Design Verification and Fabrication of Active Control Systems for the DAST ARW-2 High Aspect Ratio Wing, Part 2 - Appendices

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This volume contains the appendices for Boeing document D500-10897-1, "Design Verification and Fabrication of Active Control Systems for the DAST ARW-2 High Aspect Ratio Wing", the final report summarizing the work accomplished under Contract NAS1-16010.

Appendix A contains data defining the aerodynamics and inertias used in the airplane and control systems linear analyses and nonlinear simulation. A study is presented in Appendix B that compares servoactuator bench test results to analysis and investigates various factors that affect actuator performance and stability. Appendix C contains data which summarizes the airplane stability and performance with the final flutter suppression system. The data contained in Appendix D shows stability and performance sensitivity to variation in the dynamics and location of the control system components. Appendix E contains data that shows the relative gain and phase stability margins of each individual ACS and AFCS feedback loop and the compatibility of the combined loops.
APPENDIX A

DAST ARW-2 AERODYNAMIC, INERTIA AND THRUST DATA

This appendix contains the aerodynamic and inertia data used in airplane and control systems linear analyses and non-linear simulation. It also contains speed brake and thrust data used in the determination of speed brake requirements.

List of data included:

- Longitudinal derivatives
  
  25 percent MAC C.G.
  8 flight conditions

- Lateral-directional derivatives
  
  25 percent MAC C.G.
  8 flight conditions

- Non-linear C_L and C_M versus alpha
  
  8 flight conditions

- Moments of inertia
  
  3 weight-C.G. combinations, body axis

- Plots of C_D versus alpha with speed brakes

- Plots of thrust versus altitude for constant Mach numbers and percent RPM
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<th>HIGH ALTITUDE</th>
<th>CRUISE</th>
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**FIGURE 1** LONGITUDINAL STABILITY DERIVATIVES AND TRIM COEFFICIENTS
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<tr>
<td>C_z, r</td>
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**FIGURE 2** LATERAL-DIRECTIONAL STABILITY DERIVATIVES
APPENDIX A

- MACH: 0.40
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

FIGURE 3

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, LAUNCH CONDITION
MACH: 0.40
ALTITUDE: 15,000 FEET
STABILIZER: 0.0

FIGURE 4
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, LAUNCH CONDITION
APPENDIX A

- MACH: 0.42
- ALTITUDE: 10,000 FEET
- STABILIZER: 0.0

FIGURE 5

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA TEST CONDITION
APPENDIX A

- MACH: 0.42
- ALTITUDE: 10,000 FEET
- STABILIZER: 0.0

FIGURE 6
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA TEST CONDITION
APPENDIX A

- MACH: 0.35
- ALTITUDE: SEA LEVEL
- STABILIZER: 0.0

FIGURE 7

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA DESIGN CONDITION
APPENDIX A

• MACH: 0.35
• ALTITUDE: SEA LEVEL
• STABILIZER: 0.0

FIGURE 8

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA DESIGN CONDITION
APPENDIX A

- MACH: 0.70
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

FIGURE 9
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA TEST CONDITION
- MACH: 0.70
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

FIGURE 10
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA TEST CONDITION
APPENDIX A

- MACH: 0.60
- ALTITUDE: 7,000 FEET
- STABILIZER: 0.0

FIGURE 11
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA DESIGN CONDITION
APPENDIX A

ORIGIAL FAX IS OF POOR QUALITY

- MACH: 0.60
- ALTITUDE: 7,000 FEET
- STABILIZER: 0.0

FIGURE 12
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA DESIGN CONDITION
APPENDIX A

- MACH: 0.70
- ALTITUDE: 50,000 FEET
- STABILIZER: 0.0

FIGURE 13
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, HIGH ALTITUDE CONDITION
APPENDIX A

- MACH: 0.70
- ALTITUDE: 50,000 FEET
- STABILIZER: 0.0

FIGURE 14

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, HIGH ALTITUDE CONDITION
APPENDIX A

- MACH: 0.80
- ALTITUDE: 46,800 FEET
- STABILIZER: 0.0

FIGURE 15
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, CRUISE CONDITION
APPENDIX A

- MACH: 0.80
- ALTITUDE: 46,800 FEET
- STABILIZER: 0.0

FIGURE 16
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, CRUISE CONDITION
APPENDIX A

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

FIGURE 17

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX A

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

FIGURE 18
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK,
MAXIMUM DYNAMIC PRESSURE CONDITION
### APPENDIX A

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LBS)</th>
<th>C.G. (% MAC)</th>
<th>*MOMENT OF INERTIA (SLUG-FT²)</th>
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<tr>
<td></td>
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<td>IXX</td>
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<tr>
<td>2500</td>
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<tr>
<td>2200</td>
<td>32.75</td>
<td>163.1</td>
</tr>
</tbody>
</table>

*BODY AXIS

**FIGURE 19**

MOMENTS OF INERTIA
FIGURE 20

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES
FIGURE 21

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES
FIGURE 22

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES
FIGURE 23
DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES
FIGURE 24

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES
FIGURE 25
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES

FIGURE 26

NOT CORRECTED FOR FLEXIBILITY

APPENDIX A

ORIGINAl PAGE IS
OF POOR QUALITY
FIGURE 27
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES
FIGURE 28

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES
FIGURE 29

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES
FIGURE 30
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES
FIGURE 31
PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES
FIGURE 32
THRU'T DATA FOR 80 PERCENT ENGINE RPM
FIGURE 33
THRUSt DATA FOR 85 PERCENT ENGINE RPM
APPENDIX A

FIGURE 34

THRUST DATA FOR 90 PERCENT ENGINE RPM
FIGURE 35
THRUST DATA FOR 95 PERCENT ENGINE RPM
FIGURE 36
THRUST DATA FOR 100 PERCENT ENGINE RPM
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Appendix B
DAST ARW-2 Outboard Aileron Servovalve Relocation Study

This appendix contains a study (see Figure 37) initiated when data obtained during bench testing of the servoactuator of DAST ARW-1 did not compare favorably with the model used for analysis.

The testing was conducted to determine if the DAST ARW-2 outboard aileron servovalves should be moved outboard closer to the actuators. Line lengths, load variations and position feedback gain variations were investigated.
APPENDIX B

COORDINATION SHEET

TO Gary Hodges

NO. 3-75610-79-015

DATE 31 October 1979

MODEL DAST ARW-2

GROUP INDEX Flight Controls Analysis

SUBJECT DAST ARW-2 Outboard Aileron Servovalve Relocation Study

1.0 INTRODUCTION AND SUMMARY

The DAST ARW-1 outboard aileron servoactuators installed in the test vehicle have about 84 inches of 3/16-inch outside diameter steel tubing between the servovalves mounted in the center wing section and the actuators mounted out in the wing at the inboard edges of the ailerons. Ground testing on the test vehicle shows higher frequency servoactuator modes, at about 112, 155 and 380 hertz, which cause servoactuator instability at the desired feedback gains. In addition, a lower frequency dominant mode with peak at 30-60 hertz has been shown by analysis to couple adversely with wing structural elastic modes with the flutter suppression systems engaged. The higher frequency modes required addition of notch filters to reduce actuator gain at the mode frequencies. The lower frequency dominant mode will also require additional compensation to provide satisfactory performance from the flutter suppression system on the test vehicle.

As part of the subject study, testing was accomplished on a breadboard of the DAST ARW-I outboard aileron servoactuator to establish the effects of line length between the servovalve and actuator and load inertia variations on the servoactuator dynamic performance. The testing was conducted to determine if the DAST ARW-2 outboard aileron servovalves should be moved outboard closer to the actuators and, if so, how much to alleviate the difficulties encountered with the DAST ARW-1 servoactuator:

The test results show that the servoactuator bandpass does not improve significantly as the length of the lines between the servoactuator and servovalve is shortened. In general, damping of the dominant, low frequency hydraulic fluid-actuator coupled mode increases as line length is shortened and as control surface inertia is decreased. But, the frequency of this mode, with position and pressure feedback gains constant, does not vary significantly with line length or load inertia variations.

The dominant mode, which appears to be a coupled hydraulic fluid-actuator mode, does not vary significantly in frequency or damping with changes in position feedback loop gain. The general trend is to decrease frequency and damping as position feedback gain increases. Pressure feedback increases the damping on this mode, but decreases damping on higher frequency fluid modes.

The two higher frequency fluid modes increase in frequency as the servovalve is moved closer to the actuator. With full length (84-inch) lines, the modes are at 160 and 380 hertz, but with lines reduced by half, the lower frequency mode is at 230 hertz and the other above 500 hertz.

FIGURE 37

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
The test results show that improved performance can be attained with shorter lines and reduced control surface inertia. The DAST ARW-2 outboard aileron servovalve should be moved farther outboard in the wing and the control surface inertia should be reduced. While this should improve the servoactuator performance, additional electronic compensation may be required to provide satisfactory performance from the flutter suppression system.

2.0 TEST RESULTS

The tests were conducted on a breadboard of the DAST ARW-1 outboard aileron servoactuator set up in the Hydraulics Laboratory. Position and load pressure feedback loops were closed on an EAI TR-48 analog computer. A 741 operational amplifier with current feedback was used to drive the electrohydraulic servovalve. Hydraulic power was provided by a portable hydraulic power unit capable of about 5 gallons per minute. The test set up with long lines between the servovalve and actuator was identical to the servoactuator functional test set up in August 1978.

The simulated load inertia used in the functional test was cut in half with a long bolt added so testing could be accomplished with full or half inertia, or with no inertia by removing the inertia from the actuator shaft. The lines between the servovalve and actuator used for the functional test were used for the full length lines tests. Another pair of lines were made up for the shorter lines tests.

Three groups of tests were accomplished. The first series were frequency response tests with variations in line length and simulated control surface inertia. The second series of tests were all with full line length to determine more exactly the nature of the dynamic response. In the third set, dynamic responses were obtained with full and 10-inch lines with position feedback gain variations.

Each time a change in the lines was made, the lines were bled and the actuator oscillated 4 or 5 degrees amplitude at 10 Hz for about 5 minutes to preclude air being trapped in the lines and actuator.

2.1 Line Length and Load Inertia Variations

The servoactuator was first set up with the full length lines (84 inches) and frequency responses obtained for actuator shaft displacement due to displacement command for full (0.004 in-lb-sec^2), half and no load inertia. Then, the line length was shortened to three-quarter (63 inches), half (42 inches), one-quarter (21 inches) and the shortest practical lines (10 inches), consecutively, and the same frequency responses obtained. The resulting plots are shown on Figures 1 through 15. These frequency responses were all run with the nominal position and pressure feedback loop gains, 329.6 rad/sec and 0.5678 rad/sec, respectively. Different notch filters were required as the lines were shortened, because the higher frequency fluid modes increased in frequency.

The notch filters implemented in the servoactuator feedforward path for each of the line lengths are tabulated below.
The frequency responses all show a first order roll-off followed by a dominant mode peak in the 50-60 hertz range. Table I shows a summary of the frequency responses. In general, for a given line length, reducing the load inertia increased damping of the dominant mode (reduced peak magnitude), but changing line length did not affect this mode significantly in either damping or frequency. The dominant mode appears to be the coupled hydraulic fluid-actuator mode. With full load inertia, the actuator-surface mode is at 110-115 hertz.

With full length lines, higher frequency fluid modes are evident at 160 and 380 hertz (a notch filter was required at 380 hertz to reach the nominal feedback gains). With the lines reduced to 63 inches, these modes are at about 185 and 460 hertz. At half line length, the lower frequency mode has moved up to 230 hertz and the other is above 500 hertz. Thus, the two higher frequency fluid modes increase in frequency as the lines are shortened. The 230 hertz mode evident in the frequency responses with 10-inch lines is the servovalve. The servovalve mode is not apparent in the other frequency responses.

The dominant mode appears to change in damping and frequency with time. Figure 16 shows the frequency response of actuator position obtained in the functional tests in September 1978, with full length lines, full inertia and the same position and pressure feedback gains and notch filter as the response shown on Figure 1. The functional test frequency response shows the dominant mode peak at 72 hertz with amplitude about 2.27 degrees for the one degree amplitude command. Figure 1 shows the peak at 60 hertz with amplitude of about 2.03 degrees. The frequency response obtained during the functional test was run for 0.1 to 100 hertz frequency range, so the higher frequency modes cannot be compared. The 380 hertz mode was present and a notch filter at 380 hertz was required to attain the desired feedback gains. The difference in this mode would tend to suggest air was entrapped in the lines during the current test, but efforts were made to eliminate trapped air before any data was taken.

2.2 Dominant Mode Tests

After completion of the line length variation tests, the servoactuator breadboard was reassembled with the full length lines. Figures 17, 18 and 19 show frequency responses obtained at this time for full, half and no load inertia, respectively. A comparison of these plots with responses obtained initially,
Figures 1, 2 and 3, show the dominant mode to be lighter damped and at lower frequency. This response is more like that obtained on the servo-actuators installed in the DAST ARM-1 vehicle. Throughout the remainder of the testing on the breadboard setup, the response changed some from day to day, but essentially was the same.

A frequency response with the load inertia removed and low position feedback gain (90.91 rad/sec) only was run to compare with a response obtained during the DAST ARM-1 functional tests. The two responses are plotted on Figure 20. The dominant mode frequency is at 100 hertz for both responses. The lower frequency differences in the responses are probably due to actuator friction, with the friction less now than a year ago. However, the measured phase angles agree very well throughout the frequency range tested.

The hydraulic fluid mode at 160 hertz also changed some in nature. A notch filter had to be added when the breadboard was revised to return to full length lines. This notch was not required during the functional tests or when the breadboard was first assembled for the current tests.

A frequency response of the valve drive amplifier output voltage, shown on Figure 21, was run for a one degree actuator command, to determine if amplifier saturation was occurring. Near the dominant mode peak frequency, around 60 hertz, the voltage peaks at about 2.70 volts, with the maximum peak at 500 hertz of about 15.2 volts. Thus, the dominant mode is not being caused by nonlinear effects due to valve drive amplifier saturation.

Figure 22 shows the servoactuator frequency response obtained with the hydraulic supply pressure increased to 2000 psi. The dominant mode peak occurs at 62 hertz, slightly higher than obtained with 1500 psi supply pressure shown on Figure 17. Supply pressure does not affect the servoactuator dynamic response significantly.

2.3 Position Feedback Gain Variations

The final set of data run on the DAST ARM-1 outboard aileron servoactuator breadboard consisted of frequency responses for actuator displacement and load pressure for four low position loop gains and no pressure feedback or notch filters. Figures 23 through 26 show the actuator responses for the full length lines, and Figures 27 through 30 show the corresponding load pressure frequency responses. The actuator responses for 10-inch lines are shown on Figures 31 through 34 and Figures 35 through 38 show load pressure responses. The responses were obtained to determine if the dominant mode was affected by position feedback for the full length and 10-inch lines.

The four gains run were 19.18, 38.36, 76.72 and 115.08 rad/sec. The first two were obtained using a 2 degree command because the response was so small at the higher frequency fluid mode frequencies.
The dominant mode frequency, with full length lines, show only a weak dependence on position feedback gain. The peak frequency varies from about 85 hertz at 19.18 rad/sec down to about 80 hertz at 115.08 rad/sec. The higher frequency fluid modes are more apparent in the load pressure frequency responses.

The responses with 10-inch lines show little effect on the dominant mode frequency by the position loop gain. The peak occurs at about 85 hertz, except for the highest gain, 115.08 rad/sec, when it drops to about 82 hertz. With 10-inch lines, position feedback gain could be raised to higher loop gain without driving the dominant mode unstable than with full length lines.

In general, results of these tests show little dependence of the dominant mode on position feedback gain, in either frequency or damping. Mode damping is hard to assess because as position loop gain is increased the first order actuator mode moves farther out on the real axis, resulting in increased response at the dominant mode frequency.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The test results discussed in Section 2, above, show that the dominant mode in the DAST ARW-1 outboard aileron response limits the dynamic performance capability of the servoactuator. Because the DAST ARW-2 outboard aileron servoactuator is similar in structure and actuator size, it will also have a dominant fluid-actuator mode of similar frequency and damping which will limit its capability.

This mode is not a strong function of line length (between the servovalve and actuator) or position feedback gain. The nature of the response does vary some with time, probably due to actuator and servovalve wear-in. The higher frequency modes increase in frequency as the line length is shortened, with the higher frequency mode above 500 hertz for 42-inch and shorter lines.

The dominant mode damping increased with a decrease in the simulated control surface inertia, but the inertia had no effect on the higher frequency fluid modes.

While the test results are not totally conclusive, the general trend shows that better dynamic performance can be attained with shorter lines between the servovalve and actuator and with lower control surface inertia. Therefore, it is recommended that the DAST ARW-2 outboard aileron servoactuator be moved outboard in the wing from that shown on the design drawings to no more than 40-45 inches from the actuator between the wing spars. Also, the inertia of the outboard aileron should be reduced to the lowest value consistent with maintaining structural strength.

FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
A more accurate mathematical representation of the outboard aileron servo-actuator should be developed to permit analytical exploration for additional electrical compensation to improve the actuator response. The data generated in this series of tests should aid in the mathematical formulation.

Other tests could be run on the breadboard test setup, such as other compensation and line diameter variations. Changing line diameter would require a change in the feedback potentiometer mounting to provide clearance for larger tube fittings at the actuator ports.

F. Sevart

CC: J. Arnold
## APPENDIX B

### TABLE 1

<table>
<thead>
<tr>
<th>LINE LENGTH</th>
<th>INERTIA</th>
<th>DOMINANT MODE</th>
<th>FREQUENCY PEAK AMPLITUDE (IN-HZ)</th>
<th>90° PHASE DELAY</th>
<th>HIGHER FREQUENCY MODES (FREQUENCY - Hz)</th>
<th>SERVO-VALVE</th>
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<td>FULL (84 INCHES)</td>
<td>FULL</td>
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<th>DOMINANT MODE</th>
<th>FREQUENCY PEAK AMPLITUDE (IN-HZ)</th>
<th>90° PHASE DELAY</th>
<th>HIGHER FREQUENCY MODES (FREQUENCY - Hz)</th>
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<th>DOMINANT MODE</th>
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<th>FREQUENCY PEAK AMPLITUDE (IN-HZ)</th>
<th>90° PHASE DELAY</th>
<th>HIGHER FREQUENCY MODES (FREQUENCY - Hz)</th>
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### FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
NOTE:
FULL LINE LENGTH (84 INCHES)
FULL LOAD INERTIA (0.004 IN-LB-SEC^2)
1.00 DEG COMMAND AMPLITUDE

FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

FIGURE 1. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARM-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

NOTE:
- 3/4 LINE LENGTH (63 INCHES)
- FULL LOAD INERTIA (0.004 IN.-LB-SEC²)
- 1.00 DEG COMMAND AMPLITUDE

FIGURE 4. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, FULL LOAD INERTIA
FIGURE 37 (CONTINUED)

CAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

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FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
APPENDIX B

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

74
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 15. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, NO LOAD INERTIA

NOTE: 10-INCH LINE LENGTH
NO LOAD INERTIA
1.00 DEG COMMAND AMPLITUDE

FIGURE 37 (CONTINUED)

DAST ARM-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
APPENDIX B

Figure 37 (Continued)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

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FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

APPENDIX B
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARDAILERON SERVOVALVERELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARDAILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

APPENDIX B
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILeron SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

93
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)
DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONCLUDED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
This appendix contains data which summarizes the airplane stability and performance with the final flutter suppression system.

Figures 38 through 47 show the symmetric and antisymmetric mode damping ratios and frequencies for the critical flight conditions determined from analysis. This data verifies that the FSS meets the requirements to provide flutter mode stability and not reduce mode damping ratio below 0.01 or degrade damping of modes with damping ratios below 0.01.

Figures 48 through 59 show the improvement in flutter mode damping with the FSS operating. Damping ratio data is presented as a function of altitude and Mach number.

Figures 60 through 71 present root loci showing structural mode stability for flight conditions within the specified flight envelope. Figures 66, 67, 69 and 71 show the requirement for FSS antisymmetric filter gain scheduling and with gain scheduling, the FSS meets the specifications contained in the final report.
### APPENDIX C

- MACH: 0.80
- ALTITUDE: 2,000 FEET
- UNSCALED EOM

<table>
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<tr>
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<th>CLOSED LOOP</th>
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<td>FREQUENCY (HZ)</td>
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<td>67.6099</td>
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**Figure 38**

Symmetric elastic mode damping and frequency, MACH: 0.80, ALTITUDE: 2,000 FEET, UNSCALED EOM
- MACH: 0.83
- ALTITUDE: 3,000 FEET
- UNSCALED EOM

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<th>CLOSED LOOP</th>
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<td>DAMPING ((\zeta))</td>
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</tr>
<tr>
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</tr>
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<td>ACTUATOR NOTCH</td>
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<tr>
<td>FILTER</td>
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<td>75.9960</td>
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**FIGURE 39**

SYMmetric ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.83, ALTITUDE: 3,000 FEET
UNSCALED EOM
<table>
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<tr>
<th>MODE</th>
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<th>CLOSED LOOP</th>
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<tbody>
<tr>
<td></td>
<td>DAMPING ($\zeta$)</td>
<td>FREQUENCY (Hz)</td>
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<tr>
<td>$q_1$ (FLUTTER MODE)</td>
<td>0.0122</td>
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</table>

**FIGURE 40**

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.86, ALTITUDE: 4,500 FEET
UNSCALED EOM
### APPENDIX C

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP DAMPING ($\zeta$)</th>
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<th>CLOSED LOOP DAMPING ($\zeta$)</th>
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**Symmetric Elastic Mode Damping and Frequency, MACH: 0.83, ALTITUDE: 12,000 FEET, UNSCALED EOM**

**Figure 41**
### APPENDIX C

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- UNSCALED EOM

<table>
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<td>FREQUENCY (HZ)</td>
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<td>((\xi))</td>
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<tr>
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**Figure 42**

Symmetric elastic mode damping and frequency, MACH: 0.86, ALTITUDE: 15,000 FEET
UNSCALED EOM
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<td>DAMPING ((\xi))</td>
<td>FREQUENCY (HZ)</td>
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</table>

**FIGURE 43**

Symmetric elastic mode damping and frequency, Mach: 0.91, Altitude: 8,000 Feet
Unscaled EOM
<table>
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<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP</th>
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</tr>
</thead>
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<tr>
<td></td>
<td>DAMPING ($\zeta$)</td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING ($\zeta$)</td>
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<tr>
<td>$q_1$ (FLUTTER MODE)</td>
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</tr>
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<td>$q_{10}$</td>
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<td>70.9873</td>
<td>0.0166</td>
</tr>
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<td>0.3997</td>
<td>49.9746</td>
<td>0.3997</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
<td>0.2389</td>
<td>75.9964</td>
<td>0.1453</td>
</tr>
<tr>
<td>FILTER</td>
<td>0.2995</td>
<td>75.9964</td>
<td>0.3397</td>
</tr>
<tr>
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<td>1.0000</td>
<td>101.8590</td>
<td>1.0000</td>
</tr>
<tr>
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<td>0.9998</td>
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<td>1.0000</td>
<td>3.1986</td>
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<tr>
<td>FILTER</td>
<td>1.0000</td>
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<td>0.5507</td>
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<tr>
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<td>1.0000</td>
<td>23.8854</td>
<td>0.9421</td>
</tr>
<tr>
<td>NOTCH 1</td>
<td>0.9089</td>
<td>15.7675</td>
<td>0.8963</td>
</tr>
<tr>
<td>NOTCH 2</td>
<td>0.3610</td>
<td>17.5159</td>
<td>0.8314</td>
</tr>
</tbody>
</table>

**FIGURE 44**

Antisymmetric elastic mode damping and frequency with parameter scheduling, Mach: 0.91, Altitude: 4,250 feet, Unscaled EOM
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th></th>
<th>CLOSED LOOP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAMPING ($\zeta$)</td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING ($\zeta$)</td>
<td>FREQUENCY (HZ)</td>
</tr>
<tr>
<td>$q_1$ (FLUTTER MODE)</td>
<td>0.0064</td>
<td>20.1646</td>
<td>0.0178</td>
<td>20.2533</td>
</tr>
<tr>
<td>$q_2$</td>
<td>-0.1899</td>
<td>23.1418</td>
<td>0.0777</td>
<td>26.8312</td>
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<tr>
<td>$q_3$</td>
<td>0.0054</td>
<td>22.1658</td>
<td>0.0090</td>
<td>22.1938</td>
</tr>
<tr>
<td>$q_4$</td>
<td>0.5910</td>
<td>21.9851</td>
<td>0.2517</td>
<td>21.9972</td>
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<tr>
<td>$q_5$</td>
<td>0.0566</td>
<td>36.8325</td>
<td>0.0541</td>
<td>37.0458</td>
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<tr>
<td>$q_6$</td>
<td>0.0503</td>
<td>44.0965</td>
<td>0.0503</td>
<td>44.1000</td>
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<tr>
<td>$q_7$</td>
<td>0.0074</td>
<td>47.3661</td>
<td>0.0074</td>
<td>47.3575</td>
</tr>
<tr>
<td>$q_8$</td>
<td>0.0226</td>
<td>66.8679</td>
<td>0.0224</td>
<td>66.8731</td>
</tr>
<tr>
<td>$q_9$</td>
<td>0.0213</td>
<td>70.1247</td>
<td>0.0213</td>
<td>70.1275</td>
</tr>
<tr>
<td>$q_{10}$</td>
<td>0.0166</td>
<td>74.0549</td>
<td>0.0220</td>
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<td>SERVOVALVE ACTUATOR</td>
<td>0.3997</td>
<td>49.9746</td>
<td>0.3997</td>
<td>49.9746</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
<td>0.2398</td>
<td>75.9964</td>
<td>0.1453</td>
<td>76.5859</td>
</tr>
<tr>
<td>FILTER</td>
<td>0.2995</td>
<td>75.9964</td>
<td>0.3397</td>
<td>106.6853</td>
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<td>FILTER</td>
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<td>101.8590</td>
<td>1.0000</td>
<td>64.6007</td>
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<td>49.6563</td>
<td>0.9998</td>
<td>40.8756</td>
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<tr>
<td>FILTER</td>
<td>1.0000</td>
<td>0.3183</td>
<td>0.0960</td>
<td>0.2884</td>
</tr>
<tr>
<td>FILTER</td>
<td>1.0000</td>
<td>278.5212</td>
<td>0.5507</td>
<td>285.9078</td>
</tr>
<tr>
<td>FILTER</td>
<td>1.0000</td>
<td>23.8732</td>
<td>1.0000</td>
<td>23.8732</td>
</tr>
<tr>
<td>NOTCH 1</td>
<td>0.9089</td>
<td>15.7601</td>
<td>0.9196</td>
<td>14.0567</td>
</tr>
<tr>
<td>NOTCH 2</td>
<td>0.3610</td>
<td>17.5070</td>
<td>0.3085</td>
<td>7.7074</td>
</tr>
</tbody>
</table>

**FIGURE 45**

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.83, ALITUDE: 12,000 FEET, UNSCALED EOM
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th></th>
<th>CLOSED LOOP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAMPING (c)</td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING (c)</td>
<td>FREQUENCY (Hz)</td>
</tr>
<tr>
<td>q1 (FLUTTER MODE)</td>
<td>0.0032</td>
<td>20.1276</td>
<td>0.0323</td>
<td>19.7278</td>
</tr>
<tr>
<td>q2</td>
<td>-0.1372</td>
<td>21.4575</td>
<td>0.0713</td>
<td>21.9226</td>
</tr>
<tr>
<td>q3</td>
<td>0.0040</td>
<td>22.1686</td>
<td>0.0107</td>
<td>22.2626</td>
</tr>
<tr>
<td>q4</td>
<td>0.4735</td>
<td>25.1816</td>
<td>0.2325</td>
<td>26.6431</td>
</tr>
<tr>
<td>q5</td>
<td>0.0602</td>
<td>36.8933</td>
<td>0.0556</td>
<td>36.8799</td>
</tr>
<tr>
<td>q6</td>
<td>0.0487</td>
<td>44.0945</td>
<td>0.0487</td>
<td>44.0945</td>
</tr>
<tr>
<td>q7</td>
<td>0.0077</td>
<td>47.3698</td>
<td>0.0078</td>
<td>47.3650</td>
</tr>
<tr>
<td>q8</td>
<td>0.0214</td>
<td>66.9585</td>
<td>0.0212</td>
<td>66.9546</td>
</tr>
<tr>
<td>q9</td>
<td>0.0209</td>
<td>70.4047</td>
<td>0.0208</td>
<td>70.4031</td>
</tr>
<tr>
<td>q10</td>
<td>0.0367</td>
<td>74.5435</td>
<td>0.0361</td>
<td>74.6541</td>
</tr>
<tr>
<td>SERVOVALVE ACTUATOR</td>
<td>0.3997</td>
<td>49.9746</td>
<td>0.3997</td>
<td>49.9746</td>
</tr>
<tr>
<td></td>
<td>0.2398</td>
<td>75.9964</td>
<td>0.1254</td>
<td>78.3808</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
<td>0.2995</td>
<td>75.9964</td>
<td>0.1139</td>
<td>61.1523</td>
</tr>
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<td>FILTER</td>
<td>1.0000</td>
<td>101.8590</td>
<td>1.0000</td>
<td>76.3762</td>
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<td>FILTER</td>
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<td>49.6563</td>
<td>1.0000</td>
<td>55.4267</td>
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<td>1.0000</td>
<td>0.2939</td>
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<tr>
<td>FILTER</td>
<td>1.0000</td>
<td>23.8732</td>
<td>0.9547</td>
<td>19.6087</td>
</tr>
<tr>
<td>NOTCH 1</td>
<td>0.9089</td>
<td>15.7601</td>
<td>0.9574</td>
<td>15.5153</td>
</tr>
<tr>
<td>NOTCH 2</td>
<td>0.3610</td>
<td>17.5070</td>
<td>0.3177</td>
<td>7.7501</td>
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</tbody>
</table>

**FIGURE 46**

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.86, ALTITUDE: 15,000 FEET, UNSCALED EOM
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th></th>
<th>CLOSED LOOP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAMPING</td>
<td>FREQUENCY</td>
<td>DAMPING</td>
<td>FREQUENCY</td>
</tr>
<tr>
<td></td>
<td>(ζ)</td>
<td>(HZ)</td>
<td>(ζ)</td>
<td>(HZ)</td>
</tr>
<tr>
<td>$q_1$ (FLUTTER MODE)</td>
<td>.0050</td>
<td>20.2343</td>
<td>0.0137</td>
<td>20.2866</td>
</tr>
<tr>
<td>$q_2$</td>
<td>-.3671</td>
<td>21.7161</td>
<td>0.1111</td>
<td>22.4110</td>
</tr>
<tr>
<td>$q_3$</td>
<td>.0056</td>
<td>22.2082</td>
<td>0.0087</td>
<td>22.1624</td>
</tr>
<tr>
<td>$q_4$</td>
<td>.9876</td>
<td>27.8758</td>
<td>0.8512</td>
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<td>$q_5$</td>
<td>.7216</td>
<td>32.9130</td>
<td>0.2549</td>
<td>25.8599</td>
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<tr>
<td>$q_6$</td>
<td>.0810</td>
<td>37.8481</td>
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<td>37.8583</td>
</tr>
<tr>
<td>$q_7$</td>
<td>.0093</td>
<td>47.3721</td>
<td>0.0094</td>
<td>47.3698</td>
</tr>
<tr>
<td>$q_8$</td>
<td>.0271</td>
<td>67.2262</td>
<td>0.0214</td>
<td>66.8768</td>
</tr>
<tr>
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<td>.0562</td>
<td>73.7946</td>
<td>0.0213</td>
<td>70.1275</td>
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<td>.0258</td>
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<tr>
<td>SERVOVALVE ACTUATOR</td>
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<td>49.9746</td>
<td>.3997</td>
<td>49.9746</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
<td>.2398</td>
<td>75.9964</td>
<td>.1453</td>
<td>76.5859</td>
</tr>
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<tr>
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<td>1.000</td>
<td>285.9078</td>
</tr>
<tr>
<td>FILTER</td>
<td>1.000</td>
<td>49.6815</td>
<td>.9998</td>
<td>40.8756</td>
</tr>
<tr>
<td>FILTER</td>
<td>1.0000</td>
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<td>.0980</td>
<td>.3615</td>
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<td>1.0000</td>
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<td>1.000</td>
<td>106.6853</td>
</tr>
<tr>
<td>NOTCH 1</td>
<td>.9089</td>
<td>15.7681</td>
<td>.9418</td>
<td>19.3288</td>
</tr>
<tr>
<td>NOTCH 2</td>
<td>.3610</td>
<td>17.5159</td>
<td>.8504</td>
<td>17.7972</td>
</tr>
</tbody>
</table>

**FIGURE 47**

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 8,000 FEET, UNSCALED EOM
FIGURE 46
SYMmetric FLUTTER mode Damping, Mach: 0.80
APPENDIX C

FIGURE 50

SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.86

DAMPING RATIO

0.30

0.20

0.10

0

-0.10

-0.20

FSS ON

FSS OFF

5,000

10,000

15,000

20,000

25,000

30,000

ALTITUDE (FEET)
APPENDIX C

FIGURE 52
ANTI-SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.80
APPENDIX C

FIGURE 53
ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.83

ALTITUDE (FEET)

0 5,000 10,000 15,000 20,000 25,000 30,000

DAMPING RATIO (ξ)

0.30 0.20 0.10 0

FSS ON

-0.10 -0.20
APPENDIX C

FIGURE 54

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.86
FIGURE 55

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.91
FIGURE 56

SYMmetric FLUTTER MODE DAMPING, ALTITUDE: 15,000 FEET
FIGURE 57

ASYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 15,000 FEET
FIGURE 58

SYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 12,000 FEET
MACH = 0.80
ALITUDE = 2,000 FEET

FIGURE 60

PHASE-GAIN ROOT LOCUS OF SYMMETRICAL FSS, NOMINAL SYSTEM,
MACH: 0.80, ALTITUDE: 2,000 FEET
MACH = 0.83
ALTIMETER = 3,000 FEET

Figure 61
Phase-Gain Root Locus of Symmetric FSS, Nominal System,
MACH: 0.83, ALTITUDE: 3,000 FEET
APPENDIX C

MACH = 0.83
ALTITUDE = 12,000 FEET

Figure 62

Phase-gain root locus of symmetric FSS, nominal system,
mach: 0.83, altitude: 12,000 feet
PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 15,000 FEET

FIGURE 64
MACH = 0.91
ALTITUDE = 8,000 FEET

FIGURE 65

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.91, ALTITUDE: 8,000 FEET
APPENDIX C

\( jw \text{ - RAD/SEC} \)

\[ 750.0 \quad 700.0 \quad 650.0 \quad 600.0 \quad 550.0 \quad 500.0 \quad 450.0 \quad 400.0 \]

\[ 100.0 \quad 50.0 \quad 0.0 \quad -50.0 \quad -100.0 \quad -200.0 \quad -300.0 \quad -400.0 \]

**Figure 66**

Phase-Gain Root Locus of Antisymmetric FSS with Parameter Scheduling,
Mach = 0.80, Altitude = 2,000 Feet

Mach = 0.80
Altitude = 2,000 Feet

SERVOVALVE ACTUATOR

\( jw \text{ - RAD/SEC} \)

SERVOVALVE ACTUATOR

Flutter Mode

Notch 1

\( 0 \quad 50.0 \quad 100.0 \quad 150.0 \quad 200.0 \quad 250.0 \quad 300.0 \quad 350.0 \quad 400.0 \quad 450.0 \quad 500.0 \quad 550.0 \quad 600.0 \quad 650.0 \quad 700.0 \quad 750.0 \)

\( J \text{ - RAD/SEC} \)

\( \sigma \text{ - RAD/SEC} \)
APPENDIX C

- MACH = 0.83
- ALTITUDE = 3000 FEET

Figure 67

Phase-Gain Root Locus of Antisymmetric FSS with Parameter Scheduling,
MACH: 0.83, ALTITUDE: 3,000 FEET
MACH = 0.83
ALITUDE = 12,000 FEET

FIGURE 68
PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.83, ALTITUDE: 12,000 FEET
APPENDIX C

MACH = 0.86
ALTITUDE = 4250 FEET

Phase-Gain Root Locus of Antisymmetric FSS with Parameter Scheduling,
MACH: 0.86, ALTITUDE: 4,250 FEET
MACH = 0.86
ALTITUDE = 15,000 FEET

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 15,000 FEET
APPENDIX C

ORIGINAL PAGE IS OF POOR QUALITY

\[ j\omega - \text{RAD/SEC} \]

\[ \sigma - \text{RAD/SEC} \]

\[ \text{GAIN (NORMAL)} \]

\[ 0.5, 2.0 \]

\[ 350.0, 150.0, 50.0, 0.0 \]

\[ 750.0, 600.0, 550.0, 500.0, 450.0, 400.0 \]

\[ \text{MACH} = 0.91, \text{ALTITUDE} = 8000 \text{ FEET} \]

\[ \text{PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 8000 FEET} \]

\[ 135 \]
This appendix contains data which summarizes the sensitivity of structural mode stability to variations in dynamics and locations of control system components. For the most part the sensitivity analysis was not repeated for the final FSS filters, however sensitivity to changes shown in this data and the root loci analysis performed using the latest filters indicate that results of this study are valid.

Figures 72 and 73 compare structural mode damping ratios for various accelerometer wing locations. The optimal sensor locations were selected by zero root locus as presented in the final report for sensors moved along front and rear spars. The sensor locations were varied inboard and outboard of the optimal up to two inches. The symmetric gain margin was not reduced below plus or minus 6 dB but the phase margin was reduced to 20 degrees when the sensors were separated by six inches. The antisymmetric gain and phase margins were reduced significantly when the sensors were separated by four inches.

The recommended installation of the symmetric accelerometers was plus or minus one inch of the wing station 82 on front spar and 84 on rear spar. The recommended installation of the antisymmetric accelerometers was plus or minus 0.5 inch of wing station 92 on both front and rear spars. The vertical accelerometer recommended location was at body station 265 plus or minus 2.5 inches.

Notch filters are used both in the FSS filter and servoactuator compensation. Sensitivity to notch filter parameter changes was analyzed. Figure 74 shows the transfer functions of the notch filters used in the symmetric and antisymmetric compensation. The final filters did not include the 170 and 230 radian notch filters, however the sensitivity analysis is presented here for future reference.

The summary of the notch filter sensitivity analysis is shown on Figures 74 through 82. The capacitors and resistors of the notch filters have very close tolerances and small sensitivity to temperature changes, therefore the parameter changes from nominal is expected to be small over the flight envelope. The damping ratio and frequency of the notch filters were varied plus and minus five percent and the damping ratio of the actual modes changed less than eight percent.

Several servovalves were evaluated in an effort to extend the servoactuator bandwidth. A Moog Series 31 servovalve was initially selected for the actuator model and later bench tested. The Series 31 servovalve has a wide bandwidth and improved FSS performance but was expensive and required complicated closed loop circuitry. A Hydraulic Research Model AR-25 servovalve was selected because it was a direct replacement for the Series 30 used for the ARW-I servoactuator but had a wider bandwidth. The structural mode
stability results of the three servovalves are shown on Figures 83 through 88. Figure 85 shows that a plus 6 dB gain margin cannot be achieved with the Series 30 servovalves. Although the AR-25 servovalve did not increase the servoactuator bandwidth, the increased servovalve bandwidth provided increased performance and 6 dB of gain margin was achieved.

Figures 88 and 89 when compared with Figures 83 and 86 respectively verify that the compensating actuator filter which cancels the surface-actuator mode is required. Figures 90 through 92 summarize the sensitivity analysis performed by varying the frequency of the surface-actuator mode with respect to the compensating filter frequency.

The results of this sensitivity study indicated that when the compensating filter was removed the symmetric airplane modes were destabilized and were difficult to stabilize and the antisymmetric filter mode lead phase margin was decreased to 40 degrees. The FSS was relatively insensitive to a plus or minus 20 percent frequency change in the surface-actuator mode.

Servoactuator pressure feedback gain was reduced to determine the effect on airplane stability. Figures 93 through 96 summarize this analysis. A reduction of 30 percent in pressure feedback gain did not reduce symmetric stability below specifications and the antisymmetric lag phase margin was reduced only to 40 degrees.

A hinge moment sensitivity analysis was performed to determine stability effects. Figure 97 shows the servoactuator gain and phase response to a hinge moment change at the filter frequency. The maximum aiding (surface trailing edge up) to the maximum resisting (trailing edge down) hinge moment causes approximately 45 degrees of phase lag and 4 dB loss in gain. Figures 98 through 104 summarize the hinge moment sensitivity analysis. Changes in hinge moment may require servoactuator gain scheduling. This should be evaluated further by ground and flight testing.

Other sensitivity studies showed that the airplane is relatively insensitive to small changes in stability derivatives and the active control systems tend to increase frequency and damping of the fuselage mode as shown on Figure 105.
### APPENDIX D

#### Closed Loop Lamping Ratio $(c)$ - Nominal Gain

<table>
<thead>
<tr>
<th>Mode</th>
<th>OPEN LOOP Damping Ratio $(c)$</th>
<th>FREQUENCY (Hz)</th>
<th>CLOSED LOOP Damping Ratio $(c)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0105</td>
<td>14.2</td>
<td>0.0125</td>
</tr>
<tr>
<td>2</td>
<td>0.0190</td>
<td>20.1</td>
<td>0.024</td>
</tr>
<tr>
<td>3</td>
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<td>73.6</td>
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#### Design Specifications

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

---

**Figure 72**

**Symmetric Sensor Location Sensitivity**
<table>
<thead>
<tr>
<th>MODE</th>
<th>FREQUENCY (HZ)</th>
<th>DAMPING RATIO (ξ)</th>
<th>OPEN LOOP</th>
</tr>
</thead>
<tbody>
<tr>
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<td>14.2</td>
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<td>0.0129</td>
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<td>q_2</td>
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<td>0.0743</td>
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<td>0.0024</td>
<td>0.0098</td>
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<td>q_4</td>
<td>23.3</td>
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<td>0.7640</td>
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<td>q_5</td>
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<td>q_6</td>
<td>33.7</td>
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<td>0.0428</td>
</tr>
<tr>
<td>q_7</td>
<td>49.1</td>
<td>0.0527</td>
<td>0.0565</td>
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<tr>
<td>q_8</td>
<td>63.2</td>
<td>0.0118</td>
<td>0.0119</td>
</tr>
<tr>
<td>q_9</td>
<td>67.6</td>
<td>0.0238</td>
<td>0.0226</td>
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<tr>
<td>q_10</td>
<td>73.6</td>
<td>0.0524</td>
<td>0.0428</td>
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<table>
<thead>
<tr>
<th>SENSOR LOCATION</th>
<th>FS 82 AND RS 82</th>
<th>FS 82 AND RS 84</th>
<th>FS 82 AND RS 86</th>
</tr>
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<td>NOMINAL -45 DEGREES</td>
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<td>0.0126</td>
<td>0.0117</td>
</tr>
<tr>
<td>NOMINAL +45 DEGREES</td>
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<td>0.0126</td>
<td>0.0117</td>
</tr>
<tr>
<td>NOMINAL -45 DEGREES</td>
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</tr>
<tr>
<td>NOMINAL +45 DEGREES</td>
<td>0.0126</td>
<td>0.0126</td>
<td>0.0117</td>
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</tbody>
</table>

Figure 72 (Continued)

Symmetric Sensor Location Sensitivity

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

Below Design Specs.
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO ($\zeta$) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY</td>
<td>SENSOR LOCATION</td>
</tr>
<tr>
<td></td>
<td>(Hz)</td>
<td>FS 84 AND RS 82</td>
</tr>
<tr>
<td></td>
<td>DAMPING</td>
<td>+45 DEGREES NOMINAL -45 DEGREES</td>
</tr>
<tr>
<td></td>
<td>RATIO ($\zeta$)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FS 84 AND RS 84</td>
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<tr>
<td></td>
<td></td>
<td>+45 DEGREES NOMINAL -45 DEGREES</td>
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<tr>
<td></td>
<td></td>
<td>FS 84 AND RS 86</td>
</tr>
<tr>
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<td></td>
<td>+45 DEGREES NOMINAL -45 DEGREES</td>
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<tr>
<td>$q_1$</td>
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<td>0.0127 0.0127 0.0127 0.0129 0.0129 0.0129</td>
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<td>-0.1190</td>
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<tr>
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<td></td>
<td>0.0496 0.0699 0.0684 0.0771 0.1071 0.0913</td>
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<td>0.0024</td>
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<td>0.4521</td>
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<td>0.7357 0.1985 0.1591 0.7618 0.1844 0.1799</td>
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<td>$q_5$</td>
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<td>0.0084</td>
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<tr>
<td></td>
<td></td>
<td>0.0087 0.0085 0.0093 0.0085 0.0084 0.0105</td>
</tr>
<tr>
<td>$q_6$</td>
<td>33.7</td>
<td>0.0619</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0417 0.0472 0.0526 0.0421 0.0574 0.0405</td>
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<tr>
<td>$q_7$</td>
<td>49.1</td>
<td>0.0527</td>
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<tr>
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<td></td>
<td>0.0565 0.0565 0.0565 0.0565 0.0565 0.0565</td>
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<tr>
<td>$q_8$</td>
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<td>0.0118</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>$q_9$</td>
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<tr>
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<td></td>
<td>0.0231 0.0222 0.0236 0.0225 0.0213 0.0233</td>
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<td>$q_{10}$</td>
<td>73.6</td>
<td>0.0524</td>
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<td></td>
<td></td>
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</tbody>
</table>

**FIGURE 72 (CONCLUDED)**

SYMMETRIC SENSOR LOCATION SENSITIVITY
# APPENDIX D

<table>
<thead>
<tr>
<th>Mode</th>
<th>Open Loop Damping Ratio (ζ)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9_1</td>
<td>0.0032</td>
<td>20.1</td>
</tr>
<tr>
<td>9_2</td>
<td>0.0172</td>
<td>21.5</td>
</tr>
<tr>
<td>9_3</td>
<td>0.0156</td>
<td>22.2</td>
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<tr>
<td>9_4</td>
<td>0.0135</td>
<td>25.2</td>
</tr>
<tr>
<td>9_5</td>
<td>0.0082</td>
<td>36.9</td>
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<tr>
<td>9_6</td>
<td>0.0135</td>
<td>44.1</td>
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<td>9_7</td>
<td>0.0112</td>
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<td>9_8</td>
<td>0.0117</td>
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<td>70.4</td>
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<tr>
<td>9_10</td>
<td>0.0135</td>
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### Closed Loop Damping Ratio (ζ) - Nominal Gain

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<th>90° and RS 92</th>
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<td>Degrees</td>
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<td>Degrees</td>
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### Below Design Specs.
- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
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<td>DAMPING RATIO (ζ)</td>
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<td>q₂</td>
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<td>-0.1372</td>
</tr>
<tr>
<td>q₃</td>
<td>22.2</td>
<td>0.0040</td>
</tr>
<tr>
<td>q₄</td>
<td>25.2</td>
<td>0.4735</td>
</tr>
<tr>
<td>q₅</td>
<td>36.9</td>
<td>0.0602</td>
</tr>
<tr>
<td>q₆</td>
<td>44.1</td>
<td>0.0487</td>
</tr>
<tr>
<td>q₇</td>
<td>47.4</td>
<td>0.0077</td>
</tr>
<tr>
<td>q₈</td>
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<td>0.0214</td>
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<tr>
<td>q₉</td>
<td>70.4</td>
<td>0.0209</td>
</tr>
<tr>
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BOLD BELOW DESIGN Specs.

FIGURE 73 (CONTINUED)

ANTISYMMETRIC SENSOR LOCATION SENSITIVITY
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO ((\zeta)) - NOMINAL GAIN</th>
<th>SENSOR LOCATION</th>
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<td>0.0219</td>
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<td>-0.1372</td>
<td>0.0001</td>
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<td>0.0015</td>
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<td>0.4735</td>
<td>0.7721</td>
</tr>
<tr>
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<td>0.0602</td>
<td>0.0569</td>
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<tr>
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<td>0.0487</td>
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<td>0.0077</td>
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<td>0.0190</td>
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<td>(q_{10})</td>
<td>74.5</td>
<td>0.0367</td>
<td>0.0435</td>
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</table>

FIGURE 73 (CONCLUDED)

ANTISYMMETRIC SENSOR LOCATION SENSITIVITY

MACH = 0.86
ALTITUDE = 15,000 FEET
WITHOUT FSS WASHOUT

BELOW DESIGN SPECS.
## APPENDIX D

### SYMMETRIC

<table>
<thead>
<tr>
<th></th>
<th>85 RAD. NOTCH</th>
<th>170 RAD. NOTCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL</td>
<td>$S^2 + 147.2S + 7225.0$</td>
<td>$S^2 + 68.0S + 28900$</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 61.4S + 7225.0$</td>
<td>$S^2 + 136.0S + 28900$</td>
</tr>
<tr>
<td>$\omega_N$ 5% INCREASE</td>
<td>$S^2 + 154.6S + 7965.5$</td>
<td>$S^2 + 71.5S + 31862$</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 64.4S + 7965.5$</td>
<td>$S^2 + 142.8S + 31862$</td>
</tr>
<tr>
<td>$\omega_N$ 5% DECREASE</td>
<td>$S^2 + 139.9S + 6520.6$</td>
<td>$S^2 + 64.6S + 26082$</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 58.3S + 6520.6$</td>
<td>$S^2 + 129.3S + 26082$</td>
</tr>
<tr>
<td>$</td>
<td>M</td>
<td>$ 5% INCREASE</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 59.3S + 7225.0$</td>
<td>$S^2 + 138.19S + 28900$</td>
</tr>
<tr>
<td>$</td>
<td>M</td>
<td>$ 5% DECREASE</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 63.6S + 7225.0$</td>
<td>$S^2 + 133.7S + 28900$</td>
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</table>

### ANTISYMMETRIC

<table>
<thead>
<tr>
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<th>110 RAD. NOTCH</th>
<th>230 RAD. NOTCH</th>
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</thead>
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<tr>
<td>NOMINAL</td>
<td>$S^2 + 190.5S + 12100$</td>
<td>$S^2 + 92.0S + 52900$</td>
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<tr>
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<td>$S^2 + 79.4S + 12100$</td>
<td>$S^2 + 184.0S + 52900$</td>
</tr>
<tr>
<td>$\omega_N$ 5% INCREASE</td>
<td>$S^2 + 200.1S + 13340$</td>
<td>$S^2 + 96.6S + 58322$</td>
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<tr>
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<td>$S^2 + 83.4S + 13340$</td>
<td>$S^2 + 193.2S + 58322$</td>
</tr>
<tr>
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<td>$S^2 + 87.4S + 47742$</td>
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<tr>
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<td>$S^2 + 75.5S + 10920$</td>
<td>$S^2 + 174.8S + 47742$</td>
</tr>
<tr>
<td>$</td>
<td>M</td>
<td>$ 5% INCREASE</td>
</tr>
<tr>
<td></td>
<td>$S^2 + 76.7S + 12100$</td>
<td>$S^2 + 186.0S + 52900$</td>
</tr>
<tr>
<td>$</td>
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</tr>
<tr>
<td></td>
<td>$S^2 + 82.3S + 12100$</td>
<td>$S^2 + 180.8S + 52900$</td>
</tr>
</tbody>
</table>

**FIGURE 74**

NOTCH FILTER TRANSFER FUNCTION FOR SENSITIVITY STUDIES
FIGURE 75

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 85 RAD. NOTCH
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING RATIO (ζ)</td>
</tr>
<tr>
<td></td>
<td>5% INCREASE</td>
<td>5% DECREASE</td>
</tr>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</td>
</tr>
<tr>
<td>q₂</td>
<td>20.1</td>
<td>-0.1190</td>
</tr>
<tr>
<td>q₃</td>
<td>21.7</td>
<td>0.0024</td>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
</tr>
<tr>
<td>q₅</td>
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<td>0.0084</td>
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<tr>
<td>q₆</td>
<td>33.7</td>
<td>0.0619</td>
</tr>
<tr>
<td>q₇</td>
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<td>0.0</td>
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<td>q₈</td>
<td>63.2</td>
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<td>q₉</td>
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<td>q₁₀</td>
<td>73.6</td>
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</table>

**Figure 76**

Symmetric Notch Filter Sensitivity to Notch Frequency, 170 Rad. Notch
MACH = 0.86
ALTITUDE = 15,000 FEET
WITHOUT FSS WASHOUT

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO (ζ)</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</td>
</tr>
<tr>
<td>q₂</td>
<td>20.1</td>
<td>0.1190</td>
</tr>
<tr>
<td>q₃</td>
<td>21.7</td>
<td>0.0024</td>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
</tr>
<tr>
<td>q₅</td>
<td>33.2</td>
<td>0.0084</td>
</tr>
<tr>
<td>q₆</td>
<td>33.7</td>
<td>0.0619</td>
</tr>
<tr>
<td>q₇</td>
<td>49.1</td>
<td>0.05</td>
</tr>
<tr>
<td>q₈</td>
<td>63.2</td>
<td>0.0118</td>
</tr>
<tr>
<td>q₉</td>
<td>67.6</td>
<td>0.0238</td>
</tr>
<tr>
<td>q₁₀</td>
<td>73.6</td>
<td>0.524</td>
</tr>
</tbody>
</table>

FIGURE 77
SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 85 RAD. NOTCH
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO ($\zeta$) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO ($\zeta$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</td>
</tr>
<tr>
<td>q₂</td>
<td>20.1</td>
<td>-0.1190</td>
</tr>
<tr>
<td>q₃</td>
<td>21.7</td>
<td>0.0024</td>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
</tr>
<tr>
<td>q₅</td>
<td>33.2</td>
<td>0.0084</td>
</tr>
<tr>
<td>q₆</td>
<td>33.7</td>
<td>0.0619</td>
</tr>
<tr>
<td>q₇</td>
<td>49.1</td>
<td>0.0527</td>
</tr>
<tr>
<td>q₈</td>
<td>63.2</td>
<td>0.0118</td>
</tr>
<tr>
<td>q₉</td>
<td>67.6</td>
<td>0.0238</td>
</tr>
<tr>
<td>q₁₀</td>
<td>73.6</td>
<td>0.524</td>
</tr>
</tbody>
</table>

**FIGURE 78**

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 170 RAD. NOTCH
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO (ζ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q1</td>
<td>20.1</td>
<td>0.0032</td>
</tr>
<tr>
<td>q2</td>
<td>21.5</td>
<td>-0.1372</td>
</tr>
<tr>
<td>q3</td>
<td>22.2</td>
<td>0.0040</td>
</tr>
<tr>
<td>q4</td>
<td>25.2</td>
<td>0.4735</td>
</tr>
<tr>
<td>q5</td>
<td>39.9</td>
<td>0.0602</td>
</tr>
<tr>
<td>q6</td>
<td>44.1</td>
<td>0.0487</td>
</tr>
<tr>
<td>q7</td>
<td>47.4</td>
<td>0.0077</td>
</tr>
<tr>
<td>q8</td>
<td>67.0</td>
<td>0.0214</td>
</tr>
<tr>
<td>q9</td>
<td>70.4</td>
<td>0.0209</td>
</tr>
<tr>
<td>q10</td>
<td>74.5</td>
<td>0.0367</td>
</tr>
</tbody>
</table>

**FIGURE 79**

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 110 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

### BELOW DESIGN SPECS.
**MACH = 0.86**  
**ALTITUDE = 15,000 FEET**  
**WITHOUT FSS WASHOUT.**

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO (ζ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q_1</td>
<td>20.1</td>
<td>0.0032</td>
</tr>
<tr>
<td>q_2</td>
<td>21.5</td>
<td>-0.1372</td>
</tr>
<tr>
<td>q_3</td>
<td>22.2</td>
<td>0.0040</td>
</tr>
<tr>
<td>q_4</td>
<td>25.2</td>
<td>0.4735</td>
</tr>
<tr>
<td>q_5</td>
<td>39.9</td>
<td>0.0602</td>
</tr>
<tr>
<td>q_6</td>
<td>44.1</td>
<td>0.0487</td>
</tr>
<tr>
<td>q_7</td>
<td>47.4</td>
<td>0.0077</td>
</tr>
<tr>
<td>q_8</td>
<td>67.0</td>
<td>0.0214</td>
</tr>
<tr>
<td>q_9</td>
<td>70.4</td>
<td>0.0209</td>
</tr>
<tr>
<td>q_{10}</td>
<td>74.5</td>
<td>0.0367</td>
</tr>
</tbody>
</table>

**FIGURE 80**

ASYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 230 RAD. NOTCH
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO ($\xi$) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>Damping Ratio ($\xi$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q1</td>
<td>20.1</td>
<td>0.0032</td>
</tr>
<tr>
<td>q2</td>
<td>21.5</td>
<td>-0.1372</td>
</tr>
<tr>
<td>q3</td>
<td>22.2</td>
<td>0.0040</td>
</tr>
<tr>
<td>q4</td>
<td>25.2</td>
<td>0.4735</td>
</tr>
<tr>
<td>q5</td>
<td>39.9</td>
<td>0.0602</td>
</tr>
<tr>
<td>q6</td>
<td>44.1</td>
<td>0.0487</td>
</tr>
<tr>
<td>q7</td>
<td>47.4</td>
<td>0.0077</td>
</tr>
<tr>
<td>q8</td>
<td>67.0</td>
<td>0.0214</td>
</tr>
<tr>
<td>q9</td>
<td>70.4</td>
<td>0.0209</td>
</tr>
<tr>
<td>q10</td>
<td>74.5</td>
<td>0.0367</td>
</tr>
</tbody>
</table>

**FIGURE 81**

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 110 RAD. NOTCH
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING RATIO (ζ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q1</td>
<td>20.1</td>
<td>0.0032</td>
</tr>
<tr>
<td>q2</td>
<td>21.5</td>
<td>-0.1372</td>
</tr>
<tr>
<td>q3</td>
<td>22.2</td>
<td>0.0040</td>
</tr>
<tr>
<td>q4</td>
<td>25.2</td>
<td>0.4735</td>
</tr>
<tr>
<td>q5</td>
<td>39.9</td>
<td>0.0602</td>
</tr>
<tr>
<td>q6</td>
<td>44.1</td>
<td>0.0487</td>
</tr>
<tr>
<td>q7</td>
<td>47.4</td>
<td>0.0077</td>
</tr>
<tr>
<td>q8</td>
<td>67.0</td>
<td>0.0214</td>
</tr>
<tr>
<td>q9</td>
<td>70.4</td>
<td>0.0209</td>
</tr>
<tr>
<td>q10</td>
<td>74.5</td>
<td>0.0367</td>
</tr>
</tbody>
</table>

**FIGURE 82**

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 230 RAD. NOTCH

MACH = 0.86
ALITUDE = 15,000 FEET
WITHOUT FSS WASHOUT.
APPENDIX D

PHASE-GAIN ROOT LOCI OF SYMMETRIC FSS, NOMINAL SYSTEM

SERIES 31 SERVOVALVE
MACH = 0.86
ALTITUDE = 15,000 FEET

Hz, RAD/SEC

1 0.50 (nominal)
2 1.00
3 2.00

NO. GAIN

Figure 83
PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS WITH AR-25 SERVOVALVE
APPENDIX D

FIGURE 86

PHASE-GAIN ROOT LOCUS OF ASYMMETRIC FSS, NOMINAL SYSTEM
APPENDIX D

PHASE-GAIN ROOT LOCALL OF ASYNTHETIC FSS WITH AR-25 SERVO

MACH = 0.86
ALTITUDE = 15,000 FEET

Figure 87
APPENDIX D

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF UNCOMPENSATING ACTUATOR

MACH = 0.86
ALITUDE = 15,000 FEET

Figure 88
MACH = 0.86
ALTITUDE = 15,000 FEET
WITHOUT FSS WASHOUT

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO ($\zeta$) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING RATIO ($\zeta$)</td>
</tr>
<tr>
<td>$q_1$</td>
<td>14.2</td>
<td>0.0105</td>
</tr>
<tr>
<td>$q_2$</td>
<td>20.1</td>
<td>-0.1190</td>
</tr>
<tr>
<td>$q_3$</td>
<td>21.7</td>
<td>0.0024</td>
</tr>
<tr>
<td>$q_4$</td>
<td>23.3</td>
<td>0.4521</td>
</tr>
<tr>
<td>$q_5$</td>
<td>33.2</td>
<td>0.0084</td>
</tr>
<tr>
<td>$q_6$</td>
<td>33.7</td>
<td>0.0619</td>
</tr>
<tr>
<td>$q_7$</td>
<td>49.1</td>
<td>0.0527</td>
</tr>
<tr>
<td>$q_8$</td>
<td>63.2</td>
<td>0.0118</td>
</tr>
<tr>
<td>$q_9$</td>
<td>67.6</td>
<td>0.0238</td>
</tr>
<tr>
<td>$q_{10}$</td>
<td>73.6</td>
<td>0.524</td>
</tr>
</tbody>
</table>

**Figure 90**

Symmetric FSS Sensitivity to Surface-Actuator Mode Change
- MACH = 0.86
- ALTITUDE = 15,000 FEET
- COMPENSATED ACTUATOR

FIGURE 92

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF A 20% SURFACE-ACTUATOR MODE FREQUENCY DECREASE
- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

<table>
<thead>
<tr>
<th>MODE</th>
<th>FREQUENCY (HZ)</th>
<th>DAMPING RATIO (ζ)</th>
<th>NOMINAL PRESSURE</th>
<th>30% DECREASE</th>
<th>NOMINAL PRESSURE</th>
<th>30% DECREASE</th>
<th>NOMINAL PRESSURE</th>
<th>30% DECREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</td>
<td>0.0126</td>
<td>0.0126</td>
<td>0.0126</td>
<td>0.0126</td>
<td>0.0126</td>
<td>0.0126</td>
</tr>
<tr>
<td>q₂</td>
<td>20.1</td>
<td>-0.1190</td>
<td>0.1082</td>
<td>0.1297</td>
<td>0.1398</td>
<td>0.1498</td>
<td>0.1134</td>
<td>0.1272</td>
</tr>
<tr>
<td>q₃</td>
<td>21.7</td>
<td>0.0024</td>
<td>0.0094</td>
<td>0.0094</td>
<td>0.0094</td>
<td>0.0094</td>
<td>0.0094</td>
<td>0.0094</td>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
<td>0.7893</td>
<td>0.7982</td>
<td>0.1791</td>
<td>0.1763</td>
<td>0.2015</td>
<td>0.2055</td>
</tr>
<tr>
<td>q₅</td>
<td>33.2</td>
<td>0.0084</td>
<td>0.0083</td>
<td>0.0083</td>
<td>0.0083</td>
<td>0.0083</td>
<td>0.0131</td>
<td>0.0200</td>
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<td>33.7</td>
<td>0.0619</td>
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<td>0.0505</td>
<td>0.0484</td>
<td>0.0299</td>
<td>0.0083</td>
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<tr>
<td>q₇</td>
<td>49.1</td>
<td>0.0527</td>
<td>0.0565</td>
<td>0.0565</td>
<td>0.0565</td>
<td>0.0565</td>
<td>0.0565</td>
<td>0.0565</td>
</tr>
<tr>
<td>q₈</td>
<td>63.2</td>
<td>0.0118</td>
<td>0.0120</td>
<td>0.0120</td>
<td>0.0113</td>
<td>0.0104</td>
<td>0.0120</td>
<td>0.0120</td>
</tr>
<tr>
<td>q₉</td>
<td>67.6</td>
<td>0.0238</td>
<td>0.0201</td>
<td>0.0196</td>
<td>0.0168</td>
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<td>0.0228</td>
<td>0.0228</td>
</tr>
<tr>
<td>q₁₀</td>
<td>73.6</td>
<td>0.0524</td>
<td>0.0419</td>
<td>0.0410</td>
<td>0.0500</td>
<td>0.0503</td>
<td>0.0573</td>
<td>0.0579</td>
</tr>
</tbody>
</table>

FIGURE 93

SYMMETRIC FSS SENSITIVITY TO PRESSURE FEEDBACK GAIN REDUCTION
<table>
<thead>
<tr>
<th>Mode (n)</th>
<th>Open Loop Damping Ratio (ζ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>0.0274</td>
</tr>
<tr>
<td>92</td>
<td>0.0454</td>
</tr>
<tr>
<td>93</td>
<td>0.0815</td>
</tr>
<tr>
<td>94</td>
<td>0.1554</td>
</tr>
<tr>
<td>95</td>
<td>0.0556</td>
</tr>
<tr>
<td>96</td>
<td>0.0556</td>
</tr>
<tr>
<td>97</td>
<td>0.0487</td>
</tr>
<tr>
<td>98</td>
<td>0.0487</td>
</tr>
<tr>
<td>99</td>
<td>0.0487</td>
</tr>
<tr>
<td>90</td>
<td>0.0487</td>
</tr>
</tbody>
</table>

APPENDIX D

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN

<table>
<thead>
<tr>
<th>Nominal Phase</th>
<th>-45 Degrees</th>
<th>0 Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0178</td>
<td>0.0188</td>
<td></td>
</tr>
<tr>
<td>0.0107</td>
<td>0.0107</td>
<td></td>
</tr>
<tr>
<td>0.0095</td>
<td>0.0078</td>
<td></td>
</tr>
<tr>
<td>0.0083</td>
<td>0.0078</td>
<td></td>
</tr>
<tr>
<td>0.0077</td>
<td>0.0077</td>
<td></td>
</tr>
<tr>
<td>0.0077</td>
<td>0.0077</td>
<td></td>
</tr>
<tr>
<td>0.0077</td>
<td>0.0077</td>
<td></td>
</tr>
<tr>
<td>0.0077</td>
<td>0.0077</td>
<td></td>
</tr>
<tr>
<td>0.0077</td>
<td>0.0077</td>
<td></td>
</tr>
</tbody>
</table>

Diagram 95

ANTISYMMETRIC FSS SENSITIVITY TO PRESSURE FEEDBACK GAIN REDUCTION

LESS THAN DESIGN SPEC.
<table>
<thead>
<tr>
<th>Hinge Moment</th>
<th>GAIN</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Load</td>
<td>+0.19 dB</td>
<td>-38.8 deg.</td>
</tr>
<tr>
<td>Maximum Aiding - 230 in-lbs</td>
<td>+0.62 dB</td>
<td>-23.9 deg.</td>
</tr>
<tr>
<td>Static - 150 in-lbs}</td>
<td>-2.00 dB</td>
<td>-61.8 deg.</td>
</tr>
<tr>
<td>Maximum Resisting - 230 in-lbs</td>
<td>-3.04 dB</td>
<td>-68.6 deg.</td>
</tr>
</tbody>
</table>
Figure 98

Effect of hinge moment on outboard servoactuator amplitude frequency response.
• MACH = 0.86
• ALTITUDE = 15,000 FEET

Figure 103

EFFECT OF HINGE MOMENT ON ANTISYMMETRIC FSS, UNCOMPENSATED ACTUATOR
FIGURE 104

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, MAXIMUM HINGE MOMENT AIDING (230 IN-LBS)
<table>
<thead>
<tr>
<th>MACH NO.</th>
<th>ALTITUDE (FEET)</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP (PCS, RSS, AND GLA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>REAL</td>
<td>IMAGINARY</td>
</tr>
<tr>
<td>0.35</td>
<td>SEA LEVEL</td>
<td>-0.660</td>
<td>±j88.500</td>
</tr>
<tr>
<td>0.40</td>
<td>15,000</td>
<td>-0.590</td>
<td>±j88.480</td>
</tr>
<tr>
<td>0.41</td>
<td>10,000</td>
<td>-0.645</td>
<td>±j89.379</td>
</tr>
<tr>
<td>0.60</td>
<td>7,000</td>
<td>-0.915</td>
<td>±j89.463</td>
</tr>
<tr>
<td>0.70</td>
<td>15,000</td>
<td>-0.921</td>
<td>±j89.455</td>
</tr>
<tr>
<td>0.70</td>
<td>50,000</td>
<td>-0.518</td>
<td>±j89.329</td>
</tr>
<tr>
<td>0.80</td>
<td>46,800</td>
<td>-0.577</td>
<td>±j89.400</td>
</tr>
<tr>
<td>0.86</td>
<td>15,000</td>
<td>-0.936</td>
<td>±j89.436</td>
</tr>
</tbody>
</table>

**FIGURE 105**

EFFECT OF ACS ON FUSELAGE MODE SYMMETRIC AIRPLANE
APPENDIX E

ACS/AFCS SYSTEMS ROOT LOCI

Gain and phase stability margins of each individual ACS and AFCS feedback loop, except the flutter system, are shown on the figures of this section. The stability margins of each loop were determined with each combination of systems that may be closed during some phase of flight testing. The margins were determined at various flight conditions spanning the total flight range. The root loci plots are identified in Figure 106 and shown on Figures 107 through 204. The stability margins were evaluated using QSE equations of motion. Each system loop was evaluated by +4.5 dB gain and +30 degrees phase margin criteria. Refer to Figure 106 as a guide to read gain and phase information.
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<th>FLIGHT CONDITION</th>
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<th>RSS WITH BCS CLOSED</th>
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<th>BCS WITH RSS CLOSED</th>
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</thead>
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<td>MLA TEST MACH - 0.42 ALT - 10,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
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<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>114</td>
<td>115</td>
<td>116</td>
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<td>118</td>
<td>119</td>
<td>120</td>
<td>121</td>
</tr>
<tr>
<td>GLA TEST MACH - 0.70 ALT - 15,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
<td>123</td>
<td>124</td>
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<td>126</td>
<td>127</td>
<td>128</td>
<td>129</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>132</td>
<td>133</td>
<td>134</td>
<td>135</td>
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</tr>
<tr>
<td>LAUNCH MACH - 0.40 ALT - 15,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
<td>141</td>
<td>142</td>
<td>143</td>
<td>144</td>
<td>145</td>
<td>146</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>148</td>
<td>149</td>
<td>150</td>
<td>151</td>
<td>152</td>
<td>153</td>
<td>154</td>
<td>155</td>
</tr>
<tr>
<td>HIGH ALTITUDE MACH - 0.70 ALT - 50,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
<td>157</td>
<td>158</td>
<td>159</td>
<td>160</td>
<td>161</td>
<td>162</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>164</td>
<td>165</td>
<td>166</td>
<td>167</td>
<td>168</td>
<td>169</td>
<td>170</td>
<td>171</td>
</tr>
<tr>
<td>CRUISE MACH - 0.80 ALT - 46,800 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC 1.0g FLIGHT</td>
<td>173</td>
<td>174</td>
<td>175</td>
<td>176</td>
<td>177</td>
<td>178</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC 1.2g FLIGHT</td>
<td>180</td>
<td>181</td>
<td>182</td>
<td>183</td>
<td>184</td>
<td>185</td>
<td>186</td>
<td>187</td>
</tr>
<tr>
<td>MAXIMUM Q (V_d) MACH - 0.86 ALT - 15,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
<td>189</td>
<td>190</td>
<td>191</td>
<td>192</td>
<td>193</td>
<td>194</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>196</td>
<td>197</td>
<td>198</td>
<td>199</td>
<td>200</td>
<td>201</td>
<td>202</td>
<td>203</td>
</tr>
</tbody>
</table>

**FIGURE 106**

ROOT LOCI FIGURE IDENTIFICATION
APPENDIX E

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 107
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MLA TEST CONDITION
FIGURE 107 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 108
DAST ARM-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

**Figure 108 (Concluded)**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 109

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 109 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 110

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 110 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 111

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 111 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

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APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

**Figure 112**

DAST ARM-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 112 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 113

DAST ARW-2 BCS SYSTEM GAIN/Pbahse ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

\[ \begin{align*}
\text{NO.} & & \text{GAIN} & & \text{PHASE} \\
3 & & 1.00 & & 0.80 \\
\end{align*} \]

FIGURE 113 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 114

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 114 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PRIASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 115

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 115 (CONCLUDED)**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 116

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 116 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION

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APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 117

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 117 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 118

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 118 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 119

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 119 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA AILeron WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 120

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 120 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 120 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS
  AND GLA AILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 121

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA
AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS
  AND GLA AILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 121 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA
AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLAAILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 121 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHTASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 122

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION
APPENDIX E

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 122 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR
AFT C.G. MLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 123

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCUS WITH BASIC AIRPLANE FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 123 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 124
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 124 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PдEASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 125

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 125 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

FIGURE 126
APPENDIX E

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.7U
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 126 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 127
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 127 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCUS WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 128
DAST AHW-2 PCS GAIN/PHASE ROOT LOCi WITH RSS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 128 (CONCLUDED)
DAST ARM-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 129

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND
  GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

Figure 129 (continued)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 129 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 130
DAST ARW-2 GLA STABILIZER LOOP GAIN/PHERE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 130 (CONTINUED)

DASt ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

![Diagram showing gain/phase root loci with RSS, PCS, and GLA aileron loops closed for forward C.G. GLA test condition.](image)

**Figure 130 (Concluded)**

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 131
DAST ARM-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 131 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/P RSS CLOSED FOR Forward C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 132
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 132 (CONCLUDED)**

DAST ARW-2 RSS SYSTEM GAIN/P HASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 133

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 133 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 134

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION

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APPENDIX E

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**Figure 134 (Concluded)**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 135
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 135 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 136

DAST ARM-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 136 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 137

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 137 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION
FIGURE 138

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 138 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 138 (CONCLUDED)
DAST ARW-2 GLA AILERON LOOP GAIN PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 139

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 139 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 139 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 140

DAST ARW-2 BCS SYSTEM GAIN/PDASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 140 (CONCLUDED)
DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION
APPENDIX E

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 141
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 141 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 142

DAST ARM-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

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APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 142 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 143
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 143 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 144

DAS® ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 144 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20\% MAC

FIGURE 145
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 145 (CONCLUDED)
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 146
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR
FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 146 (CONCLUDED)
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 147
DAST ARW-2 BCS SYSTEM GAIN/P.HASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 147 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PDASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 148

DASD AHM-2 RSS SYSTEM GAIN/PARTHEN ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G., LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 148 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 149**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 149 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 150
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 150 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 151
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 151 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/P HASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 152
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 152 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 153

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 153 (CONCLUDED)
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 154
DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 154 (CONTINUED)
DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 154 (CONCLUDED)**

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- GLA STABILIZER WITH RSS, PCS
  AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 155

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA
AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 155 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

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APPENDIX E

- LAUNCH
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 155 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 156
DAST ARW-2 BCS SYSTEM GAIN/P HASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION
APPENDIX E

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 156 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION

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APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 157
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 157 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 158

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 158 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

**FIGURE 159**

DA^ST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

FIGURE 159 (CONCLUDED)
APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 160
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 160 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 161
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

![Diagram](image)

**FIGURE 161 (CONCLUDED)**

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

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APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 162

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR
FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 162 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

• HIGH ALTITUDE
• BCS WITH RSS CLOSED
• MACH: 0.70
• ALTITUDE: 50,000 FT.
• GROSS WEIGHT: 2500 LBS.
• C.G.: 20% MAC

FIGURE 163

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 163 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 164

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 164 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCUS WITH BASIC AIRPLANE FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 165
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 165 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 166

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

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APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 166 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 167

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 167 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 168

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 168 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

![Diagram of gain/phase root loci with RSS and GLA closed for aft C.G. high altitude condition.](image)

**FIGURE 169**

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 169 (CONCLUDED)
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 170

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 170 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

![Diagram](image)

FIGURE 170 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 171

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS
  AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 171 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 172

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 172 (CONCLUDED)
DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION
APPENDIX E

- CRUISE
- RSS
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 173

DAST ARW-2 RSS SYSTEM GAIN/PAGE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 173 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 174

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 174 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCUS WITH PCS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 175
DA 2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 175 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 176

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20\% MAC

FIGURE 176 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 177

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

• CRUISE
• PCS WITH RSS CLOSED
• 1.0g FLIGHT
• MACH: 0.80
• ALTITUDE: 46,800 FT.
• GROSS WEIGHT: 2500 LBS.
• C.G.: 20% MAC

FIGURE 177 (CONCLUDED)
DAST AKW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 178

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 45,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 178 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 179

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 179 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 180

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 180 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 181
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 181 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

![Graph of RSS System Gain/Phase Root Loci with PCS and GLA Closed for Aft C.G. Cruise Condition](image)

FIGURE 182

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 182 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 183

DAST ARW-2 RSS SYSTEM GAIN/P HASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 183 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHERE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 184

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

DAST ARW-2 PCS GAIN/PDASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.2g FLIGHT
- MACH= 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 185
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

![Diagram]

**FIGURE 185 (CONCLUDED)**

DAST ARM-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 186

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 186 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 186 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

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APPENDIX E

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 187
DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 187 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 187 (CONCLUDED)

DAST ARM-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 188
DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 188 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 189

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- Maximum Q (Vd)
- RSS
- Mach: 0.86
- Altitude: 15,000 FT.
- Gross Weight: 2500 LBS.
- C.G.: 20% MAC

Figure 189 (Concluded)

DAST ARW-2 RSS System Gain/Phase Root Loci with Basic Airplane for Forward C.G. Maximum Dynamic Pressure Condition
APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 190
DAST ARW-2 RSS SYSTEM GAIN/P HASE ROOT LOCI WITH PCS CLOSED FOR
FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
DAST ARW-2 RSS SYSTEM GAIN/P/ASE ROOT LOCI WITH PCS CLOSED FOR
FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM $Q (V_d)$
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 191
DAST ARW-2 RSS SYSTEM GAIN/P HASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM $Q (V_d)$
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 191 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q \( (V_d) \)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 192
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 192 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PAGE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (V_d)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 193
DAST A(NW-2) PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM $Q (v_d)$
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 193 (CONCLUDED)
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

<Diagram>

FIGURE 194
DAST ARW-2 PCS GAIN/PHTASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 194 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM $Q (V_d)$
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 195

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- Maximum Q (V_d)
- BCS with RSS Closed
- Mach: 0.86
- Altitude: 15,000 ft.
- Gross weight: 2500 lbs.
- C.G.: 20% MAC

FIGURE 195 (CONCLUDED)

DAST ARM-2 BCS system gain/phase root loci with RSS closed for forward C.G. maximum dynamic pressure condition
APPENDIX E

- MAXIMUM Q (V_d)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 196
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

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APPENDIX E

• MAXIMUM Q (Vd)
• RSS
• MACH: 0.86
• ALTITUDE: 15,000 FT.
• GROSS WEIGHT: 2200 LBS.
• C.G.: 33% MAC

FIGURE 196 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($Q_d$)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

---

**FIGURE 197**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 197 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 198
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 198 (CONCLUDED)**

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q \( (V_d) \)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33\% MAC

FIGURE 199

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 199 (CONCLUDED)

DAST ARM-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

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<tr>
<td>3</td>
<td>+4.5dB</td>
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</tbody>
</table>

FIGURE 200
DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

![Diagram of root loci](image)

**FIGURE 200 (CONCLUDED)**

DAST ARW-2 PCS GAIN/PHTASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

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APPENDIX E

- MAXIMUM $Q (V_d)$
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 201

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (V_d)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 201 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- Maximum Q ($V_d$)
- GLA aileron with RSS, PCS and GLA stabilizer closed
- Mach: 0.86
- Altitude: 15,000 FT.
- Gross weight: 2200 LBS.
- C.G.: 33% MAC

![Diagram](image)

**Figure 202**

DAST ARW-2 GLA aileron loop gain/phase root loci with RSS, PCS and GLA stabilizer loops closed for aft C.G. maximum dynamic pressure condition
APPENDIX E

- MAXIMUM Q ($V_d$)
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 202 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

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APPENDIX E

- MAXIMUM $Q (V_d)$
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

**FIGURE 202 (CONCLUDED)**

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM $Q (V_d)$
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 203
DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q (\(V_d\))
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 203 (CONTINUED)
DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

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APPENDIX E

- MAXIMUM Q (V_d)
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 203 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PĐHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E

- MAXIMUM Q ($V_d$)
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 204

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
APPENDIX E.

- MAXIMUM $Q (V_d)$
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

FIGURE 204 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
A study was conducted under Drones for Aerodynamic and Structural Testing (DAST) program to accomplish the final design and hardware fabrication for four active control systems compatible with and ready for installation in the NASA Aeroelastic Research Wing No. 2 (ARW-2) and Firebee II drone flight test vehicle. The wing structure was designed so that Active Control Systems (ACS) are required in the normal flight envelope by integrating control system design with aerodynamics and structure technologies. The DAST ARW-2 configuration uses flutter suppression, relaxed static stability and gust and maneuver load alleviation ACS systems, and an automatic flight control system. Performance goals and criteria were applied to individual systems and the systems collectively to assure that vehicle stability margins, flutter margins, flying qualities and load reductions were achieved.

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