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

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</tr>
<tr>
<td>184</td>
<td>DAST ARW-2 PCS gain/phase root loci with RSS closed for aft C.G. cruise condition</td>
</tr>
<tr>
<td>185</td>
<td>DAST ARW-2 PCS gain/phase root loci with RSS and GLA closed for aft C.G. cruise condition</td>
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<td>DAST ARW-2 RSS system gain/phase root loci with PCS closed for forward C.G. maximum dynamic pressure condition</td>
</tr>
<tr>
<td>191</td>
<td>DAST ARW-2 RSS system gain/phase root loci with PCS and GLA closed for forward C.G. maximum dynamic pressure condition</td>
</tr>
<tr>
<td>192</td>
<td>DAST ARW-2 RSS system gain/phase root loci with BCS closed for forward C.G. maximum dynamic pressure condition</td>
</tr>
<tr>
<td>193</td>
<td>DAST ARW-2 PCS gain/phase root loci with RSS closed for forward C.G. maximum dynamic pressure condition</td>
</tr>
<tr>
<td>194</td>
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</tr>
</tbody>
</table>
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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 380

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 383

204  DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION 386
INTRODUCTION

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.
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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
APPENDIX A

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## APPENDIX A

### Maximum q

<table>
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<tr>
<th>Condition</th>
<th>MACH</th>
<th>q (FT)</th>
<th>q (PSF)</th>
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<td>15,000</td>
<td>0.0215</td>
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<td>0.80</td>
<td>46,800</td>
<td>126.4</td>
<td>0.0270</td>
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<tr>
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<td>50,000</td>
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<td>0.0381</td>
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<td>0.42</td>
<td>10,000</td>
<td>41.0</td>
<td>0.0009</td>
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<tr>
<td>Maneuver</td>
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<td>0.0203</td>
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<tr>
<td>0.42</td>
<td>10,000</td>
<td>41.0</td>
<td>0.0009</td>
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### Design Derivatives

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<td>Condition</td>
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<td>0.0026</td>
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<tr>
<td>Sea Level</td>
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<td>0.0003</td>
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<td>0.0036</td>
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</tr>
<tr>
<td>0.42</td>
<td>0.0035</td>
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### Units

- 1 degree
- 1/radian
- 1/degree

### Derivative

- $C_{y,x}$
- $C_{y,\phi}$
- $C_{y,\delta r}$
- $C_{y,\delta}$
- $C_{y,f}$
- $C_{y,\delta c}$
- $C_{y,\delta s}$
- $C_{y,\phi s}$
- $C_{y,\delta r s}$
- $C_{y,\phi s}$
- $C_{y,\delta s}$
APPENDIX A

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

FIGURE 3
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, LAUNCH CONDITION
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
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
FIGURE 11
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA DESIGN CONDITION
APPENDIX A

ORIGINAL PAGES 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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<td></td>
<td></td>
<td>IXX</td>
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<tr>
<td>2500</td>
<td>19.93</td>
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<td>2350</td>
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<td>163.3</td>
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<tr>
<td>2200</td>
<td>32.75</td>
<td>163.1</td>
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*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
FIGURE 26
LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES
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
APPENDIX A

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
THRUST DATA FOR 80 PERCENT ENGINE RPM
FIGURE 33
THRUST DATA FOR 85 PERCENT ENGINE RPM
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
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.
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.
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-sec²), 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.

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
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 150 hertz.

With full length lines, higher frequency fluid modes are evident at 160 and 300 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 servoaotuator 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 servovalves 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.
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.

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F. Sevart

CC: J. Arnold
TABLE I
SUMMARY OF FREQUENCY RESPONSE WITH LINE LENGTH AND LOAD INERTIA VARIATIONS BASED ON FIGURES 1 THROUGH 15

<table>
<thead>
<tr>
<th>LINE LENGTH</th>
<th>INERTIA</th>
<th>DOMINANT MODE PEAK FREQUENCY (Hz)</th>
<th>PEAK AMPLITUDE (DEG)</th>
<th>90° PHASE FREQUENCY (Hz)</th>
<th>SURFACE ACTUATOR</th>
<th>#1 FLUID</th>
<th>#2 FLUID</th>
<th>#3 FLUID</th>
<th>SERVO-VALVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL (84 INCHES)</td>
<td>FULL (0.004 IN-LB-SEC²)</td>
<td>60</td>
<td>2.03</td>
<td>51</td>
<td>---</td>
<td>160</td>
<td>380</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>FULL</td>
<td>HALF (0.002 IN-LB-SEC²)</td>
<td>62</td>
<td>1.54</td>
<td>50</td>
<td>---</td>
<td>130</td>
<td>380</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>FULL</td>
<td>NONE</td>
<td>50</td>
<td>1.14</td>
<td>52</td>
<td>---</td>
<td>140</td>
<td>380</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3/4 (63 INCHES)</td>
<td>FULL</td>
<td>46</td>
<td>1.69</td>
<td>43</td>
<td>---</td>
<td>185</td>
<td>460</td>
<td>145</td>
<td>---</td>
</tr>
<tr>
<td>3/4</td>
<td>HALF</td>
<td>44</td>
<td>1.58</td>
<td>43</td>
<td>---</td>
<td>185</td>
<td>460</td>
<td>145</td>
<td>---</td>
</tr>
<tr>
<td>3/4</td>
<td>NONE</td>
<td>42</td>
<td>1.46</td>
<td>44</td>
<td>---</td>
<td>185</td>
<td>460</td>
<td>145</td>
<td>---</td>
</tr>
<tr>
<td>1/2 (42 INCHES)</td>
<td>FULL</td>
<td>52</td>
<td>1.73</td>
<td>46</td>
<td>105</td>
<td>230</td>
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</tr>
<tr>
<td>1/2</td>
<td>HALF</td>
<td>50</td>
<td>1.45</td>
<td>47</td>
<td>115</td>
<td>230</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1/2</td>
<td>NONE</td>
<td>48</td>
<td>1.35</td>
<td>49</td>
<td>---</td>
<td>230</td>
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</tr>
<tr>
<td>1/4 (21 INCHES)</td>
<td>FULL</td>
<td>50</td>
<td>1.61</td>
<td>50</td>
<td>115</td>
<td>330</td>
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<td>---</td>
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<tr>
<td>1/4</td>
<td>HALF</td>
<td>54</td>
<td>1.41</td>
<td>53</td>
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<td>340</td>
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<td>---</td>
</tr>
<tr>
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<td>NONE</td>
<td>52</td>
<td>1.31</td>
<td>55</td>
<td>---</td>
<td>340</td>
<td>---</td>
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</tr>
<tr>
<td>10 INCHES</td>
<td>FULL</td>
<td>60</td>
<td>1.62</td>
<td>56</td>
<td>115</td>
<td>430</td>
<td>---</td>
<td>---</td>
<td>230</td>
</tr>
<tr>
<td>10 INCHES</td>
<td>HALF</td>
<td>56</td>
<td>1.33</td>
<td>55</td>
<td>---</td>
<td>430</td>
<td>---</td>
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<td>230</td>
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<td>1.20</td>
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<td>410</td>
<td>---</td>
<td>---</td>
<td>230</td>
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</table>

NOTE: Position and pressure feedback gains held constant. Input amplitude 1.00 deg. Position loop gain 329.6 rad/sec, pressure loop gain 0.5678 rad/sec.
FIGURE 37 (CONTINUED)

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

DAST ARM-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

FIGURE 4. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, FULL LOAD INERTIA
APPENDIX B

FIGURE 37 (CONTINUED)

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

FIGURE 6. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, NO LOAD INERTIA

NOTE: 3/4 LINE LENGTH (63 INCHES) NO LOAD INERTIA

PHASE LAG ~ DEG

AMPLITUDE ~ DEG

FREQUENCY ~ Hz

OF POOR QUALITY
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

APPENDIX B

FIGURE 11. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - ONE-QUARTER LINE LENGTH, HALF LOAD INERTIA

PHASE LAG ~ DEG

F. Travel Angle

NOTE: 1/4 LINE LENGTH (2 INCHES)
1/2 LOAD INERTIA (0.002 IN-LB-SEC^2)

AMPLITUDE ~ DEG

FREQUENCY ~ Hz

0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
10.0
100.0
1.0
0.1
0.01
0.001
0.0001

0
2.0
4.0
6.0
8.0
10.0
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
FIGURE 37 (CONTINUED)

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

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

ORIGINAL PAGE IS
OE POOR QUALITY
Figure 37 (continued)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
FIGURE 19. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, NO LOAD INERTIA
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 OUTBOARDAILERON SERVOVALVE RELOCATION STUDY
FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVO VALVE 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)

Figure 27. Load Pressure Frequency Response - Full Line Length, Full Load Inertia, Position Loop Gain 19.18 Rad/sec.
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 (CONTINUED)

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

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY
APPENDIX C
DAST ARW-2 FINAL FLUTTER SUPPRESSION SYSTEM PERFORMANCE DATA

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.
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAMPING (ζ)</td>
<td>FREQUENCY (HZ)</td>
</tr>
<tr>
<td>q₁ (FLUTTER MODE)</td>
<td>0.0122</td>
<td>14.2596</td>
</tr>
<tr>
<td>q₂</td>
<td>0.3347</td>
<td>17.1592</td>
</tr>
<tr>
<td>q₃</td>
<td>0.9976</td>
<td>21.9268</td>
</tr>
<tr>
<td>q₄</td>
<td>0.0050</td>
<td>21.7325</td>
</tr>
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<td>q₅</td>
<td>0.6064</td>
<td>25.5127</td>
</tr>
<tr>
<td>q₆</td>
<td>0.0088</td>
<td>33.1990</td>
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<td>q₇</td>
<td>0.0883</td>
<td>33.9358</td>
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<td>q₈</td>
<td>0.0143</td>
<td>63.2038</td>
</tr>
<tr>
<td>q₉</td>
<td>0.0332</td>
<td>67.6099</td>
</tr>
<tr>
<td>q₁₀ (SERVOVALVE ACTUATOR)</td>
<td>0.0524</td>
<td>70.5048</td>
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<td>ACTUATOR NOTCH</td>
<td>0.3997</td>
<td>49.9750</td>
</tr>
<tr>
<td>FILTER</td>
<td>0.2398</td>
<td>75.9960</td>
</tr>
<tr>
<td>FILTER</td>
<td>0.2995</td>
<td>75.9960</td>
</tr>
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<td>101.859</td>
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<td>FILTER</td>
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<td>NOTCH 2</td>
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<td>13.528</td>
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**FIGURE 3B**

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.80, ALTITUDE: 2,000 FEET, UNSCALED EOM
MACH: 0.83
ALTITUDE: 3,000 FEET
UNSCALED EOM

<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAMPING ($\xi$)</td>
<td>FREQUENCY (Hz)</td>
</tr>
<tr>
<td>$q_1$ (FLUTTER MODE)</td>
<td>0.0124</td>
<td>14.2621</td>
</tr>
<tr>
<td>$q_2$</td>
<td>-0.3887</td>
<td>22.6863</td>
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<tr>
<td>$q_3$</td>
<td>0.0052</td>
<td>21.7357</td>
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<td>$q_4$</td>
<td>0.7247</td>
<td>26.1847</td>
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<tr>
<td>$q_5$</td>
<td>0.0089</td>
<td>33.2006</td>
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<tr>
<td>$q_6$</td>
<td>0.0879</td>
<td>34.0812</td>
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<tr>
<td>$q_7$</td>
<td>0.0719</td>
<td>49.9889</td>
</tr>
<tr>
<td>$q_8$</td>
<td>0.0135</td>
<td>63.1943</td>
</tr>
<tr>
<td>$q_9$</td>
<td>0.0311</td>
<td>67.4124</td>
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<tr>
<td>$q_{10}$ SERVOVALVE ACTUATOR</td>
<td>0.0275</td>
<td>70.6794</td>
</tr>
<tr>
<td></td>
<td>0.3997</td>
<td>49.9750</td>
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<td>0.2398</td>
<td>75.9960</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
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<td>75.9960</td>
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<tr>
<td>FILTER</td>
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<td>0.3183</td>
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<td>15.7600</td>
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<tr>
<td>NOTCH 2</td>
<td>0.3610</td>
<td>13.5280</td>
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</table>

**FIGURE 39**

SYMmetric ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.83, ALTITUDE: 3,000 FEET
UNSCALED EOM
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP Damping (ξ)</th>
<th>OPEN LOOP Frequency (Hz)</th>
<th>CLOSED LOOP Damping (ξ)</th>
<th>CLOSED LOOP Frequency (Hz)</th>
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</thead>
<tbody>
<tr>
<td>q1 (FLUTTER MODE)</td>
<td>0.0122</td>
<td>14.2672</td>
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<td>14.2990</td>
</tr>
<tr>
<td>q2</td>
<td>-0.3804</td>
<td>21.5541</td>
<td>-0.0052</td>
<td>22.8822</td>
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<tr>
<td>q3</td>
<td>0.0052</td>
<td>21.7436</td>
<td>0.0395</td>
<td>21.1449</td>
</tr>
<tr>
<td>q4</td>
<td>0.9926</td>
<td>17.0430</td>
<td>0.9421</td>
<td>19.6067</td>
</tr>
<tr>
<td>q5</td>
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<td>27.0143</td>
<td>0.5395</td>
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<td>q6</td>
<td>0.0099</td>
<td>33.1943</td>
<td>0.0099</td>
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<tr>
<td>q7</td>
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<td>0.0909</td>
<td>69.4682</td>
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<td>q10</td>
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<td>0.0249</td>
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<td>SERVOVALVE ACTUATOR</td>
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<td>49.975</td>
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<td>0.2398</td>
<td>75.996</td>
<td>0.1390</td>
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<td>ACTUATOR NOTCH</td>
<td>0.2995</td>
<td>75.996</td>
<td>0.1078</td>
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<td>23.873</td>
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<td>27.1561</td>
</tr>
<tr>
<td>FILTER</td>
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<td>0.3183</td>
<td>1.0000</td>
<td>0.0039</td>
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<td>NOTCH 1</td>
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<td>13.528</td>
<td>0.1410</td>
<td>9.9618</td>
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</tbody>
</table>

**Figure 40**

Symmetric elastic mode damping and frequency, MACH: 0.83, ALTITUDE: 4,500 FEET
UNSCALED EOM
<table>
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<th>MODE</th>
<th>OPEN LOOP</th>
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<th>CLOSED LOOP</th>
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</thead>
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<td></td>
<td>DAMPING ((\zeta))</td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING ((\zeta))</td>
<td>FREQUENCY (Hz)</td>
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<tr>
<td>(q_1)</td>
<td>0.0109</td>
<td>14.2383</td>
<td>0.0127</td>
<td>14.2723</td>
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<tr>
<td>(q_2) (FLUTTER MODE)</td>
<td>-0.1750</td>
<td>21.9798</td>
<td>0.0758</td>
<td>24.0437</td>
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<tr>
<td>(q_3)</td>
<td>0.0043</td>
<td>21.6806</td>
<td>0.0113</td>
<td>21.7943</td>
</tr>
<tr>
<td>(q_4)</td>
<td>0.5444</td>
<td>21.3533</td>
<td>0.3379</td>
<td>18.2829</td>
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<tr>
<td>(q_5)</td>
<td>0.0078</td>
<td>33.2336</td>
<td>0.0075</td>
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<tr>
<td>(q_6)</td>
<td>0.0574</td>
<td>33.7194</td>
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</tr>
<tr>
<td>(q_7)</td>
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<td>49.1129</td>
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<td>49.1155</td>
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<tr>
<td>(q_8)</td>
<td>0.0117</td>
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<td>0.0114</td>
<td>63.0909</td>
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<td>(q_9)</td>
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<td>76.9607</td>
<td>0.0236</td>
<td>76.9206</td>
</tr>
<tr>
<td>ACTUATOR NOTCH</td>
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<td>49.9746</td>
<td>0.3997</td>
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<td>13.528</td>
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**Figure 41**

Symmetric elastic mode damping and frequency, MACH: 0.83, ALTITUDE: 12,000 FEET
UNSCALED EOM
<table>
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<tr>
<th>MODE</th>
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<td>FREQUENCY (Hz)</td>
<td>DAMPING ($\zeta$)</td>
<td>FREQUENCY (Hz)</td>
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<td>0.0526</td>
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<td>0.0525</td>
<td>73.6068</td>
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<td>0.3997</td>
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<td>75.0067</td>
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<td>0.3610</td>
<td>13.528</td>
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**Figure 42**

Symmetric elastic mode damping and frequency, MACH: 0.86, ALTITUDE: 15,000 FEET, UNSCALED EOM
<table>
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<tr>
<th>MODE</th>
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<td>FREQUENCY (Hz)</td>
<td>DAMPING (ζ)</td>
<td>FREQUENCY (Hz)</td>
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<td>.0104</td>
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<td>63.1401</td>
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<td>.0775</td>
<td>73.8694</td>
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<td>.0264</td>
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<td>.3997</td>
<td>.3997</td>
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**FIGURE 43**

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.91, ALTITUDE: 8,000 FEET
UNSCALED EOM
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</table>

FIGURE 44

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 4,250 FEET, UNSCALED EOM
### Figure 45

Antisymmetric elastic mode damping and frequency with parameter scheduling, Mach: 0.83, altitude: 12,000 feet, unscaled EOM

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</tr>
<tr>
<td>$q_7$</td>
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<td>Actuator Notch</td>
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</table>
MACH: 0.86
ALTIMETE: 15,000 FEET
UNSCALED EOM

<table>
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<th>CLOSED LOOP</th>
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<td>FREQUENCY (HZ)</td>
<td>DAMPING (c)</td>
<td>FREQUENCY (HZ)</td>
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FIGURE 46

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.86, ALTIUMETE: 15,000 FEET, UNSCALED EOM
<table>
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<td>(HZ)</td>
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FIGURE 47

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 8,000 FEET, UNSCALED EOM
FIGURE 49

SYMmetric flutter mode damping, Mach: 0.83
FIGURE 50

SYMmetric FLUTTER MODE DAMPING, MACH: 0.86
APPENDIX C

FIGURE 51

ASYMMETRIC FLUTTER MODE DAMPING, MACH 0.91

DAMPING RATIO ($\zeta$)

0.30
0.20
0.10
0.0

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

ALTITUDE (FEET)

FSS ON
FSS OFF

-0.20
-0.10

115
Figure 54
Antisymmetric Flutter Mode Damping, Mach: 0.86
APPENDIX C

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
APPENDIX C

FIGURE 59

ASYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 12,000 FEET

DAMPING RATIO (z)

MACH NO.

0.20  0.10  0  -0.10  -0.20

FSS ON  FSS OFF
APPENDIX C

\[ j_0 - \text{RAD/SEC} \]

- MACH = 0.80
- ALTITUDE = 2,000 FEET

\[ j_0 - \text{RAD/SEC} \]

- GAIN
  1 1.50
  2 1.00
  3 0.50
  4 0.00

SERVOVALVE ACTUATOR

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FG'S: NOMINAL SYSTEM

MACH: 0.80, ALTITUDE: 2,000 FEET

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

-200.0 -150.0 -100.0 -50.0 0 50.0 100.0 150.0 200.0

-350.0 -300.0 -250.0 -200.0 -150.0 -100.0 -50.0 0

124
APPENDIX C

ORIGINAL PAGE IS OF POOR QUALITY

FIGURE 61

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM, MACH = 0.83, ALTITUDE: 3,000 FEET
MACH = 0.83
ALTITUDE = 12,000 FEET

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.83, ALTITUDE: 12,000 FEET
MACH = 0.86

ALTITUDE = 4,250 FEET

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 4,250 FEET
MACH = 0.86
ALTITUDE = 15,000 FEET

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 15,000 FEET
MACH = 0.91
ALTITUDE = 8,000 FEET

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.91, ALTITUDE: 8,000 FEET
PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.80, ALTITUDE: 2,000 FEET
MACH = 0.83
ALTITUDE = 3000 FEET

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.83, ALTITUDE: 3,000 FEET
FIGURE 68

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

ORIGINAL PAGE IS OF POOR QUALITY

MACH = 0.91
ALITUDE = 8000 FEET

FIGURE 71

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING.
MACH = 0.91, ALITUDE: 8,000 FEET

GAIN
0
0.50
1.00
NORMAL
NOMINAL

NOTCH 1
CUTON MODE
SEPARATIVE ACTUATOR
SEPARATIVE ACTUATOR

ω = RAD/SEC

σ - RAD/SEC
APPENDIX D

DAST ARW-2 SENSITIVITY ANALYSIS DATA

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-1 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.
<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>(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>
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<td>(q_8)</td>
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<td>(q_9)</td>
<td>67.6</td>
<td>0.0233</td>
</tr>
<tr>
<td>(q_{10})</td>
<td>73.6</td>
<td>0.0524</td>
</tr>
</tbody>
</table>

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

Figure 72

Symmetric Sensor Location Sensitivity

Below design specs.
<table>
<thead>
<tr>
<th>FREQUENCY (Hz)</th>
<th>OPEN LOOP DAMPING RATIO (ζ)</th>
<th>CLOSED LOOP DAMPING RATIO (ζc) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.2</td>
<td>0.00105</td>
<td>0.0129 +45 DEGREES</td>
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<tr>
<td>20.1</td>
<td>-0.1190</td>
<td>0.0098 +45 DEGREES</td>
</tr>
<tr>
<td>21.7</td>
<td>0.0024</td>
<td>0.0098 +45 DEGREES</td>
</tr>
<tr>
<td>23.3</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>33.2</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>33.7</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>49.1</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>63.2</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>67.6</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
<tr>
<td>73.6</td>
<td>0.0084</td>
<td>0.0084 +45 DEGREES</td>
</tr>
</tbody>
</table>

**MODE**
- 91
- 92
- 93
- 94
- 95
- 96
- 97
- 98
- 99
- 100

**APPENDIX D**

**SYMMETRIC SENSOR LOCATION SENSITIVITY**

**FIGURE 72 (CONTINUED)**

**BELOW DESIGN SPECS.**
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
<th>SENSOR LOCATION</th>
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</thead>
<tbody>
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<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO (ζ)</td>
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<td>-0.1190</td>
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<td>0.0417</td>
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<td>0.0527</td>
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<td>73.6</td>
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**FIGURE 72 (CONCLUDED)**

Symmetric sensor location sensitivity
<table>
<thead>
<tr>
<th>OPEN LOOP DAMPING RATIO ((\zeta))</th>
<th>FREQUENCY (HZ)</th>
<th>MODE</th>
<th>FS 90 AND RS 90 NOMINAL DEGREES</th>
<th>FS 90 AND RS 92 NOMINAL DEGREES</th>
<th>FS 90 AND RS 94 NOMINAL DEGREES</th>
<th>FS 90 AND RS 90 -45 DEGREES</th>
<th>FS 90 AND RS 92 -45 DEGREES</th>
<th>FS 90 AND RS 94 -45 DEGREES</th>
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<td>MODE</td>
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<td>FS 92 AND RS 94</td>
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<td>-45 DEGREES</td>
<td>+45 DEGREES</td>
<td>NOMINAL</td>
<td>-45 DEGREES</td>
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</table>

---

**Figure 73 (Continued)**

antisymmetric sensor location sensitivity
### APPENDIX D

#### CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN WITHOUT FSS WASHOUT

<table>
<thead>
<tr>
<th>OPEN LOOP</th>
<th>FREQUENCY (Hz)</th>
<th>MODE</th>
<th>DAMPING RATIO (ζ)</th>
<th>SENSOR LOCATION</th>
<th>NOMINAL DEGREES</th>
<th>DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS 94 AND RS 90</td>
<td>20.1</td>
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<td>0.0032</td>
<td>+45</td>
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</tr>
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<td>36.9</td>
<td>95</td>
<td>0.0069</td>
<td>0.0919</td>
<td>0.0487</td>
<td>0.0077</td>
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<td>44.1</td>
<td>96</td>
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</tr>
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<td>0.0487</td>
<td>0.0077</td>
</tr>
<tr>
<td></td>
<td>74.5</td>
<td>10</td>
<td>0.0077</td>
<td>0.0487</td>
<td>0.0487</td>
<td>0.0077</td>
</tr>
</tbody>
</table>

**FIGURE 75 (CONCLUDED)**

**ASYMMETRIC SENSOR LOCATION SENSITIVITY**
### 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>
</tr>
</tbody>
</table>

### ANTISYMMETRIC

<table>
<thead>
<tr>
<th></th>
<th>110 RAD. NOTCH</th>
<th>230 RAD. NOTCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL</td>
<td>$S^2 + 190.5S + 12100$</td>
<td>$S^2 + 92.0S + 52900$</td>
</tr>
<tr>
<td></td>
<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>
</tr>
<tr>
<td></td>
<td>$S^2 + 83.4S + 13340$</td>
<td>$S^2 + 193.2S + 58322$</td>
</tr>
<tr>
<td>$\omega_N$ 5% DECREASE</td>
<td>$S^2 + 181.0S + 10920$</td>
<td>$S^2 + 87.4S + 47742$</td>
</tr>
<tr>
<td></td>
<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>$</td>
<td>M</td>
<td>$ 5% DECREASE</td>
</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
### APPENDIX D

- **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>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 75**

**SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 85 RAD. NOTCH**
- Mach = 0.86
- Altitude = 15,000 feet
- Without FSS Washout

<table>
<thead>
<tr>
<th>Mode</th>
<th>Frequency (Hz)</th>
<th>Open Loop Damping Ratio (ζ)</th>
<th>Closed Loop Damping Ratio (ζ) - Nominal Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>+45 Degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5% Increase</td>
</tr>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</td>
<td>0.0126</td>
</tr>
<tr>
<td>q₂</td>
<td>20.1</td>
<td>-0.1190</td>
<td>0.1130</td>
</tr>
<tr>
<td>q₃</td>
<td>21.7</td>
<td>0.0024</td>
<td>0.0094</td>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
<td>0.7888</td>
</tr>
<tr>
<td>q₅</td>
<td>33.2</td>
<td>0.0084</td>
<td>0.0083</td>
</tr>
<tr>
<td>q₆</td>
<td>33.7</td>
<td>0.0619</td>
<td>0.0480</td>
</tr>
<tr>
<td>q₇</td>
<td>49.1</td>
<td>0.0</td>
<td>0.0565</td>
</tr>
<tr>
<td>q₈</td>
<td>63.2</td>
<td>0.0118</td>
<td>0.0120</td>
</tr>
<tr>
<td>q₉</td>
<td>67.6</td>
<td>0.0238</td>
<td>0.0202</td>
</tr>
<tr>
<td>q₁₀</td>
<td>73.6</td>
<td>0.524</td>
<td>0.419</td>
</tr>
</tbody>
</table>

**Figure 76**

Symmetric Notch Filter Sensitivity to Notch Frequency, 170 rad. Notch
<table>
<thead>
<tr>
<th>MODE (n)</th>
<th>OPEN LOOP FREQUENCY (Hz)</th>
<th>OPEN LOOP DAMPING RATIO ((\zeta))</th>
<th>CLOSED LOOP DAMPING RATIO ((\zeta)) - NOMINAL GAIN +45 DEGREES</th>
<th>NOMINAL</th>
<th>-45 DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>5% INCREASE</td>
<td>5% DECREASE</td>
<td>5% INCREASE</td>
</tr>
<tr>
<td>q₁</td>
<td>14.2</td>
<td>0.0105</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>0.1162</td>
<td>0.0986</td>
<td>0.1413</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>
</tr>
<tr>
<td>q₄</td>
<td>23.3</td>
<td>0.4521</td>
<td>0.7881</td>
<td>0.7904</td>
<td>0.1770</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>
</tr>
<tr>
<td>q₆</td>
<td>33.7</td>
<td>0.0619</td>
<td>0.0480</td>
<td>0.0480</td>
<td>0.0503</td>
</tr>
<tr>
<td>q₇</td>
<td>49.1</td>
<td>0.05</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>
</tr>
<tr>
<td>q₉</td>
<td>67.6</td>
<td>0.0238</td>
<td>0.0200</td>
<td>0.0202</td>
<td>0.0168</td>
</tr>
<tr>
<td>q₁₀</td>
<td>73.6</td>
<td>0.524</td>
<td>0.0420</td>
<td>0.0419</td>
<td>0.0501</td>
</tr>
</tbody>
</table>

**FIGURE 77**

*Symmetric notch filter sensitivity to notch magnitude, 85 rad. notch*
**APPENDIX D**

- **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</td>
<td>+45 DEGREES</td>
</tr>
<tr>
<td></td>
<td>(HZ)</td>
<td>5% INCREASE</td>
</tr>
<tr>
<td>q1</td>
<td>14.2</td>
<td>0.0126</td>
</tr>
<tr>
<td>q2</td>
<td>20.1</td>
<td>0.1064</td>
</tr>
<tr>
<td>q3</td>
<td>21.7</td>
<td>0.0094</td>
</tr>
<tr>
<td>q4</td>
<td>23.3</td>
<td>0.7905</td>
</tr>
<tr>
<td>q5</td>
<td>33.2</td>
<td>0.0083</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>0.0120</td>
</tr>
<tr>
<td>q9</td>
<td>67.6</td>
<td>0.0202</td>
</tr>
<tr>
<td>q10</td>
<td>73.6</td>
<td>0.0419</td>
</tr>
</tbody>
</table>

**FIGURE 78**

**SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 170 RAD. NOTCH**
## APPENDIX D

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

### Table: Open Loop vs. Closed Loop Damping Ratio (ζ) - Nominal Gain

<table>
<thead>
<tr>
<th>MODE</th>
<th>FREQUENCY (Hz)</th>
<th>DAMPING RATIO (ζ)</th>
<th>CLOSED LOOP DAMPING RATIO (ζ)</th>
<th>NOMINAL</th>
<th>-45 DEGREES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>+45 DEGREES</td>
<td>5% INCREASE</td>
<td>5% DECREASE</td>
</tr>
<tr>
<td>q₁</td>
<td>20.1</td>
<td>0.0032</td>
<td>0.0274</td>
<td>0.0226</td>
<td>0.0358</td>
</tr>
<tr>
<td>q₂</td>
<td>21.5</td>
<td>-0.1372</td>
<td>0.0490</td>
<td>0.0426</td>
<td>0.0174</td>
</tr>
<tr>
<td>q₃</td>
<td>22.2</td>
<td>0.0040</td>
<td>0.0107</td>
<td>0.0107</td>
<td>0.0107</td>
</tr>
<tr>
<td>q₄</td>
<td>25.2</td>
<td>0.4735</td>
<td>0.8116</td>
<td>0.8206</td>
<td>0.1541</td>
</tr>
<tr>
<td>q₅</td>
<td>39.9</td>
<td>0.0602</td>
<td>0.0556</td>
<td>0.0556</td>
<td>0.0556</td>
</tr>
<tr>
<td>q₆</td>
<td>44.1</td>
<td>0.0487</td>
<td>0.0487</td>
<td>0.0487</td>
<td>0.0487</td>
</tr>
<tr>
<td>q₇</td>
<td>47.4</td>
<td>0.0077</td>
<td>0.0077</td>
<td>0.0077</td>
<td>0.0077</td>
</tr>
<tr>
<td>q₈</td>
<td>67.0</td>
<td>0.0214</td>
<td>0.0211</td>
<td>0.0212</td>
<td>0.0201</td>
</tr>
<tr>
<td>q₉</td>
<td>70.4</td>
<td>0.0209</td>
<td>0.0201</td>
<td>0.0202</td>
<td>0.0189</td>
</tr>
<tr>
<td>q₁₀</td>
<td>74.5</td>
<td>0.0367</td>
<td>0.0431</td>
<td>0.0431</td>
<td>0.0373</td>
</tr>
</tbody>
</table>

### Figure 79

Antisymmetric notch filter sensitivity to notch frequency, 110 rad. notch

---

#### 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>5% INCREASE</td>
<td>5% DECREASE</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>

Below Design Specs.

Figure 80

Anti-Symmetric Notch Filter Sensitivity to Notch Frequency, 230 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 ((\xi)) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (HZ)</td>
<td>DAMPING RATIO ((\xi))</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
SERIES 31 SERVOVALVE
MACH = 0.86
ALTITUDE = 15,000 FEET

FIGURE 86

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

Figure 87

Phase-Gain Root Locus of Asymmetric FSS with AR-25 Servovalve

Mach = 0.86
Altitude = 15,000 Feet

Gain

-200 -150 -100 -50 0 50 100 150 200 250 300 350

Rad/Sec

-50 -200 -150 -100 0 50 100 150 200 300
APPENDIX D

- MACH = 0.86
- ALTITUDE = 15,000 FEET

**Figure 88**

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF UNCOMPENSATING ACTUATOR
**MACH = 0.86**
**ALTIMETE = 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></td>
<td>20% INCREASE</td>
<td>20% DECREASE</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
<table>
<thead>
<tr>
<th>OPEN LOOP FREQUENCY (Hz)</th>
<th>NODE</th>
<th>DAMPING RATIO (ζ)</th>
<th>CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>91</td>
<td>20.1</td>
<td>0.0126</td>
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<tr>
<td></td>
<td>92</td>
<td>21.7</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>93</td>
<td>23.3</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>94</td>
<td>33.2</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>95</td>
<td>33.7</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>49.1</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>97</td>
<td>63.2</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>98</td>
<td>67.6</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>73.6</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
<td>0.0126</td>
</tr>
</tbody>
</table>

Note: MACH = 0.86, ALTITUDE = 15,000 FEET WITHOUT FSS MASHOUT.
APPENDIX D

FIGURE 94

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS. EFFECTS OF A 30% PRESSURE FEEDBACK GAIN REDUCTION

• MACH = 0.86
• ALTITUDE = 15,000 FEET

NO. GAIN
1 0.50 (NORMAL)
2 1.00
3 2.00

φ, RAD/SEC
<table>
<thead>
<tr>
<th>MODE</th>
<th>OPEN LOOP</th>
<th>CLOSED LOOP DAMP RATIO (ζ) - NOMINAL GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY (Hz)</td>
<td>DAMPING RATIO (ζ)</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>0.214</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>

LESS THAN DESIGN SPECS.

FIGURE 95

ANTISYMMETRIC FSS SENSITIVITY TO PRESSURE FEEDBACK GAIN REDUCTION
MACH = 0.86
ALTITUDE = 15,000 FEET

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH A 30 PERCENT PRESSURE FEEDBACK GAIN REDUCTION
<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>
EFFECT OF HINGE MOMENT ON OUTBOARD SERVOACTUATOR AMPLITUDE FREQUENCY RESPONSE
Figure 101

Effect of Hinge Moment on Symmetric FSS
FIGURE 102

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, MAXIMUM HINGE MOMENT AIDING
(250 IN-LBS)
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
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 $\pm 4.5$ dB gain and $\pm 30$ degrees phase margin criteria. Refer to Figure 106 as a guide to read gain and phase information.
<table>
<thead>
<tr>
<th>FLIGHT CONDITION</th>
<th>AIRPLANE CONFIGURATION</th>
<th>RSS</th>
<th>RSS WITH PCS CLOSED</th>
<th>RSS WITH PCS AND GLA CLOSED</th>
<th>RSS WITH BCS CLOSED</th>
<th>PCS WITH RSS CLOSED</th>
<th>PCS WITH RSS AND GLA CLOSED</th>
<th>GLA AILERON WITH RSS,PCS AND GLA STAB. CLOSED</th>
<th>GLA STAB. WITH RSS,PCS AND GLA AILERON CLOSED</th>
<th>BCS WITH RSS CLOSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLA TEST MACH - 0.42 ALT - 10,000 FT</td>
<td>G.W. - 2500 LBS C.G. - 20% MAC</td>
<td>107</td>
<td>108</td>
<td>109</td>
<td>110</td>
<td>111</td>
<td>112</td>
<td>---</td>
<td>---</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>G.W. - 2200 LBS C.G. - 33% MAC</td>
<td>114</td>
<td>115</td>
<td>116</td>
<td>117</td>
<td>118</td>
<td>119</td>
<td>120</td>
<td>121</td>
<td>122</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>
<td>125</td>
<td>126</td>
<td>127</td>
<td>128</td>
<td>129</td>
<td>130</td>
<td>131</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>
<td>136</td>
<td>137</td>
<td>138</td>
<td>139</td>
<td>140</td>
</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>
<td>147</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>
<td>156</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>
<td>163</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>
<td>172</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>
<td>179</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>
<td>188</td>
</tr>
<tr>
<td>MAXIMUM Q (Vd) 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>
<td>195</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>
<td>204</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 AKW-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

DO 6000 2145 REV 9/82
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
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 ARW-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/PHASE 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

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/PHASE 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/FREQUENCY ROOT LOCUS 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
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/PAGE 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

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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 (CONCLUDED)

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
- 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/PYASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION

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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/PHASE 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

FIGURE 126
DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION
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/P HASE ROOT LOCI 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/P HASE 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/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

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

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/PHASE ROOT LOCI WITH 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/PHASE 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

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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
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 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/PDASE 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
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

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 ARM-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/PHASE 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/PHTASE 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
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/P HASE 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

![Diagram](image)

**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

DASR ARW-2 RSS SYSTEM GAIN/PSEUDE 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/PHASER 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
DAST ARW-2 RSS SYSTEM GAIN/PDASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. LAUNCH CONDITION

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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

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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/P.HASE 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/P HASE 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

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

FIGURE 151 (CONCLUDED)
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/P.HASE 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/P HASE 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
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/PWASE 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/PHASE 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
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

DAST 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

FIGURE 159 (CONCLUDED)
DAST 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 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/PHASER ROOT LOCUS 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

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FIGURE 161 (CONCLUDED)

DAS T ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS 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
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/PAGE 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 LOCI 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/PDASE 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 LOCUS 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

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

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

FIGURE 171 (CONTINUED)
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/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. CRUISE CONDITION

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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 LOCI WITH PCS CLOSED FOR FORWARD C.G. CRUISE CONDITION

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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

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

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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: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

FIGURE 178 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHELSE 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/PSEASE ROOT LOCES 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

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/PHASE 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/PHASE 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

FIGURE 184 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE 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

![Diagram of gain/phase root loci with RSS and GLA closed for aft C.G. cruise condition.

FIGURE 185

DAST ARW-2 PCS GAIN/P�ASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION

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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 (CONCLUDED)

DAST ARW-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

DASTARW-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 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

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

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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

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APPENDIX E

- MAXIMUM Q ($V_d$)
- 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/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION
• 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 (CONCLUDED)
DAST ARW-2 RSS SYSTEM GAIN/PHASE 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/PHASE 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

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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/PHASE 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 ANW-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

FIGURE 194

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 ($V_d$)
- 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 LOCUS 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
APPENDIX E

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

<table>
<thead>
<tr>
<th>NO.</th>
<th>GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-4.5dB</td>
</tr>
<tr>
<td>2</td>
<td>0 dB (NOMINAL)</td>
</tr>
<tr>
<td>3</td>
<td>+4.5dB</td>
</tr>
</tbody>
</table>

**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)

DAS T ARW-2 RSS SYSTEM GAIN/P HASE 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 (Vd)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

<table>
<thead>
<tr>
<th>NO.</th>
<th>GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-4.5dB</td>
</tr>
<tr>
<td>2</td>
<td>0 dB  (NOMINAL)</td>
</tr>
<tr>
<td>3</td>
<td>+4.5dB</td>
</tr>
</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

FIGURE 200 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOC1 WITH RSS 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
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 ($V_q$)
- 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

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
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/PREASE 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 ARV-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 (CONCLUDED)

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 $Q (V_d)$
- 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 $Q \left( V_d \right)$
- 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
### Abstract

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.

### Key Words (Suggested by Authors(s))

- Flutter Suppression
- Relaxed Static Stability
- Maneuver Load Alleviation
- Gust Load Alleviation

### Distribution Statement

Until January 1988