ENGINEERING FLIGHT TEST-AH-1G HELICOPTER WITH MODEL 212 TAIL ROTOR. PART II. PERFORMANCE AND HANDLING QUALITIES

John I. Nagata, et al

Army Aviation Systems Test Activity
Edwards Air Force Base, California

September 1973
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<td>The United States Army Aviation Systems Test Activity conducted a limited performance and handling qualities evaluation of the AH-1G helicopter with a Bell Helicopter Company commercial Model 212 tail rotor installed. This installation included changes to the pitch links and pitch control tube to accommodate the Model 212 tail rotor; however, the remaining components of the tail rotor drive system were standard AH-1G items. The evaluation was performed during the period 29 May to 7 August 1973 at Edwards Air Force Base, Bakersfield, and Bishop.</td>
</tr>
</tbody>
</table>
20. Abstract

California. Data were obtained for comparison with the tractor tail rotor (Model 801) configured AH-1G. Twenty-seven productive flight hours were required for this evaluation. As compared with the tractor tail rotor the Model 212 tail rotor configured AH-1G required slightly less power to hover. The hover ceiling (even when limited by a 10-percent directional control margin) was higher with the Model 212 tail rotor. Level flight performance was essentially unchanged. The AH-1G/Model 212 configuration provided a significant improvement in directional control during hover and right sideward flight at high gross weights and density altitudes. Hovering turns were arrested more rapidly and with less tail rotor drive train loading; however, tail rotor component horsepower limits may be exceeded during abrupt full left pedal inputs. Static longitudinal and lateral-directional stability characteristics are essentially unchanged by the Model 212 modification. A shortcoming was the undesirable lateral-directional oscillation above 120 knots. Further testing should be conducted to determine the effects of increasing the tail rotor maximum blade angle limits.
ERRATA

USAAMTA PROJECT NO. 72-30
FINAL REPORT
ENGINEERING FLIGHT TEST
AH-1G HELICOPTER WITH MODEL 212 TAIL ROTOR
PART II
PERFORMANCE AND HANDLING QUALITIES

Page 13, table 2, footnote 1, line 4: Change to read

Outside air temperature: 23.5°C

Page 35: Add the following paragraph

Translational Flight

20. Translational handling qualities were investigated by conducting tests at various combinations of wind azimuth and airspeed (TAS). A pace vehicle with a calibrated speedometer was used as a reference when attempting to stabilize the helicopter at the desired airspeed and azimuth. Ambient wind velocity and direction were incorporated into the analysis when determining airspeed and wind azimuth.

Where:

TAS = Vectorial sum of ground speed and wind velocity

Azimuth = Vectorial sum of ground speed direction and wind velocity direction with respect to aircraft heading

Page 37, line 22: Change to read

Roll angular acceleration 1 deg/sec²

Page 116, Figure 76: Under column heading titled "Flight Condition" add the following word

Level
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INTRODUCTION

BACKGROUND

1. Results of Phase D testing of the AH-1G helicopter by the United States Army Aviation Systems Test Activity (USAASTA) showed that directional control power was inadequate within a large portion of the proposed low-speed in-ground-effect (IGE) maneuver envelope (ref 1, app A). Subsequent testing with the tractor tail rotor showed continuing directional control problems and significant flight and gross weight restrictions (ref 2). The USAASTA was directed by the United States Army Aviation Systems Command (AVSCOM) to evaluate the AH-1G helicopter with the Model 212 tail rotor (app B).

TEST OBJECTIVES

2. The objectives of the AH-1G/Model 212 tail rotor evaluation were as follows:
   a. To conduct a tail boom load survey with the Model 212 tail rotor.
   b. To conduct a limited performance evaluation of the Model 212 tail rotor.
   c. To obtain quantitative and qualitative stability and control flight test data on the AH-1G in the Model 212 tail rotor configuration.
   d. To determine the instrument-flight-rules (IFR) capability of the AH-1G helicopter with the Model 212 tail rotor.

3. This report presents the results of the performance and handling qualities tests (paras 2b and c). Results of the load survey (para 2a) are reported in USAASTA Final Report No. 72-30, Part I (ref 3, app A). The IFR evaluation with this tail rotor has been delayed for an indefinite period of time because of a requirement to use the instrumented tail rotor in other tests by the prime contractor.

DESCRIPTION

4. The test helicopter, AH-1G serial number 71-20985, is a production aircraft with a tractor tail rotor. The AH-1G features two-place tandem seating, and two-bladed main and tail rotors. A three-axis stability and control augmentation system (SCAS) is provided. The power plant is a Lycoming T53-L-13B rated at 1400 shaft horsepower (shp) at sea-level, standard-day, static conditions. Installed in the AH-1G, the engine is limited to 1100 shp by the main transmission torque limit. The maximum gross weight of the AH-1G is 9500 pounds. The Model 212 tail rotor, installed for this evaluation, is a flex-beam rotor which is standard on the Bell Model 212 commercial helicopter. Compared to the tractor tail rotor
(Model 801), the Model 212 tail rotor has an increased chord from 8.4 inches to 11.5 inches, and a cambered airfoil blade section. The tail rotor drive system included standard AH-IG components except for the changes to the pitch links and pitch control tube necessary to accommodate the Model 212 tail rotor. In order to remain within the standard AH-IG tail rotor drive train torque rating, tie-down tests were performed to determine the maximum referred tail rotor shp of the Model 801 tail rotor and this limit was established as the desired maximum referred horsepower setting for the Model 212 tail rotor. The resulting tail rotor collective pitch stop settings for the Model 212 installation occur at blade angles of 17.7 degrees (full left pedal) and 10.3 degrees (full right pedal). A description of the tractor and the Model 212 tail rotors is presented in appendix C. The Model 801 tail rotor is more fully described in Bell Helicopter Company Engineering Change Proposal AH-IG 350 (ref 5, app A). A more detailed description of the AH-IG helicopter is contained in the operator's manual (ref 6). Photographs of the Model 801 and 212 tail rotor installations are presented in appendix D.

TEST SCOPE

5. The AH-IG/Model 212 tail rotor performance and handling qualities tests were conducted in California at Bakersfield (elevation 420 feet), Edward Air Force Base (elevation 2302 feet), Bishop (elevation 4112 feet), and Coyote Flats (elevation 9500 feet) from 29 May 1973 to 7 August 1973. During this evaluation, 44 flights were conducted for a total of 42 flight hours, of which 27 were productive. The two configurations tested were clean (no external stores), and Hog (two XM159C pods on each wing). Forward flight testing was accomplished at approximately 8000 and 9000 pounds, aft center of gravity (cg), 5000 feet density altitude, 324 rpm main rotor speed, airspeeds up to maximum for level flight, and with the SCAS ON. In addition, hover and low-speed testing were conducted at approximately 2000 feet and 11,000 feet density altitude. The flight restrictions and operating limitations applicable to this evaluation are contained in the operator's manual (ref 6, app A), as modified by the safety-of-flight release (refs 7 and 8).

METHODS OF TEST

6. Established flight test techniques and data reduction procedures were used (refs 9 and 10, app A). The test methods are briefly described in the Results and Discussion section of this report. Test results were compared with the results of testing conducted on the AH-IG with the Model 801 tail rotor (ref 2) and the applicable portions of military specification MIL-H-8501A (ref 11). A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app E). Data reduction techniques utilized are described in appendix F.
7. The flight test data were obtained from test instrumentation displayed on the pilot and copilot/gunner panels and recorded on magnetic tape. A detailed listing of test instrumentation is contained in appendix G.

**CHRONOLOGY**

8. Chronology of the AH-1G/Model 212 tail rotor evaluation is as follows:

<table>
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<tr>
<th>Event</th>
<th>Date</th>
<th>Year</th>
</tr>
</thead>
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<tr>
<td>Test directive received</td>
<td>27 July</td>
<td>1972</td>
</tr>
<tr>
<td>Test aircraft received</td>
<td>9 May</td>
<td>1973</td>
</tr>
<tr>
<td>Test began</td>
<td>29 May</td>
<td>1973</td>
</tr>
<tr>
<td>Test terminated</td>
<td>7 August</td>
<td>1973</td>
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</table>
RESULTS AND DISCUSSION

GENERAL

9. A limited evaluation of the performance and handling qualities of the AH-1G helicopter with a Model 212 tail rotor installed was conducted. Performance testing was limited to hover and level flight. Handling qualities were evaluated during hover, translational flight, and forward flight. Static and dynamic stability and controllability tests were performed. A slight decrease in power required was noted for hovering flight with the Model 212 tail rotor installed as compared with the tractor (Model 801) tail rotor. Directional control limits the hover ceiling of the AH-1G IGE and out of ground effect (OGE); however, an increase in hover ceiling was realized with the Model 212 tail rotor configuration. The AH-1G/Model 212 configuration provides a significant improvement in directional control during hover and right sideward flight at high gross weights and density altitudes. Hovering turns were arrested more rapidly and with less tail rotor power than the tractor tail rotor AH-1G; however, tail rotor power train horsepower limits may be exceeded with abrupt full left pedal inputs. One shortcoming was identified: an undesirable lateral-directional oscillation above 120 knots. Static longitudinal and lateral-directional stability characteristics are essentially unchanged. Further testing should be conducted to determine the effects of increasing tail rotor blade angle limits.

PERFORMANCE

General

10. Hover performance and level flight performance tests were conducted during this evaluation. The hover performance data indicate a slight decrease in power required to hover with the Model 212 tail rotor installed. Directional control margin limited hover ceiling but was less stringent with the Model 212 tail rotor than with the Model 801 tail rotor. There was no significant change in the level flight performance of the AH-1G with the Model 212 tail rotor installed.

Hover Performance

11. Hover performance testing was conducted IGE at a skid height of 5 feet and OGE at two elevations, 2302 feet and 9500 feet. The tethered hover method was used to obtain the majority of the hover performance data and a limited amount of free flight hovering was accomplished to verify the results. A cargo hook arrangement incorporating a calibrated load cell was attached to the helicopter as shown in photo 1, appendix D. Tests were performed within a rotor speed range of 294 to 324 rpm. The results of the hover performance tests are presented in figures 1 through 8, appendix H. Test data indicate a slight decrease in power required to hover with the Model 212 tail rotor configuration when compared with the Model 801 tail rotor, as shown in figure A.
**Figure A**

**QGE Hover Performance Comparison**

**Note:** Broken line denotes extrapolated data.
12. Hover capability for both a standard day and a hot day (35° C at all altitudes) were determined from figures 1, 2, and 9, appendix H. On a hot day, the AH-1G helicopter with the Model 212 tail rotor installed can hover at a skid height of 5 feet IGE at 1660 feet at the maximum gross weight of 9500 pounds, while the gross weight must be reduced to 9100 pounds at sea level to hover OGE. Hover capability IGE with the Model 801 tail rotor at maximum gross weight was 1600 feet, and the maximum gross weight for OGE hover at sea level was 9070 pounds. The standard-day hover ceiling, based on maximum engine power available, was 9680 feet at a 5-foot skid height IGE and 700 feet OGE at 9500 pounds with the Model 212 tail rotor as compared to 9580 feet and 340 feet, respectively, with the Model 801. Test data indicate a slight increase in hover performance with the Model 212 tail rotor configuration when compared with the Model 801 tail rotor as shown in figure B.

13. To satisfy the directional control requirement intent of MIL-H-8501A, a minimum of 10 percent of full directional control remaining has been established as a limit. This directional control requirement limits standard-day hovering performance of both the Model 212 and 801 tail rotor configured AH-1G helicopters. The effects of this limit on hovering performance are shown in figure B. As shown in the figure, this reduced IGE 5-foot skid height hover capability, at a maximum gross weight of 9500 pounds, occurs at altitudes above 8200 feet in the Model 212 configuration as compared to 7720 feet in the Model 801 configuration. The altitude at which maximum OGE hovering performance becomes limited by the 10-percent tail rotor control restriction was 7940 feet for the Model 801 and 12,700 feet for the Model 212, irrespective of gross weight. At a gross weight of 7860 pounds, the OGE hover capability was increased from 11,520 to 12,700 feet with the Model 212 tail rotor installed. This altitude increase corresponds to an increase in net payload capability of approximately 280 pounds at altitudes above 12,700 feet.

**Level Flight Performance**

14. Level flight performance tests were conducted in conjunction with control position characteristics tests to facilitate testing. Tests were conducted at gross weights of 8000 and 9000 pounds in the Hog configuration. The results are presented in figures 10 and 11, appendix H. Data were obtained in stabilized level flight at the desired gross weight/density altitude ratio (W/d). The data indicate no essential difference between the level flight performance of the Model 212 and Model 801 tail rotor configured AH-1G helicopters.

**HANDLING QUALITIES**

**General**

15. The handling qualities of the AH-1G helicopter with the Model 212 tail rotor installed were evaluated under a variety of operating conditions. The AH-1G/Model 212 configuration provides a significant improvement in directional
FIGURE 8
HOVER CAPABILITY COMPARISON
STANDARD DAY

NOTES:
1. SOLID LINE REPRESENTS HOVER CEILING BASED UPON MAXIMUM ENGINE POWER AVAILABLE.
2. BROKEN LINE REPRESENTS HOVER CEILING BASED UPON 10 PERCENT DIRECTIONAL CONTROL MARGIN AVAILABLE.

GROSS WEIGHT ~ POUNDS

MAXIMUM GROSS WEIGHT

PRESSURE ALTITUDE ~ FEET

SFOOT 1GE

OGE

AH-1G/212
AH-1G/BO1
control during low-speed flight at high gross weights and density altitudes. Hovering
turns can be arrested more rapidly with lower tail rotor power train loads than
the Model 801 tail rotor configured AH-1G; however, tail rotor horsepower limits
may be exceeded by abrupt full left pedal application. The AH-1G/Model 212
undesirable lateral-directional gust response at airspeeds above 120 knots calibrated
airspeed (KCAS) is a shortcoming. Static longitudinal and lateral-directional stability
are essentially unchanged. Further testing should be conducted to determine the
effects of increasing tail rotor blade angles beyond the current 17.7-degree limit.

Control System Characteristics

16. Control system characteristics were measured in a static condition on the
ground with the engine and rotor stopped. Electrical and hydraulic power were
furnished by external sources. Both aircraft hydraulic systems were pressurized.
Control displacement and force measurements were recorded on magnetic tape.
Control force as a function of displacement is presented in figures 12 through 15,
appendix H. The cyclic pitch control pattern is presented in figure 16. Control
system characteristics in flight were essentially the same as those determined under
the above described static test conditions.

17. The results of the control system evaluation, as summarized in table 1 and
compared with the requirements of MIL-H-8501A, are essentially the same as the
Model 801 tail rotor configured AH-1G. Although the control forces generally
exceed the specification requirements, they are satisfactory.

<table>
<thead>
<tr>
<th>Control</th>
<th>Breakout Force Including Friction (lb)</th>
<th>Control Force Gradient (lb/in.)</th>
<th>Maximum Control Force (lb)</th>
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<td>Test Results</td>
<td>MIL-H-8501A Maximum</td>
<td>Test Results</td>
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<tr>
<td>Longitudinal</td>
<td>2.5</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Lateral</td>
<td>2.5</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Directional</td>
<td>2.5</td>
<td>7</td>
<td>N/A</td>
</tr>
<tr>
<td>Collective</td>
<td>7.5</td>
<td>3</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1 Force trim: ON.
Control force measured at center of pilot grip and pedal.
Control Positions in Trimmed Forward Flight

18. Control positions were determined in trimmed level flight, climbs, and autorotations with the aircraft stabilized at zero sideslip. Data were recorded at airspeeds from 45 KCAS to the maximum airspeed for level flight ($V_L$) at 8000 and 9000 pounds gross weight at a 5000-foot density altitude. Figures 17 through 19, appendix H, present the results of these tests.

19. Comparison of Model 212 test results with the Model 801 tail rotor (ref 2, app A) shows that for all airspeeds tested the left pedal requirement for stabilized level flight was less with the Model 212 tail rotor. This difference was minimum (approximately 0.2 inch) at 74 KCAS and increased at higher and lower airspeeds up to approximately 0.3 inch at 65 and 125 KCAS. The Model 212 tail rotor required less directional trim shift with increase in airspeed in level flight. Lateral control positions of the AH-1G/212 generally parallel the lateral control positions of the Model 801 tail rotor configured AH-1G but are approximately 1 inch to the right. This yields a nearly centered cyclic control in level flight throughout the airspeed range tested. In forward flight these differences were barely noticeable. In climbs and autorotations, the Model 212 tail rotor configuration generally exhibited the same trim position characteristics as the Model 801.

Static Longitudinal Stability

20. Static longitudinal stability characteristics were evaluated in level flight at 75, 95, and 120 KCAS and in climbs and autorotations at 75 KCAS. Tests were conducted at 8500 pounds and a 5000-foot density altitude at an aft cg with SCAS ON. For each test condition the aircraft was trimmed in steady-heading, zero sideslip flight. With the collective control held fixed, the aircraft was stabilized at incremental speeds greater and less than the trim speed. Test results are presented in figures 20 and 21, appendix H.

21. Static longitudinal stability, as indicated by the variation of longitudinal control position with airspeed, was positive at all airspeeds and conditions tested, with essentially the same gradient as the standard AH-1G. Within the scope of this test, the static longitudinal stability of the AH-1G/212 helicopter is essentially the same as the standard AH-1G and is satisfactory.

Static Lateral-Directional Stability

22. Static lateral-directional stability characteristics of the AH-1G helicopter with Model 212 tail rotor installed were evaluated in level flight, climbs, and autorotations at 8500 pounds, a 5000-foot density altitude, and an aft cg. The aircraft was trimmed in zero sideslip flight at the desired conditions. With the collective control fixed, the aircraft was then stabilized at incremental sideslip angles on both sides of trim to the limits of the sideslip envelope. Test results are presented in figures 22 through 24, appendix H.
23. Static directional stability, as indicated by the variation of directional control position with sideslip, was positive and essentially linear at all test airspeeds and conditions. This gradient increased with increasing airspeed. Dihedral effect, as indicated by the variation of lateral control position with sideslip, was positive and essentially linear at all test airspeeds. Pitch with sideslip occurred at all trim airspeeds and was similar to the Model 801 configuration. The side-force characteristic, as indicated by the variation of bank angle with sideslip, was positive for all test conditions, and essentially the same as the standard AH-1G. The static lateral-directional stability characteristics of the AH-1G/212 helicopter are similar to the Model 801 tail rotor configured AH-1G and are satisfactory.

Dynamic Stability

24. Lateral and directional dynamic stability tests were conducted with SCAS ON and OFF in forward flight to evaluate the short-term response of the aircraft following a gust disturbance. Tests were conducted at 8500 pounds, a 5000-foot density altitude, and aft cg. Data were recorded during 1-inch lateral and directional pulse inputs and during releases from steady-heading sideslips. A summary of dynamic stability characteristics is presented in figure 25, appendix H. Typical time histories of aircraft response are presented in figures 26 through 31.

25. Aircraft response to lateral and directional pulse inputs with SCAS ON was similar to the standard AH-1G. Lateral response was essentially deadbeat and directional response was moderately damped with no apparent tendency for small residual yaw oscillations. At 75 and 95 KCAS, the AH-1G/212 lateral-directional (Dutch roll) response to a release from a steady-heading sideslip was a lightly damped oscillation, returning to stabilized flight in approximately two cycles. At 121 and 131 KCAS, the aircraft rolled to nearly wings level, hesitated, then rolled rapidly away from the original bank. The aircraft then exhibited one lightly damped roll cycle and slowly returned to trim. Moderate pilot compensation would be required while flying in turbulence to maintain balanced flight above 120 KCAS (HORS 4). The AH-1G/212 lateral-directional response at airspeeds above 120 KCAS following a gust disturbance is a shortcoming. Further testing should be conducted to determine airspeed and power combinations which produce acceptable lateral-directional handling qualities during flight in turbulence.

26. A summary of lateral and directional dynamic stability characteristics with SCAS OFF is presented in table 2 and typical time histories are presented in figures 30 and 31, appendix H. The Model 801 configuration was qualitatively evaluated as being essentially the same as the standard AH-1G (ref 2, app A). Lateral and directional damping with the Model 212 tail rotor was essentially the same as the standard AH-1G.
Table 2. Lateral and Directional Dynamic Stability Characteristics.

<table>
<thead>
<tr>
<th>Control Axis</th>
<th>Average Gross Weight (lb)</th>
<th>Calibrated Airspeed (kt)</th>
<th>Average Damping Ratio</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Directional</td>
<td>8600</td>
<td>94</td>
<td>0.24</td>
<td>Light damping</td>
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<tr>
<td>Lateral</td>
<td>8800</td>
<td>94</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Directional</td>
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<td>121</td>
<td>0.23</td>
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</tr>
<tr>
<td>Lateral</td>
<td>8500</td>
<td>121</td>
<td>0.23</td>
<td></td>
</tr>
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1SCAS OFF.
Center-of-gravity location: 199.5 inches.
Density altitude: 5000 feet.
Outside air temperature: 23.5°C.
Rotor speed: 324 rpm.
Configuration: Hog.

Controllability

27. Controllability characteristics with the SCAS ON and OFF were evaluated in hover and forward flight. Tests were conducted at 7500 and 8500 pounds in the Hog configuration at an aft cg and at density altitudes of 2000, 5000, and 11,000 feet. Single-axis control step inputs were applied to the lateral-directional controls, using mechanical fixtures to obtain the desired control input size. The control inputs were held constant and the subsequent angular displacement (control power), angular rate (control response), and angular acceleration (control sensitivity) were measured. The results of these tests are presented in figures 32 through 43, appendix H. Hover control power is summarized in table 3 and compared with the requirements of MIL-H-8501A (ref 11, app A).

28. Lateral controllability characteristics are summarized in figure 32, appendix H. Comparison of these data with that obtained during the evaluation of the Model 801 tail rotor (ref 2, app A) indicates essentially no change in lateral controllability as a result of the Model 212 tail rotor modification.
Table 3. Hover Control Power.\textsuperscript{1}

<table>
<thead>
<tr>
<th>Axis</th>
<th>Direction</th>
<th>Control Power\textsuperscript{2} (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test Results</td>
</tr>
<tr>
<td>Roll</td>
<td>Left</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>2.6</td>
</tr>
<tr>
<td>Yaw</td>
<td>Left</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>13.5</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Gross weight: 8700 pounds.
Center-of-gravity location: 199.5 inches.
Density altitude: 1720 feet.
Outside air temperature: 25\degree C.
Rotor speed: 324 rpm.
Configuration: Hog.
\textsuperscript{2}Displacement measured at 1/2 second for roll and 1 second for yaw.

29. Directional controllability characteristics are summarized in figure 38, appendix H. Directional control response and sensitivity at a hover with SCAS ON was essentially the same as the Model 801 tail rotor. With SCAS OFF, left directional control response and sensitivity in a hover was approximately 30 percent higher with the Model 212 tail rotor. In forward flight, with SCAS ON and OFF, left directional control response and sensitivity were approximately 30 percent higher with the Model 212 tail rotor and essentially linear with respect to the magnitude of pedal application. Directional controllability tests indicate essentially no change in aircraft response or sensitivity with right pedal application.

**Arrestment of Hover Turn Rates**

30. Hover turn arrestsments were executed IGE at approximately 10 feet skid height to determine peak tail rotor power and any associated operational limitations due to tail rotor power train limits. Tests were performed in the Hog configuration at 9,000 pounds and 2000 feet density altitude and 8000 pounds at 11,000 feet density altitude. Arrestments were performed by establishing a steady hovering turn at the desired rate, then rapidly applying directional control to stop the turn. As much as full left pedal was used to arrest right hovering turns.
31. Hover turn arrestment data are summarized in figure 44, appendix H. Time histories of hover turn arrestments from a 30-deg/sec right turn at low and high elevations are presented in figures 45 and 46. The peak tail rotor power recorded for the low-density altitude was 220 shp, during which the power was in excess of the 165-shp continuous power limit for 0.6 second. This compares with 225 peak shp and 2.9 seconds for similar conditions with the Model 801 tail rotor (ref 2, app A). At the high test elevation, peak horsepower was 165 shp and the 30-deg/sec turn was arrested in 1.2 seconds from control input. The Model 212 tail rotor provided a more rapid arrestment of the hover turn with lower tail rotor drive train power demands than the Model 801 tail rotor.

32. The current operational turn rate limit is 30 deg/sec. During this evaluation, an arrestment from a 35-deg/sec turn rate was executed at approximately 2000 feet density altitude. This was performed with rapid full left pedal application (approximately 1.2 inches in 0.1 second). Peak tail rotor power was 248 shp and the turn was arrested in 0.7 seconds. The 42-degree gear box exhibited an unusual wear pattern and was changed. Model 212 test results indicate that abrupt arrestment of hover turn rates greater than 30 deg/sec produces excessive loads in the tail rotor drive system. This was also noted during the Model 801 evaluation (ref 2, app A). Large rapid pedal inputs to the left control limit should be avoided to prevent excessive power loading of the AH-1G tail rotor drive train. The operator’s manual should be amended to include the following:

**CAUTION**

Abrupt full left tail rotor control pedal application should be avoided. Abrupt control motion may cause tail rotor overtorque and damage to tail rotor drive train components.

**Translational Flight**

33. Translational flight tests were conducted to determine trim requirements and control margins which would be experienced while hovering in winds. Tests were performed at a skid height of approximately 10 feet with flight paths at 45-degree aircraft azimuth increments with SCAS ON in the Hog configuration, at density altitudes of 2000, 5000, and 11,000 feet at 8000 and 9000 pounds. The safety-of-flight release (ref 8, app A) authorized testing to 40 knots true airspeed (KTAS) in sideward flight (90-degree and 270-degree azimuths) which is beyond the planned operational flight envelope of 30 KTAS. A pace vehicle was used to establish ground speed. Translational flight test results are presented in figures 47 through 73, appendix H.

34. The critical wind azimuth for the Model 212 tail rotor configuration is a right crosswind, essentially the same as for the Model 801 tail rotor. The Model 801 tail rotor directional control summary (fig. 20, ref 2, app A) indicates that at a referred gross weight of 11,230 pounds, hovering flight could not be achieved with 10 percent directional control margin remaining. An aiding left crosswind of 8 KTAS was required before adequate directional control margin
could be achieved in a hover. The Model 212 tail rotor configuration at a referred gross weight of 11,270 pounds was capable of approximately 3 KTAS right sideward flight with 10 percent control margin and was flown to 15 KTAS without loss of directional control. At a referred gross weight of 9760 pounds, right sideward flight was performed up to 43 KTAS without loss of directional control; however, this was near the left pedal control limit and is not recommended as an operational capability. As indicated in figure C, comparison of the two tail rotors illustrates that the requirement for a large change in pedal position with airspeed with the AH-1G/801 tail rotor may not provide sufficient gust control, whereas the small change in pedal position with the AH-1G/212 tail rotor will allow more control available (or less control required) to counteract airspeed gusts. The Model 212 tail rotor affords a significant improvement in directional control during right sideward flight at high gross weights and density altitudes. Further testing should be conducted to determine the effects of increased blade angle settings beyond the current 17.7-degree limit.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY ALTITUDE (FT)</th>
<th>AVG CG LOCATION (IN)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG C7</th>
<th>AVG WHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>801</td>
<td>8440</td>
<td>4680</td>
<td>92.3</td>
<td>324</td>
<td>.009800</td>
<td>9670</td>
</tr>
<tr>
<td>212</td>
<td>8340</td>
<td>5380</td>
<td>99.9</td>
<td>325</td>
<td>.009832</td>
<td>9790</td>
</tr>
</tbody>
</table>

![Figure C. Tail Rotor Comparison in Right Sideward Flight.](image-url)
35. A directional control position margin of 10 percent was discussed in the AH-IG Phase D report (ref 1, app A) and the tractor tail rotor evaluation report (ref 2) as providing minimum adequate directional control margin. The Model 212 tail rotor configured AH-IG was qualitatively evaluated as having adequate directional control margin with 7 percent remaining directional control. This reduced control margin requirement results from the more precise directional control available and the smaller yaw excursions with the Model 212 tail rotor, especially near the control limits. On several occasions, right sideward flight could be made at airspeeds where full left pedal application was required. At similar flight conditions with the Model 801 tail rotor, considerable pilot effort was required to maintain directional control. These factors represent significant improvement in sideward flight handling qualities with the Model 212 installation.

Autorotational Entry Characteristics

36. Autorotational entry characteristics (throttle chops) were evaluated to determine aircraft response following sudden engine failure. Engine failure was simulated by rapidly closing the twist grip throttle to the flight-idle position while stabilized at 8500 pounds gross weight, 5000 feet density altitude, aft cg, and airspeeds from 75 KCAS to VNF. Following the simulated engine failure, the flight controls (including collective pitch) were held fixed for 2 seconds or until recovery was necessary. Aircraft reaction with SCAS ON and OFF was recorded during the simulated failure and recovery. Results are summarized in figure 74, appendix H. Time histories are presented in figures 75 and 76.

37. The AH-IG with Model 212 tail rotor generally exhibited significantly less severe response following a throttle chop (SCAS ON) than was reported in the Phase D testing (ref 1, app A) of the AH-IG, as is shown in table 4. Delay times prior to recovery were the same for both the standard AH-IG and the AH-IG/212 and failed to meet the military specification (ref 11) minimum of 2 seconds delay time until recovery at high power settings. Maximum yaw rates were 10 to 11 deg/sec for the AH-IG/212, as compared to 12.5 to 14.0 deg/sec with the standard AH-IG at the same airspeed. Aircraft pitch rates were negligible during the simulated failure and recovery.

38. The AH-IG/212 response to simulated sudden engine failure with SCAS OFF was considerably more severe in the roll axis than with SCAS ON. The time histories show roll acceleration approximately three times higher with SCAS OFF and delay time reduced by 0.6 second. The AH-IG autorotational entry characteristics report (ref 12, app A) recommends limiting airspeed to less than 100 KCAS when the SCAS is inoperative. Test data support this recommendation for the 212 tail rotor modified AH-IG. The AH-IG/212 was qualitatively evaluated as being slightly less severe in response to simulated engine failure than the Model 801.
<table>
<thead>
<tr>
<th>Calibrated Airspeed (kt)</th>
<th>Maximum Roll Acceleration (deg/sec²)</th>
<th>Maximum Roll Rate (deg/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AH-1G²</td>
<td>AH-1G/212³</td>
</tr>
<tr>
<td>114</td>
<td>16.0</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>25.5</td>
<td>14.0</td>
</tr>
<tr>
<td>126</td>
<td>22.0</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>34.0</td>
<td>17.0</td>
</tr>
<tr>
<td>133</td>
<td>26.5</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
<td>24.0</td>
</tr>
</tbody>
</table>

¹SCAS ON.
Center-of-gravity location: aft.
Density altitude: 5000 feet.
Rotor speed: 324 rpm.
Configuration: Hog.
²Gross weight: 9500 pounds.
³Gross weight: 8530 pounds.
CONCLUSIONS

GENERAL

39. The following conclusions were reached upon completion of testing:

a. Hover performance of the AH-1G helicopter was slightly improved with the Model 212 tail rotor installation (paras 11, 12, and 13).

b. The Model 212 tail rotor provided a more rapid arrestment of hover turns with lower tail rotor drive train power than the Model 801 tractor tail rotor (para 31).

c. Abrupt arrestment of hover turn rates greater than 30 deg/sec produces excessive loading of the tail rotor drive system (para 32).

d. The Model 212 tail rotor affords a significant improvement in directional control during right sideward flight at high gross weights and density altitudes (para 34).

e. The level flight performance, control system characteristics, static longitudinal stability, static lateral and directional stability, dynamic lateral and directional stability below 120 KCAS, lateral controllability, right directional controllability, and critical azimuth characteristics of the Model 212 tail rotor configured AH-1G helicopter are essentially the same as the Model 801 tail rotor (paras 14, 16, 21, 23, 25, 28, and 34).

SHORTCOMINGS

40. The lateral-directional gust response at airspeeds above 120 KCAS (para 25).

SPECIFICATION CONFORMANCE

41. Within the scope of this test, the AH-1G helicopter with the Model 212 tail rotor installed failed to meet the following requirements of MIL-H-8501A:

a. Paragraph 3.3.11 - Directional control force of 34 pounds exceeded the 15-pound limit (table 1).

b. Paragraph 3.5.5 - A 2-second collective control delay could not be achieved at high power settings in forward flight following a simulated power failure (para 37).
RECOMMENDATIONS

42. The shortcoming should be corrected (para 25).

43. The operator's manual should include the following caution:

CAUTION

Abrupt full left tail rotor control pedal application should be avoided. Abrupt control motion may cause tail rotor overtorque and damage to tail rotor drive train components.

44. Further testing should be conducted to determine:

   a. Airspeed and power combination which produce acceptable short-term lateral-directional handling qualities during flight in turbulence (para 25).

   b. Performance and handling qualities with tail rotor blade angle settings beyond the current 17.7-degree limit (para 34).
APPENDIX A. REFERENCES


APPENDIX B. TEST DIRECTIVE

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

AMSAR-EFT

SUBJECT: AH-1G/212 Tail Rotor Evaluation

Commanding Officer
US Army Aviation Systems
Test Activity
ATTN: SAVTE-P

This letter transmits AVSCOM Test Directive No. 72-30, subject as above.

FOR THE COMMANDER:

[Signature]

ROBERT D. HUBBARD
Acting Chief, Flt Stds & Qual Div
Directorate for RD&E

1 Incl
AVSCOM Test Directive
No. 72-30
AH-1G/212 Tail Rotor Evaluation

1. Purpose.

This test directive tasks ASTA to conduct a flight test evaluation of the Tractor 212 Flex Beam Tail Rotor on the AH-1G Helicopter.

2. Background.

Bell Helicopter recently completed a preliminary load level survey of their Model 212 Tractor Tail Rotor Configuration on the AH-1G Helicopter and the Cobra Product Manager has subsequently requested an Army Flight Test Evaluation be conducted. Indications are that this tail rotor test may be a prelude to a full blown AH-1G IFR evaluation.

3. Test Objective.

To obtain quantitative and qualitative stability and control flight test data on the AH-1G/212 Tractor Tail Rotor Configuration.

4. Special Instructions.

a. Handling qualities are to be evaluated against the MIL-H-8501A IFR handling qualities requirements.

b. The Model 212 flex beam tractor tail rotor will be provided and installed by BHC personnel.

c. Instrumentation of the AH-1G should be initiated at the earliest practical date and will be extensive enough to conduct a follow-on IFR evaluation.

5. Test Schedule.

Tentative schedule is for BHC to initiate tail rotor installation at ASTA the latter part of August 1972 with ASTA flight testing to commence immediately thereafter.

6. Description.

A technical description of the 212 flex beam tractor tail rotor will be provided by on-site BHC personnel.
7. **Points of Contact.**

AMCPM-CO  .  .  .  Mr. C. Gaiser, autovon 698-3304
  .  .  .  CWO Gay, autovon 698-3304

AMSAV-EF  .  .  .  Mr. J. Dettmer, autovon 698-5446

BHC  .  .  .  Mr. G. Nanchy, commercial (817) 280-3231

8. **Funding.**

The Cobra Product Manager is responsible for reimbursable expense requirements associated with this project and will provide $6000 to ASTA based on the preliminary estimate.

9. **Priority.**

AVSCOM Priority Number 8 is assigned.

10. **Reports.**

Seven copies of an ASTA report in letter format is required to be submitted to AMSAV-EF not later than 45 calendar days after test completion.

11. **Security Classification.**

Unclassified.

12. **Equipment.**

The tail rotor will be provided by BHC. All other test and test support is the responsibility of ASTA.

13. **Safety of Flight Release.**

A safety of flight release will be issued to ASTA by the Flight Standards & Qualification Division prior to initiation of flight testing.
APPENDIX C. TAIL ROTOR DESCRIPTION

TRACTOR TAIL ROTOR (MODEL 801)

1. The tractor tail rotor (Model 801) is a two-bladed, delta-three hinge type employing preconing. The blade and yoke assembly is mounted to the tail rotor shaft by means of a delta-hinge trunnion. Blade pitch angle is varied by movement of the tail rotor control pedals. Power to drive the tail rotor is supplied by a takeoff on the lower end of the main transmission.

TAIL ROTOR (MODEL 212)

2. The Model 212 tail rotor is a two-bladed, delta-three hinge type employing a flex-beam yoke. A double counter-weight arrangement reduces the blade feathering moments at high tail rotor collective pitch settings. Location, power source, and controls are essentially the same as the Model 801 tail rotor.

ANTITORQUE ROTOR DATA

<table>
<thead>
<tr>
<th></th>
<th>Model 801</th>
<th>Model 212</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of blades</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Diameter</td>
<td>8.5 ft</td>
<td>8.5 ft</td>
</tr>
<tr>
<td>Blade chord</td>
<td>8.4 in. (constant)</td>
<td>11.5 in. (constant)</td>
</tr>
<tr>
<td>Rotor solidity</td>
<td>0.105</td>
<td>0.1436</td>
</tr>
<tr>
<td>Blade airfoil</td>
<td>NACA 0010 modified</td>
<td>NACA 0018 at fuselage station (FS) 12.75, tapering linearly to BHC cambered blade section with thickness ratio 8.27 at FS 51 (No NACA number)</td>
</tr>
<tr>
<td>Blade twist</td>
<td>Zero deg</td>
<td>Zero deg</td>
</tr>
</tbody>
</table>
Photo 1. Tie-Down.
Photo 2. Model 801 Tail Rotor.

Photo 3. Model 212 Tail Rotor.

Photo 5. Model 212 Blade Tip.

Photo 7. Model 212 Tail Rotor Hub.
APPENDIX E.

HANDLING QUALITIES RATING SCALE

<table>
<thead>
<tr>
<th>ADEQUACY FOR SELECTED TASK OR REQUIRED OPERATION*</th>
<th>AIRCRAFT CHARACTERISTICS</th>
<th>DEMANDS ON THE PILOT IN SELECTED TASK OR REQUIRED OPERATION*</th>
<th>PILOT RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it Satisfactory Without Improvement?</td>
<td>EXCELLENT - HIGHLY DESIRABLE</td>
<td>Pilot compensation not a factor for desired performance.</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>GOOD - DESIRABLE</td>
<td>Pilot compensation not a factor for desired performance.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>FAIR - SOME MILDLY</td>
<td>Minimal pilot compensation required for desired performance.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>UNPLEASANT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is Adequate Performance Attainable With A Tolerable Pilot Workload?</td>
<td>MINOR BUT ANNOYING SHORTCOMINGS</td>
<td>Desired performance requires moderate pilot compensation.</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>MODERATELY OBJECTIONABLE SHORTCOMINGS</td>
<td>Adequate performance requires considerable pilot compensation.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>VERY OBJECTIONABLE BUT TOLERABLE SHORTCOMINGS</td>
<td>Adequate performance requires extensive pilot compensation.</td>
<td>6</td>
</tr>
<tr>
<td>Is It Controllable?</td>
<td>MAJOR DEFICIENCIES</td>
<td>Adequate performance not attainable with maximum tolerable pilot compensation. Controlability not in question.</td>
<td>7</td>
</tr>
<tr>
<td>No</td>
<td>MAJOR DEFICIENCIES</td>
<td>Considerable pilot compensation required for control.</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>MAJOR DEFICIENCIES</td>
<td>Intense pilot compensation required to retain control.</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>MAJOR DEFICIENCIES</td>
<td>Control will be lost during some portion of required operation.</td>
<td>10</td>
</tr>
</tbody>
</table>

PILOT DECISIONS

*Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref. NASA TN-D-6538) and Definitions In Accordance With AR 314-28

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.
APPENDIX F. DATA REDUCTION TECHNIQUES

INSTRUMENTATION

1. All instrumentation was calibrated prior to commencing the test program. All quantitative data obtained during this flight test program were derived from the special sensitive instrumentation listed in appendix G. Data were obtained from three aircraft sources and two ground sources. The aircraft sources were a magnetic tape, the engineer panel, and the pilot panel. The ground support sources were a ground weather station (used for hover and translational flight tests), and a calibrated pace vehicle (used for translational flight tests).

WEIGHT AND BALANCE

2. The test aircraft was weighed after the installation of test instrumentation. The fuel load for each test flight was determined prior to engine start and after engine shutdown by measuring the fuel specific gravity and temperature of the fuel, and by using an external calibrated sight gauge connected to the fuel cell to determine total fuel volume. Fuel used in flight was recorded by a calibrated fuel-used system, and the final fuel-used reading following engine shutdown was cross-checked with the sight gauge readings following each flight. Helicopter loading and cg were controlled by ballast installed at various locations in the aircraft.

AIRSPEED CALIBRATION

3. The calibration of the airspeed system was accomplished by determining the existing airspeed position error of the test nose boom in level, climbing, diving, and autorotational flight. A mathematical curve fit was applied to the data obtained from these tests, and is graphically presented in figure 1, appendix G, depicting calibrated airspeed (V<sub>cal</sub>) as a function of instrument corrected indicated airspeed (V<sub>IC</sub>). With the following functional relationship a standard estimate of error of 0.91 knot was obtained.

\[
V_{cal} = 12.645 + 0.707 (V_{IC}) + 3.38 \times 10^{-3} (V_{IC})^2 \\
- 1.15 \times 10^{-5} (V_{IC})^3 \tag{1}
\]
NONDIMENSIONAL METHOD

4. The helicopter performance results may be generalized through the use of nondimensional coefficients. The test results obtained at specific test conditions may be used to accurately define performance at conditions not specifically tested. The following nondimensional coefficients were used.

\[
C_T = \frac{\text{Thrust}}{\rho A (\Omega R)^2} = \frac{GW}{\rho A (\Omega R)^2}
\]

\[
C_P = \frac{(SHP)(550)}{\rho A (\Omega R)^3}
\]

Where:  
GW = Gross weight (lb)  
\(\rho\) = Air density (slug/ft\(^3\))  
A = Main rotor disc area (ft\(^2\))  
\(\Omega\) = Main rotor rotational frequency (rad/sec)  
R = Main rotor radius (ft)  
SHP = Shaft horsepower

PERFORMANCE

Power Determination

5. Horsepower transmitted by a rotating shaft may be expressed as follows.

\[
\text{SHP} = \frac{2\pi}{(12)(33,000)} (N) (Q)
\]

Where:  
N = Output shaft rotational speed (rpm)  
Q = Output shaft torque (in.-lb)

6. The calibration of the engine torquemeter system for engine S/N LE 17292 is graphically presented in figure 2, appendix G. The data obtained from this calibration correlated with the specification engine, but were insufficient to cover the entire operating torque range. Therefore, a mathematical curve fit was applied to the data and this curve was used to obtain engine output shaft torque (ESQ) as a function of engine output torque pressure (QE). The following equation was used and yielded a standard estimate of error of 56.9 in-lb.

\[
\text{ESQ} = 150.178 + 218.458(QE) - 1.34 \times 10^{-2}(QE)^2
\]
7. Antitorque system output torque was measured at the output shaft of the 90-degree tail rotor gearbox using a strain gage bridge and slip ring assembly. The following calibration equation for converting encoded pulse code modulation (PCM) counts from the magnetic tape system into tail rotor torque (TRQ) was used.

\[
TRQ(\text{in.-lb}) = -115.572 + 38.556(V)
\] (6)

Where: \(V\) = Differential bridge voltage expressed in PCM counts

8. Engine output shaft speed and tail rotor speed were determined from rotor speed as follows.

\[N_E = (N_R)(20.383)\] (7)

\[N_{TR} = (N_R)(5.10859)\] (8)

Where: \(N_E\) = Engine output shaft rotational speed
\(N_R\) = Main rotor rotational speed
\(N_{TR}\) = Tail rotor rotational speed

9. Substituting equations 5, 6, 7, and 8 into equation 4 (as appropriate), equations for determining engine output shaft horsepower (SHP\(_E\)) and tail rotor shaft horsepower (SHP\(_{TR}\)) may be developed.

\[
SHP_E = \left[\frac{2\pi}{(12)(33,000)}\right]\left[150.178 + 218.458(\text{QE}) - 1.34 \times 10^{-2}(\text{QE})^2\right]\left[N_E\right]
\]

\[
SHP_E = (3.234 \times 10^{-6})(\text{ESQ})(N_R)
\] (9)

\[
SHP_{TR} = \left[\frac{2\pi}{(12)(33,000)}\right]\left[-115.572 + 38.556(V)\right]\left[N_{TR}\right]
\]

\[
SHP_{TR} = (8.106 \times 10^{-5})(\text{TRQ})(N_R)
\] (10)

**Antitorque System Performance**

10. The performance of the antitorque rotor system in hover and translational flight was defined by tail rotor horsepower, tail rotor thrust, and directional control (pedal) position.

33
11. Assuming all restoring directional moment to maintain stabilized hover to be generated by the antitorque system, the thrust from the tail rotor in a hover (thrust\textsubscript{TR}) can be determined from the tail fin lateral bending moment (TFLB) and its moment arm of 41 inches by the following equation.

\[ \text{Thrust}_{TR} = \frac{TFLB}{41} \] (11)

12. Assuming that in hover the free air temperature of the air mass flow passing through the tail rotor was not influenced by the hot gases emitted from the engine, the nondimensional thrust coefficient of the tail rotor in hover was determined from the definition of equation 2.

\[ C_{TTR} = \frac{\text{Thrust}_{TR}}{\rho\omega_{TR}(\Omega R)^2_{TR}} \] (12)

Where: Subscript TR = Tail rotor

13. The position of the directional control was determined by measuring pedal position. Full left directional control application resulted in an average tail rotor blade angle of 17.7 degrees for the test aircraft. The total directional control (pedal) displacement (full left to full right) resulted in a 28.0-degree change in tail rotor blade angle. Total control position equals pilot control input plus SCAS input.

**Hover Performance**

14. Hovering data collected in terms of gross weight, shp required, and ambient air conditions were used to define the relationship between thrust (C\textsubscript{T}) and power (C\textsubscript{p}) coefficients as shown in equations 2 and 3, respectively. This relationship is unique for every skid height. Summary hovering performance was calculated from nondimensional hovering curves by dimensionalizing the curves at selected ambient conditions.

15. To establish a trend between the Model 801 and 212 tail rotor configured AH-1G helicopters, with the limited amount of data available from the Model 801 configuration testing, hover data from both were subjected to a least-squares parabolic curve fit. Model 801 configuration hover performance values presented in this report are based upon this curve fit and do not exactly represent the curves depicted in reference 2, appendix A.

**Level Flight Performance**

16. Level flight data were obtained by measuring the shaft horsepower required to maintain level flight at various airspeeds. An almost constant C\textsubscript{T} was maintained by increasing altitude as fuel was consumed.
17. From the definition of $C_p$ in equation 3, the following relationship can be derived for presentation of test day data at a standard-day average density altitude. Each level flight speed-power point was corrected to standard-day conditions by this method.

$$\text{SHP}_S = (\text{SHP}_T) \frac{\rho_S}{\rho_T} \quad (13)$$

Where: Subscript $S$ = Standard day  
Subscript $T$ = Test day

18. True airspeed ($V_T$) was calculated from calibrated airspeed as follows.

$$V_T = \frac{V_{CAL}}{\sqrt{\sigma}} \quad (14)$$

Where: $\sigma$ = Density ratio

**HANDLING QUALITIES**

**Stability**

19. The damping ratio for an oscillatory aircraft response to a pulse input of the flight controls was determined by the ratio of maximum method presented in reference 13, appendix A. Briefly, this method involved the determination of the ratio of alternate successive maximum values of the parameter being observed. The ratio of maximums obtained was related to the damping ratio by graphical means given in the previously cited reference. A time history of sideslip angle was used to determine damping ratio for directional pulses and a time history of roll rate was used for lateral pulses.
APPENDIX G. TEST INSTRUMENTATION

1. The test instrumentation was installed, calibrated, and maintained by the Instrumentation and Calibration Division of USAASTA. The tail rotor slip ring assembly, tail rotor blade pitch angle potentiometer, and tail fin lateral bending strain gage were installed and calibrated under contract by Bell Helicopter Company. A test boom with a swiveling pitot-static head was installed at the nose of the aircraft, and was connected to sensitive airspeed and altimeter indicators on both instrument panels and recorded on magnetic tape. All data were obtained from sensitive instrumentation and displayed or recorded on the following aircraft sources.

PILOT PANEL

- Airspeed (boom)
- Airspeed (ship's system)
- Altitude (boom)
- Altitude (ship's system)
- Rate of climb
- Main rotor speed
- Angle of sideslip
- Center-of-gravity normal acceleration
- Engine torque (standard system)

ENGINEER PANEL

- Airspeed (boom)
- Altitude (boom)
- Main rotor speed
- Outside air temperature
- Fuel used (counter)
- Directional control position
- Remote time code
- Exhaust gas temperature
- Gas producer speed (N1)
- Engine torque (standard system)
- Tail rotor shaft torque
- Tether rig cable tension
2. Cyclic and pedal mechanical fixtures were utilized in the forward cockpit to obtain a desired control input size about the lateral and directional axes.

3. The following calibrations graphically depict the equations used for determining engine torque and calibrated airspeed.
## Figure 1

**Airspeed Calibration**

AN-15 USAF 54-71-20386

**Main Motor Speed = 324 RPM**

**Longitudinal Center of Gravity = 130.0 IN**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>FLIGHT CONDITION</th>
<th>AVG DENSITY ALTITUDE (FT)</th>
<th>AVG GAT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>LEVEL</td>
<td>4200</td>
<td>6.0</td>
</tr>
<tr>
<td>□</td>
<td>CLIMB</td>
<td>5100</td>
<td>6.0</td>
</tr>
<tr>
<td>△</td>
<td>AUTO</td>
<td>4300</td>
<td>6.0</td>
</tr>
<tr>
<td>●</td>
<td>DIVE</td>
<td>3000</td>
<td>8.0</td>
</tr>
</tbody>
</table>

**Note:**

\[
V_{cal} = 12.645 + 0.707V_{IC} + 3.38 \times 10^{-9}(V_{IC})^2 - 1.15 \times 10^{-9}(V_{IC})^3 \pm 0.91 \text{ KNOTS}
\]
1. Points obtained from engine acceptance calibration test conducted 9 April 1972.
2. Solid line depicts engine 5M17232.

\[ E39 = 160.170 + 2.16.448 (Qe) - 1.89 \times 10^{-2} (Qe)^2 \pm 66.9 \text{ in.-lb} \]
**APPENDIX H. AH-1G/212 TEST DATA**

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<td>25 through 31</td>
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<td>32 through 37</td>
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<td>38 through 43</td>
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<td>Simulated Engine Failures</td>
<td>74 through 76</td>
</tr>
</tbody>
</table>
FIGURE 1

NOTES:
1. SLP OBTAINED FROM FIGURE 7.
2. CURVES DERIVED FROM FIGURE 3.
3. WIND LESS THAN 3 KNOTS.
4. ROTOR SPEED = 320 RPM.
5. VERTICAL HEIGHT FROM BOTTOM
   OF SKID TO CENTER OF ROTOR
   HUB = 1150 FT.
6. BROKEN LINE DEPICTS 10 PERCENT
   DIRECTIONAL CONTROL MARGIN
   RESTRICTION.
Figure 2

AHO HOVER CAPABILITY
AH-1G USA SIN 71-20998
MILITARY RATED POWER AVAILABLE

NOTES:
1. SHP OBTAINED FROM FIGURE 7.
2. CURVES DERIVED FROM FIGURE 4.
3. WIND LESS THAN 3 KNOTS.
4. ROTOR SPEED = 320 RPM.
5. VERTICAL HEIGHT FROM BOTTOM
OF SKID TO CENTER OF ROTOR
HUB = 11.50 FT.
6. BROKEN LINE DEPICTS 10 PERCENT
DIRECTIONAL CONTROL MARGIN
RESTRICITION.
NOTE:
1. SKID HEIGHT MEASURED FROM BOTTOM OF RIGHT-SKID.
2. VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 152 FT.
3. WIND LESS THAN 3 KNOTS.
4. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3760 FT.
   AIR TEMPERATURE OF 72.5°C.
   TETHERED HOVER METHOD.
5. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 1750 FT.
   AIR TEMPERATURE OF 52.0°C.
   FREE FLIGHT HOVER METHOD.

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.82 IN.

ENGINE POWER COEFFICIENT

\[ C_{p} \times 10^{2} \times 10^{3} \]

\[ C_{TMR} \times 10^{2} = \frac{C_{GRW} \times 10^{0}}{\text{PAC/SR}^{2}} \]
FIGURE 5
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
AH-16 USA S/N 71-29985
ICE SKID HEIGHT = 3 FEET

NOTES:
1. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3600 FT.
   AIR TEMPERATURE OF 22.0°C.
   TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 10620 FT.
   AIR TEMPERATURE OF 6.0°C.
   TETHERED HOVER METHOD.
3. FLAGGED SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 12000 FT.
   AIR TEMPERATURE OF 18.0°C.
   FREE FLIGHT HOVER.
4. L (PERPENDICULAR DISTANCE
   BETWEEN CENTERLINES OF MAIN
   AND TAIL ROTOR SHAFTS) = 26.73 FT.

SYMBOL MAIN ROTOR TAIL ROTOR
SPEED (RPM) SPEED (RPM)
• 324 1638
□ 309 1579
△ 294 1502

TAIL ROTOR THRUST COEFFICIENT,

\[ C_{TTR} \times 10^3 \]

\[ \frac{\text{THRA}_T}{\text{GRA}_T (A_R)^2} \times 10^6 \]
FIGURE 6  
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE  
AN-14 USA SIN 71-20006  
OBE SKID HEIGHT = 100 FEET  

NOTES:  
1. OPEN SYMBOLS DENOTE:  
   DENSITY ALTITUDE OF 3760 FT.  
   AIR TEMPERATURE OF 22.5 °C.  
   TETHERED HOVER METHOD.  
2. SOLID SYMBOLS DENOTE:  
   DENSITY ALTITUDE OF 11760 FT.  
   AIR TEMPERATURE OF 15.0 °C.  
   FREE FLIGHT HOVER METHOD. 
3. A (PERPENDICULAR DISTANCE  
   BETWEEN CENTERLINES OF MAIN  
   AND TAIL ROTOR SHAFTS) = 26.73 FT. 

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MAIN ROTOR SPEED (RPM)</th>
<th>TAIL ROTOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>324</td>
<td>168</td>
</tr>
<tr>
<td>□</td>
<td>303</td>
<td>157</td>
</tr>
<tr>
<td>Δ</td>
<td>294</td>
<td>160</td>
</tr>
</tbody>
</table>

TAIL ROTOR THRUST COEFFICIENT,  
\[ C_{TR} \times 10^4 = \frac{\text{THRUST}_{TR}}{\text{C}_{\text{TR}} (AR)^2} \times 10^4 \]
Figure 7

Non-dimensional Tail Rotor Performance
RH-1G USA 511 71-20985
1GE Skid Height 3 Feet

Notes:
1. Open symbols denote:
   Density Altitude of 3600 ft.
   Air Temperature of 22.0 °C.
   Tethered Hover Method.
2. Solid symbols denote:
   Density Altitude of 10620 ft.
   Air Temperature of 6.0 °C.
   Tethered Hover Method.
3. Flagged symbols denote:
   Density Altitude of 12000 ft.
   Air Temperature of 18.0 °C.
   Free Flight Hover Method.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Main Rotor Speed (RPM)</th>
<th>Tail Rotor Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>324</td>
<td>1635</td>
</tr>
<tr>
<td>□</td>
<td>303</td>
<td>1679</td>
</tr>
<tr>
<td>△</td>
<td>294</td>
<td>1502</td>
</tr>
</tbody>
</table>

$CTr x 10^4 = \frac{\text{Thrust}_{TR}}{\text{Pat}_{TR}} \times 10^8$

Tail Rotor Thrust Coefficient,
FIGURE 3
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
AH-1G USA SIN 71-20385
OGC SKID HEIGHT = 100 FEET

NOTES:
1. OPEN SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 3760 FT.
   AIR TEMPERATURE OF 22.5 °C.
   TETHERED HOVER METHOD.
2. SOLID SYMBOLS DENOTE:
   DENSITY ALTITUDE OF 11760 FT.
   AIR TEMPERATURE OF 15.0 °C.
   FREE FLIGHT HOVER METHOD.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MAIN ROTOR SPEED (RPM)</th>
<th>TAIL ROTOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>324</td>
<td>1685</td>
</tr>
<tr>
<td>□</td>
<td>309</td>
<td>1579</td>
</tr>
<tr>
<td>△</td>
<td>294</td>
<td>1502</td>
</tr>
</tbody>
</table>

\[
C_{TR} = \frac{\text{THrust}_{TR}}{\text{MATR} \cdot \text{(LR)}_{TR}} \\
C_{TR} \times 10^4 = \frac{\text{THrust}_{TR}}{\text{MATR} \cdot \text{(LR)}_{TR}} \times 10^4
\]
FIGURE 9
MILITARY RATED SHAFT HORSEPOWER AVAILABLE
TS3-L-13 ENGINE
HOVER

NOTES:
1. DATA BASED ON LYCOMING TS3-L-13
   ENGINE MODEL SPECIFICATION
   NUMBER 109.33.
2. ENGINE PARTICLE SEPARATOR
   INSTALLED.
3. ROTOR SPEED = 324 RPM.
4. COMPRESSOR INLET TEMPERATURE RISE = 3°C.
5. COMPRESSOR INLET PRESSURE LOSS = 0.985.
6. GENERATOR ELECTRICAL LOAD = ZERO.
7. AIR BLEED = 0.6%.
FIGURE 12
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
AH-10 UH-1H T-2000

NAMES:
1. MOTOR STALL.
2. CYCLE RANGE AT MANUFACTURER'S MAX-BET VALUE.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNIT.
4. HYDRAULIC BOOST SYSTEMS ON.
5. LATERAL CONTROL POSITIONS CHANGED DURING TEST.
6. SHOWN SYMBOLS DENOTE THIN POINTS.
7. CONTROL FORCES MEASURED AT CENTER OF GAIN.

PILOT STATION

FORCE TRIM ON
TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 5.82 IN.

FWD RHD

RFT FWD

CAPTAIN/GUNNER STATION

FORCE TRIM ON
TOTAL LONGITUDINAL CONTROL DISPLACEMENT = 6.50 IN.

FWD RHD

RFT FWD

LONGITUDINAL CONTROL POSITION - INCHES
**FIGURE 15**

**LATERAL CONTROL SYSTEM OPERATING CHARACTERISTICS**

AN-12 VSA-95 V-3-2000

**NOTES:**
1. Motor on.
2. Cyclic position at manufacturer's pre-set value.
3. Hydraulic and electrical power provided by ground units.
4. Hydraulic boost systems on.
5. Longitudinal control position centered during test.
6. Shaded symbols denote trim points.
7. Control values measured at center of grip.

**PILOT STATION**

**FORCE TRIM ON**

TOTAL LATERAL CONTROL DISPLACEMENT = 10.88 IN.

**FORCE TRIM OFF**

TOTAL LATERAL CONTROL DISPLACEMENT = 4.00 IN.

**COPILOT/ENGINEER STATION**

**FORCE TRIM ON**

TOTAL LATERAL CONTROL DISPLACEMENT = 10.50 IN.

**FORCE TRIM OFF**

TOTAL LATERAL CONTROL DISPLACEMENT = 4.60 IN.
Notes:
1. Rotor static.
2. Hydraulic and electrical power provided by ground units.
3. Cyclic control centered.
4. Shaded symbols denote trim points.
5. Control forces measured at center of pedals.

Pilot and copilot/gunner stations
force trim on
Total directional control displacement = 0.82 in

Pilot and copilot/gunner stations
force trim off
Total directional control displacement = 0.82 in

Directional control forces

LT
Pilot and copilot/gunner stations
force trim on
Total directional control displacement = 0.82 in

LT
Directional control position—Inches
FIGURE 10
COLLECTIVE CONTROL SYSTEM CHARACTERISTICS
AH-1G VFO-101-102

NOTES:
1. ROTOR STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY
   GROUND UNIT.
3. HYDRAULIC BRAKE SYSTEMS ON.
4. CYCLIC CONTROL CENTRES.
5. SHADED SYMBOLS DENOTE THIN PANELS.
6. CONTROL FORCES MEASURED AT CENTER OF GAP.

PILOT STATION
TOTAL COLLECTIVE CONTROL DISPLACEMENT: 3.21 IN.

COLLECTIVE CONTROL FORCE - INCHES

[Graph showing control forces at different positions]

GUNNER/GUNNER STATION
TOTAL COLLECTIVE CONTROL DISPLACEMENT: 6.25 IN.

[Graph showing control forces at different positions]

55
Figure 15
Cyclic Push Control Pattern

Notes:
1. Motor static.
2. Hydraulic and electrical power provided by
   landing units.
3. Hydraulically boosted systems on.
4. Directional control position 2.56 inches forward/turn
   left.
5. Collective control position did not exceed cyclic
   movement limits.
6. Total control displacement:
   Longitudinal: 5.80 inches (pilot)
   Lateral: 0.84 inches (pilot)
   Longitudinal: 4.10 inches (co-pilot/gunner)
   Lateral: 4.60 inches (co-pilot/gunner)

Pilot Station

0 1 2 3 4 5 6 7 8 9 10
LT   RT
Lateral control position
= inches from full left

COPilot/Gunner Station

0 1 2 3 4 5
LT   RT
Lateral control position
= inches from full left
FIGURE 17
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
AN-1G USA S/N 71-20385

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>AVG WEIGHT (LB)</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG CG LOCATION (IN)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL</td>
<td>7760</td>
<td>5080</td>
<td>13.0</td>
<td>193.5</td>
<td>328</td>
<td>.004483</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HOG CONFIGURATION

ANGLE OF ATTACK INOPERATIVE

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.02 IN.

TOTAL LATERAL CONTROL TRAVEL = 10.06 IN.

TOTAL LONGITUDINAL CONTROL TRAVEL = 9.82 IN.

CALIBRATED AIRSPEED = KNOTS

57
**Figure 18**

**CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT**

<table>
<thead>
<tr>
<th>FLIGHT CONDITION</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY ALTITUDE (FT)</th>
<th>AVG OAT LOCATION (°C)</th>
<th>AVG CG LOCATION (IN)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG OF</th>
<th>HOG CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL</td>
<td>8620</td>
<td>9000</td>
<td>25.0</td>
<td>195.6</td>
<td>324</td>
<td>.004368</td>
<td>ANGLE OF ATTACH INOPERATIVE</td>
</tr>
</tbody>
</table>

**TOTAL DIRECTIONAL CONTROL TRAVEL** = 5.82 IN.

**TOTAL LATERAL CONTROL TRAVEL** = 10.06 IN.

**TOTAL LONGITUDINAL CONTROL TRAVEL** = 3.82 IN.

CALIBRATED AIRSPEED ~ KNOTS

58
### Figure 19
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT

<table>
<thead>
<tr>
<th>Flight Symbol</th>
<th>Condition</th>
<th>Avg Gross Weight (lb)</th>
<th>Avg Density (°F)</th>
<th>Avg Altitude (ft)</th>
<th>Avg CG Location (in.)</th>
<th>Avg Rotor Speed (rpm)</th>
<th>Avg CT</th>
<th>NOS Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>Auto</td>
<td>8810</td>
<td>9500</td>
<td>35.0</td>
<td>139.6</td>
<td>324</td>
<td>0.0050/3</td>
<td></td>
</tr>
</tbody>
</table>

ANGLE OF ATTACK INOPERATIVE

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.02 IN.

TOTAL LATERAL CONTROL TRAVEL = 10.06 IN.

TOTAL LONGITUDINAL CONTROL TRAVEL = 3.82 IN.

CALIBRATED AIRSPEED ~ KNOTS
Figure 20
Static longitudinal stability
AVN USA NAVY YF-29383

| SYMBOL | FLIGHT CONDITION | AVG GROSS WEIGHT (LB) | AVG DENSITY ALTITUDE (FT) | AVG CG LOCATION (IN) | AVG SPEED (KIAS) | AVG CF | COUP \n|---|---|---|---|---|---|---|---|
| o | LEVEL | 6070 | 4400 | 51.5 | 133.7 | 319 | 0.00204 | NOE |
| □ | LEVEL | 6700 | 4600 | 53.0 | 133.4 | 325 | 0.00205 | NOE |
| △ | LEVEL | 6740 | 4800 | 53.6 | 133.6 | 328 | 0.00206 | NOE |

NOTE:
1. Collective control position held fixed during test.
2. Shaded symbols denote trim points.
<table>
<thead>
<tr>
<th>TOTAL CONTROL POSITIONS</th>
<th>CONTROL FORCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONGITUDINAL</td>
<td>LONGITUDINAL</td>
</tr>
<tr>
<td>- FROM FULL</td>
<td>- PITCH ATTITUDE</td>
</tr>
<tr>
<td>FORWARD</td>
<td>- ATTITUDE</td>
</tr>
<tr>
<td>PND</td>
<td>- REQUIRED</td>
</tr>
<tr>
<td>AFT</td>
<td>- UP</td>
</tr>
<tr>
<td></td>
<td>- PUSH</td>
</tr>
<tr>
<td></td>
<td>- PULL</td>
</tr>
<tr>
<td></td>
<td>- LT</td>
</tr>
<tr>
<td></td>
<td>- RT</td>
</tr>
</tbody>
</table>

The table above is a chart showing control positions and forces with values expressed in pounds. The chart includes columns for longitudinal, lateral, and directional forces, along with pitch attitude and control positions. The values range from 0 to 25, indicating different levels of control and force application. The chart is used to illustrate the relationship between control inputs and the resulting forces in a system, likely in aeronautical or vehicular applications. The diagram on the right side of the image provides a visual representation of these forces and their effects, showing how changes in control inputs can affect the system's behavior.
Figure 88
Static Control-Directional Stability
AV-16 Using an TI-808

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>6750</td>
<td>6750</td>
<td>20.0</td>
<td>125.6</td>
<td>324</td>
<td>.410.8930</td>
</tr>
</tbody>
</table>

NOTES:
1. Collective control position held fixed during test.
2. Shaded symbols denote trim points.
3. Broken lines denote sideslip limits.

Total Directional Control Travel = 582 in.
Total Lateral Control Travel = 10.66 in.
Total Longitudinal Control Travel = 9.82 in.
### FIGURE 83
**STATIC LATERAL-DIRECTIONAL STABILITY**
AM-16 USAF SN 71-20245

<table>
<thead>
<tr>
<th>FLIGHT SYMBOL CONDITION</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY (SF)</th>
<th>AVG CE LOCATION (IN)</th>
<th>AVG SPEED (KIAS)</th>
<th>AVG TRIM</th>
<th>AIRSPEED CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL</td>
<td>6370</td>
<td>6600</td>
<td>27.0</td>
<td>133.5</td>
<td>32%</td>
<td>111</td>
</tr>
<tr>
<td>LEVEL</td>
<td>6390</td>
<td>6620</td>
<td>28.5</td>
<td>139.9</td>
<td>32%</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>6290</td>
<td>6520</td>
<td>25.3</td>
<td>132.8</td>
<td>32%</td>
<td>133</td>
</tr>
</tbody>
</table>

**NOTES:**
1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST.
2. SHARDED SYMBOLS DENOTE TRIM LIMITS.
3. BROKEN LINES DENOTE SIDESLIP LIMITS.

- **Total Directional Control Travel:** 5-8 in.
- **Total Lateral Control Travel:** 12-16 in.
- **Total Longitudinal Control Travel:** 34-52 in.

---

**Angle of Sideslip (Degrees):**
- Left: 0 to 10, 10 to 20, 20 to 30, 30 to 40
- Right: 0 to 10, 10 to 20, 20 to 30, 30 to 40
**FIGURE 2a**

**STATIC LATERAL-DIRECTIONAL STABILITY**

**ANNE USA 24 IN 71-20985**

<table>
<thead>
<tr>
<th>Flight Condition</th>
<th>AVG Grav. Density</th>
<th>AVG A/T Location</th>
<th>CG Motor</th>
<th>A/V Trim Increase</th>
<th>CG Trim Increase</th>
<th>Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climb</td>
<td>67.0</td>
<td>0.6</td>
<td>53.6</td>
<td>300</td>
<td>78</td>
<td>Ave.</td>
</tr>
<tr>
<td>Auto</td>
<td>32.0</td>
<td>0.6</td>
<td>53.6</td>
<td>380</td>
<td>78</td>
<td>Ave.</td>
</tr>
</tbody>
</table>

**Notes:**
1. Collective control position held fixed during test.
2. Shaded symbols denote trim points.
3. Broken lines denote sideward limits.

**Total Directional Control Travel, 3.82 in.**

**Total Lateral Control Travel, 1.18 in.**

**Total Longitudinal Control Travel, 3.82 in.**
FIGURE 23
SUMMARY DYNAMIC STABILITY
AH-1G USA SHI-20385

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>CONDITION</th>
<th>WEIGHT</th>
<th>ALTITUDE</th>
<th>CG LOCATION</th>
<th>SPEED</th>
<th>CONFIG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCAS Gross Density Ave</td>
<td>Ave</td>
<td>Avg</td>
<td>(lb)</td>
<td>(ft)</td>
<td>(°C)</td>
</tr>
<tr>
<td>O</td>
<td>ON</td>
<td>8680</td>
<td>9820</td>
<td>260</td>
<td>133.9</td>
<td>323</td>
</tr>
<tr>
<td>□</td>
<td>OFF</td>
<td>8680</td>
<td>8560</td>
<td>23.0</td>
<td>133.9</td>
<td>324</td>
</tr>
</tbody>
</table>

NOTES:
1. OPEN SYMBOLS DENOTE LEFT INPUT.
2. SOLID SYMBOLS DENOTE RIGHT INPUT.

LATERAL

NOTE:
DAMPING WITH SCAS ON IS ESSENTIALLY DEADBEAT.

DIRECTIONAL

CALIBRATED AIRSPEED ~ KNOTS

65
FIGURE 26

AIRCRAFT RESPONSE FOLLOWING A RIGHT LATERAL PULSE

<table>
<thead>
<tr>
<th>CONFIGURATION</th>
<th>FLIGHT ATTITUDE</th>
<th>CROSS WIND</th>
<th>OVERTHREAD (MPH)</th>
<th>G-LOC</th>
<th>TRIM AIRSPEED</th>
<th>CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOG</td>
<td>LEVEL</td>
<td>8840</td>
<td>9860</td>
<td>25.0</td>
<td>139.6</td>
<td>0.03189</td>
</tr>
</tbody>
</table>

NOTE:
SEASON

TIME ~ SECONDS

LATERAL
ROLL
PITCH
YAW
LONG ITIONAL
DIAGONAL

DROPS CONTROL ATTITUDES PITCH ROLL LONG ITIONAL
CROSS WIND ATTITUDES PITCH ROLL LATERAL
### Aircraft Response Following Release from Sideslip

**AN-1G USAF 4/11 71-20985**

<table>
<thead>
<tr>
<th>Flight Condition</th>
<th>Gross Weight (lb)</th>
<th>Density Altitude (ft)</th>
<th>GTX</th>
<th>SG Location</th>
<th>CG Location (in.)</th>
<th>Gyro</th>
<th>Airspeed (knots)</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>1500</td>
<td>0</td>
<td>260</td>
<td>0</td>
<td>135.1</td>
<td>3/9</td>
<td>100</td>
<td>131</td>
</tr>
</tbody>
</table>

**Figure 29**

- **Control Action**
  - Sideslip: Right, Left
  - Roll: Right, Left
  - Pitch: Up, Down
  - Yaw: Left, Right

**Notes:**
- Scoson

**Time ~ Seconds**

- **Axis:**
  - Vertical: 0 - 25 ft
  - Horizontal: 0 - 16 seconds

**Graph Elements:**
- **Axes:**
  - "Time ~ Seconds"
  - "Pitch" (Vertical)
  - "Roll" (Horizontal)
  - "Yaw" (Horizontal)
  - "Sideslip" (Horizontal)
  - "Control Action" (Vertical)
FIGURE 31
AIRCRAFT RESPONSE FOLLOWING A RIGHT DIRECTIONAL PULSE
AN-16 USA NAV 71-20985

FLIGHT CONDITION CRUISE DISTANCE DEPARTURE "CT" ZODIAC CT WINDING PRIM AIRCRAFT CONFIGURATION
LEVEL 1500 120 199.5 329 128333 93 NOS

NOTE:
DIRECTIONAL SEAS OFF

TOTAL CONTROL POSITIONAL INCHES DIRECTIONAL DIRECTIONAL
LATERAL 1.0 3.0 2.0 2.0
LONGITUDINAL 2.0 2.0 2.0 2.0
LATERAL 1.0 3.0 2.0 2.0
LONGITUDINAL 2.0 2.0 2.0 2.0

TIME ~ SECONDS
FIGURE 38
SUMMARY CONTROL RESPONSE AND SENSITIVITY
AN-14 DUR THRU J-3580

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>FLIGHT STATE</th>
<th>AVG ( \text{GROSS} ) ( \text{WEIGHT} ) ( (\text{lb}) )</th>
<th>AVG ( \text{DENSITY} ) ( \text{ALTITUDE} ) ( (\text{FT}) )</th>
<th>AVG ( \text{CG} ) ( \text{LOCATION} ) ( (\text{IN}) )</th>
<th>AVG ( \text{ROTOR} ) ( \text{SPREAD} ) ( (\text{RPM}) )</th>
<th>AVG ( \text{CT} )</th>
<th>( \text{SAMPLE} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>HOVER</td>
<td>80.00 1700 55.0 133.5 329 .006390</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>HOVER</td>
<td>75.70 11800 12.5 133.5 320 .066330</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>LEVEL</td>
<td>6600 9800 26.0 133.5 325 .006523</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>CLIMB</td>
<td>6000 9800 26.0 133.5 329 .006097</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>DESCENT</td>
<td>6000 9000 26.0 133.7 323 .006063</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>AUTO</td>
<td>6700 6600 26.0 133.3 322 .005971</td>
<td>NOE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. OPEN SYMBOLS DENOTE LEFT INPUT.
2. SOLID SYMBOLS DENOTE RIGHT INPUT.
3. POINTS DERIVED FROM FIGURES 31 THROUGH 35.
4. CONTROL RESPONSE IN HOVER MEASURED AT ONE SECOND.

SCAS ON

SCAS OFF
### Figure 3.3
**Lateral Controllability**

**AH-1G USAF S/N 71-20305, HOG Configuration**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>CONDITION</th>
<th>AVE GROSS WEIGHT (LB)</th>
<th>AVE DENSITY (ft)</th>
<th>AVE CG LOCATION (IN)</th>
<th>AVE ROTOR SPEED (RPM)</th>
<th>AVE TRIM AIRSPEED (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ON</td>
<td>7670</td>
<td>11400</td>
<td>12.5</td>
<td>19.5</td>
<td>324</td>
</tr>
<tr>
<td>□</td>
<td>ON</td>
<td>850</td>
<td>1740</td>
<td>25.5</td>
<td>19.5</td>
<td>324</td>
</tr>
<tr>
<td>△</td>
<td>OFF</td>
<td>8840</td>
<td>1660</td>
<td>29.5</td>
<td>19.6</td>
<td>328</td>
</tr>
</tbody>
</table>

#### Graphs:
- **Hover**: Attitude change at 1 sec
- **Rate Measured**: Rate at 1 sec
- **Maximum Drive**: Maximum drive at 1 sec
- **Maximum Acceleration**: Maximum acceleration at 1 sec

*Control Displacement from Trim ~ Inches*
FIGURE 34
LATERNAL CONTROLLABILITY
AH-66 USAF S/N 71-20285
HOG CONFIGURATION

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SCAS</th>
<th>GROSS WEIGHT (LBS)</th>
<th>DENSITY (LBS/FT)</th>
<th>AVERAGE ATTITUDE (DEG)</th>
<th>AVERAGE CG LOCATION (IN)</th>
<th>AVERAGE ROTOR SPEED (RPM)</th>
<th>AVERAGE TRIM AIRSPEED (KCAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>ON</td>
<td>8720</td>
<td>9960</td>
<td>260</td>
<td>193.5</td>
<td>32.3</td>
<td>.005067</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>8820</td>
<td>9740</td>
<td>25.0</td>
<td>199.7</td>
<td>32.3</td>
<td>.005075</td>
</tr>
</tbody>
</table>

**LEVEL FLIGHT**

**AVG TIME TO MAXIMUM RATE = 1.21 SEC**

**AVG TIME TO MAXIMUM ACCELERATION = 0.35**

**CONTROL DISPLACEMENT FROM TRIM ~ INCHES**

74
### FIGURE 35
**LATERAL CONTROLLABILITY**
**AN-16 USA NAV 71-20985**
**HOG CONFIGURATION**

<table>
<thead>
<tr>
<th>SYMBOL CONDITION</th>
<th>SCAS</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>DENSITY (FT)</th>
<th>AVG CG LOCATION (°)</th>
<th>AVG ROTOR RPM</th>
<th>AVG TRIM AIRSPEED (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>0</td>
<td>8870</td>
<td>9780</td>
<td>250</td>
<td>133.4</td>
<td>323</td>
</tr>
<tr>
<td>OFF</td>
<td>□</td>
<td>8570</td>
<td>9300</td>
<td>28.0</td>
<td>133.5</td>
<td>323</td>
</tr>
</tbody>
</table>

### LEVEL FLIGHT

- **Attitude Change (°/SEC)**: 0 to 50
- **Maximum Rate ~ °/SEC**: 0 to 50
- **Maximum Acceleration ~ °/SEC**
  - **Left**: 0 to 50
  - **Right**: 0 to 50

**Average Time to Maximum Rates**
- **Left**: 0.34 sec
- **Right**: 0.37 sec

**Average Time to Maximum Acceleration**
- **Left**: 0.34 sec
- **Right**: 0.37 sec

**Control Displacement from Trim (°)**
- **Left**: 0 to 1
- **Right**: 0 to 1

---

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**FIGURE 36**

**LATERAL CONTROLLABILITY**

**AH-1G USA SH-71-20385**

**NOSE CONFIGURATION**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>CONDITION</th>
<th>SCAS</th>
<th>GROSS</th>
<th>DENSITY</th>
<th>AVG</th>
<th>ROTOR</th>
<th>AVG</th>
<th>AVG</th>
<th>TRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>ON</td>
<td>8800</td>
<td>9840</td>
<td>24.0</td>
<td>193.5</td>
<td>324</td>
<td>.005041</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>□</td>
<td>ON</td>
<td>8840</td>
<td>4720</td>
<td>25.5</td>
<td>199.7</td>
<td>323</td>
<td>.005083</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>

**CLIMB**

**AVG TIME TO MAXIMUM**

RATE = 0.08 SEC

**MAXIMUM**

ACCELERATION = 0.31 SEC

**DESCENT**

**AVG TIME TO MAXIMUM**

RATE = 1.23 SEC

**MAXIMUM**

ACCELERATION = 0.39 SEC

**LEFT**

CONTROL DISPLACEMENT FROM TRIM

- INCHES
FIGURE 37
LATERAL CONTROLLABILITY
AN-16 USA SN 71-20885
HOG CONFIGURATION

<table>
<thead>
<tr>
<th>SCAS SYMBOL</th>
<th>CONDITION</th>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG ALTITUDE (°C)</th>
<th>AVG CG LOCATION (IN)</th>
<th>AVG ROTOR AVG SPEED (RPM)</th>
<th>AVG TRIM AIRSPEED (KCAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ON</td>
<td>8750</td>
<td>4700</td>
<td>25.5</td>
<td>199.5</td>
<td>322.005082</td>
<td>78</td>
</tr>
<tr>
<td>□</td>
<td>OFF</td>
<td>8760</td>
<td>4600</td>
<td>25.0</td>
<td>199.5</td>
<td>321.005081</td>
<td>77</td>
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</tbody>
</table>

AUTOROTATION

<table>
<thead>
<tr>
<th>ATTITUDE CHANGE AT 1/2 SEC</th>
<th>LT AT</th>
<th>RT AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AVG TIME TO MAXIMUM RATE = 1.10 SEC

<table>
<thead>
<tr>
<th>MAXIMUM RATE AT 1/2 SEC</th>
<th>LT AT</th>
<th>RT AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AVG TIME TO MAXIMUM ACCELERATION = 0.40 SEC

<table>
<thead>
<tr>
<th>MAXIMUM ACCELERATION AT 1/2 SEC</th>
<th>LT AT</th>
<th>RT AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONTROL DISPLACEMENT FROM TRIM 0 INCHES
**FIGURE 38**

**SUMMARY DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>FLYING CONDITION</th>
<th>AVERAGE WEIGHT (LB)</th>
<th>AVERAGE ALTITUDE (FT)</th>
<th>AVERAGE DEPTH (FT)</th>
<th>AVERAGE SPAN (IN)</th>
<th>AVERAGE SPEED (KNOTS)</th>
<th>CTR</th>
<th>CONFIDENCE</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Hover</td>
<td>6700</td>
<td>1720</td>
<td>25.0</td>
<td>155.0</td>
<td>923</td>
<td>.004/0.004</td>
<td>Neutral</td>
</tr>
<tr>
<td>0</td>
<td>Level</td>
<td>7200</td>
<td>1220</td>
<td>25.5</td>
<td>135.4</td>
<td>928</td>
<td>.003/0.004</td>
<td>Neutral</td>
</tr>
<tr>
<td>0</td>
<td>Climb</td>
<td>6600</td>
<td>1660</td>
<td>25.6</td>
<td>133.6</td>
<td>922</td>
<td>.005/0.005</td>
<td>Neutral</td>
</tr>
<tr>
<td>0</td>
<td>Descent</td>
<td>6700</td>
<td>1760</td>
<td>25.8</td>
<td>133.6</td>
<td>923</td>
<td>.003/0.004</td>
<td>Neutral</td>
</tr>
<tr>
<td>0</td>
<td>Auto</td>
<td>6800</td>
<td>1760</td>
<td>25.9</td>
<td>133.6</td>
<td>923</td>
<td>.003/0.004</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Open symbols denote left input.
2. Solid symbol denotes right input.
3. Points derived from figures 37 through 41.
4. Control response in hover measured at one second.

**SCAS ON**

*Graphs showing directional control response and sensitivity with SCAS on.*

**SCAS OFF**

*Graphs showing directional control response and sensitivity with SCAS off.*

**CALIBRATED AIRSPEED ~ KNOTS**

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### FIGURE 33

**DIRECTIONAL CONTROLLABILITY**

**AN-1G USA S/N 71-20385**

**HOG CONFIGURATION**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SGAS SYMBOL</th>
<th>GROSS Wt</th>
<th>DENSITY</th>
<th>AVG ALTITUDE</th>
<th>AVG CG LOCATION</th>
<th>AVG ROTA SPEED</th>
<th>AVG TRIM AIRSPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(LB)</td>
<td>(FT)</td>
<td>(°C)</td>
<td>(IN)</td>
<td>(RPM)</td>
<td>(KCAS)</td>
</tr>
<tr>
<td>0</td>
<td>ON</td>
<td>7320</td>
<td>11220</td>
<td>10.3</td>
<td>193.6</td>
<td>323</td>
<td>.003569</td>
</tr>
<tr>
<td>□</td>
<td>ON</td>
<td>6530</td>
<td>1800</td>
<td>26.0</td>
<td>193.5</td>
<td>323</td>
<td>.004527</td>
</tr>
<tr>
<td>△</td>
<td>OFF</td>
<td>8820</td>
<td>1640</td>
<td>24.0</td>
<td>193.5</td>
<td>323</td>
<td>.004625</td>
</tr>
</tbody>
</table>

#### HOVER

- **Rate Measured**
  - Rate measured at 1 sec

- **Avg Time to Maximum Acceleration**: 0.30 sec

- **Maximum Acceleration**

- **Control Displacement from Trim**
  - Left
  - Right

- **Diagram of Hover Data**

---

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**Figure 40**

**DIRECTIONAL CONTROLLABILITY**

**AH-1G USAS/N 71-20365**

**HOG CONFIGURATION**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>CONDITION</th>
<th>WEIGHT (LB)</th>
<th>HEIGHT (FT)</th>
<th>ALTITUDE (FT)</th>
<th>DENSITY (LBS/FT$^3$)</th>
<th>LOCATION (IN)</th>
<th>SPEED (RPM)</th>
<th>CENS (FT/LB)</th>
<th>AIRSPEED (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>ON</td>
<td>8670</td>
<td>9780</td>
<td>25.0</td>
<td>193.5</td>
<td>323</td>
<td>0.00433</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>8680</td>
<td>9820</td>
<td>25.0</td>
<td>199.6</td>
<td>324</td>
<td>0.004976</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>

**LEVEL FLIGHT**

- **AVG TIME TO MAXIMUM RATE = 0.08 SEC**
- **AVG TIME TO MAXIMUM ACCELERATION = 0.25 SEC**

**CONTROL DISPLACEMENT FROM TRIM ~ INCHES**
# Figure 91

**Directional Controllability**

- **AH-1G USA SN 71-20385**
- **HOG Configuration**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Condition</th>
<th>CAS</th>
<th>Avg Gross Density (lb)</th>
<th>Avg Altitude (ft)</th>
<th>Avg CG Location (in)</th>
<th>Avg Rotor Speed (RPM)</th>
<th>Avg Trim Airspeed (KCAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>On</td>
<td>8510</td>
<td>4380</td>
<td>27.5</td>
<td>193.4</td>
<td>324</td>
<td>.004901</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>8410</td>
<td>4860</td>
<td>27.5</td>
<td>193.4</td>
<td>323</td>
<td>.004856</td>
</tr>
</tbody>
</table>

**Level Flight**

- **Avg Time to Maximum Rate**: 0.78 sec
- **Avg Time to Maximum Acceleration**: 0.26 sec

**Control Displacement from Trim**

- ~ Inches

---

*Notes:* Details on the table and graphs provide specific values and calculations for directional controllability under different conditions and configurations. The figure illustrates the impact of various settings on flight performance, emphasizing the importance of understanding flight dynamics for AH-1G helicopters.
**Figure 92**

**Directional Controllability**

AN-15 USA SN 71-20385

HOS Configuration

<table>
<thead>
<tr>
<th>SYMBOL CONDITION</th>
<th>AVG SCAS (lb)</th>
<th>AVG GROSS WEIGHT (lb)</th>
<th>AVG DENSITY (g/ft³)</th>
<th>AVG ALTITUDE (ft)</th>
<th>AVG CG LOCATION (in)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG TRIM AIRSPEED (KCAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>⊙ ON</td>
<td>8600</td>
<td>4660</td>
<td>28.5</td>
<td>153.5</td>
<td>323</td>
<td>0.004906</td>
<td>75</td>
</tr>
<tr>
<td>⊘ ON</td>
<td>8700</td>
<td>4780</td>
<td>28.5</td>
<td>153.6</td>
<td>324</td>
<td>0.004980</td>
<td>95</td>
</tr>
</tbody>
</table>

**Climb**

- Average time to maximum rate: 0.93 sec

**Descent**

- Average time to maximum rate: 0.93 sec

- Maximum acceleration: 0.25 sec

- Maximum acceleration: 0.27 sec

Control Displacement from Trim In Inches:

- Left: 1 inch
- Right: 1 inch
### FIGURE 43

**DIRECTIONAL CONTROLLABILITY**

**AN-15 USAF/ N 71-20985**

**NAC Configuration**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>condition</th>
<th>SCAS</th>
<th>GROSS</th>
<th>DENSITY</th>
<th>AVE</th>
<th>AVG</th>
<th>AVG</th>
<th>AVG</th>
<th>AVG</th>
<th>TRIM</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(LB)</td>
<td>(FT)</td>
<td>(°C)</td>
<td>(IN)</td>
<td>(RPM)</td>
<td>(KGS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>ON</td>
<td>8590</td>
<td>4820</td>
<td>25.5</td>
<td>199.5</td>
<td>322</td>
<td>.004987</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□</td>
<td>OFF</td>
<td>8530</td>
<td>4700</td>
<td>26.5</td>
<td>199.5</td>
<td>323</td>
<td>.004902</td>
<td>75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Autorotation

- **Average Time to Maximum Rate**: 1.19 sec
- **Average Time to Maximum Acceleration**: 0.28 sec

- **Left Control Displacement from Trim**: 1 inch
- **Right Control Displacement from Trim**: 1 inch

---

83
**Figure 6A**

**Summary of Hover Turn Arrestments**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Weight (lbs)</th>
<th>Gross Density (ft)</th>
<th>Altitude (ft)</th>
<th>CG Location (in.)</th>
<th>Rotor Speed (RPM)</th>
<th>Average CG</th>
<th>Avg Cg</th>
<th>Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9200</td>
<td>2680</td>
<td>31.0</td>
<td>195.1</td>
<td>325</td>
<td>0.004930</td>
<td>N0G</td>
<td></td>
</tr>
<tr>
<td>□</td>
<td>8170</td>
<td>10800</td>
<td>3.0</td>
<td>200.2</td>
<td>325</td>
<td>0.003599</td>
<td>N0G</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. Delta tail rotor (TR) shaft horsepower equals peak TR shaft horsepower during arrestment minus TR shaft horsepower required for steady rate turn.
2. Less pedal travel available for arrestments at high altitude due to increased TR shaft horsepower requirement for steady rate turn.

**Diagram:**

- Total directional control travel = 3.82 in.
- Pedal displacement from trim
- Time between application and arrestment of turn rate in sec

*Initial yaw rate ~ deg/sec*
**Figure 45**

**Turn Arrestment in Hover**

AN/G USA SN 71-20885

<table>
<thead>
<tr>
<th>Gross Weight (lb)</th>
<th>Density Altitude (ft)</th>
<th>QAP (°C)</th>
<th>CE Location (ft)</th>
<th>Rotor Speed (rpm)</th>
<th>C_F</th>
<th>Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>9130</td>
<td>2000</td>
<td>31.0</td>
<td>155.1</td>
<td>323</td>
<td>0.009887</td>
<td>NOS</td>
</tr>
</tbody>
</table>

**Notes:**
1. Pull left directional control 4/5 degrees this motor blade pitch angle.
2. Rotor Height: 7 to 10 feet.

**Total Directional Control Travel:** 6.88 in.

**Time in Seconds**
FIGURE 46
TURN ARRESTMENT IN HOVER
AH-1G USA SIN 71-20385

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>DENSITY ALTITUDE (DPF)</th>
<th>QST (°C)</th>
<th>CG LOCATION (IN)</th>
<th>Rotor Speed (RPM)</th>
<th>Gyro</th>
<th>Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>8130</td>
<td>10720</td>
<td>8.5</td>
<td>200.2</td>
<td>326</td>
<td></td>
<td>NGC</td>
</tr>
</tbody>
</table>

NOTES:
1. FULL LAST DIRECTIONAL CONTROL "W.T." CHANGES FULL ROTOR BLADE PITCH ANGLES.
2. KILO HEIGHT = 770/8 RASHT.

TOTAL DIRECTIONAL CONTROL TRAVEL = 388 IN.

TIME ~ SECONDS

16
FIGURE 42
HOVERING IN WIND CAPABILITY FOR A TEN PERCENT
DIRECTIONAL CONTROL MARGIN
AH-1G USA SH-71-20985
HOG CONFIGURATION
NOTES:
1. LONGITUDINAL CENTER OF GRAVITY
   = 134.9 IN.
2. SKID HEIGHT = 7 TO 10 FEET.
3. WIND VELOCITY DEPICTS MOST
   CRITICAL WIND AZIMUTH.
4. FULL LEFT DIRECTIONAL CONTROL
   = 17.7 DEGREES TAIL ROTOR BLADE
   PITCH ANGLE.
5. POINTS OBTAINED FROM FIGURES
   47 THROUGH 67.
**Figure 48**

**Summary Translational Flight**

**Directional Control Margin**

AN-16 USA 9471-20985

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td></td>
<td>8360</td>
<td>2040</td>
<td>28.0</td>
<td>194.9</td>
<td>325</td>
<td>.004937</td>
</tr>
<tr>
<td>■</td>
<td></td>
<td>8340</td>
<td>3360</td>
<td>18.3</td>
<td>194.9</td>
<td>325</td>
<td>.004840</td>
</tr>
<tr>
<td>△</td>
<td></td>
<td>80.70</td>
<td>109.80</td>
<td>9.5</td>
<td>194.9</td>
<td>324</td>
<td>.005531</td>
</tr>
</tbody>
</table>

**Notes:**

1. Data based on 10 percent direction control remaining for stabilized flight.
2. Broken lines denote extrapolated curves.
3. Skid weight = 1700 feet
4. Data obtained from following figures:
   - 47 through 49
   - 55 through 62
   - 63 through 67
### Figure 99

**Directional Control at Various Relative Wind Angles**

<table>
<thead>
<tr>
<th>Average</th>
<th>Average</th>
<th>Average</th>
<th>Average</th>
<th>Average</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross</td>
<td>Density</td>
<td>Altitude</td>
<td>Lift</td>
<td>Location</td>
<td>Speed</td>
</tr>
<tr>
<td>Weight</td>
<td>(g)</td>
<td>(ft.)</td>
<td>(c)</td>
<td>(in.)</td>
<td>(rpm)</td>
</tr>
<tr>
<td>320</td>
<td>8000</td>
<td>460</td>
<td>1945</td>
<td>3288</td>
<td>6000</td>
</tr>
</tbody>
</table>

**Notes:**
1. True averaged as the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control (+57 degrees tail rotor blade pitch angle)
4. Full right directional control (+57 degrees tail rotor blade pitch angle)
5. Wind less than 3 knots.

---

**Diagram:**

- **Total directional control travel:** 5.82 in.
- **Relative wind azimuth:**
  - Right heading
  - Right tailwind
  - Left tailwind
  - Left heading

---

**Table:**

<table>
<thead>
<tr>
<th>40</th>
<th>80</th>
<th>120</th>
<th>160</th>
<th>200</th>
<th>240</th>
<th>280</th>
<th>320</th>
<th>360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right heading</td>
<td>Right tailwind</td>
<td>Left tailwind</td>
<td>Left heading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative wind azimuth (degrees)</td>
<td>40</td>
<td>80</td>
<td>120</td>
<td>160</td>
<td>200</td>
<td>240</td>
<td>280</td>
<td>320</td>
</tr>
</tbody>
</table>
FIGURE 5A
DIRECTIVE CONTROL AT VARIOUS RELATIVE WIND ROATIENT
AF 16 USN D-71-P2-20036

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (Lb)</th>
<th>AVG ACTUAL MAXIMUM (CPS)</th>
<th>AVG DEPART COMBAT (RPM)</th>
<th>AVG TRUE AIRSPEED (KIAS)</th>
<th>AVG TRUE AIRSPEED CONF.</th>
<th>AVG TRUE AIRSPEED CONF.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2960</td>
<td>2600</td>
<td>98.0</td>
<td>159.3</td>
<td>388</td>
<td>609</td>
</tr>
</tbody>
</table>

NOTES:
1. TRUE AIRSPEED IS THE VECTOREAL SUM OF GROUND SPEED AND WIND VELOCITY
2. GROUND SPEED DETERMINED WITH CALIBRATED GROUND VELOCITY
3. FULL LEFT DIRECTIONAL CONTROL: +1 DEGREES TAIL ROTOR BLADE PITCH ANGLE
4. FULL RIGHT DIRECTIONAL CONTROL: -3 DEGREES TAIL ROTOR BLADE PITCH ANGLE
5. WIND LESS THAN 3 KNOTS.

TOTAL DIRECTIONAL CONTROL TRAVEL: ±0.82 IN.

DEGREES
**Figure 81**

**DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND REMOTES**

<table>
<thead>
<tr>
<th>AVE HEIGHT (ft)</th>
<th>AVE DEPTH ALTITUDE (ft)</th>
<th>AVE OAT (°F)</th>
<th>AVE CG LOCATION (in)</th>
<th>AVE MOTOR SPEED (RPM)</th>
<th>AVE OF AVERAGE SPINDLE CONFL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>060</td>
<td>5080</td>
<td>48.4</td>
<td>19.3</td>
<td>922</td>
<td>.00074</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated ace vehicle.
3. Full left directional control = 127 degrees tail rotor blade pitch angle.
4. Full right directional control = 120 degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.

---

**Graphs:**
- **Graph 1:** Tail Rotor Blade Pitch Angle (degrees)
- **Graph 2:** Tail Rotor Blade Pitch Angle (degrees)
- **Graph 3:** Total Directional Control Travel (8.81 in)
- **Graph 4:** Directional Control Rotation (pitch) from full left to right

---

**Legend:**
- **Right Headwind**
- **Right Tailwind**
- **Left Tailwind**
- **Left Headwind**

Relative Wind Remoteness Degrees
FIGURE 61
DIRECTIONAL CONTROL OF VARIOUS RELATIVE WIND ANGLES
AN-12 U.S. NAVY VS. 10-2005

<table>
<thead>
<tr>
<th>AVE. GROSS</th>
<th>AVE. DENSITY</th>
<th>AVE. GATC</th>
<th>AVE. LOCATION</th>
<th>AVE. ROLL</th>
<th>AVE. YD.</th>
<th>AVE. TRUE</th>
<th>CONIFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT (LB)</td>
<td>ALTITUDE (FT)</td>
<td>TEMP (°C)</td>
<td>ALT (M)</td>
<td>SPEED (KMPH)</td>
<td>CD</td>
<td>AIRSPEED</td>
<td>(KMPH)</td>
</tr>
<tr>
<td>5000</td>
<td>2000</td>
<td>20.0</td>
<td>150.0</td>
<td>323</td>
<td>0.0</td>
<td>81</td>
<td>405</td>
</tr>
</tbody>
</table>

NOTES:
1. TRUE AIRSPEED IS THE VECTOREAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL +57 DEGREES THRUST MOTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL -63 DEGREES THRUST MOTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 5 KNOTS.

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.82 IN.

<table>
<thead>
<tr>
<th>0</th>
<th>60</th>
<th>120</th>
<th>180</th>
<th>240</th>
<th>300</th>
<th>360</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIGHT HEADWIND</td>
<td>RIGHT TAILWIND</td>
<td>LEFT HEADWIND</td>
<td>LEFT TAILWIND</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RELATIVE WIND AZIMUTH = DEGREES
**Figure 23**

**Directional Control at Various Relative Wind Angles**

<table>
<thead>
<tr>
<th>Avg Gross Weight (lb)</th>
<th>Ave Density Altitude (ft)</th>
<th>Ave GaT (C%)</th>
<th>Ave CG Location (in)</th>
<th>Ave Rotor Speed (rpm)</th>
<th>Ave Gy</th>
<th>Ave True Airspeed (kts)</th>
<th>Compl</th>
</tr>
</thead>
<tbody>
<tr>
<td>5200</td>
<td>2000</td>
<td>26.6</td>
<td>194.3</td>
<td>385</td>
<td>0.0076</td>
<td>26</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Notes:**

1. True airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control 1371°
4. Degrees tail rotor blade pitch angle.
5. Full right directional control 182°
6. Degrees tail rotor blade pitch angle.
7. Wind less than 3 knts.

**Total directional control travel = 5.88 in.**
### Table 1: Directional Control at Various Relative Wind Angles

<table>
<thead>
<tr>
<th>Relative Wind Aiming (Degrees)</th>
<th>0°</th>
<th>30°</th>
<th>90°</th>
<th>270°</th>
<th>330°</th>
<th>360°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Hand</td>
<td>Left Hand</td>
<td>Right Hand</td>
<td>Left Hand</td>
<td>Right Hand</td>
<td>Left Hand</td>
<td>Right Hand</td>
</tr>
<tr>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
</tr>
<tr>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
</tr>
<tr>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
</tr>
<tr>
<td>270°</td>
<td>270°</td>
<td>270°</td>
<td>270°</td>
<td>270°</td>
<td>270°</td>
<td>270°</td>
</tr>
<tr>
<td>330°</td>
<td>330°</td>
<td>330°</td>
<td>330°</td>
<td>330°</td>
<td>330°</td>
<td>330°</td>
</tr>
<tr>
<td>360°</td>
<td>360°</td>
<td>360°</td>
<td>360°</td>
<td>360°</td>
<td>360°</td>
<td>360°</td>
</tr>
</tbody>
</table>

### Notes:
1. True Airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control = 17°.
4. Full right directional control = 17°.
5. Full left motor blade pitch angle.
6. Full right motor blade pitch angle.
7. Wind less than 3 knots.

---

Diagram explaining directional control at various wind angles with curves illustrative of control travel and relative wind aiming.
### FIGURE 98

**DIRECTIONAL CONTROL AT VARIOUS RELATIVE GROUND VELOCITIES**

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (lb)</th>
<th>AVE GROSS WEIGHT (ft)</th>
<th>AVE GROUND SPEED (mph)</th>
<th>AVE ROTOR BLADE PITCH ANGLE</th>
<th>AVG Y</th>
<th>AVG TRUE AVERAGE (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>550</td>
<td>2000</td>
<td>22.0</td>
<td>104.5</td>
<td>0.45</td>
<td>50.0</td>
</tr>
</tbody>
</table>

**NOTES:**
1. TRUE AVERAGE IS THE VERTICAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED HODOMETER.
3. FULL LEFT DIRECTIONAL CONTROL 10° DEGESS THRU ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL 10° DEGESS THRU ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.
FIGURE 86

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND ANGLES

<table>
<thead>
<tr>
<th>AVE WEIGHT (lb)</th>
<th>AVE DENSITY ALTITUDE (ft)</th>
<th>AVE CG ELEVATION (in)</th>
<th>AVE ROTOR SPREAD (mph)</th>
<th>AVE CT</th>
<th>AVE TRUE AIRSPEED (MPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0200</td>
<td>2000</td>
<td>88.0</td>
<td>134.9</td>
<td>325</td>
<td>000600</td>
</tr>
</tbody>
</table>

NOTES:
1. TRUE AIRSPEED IS THE VECTORSUM
   OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH
   CALIBRATED RACE VEHICLE.
3. FULL LEFT DIRECTIONAL CONTROL +7.7
   DEGREES TWIN ROTOR BLADE PITCH ANGLE
4. FULL RIGHT DIRECTIONAL CONTROL -4.3
   DEGREES TWIN ROTOR BLADE PITCH ANGLE
5. WIND LESS THAN 3 KNOTS

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.02 IN.

DIRECTIONAL CONTROL ADJUSTMENT FROM FULL LEFT
Figure 8. Directional Control at Various Relative Wind Azimuths

<table>
<thead>
<tr>
<th>Relative Wind Azimuth</th>
<th>Right Narrow</th>
<th>Right Parallel</th>
<th>Left Parallel</th>
<th>Left Narrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>0°</td>
<td>180°</td>
<td>90°</td>
<td>270°</td>
</tr>
<tr>
<td>180°</td>
<td>0°</td>
<td>180°</td>
<td>90°</td>
<td>270°</td>
</tr>
<tr>
<td>90°</td>
<td>0°</td>
<td>180°</td>
<td>90°</td>
<td>270°</td>
</tr>
<tr>
<td>270°</td>
<td>0°</td>
<td>180°</td>
<td>90°</td>
<td>270°</td>
</tr>
</tbody>
</table>

Notes:
1. True Azimuth is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated hand-held device.
3. Full Left Directional Control 33° degrees tail rotor blade pitch angle.
4. Full Right Directional Control 33° degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.
Figure 68
DIRECTIONAL CONTROL OF VARIOUS RELATIVE WIND RELATIONSHIPS
AN-10 USAF 51-27558

<table>
<thead>
<tr>
<th>AVE GROSS WEIGHT (Lb)</th>
<th>AVE DENSITY ALTITUDE (FT)</th>
<th>AVE CO LOCATION (IN)</th>
<th>AVE ROVER SPEED (RPM)</th>
<th>AVE TRUE AIRSPEED (KTS)</th>
<th>AVE COMP.MO (DEG)</th>
<th>AVE FLAP. MO (DEG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6600</td>
<td>4060</td>
<td>10.8</td>
<td>194.5</td>
<td>320</td>
<td>1.004029</td>
<td>10</td>
</tr>
</tbody>
</table>

NOTES:
1. TRUE AIRSPEED IS THE VECTÖRAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED MACH NUNNEL.
3. FULL LEFT DIRECTIONAL CONTROL 20 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL 10 DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

TOTAL DIRECTIONAL CONTROL TRAVEL: 0.82 IN
### Figure 53

**Directional Control at Various Relative Wind Angles**

<table>
<thead>
<tr>
<th>AVE GROSS WEIGHT (lb)</th>
<th>AVE DENSITY ALTITUDE (ft)</th>
<th>AVE CG HEIGHT location (in)</th>
<th>AVE Rotor Speed (rpm)</th>
<th>AVE TRUE AVERAGE CASM</th>
<th>AVE TRUE AVERAGE EVCAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8360</td>
<td>8260</td>
<td>125</td>
<td>1,095</td>
<td>325</td>
<td>102.00</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed at the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated drogue vehicle.
3. Full left directional control = 15° deflection, 90° deflection = full right directional control.
4. Deflection 90° = full blade pitch angle.
5. Wind less than 3 knots.

---

**Graphs:**

- **Total Directional Control Travel:** 628 in
- **Recovery from Full Left:**
  - 0
  - 60
  - 120
  - 180
  - 240
  - 300
  - 360

**Legend:**
- **Right Recovery:**
  - **Right Tailwind:**
  - **Left Tailwind:**
- **Recovery from Full Left:**
  - **Right Tailwind:**
  - **Left Tailwind:**
  - **Left Recovery:**
**Figure 69**

**Directional Control at various Relative Wind Azimuths**

<table>
<thead>
<tr>
<th>Ave Gross Weight (lb)</th>
<th>Ave Velocity Altitude (ft)</th>
<th>Ave CG Location (in)</th>
<th>Ave Rotor Speed (RPM)</th>
<th>Ave Gyro</th>
<th>Ave Time Average Config (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.980</td>
<td>6800</td>
<td>18</td>
<td>1545</td>
<td>520</td>
<td>0.0200</td>
</tr>
</tbody>
</table>

**Notes:**

1. True average is the arithmetic mean of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control 170 degrees tail rotor blade pitch angle.
4. Full right directional control 168 degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.

**Diagram:**

- Total directional control travel = 0.02 in.
- Direction Positive - from full left to full right.
**Figure 12**

**Directional Control at Various Relative Wind Azimuths**

<table>
<thead>
<tr>
<th>Average Gross Weight (lb)</th>
<th>Average density Altitude (ft)</th>
<th>Average CG Location (in)</th>
<th>Average Rotor Speed (rpm)</th>
<th>Average Sp</th>
<th>Average True Airspeed (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>630</td>
<td>2900</td>
<td>13.0</td>
<td>1393</td>
<td>338</td>
<td>115</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control at 15° degrees tail rotor blade pitch angle.
4. Full right directional control at 15° degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.

---

**Graphs:**
- **Tail Rotor Blade Pitch Angle vs. Relative Wind Azimuth**
- **Tail Rotor Blade Pitch Angle vs. Total Directional Control Travel**
- **Total Directional Control Travel vs. Relative Wind Azimuth**

---

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Figure 68
Directional Control at Various Relative Wind Azimuth

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DESIRED ALTITUDE (FT)</th>
<th>AVG GAT (%)</th>
<th>AVG ROCKER LOCATION (IN)</th>
<th>AVG ROCKER SPEED (IN/HR)</th>
<th>AVG C/F</th>
<th>AVG TRUE AIRSPEED (KTAS)</th>
<th>AVG AIRSPEED CUMUL</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6330</td>
<td>4000</td>
<td>0.0</td>
<td>199.3</td>
<td>388</td>
<td>0.8</td>
<td>305</td>
<td>31</td>
<td>1/28</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control -17 degrees tail rotor blade pitch angle.
4. Full right directional control +17 degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.
**FIGURE 63**

**DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS**

<table>
<thead>
<tr>
<th>Average Gross Weight (lb)</th>
<th>Average Density Altitude (ft)</th>
<th>Average Site Location (ML)</th>
<th>Average Rotor Speed (rpm)</th>
<th>Average Thrust (HP)</th>
<th>Average Time Averaged (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>533</td>
<td>3,300</td>
<td>15.6</td>
<td>134.3</td>
<td>32.8</td>
<td>38.6</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Time averaged is the arithmetic mean of ground speed and wind velocity.
2. Ground speed determined with calibrated anemometer.
3. Full left directional control +177 degrees tail rotor blade pitch angle.
4. Full right directional control -177 degrees tail rotor blade pitch angle.
5. Wind less than 3 knots.

---

**Graphs:**
- Directional control from full left.
- Total directional control travel - 0.82 in.
### Diagram Description

**Title:** Directional Control of Merge

**Legend:**
- **Tail Rotor Blade Pitch Angle (Degrees):**
- **Total Directional Control Travel (Inches):**
- **Notes:**
  1. True airspeed is the vectorial sum of ground speed and wind velocity.
  2. Ground speed determined with calibrated pace vehicle.
  3. Full left directional control = 1.37 degrees tail rotor blade pitch angle.
  4. Full right directional control = 1.37 degrees tail rotor blade pitch angle.
  5. Wind less than 3 knots.

<table>
<thead>
<tr>
<th>AVE GROSS</th>
<th>AVE DEPOT ALTITUDE</th>
<th>AVE GELocation</th>
<th>AVE Rotor Rated HP</th>
<th>AVE True AIRSPEED</th>
<th>AVE True AIRSPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>6320</td>
<td>6360</td>
<td>105.5</td>
<td>326</td>
<td>.009100</td>
<td>42</td>
</tr>
</tbody>
</table>

**Diagram Notes:**
- $x$ value
- $y$ value

**Total Directional Control Travel = 6.25 inches**
**FIGURE 68**

**DIRECTIONAL CONTROL OF VARIOUS RELATIVE WIND ORIENTATIONS**

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (lb)</th>
<th>AVG DENSITY ALTITUDE (ft)</th>
<th>AVG CAS (KIAS)</th>
<th>AVG FLIGHT SPEED (KIAS)</th>
<th>AVG Q-</th>
<th>AVG TIME (MINUTES)</th>
<th>AVG CENTER OF CONTROL</th>
<th>AVG WIND DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>18000</td>
<td>30</td>
<td>120.3</td>
<td>324.0</td>
<td>0.00985</td>
<td>0</td>
<td>1000</td>
</tr>
</tbody>
</table>

**NOTES:**
1. TRUE AVERAGE IS THE VECTOREAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED DRAG SLED.
3. FULL LEFT DIRECTIONAL CONTROL = 15° DEGREES PLUS ROOF BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 15° DEGREES PLUS ROOF BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.

**Graphs:**
- **Pitch Angle Difference:**
- **Roll Angle Difference:**
- **Directional Control Travel:** 3.82 in.

**Legend:**
- RIGHT HEADING
- RIGHT TURNING
- LEFT TURNING
- LEFT HEADING
- RELATIVE WIND AZIMUTH DEGREES

---

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FIGURE 68
AVERAGE CONTROL AT VARIOUS RELATIVE WIND ANGLES
AVG USA 50' X 50' X 40'

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS WEIGHT (LB)</td>
<td>DENSITY (CT)</td>
<td>ALTITUDE (FT)</td>
<td>LOCATION (M)</td>
<td>SPEED (K)</td>
</tr>
<tr>
<td>1000</td>
<td>1000</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

NOTES:
1. TRUE AIRSPEED IS THE VECTORES SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED ACE VEHICLE.
3. PULL LEFT DIRECTIONAL CONTROLS V.P.
4. DEGREES TAIL ROTOR BLADE PITCH ANGLE.
5. PULL RIGHT DIRECTIONAL CONTROLS V.P.
6. DEGREES TAIL ROTOR BLADE PITCH ANGLE.
7. WIND LESS THAN 8 KNOTS.

TOTAL DIRECTIONAL CONTROL TRAVEL = 0.88 MW
### Figure G7
Directional Control at Various Relative Wind Directions
Aging Data Jan 73 to 2058

<table>
<thead>
<tr>
<th>Average Weight (Lb)</th>
<th>Average Density Altitude (ft)</th>
<th>Average CG (In)</th>
<th>Power Speed (RPM)</th>
<th>Average True Airspeed (Kts)</th>
<th>Average Directional Control Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>1500</td>
<td>8.4</td>
<td>124.3</td>
<td>220</td>
<td>103</td>
</tr>
</tbody>
</table>

**Notes:**
1. True Airspeed is the horizontal sum of ground speed and wind velocity.
2. Ground speed determined with calibrated pace vehicle.
3. Full left directional control 120 degrees tail rotor blade pitch angle.
4. Full right directional control 120 degrees tail rotor blade pitch angle.
5. Wind less than 5 knots.

---

**Diagram:**
- Total Directional Control Travel = 6.8 in.
- Relative Wind Magnitude
  - Right Heading
  - Right Trailblaze
  - Left Trailblaze
  - Left Heading

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### Figure 68
**DIRECTIONAL CONTROL AT VARIOUS ALTITUDES AND VELOCITIES**

<table>
<thead>
<tr>
<th>AVG</th>
<th>ALTITUDE (FT)</th>
<th>AVG</th>
<th>LOCATION (MI)</th>
<th>AVG</th>
<th>ROLL</th>
<th>AVG</th>
<th>TRUE</th>
<th>AVG</th>
<th>SPEED (KIAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G 60</td>
<td>1/800</td>
<td>1/600</td>
<td>1/400</td>
<td>320</td>
<td>288</td>
<td>21</td>
<td>140</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. True airspeed is the vectorial sum of ground speed and wind velocity.
2. Ground speed determined with calibrated airspeed.
3. Full left directional control at 100 degrees tail rotor blade pitch angle.
4. Full right directional control at 100 degrees tail rotor blade pitch angle.
5. Wind less than 5 knots.
### Table: Directional Control of Various Relative Wind Angles

<table>
<thead>
<tr>
<th>RELATIVE WIND ANGLE (DEG)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
<th>AVERAGE DIRECTIONAL CONTROL (IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>120</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>150</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>180</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Notes:
1. TRUE AVERAGE IS THE VECTORD SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PROPELLERS.
3. FULL LEFT DIRECTIONAL CONTROL = 7 DEGREES FULL ROTOR BLADE PITCH ANGLE.
4. FULL RIGHT DIRECTIONAL CONTROL = 7 DEGREES FULL ROTOR BLADE PITCH ANGLE.
5. WIND LESS THAN 3 KNOTS.
FIGURE 10
TRIMMED SIDeward AND Rearward FLIGHT
AH-1G UnC 35M 11-22-88

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVE DENSITY (FT)</th>
<th>AVE GAT (°)</th>
<th>AVE CC LOCATION (IN)</th>
<th>AVE AUTO SPEED (RPM)</th>
<th>AVE Cm CONTIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2840</td>
<td>2820</td>
<td>12.6</td>
<td>1.9</td>
<td>325</td>
<td>-0.0003</td>
</tr>
</tbody>
</table>

NOTE:
1. TRUE AIRSPEED DETERMINED WITH CALIBRATED POSE CAP.
2. FULL LEFT DIRECTIONAL CONTROL = 15°
3. FULL TAIL ROTOR BLADE PITCH ANGLE.
4. S/N/0 HAWK = 7 FT AS FART.

TOTAL COLLECTIVE CONTROL TRAVEL = 3.81/IN.

TOTAL DIRECTIONAL CONTROL TRAVEL = 3.82/IN.

TOTAL LATERAL CONTROL TRAVEL = 10.06/IN.

TOTAL CONSTRUCTIONAL CONTROL TRAVEL = 3.82/IN.
**Figure 31**

**Trimmed-Sideboard and Rearward Flight**

**AN-16 USAF IN 71-R-686**

<table>
<thead>
<tr>
<th>Average Acro Weight (LB)</th>
<th>Average Altitude (FT)</th>
<th>Average Bearing (ML)</th>
<th>Average Rudder Speed (mph)</th>
<th>Average CT</th>
<th>Gunfire</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>50</td>
<td>100</td>
<td>50</td>
<td>200</td>
<td>No</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed determined with calibrated pressure.
2. Full left directional control/3.7 degrees true rudder blade/pitch angle.
3. Sky height=7 to 16 feet.

**Total Collective Control Travel = 3.21 in.**

**Total Directional Control Travel = 5.82 in.**

**Total Lateral Control Travel = 10.86 in.**

**Total Longitudinal Control Travel = 5.82 in.**

**True Airspeed ~ Knots**
**Figure 70**

**Trimmed Sideways and Rearward Flight**

<table>
<thead>
<tr>
<th>AVG LOAD</th>
<th>AVG ROLL</th>
<th>AVG ROLL &amp; Yaw</th>
<th>AVG Yaw &amp; Roll</th>
<th>AVG Yaw &amp; Pitch</th>
<th>AVG Pitch &amp; Roll</th>
<th>AVG Pitch &amp; Yaw</th>
<th>AVG Yaw &amp; Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lb)</td>
<td>(Ft)</td>
<td>(Ft)</td>
<td>(Ft)</td>
<td>(Ft)</td>
<td>(Ft)</td>
<td>(Ft)</td>
<td>(Ft)</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Notes:**
1. True airspeed determined with calibrated AOA gauge.
2. Full left directional control = 25 degrees from normal blade pitch angle.
3. Skin height = 7 to 10 feet.

**Total Collective Control Travel = 3.21 in.**

**Total Directional Control Travel = 6.88 in.**

**Total Lateral Control Travel = 1.02 in.**

**Total Longitudinal Control Travel = 3.82 in.**

**True Airspeed = Knots**
### Figure 70

**Summary of Aircraft Response Factors**

A Simulated Engine Failure

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>6000</td>
<td>8000</td>
<td>2.5</td>
<td>150.0</td>
<td>32.0</td>
</tr>
<tr>
<td>Climb</td>
<td>8000</td>
<td>1200</td>
<td>2.2</td>
<td>150.0</td>
<td>32.0</td>
</tr>
<tr>
<td>Descent</td>
<td>6000</td>
<td>8000</td>
<td>2.0</td>
<td>150.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

*Note:*

1. Open symbols denote scas on.
2. Solid symbols denote scas off.

---

**Graphs:**

- Aircraft performance metrics such as maximum deviation, pitch, and roll in response to various flight conditions.
- Calibrated airspeed vs. knots.

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