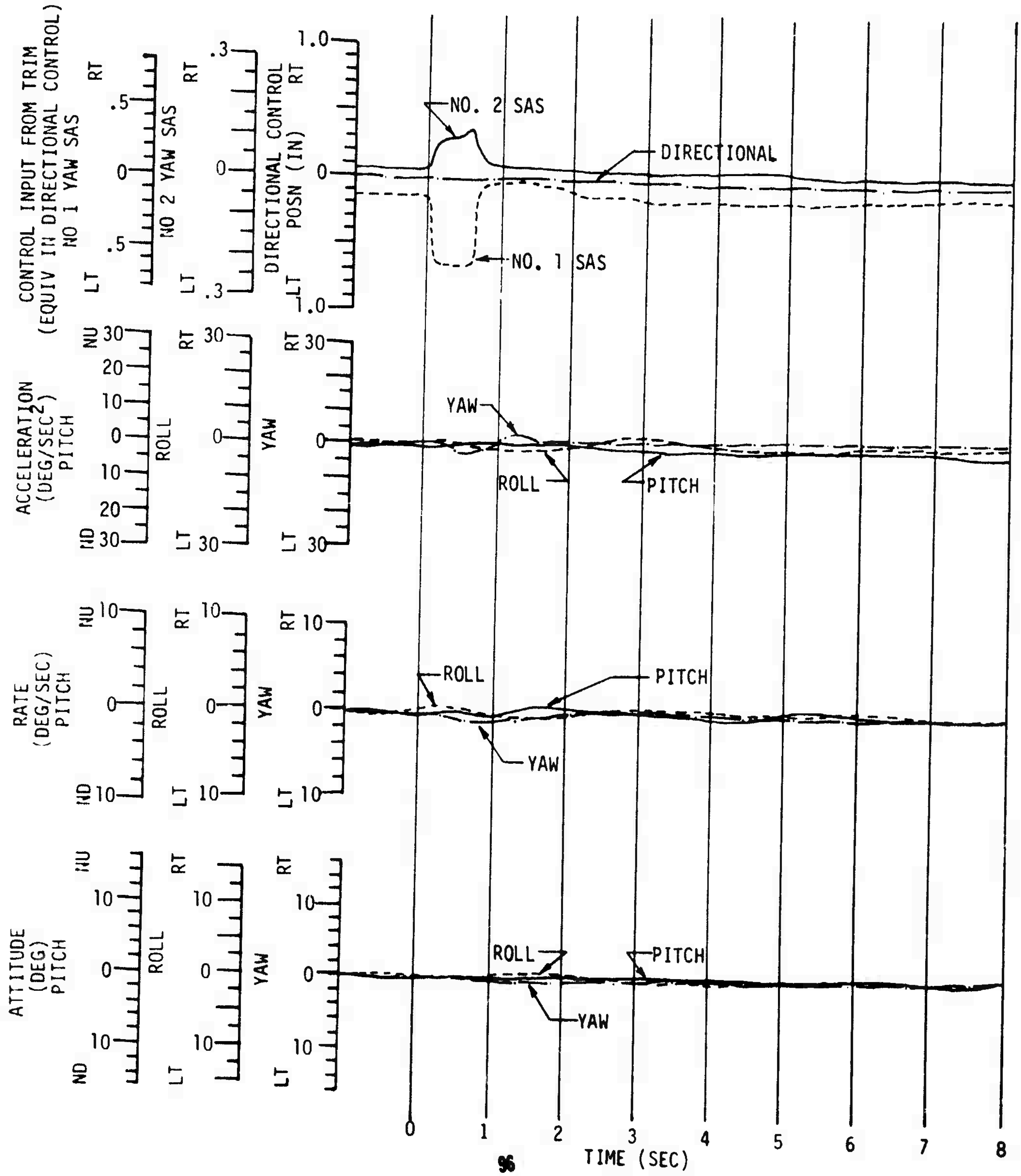


FIGURE 41
LONGITUDINAL CONTROLLABILITY
BOEING 347 S/N 65-7992
HOVER OGE

AVG GROSS WEIGHT (LB)	AVG DENSITY AFT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
46150	100	14.5	375.5(FWD)	220	22.09	0	1.02	0.50

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR EXTENDED
4. WING 85° INCIDENCE

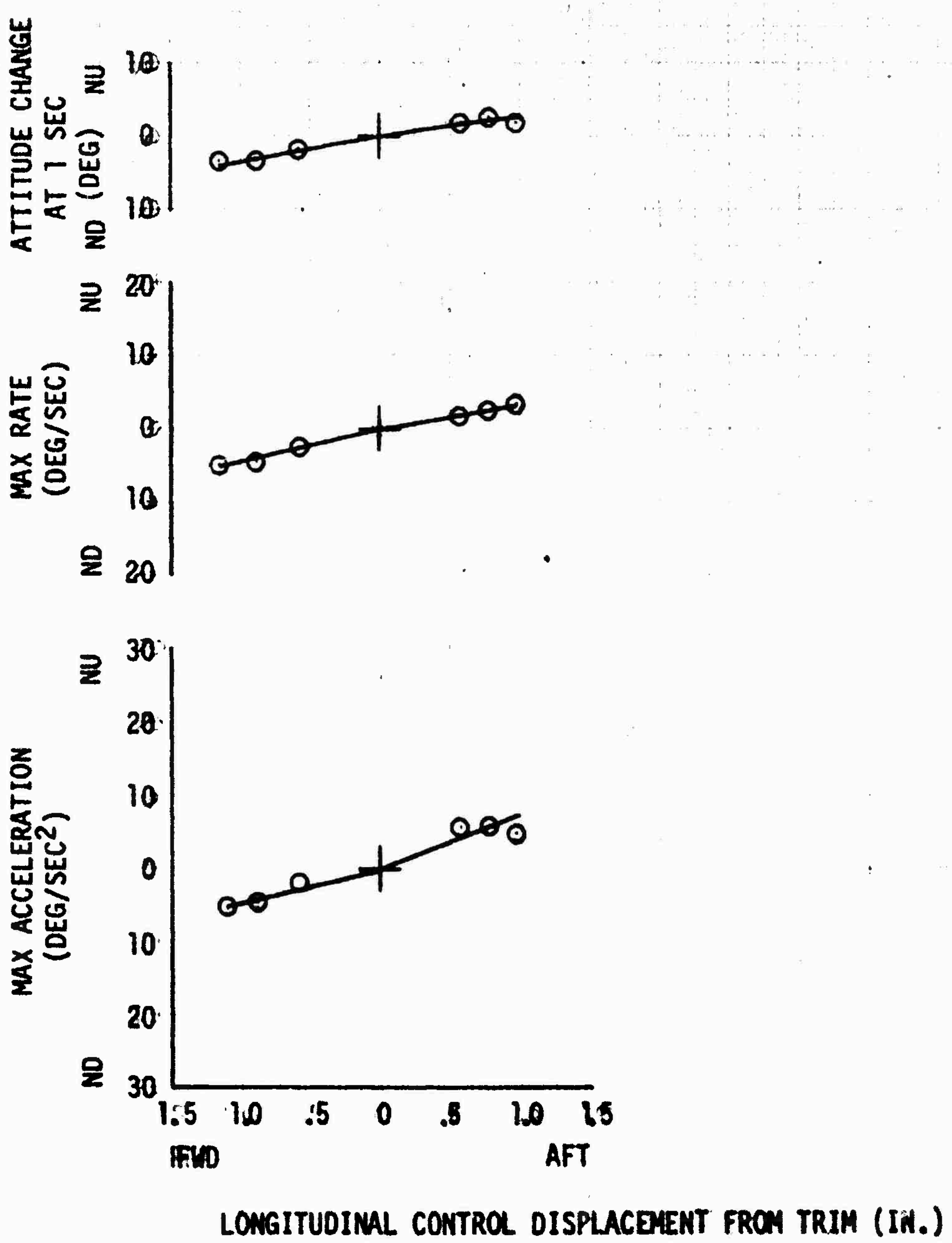


FIGURE 42

LONGITUDINAL CONTROLLABILITY

BOEING 347 S/N 65-7992

LEVEL FLIGHT

(SYM)	AVG GROSS WEIGHT (LB)	AVG DENSITY AFT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_T X10[4])	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
⊙	45050	5000	5.0	375.5(FWD)	220	81.42	83	0.98	0.47
⊡	43950	5000	5.0	375.5(FWD)	230	79.44	112	1.05	0.45
▲	45150	5000	3.5	375.5(FWD)	220	81.61	129	1.15	0.71

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°

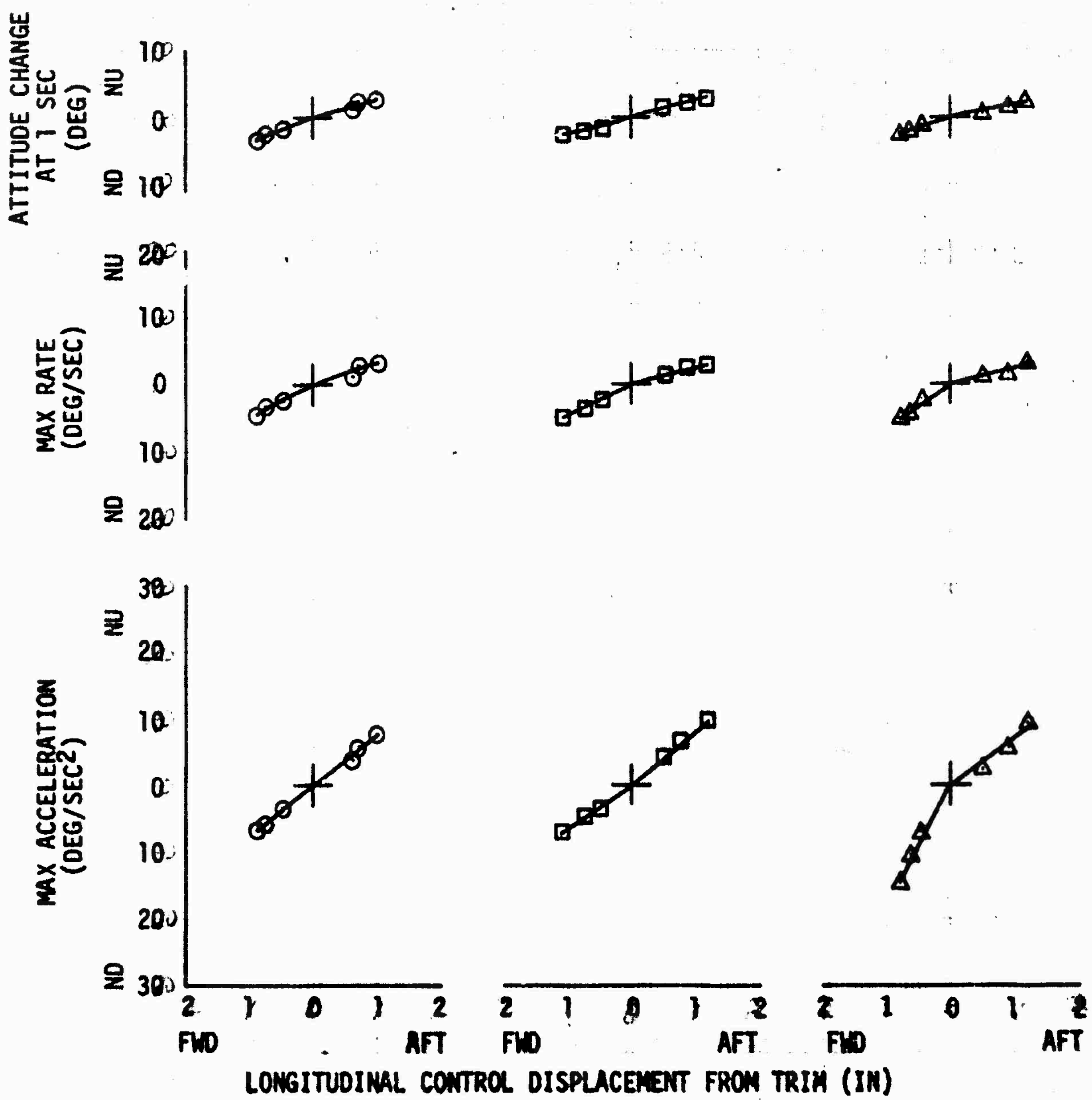


FIGURE 43
LATERAL CONTROLLABILITY
BOEING 347 S/N 65-7992
HOVER OGE

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
46250	-1100	3.5	375.5(FWD)	220	69.76	0	1.64	0.75

NOTES: 1. SAS ON
2. DASH ON
3. LANDING GEAR EXTENDED
4. WING INCIDENCE 85°

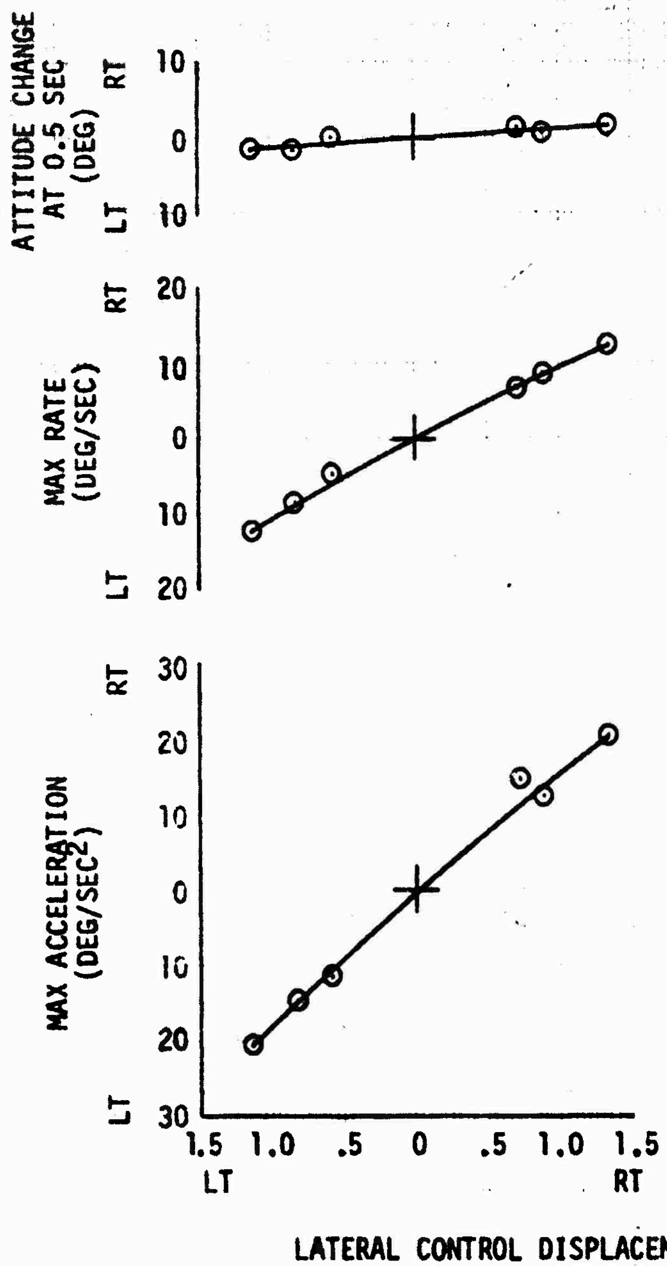
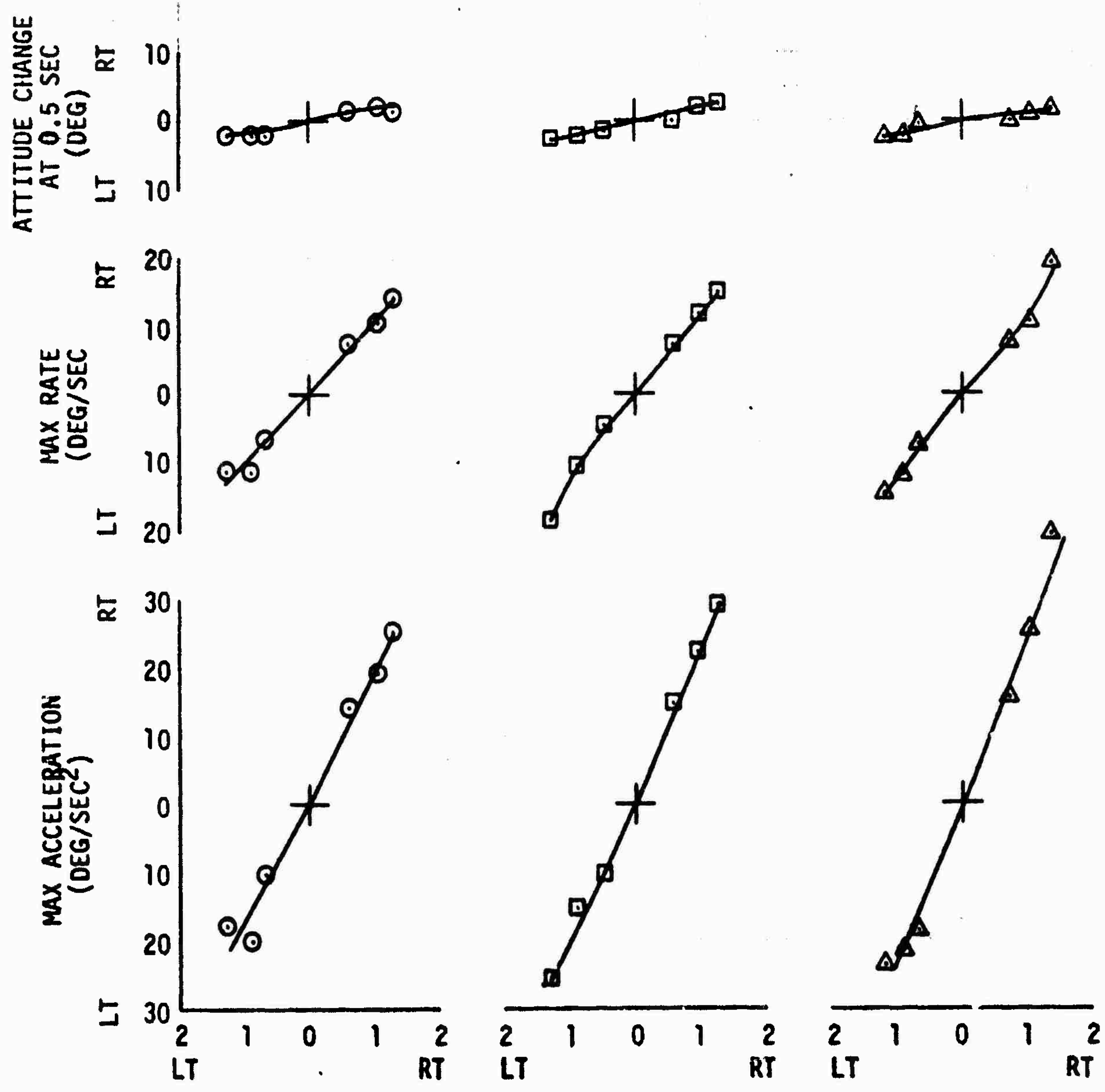


FIGURE 44
LATERAL CONTROLLABILITY
BOEING 347 S/N 65-7992
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_Tx10^4)	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
⊙	45050	5000	5.0	375.5(FWD)	220	81.42	83	1.39	0.59
⊡	43950	5000	5.0	375.5(FWD)	220	79.44	112	1.52	0.53
△	45150	5000	3.5	375.5(FWD)	220	81.61	129	2.61	0.92

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°



LATERAL CONTROL DISPLACEMENT FROM TRIM (IN.)

FIGURE 45
DIRECTIONAL CONTROLLABILITY
BOEING 347 S/N 65-7992
HOVER OGE

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_T X 10^4)	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
46250	-1100	3.5	375.5(FWD)	220	69.76	0	2.91	0.92

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR EXTENDED
4. WING INCIDENCE 85°

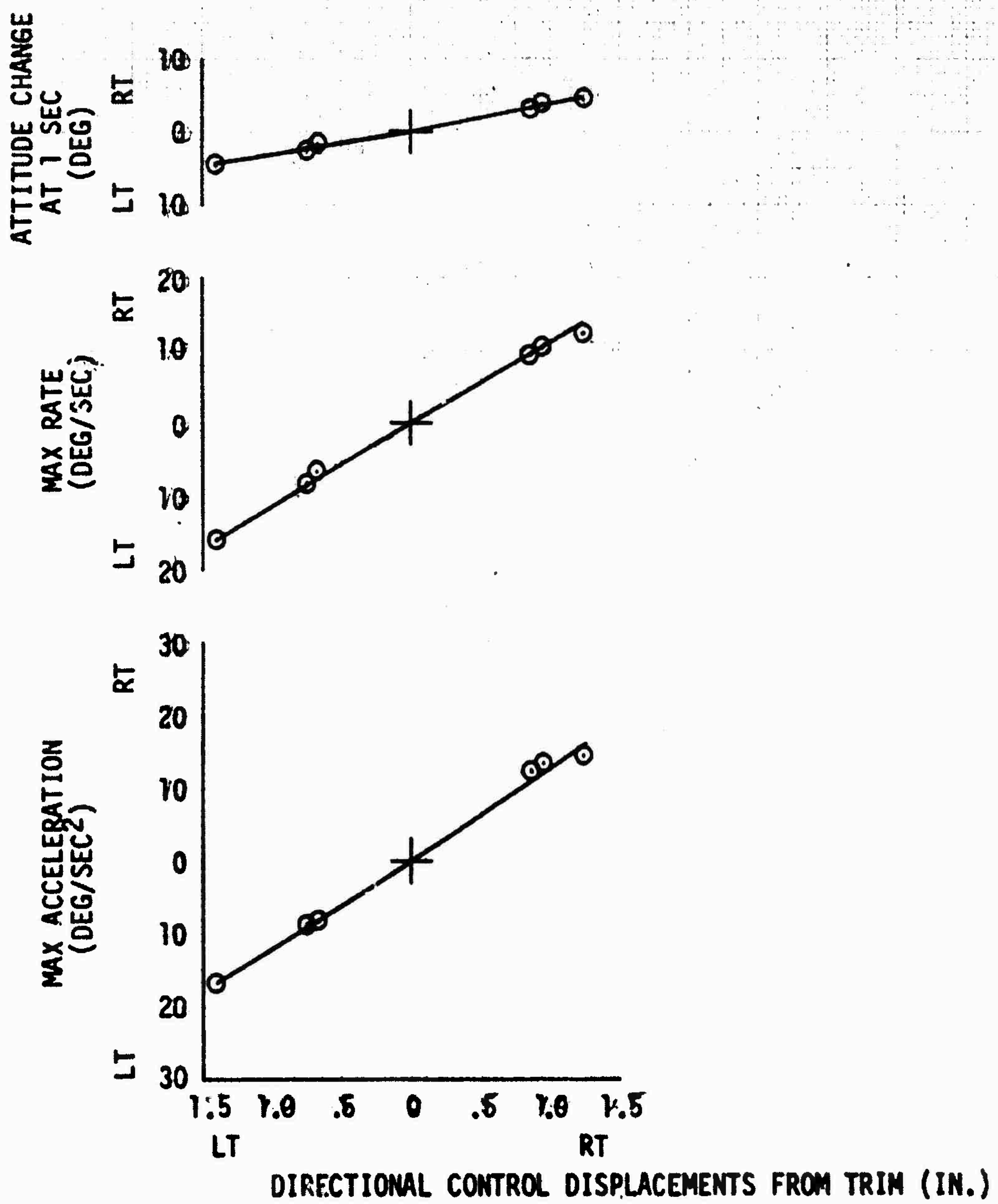


FIGURE 46
DIRECTIONAL CONTROLLABILITY
BOEING 347 S/N 65-7992
LEVEL FLIGHT

(SYM)	AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	TRIM A/S (KCAS)	AVG TIME TO MAX RATE (SEC)	AVG TIME TO MAX ACCEL (SEC)
⊙	45050	5000	5.0	375.5(FWD)	220	81.42	83	1.83	0.72
⊡	43950	5000	5.0	375.5(FWD)	220	79.44	112	1.90	0.66
△	45150	5000	3.5	375.5(FWD)	220	81.61	129	1.98	0.84

NOTES:
1. SAS ON
2. DASH ON
3. LANDING GEAR RETRACTED
4. WING INCIDENCE 10.5°

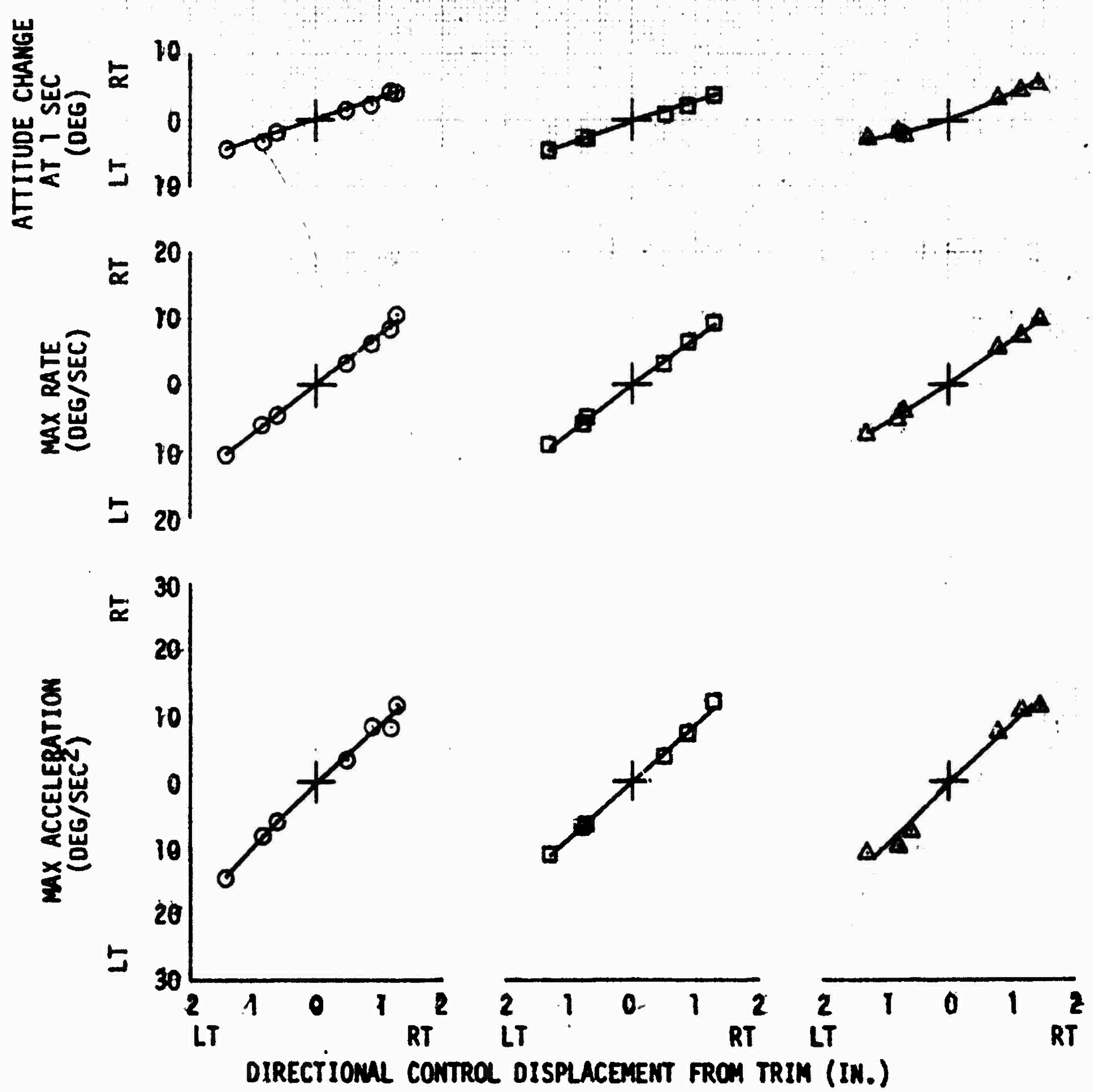


FIGURE 47
AIRCRAFT RESPONSE DURING TAKEOFF
BOEING 347 S/N 65-7992

AVG GROSS WT (LB)	AVG OENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEEO (RPM)	THRUST COEFFIENT (C_T X10^4)
43100	-550	9.5	375.5(FWD)	220	66.06

NOTE: 1 WING IN AUTOMATIC MOOE.

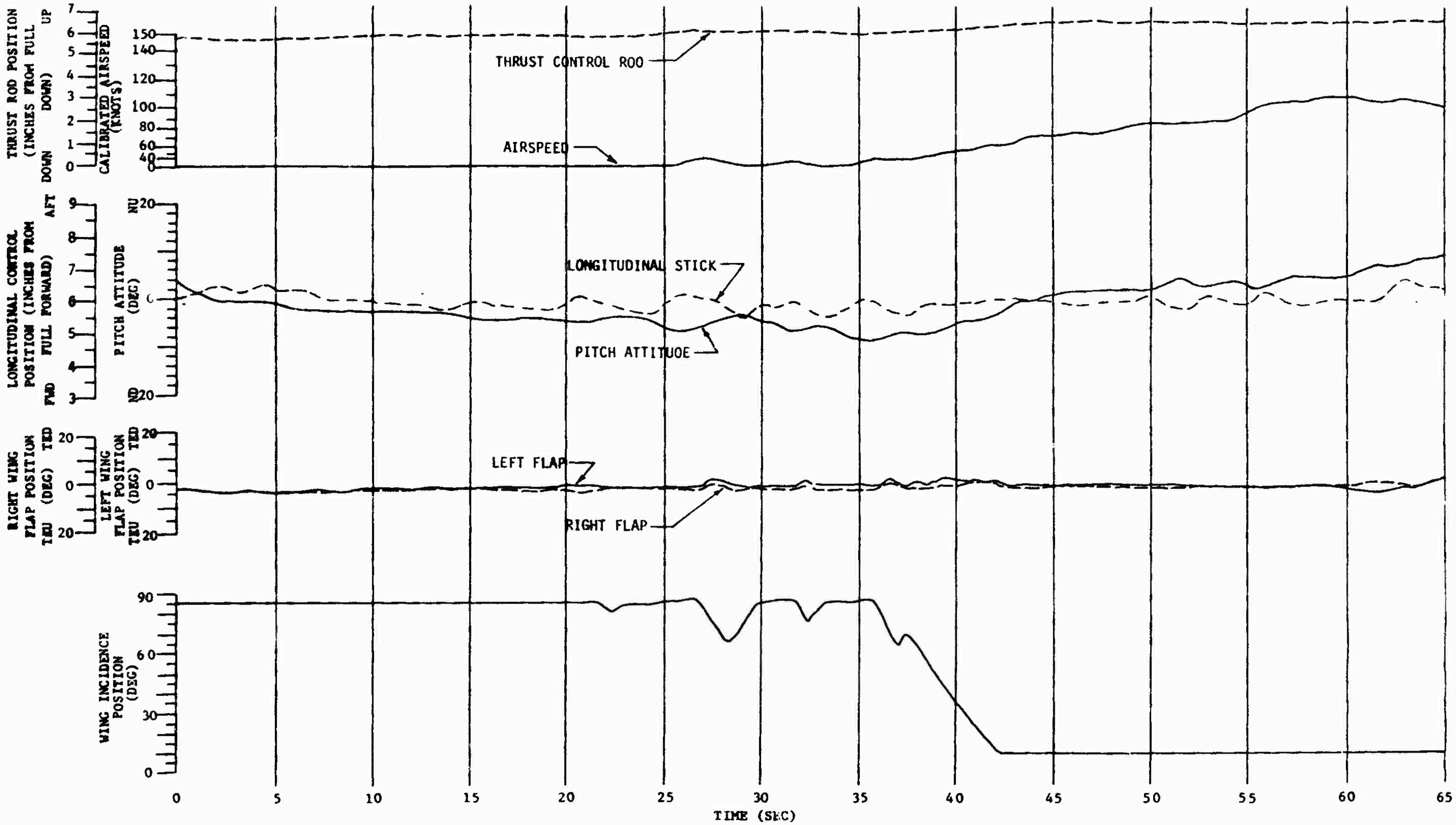


FIGURE 48
AIRCRAFT RESPONSE DURING TAKEOFF
BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFFIENT ($C_T \times 10^4$)
43100	-550	9.5	375.5(FWD)	220	66.06

NOTE: 1 WING IN AUTOMATIC MODE

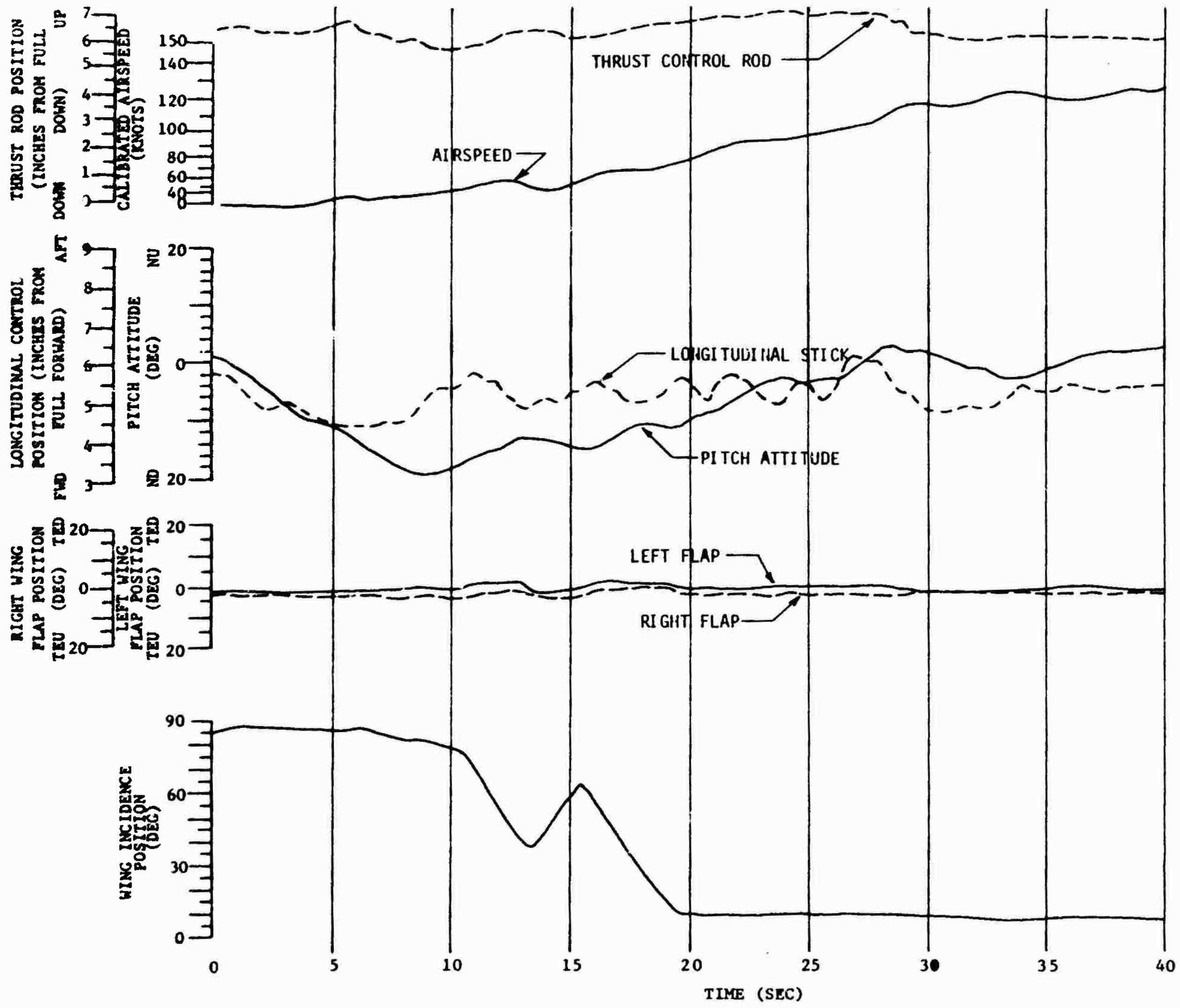


FIGURE 49
AIRCRAFT RESPONSE DURING APPROACH
BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFFICIENT ($C_T X10^4$)
43100	-550	9.5	375.5(FWD)	220	66.06

NOTE: 1 WING IN AUTOMATIC MODE

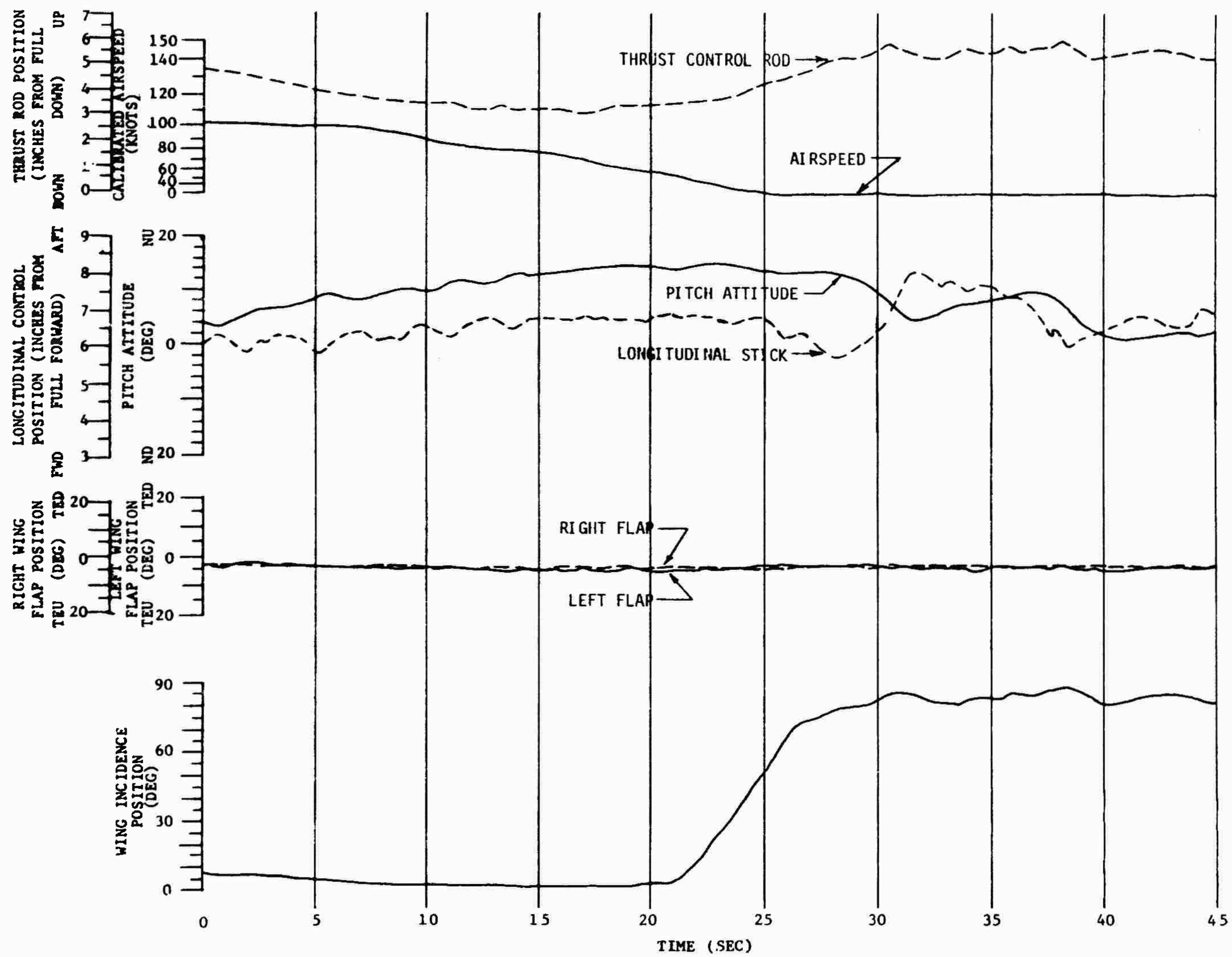


FIGURE 50
AIRCRAFT RESPONSE DURING APPROACH
BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN)	AVG ROTOR SPEED (RPM)	THRUST COEFFICIENT (C_TX10^4)
43100	-550	9.5	375.5(FWD)	220	66.06

NOTE: 1 WING IN AUTOMATIC MODE.

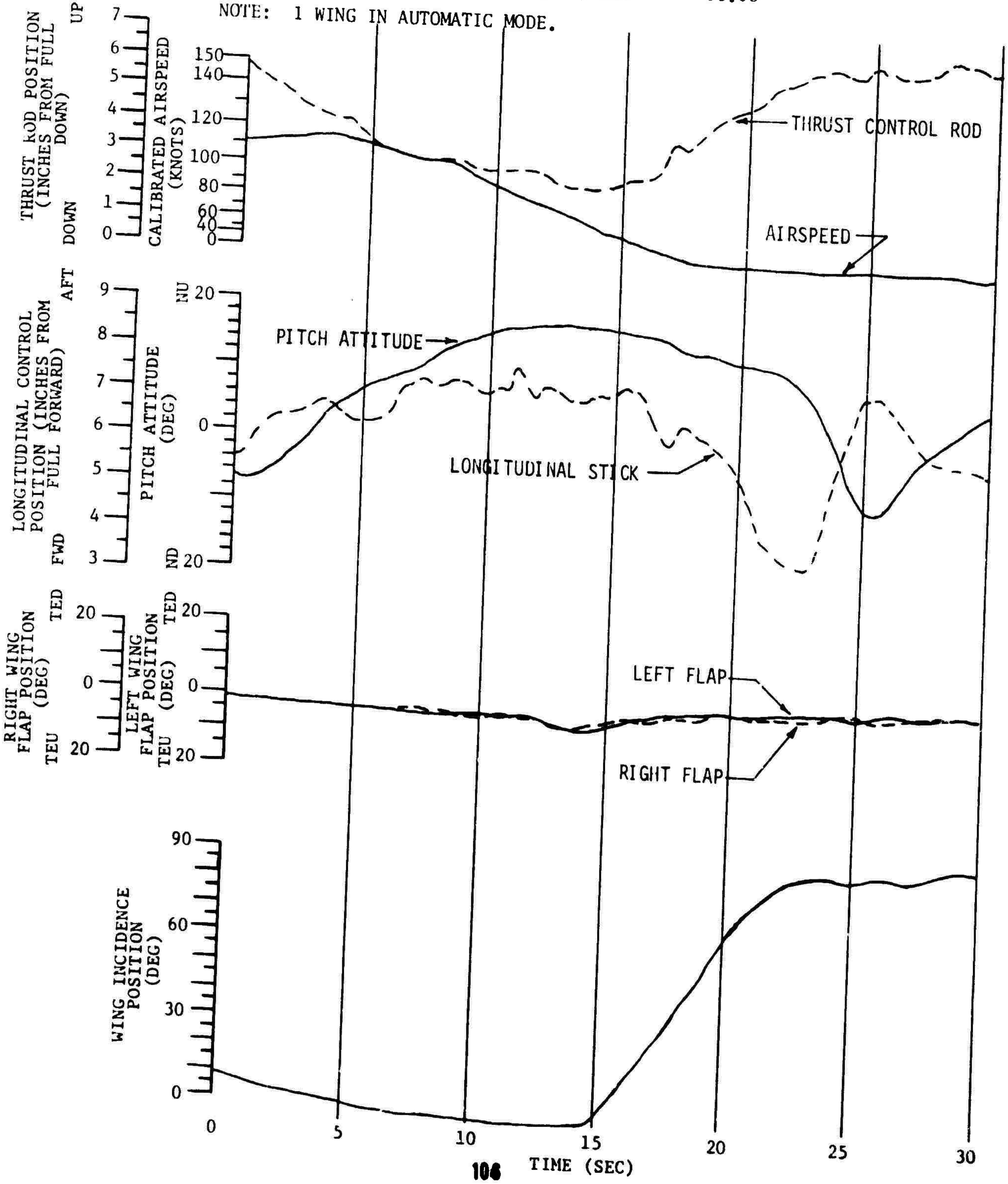


FIGURE 51

STA 50 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10⁴)	FLIGHT CONDITION
44500	5000	-70	375.0(FWD)	220	80.43	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. ▲ 30 KTAS LEFT SIDEWARDS WING INCIDENCE 10.5°
5. ⊡ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 85°
6. ⊡ SYMBOL OFF SCALE HAS AMPLITUDE IN BRACKETS

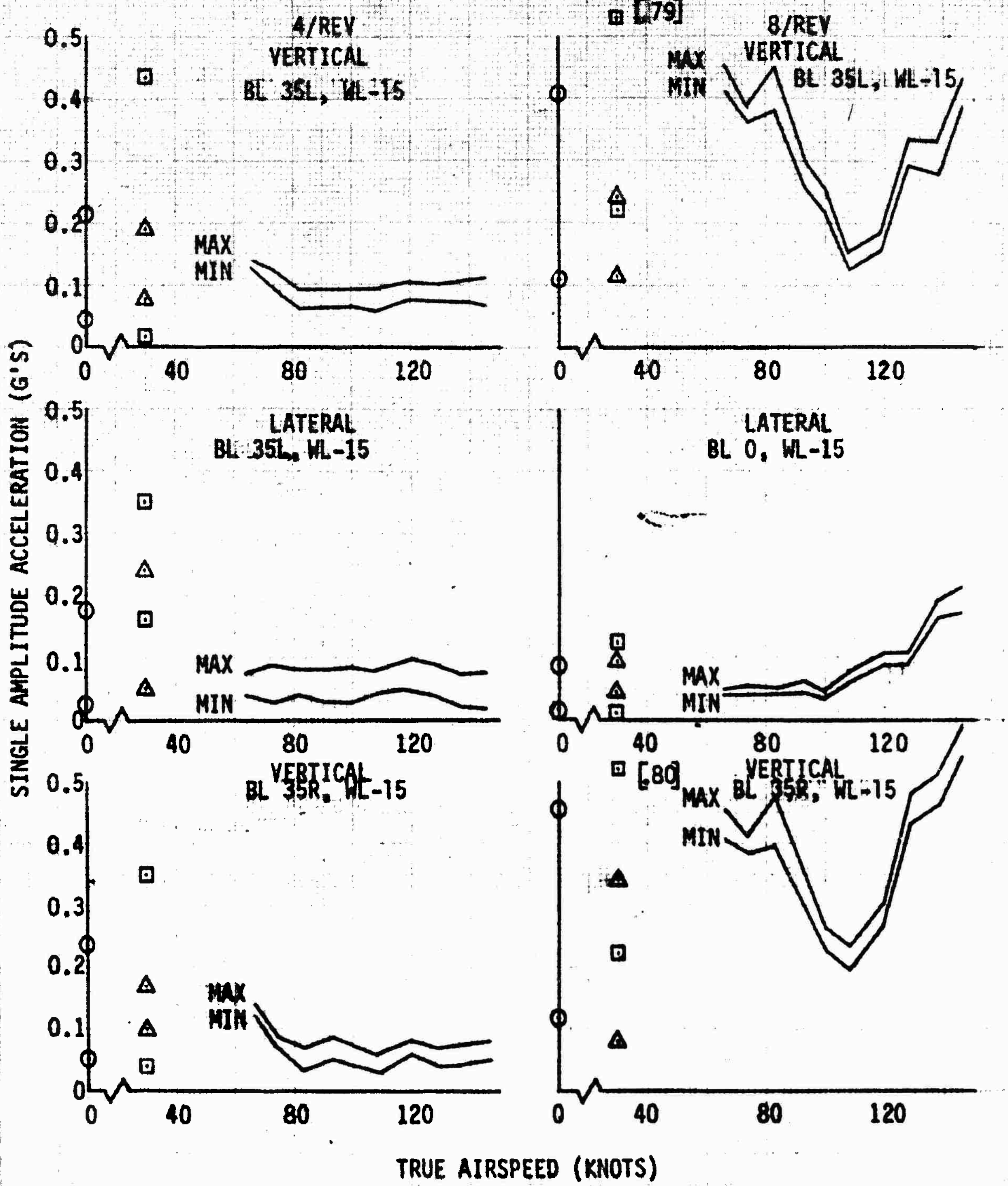


FIGURE 52

STA 95 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	FLIGHT CONDITION
44500	5000	-7.0	375.0(FWD)	220	80.43	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. △ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 10.5°
5. ⊡ 30 KTAS LEFT SIDEWARD:WING INCIDENCE 85 ⊡[.60]
6. ⊡ SYMBOL OFF SCALE HAS AMPLITUDE IN BRACKETS

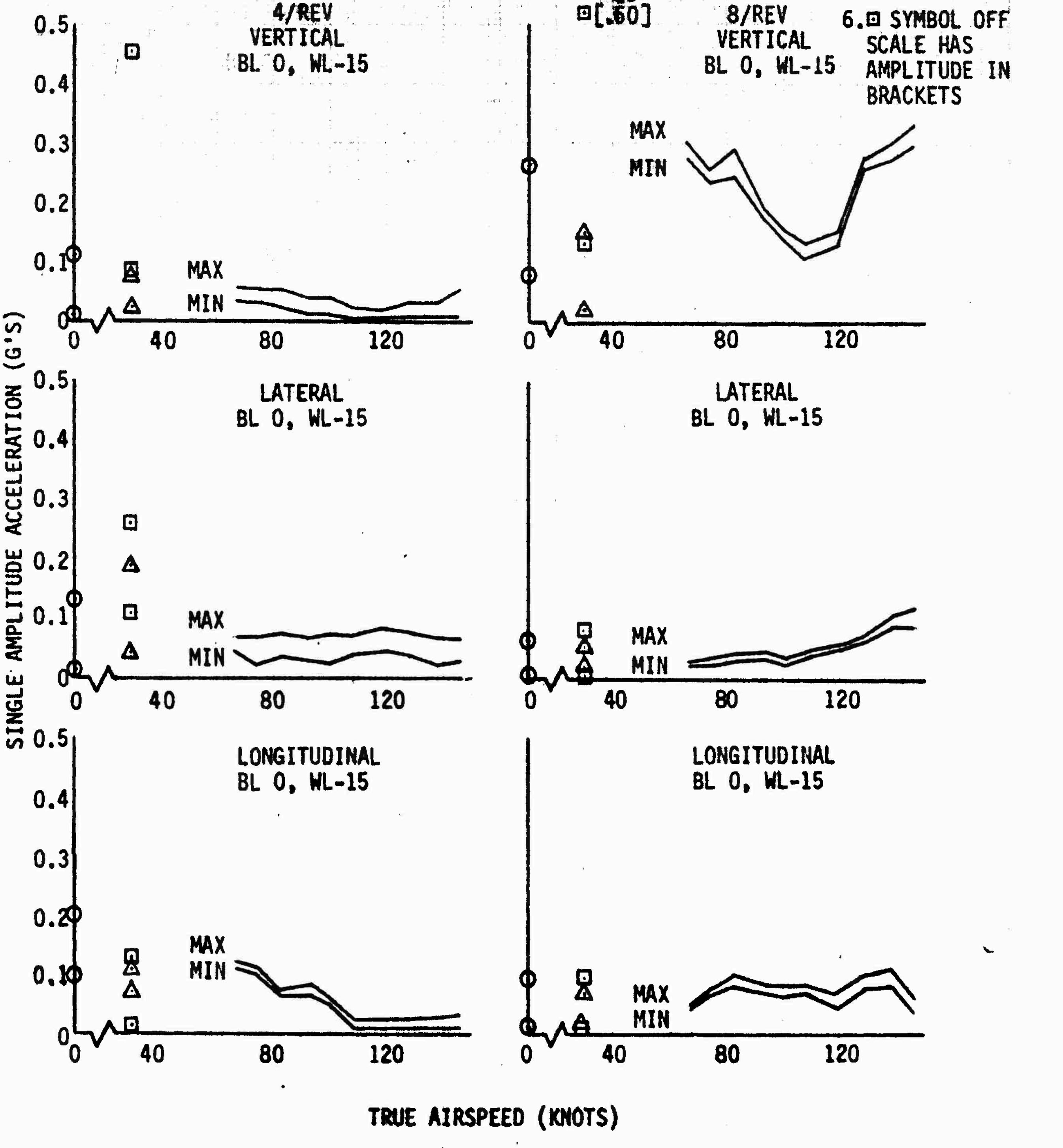


FIGURE 53

STA 360 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	FLIGHT CONDITION
44500	5000	-7.0	375.0(FWD)	220	80.43	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. △ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 10.5°
5. ⊡ 30 KTAS LEFT SIDEWARD: WING INCIDENCE 85°

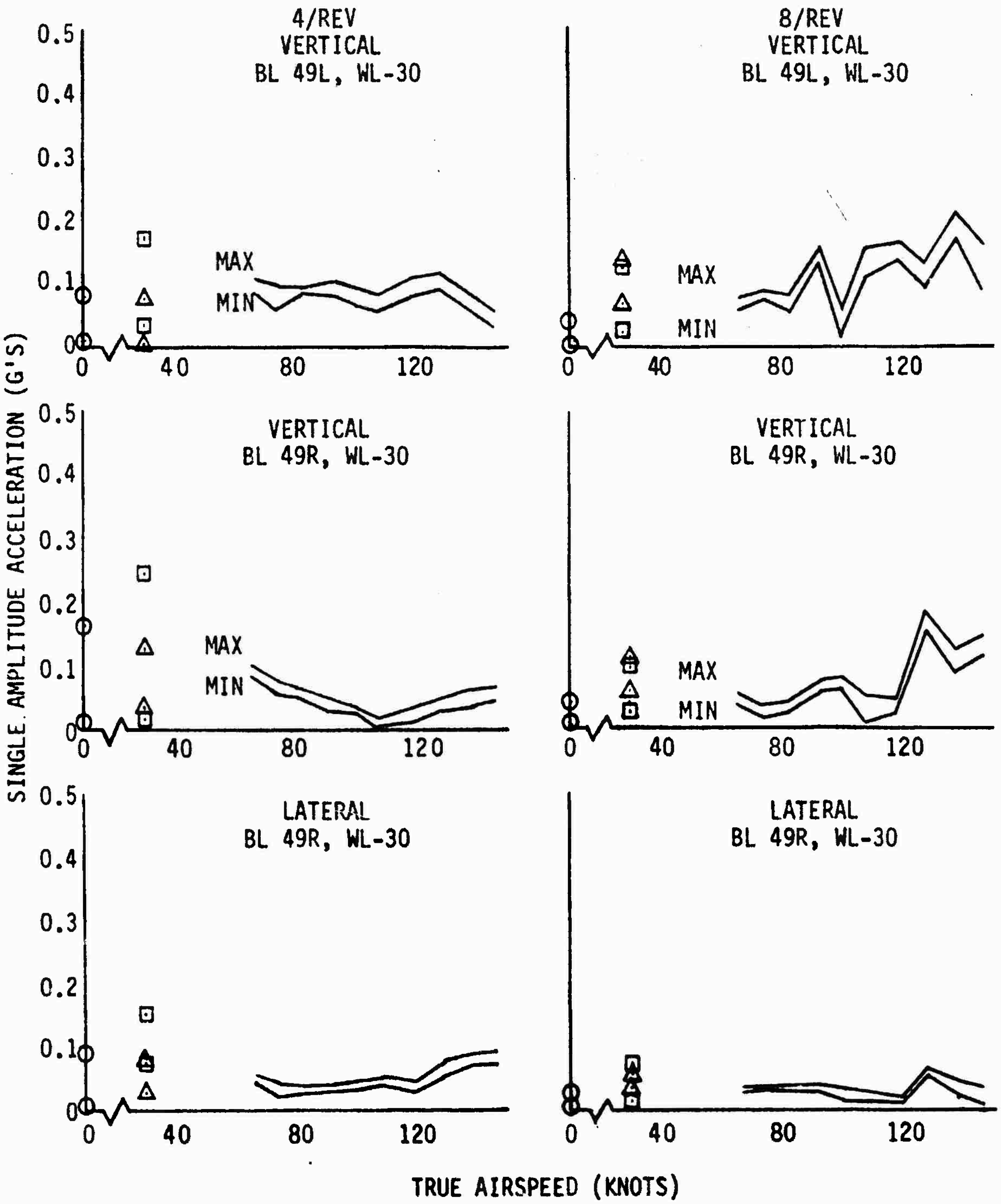


FIGURE 54

STA 592 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X 10^4$)	FLIGHT CONDITION
44500	5000	-7.0	375.0(FWD)	220	80.43	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. △ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 10.5°
5. □ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 85°

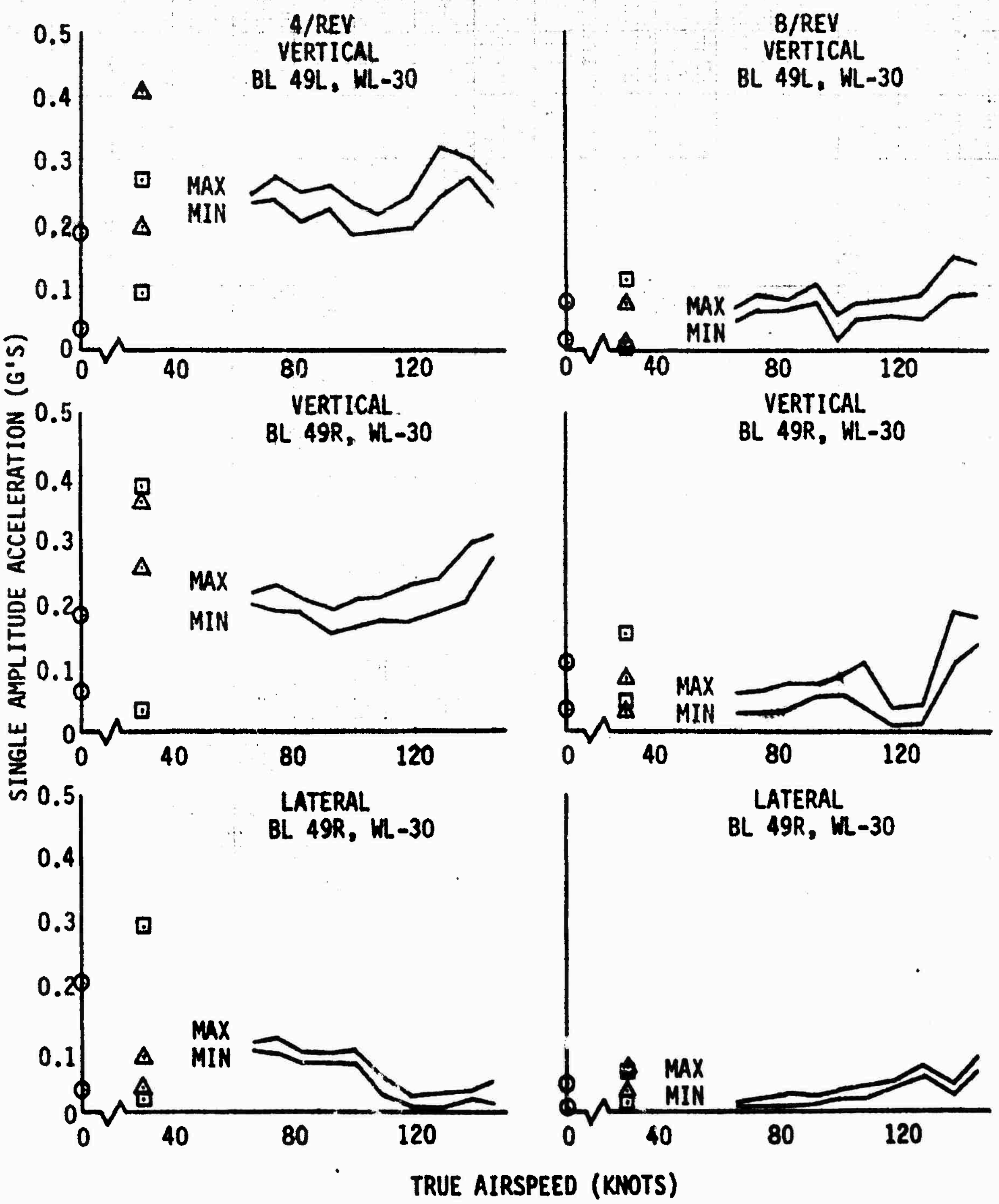


FIGURE 55

STATION 95 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF ($C_T X10^4$)	FLIGHT CONDITION
44500	5000	-7.0	375.0(FWD)	220	80.43	LEVEL

NOTES: 1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. ▲ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 10.5°
5. ⊡ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 85°

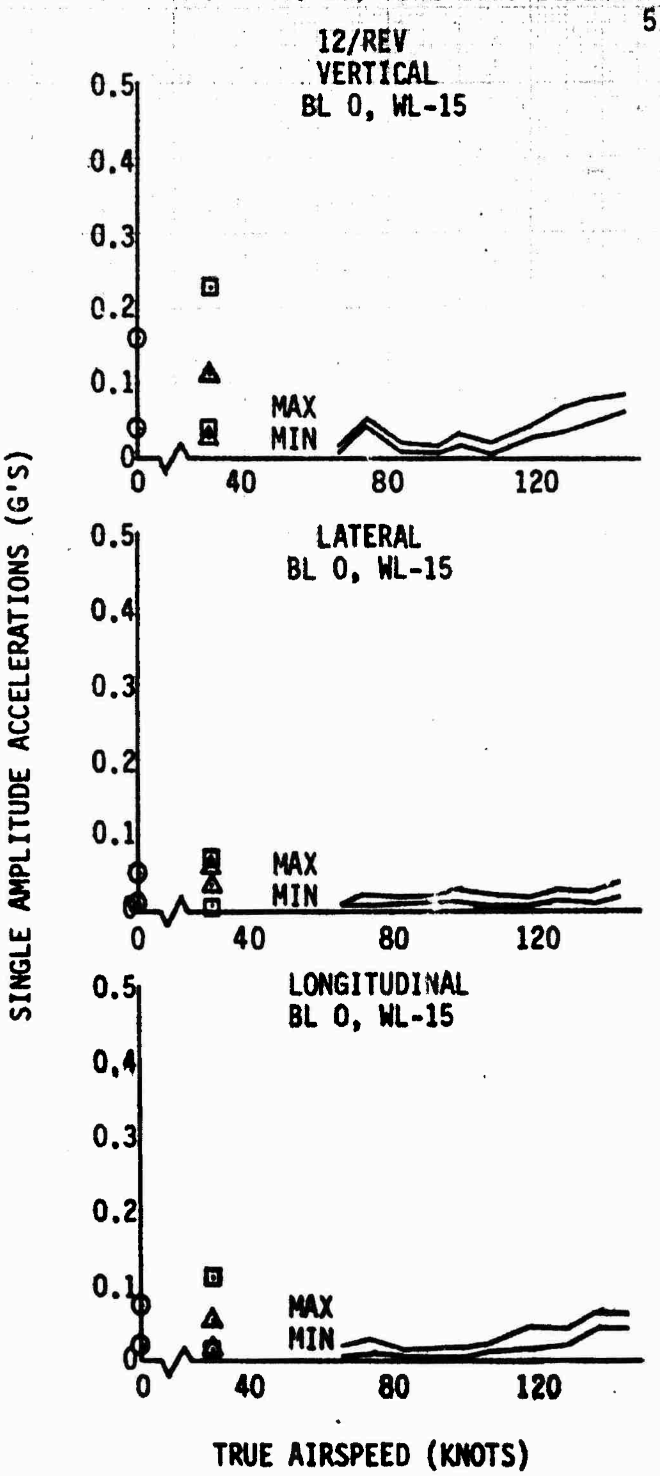


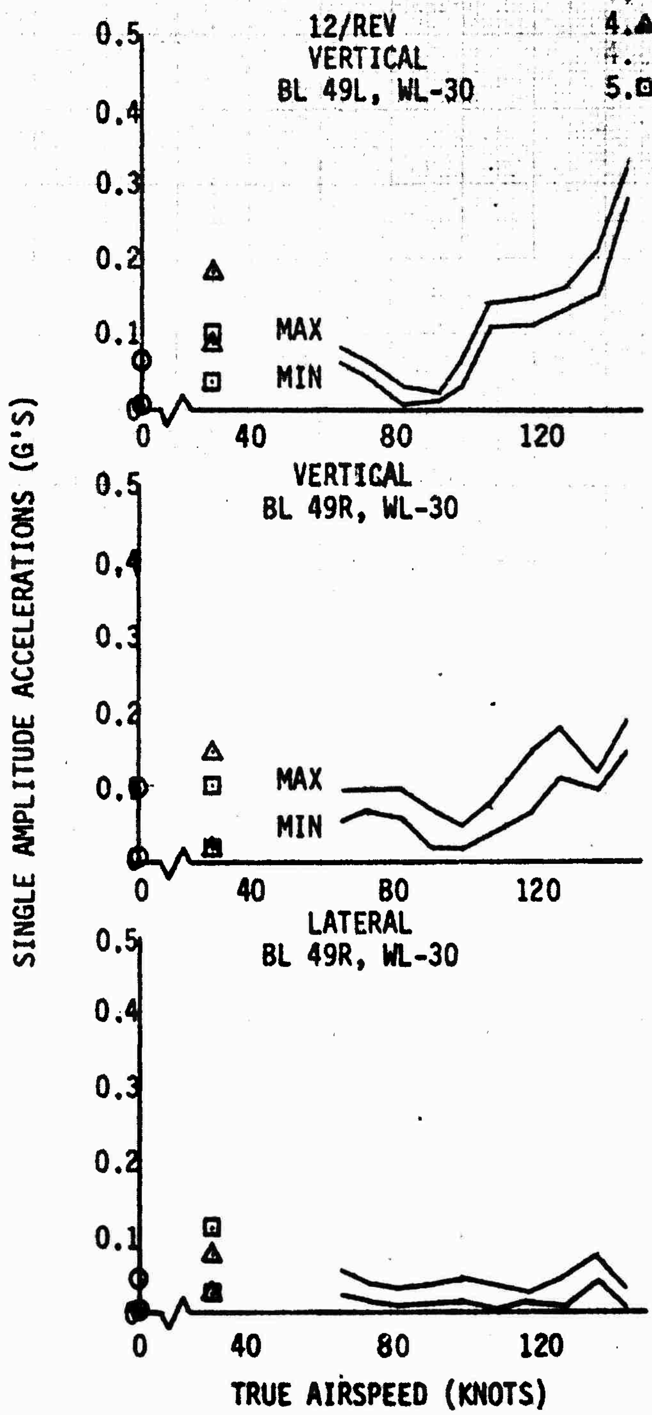
FIGURE 56

STATION 592 VIBRATION CHARACTERISTICS.

BOEING 347 S/N 65-7992

AVG GROSS WEIGHT (LB)	AVG DENSITY ALT (FT)	AVG OAT (°C)	AVG CG (IN.)	AVG ROTOR SPEED (RPM)	THRUST COEFF (C_TX10^4)	FLIGHT CONDITION
44500	5000	-7.0	375.0(FWD)	220	80.43	LEVEL

NOTES:
1. SAS ON
2. DASH ON
3. WING INCIDENCE 10.5°
4. ▲ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 10.5°
5. ◻ 30 KTAS LEFT SIDEWARD; WING INCIDENCE 85°



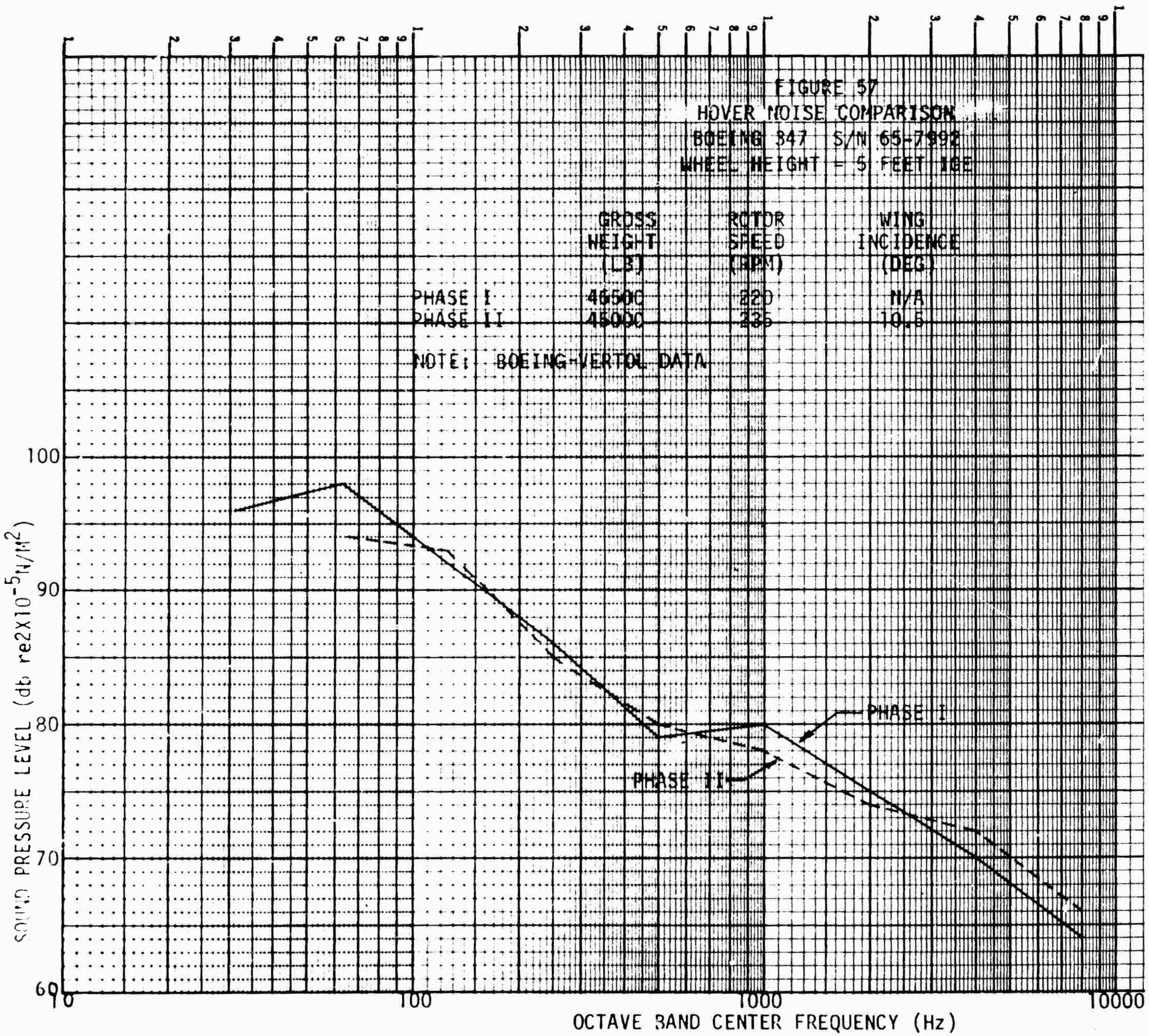


FIGURE 57
HOVER NOISE COMPARISON
BOEING 347 S/N 65-7992
WHEEL HEIGHT = 5 FEET IGE

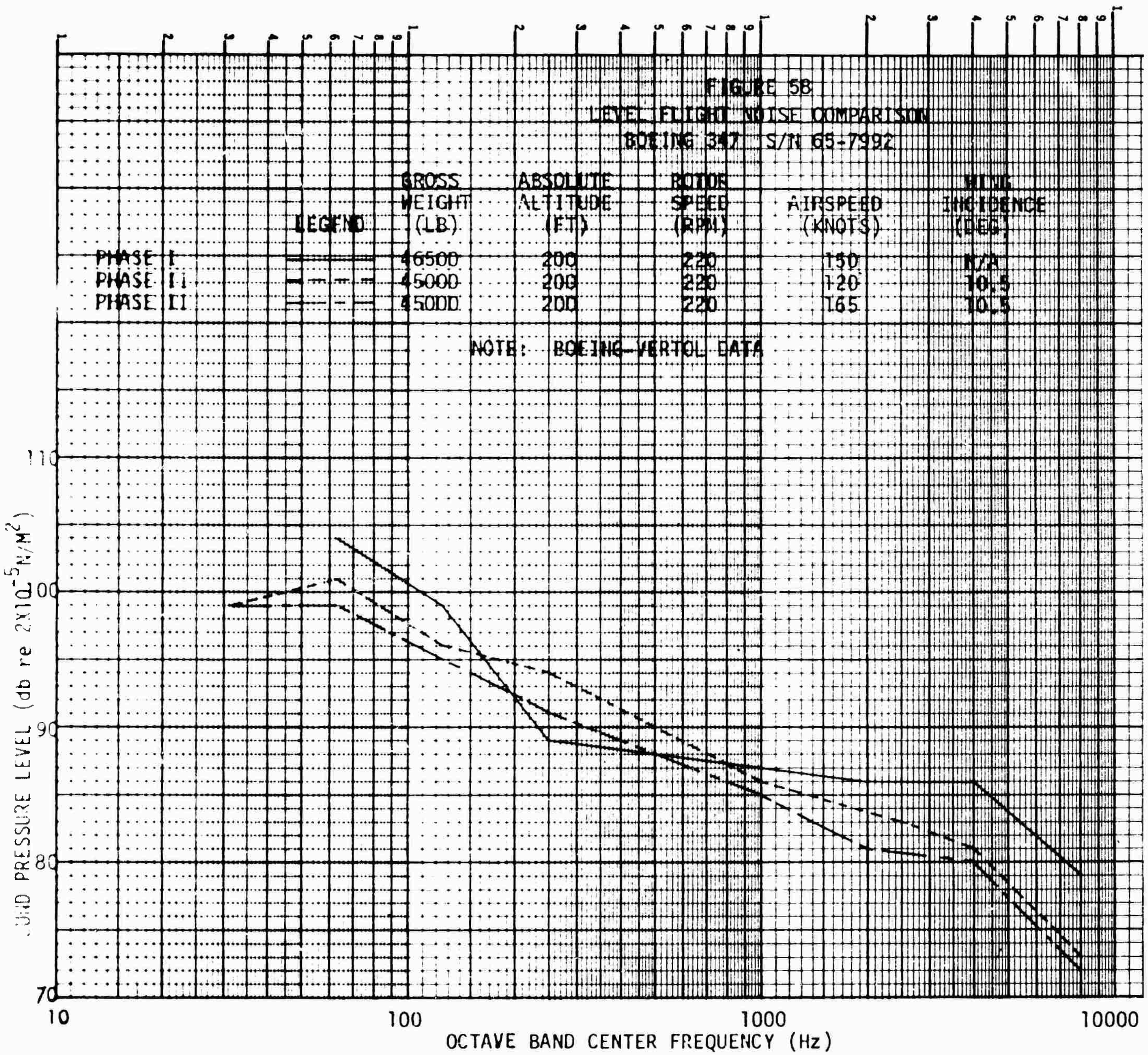


FIGURE 58
LEVEL FLIGHT NOISE COMPARISON
BOEING 347 S/N 65-7992
LEGEND
GROSS WEIGHT (LB)
ABSOLUTE ALTITUDE (FT)
ROTOR SPEED (RPM)
AIRSPEED (KNOTS)
WING INCIDENCE (DEG)
PHASE I 46500 200 220 150 N/A
PHASE II 45000 200 220 120 10.5
PHASE II 45000 200 220 165 10.5
NOTE: BOEING-VERTOL DATA
SOUND PRESSURE LEVEL (db re 2X10^{-5}N/M^2)
110
100
90
80
70
10
100
1000
10000
OCTAVE BAND CENTER FREQUENCY (Hz)

DISTRIBUTION

Director of Defense Research and Engineering	2
Assistant Secretary of the Army (R&D)	1
Assistant Chief of Staff for Force Development, DA (DAFD-AVP)	1
Deputy Chief of Staff for Logistics, DA (DALO-ZP)	1
Chief of Research and Development, DA (DARD-PPM-T, DARD-DDA(3D364)	3
Deputy Chief of Staff for Personnel, DA (DAPE-ZXM)	1
Deputy Chief of Staff for Military Operations, DA (DAMO-ZO)	1
Assistant Chief of Staff for Communications – Electronics, DA (DACE-CSE)	1
US Army Materiel Command (AMCPM-HLS, AMCRD-FQ, AMCSF-A, AMCQA)	5
US Army Aviation Systems Command (AMSAV-EF)	12
US Army Combat Developments Command (USACDC LnO)	11
US Army Continental Army Command	1
US Army Test and Evaluation Command (AMSTE-BG, USMC LnO)	2
US Army Electronics Command (AMSEL-VL-D)	1
US Army Weapons Command (AMSWE-REW)	2
US Army Missile Command	1
US Army Munitions Command	1
HQ US Army Air Mobility R&D Laboratory (SAVDL-D)	2
US Army Air Mobility R&D Laboratory (SAVDL-SR)	2
Ames Directorate, US Army Air Mobility R&D Laboratory (SAVDL-AM)	2
Eustis Directorate, US Army Air Mobility R&D Laboratory (SAVDL-EU-TD)	4
Langley Directorate, US Army Air Mobility R&D Laboratory (MS 124)	2
Lewis Directorate, US Army Air Mobility R&D Laboratory	2
US Army Aeromedical Research Laboratory	1
US Army Aviation Center (ATSAV-AM, ATSAV-AAP)	2
US Army Aviation Test Board	1
US Army Agency for Aviation Safety (FDAR-P-OC)	1
US Army Maintenance Board (AMXMB-ME-A)	1
US Army Primary Helicopter School	1
US Army Transportation School	1
US Army Logistics Control Office	1
US Army Logistics Management Center	1

US Army Foreign Science and Technology Center	1
US Marine Corps Development and Education Command	2
US Naval Air Test Center (FT 23)	1
US Air Force Aeronautical Systems Division (ASD-ENFDP)	1
US Air Force Flight Dynamics Laboratory (AFSC) (DOO Library)	1
US Air Force Flight Test Center (SSD, TGE)	4
Department of Transportation Library	2
US Army Boeing-Vertol Plant Activity	5
The Boeing Company, Vertol Division	5
Lycoming Division of AVCO Corporation	5
Defense Documentation Center	2

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY EDWARDS AIR FORCE BASE, CALIFORNIA 93523	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
	2b. GROUP

3. REPORT TITLE
ENGINEERING FLIGHT TEST
BOEING-VERTOL MODEL 347 ADVANCED TECHNOLOGY HELICOPTER
PHASE II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
FINAL REPORT 3 through 11 April 1972

5. AUTHOR(S) (First name, middle initial, last name) ARLIN DEEL, LTC, CE, US ARMY, PROJECT OFFICER/PILOT
WILLIAM R. HORTON, MAJ, FA, US ARMY, PROJECT PILOT
ALTON G. STEINMETZ, PROJECT ENGINEER
CHARLES J. BOWERS, SP4, US ARMY, ENGINEER

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
OCTOBER 1972	124	11

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. AVSCOM PROJECT NO. 72-12	USAASTA PROJECT NO. 72-12
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	NA

10. DISTRIBUTION STATEMENT Distribution limited to United States Government agencies only; test and evaluation, October 1972. Other requests for this document must be referred to the Commander, United States Army Aviation Systems Command, Attention: AMSAV-EF, Post Office Box 209, St. Louis, Missouri 63166.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	US ARMY AVIATION SYSTEMS COMMAND ATTN: AMSAV-EF PO Box 209, St. Louis, Missouri 63166

13. ABSTRACT
The US Army Aviation Systems Test Activity conducted the Phase II technical evaluation of the Boeing-Vertol Model 347 winged helicopter during the period 3 through 11 April 1972. The Model 347 winged helicopter, a derivative of the CH-47 transport helicopter incorporating a variable incidence wing with normal acceleration load-sensitive flaps, was tested at the contractor's facility near Philadelphia, Pennsylvania. The evaluation was conducted to determine the improvements provided by addition of a wing system to a transport helicopter. Compliance with the provisions of military specification MIL-H-8501A was determined. Evaluations of the variable incidence wing system and the retractable landing gear system were also made. With the wing in the hover position, out-of-ground-effect hover performance of the Model 347 winged helicopter was similar to the unwinged aircraft. Both the winged and nonwinged Model 347 helicopter could hover out of ground effect using less power than could the CH-47C. Level flight performance at a heavy referred gross weight (54,000 pounds) was improved over both the nonwinged helicopter and the production CH-47C. Addition of the wing to the Model 347 helicopter did not significantly change the generally excellent handling qualities reported for the nonwinged version of the aircraft. The strong longitudinal stability exhibited by the aircraft reduced pilot workload in maintaining trim airspeed and pitch attitude. Only minimal trim changes in all control axes were required when transitioning between climbs or descents and level flight. The Model 347 winged helicopter failed to meet the requirements of five paragraphs of MIL-H-8501A. Twelve shortcomings were identified. The most significant of these shortcomings were the high pilot workload required to accomplish takeoffs and landings with the wing incidence control system functioning in the automatic mode, an excessive longitudinal oscillation in turns above 30-degrees angle of bank at 85 knots calibrated airspeed, the excessive sensitivity of rotor speed to thrust control rod position during autorotational flight, slippage of the thrust control rod at high power settings, and an excessive 8-per-revolution vibration during hover, approach to a hover, and in left sideward flight at 30 knots calibrated airspeed. The variable incidence wing and normal acceleration load-sensitive flaps installed on the Model 347 winged helicopter increased the accelerated flight capability of the aircraft. Stabilized turns in excess of a 60-degree angle of bank (2.0 load factor) were accomplished at all test airspeeds without overstressing the rotor or associated control system components. The retractable landing gear system reduced parasite drag and resulted in an airspeed increased of approximately 4 to 5 knots at indicated airspeeds above 120 knots. The advantages gained with the wing and the retractable landing gear are gained at the expense of increased weight and complexity.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Boeing-Vertol Model 347 Advanced Technology helicopter						
CH-47 transport helicopter						
Winged and non-winged Model 347 helicopter						
Variable incidence wing with normal acceleration load sensitive flaps						
MIL-H-8501A compliance						
Heavy referred gross weight (54,000 pounds)						
Handling qualities						
Longitudinal stability						
Pilot workload						
Longitudinal oscillations in turns						
Sensitivity of rotor speed to thrust control rod position						
Slippage of the thrust control rod						
8-per-revolution vibration						