AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN H-33 ORBITER MATED TO A THREE SEGMENT SOLID PROPELLANT BOOSTER

BY

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R. OLIVE, MSFC

MSFC 14-INCH TRISONIC WIND TUNNEL

Marshall Space Flight Center

NASA

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SADSAC/SPACE SHUTTLE

WIND TUNNEL TEST DATA REPORT

CONFIGURATION: Grumman H-33 Orbiter & 3 Segment 156-In. Solid Propellant Booster

TEST PURPOSE: To Investigate Aerodynamic Characteristics of the Grumman H-33 Orbiter Mated to 3 Segment Solid Propellant Booster

TEST FACILITY: MSFC 14-x-14 Inch Trisonic Wind Tunnel

TESTING AGENCY: NASA/MSFC

TEST NO. & DATE: MSFC TWT 504; August 30 to Sept. 1, 1971

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DATA OPERATIONS: J. R. Zier

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Aero Thermo Data Group

CONTRACT NAS 8-4016

AMENDMENT 153

DRL 184-58

This report has been prepared by Chrysler Corporation Space Division under a Data Management Contract to the NASA. Chrysler assumes no responsibility for the data presented herein other than its display characteristics.
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ABSTRACT

Experimental aerodynamic investigations were conducted on a .003366-scale model of the Grumman Space Shuttle configuration mounted to a three (3) segmented solid propellant booster. These tests were conducted in the MSFC 14-Inch Trisonic Wind Tunnel over a Mach number range of 0.6 to 4.96. The purpose of the test was to determine the aerodynamic characteristics of this configuration. Aerodynamic data was taken over a nominal angle of attack and angle of sideslip of -10 degrees to 10 degrees at zero degrees $\beta$ and $\alpha$ respectively. In addition, H-33 orbiter alone data was obtained to supplement data from TWT 502 and TWT 503.
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<td>5</td>
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</table>
SUMMARY

These tests were conducted at the MSFC 14-Inch Trisonic Wind Tunnel August 30 through September 1, 1971. Configurations tested included an orbiter with drop tanks alone and an orbiter with drop tanks mated to a 3-segment solid propellant booster. In addition, tests were performed with drop tanks removed.

Six component static aerodynamic force and moment data were recorded over a Mach number range of 0.6 to 4.96 with Reynolds number varying from 5.1 to $7.5 \times 10^6$ per foot. Longitudinal data were taken over an angle of attack range of $\pm 10^\circ$ at $0^\circ$ sideslip while lateral-directional data covered a range of $\pm 10^\circ$ sideslip at $0^\circ$ angle of attack.
The configurations investigated were 0.003366 scale models of the Grumman H-33 Orbiter Launch Configuration with/without drop tanks, and mated with three expendable solid propellant booster motors.

**Configuration Nomenclature**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Grumman H-33 Orbiter with drop tanks</td>
</tr>
<tr>
<td>02</td>
<td>Grumman H-33 Orbiter without drop tanks</td>
</tr>
<tr>
<td>H33/3x156</td>
<td>Grumman H-33 Orbiter with drop tanks and cluster of three 156 diameter solid propellant booster motors</td>
</tr>
</tbody>
</table>

**Model Component Nomenclature**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Orbiter</td>
</tr>
<tr>
<td>W</td>
<td>Clipped delta wing</td>
</tr>
<tr>
<td>V</td>
<td>Vertical stabilizer</td>
</tr>
<tr>
<td>T</td>
<td>Drop tanks</td>
</tr>
</tbody>
</table>

Pertinent dimensional details are presented in the Model Component Description Section of this document.
<table>
<thead>
<tr>
<th>COEFFICIENT</th>
<th>COEFFICIENT NAME</th>
<th>SADSAC NOMENCLATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>Total Axial Force</td>
<td>CA</td>
</tr>
<tr>
<td>CAB</td>
<td>Base Axial Force</td>
<td>CAB</td>
</tr>
<tr>
<td>CAF</td>
<td>Forebody Axial Force</td>
<td>CAF</td>
</tr>
<tr>
<td>CD</td>
<td>Total Drag Force</td>
<td>CD</td>
</tr>
<tr>
<td>CDB</td>
<td>Base Drag Force</td>
<td>CDB</td>
</tr>
<tr>
<td>CDF</td>
<td>Forebody Drag Force</td>
<td>CDF</td>
</tr>
<tr>
<td>CL</td>
<td>Lift Force</td>
<td>CL</td>
</tr>
<tr>
<td>CN</td>
<td>Normal Force</td>
<td>CN</td>
</tr>
<tr>
<td>CY</td>
<td>Side Force</td>
<td>CY, CY</td>
</tr>
<tr>
<td>CM</td>
<td>Pitching Moment</td>
<td>CM, CM</td>
</tr>
<tr>
<td>CN</td>
<td>Yawing Moment</td>
<td>CN, CN</td>
</tr>
<tr>
<td>L/D</td>
<td>Lift-To-Drag Force Ratio</td>
<td>L/D</td>
</tr>
<tr>
<td>L/D</td>
<td>Lift-To-Forebody Drag Force Ratio</td>
<td>L/D</td>
</tr>
<tr>
<td>N/A</td>
<td>Normal-To-Axial Force Ratio</td>
<td>N/A</td>
</tr>
<tr>
<td>N/A</td>
<td>Normal-To-Forebody Axial Force Ratio</td>
<td>CN/CAF</td>
</tr>
</tbody>
</table>

TABLE I. SUMMARY OF SADSAC NOMENCLATURE - AERODYNAMIC FORCE AND MOMENT COEFFICIENTS
# Test Data Set/Run Number

## Collation Summary

**PRETEST**

**POSTTEST**

<table>
<thead>
<tr>
<th>DATA SET IDENTIFIER</th>
<th>CONFIGURATION</th>
<th>SCHD.</th>
<th>PARAMETERS/VALUES</th>
<th>NO. OF RUNS</th>
<th>MACH NUMBERS (OR ALTERNATE INDEPENDENT VARIABLE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rv601</td>
<td>O</td>
<td>A0</td>
<td></td>
<td>9</td>
<td>0.6, 0.9, 1.0, 1.1, 1.2, 1.5, 1.9, 3.5, 4.9</td>
</tr>
<tr>
<td>Rv6012</td>
<td>O</td>
<td>A0</td>
<td></td>
<td>9</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10</td>
</tr>
<tr>
<td>Rv6021</td>
<td>O</td>
<td>A0</td>
<td></td>
<td>9</td>
<td>20, 19, 18, 17, 16, 15, 14, 13, 12</td>
</tr>
<tr>
<td>Rv6022</td>
<td>O</td>
<td>B</td>
<td></td>
<td>5</td>
<td>11, 12, 13, 14, 15</td>
</tr>
<tr>
<td>Rv6024</td>
<td>133/156° DROP TANK:</td>
<td>A0</td>
<td></td>
<td>5</td>
<td>21, 22, 23, 24, 25</td>
</tr>
<tr>
<td>Rv6022</td>
<td>133/156° DROP TANK:</td>
<td>O</td>
<td></td>
<td>5</td>
<td>30, 29, 28, 27, 26</td>
</tr>
<tr>
<td>Rv6031</td>
<td>133/156° DROP TANK:</td>
<td>A0</td>
<td></td>
<td>9</td>
<td>37, 36, 35, 34, 33, 32, 31, 30, 29</td>
</tr>
<tr>
<td>Rv6032</td>
<td>133/156° DROP TANK:</td>
<td>O</td>
<td></td>
<td>9</td>
<td>38, 37, 36, 35, 34, 33, 32, 31, 30</td>
</tr>
</tbody>
</table>

**COEFFICIENTS:**

\[
\alpha = -10, -9, -8, -7, -6, -5, -4, -3, 0 \times 10
\]

\[
\beta = -10, -9, -8, -7, -6, -5, -4, -3, 0 \times 10
\]

NASA-MSFC-MAF
TEST FACILITY DESCRIPTION

The Marshall Space Flight Center 14" x 14" Trisonic Wind Tunnel is an intermittent blowdown tunnel which operates by high pressure air flowing from storage to either vacuum or atmospheric conditions. A Mach number range from .2 to 5.85 is covered by utilizing two interchangeable test sections. The transonic section permits testing at Mach 0.20 through 2.50, and the supersonic section permits testing at Mach 2.74 through 5.85. Mach numbers between .2 and .9 are obtained by using a controllable diffuser. The range from .95 to 1.3 is achieved through the use of plenum suction and perforated walls. Mach numbers of 1.44, 1.93 and 2.50 are produced by interchangeable sets of fixed contour nozzle blocks. Above Mach 2.50 a set of fixed contour nozzle blocks are tilted and translated automatically to produce any desired Mach number in .25 increments.

Air is supplied to a 6000 cubic foot storage tank at approximately -40°F dew point and 500 psi. The compressor is a three-stage reciprocating unit driven by a 1500 hp motor.

The tunnel flow is established and controlled with a servo actuated gate valve. The controlled air flows through the valve diffuser into the stilling chamber and heat exchanger where the air temperature can be controlled from ambient to approximately 180°F. The air then passes through the test section which contains the nozzle blocks and test region.

Downstream of the test section is a hydraulically controlled pitch sector that provides a total angle of attack range of 20° (±10°). Sting offsets are available for obtaining various maximum angles of attack up to 25°.
<table>
<thead>
<tr>
<th>MACH NUMBER</th>
<th>REYNOLDS NUMBER per unit length</th>
<th>DYNAMIC PRESSURE (pounds/sq. inch)</th>
<th>STAGNATION TEMPERATURE (degrees Fahrenheit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>$5.1 \times 10^6$/IN</td>
<td>4.4</td>
<td>100</td>
</tr>
<tr>
<td>0.9</td>
<td>$6.3 \times 10^6$/IN</td>
<td>7.4</td>
<td>100</td>
</tr>
<tr>
<td>1.0</td>
<td>$6.6 \times 10^6$/IN</td>
<td>8.2</td>
<td>100</td>
</tr>
<tr>
<td>1.1</td>
<td>$6.8 \times 10^6$/IN</td>
<td>8.7</td>
<td>100</td>
</tr>
<tr>
<td>1.2</td>
<td>$6.8 \times 10^6$/IN</td>
<td>9.2</td>
<td>100</td>
</tr>
<tr>
<td>1.46</td>
<td>$7.4 \times 10^6$/IN</td>
<td>10.8</td>
<td>100</td>
</tr>
<tr>
<td>1.96</td>
<td>$7.5 \times 10^6$/IN</td>
<td>10.9</td>
<td>100</td>
</tr>
<tr>
<td>3.59</td>
<td>$7.0 \times 10^6$/IN</td>
<td>6.8</td>
<td>100</td>
</tr>
<tr>
<td>4.96</td>
<td>$5.4 \times 10^6$/IN</td>
<td>3.07</td>
<td>100</td>
</tr>
</tbody>
</table>

BALANCE UTILIZED: MSFC #201

CAPACITY: ACCURACY: COEFFICIENT TOLERANCE:

<table>
<thead>
<tr>
<th>NF</th>
<th>SF</th>
<th>AF</th>
<th>PM</th>
<th>YM</th>
<th>RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>60#</td>
<td>20#</td>
<td>30#</td>
<td>120 IN-#</td>
<td>40 IN-#</td>
<td>25 IN-#</td>
</tr>
</tbody>
</table>

COMMENTS:
DATA REDUCTION

Six component aerodynamic force and moment data were measured on the model employing MSFC internal strain gage balance #201. Pressure orifices depicted in Figure 7 were used to measure the pressure acting on the base region of the orbiter, segmented booster, and the balance cavity. These pressures were reduced to coefficients and utilized to correct the measured total axial force (CAT) coefficient to free-stream pressure acting on these regions (CAF). The following equations were used to make this correction:

\[ C_{AF} = C_{A} - C_{ABO} - C_{ABS} - C_{AC} \]
\[ C_{ABO} = -C_{P\text{ORBITER}} \cdot \frac{A_{BO}}{S_{REF}} \]
\[ C_{AB} = -C_{P\text{SOLIDS}} \cdot \frac{A_{S}}{S_{REF}} \]
\[ C_{AC} = -C_{P\text{CAVITY}} \cdot \frac{A_{C}}{S_{REF}} \]

The force and moment data were reduced to coefficient form using the following reference values:

\[ S_{REF} = 9.376 \text{ IN.}^2 \]
\[ l_{REF} = 6.495 \text{ IN.} \]
\[ b_{REF} = 3.940 \text{ IN.} \]
\[ A_{BO} = 0.362 \text{ IN.}^2 \]
\[ A_{BS} = 1.348 \text{ IN.}^2 \]
\[ A_{C} = 0.399 \text{ IN.}^2 \]
Moment Reference Center:

$X_{MRP} = 3.231$ inches aft of orbiter nose

$Y_{MRP} = 0.0$ inch

$Z_{MRP} = 0.3024$ inch below balance center line
SUMMARY DATA PLOT INDEX

<table>
<thead>
<tr>
<th>PLOT TITLE</th>
<th>PLOTTED COEFFICIENTS SCHEDULE</th>
<th>CONDITION VARYING</th>
<th>PAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal Stability</td>
<td>A</td>
<td>Mach Number</td>
<td>1-21</td>
</tr>
<tr>
<td>Lateral Stability</td>
<td>B</td>
<td>Mach Number</td>
<td>22-39</td>
</tr>
<tr>
<td>Longitudinal Stability at Alpha = Zero Degrees</td>
<td>C</td>
<td>Configuration</td>
<td>40-59</td>
</tr>
<tr>
<td>Lateral Stability at Beta = Zero Degrees</td>
<td>D</td>
<td>Configuration</td>
<td>60-75</td>
</tr>
</tbody>
</table>

PLOTTED COEFFICIENTS SCHEDULE:

**SCHEDULE A:**
- CN
- CLM $\{v_s \alpha$  

**SCHEDULE B:**
- CY
- CYN $\{v_s \beta$  

**SCHEDULE C:**
- CNAAF0
- CMAAF0
- CAF0
- CDAF0
- DCMLO
- MACH NO.

**SCHEDULE D:**
- CYBO
- CYNBO
- CBLBO
- DCYNOL
- MACH NO.
FIGURES
Notes:
1. Positive directions of force coefficients, moment coefficients, and angles are indicated by arrows.

2. For clarity, origins of wind and stability axes have been displaced from the center of gravity.

Figure 1. Axis systems, showing direction and sense of force and moment coefficients, angle of attack, and sideslip angle.
Figure 2 -
Side View of 3 x 156 Solid Prop. Boost/Grumman H-33 .003366 Scale Orbiter Model

MSFC TWT 504
AUG 31 1971
CONFIG
H 33 3 156
Figure 3 -
One-Half Bottom View of 3 x 156
Solid Prop. Boost/Grumman H-33
.003356 Scale Orbiter Model
Figure 4 -
Model Installation Photograph in the MSFC 14 x 14-Inch Wind Tunnel
Figure 5. Side and Planview Sketch of the Grumman H-33 Orbiter With Drop Tanks Installed
Figure 6. Side and Planview Sketch of the Grumman H-33 Orbiter With Drop Tanks and Three Solid Propellant Booster Motors Installed
Figure 7. Base Pressure Measurements
MODEL COMPONENT DESCRIPTION SHEETS
MODEL COMPONENT: BODY - (O) ORBITER

GENERAL DESCRIPTION: 0.003366 SCALE GRUMMAN (H33) ORBITER

<table>
<thead>
<tr>
<th>DIMENSIONS:</th>
<th>FULL-SCALE</th>
<th>MODEL SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1621 in</td>
<td>5.456 in</td>
</tr>
<tr>
<td>Max. Width</td>
<td>300 in</td>
<td>1.0098 in</td>
</tr>
<tr>
<td>Max. Depth</td>
<td>330 in</td>
<td>1.111 in</td>
</tr>
<tr>
<td>Fineness Ratio</td>
<td>5.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Cross-Sectional Planform</td>
<td>3,120 ft²</td>
<td>5.09 in²</td>
</tr>
<tr>
<td>Wetted (Less Base)</td>
<td>10,345 ft²</td>
<td>16.87 in²</td>
</tr>
<tr>
<td>Base</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**MODEL COMPONENT:** WING (W)

**GENERAL DESCRIPTION:** Clipped Delta Wing for H-33 Orbiter (0.003366 Scale)

---

**DRAWING NUMBER:**

**DIMENSIONS:**

<table>
<thead>
<tr>
<th>TOTAL DATA</th>
<th>FULL-SCALE</th>
<th>MODEL SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>4840 ft²</td>
<td>7.896 in²</td>
</tr>
<tr>
<td>Planform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span (equivalent)</td>
<td>94.5 ft</td>
<td>3.817 in</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>1.846</td>
<td>1.846</td>
</tr>
<tr>
<td>Rate of Taper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taper Ratio</td>
<td>0.178</td>
<td>0.178</td>
</tr>
<tr>
<td>Diehedral Angle, degrees</td>
<td>5°</td>
<td>5°</td>
</tr>
<tr>
<td>Incidence Angle, degrees</td>
<td>2°</td>
<td>2°</td>
</tr>
<tr>
<td>Aerodynamic Twist, degrees</td>
<td>-5°</td>
<td>-5°</td>
</tr>
<tr>
<td>Toe-In Angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cant Angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweep Back Angles, degrees</td>
<td>55°</td>
<td>55°</td>
</tr>
<tr>
<td>Leading Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trailing Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25 Element Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chords:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root (Wing Sta. 0.0)</td>
<td>1043.52 in</td>
<td>3.5125 in</td>
</tr>
<tr>
<td>Tip, (equivalent)</td>
<td>185.76 in</td>
<td>0.625 in</td>
</tr>
<tr>
<td>MAC</td>
<td>714.0 in</td>
<td>2.4033 in</td>
</tr>
<tr>
<td>Fus. Sta. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.P. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.L. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airfoil Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>t/c = 9.5% Camberred</td>
<td>t/c = 9.5% Camberred</td>
</tr>
<tr>
<td>Tip</td>
<td>t/c = 9.5% Camberred</td>
<td>t/c = 9/5% Camberred</td>
</tr>
</tbody>
</table>

**EXPOSED DATA**

| Area       | 2900 ft²   | 4.7313 in² |
| Span, (equivalent) | 94.5 ft   | 3.817      |
| Aspect Ratio | 1.846  | 1.846      |
| Taper Ratio      | 0.178   | 0.178      |
| Chords:      |            |             |
| Root         | 815.76 in  | 2.7458 in  |
| Tip          | 185.76 in  | 0.625 in   |
| MAC          | 714.0 in   | 2.4033 in  |
| Fus. Sta. of .25 MAC |          |             |
| W.P. of .25 MAC |          |             |
| B.L. of .25 MAC |          |             |
MODEL COMPONENT: VERTICAL STABILIZER (V)

GENERAL DESCRIPTION: Centerline Vertical Stabilizer for H-33 Orbiter

(0.003366 Scale)

DRAWING NUMBER:

DIMENSIONS:

<table>
<thead>
<tr>
<th>TOTAL DATA</th>
<th>FULL-SCALE</th>
<th>MODEL SCALE</th>
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</thead>
<tbody>
<tr>
<td>Area</td>
<td></td>
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</tr>
<tr>
<td>Planform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span (equivalent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of Taper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taper Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diehedral Angle, degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidence Angle, degrees</td>
<td></td>
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<tr>
<td>Aerodynamic Twist, degrees</td>
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<tr>
<td>Toe-In Angle</td>
<td></td>
<td></td>
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<tr>
<td>Cant Angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweep Back Angles, degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leading Edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trailing Edge</td>
<td></td>
<td></td>
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<tr>
<td>0.25 Element Line</td>
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<td></td>
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<tr>
<td>Chords:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root (Wing Sta. 0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tip, (equivalent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fus. Sta. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.P. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.L. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airfoil Section</td>
<td></td>
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</tr>
<tr>
<td>Root</td>
<td>NACA 64A010</td>
<td>NACA 64A010</td>
</tr>
<tr>
<td>Tip</td>
<td>NACA 64A010</td>
<td>NACA 64A010</td>
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<table>
<thead>
<tr>
<th>EXPOSED DATA</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>855 ft²</td>
<td>1.395 in²</td>
</tr>
<tr>
<td>Span, (equivalent)</td>
<td>405 in</td>
<td>1.363 in</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>1.33</td>
<td>1.33</td>
</tr>
<tr>
<td>Taper Ratio</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Chords:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>439.92 in</td>
<td>1.48 in</td>
</tr>
<tr>
<td>Tip</td>
<td>168.0 in</td>
<td>0.5655 in</td>
</tr>
<tr>
<td>MAC</td>
<td>324.0 in</td>
<td>1.09 in</td>
</tr>
<tr>
<td>Fus. Sta. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W.P. of .25 MAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.L. of .25 MAC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MODEL COMPONENT: DROP TANKS (T)

GENERAL DESCRIPTION: Orbiter Externally Mounted Drop Tanks (0.003366 Scale)

DRAWING NUMBER:

DIMENSIONS:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>FULL-SCALE</th>
<th>MODEL SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>102.17 ft</td>
<td>4.127 in</td>
</tr>
<tr>
<td>Max. Width</td>
<td>14.854 ft</td>
<td>0.60 in</td>
</tr>
<tr>
<td>DIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Depth</td>
<td>14.854 ft</td>
<td>0.60 in</td>
</tr>
<tr>
<td>Fineness Ratio</td>
<td>6.878</td>
<td>6.878</td>
</tr>
<tr>
<td>Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Cross-Sectional Planform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetted Base</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### NOMENCLATURE

*(General)*

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SADSAC SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>ALPHA</td>
<td>angle of attack, angle between the projection of the wind $X_w$-axis on the body X, Z-plane and the body X-axis; degrees</td>
</tr>
<tr>
<td>$\beta$</td>
<td>BETA</td>
<td>sideslip angle, angle between the wind $X_w$-axis and the projection of this axis on the body X-Z-plane; degrees</td>
</tr>
<tr>
<td>$\psi$</td>
<td>PSI</td>
<td>yaw angle, angle of rotation about the body Z-axis, positive when the positive X-axis is rotated toward the positive Y-axis; degrees</td>
</tr>
<tr>
<td>$\phi$</td>
<td>PHI</td>
<td>roll angle, angle of rotation about the body X-axis, positive when the positive Y-axis is rotated toward the positive Z-axis; degrees</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td>air density; $kg/m^3$, slugs/ft$^3$</td>
</tr>
<tr>
<td>$a$</td>
<td></td>
<td>speed of sound; m/sec, ft/sec</td>
</tr>
<tr>
<td>$V$</td>
<td></td>
<td>speed of vehicle relative to surrounding atmosphere; m/sec, ft/sec</td>
</tr>
<tr>
<td>$q$</td>
<td>$Q(PSI)$</td>
<td>dynamic pressure; $1/2\rho V^2$, psi, psf</td>
</tr>
<tr>
<td></td>
<td>$Q(PSF)$</td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>MACH</td>
<td>Mach number; $V/a$</td>
</tr>
<tr>
<td>$RN/L$</td>
<td>RN/L</td>
<td>Reynolds number per unit length; million/ft</td>
</tr>
<tr>
<td>$p$</td>
<td></td>
<td>static pressure; psi</td>
</tr>
<tr>
<td>$P$</td>
<td></td>
<td>total pressure; psi</td>
</tr>
<tr>
<td>$C_p$</td>
<td>CP</td>
<td>pressure coefficient; $(p-p_\infty)/q$</td>
</tr>
</tbody>
</table>
# Nomenclature (Continued)

## Body & Stability Axis System

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SADSAC SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_N )</td>
<td>CN</td>
<td>normal force coefficient; ( F_N/qS )</td>
</tr>
<tr>
<td>( C_A )</td>
<td>CA</td>
<td>axial force coefficient; ( F_A/qS )</td>
</tr>
<tr>
<td>( C_{Ab} )</td>
<td>CAB</td>
<td>base axial force coefficient; ( [-1 \left( \frac{P_b - P_m}{q} \right) \frac{A_b}{S} )</td>
</tr>
<tr>
<td>( C_{Af} )</td>
<td>CAF</td>
<td>forebody axial force coefficient; ( C_A - C_{Ab} )</td>
</tr>
<tr>
<td>( C_n )</td>
<td>CYN</td>
<td>yawing moment coefficient; ( M_Z/qS ) _ref</td>
</tr>
<tr>
<td>( C_l )</td>
<td>CBL</td>
<td>rolling moment coefficient; ( M_X/qS ) _ref</td>
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</tbody>
</table>

## Common to Both Axis Systems

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SADSAC SYMBOL</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_m )</td>
<td>CLM</td>
<td>pitching moment coefficient; ( M_Y/qS ) _ref</td>
</tr>
<tr>
<td>( C_y )</td>
<td>CY</td>
<td>side force coefficient; ( F_Y/qS )</td>
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</table>

## Stability Axis System

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SADSAC SYMBOL</th>
<th>DEFINITION</th>
</tr>
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<tbody>
<tr>
<td>( C_L )</td>
<td>CL</td>
<td>lift force coefficient; ( F_L/qS )</td>
</tr>
<tr>
<td>( C_D )</td>
<td>CD</td>
<td>drag force coefficient; ( F_D/qS )</td>
</tr>
<tr>
<td>( C_{Db} )</td>
<td>CDB</td>
<td>base drag coefficient</td>
</tr>
<tr>
<td>( C_{Df} )</td>
<td>CDF</td>
<td>forebody drag coefficient; ( C_D - C_{Db} )</td>
</tr>
<tr>
<td>( C_n )</td>
<td>CLN</td>
<td>yawing moment coefficient; ( M_{Z,s}/qS ) _ref</td>
</tr>
<tr>
<td>( C_l )</td>
<td>CSL</td>
<td>rolling moment coefficient; ( M_{X,s}/qS ) _ref</td>
</tr>
<tr>
<td>( L/D )</td>
<td>L/D</td>
<td>lift-to-drag ratio; ( C_L/C_D )</td>
</tr>
<tr>
<td>( L/D_{f} )</td>
<td>L/DF</td>
<td>lift to forebody drag ratio; ( C_L/C_{Df} )</td>
</tr>
</tbody>
</table>
## NOMENCLATURE (Continued)

### Axis System General

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>F</td>
<td>force; $F$, lbs</td>
</tr>
<tr>
<td>M</td>
<td>moment; $M$, in-lb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subscript</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>normal force</td>
</tr>
<tr>
<td>A</td>
<td>axial force</td>
</tr>
<tr>
<td>L</td>
<td>lift force</td>
</tr>
<tr>
<td>D</td>
<td>drag force</td>
</tr>
<tr>
<td>Y</td>
<td>force or moment about the $Y$ axis</td>
</tr>
<tr>
<td>Z</td>
<td>moment about the $Z$ axis</td>
</tr>
<tr>
<td>X</td>
<td>moment about the $X$ axis</td>
</tr>
<tr>
<td>s</td>
<td>stability axis system</td>
</tr>
<tr>
<td>w</td>
<td>wind axis system</td>
</tr>
<tr>
<td>ref</td>
<td>reference conditions</td>
</tr>
<tr>
<td>$\infty$</td>
<td>free stream conditions</td>
</tr>
<tr>
<td>t</td>
<td>total conditions</td>
</tr>
<tr>
<td>b</td>
<td>base</td>
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## NOMENCLATURE (Continued)

**Reference & C. G. Definitions**

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<th>SYMBOL</th>
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<th>DEFINITION</th>
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<tr>
<td>s</td>
<td>S</td>
<td>wing area; m², ft²</td>
</tr>
<tr>
<td>S</td>
<td>SREF</td>
<td>reference area; m², ft²</td>
</tr>
<tr>
<td>c</td>
<td>SREF</td>
<td>wing mean aerodynamic chord or reference chord; m, ft, in (see (l_{ref}) or LREF)</td>
</tr>
<tr>
<td>(l_{ref})</td>
<td>LREF</td>
<td>reference length; m, ft, in.; (see c)</td>
</tr>
<tr>
<td>bref</td>
<td>BREF</td>
<td>wing span or reference span; m, ft, in</td>
</tr>
<tr>
<td>Ab</td>
<td></td>
<td>base area; m², ft², in²</td>
</tr>
<tr>
<td>c. g.</td>
<td></td>
<td>center of gravity</td>
</tr>
<tr>
<td>MRP</td>
<td>MRP</td>
<td>abbreviation for moment reference point</td>
</tr>
<tr>
<td>XMRP</td>
<td></td>
<td>abbreviation for moment reference point on X-axis</td>
</tr>
<tr>
<td>YMRP</td>
<td></td>
<td>abbreviation for moment reference point on Y-axis</td>
</tr>
<tr>
<td>ZMRP</td>
<td></td>
<td>abbreviation for moment reference point on Z-axis</td>
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## ADDITIONS TO GENERAL NOMENCLATURE

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<tr>
<th>SYMBOL</th>
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<tbody>
<tr>
<td>ABO</td>
<td>orbiter base area, in.²</td>
</tr>
<tr>
<td>ABS</td>
<td>solid propellant booster motors total base area, in.²</td>
</tr>
<tr>
<td>AC</td>
<td>model strain balance cavity area, in.²</td>
</tr>
<tr>
<td>C_ABO</td>
<td>orbiter base axial force coefficient</td>
</tr>
<tr>
<td>C_ABS</td>
<td>solid propellant booster motors base axial force coefficient</td>
</tr>
<tr>
<td>C_AC</td>
<td>model strain gage cavity axial force coefficient</td>
</tr>
<tr>
<td>CNAAFO</td>
<td>zero angle of attack normal force coefficient gradient</td>
</tr>
<tr>
<td>CMAAFO</td>
<td>zero angle of attack pitching moment coefficient gradient</td>
</tr>
<tr>
<td>CAFAPO</td>
<td>zero angle of attack forebody axial force coefficient</td>
</tr>
<tr>
<td>CDAFPO</td>
<td>zero angle of attack drag force coefficient</td>
</tr>
<tr>
<td>DCMLO</td>
<td>zero angle of attack center of pressure</td>
</tr>
<tr>
<td>CYBO</td>
<td>zero sideslip angle side force gradient</td>
</tr>
<tr>
<td>CYNBO</td>
<td>zero sideslip angle yawing moment gradient</td>
</tr>
<tr>
<td>CBLBO</td>
<td>zero sideslip angle rolling moment gradient</td>
</tr>
<tr>
<td>DCYNOL</td>
<td>zero sideslip angle center of pressure</td>
</tr>
</tbody>
</table>
A tabulated data listing, consisting of all aero data sets, both original and those created in arriving at the plotted material to be presented subsequently, is available as an addendum to this report. The tabular listing is made up in two sections:

(a) a brief summary list of all data sets containing the identifier, the descriptor, and the resident dependent variables.

(b) a full list of all data sets containing all resident or selected aerodynamic coefficients of the data sets as well as the above mentioned information.

The listing is currently sent on limited distribution to the following organizations:

NASA AMES    Mr. V. Stevens
NASA MSFC    Mr. J. Weaver

If copies of this listing are desired, please contact the above or the cognizant SADSAC personnel who, for this data, is:

Mr. J. R. Ziler
Department 2780
Chrysler Corporation Space Division
New Orleans, La. 70129

(504) 255-2304
LONGITUDINAL STABILITY

ANGLE OF ATTACK, ALPHA, DEGREES

NORMAL FORCE COEFFICIENT, CN

PARAMETRIC VALUES

REFERENCE FILE S-E-AERO-AA-

REFERENCE INFORMATION

MSFC 504 GRUMMAN H33 ORB.+DROP TANKS 01 (A46011) 16 OCT 71 PAGE 2
LONGITUDINAL STABILITY

SYMBOL MACH PARAMETRIC VALUES
0.603 BETA 0.000
0.896
1.001
1.099
1.196

REFERENCE INFORMATION
SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCENT
LONGITUDINAL STABILITY

ANGLE OF ATTACK: ALPHA: DEGREES

NORMAL FORCE COEFFICIENT, CN

PARAMETRIC VALUES

STNDO1 MACH ETA 0.000

REFERENCE INFORMATION

BREF 0.3760 80. IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3064 IN.
SCALE 0.3366 PERCENT

REFERENCE FILE 3-E-AERO-AA-

NSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (A46021) 16 OCT 71 PAGE 8
LONGITUDINAL STABILITY

SYMBOL | Mach | PARAMETRIC VALUES
--- | --- | ---
○ | 1.455 | BETA 0.000
△ | 1.966 |
□ | 3.460 |
△ | 4.958 |

REFERENCE INFORMATION

SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.1300 IN.
YNRP 0.3300 IN.
ZMNR 0.3024 IN.
SCALE 0.3366 PERCEN

REFERENCE FILE S-E-AERO-AA-

MSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (A46021) 16 OCT 71 PAGE 10
LONGITUDINAL STABILITY

REFERENCE INFORMATION
SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZNRP 0.3024 IN.
SCALE 0.3366 PERCENT

SYMBOL
- 1.459 ETA 0.000
- 1.046
- 0.400
- 4.959

PARAMETRIC VALUES

REFERENCE FILE S-E-AERO-AA-
MSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (A46021) 16 OCT 71 PAGE 12
LONGITUDINAL STABILITY

ANGLE OF ATTACK, ALPHA, DEGREES

NORMAL FORCE COEFFICIENT, CN

SYMBOL MACH PARAMETRIC VALUES
\( \Delta \) 0.60 \( \beta \) 0.050
\( \bigcirc \) 0.901
\( \diamond \) 0.996
\( \triangle \) 1.102
\( \Box \) 1.197

REFERENCE INFORMATION

\( SREF = 9.3760 \) 56 IN.
\( LREF = 6.4950 \) IN.
\( XREF = 3.5300 \) IN.
\( YNRP = 0.0000 \) IN.
\( ZNRP = 0.3024 \) IN.
\( SCALE = 0.3366 \) PEREN

S-E-AERO-AA-

MSFC 504 GRUMMAN H33 ORB.+BOOST.-DROP TANKS (A46041) 16 OCT 71 PAGE 13
LONGITUDINAL STABILITY

ANGLE OF ATTACK, ALPHA, DEGREES

SYMBOL MACH PARAMETRIC VALUES

REFERENCE FILE S-E-AERO-AA-

MSFC 504 GRUMMAN H-33 ORB.+BOOST.-DROP TANKS (A46041) 16 OCT 71 PAGE 14
LONGITUDINAL STABILITY

ANGLE OF ATTACK, ALPHA, DEGREES

NORMAL FORCE COEFFICIENT, CN

SYMBOL | MACH | DEGTA | FAROMATIC VALUES
-------|------|-------|----------------------
0.506  | 0.000|       |                      
0.600  | 0.000|       |                      
0.699  | 1.190|       |                      
1.195  | 1.195|       |                      

REFERENCE FILE  S-E-AERO-AA-

REFERENCE INFORMATION
SREF 0.3760 50. IN.
LREF 6.4050 IN.
BREF 5.8950 IN.
XMRP 3.8300 IN.
YNRP 0.0000 IN.
ZNRP 0.3024 IN.
SCALE 0.3366 PERCEN

MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS  (A46031)  16 OCT 71  PAGE 16
LONGITUDINAL STABILITY

SYMBO LOW  MACH   BETA      O.000

- 1.459
- 1.969
- 3.480
- 6.999

REFERENCE FILE 5-E-AERO-1A-

MSFC 504  GRUMMAN H33 ORB.+BOOST.+DROP TANKS  (A46031)  16 OCT 71  PAGE 17
LONGITUDINAL STABILITY

FOREBODY AXIAL FORCE COEFFICIENT, CAF

ANGLE OF ATTACK, ALPHA, DEGREES

SYMBOL | MACH | PARAMETRIC VALUES
-------|------|-----------------
      | 0.50G | BETA = 0.000
0.004 |      |                
0.008 |      |                
1.100 |      |                
1.108 |      |                

REFERENCE INFORMATION
SREF 9.3760 Sq.In.
LREF 6.4950 In.
BREF 3.9300 In.
XMRP 3.2300 In.
YNRP 0.0000 In.
ZNRP 0.3024 In.
SCALE 0.3366 PERCEN

REFERENCE FILE B-Z-AERO-AA-

MSFC 504 GRUMMAN H33 ORB. + BOOST. + DROP TANKS (A46031) 16 OCT 71 PAGE 20
LONGITUDINAL STABILITY

Parameter values:

- Angle of Attack, Alpha, Degrees
- Reference File: S-E-AERO-AA-
- Reference Information:
  - SREF: 9.3760 sq. in.
  - LREF: 6.4950 in.
  - BREF: 3.4800 in.
  - XMRP: 3.2300 in.
  - YMRP: 0.0000 in.
  - ZMRP: 0.3024 in.
  - Scale: 0.3366 percent

MSFC 504 GRUMMAN H33 ORB. + BOOST. + DROP TANKS (A46031) 16 OCT 71 PAGE 21
LATERAL STABILITY

SIDE SLIP ANGLE, BETA, DEGREES

YAWING MOMENT COEFFICIENT, CYN (BODY AXIS)

PARAMETRIC VALUES

REFERENCE INFORMATION

MSFC 504  GRUMMAN H33 ORB. + DROP TANKS  01   (A46012)  16 OCT 71  PAGE 25
LATERAL STABILITY

ROLLING MOMENT COEFFICIENT, CBL (BODY AXIS)

SIDE SLIP ANGLE, BETA, DEGREES

SYMBOL  MACH  PARAMETRIC VALUES
0.601  ALPHA  0.000
0.607
0.900
1.101
1.200

REFERENCE INFORMATION
SREF  9.3760  SQ.IN.
LREF  6.4950  IN.
BREF  3.9300  IN.
YMRP  3.2300  IN.
YMRP  0.0000  IN.
ZMRP  0.3024  IN.
SCALE  0.3566  PERCEN

REFERENCE FILE  S-E-AERO-AA-

MSFC 504  GRUMMAN H33 ORB. + DROP TANKS  01  (A46012)  16 OCT 71  PAGE  26
LATERAL STABILITY

ROLLING MOMENT COEFFICIENT, CBL (BODY AXIS)

SIDE SLIP ANGLE, BETA, DEGREES

SYMBOL  MACH  PARAMETRIC VALUES

0.600  ALPHA  0.000

0.800  LREF  0.3760  IN.

1.001  BREF  6.4950  IN.

1.102  XMRP  3.9300  IN.

1.201  YMRP  0.0000  IN.

REFERENCE INFORMATION

REFERENCE FILE  S-E-AERO-AA-

MSFC 504  GRUMMAN H3 ORB.-DROP TANKS  02  (A46022)  16 OCT 71  PAGE  30

0.3366 PERCENT
LATERAL STABILITY

SIDE SLIP ANGLE, BETA, DEGREES

LATERAL FORCE COEFFICIENT, CY

SYMBOL MACH PARANETRIC VALUES
0.604 ALPHA 0.000
0.807
1.001
1.109
1.196

REFERENCE INFORMATION
SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
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YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCEN

REFERENCE FILE S-E-AERO-4A-
MSFC 504 GRUMMAN H33 ORB.+BOOST.-DROP TANKS (M46042) 16 OCT 71 PAGE 31
LATERAL STABILITY

SIDE SLIP ANGLE, BETA, DEGREES

YAWING MOMENT COEFFICIENT, CYN (BODY AXIS)

SYMBOL  MACH  ALPHA  PARAMETRIC VALUES
0.604  0.000
0.907  
1.001  
1.109  
1.196  

REFERENCE INFORMATION
SREF  9.3760  SQ.IN.
LREF  6.4950  IN.
BREF  3.9300  IN.
XMRP  3.2300  IN.
YNRP  0.0000  IN.
ZMRRP  0.3024  IN.
SCALE  0.3366 PERCENT

MSFC 504 GRUMMAN H33 ORB. + BOOST, - DROP TANKS  (A46042)  16 OCT 71  PAGE 32
LATERAL STABILITY

ROLLING MOMENT COEFFICIENT, CBL (BODY AXIS)

SIDE SLIP ANGLE, BETA, DEGREES

SYMBOL  MACH  ALPHA  PARAMETRIC VALUES
0.604    0.000

REFERENCE INFORMATION
SREF    9.3760  SQ.IN.
LREF    6.4950  IN.
BREF    3.2350  IN.
XMRP    3.2350  IN.
YMRP    0.0000  IN.
ZMRP    0.3024  IN.
SCALE   0.3366  PERCENT

REFERENCE FILE  S-E-AERO-AA-

MSFC 504 GRUMMAN H33 ORB.+BOOST.-DROP TANKS  (A46042)  16 OCT 71  PAGE 33
LATERAL STABILITY

ROLLING MOMENT COEFFICIENT, CBL (BODY AXIS)

SIDE SLIP ANGLE, BETA, DEGREES

SYMBOL MACH  PARAMETRIC VALUES
0.595  ALPHA  0.000
0.698
0.999
1.100
1.198

REFERENCE INFORMATION
SREF  9.3760 SQ.IN.
LREF  6.4950 IN.
BREF  3.9300 IN.
XHRP  3.2300 IN.
YMRP  0.0000 IN.
ZMRP  0.3024 IN.
SCALE  0.3366 PERCENT

REFERENCE FILE  S=E-AERO-AA-

MSFC 504  GRUMMAN H33 ORB.+BOOST.+DROP TANKS  (A46032)  16 OCT 71  PAGE  30
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

MACH NUMBER

REFERENCE INFORMATION

DATA HIST. CODE #EGF

MSFC 504 GRUMMAN H33 ORB.+DROP TANKS 01 (F46011) 09 DEC 71 PAGE 40
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA  0.000

REFERENCE INFORMATION

SREF  9.3760  58.1 N.
LREF  6.4950  IN.
BREF  3.9300  IN.
XMRP  3.2300  IN.
ZMRP  0.3000  IN.
SCALE 0.3366  PERCEN

DATA HIST. CODE  #6F

MSFC 504  GRUMMAN H33 ORB. + DROP TANKS  01  (F46011)  09 DEC 71  PAGE  43
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

MACH NUMBER

PARANETRIC VALUES

BETA  0.000

REFERENCE INFORMATION

SREF  9.3760  SQ.IN.
LREF  6.4950  IN.
XREF  5.9300  IN.
YREF  0.0000  IN.
ZREF  0.3024  IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE  #6G

MSFC 504  GRUMMAN H33 ORB.-DROP TANKS  02  (F46021)  09 DEC 71  PAGE 45
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA 0.000

REFERENCE INFORMATION
SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
BREF 3.9500 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCEN

DATA HIST. CODE #EGF
MSFC 504 GRUMMAN H3 ORB.-DROP TANKS 02 (F46021) 09 DEC 71 PAGE 47
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES
BETA  0.000

REFERENCE INFORMATION
SREF  9.3760  SQ. IN.
LREF  6.4950  IN.
BREF  3.9300  IN.
XNRP  3.2300  IN.
YNRP  0.0000  IN.
ZMNP  0.3024  IN.
SCALE  0.3366  PERCENT

DATA HIST. CODE  4E6F

MSFC 504  GRUMMAN H33 ORB.-DROP TANKS  02  (F46021)  09 DEC 71  PAGE 48
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA 0.000

REFERENCE INFORMATION

SREF 9.3760 IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMNP 3.2300 IN.
YMNP 0.0000 IN.
ZMNP 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE RF

MSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (G46021) 09 DEC 71 PAGE 49
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA 0.000

REFERENCE INFORMATION

SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XHPR 0.0000 IN.
ZHPR 0.0024 IN.
SCALE 0.3366 PERCEN

DATA HIST. CODE 8060

MSFC 504 GRUMMAN H33 ORB. + BOOST. - DROP TANKS (F46041) 09 DEC 71 PAGE 50
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA 0.000

REFERENCE INFORMATION

SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
SREF 3.8300 IN.
HREF 3.8300 IN.
THRPA 0.0000 IN.
ZREF 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE #EFG

MSFC 504 GRUMMAN H33 ORB.+BOOST.-DROP TANKS (F46041) 09 DEC 71 PAGE 51
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

ZERO ANGLE OF ATTACK DRAG FORCE COEFFICIENT (CD/CD ALFA = 0)

MACH NUMBER

PARAHETRIC VALUES
BETA 0.000

REFERENCE INFORMATION
SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
XREF 5.3930 IN.
YREF 0.0000 IN.
ZREF 0.3024 IN.
SCALE 0.3366 PERCENT

DATA MIST. CODE REGF
MSFC 504 GRUMMAN H33 ORB. + BOOST. - DROP TANKS (F46041) 09 DEC 71 PAGE 53
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES

BETA  0.000

REFERENCE INFORMATION

SREF  9.3760  SQ. IN.
LREF  6.4950  IN.
BREF  3.8300  IN.
XNRP  3.2500  IN.
YNRP  0.0000  IN.
ZMNP  0.3024  IN.
SCALE 0.3366  PERCENT

DATA HIST. CODE  RF

MSFC 504  GRUMMAN H3 ORB. + BOOST.—DROP TANKS  (G46041)  09 DEC 71  PAGE  54
LONGITUDINAL STABILITY AT \( \alpha = 0 \) DEGREES

PARAMETRIC VALUES

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\text{MACH NUMBER} & \quad 0.000 \\
\text{BETA} & \quad 0.000
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\text{SCALE} & \quad 0.3366 \text{ PERCENT}
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DATA HIST. CODE  #CGF

MSFC 504  GRUMMAN H33 ORB.+BOOST.+DROP TANKS  (F46031)  09 DEC 71  PAGE 55
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

MACH NUMBER

REFERENCE INFORMATION
SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
XREF 3.9300 IN.
XMNP 3.2300 IN.
ZNRP 0.3024 IN.
SCALE 0.3366 PERCEN

PARAMETRIC VALUES
BETA 0.000

DATA HIST. CODE MEGF

MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS (F46031) 09 DEC 71 PAGE 56
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

ZERO ANGLE OF ATTACK FOREBODY AXIAL FORCE COEFF. CAFA(α=0)

MACH NUMBER

PARAMETRIC VALUES
BETA 0.000

REFERENCE INFORMATION
SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.0300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE MEGF
MSFC 504 GRUMMAN H33 ORB. + BOOST. + DROP TANKS (F46031) 09 DEC 71 PAGE 57
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCEN

REFERENCE INFORMATION
SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCEN

DATA HIST. CODE #E6F
MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS (F4603!) 09 DEC 71 PAGE 58
LONGITUDINAL STABILITY AT ALPHA = ZERO DEGREES

PARAMETRIC VALUES
BETA 0.000

REFERENCE INFORMATION
SREF 9.3760 IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCENT
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA  0.000

REFERENCE INFORMATION
SREF  9.3760  SQ.IN.
LREF  6.4950  IN.
BREF  3.9300  IN.
XMRP  3.2300  IN.
YMRP  0.0000  IN.
ZMRP  0.3024  IN.
SCALE  0.3366  PERCENT

DATA HIST. CODE  #E6F
MSFC 504  GRUMMAN H33 ORB.+DROP TANKS  01  (F46012)  09 DEC 71  PAGE 60
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA  0.000

REFERENCE INFORMATION

SREF  9.3760  SQ. IN.
LREF  6.4950  IN.
BREF  3.9300  IN.
XMRP  3.2300  IN.
YMRP  0.0000  IN.
ZMRP  0.3024  IN.
SCALE  0.3366  PERCENT

DATA HIST. CODE  #EGF

MSFC 504  GRUMMAN H33 ORB. + DROP TANKS  01  (F46012)  09 DEC 71  PAGE  61
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA  0.000

REFERENCE INFORMATION

SREF  9.3760  SQ. IN.
LREF  9.4950  IN.
BREF  3.3300  IN.
XMRP  3.2300  IN.
YMRP  0.0000  IN.
ZMRP  0.3024  IN.
SCALE 0.3366  PERCENT

DATA HIST. CODE  #66

MSFC 504  GRUMMAN H33 ORB. + DROP TANKS  01  (F46012)  09 DEC 71  PAGE 62
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
WREF 3.8500 IN.
XMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCEN

MSFC 504 GRUMMAN H33 ORB.+DROP TANKS 01 (G46012) 09 DEC 71 PAGE 63
LATERAL STABILITY AT Beta = ZERO DEGREES

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SRM 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE WECF

MSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (F46022) 09 DEC 71 PAGE 64
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SREF 9.3760 SQ. IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XNRP 3.2000 IN.
YNRP 0.0000 IN.
ZHMP 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE #EGF

NSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (F46022) 09 DEC 71 PAGE 66
LATERAL STABILITY AT $\beta = 0$ DEGREES

PARAMETRIC VALUES

$\alpha = 0.000$°

REFERENCE INFORMATION

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$ZMRP = 0.3324$ IN.
$SCALE = 0.3366$ PERCENT

DATA HIST. CODE RF

MSFC 504 GRUMMAN H33 ORB.-DROP TANKS 02 (G46022) 09 DEC 71 PAGE 67
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SQ. IN.
SREF 9.3760
LREF 6.4950
BREF 3.6300
XREF 3.3600
YMRP 0.0000
ZMRP 0.3024
SCALE 0.3366 PERCENT

DATA HIST. CODE MEGF
MSFC 504 GRUMMAN H3 ORB.+BOOST.-DROP TANKS (F46042) 09 DEC 71 PAGE 68
LATERAL STABILITY AT Beta = ZERO DEGREES

ZERO SIDESLIP ANGLE YAWING MOMENT GRADIENT CYLIND (ALFA = 0)

MACH NUMBER

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SREF 9.760  90.1N
LREF 6.4950  IN
BREF 3.9300  IN
XMPR 3.2300  IN
YMPR 0.0000  IN
ZMPR 0.3054  IN
SCALE 0.3366 PERCENT

DATA HIST. CODE 966

MSFC 504 GRUMMAN H33 ORB. + BOOST- DROP TANKS (F46042) 09 DEC 71 PAGE 69
LATERAL STABILITY AT $\beta = 0$ DEGREES

Paraetetic Values

$\alpha = 0.000$

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Data Hist. Code RF

MSFC 504 GRUMMAN H33 ORB.+BOOST.-DROP TANKS (G46042) 09 DEC 71 PAGE 71
LATERAL STABILITY AT BETA = ZERO DEGREES

PARAMETRIC VALUES
ALPHA 0.000

REFERENCE INFORMATION
SREF 0.3760 SQ. IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XREF 3.2300 IN.
YMRP 0.0000 IN.
ZHRP 0.3024 IN.
SCALE 0.3366 PERCENT

DATA HIST. CODE  #EGF

MSFC 501 GRUMMAN H3 ORB.+BOOST.+DROP TANKS (F46032) 09 DEC 71 PAGE 72
LATERAL STABILITY AT \( \beta = 0 \) DEGREES

PARAMETRIC VALUES
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\alpha = 0.000
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REFERENCE INFORMATION

SREF 9.3760 SQ.IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XMRP 3.2300 IN.
YMRP 0.0000 IN.
ZMRP 0.3024 IN.
SCALE 0.3366 PERCM

DATA MWT. CODE 066F
MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS (F46032) 09 DEC 71 PAGE 73
LATERAL STABILITY AT $\beta = 0$ DEGREES

ZER0 SIDESLIP ANGLE ROLLING MOMENT GRAD. CBLBG (ALPHA = 0)

MACH NUMBER

PARAMETRIC VALUES

ALPHA 0.000

REFERENCE INFORMATION

SREF 9.3700 SQ. IN.
LREF 6.4950 IN.
BREF 3.9300 IN.
XHBP 3.2300 IN.
YHBP 0.0000 IN.
ZHBP 0.3024 IN.
SCALE 0.3366 PERCEN

DATA HIST. CODE #E5F

MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS (F46032) 09 DEC 71 PAGE 74
LATERAL STABILITY AT $\beta = 0$ DEGREES

PARAMETRIC VALUES

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DATA LIST CODE RF

MSFC 504 GRUMMAN H33 ORB.+BOOST.+DROP TANKS (G46032) 09 DEC 71 PAGE 75