AH-1S (PROD)
AIRWORTHINESS AND FLIGHT CHARACTERISTICS FOR INSTRUMENT FLIGHT
FINAL REPORT

JOHN S. TULLOCH
CW4, USA
PROJECT OFFICER

JOHN D. OTTOMEYER
PROJECT ENGINEER

CHARLES E. FRANKENBERGER, JR.
LTC, TC
PROJECT PILOT

BARTHOLOMEW D. PICASSO III
MAJ, IN
PROJECT PILOT

NOVEMBER 1980

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523
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**Abstract**

The United States Army Aviation Engineering Flight Activity conducted an Airworthiness and Instrument Flight Characteristics evaluation of a Production AH-1S (Prod) to determine potential for the AH-1S with Enhanced Cobra Armament System (ECAS) to meet instrument meteorological conditions qualification criteria. The test aircraft was configured with two tube launched, optically tracked, wireguided (TOW) missile launchers on each outboard wing stores station and a 2-tube lightweight launcher on each inboard wing stores station. The test consisted of 16.3 flight hours which were flown during 12 test flights. Four deficiencies and seven shortcomings associated with flying the AH-1S in instrument flight conditions, were identified. The deficiencies identified were:

1. Unsatisfactory cyclic control system mechanical characteristics.
2. Large pilot-static system...
airspeed errors in climb and descent; (3) Easily excited lateral gust response; (4) Vertigo-inducing location of radio control panels. Five specification noncompliances were noted. The AH-1S (Prod) is not suitable for flight in instrument meteorological conditions, which infers that the AH-1S (HCAS) will also not be suitable.

<table>
<thead>
<tr>
<th>Aircraft For</th>
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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. The Airworthiness and Flight Characteristics (A&FC) test was conducted to evaluate the instrument flight characteristics of the AH-1S series helicopters and determine airworthiness qualifications under instrument meteorological conditions (IMC). The original IMC restrictions had been determined based on testing of the AH-1G. Several significant changes had been made to the AH-1S which prompted a new IMC evaluation. These changes included an increased gross weight, SCAS gain changes and airspeed system relocations. Based on the subject report test results the AH-1S cannot be qualified for flight under IMC due to the significant deficiencies identified.

2. This Directorate agrees with the report findings and conclusions. The following comments are made relative to the findings and conclusions and are directed to the report paragraph as indicated.

   a. Paragraph 42a. The poor cycle control mechanical system characteristics (longitudinal and lateral) significantly degraded the AH-1S IMC flight characteristics and resulted in an unacceptable pilot workload as well as adversely impacting the pilot's capability of precise aircraft control. Major poor system characteristics included excessive breakout plus friction forces, unbalanced control position gradients and excessively wide trim control displacement bands.

   b. Paragraph 42b. The large airspeed position errors exhibited during power changes significantly degraded the pilot's ability to maintain desired airspeeds and rates of climb/descent within reasonable limits under simulated IMC conditions.

   c. Paragraph 42c. The easily excited lateral gust response resulted in large roll attitude changes of up to 10 degrees with no tendency for the aircraft to return to the trim roll attitude. This resulted in considerable pilot concentration to correct at the degradation of other cockpit requirements such as navigation, tuning radios and maneuvering during approach.
d. **Paragraph 42d.** The vertigo-inducing location of the UHF, VOR, ADF and transponder control heads added significantly to the pilot workload under IMC. This deficiency is adversely impacted by the deficiencies discussed in paragraphs 2a, 2b, and 2c above.

e. **Paragraphs 43a through 43g.** The shortcomings discussed in these paragraphs compounded the difficulty of conducting IMC flight on the AH-1S. When considered in conjunction with the deficiencies addressed in paragraphs 2a through 2d above they resulted in significantly degraded flying qualities under IMC flight.

f. **Paragraphs 44a through 44e.** The non-compliance to relative paragraphs of MIL-H-8501A or deviations contained in the AH-1S Detail Specification are significant factors in the unacceptable IMC flight qualities of the AH-1S.

3. Correction of the deficiencies specified in the subject report are required for airworthiness qualification of the AH-1S for flight under IMC. Such qualification is feasible with PIP action as stated below.

a. **Cyclic control mechanical system characteristics.** Short term solutions would require a modified rigging procedure to minimize control function. Long term solution would consist of providing pilot adjustable cyclic friction, changed spring force cartridge and tailoring of spring centering cartridge.

b. **Airspeed position error.** An acceptable short term solution is not identified. Long term solutions would include possible tie-in to the air data system or relocation of pilot-static system.

c. **Lateral gust response.** An acceptable short term solution is not identified. Long term solutions would include tailoring roll and yaw SCAS axis gains and lag rate damping for desirable flying qualities.

d. **Vertigo-inducing locations of the UHF, VOR, ADF and transponder control heads.** Short term solution would be human factors analysis and wiring study to optimize current installation. Long term would consist of human factors analysis and radios study to optimize future installations.

FOR THE COMMANDER:

[Signature]

CHARLES C. CRAWFORD, JR.
Director of Development
and Qualification
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INTRODUCTION

BACKGROUND

1. The AH-1S series helicopter has not been qualified for instrument flight because of inadequate backup electrical power and marginal handling qualities. The installation of a 10-kilowatt alternator and a transformer rectifier to the electrical system of the AH-1S with the Enhanced Cobra Armament System (ECAS) provides adequate backup electrical power. An Instrument Meteorological Conditions (IMC) evaluation was previously conducted on an AH-1S (Ref 1, App A). Additional flight testing was required on an AH-1S to evaluate the changes in IMC handling qualities caused by the increased gross weight change in armament configuration, and the installation of a flat plate canopy as compared to an AH-1G. The United States Army Aviation Engineering Flight Activity (USAAEFA) was directed by the United States Army Aviation Research and Development Command (AVRDC) to conduct an airworthiness and flight characteristics (A&FC) test of the AH-1S (Prod) for IMC flight (Ref 2, App A). Previous test of the AH-1S (ECAS) (Ref 3, App A) indicated the stability and control characteristics of the AH-1S (ECAS) and AH-1S (Prod) are essentially unchanged.

TEST OBJECTIVES

2. The test objectives were:
   a. To quantitatively evaluate the instrument flight characteristics of the AH-1S (Prod) helicopter against the requirements of section 3.6. of military specification MIL-H-8856A (Ref 4, App A), and thereby infer potential for the AH-1S (ECAS) to meet IMC qualification criteria.
   b. To qualitatively evaluate the AH-1S instrument flight characteristics during simulated IMC flight.

DESCRIPTION

3. The production AH-1S is a tandem seat, two-place helicopter with a two-bladed main rotor and a two-bladed Model 212 tractor tail rotor. The helicopter is powered by a Lycoming 153-1703 turboshift engine thermodynamically rated at 1800 shaft horsepower (SHP) at sea-level, standard-day conditions derived by main transmission limitations to 1200 SHP for 30 minutes and 1134 SHP for continuous operation. Distinctive features of the helicopter include the narrow fuselage, stub wings with four stores stations, and a flat-plate canopy. A more complete description of the AH-1S is presented in the operator's manual (Ref 5, App A) and Appendix B.

4. The test aircraft AH-1S (Prod) USA Serial Number 76-22553 was configured with the K-54 main rotor blades, two M68 tube-launched, optically tracked, wire-guided (TOW) missile launchers on each outboard store station and an M240G tube lightweight lanceur (FWL) on each of the two inboard store stations as shown in Photo A. One flight was performed with four HELLfire missiles installed on each of the outboard store stations, and FWL removed.

TEST SCOPE

5. This A&FC evaluation was conducted at Edwards Air Force Base, California, from 2 May 1980 through 8 August 1980. Twelve test flights were flown for a total of
of 16.3 flight hours. Flight restrictions contained in the operator's manual (Ref 5, App A) and the airworthiness release (Ref 6) were observed. Flight test conditions are summarized in Table 1.

TEST METHODOLOGY

6. Testing was conducted in two phases. The purpose of the first phase was to quantitatively evaluate the handling qualities characteristics using standard test techniques and data reduction procedures described in Reference 7, Appendix A. The purpose of the second phase was to qualitatively evaluate the handling qualities characteristics while performing simulated IMC flight tasks. Performance standards associated with successful performance of the task are those contained in Aircrew Training Manual (Ref 8, App A). During all testing, data were recorded on magnetic tape with pilot comments hand recorded as they were made. The data parameters are presented in Appendix C. For the phase two test, all special test instrumentation and displays were removed from the pilot's station, and the cockpit was configured in accordance with the operator's manual. A Handling Qualities Rating Scale (HQRS) (App D) was used to augment pilot comments relative to handling qualities and instrument flight task.

Table 1. Test Conditions

<table>
<thead>
<tr>
<th>TEST</th>
<th>FLIGHT CONDITION</th>
<th>AVERAGE GROSS WEIGHT</th>
<th>AVERAGE DENSITY</th>
<th>TRIMMED CALIBRATED AIRSPEED</th>
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<tr>
<td>Controls system</td>
<td>Cyclic</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Rotor head</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Control positions</td>
<td>Level</td>
<td>9400</td>
<td>0.50</td>
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</tr>
<tr>
<td>Control positions</td>
<td>Pitch</td>
<td>9700</td>
<td>0.60</td>
<td>285</td>
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<td>Static longitudinal stability</td>
<td>Level</td>
<td>9600</td>
<td>0.60</td>
<td>285</td>
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<td>Static lateral-directional stability</td>
<td>Level</td>
<td>9500</td>
<td>0.60</td>
<td>285</td>
</tr>
<tr>
<td>Dynamic stability</td>
<td>Cyclic</td>
<td>9400</td>
<td>0.60</td>
<td>285</td>
</tr>
<tr>
<td>Instrument visibility</td>
<td>Typical</td>
<td>9600</td>
<td>0.60</td>
<td>285</td>
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</table>

1 Tests conducted in the 8-10W and 8-trim test environment using configuration and thrust of 80% of center of gravity using a main rotor speed of 324 RPM
2 Stability and control augmentation system (SCAS) ON
3 Rotor static, hydraulic, and electrical power provided by ground support equipment
4 SCAS OFF
RESULTS AND DISCUSSION

GENERAL

1. A quantitative and qualitative evaluation of instrument flight characteristics of the AH-1S (Prod) helicopter was conducted to infer potential for the AH-1S (CAS) to meet the IMC qualification criteria established in Military Specification MIH-88501A (Ref 4, App A). The AH-1S (Prod) is not suitable for flight in instrument meteorological conditions, which means that the AH-1S (CAS) will also not be suitable. Four deficiencies were identified: unsatisfactory cyclic control system mechanical characteristics, large pilot static system airspeed errors in climb and descent, easily excited lateral gust response, and vertigo inducing location of radio control panels. Additionally, seven shortcomings were noted: persistent lateral-directional oscillations, lateral trim changes with airspeed, weak static longitudinal stability at cruise airspeed, an engine-torque oscillation, following a power change, location of Environmental Control System (ECS) control head, obstructed view of vertical index reference mark on pilot's attitude indicator, and the lack of storage space for instrument flight publications and equipment.

HANDLING QUALITIES

General

8. The AH-1S (Prod) tested showed a degradation in handling qualities that was not previously tested AH-1G. The handling qualities classified as deficient at the cyclic control system mechanical characteristics which include objectionable cyclic plus friction force, a control force versus position gradient less than the cyclic plus friction force, the existence of a trim control displacement band and the lack of excitation lateral gust response. Shortcomings include the persistent lateral-directional oscillations and engine-torque oscillations that required in excess of 30 seconds for the engine power to stabilize.

Cyclic Control System Characteristics

9. Cyclic control system characteristics were measured in a static condition, as described in the Test Techniques section of Appendix D. Control force as a function of control displacement is presented in Figures 1 and 2, Appendix 1, and summarized in Table 2. Control system characteristics in flight were qualitatively evaluated as being essentially the same as those observed under the static test conditions described above.

10. Prior to the test, cyclic friction (not adjustable from cockpit) was set to the manufacturer's value per maintenance instructions (Ref 9, App A). The longitudinal and lateral breakaway force (including friction), control force versus position gradient, and limit control force all exceed both the limits specified in MIH-88501A and the approved deviations in the Bell Helicopter Textron detailed specification No. 299-997-098A, 5 October 1979 (Ref 10, App A).

11. The high longitudinal and lateral breakaway forces, the control force position gradient, and the large trim control displacement band all contribute to provide the smooth cyclic control movements necessary for precise aircraft attitude control required in IMC. The longitudinal and lateral breakaway force (including friction) are objectional and require the pilot to operate across an 8-pound longitudinal and 6-pound lateral force differential for any modulated control displacement such as...
<table>
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<tr>
<th>Control</th>
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<th>Breakout Force (Including Friction) (lb)</th>
<th>Control Force Versus Position Gradient (lb in)</th>
<th>Limit Control Force (lb)</th>
<th>Trim Control Displacement Band Var</th>
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<tr>
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<td>10.0</td>
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<td></td>
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Table 2: Control System Characteristics
correcting a gust upset. This is tiring and when coupled with control force versus position gradient (2.5 pounds per inch) that is less than the breakout plus friction force, the result is a control displacement that more nearly resembles a step or spike input with frequent overshoot. The step or spike input occurs because the arm muscle does not readily accommodate the force discontinuity. The problem exists in both lateral and longitudinal axis and is further amplified by the frequency and severity of any gust upset. The existence of a trim displacement, of 1.5 inches longitudinally and 1.2 inches laterally, eliminates the force one which would normally assist in returning the cyclic stick to the trim condition once it had been displaced. The effect of these unsatisfactory characteristics on the pilot’s ability to control the aircraft is discussed more fully in paragraphs 24 through 40. The poor cyclic control system mechanical characteristics are a deficiency for IMC operation.

**Control Positions in Trimmed Forward Flight**

12. Control positions were determined in trimmed level, climbing, descending, and autorotational flight with the aircraft stabilized at zero sideslip for the conditions listed in Table 1. Using the technique described in Appendix B, Test results are presented in Figure 3 (App B).

13. Longitudinal control position variations were essentially linear with airspeed and displayed increasing forward control with increasing airspeed. Lateral control position at the condition tested shows significant trim change with airspeed except for descending flight. These trim changes were particularly bothersome in level and climbing flight due to the non-linearity. A lateral control trim change of 0.3 inch occurred in level flight between 80 KIAS and 120 KIAS, while longitudinally that airspeed change required 1.1 inches of longitudinal control travel. The net result is an uncomfortable left forward movement of the cyclic at a 35° angle to the longitudinal axis of the aircraft. The lateral trim changes with power and airspeed are a shortcoming.

14. A persistent engine torque oscillation was excited each time engine power was changed. Figure A shows torque oscillations occurring at approximately three cycles per second. This persistent engine torque oscillation is an indication of engine-airframe incompatibility which may contribute to the excitation of the lateral-directional oscillation discussed in paragraph 23. The engine-airframe incompatibility, as evidenced by the persistent engine torque oscillation, is a shortcoming.

**Static Longitudinal Stability**

15. The static longitudinal stability characteristics were evaluated at the conditions specified in Table 1 with the aircraft stabilized at zero sideslip, using the technique described in Appendix D. Test results are presented in Figures 4 and 5, Appendix D.

16. The static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed was stable at all trim airspeeds and conditions tested except in level flight at airspeeds greater than 205 KIAS. Airspeeds greater than the trim airspeed the gradient was nearly neutral. This weak static longitudinal stability, while meeting the minimum requirements of MIL-H-8805A, appeared neutral in flight and when coupled with the unsatisfactory cyclic control system characteristics required considerable nonlinearity compensation (HORSE) to maintain a trim cruise airspeed. The weak static longitudinal stability at cruise airspeed is a shortcoming.
Static Lateral-Directional Stability

17. The static lateral-directional stability characteristics were evaluated at the conditions specified in Table 1 using the techniques described in Appendix D. Test results are presented in Figures 6 and 7, Appendix F.

18. Static directional stability was positive (increasing left directional control position with increasing right sideslip) throughout the sideslip envelope for all trim airspeeds and was satisfactory. Dihedral effect was also positive (increasing right lateral cyclic control position with increasing right sideslip) throughout the sideslip envelope for all trim airspeeds and is satisfactory. The side-force characteristics are essentially the same as previously reported (Refs. 3 and 11, App A). The static lateral-directional characteristics are satisfactory.

Dynamic Stability

19. Longitudinal and lateral-directional dynamic stability characteristics were evaluated at the conditions listed in Table 1. A description of each test technique is given in Appendix D. Selected time histories are presented in Figures 8 through 12, Appendix F.

20. The longitudinal short-term gust response was essentially deadbeat for all SCAS ON tests. SCAS OFF, the longitudinal pulse input excited the lateral-directional mode, and made the short-term response difficult to evaluate. The longitudinal short-term gust response, SCAS ON, met the requirements of MIL-H-8501A and is satisfactory for IMC flight.

21. A lateral-directional oscillation (Dutch roll) was the principle aircraft response to an external gust upset. Representative SCAS ON lateral-directional short-term gust response is shown in Figures 9 through 11, Appendix F. The aircraft exhibited positive but light damping in both roll and yaw. There was no tendency for the aircraft to return to steady, level flight once the roll and yaw rates subsided. This same characteristic was observed during the qualitative evaluation in gusty air. Roll attitude excursions of up to 10 degrees in the IMC environment were observed which are sufficient to interrupt the pilot’s normal instrument cross check sequence, and resulted in the pilot concentrating on returning the aircraft to level flight. Since the aircraft is easily upset in roll, the requirement to concentrate on roll attitude control impacts on the pilot’s ability to perform other flight tasks such as tuning radios, navigating, and maneuvering the aircraft during the approach phase of the flight. The lateral gust response of the AH-1S (Prod) is a deficiency for IMC operation.

22. The coupled lateral-directional oscillations with SCAS ON tend to persist following a gust upset. This characteristic was bothersome in the simulated IMC environment and precluded precise control of heading and roll attitude. This characteristic is most bothersome while maneuvering the aircraft in holding patterns, tracking from navigation aids to the airfield, and when complying with ground controlled approach (GCA) instructions. The existence of persistent lateral-directional oscillation fails to meet the requirements of paragraph 3.1.2 of MIL-H-8501A. The persistent lateral-directional oscillation characteristic is a shortcoming.

23. Spiral stability characteristics were evaluated SCAS ON and were found to be mildly divergent. Figure 12, Appendix F, is typical of the SCAS ON evaluation and...
shows a 10 degree divergence at the end of 20 seconds. The SCAS OFF spiral excitation resulted in oscillatory roll divergence. The SCAS OFF spiral stability characteristics were difficult to evaluate due to excitation of the short term lateral directional oscillation. The SCAS ON spiral stability characteristics were satisfactory.

QUALITATIVE ASSESSMENT

General

24. Simulated IMC maneuvers were evaluated from the pilot's position with side curtains installed. All external visual reference was eliminated however, the aircraft were light enough to furnish full daylight lighting of the cockpit. The IMC simulation was separated into three distinct categories: first, an evaluation of basic air maneuvers and individual IMC tasks; second, NAVAID approaches; and third, a representative IFR flight. The performance standards used were those normally associated with an annual instrument checkride (1000 feet altitude, 100 knots indicated airspeed (KIAS), and 10° heading). Additionally, the pilot's workload was qualitatively assessed throughout all flights. Six pilots participated in the qualitative evaluation. Based on the inability to meet performance standards and excessively high pilot workload, the AILTS (Pro) is considered unsuitable for IFR flight.

Basic Instrument Meteorological Conditions (IMC) Tasks

25. Each individual task was evaluated with the pilot's total attention devoted to aircraft control for the purpose of achieving the desired performance standard. No distractions, such as navigation radio tuning or communication with controllers, were performed. All tasks were performed in both smooth air and light turbulence with aircraft at mid altitude and maximum gross weight.

Straight and Level Flight:

26. The first task was to perform straight and level flight. The aircraft just response was primarily to roll with some minor accompanying yaw. The roll attitude changed as much as ten degrees from the trim condition and constantly required lateral cyclic inputs to maintain a wings level attitude. The cyclic inputs were small however, they were within the trim control friction band, and a precise return of the cyclic to the trim control friction forces resulted in the cyclic and the corresponding slip and yaw attitude maintained at zero elevation, lateral control inputs resulted in overshooting the desired control position. Straight and level flight could be performed within the desired performance standard, but required constant attention and frequent control inputs to achieve that performance (HORS). Throughout the straight and level evaluation, continuous lateral-directional oscillations were noted (paragraph 24). These were sufficient to make the pilot to make control inputs which added to the already high workload.

Standard Rate Level Turns:

27. Turns were made both left and right at 90 and 110 KIAS. The bank angle for a standard rate turn was 20 degrees. In each case, the pilot estimated the control of the bank angle extremely difficult with bank angle frequently varying.
from 15 to 30 degrees. The undesirable mechanical characteristics (paragraph 11) contributed to the difficulty of performing the standard rate turns. The established standard was achievable; however, there was a high pilot workload associated with the task (HQRS 6) and variations of 80 feet on assigned altitude were frequent. The desired rollout heading could be acquired within 10 degrees (HQRS 6).

**Constant Heading Climbs and Descents:**

28. Climbs and descents were initiated from trimmed level flight conditions at 90 and 110 KIAS. The desired vertical speed was 500 feet per minute. When power was added, the airspeed immediately showed an increase on the pilot's indicator. To correct the apparent airspeed variation, aft cyclic was applied. The pitch attitude also indicated a slight nose up change and the rate of climb went rapidly through the 500 feet per minute condition and reached approximately 1,200 feet per minute. The power was then reduced in an effort to establish the desired rate of climb. On reduction of power, the reverse effect was noted in that indicated airspeed immediately decreased indicating a requirement for forward cyclic and with the new power setting produced a climb rate well below the target 500 feet per minute. These factors were also evident when a level off at a predetermined altitude was performed. It was not possible to consistently level off within 100 feet of the desired altitude, and errors as much as 200 feet were experienced. In a 500-foot change in altitude, it was not possible to achieve a stabilized 500 feet per minute rate of climb and continue to meet performance standards (HQRS 7). Figure 13, Appendix 1, is a time history comparison between ships' and boom airspeed system. The pilot held the ship indicated airspeed constant while adding power. The boom system slowed 12 knots while the indicated airspeed remained essentially unchanged. The large airspeed position error due to the influence of power on the pitot static system is a deficiency for IMC flight.

29. There was an additional factor which contributed to the difficulties associated with stabilizing the aircraft in a steady climb. The cyclic trim control positions have substantial lateral changes with airspeed and power. These lateral cyclic requirements occur with a control system that has undesirably high breakout plus friction forces. The result was that lateral cyclic position was constantly changing throughout the maneuver due to airspeed and power variations. This increased the pilot workload and was part of the reason satisfactory performance could not be achieved. Large lateral trim changes with power and airspeed are a shortcoming previously discussed (paragraph 13).

**Climbing and Descending Standard Rate Turns:**

30. Climbing and descending turns were initiated from trimmed level flight at 90 KIAS. The difficulties identified in previous maneuvers were also evident here. The lateral gust response of the aircraft made bank angle control a constant problem. The bank angle could not be controlled within 10 degrees. The same pilot-static problems discussed above existed and, when combined with attitude control, made basic aircraft control extremely difficult and required the pilot's maximum attention (HQRS 8).

31. The attitude indicator is recessed in the instrument panel in front of the pilot. There are reference marks at 0 (vertical point), 10, 20, 30, and 45 degree bank positions. The vertical reference is an inverted triangle easily distinguished from the other reference marks which are merely short reference lines of uniform thickness.
full pilot loses the distinctive triangular identification and the vertical reference due to the obstruction of the broad portion of the triangle caused by the recessed instrument recess. The loss of this reference in turns slows the pilot's cross-check since a quick mental calculation must be made to find the vertical reference. The obstruction of the vertical reference at the instrument window by the instrument recess is a significant factor.

**Holding**

A holding pattern was preplanned prior to flight. A hold at a VOR station was identified and tested in order to form a standard holding pattern. The VOR was tuned and the pilot's attention was required to maintain a holding pattern. Then, the pilot performed holding patterns at various angles, at 1000 feet altitude. The pilot was unable to maintain the heading and 90 degrees were experienced. The pilot was able to complete the flight with the result that climb to mtops was not able to establish which was felt to adjust for one-minute interval.

**NAVADA Approach**

**VOR Approach**

A complete VOR approach was performed to include the required holding pattern, approach, turn, and descent to final approach descent. The VOR station was tuned in and checked to ensure the station was operational. The pilot was unable to maintain the correct course for the procedure time and distance after passing the station on final approach. This adversely impacted the ability to establish the descent profile and rate of descent. The pilot was also distracted when power was added on the approach. At this point, the pilot was unable to maintain the approach at MDA until missed approach was required. The desired performance was achieved; however, the pilot workload is not considered acceptable (HORS).

**Ground Controlled Approach**

A surveillant approach was performed using a ground controller's duties and a precision approach as simulated. The ground controller was able to provide information to the pilot. In both cases, satisfactory performance was achieved. However, the previous problems of poor mechanical character and pilot noise, pilot state awareness and persistent lateral directional oscillations remained to produce a high pilot workload. The ground control approach was completed to the VOR with the aid of a pilot's voice and resulted in a more realistic workload (HORS).

**Lateral Approach**

The lateral approach was not performed and no attempt was made to simulate an actual approach.
The AH-1S (Prod) are such that the aircraft consistently drifts off speed. In descending turns a desired bank angle of 20 degrees was attempted. During one point in a descending turn, the bank angle reached 40 degrees before it was corrected by the pilot. The roll response to gusting conditions made descending turns extremely difficult and in combination with pilot-static errors and poor mechanical characteristics made satisfactory achievement of the desired standards impossible. The pilot's total concentration was devoted to maintaining aircraft control (HQAR 8).

SIMULATED IFR FLIGHT

36 The flight was conducted in simulated IMC conditions and was controlled by the approach control facility serving the area. All routine communications associated with an IFR flight were performed. The gunner made some of the radio calls and was also responsible for copying clearances. He did not fly the aircraft at any time during the IM simulation due to the limited navigation and flight instruments as well as the poor flight control characteristics at the gunner's station. All radios and navigation equipment were tuned prior to takeoff. The general flight scenario was radar vectors to a VOR radial, intercept, tracking to the VOR station, holding, and terminating with a VOR approach.

37 The first problem encountered was turning the UHF communications radio. All tuning was performed by the pilot since all control heads are located in the aft cockpit. Control head locations are shown in the operator's manual (Ref 8, App A). In order to tune the UHF radio, the pilot had to exchange hands on the cyclic and look down and to the right to see the frequency numbers. With his hand on the selector, his view of the frequency was obscured. During the brief time that it took to change the hundreds digit of the frequency, the aircraft had rolled off heading approximately 10 degrees and was in a turn. Three more similar occurrences were experienced before a new UHF frequency was finally set. Once the frequency was set, the pilot made the communication or alternatively advised the copilot a new frequency was now tuned. Similar experiences were noted when VOR frequency and transponder code changes were required. The transponder control head location was particularly bad in that it is adjacent to the pilot's right hip. This location made reading the code setting very difficult and necessitated head movements which produced vertigo. The sensation of vertigo increased the difficulty of turning the aircraft to a level trim condition after tuning the transponder code. The vertigo-inducing location of the UHF, VOR, AIM, and transponder control heads is considered a deficiency for IMC flight.

38 During the course of the flight the cockpit temperature became uncomfortably warm. The pilot attempted to adjust the environmental control system (ECS) located on the right side panel aft of the transponder. The control location is shown in the operator's manual (Ref 8, App A). Again during this distraction performance standards could not be met and the tendency for vertigo was even more disconcerting to the pilot. Actual temperature adjustment is not absolutely essential for IMC operations, but it is frequently necessary to activate the ram removal switch which is located on the same control head producing the same result. The vertigo-inducing location of the ECS control head and ram removal switch is a shortcoming for IMC operations.
39. Basic navigation was extremely difficult in that the tuning of navigation radios and orienting charts resulted in the pilot exceeding the established performance standards consistently. Very little assistance was possible from the gunner since he could not see what frequencies were tuned and was unable to retain the established location by intersection. Due to the tandem seating arrangement, he was unable to assist in setting up the necessary approach plate and was limited to monitoring pertinent approach information and advising the pilot periodically during the approach. The AH-1S (Prod) in its present configuration is therefore basically a single pilot IMC aircraft. These difficulties were further complicated by the lack of storage space in the cockpit. The necessary charts and approach plates could not be organized effectively. Lack of storage space in the cockpit area is a shortcoming.

40. During the VOR holding and VOR approach portion of the flight, routine IFR tasks created a workload sufficient to cause the pilot to fail to meet performance standards consistently. Changing the course setting on the horizontal situation indicator (HSI) and selecting the desired function on the HSI control panel took enough time and caused sufficient distraction that heading and attitude changes occurred prior to reestablishing a cross check of flight instruments. Any requirements in excess of basic aircraft control taxed the pilot beyond his capabilities.
CONCLUSIONS

GENERAL

41. The AH-1S (Prod.), and by inference, the AH-1S (4 CAS) are not considered suitable for flight in Instrument Meteorological conditions.

DEFICIENCIES

42. The following deficiencies associated with flying the AH-1S (Prod) in IMC were identified:

   a. The poor cyclic control mechanical system characteristics (paragraph 11)
   b. Large airspeed position error due to the influence of power on the pitot static system (paragraph 28)
   c. The easily excited lateral gust response (paragraph 21)
   d. Vertigo-inducing location of the UHF, VOR, ADF, and transponder control heads (paragraph 37).

SHORTCOMINGS

43. The following shortcomings associated with flying the AH-1S (Prod) in IMC were identified:

   a. The persistent lateral-directional oscillation (paragraph 22)
   b. The lateral trim change with airspeed and power (paragraph 13)
   c. The weak static longitudinal stability at cruise airspeed (paragraph 16)
   d. The engine/airframe incompatibility (paragraph 14)
   e. Vertigo-inducing location of the FCS control head and rain removal switch (paragraph 38)
   f. Obstruction of the vertical reference mark on the attitude indicator (paragraph 31)
   g. Lack of storage space in the cockpit area (paragraph 39)

SPECIFICATION COMPLIANCE

44. Within the scope of this test, the AH-1S (Prod) helicopter failed to meet the following requirements of military specification MIL-H-8501A

   a. Paragraph 3.2.6 - Longitudinal control full throw forces exceed the 8.0 pound limit by 8.0 pounds forward and aft. (100 percent) (paragraph 11)
b. Paragraph 3.2.7 - Longitudinal control breakout force (including friction) exceeded the 1.50 lb maximum by 2.5 lbs (16.7 percent). Also failed to meet authorized deviation (Ref 10, App A) (paragraph 10).

c. Paragraph 3.3.12 - Lateral control full throw forces exceed the 7.0 pound limit by 9.0 pounds left and right (130 percent) (paragraph 10).

d. Paragraph 3.3.13 - Lateral control breakout force (including friction) exceeded the 1.50 lb maximum by 1.5 lbs (100 percent). Also failed to meet authorized deviation (Ref 10, App A) (paragraph 10).

e. Paragraph 3.6.1.1 - The aircraft exhibited a persistent lateral directional oscillation (paragraph 22).
RECOMMENDATIONS

45. The deficiencies identified in paragraph 42 must be corrected prior to operation in IMC.

46. The shortcomings identified in paragraph 43 should be corrected prior to operation in IMC.
APPENDIX A. REFERENCES


APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The test helicopter, S.N. 76-23573, was a production AH-1S with the K.T. main rotor blades installed. Wing stores configuration for all tests were two L0W Launchers on each of the outboard wing stores stations and one 7 tube lightweight launcher pod on each of the inboard wing stores stations.

MAIN ROTOR BLADES

2. The K.T.47 main rotor blades utilize a multicell filament wound fiberglass spar, a nomex honeycomb core afterbody, and a Kevlar trailing edge spline, all enclosed by fiberglass skin. At the inboard end, checkplates carry loads to an aluminum adapter which is attached to the hub with a pin.

3. The K.T.47 blade airfoil shape is based on a family of airfoils developed by Boeing Vertol. The airfoil shape varies from blade tip to root as follows:

<table>
<thead>
<tr>
<th>R (Blade Radius Station)</th>
<th>Airfoil Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>From tip to 0.85</td>
<td>K.T.47 8 - thick Boeing Vertol VR-8</td>
</tr>
<tr>
<td>From 0.85 to 0.67</td>
<td>Linear transition to 12*7 - thick Boeing Vertol VR-7</td>
</tr>
<tr>
<td>From 0.67 to 0.25</td>
<td>12*7 - thick Boeing Vertol VR-7</td>
</tr>
<tr>
<td>From 0.25 to 0.18</td>
<td>Gradual buildup to 25*7 - thick PVC checkplates</td>
</tr>
</tbody>
</table>

ENGINE AND TRANSMISSION TAIL ROTOR DRIVE

4. The 153-1-703 turboshaft engine is installed in the AH-1S (Proto) helicopter. This engine employs a two-stage axial-flow free power turbine, a separate twostage axial-flow turbine driving a freestage axial and one-stage centrifugal compressor variable inlet guide vanes and an external annular combustor. A 3:105 gear box located in the air inlet housing reduces power turbine speed to a nominal output shaft speed of 6000 RPM at 100 percent N2. The engine reduction gear box is limited to 1175 foot pounds 0.14 lbs torque for 30 minutes and 1110 ft-lbs torque for continuous operation. A 12 stage thrust reverser, turbine temperature sensor, and an integrated sensor measures interstage turbine temperatures and displays this information in the cockpit as turbine gas temperature on the cockpit instruments.

5. The main transmission has a 1290 SHP limit for 30 minutes and a 1134 SHP limit for continuous operation at a rotor speed of 324 RPM (100 percent N1). The aircraft is further limited to 88 percent torque above 100 KIAS. The tail rotor drive system has a 260 SHP transient limit for 4 seconds and a 18 SHP limit for continuous operation. The engine used during this test was serial number 11131452.

PRINCIPAL DIMENSIONS AND GENERAL DATA

6. The principal dimensions and general data concerning the AH-1S (Proto) helicopters are as follows.
### Overall Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, rotor turning</td>
<td>54 feet, 1 inch</td>
</tr>
<tr>
<td>Height, tail rotor vertical</td>
<td>13 feet, 9 inches</td>
</tr>
<tr>
<td>Length, rotors removed</td>
<td>44 feet, 5 inches</td>
</tr>
</tbody>
</table>

### Main Rotor

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>44 feet</td>
</tr>
<tr>
<td>Disc area</td>
<td>1839.5 ft²</td>
</tr>
<tr>
<td>Number of blades</td>
<td>4</td>
</tr>
<tr>
<td>Blade twist</td>
<td>-0.556 degrees</td>
</tr>
<tr>
<td>Airfoil</td>
<td>See paragraph 3</td>
</tr>
</tbody>
</table>

### Tail Rotor

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>8 feet, 6 inches</td>
</tr>
<tr>
<td>Disc area</td>
<td>56.75 ft²</td>
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<tr>
<td>Solidity</td>
<td>0.1350</td>
</tr>
<tr>
<td>Number of blades</td>
<td>4</td>
</tr>
<tr>
<td>Blade chord, constant</td>
<td>11.7 inches</td>
</tr>
<tr>
<td>Blade twist</td>
<td>0.9 degrees</td>
</tr>
<tr>
<td>Airfoil</td>
<td>NACA 6018 at the back root changing linearly to a special cambered section at 8.27 percent of the tip</td>
</tr>
</tbody>
</table>

### Fuselage

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>44 feet, 7 inches</td>
</tr>
</tbody>
</table>

### Height

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>To tip of tail fin</td>
<td>10 feet, 8 inches</td>
</tr>
<tr>
<td>Ground to top of mast</td>
<td>12 feet, 3 inches</td>
</tr>
<tr>
<td>Ground to top of transmission fairing</td>
<td>10 feet, 2 inches</td>
</tr>
</tbody>
</table>

### Width

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuselage only</td>
<td>3 ft</td>
</tr>
<tr>
<td>Wing span</td>
<td>10 feet, 9 inches</td>
</tr>
<tr>
<td>Skid gear tread</td>
<td>7 ft</td>
</tr>
</tbody>
</table>

### Elevator

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
<td>6 feet, 14 inches</td>
</tr>
<tr>
<td>Airfoil</td>
<td>Inverted Clark Y</td>
</tr>
</tbody>
</table>
Vertical Fin:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Area</td>
<td>18.5 ft²</td>
</tr>
<tr>
<td>Airfoil</td>
<td>Special cambered</td>
</tr>
<tr>
<td>Height</td>
<td>5 feet, 6 inches</td>
</tr>
</tbody>
</table>

Wing:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
<td>10 feet, 9 inches</td>
</tr>
<tr>
<td>Incidence</td>
<td>17 degrees</td>
</tr>
<tr>
<td>Airfoil (root)</td>
<td>NACA 0030</td>
</tr>
<tr>
<td>Airfoil (tip)</td>
<td>NACA 0024</td>
</tr>
</tbody>
</table>

**Weight and Balance**

7. The aircraft weight, longitudinal CG location and lateral CG location were determined prior to testing. A fuel cell calibration was also performed prior to testing. All weighings were accomplished with instrumentation installed without external stores or chin turret weapons installed.
APPENDIX C. INSTRUMENTATION

In addition to the standard aircraft instruments, calibrated instruments were displayed at the pilot and gunner cockpit panels. Data were obtained from cockpit instruments and from the test instrumentation system. The test instrumentation system was installed, calibrated, and maintained by USAF A personnel. All test instrumentation parameters are encoded pulse code modulation (PCM) and recorded on magnetic tape aboard the test aircraft. Side-slip vanes, angle of attack vanes, total temperature sensor, and pivoting pitot-static head are located on a test boom mounted on the nose of the aircraft.

The parameters recorded on magnetic tape are:

PCM Parameters

- Time code
- Event
- Flight number
- Run number
- Main rotor speed
- Fuel temperature
- Fuel used
- Engine fuel flow rate
- Engine gas producer speed
- Engine power turbine speed
- Airspeed (boom system)
- Airspeed (ship's system)
- Attitude (boom system)
- Attitude (ship's system)
- Total air temperature
- Angle of attack
- Angle of sideslip
- Engine torque
- Engine exhaust gas temperature
- Control positions
  - Longitudinal
  - Lateral
  - Directional
  - Collective
- Aircraft attitudes
  - Pitch
  - Roll
- Aircraft angular rates
  - Pitch
  - Roll
  - Yaw
- Main rotor shaft torque
- Main rotor blade angle

The parameters displayed in the cockpit are:

Pilot Panel

- Pressure altitude (boom system)
- Pressure altitude (ship's system)
Airspeed (boom system)
Airspeed (ship's system)
Main rotor speed
Engine torque
Engine turbine gas temperature
Engine gas producer speed
Angle of sideslip

Copilot Panel

Pressure altitude (boom system)
Airspeed (boom system)
Main rotor speed
Engine torque
Engine gas producer speed
Total air temperature
Fuel used
Time code display
Data system control

4. The calibrated instrumentation displayed at the pilot's station was used throughout the handling qualities phase of the test. The pilot's instrument panel was returned to the standard Cobra configuration (Ref 5, App A) for the test flights involving IMC maneuvers and evaluation.
APPENDIX D. TEST TECHNIQUES

AND DATA ANALYSIS METHODS

GENERAL

1. Established test techniques and data analysis methods were used in the
handle-qualities tests. Descriptions of the test techniques are contained in the
appendix. The Handling Qualities Rating Scale, presented in Figure 1, was used to
assess pilot comments relative to handling qualities. Definitions of deficiencies
and shortcomings as stipulated in Army Regulation 310-25 (Ref 14, App A),
and the note on speed variations, were applied. All other tests were
conducted to ensure that the aircraft was trimmed for flight.

WEIGHT AND BALANCE

The aircraft weight, longitudinal CG location, and lateral CG location were
determined prior to testing and checked periodically throughout the tests. The
weighting was accomplished with instrumentation modified. The aircraft was ballasted
as necessary to achieve the desired takeoff gross weight and CG.

HANDLING QUALITIES

Cyclic Control System Characteristics

3. The mechanical characteristics of the control system were evaluated on the
ground with the rotor and engine 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 pilot's cyclic grip, one finger's width below the trigger
release. A three-to-five-second data record was taken of control position while
control forces were hand recorded. All switches and systems were set to duplicate
normal in-flight conditions. Control displacements from the neutral point were
then plotted as a function of force.

Control Positions in Trimming Forward Flight

4. Control positions in trimmed forward flight at zero sideslip were determined by

stabilizing the helicopter on a constant heading and airspeed. Data were recorded on
magnetic tape. Control positions were plotted as a function of airspeed.

Static Longitudinal Stability

5. Static longitudinal stability was evaluated in level, climbing, and autorotational
flight. The aircraft was trimmed at the desired airspeed. With collective fixed,
the aircraft was stabilized at approximately 5 knot movements. At 5 knots from trim
airspeed, allowing altitude, rate of climb, or rate of descent to vary as necessary
control positions and airspeeds were recorded on magnetic tape. The control
positions were then plotted as a function of calibrated airspeed.

Static Lateral Directional Stability

6. This test was conducted using the steady-heading sideslip method and was
accomplished by establishing a trimmed flight condition and then stabilizing at
sideslip angles in 5 degree increments, to the limit of the flight envelope or until full
control deflection was reached, whichever occurred first. Collective control position was fixed at the trim value and attitude was allowed to vary. The trim airspeed and desired heading were maintained. All pertinent parameters were recorded on magnetic tape. The static directional stability, dihedral effect, and side-force characteristics of the aircraft were evaluated by plotting the variation of control position and aircraft attitude as a function of sideslip angle.

**Dynamic Stability**

7. Dynamic stability tests were conducted to evaluate the short and long-period response characteristics of the aircraft. Short-period characteristics were evaluated to determine aircraft response to sudden wind gusts and were simulated by rapidly displacing the cyclic control approximately one inch, holding the input for 0.5 second, then rapidly returning the control to the trim position while recording the resulting aircraft responses on magnetic tape. Lateral-directional short-term response was further evaluated by directional control doublets.

8. Longitudinal long-period characteristics were evaluated to determine the aircraft’s tendency to return to a trim condition after being disturbed. The long-period response was excited by stabilizing the aircraft on a trim condition with force trim ON and then displacing the longitudinal control forward or aft to effect an airspeed change of approximately 10 knots. The control was then returned to trim, and the resulting aircraft response was recorded on magnetic tape. During the response, controls were held fixed, but slight pressures directionally and laterally were used to maintain a constant heading and laterally level attitude. The long-period response was evaluated at three trim airspeeds, and a positive and negative airspeed change was tested for each point.

**SIMULATED IMC FLIGHT**

9. Simulated IMC flight was conducted to qualitatively evaluate pilot workload. Workload in the IMC environment was determined by selecting a task and performance standard, (Ref 8, App A) and then assigning a HQRS number (Figure 1) based on the amount of pilot compensation necessary to achieve the standard. The performance standards used were ±100 feet altitude, ±10 KIAS, and ±10° heading. All tasks were performed from the pilot cockpit with all external outside reference eliminated, and no assistance from the gunner.
# APPENDIX E. TEST DATA

## INDEX

<table>
<thead>
<tr>
<th>Figure</th>
<th>Mechanical Characteristics</th>
<th>1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure</td>
<td>Control Positions in Trimmed Forward Flight</td>
<td>3</td>
</tr>
<tr>
<td>Figure</td>
<td>Static Longitudinal Stability</td>
<td>4 and 5</td>
</tr>
<tr>
<td>Figure</td>
<td>Static Lateral-Directional Stability</td>
<td>6 and 7</td>
</tr>
<tr>
<td>Figure</td>
<td>Dynamic Stability</td>
<td>8 through 13</td>
</tr>
<tr>
<td>Figure</td>
<td>Ship's and Boom Airspeed Comparison</td>
<td>14</td>
</tr>
</tbody>
</table>
NOTES:
1. MOTOR STATIC
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
3. LATERAL CONTROL POSITION CENTERED DURING TEST.
4. CONTROL FORCES MEASURED AT CENTER OF GRIP.
5. FORCE TRIM ON
6. TOTAL LONGITUDINAL CONTROL TRAVEL = 10.1 INCHES

FIGURE 1
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
AH-15 USA S/N 76-22573

AVERAGE FORCE GRADIENT 2.5 LB./IN.

BREAKOUT INCLUDING FRICTION 4.0 LB. AFT
BREAKOUT INCLUDING FRICTION 4.0 LB. FWD

TRIM CONTROL DISPLACEMENT BAND 1.5 IN.

LONGITUDINAL CONTROL POSITION (INCHES)
FIGURE 2
LATERAL CONTROL SYSTEM CHARACTERISTICS
AH-1S USA S/N 76-22573

NOTES:
1. ROTOR STATIC
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS
3. LONGITUDINAL CONTROL POSITION CENTERED DURING TEST
4. CONTROL FORCES MEASURED AT CENTER OF GRIP
5. FORCE TRIM ON
6. TOTAL LATERAL CONTROL TRAVEL = 8.5 INCHES

![Graph showing lateral control system characteristics with various parameters and measurements.](image-url)
Figure 2

Control Positions in Trimmed Flight

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>9000</td>
<td>184.7 (FWD)</td>
<td>0.0 (MID)</td>
<td>9800</td>
<td>11.0</td>
<td>324</td>
<td>LEVEL</td>
</tr>
<tr>
<td>A</td>
<td>940</td>
<td>184.5 (FWD)</td>
<td>0.0 (MID)</td>
<td>1000</td>
<td>11.0</td>
<td>324</td>
<td>MCP CLIMB</td>
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<tr>
<td></td>
<td>9420</td>
<td>184.5 (FWD)</td>
<td>0.0 (MID)</td>
<td>920</td>
<td>11.0</td>
<td>324</td>
<td>DECENT</td>
</tr>
<tr>
<td></td>
<td>9440</td>
<td>184.2 (FWD)</td>
<td>0.0 (MID)</td>
<td>920</td>
<td>11.0</td>
<td>324</td>
<td>AUTOROTATION</td>
</tr>
</tbody>
</table>

Note: 1. Two MBs, 4-tow wing and 2-1261 (WL mounted on wing).
2. Zero sideslip.
3. SRS on.

Total directional control travel = 6.0 inches

Total lateral control travel = 8.5 inches

Total longitudinal control travel = 10.1 inches

Calibrated airspeed (knots)
### Table - Collective Static Longitudinal Stability

<table>
<thead>
<tr>
<th>Weight</th>
<th>Location</th>
<th>Density</th>
<th>Altitude</th>
<th>Speed</th>
<th>Condition</th>
<th>Trim</th>
<th>Calibrated Airefeld</th>
</tr>
</thead>
<tbody>
<tr>
<td>8540</td>
<td>184.0 (FWO)</td>
<td>0.00 (MID)</td>
<td>8340</td>
<td>0.6</td>
<td>824</td>
<td>MCD CLIMB</td>
<td>70</td>
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<tr>
<td>8600</td>
<td>185.9 (FWO)</td>
<td>0.00 (MID)</td>
<td>7400</td>
<td>8.0</td>
<td>824</td>
<td>AUTOROTATION</td>
<td>80</td>
</tr>
<tr>
<td>6700</td>
<td>184.7 (FWO)</td>
<td>0.00 (MID)</td>
<td>6600</td>
<td>16.0</td>
<td>824</td>
<td>DESCENT</td>
<td>70</td>
</tr>
<tr>
<td>9640</td>
<td>184.6 (FWO)</td>
<td>0.00 (MID)</td>
<td>6300</td>
<td>14.0</td>
<td>824</td>
<td>DESCENT</td>
<td>100</td>
</tr>
</tbody>
</table>

**Total Longitudinal Control Travel = 10.1 Inches**

### Diagrams

1. Total Directional Control Travel = 6.0 Inches
2. Total Lateral Control Travel = 8.5 Inches
3. Total Longitudinal Control Travel = 10.1 Inches

**Notes:**
1. Two MISS 4-ton launchers and two MISS 1-ton launched on wings.
2. Zero sideslip at trim.
3. GCAE on.
4. Shaded symbols denote trim.
The image contains a table and a chart related to flight and control data. The table includes columns for flight condition, calibrated airspeed, and trim, among others. The chart illustrates control travel measurements for different conditions.

In the table, the following data is presented:

- **AM-15 USA S/N 75-22579**
- **AVG GROSS WEIGHT (LB)**: 8200
- **AVG LOCATION (PSI)**: 193.8
- **AVG DENSITY OAT (PSI)**: 0.0
- **AVG ALTITUDE (FEET)**: 0
- **AVG Rotor speed (RPM)**: 120
- **FLIGHT CONDITION**
- **TRIM LEVEL**: 120

The chart indicates the following:

- **Total Directional Control Travel**: 6.0 inches
- **Total Lateral Control Travel**: 8.5 inches
- **Total Longitudinal Control Travel**: 10.1 inches

**Note:**
1. Two M65 4-TOW launchers, and two M261 LNL mounted on wings.
2. Zero sideslip at trim.
3. SCAB on.
4. Shaded symbols denote trim.

The chart also shows the relationship between calibrated airspeed and control movement.
FIGURE 6
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22575

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG LATERAL CG LOCATION (FS)</th>
<th>AVG LAT LATERAL DENSITY (BL)</th>
<th>AVG GROSS ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG KNOTS Rotor Speed (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9620</td>
<td>194.6(FWD)</td>
<td>0.0(MID)</td>
<td>6460</td>
<td>13.5</td>
<td>324</td>
</tr>
<tr>
<td>9560</td>
<td>194.6(FWD)</td>
<td>0.0(MID)</td>
<td>6320</td>
<td>13.5</td>
<td>324</td>
</tr>
<tr>
<td>9400</td>
<td>194.5(FWD)</td>
<td>0.0(MID)</td>
<td>6440</td>
<td>13.5</td>
<td>324</td>
</tr>
</tbody>
</table>

CLIMB 74 KIAS
DESEMT 105 KIAS
AUTO ROTATION 64 KIAS

NOTE: TWO M65 4-TOW LAUNCHERS AND TWO M260
LWL MOUNTED ON WINGS

TOTAL LONGITUDINAL CONTROL TRAVEL = 10.1 INCHES
TOTAL LATERAL CONTROL TRAVEL = 8.5 INCHES
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.0 INCHES
### FIGURE 7

**STATIC LATERAL-DIRECTIONAL STABILITY**

**AH-1S USA S/N 76-22573**

<table>
<thead>
<tr>
<th>AVG GROSS</th>
<th>AVG CB LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT</th>
<th>AVG ROTOR</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>(LB)</td>
<td>(FS) (BL)</td>
<td>(FT)</td>
<td>°C</td>
<td>(RPM)</td>
<td></td>
</tr>
<tr>
<td>9780</td>
<td>194.7 (FWD)</td>
<td>0.0 (MID)</td>
<td>6140</td>
<td>13.0</td>
<td>324</td>
</tr>
</tbody>
</table>

**NOTES:**
1. TRIM CALIBRATED AIRSPEED 115 KNOTS
2. TWO M65 4-16W LAUNCHERS
   AND TWO M260 LWD MOUNTED ON WINGS

---

**TOTAL LONGITUDINAL CONTROL TRAVEL = 10.1 INCHES**

**TOTAL LATERAL CONTROL TRAVEL = 8.5 INCHES**

**TOTAL DIRECTIONAL CONTROL TRAVEL = 6.0 INCHES**

---

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