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# COMPUTER-AIDED SPACE SHUTTLE ORBITER WING DESIGN STUDY

by W. Pelham Phillips, John P. Decker, Timothy R. Rau, and C. R. Glatt

Langley Research Center Hampton, Va. 23665



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# COMPUTER-AIDED SPACE SHUTTLE ORBITER

# WING DESIGN STUDY

By W. Pelham Phillips, John P. Decker, Timothy R. Rau, and C. R. Glatt\*

Langley Research Center

### SUMMARY

An analytical and experimental investigation has been made to define a space shuttle orbiter wing configuration meeting the requirements for landing performance, stability, and hypersonic trim for a specified center-of-gravity envelope. The analytical part of the study was facilitated by the use of the Optimal Design Integration system (ODIN). Limited experimental studies were made in the Langley low-turbulence pressure tunnel and the Langley continuous-flow hypersonic tunnel to verify the aerodynamic characteristics of the orbiter configuration selected analytically.

Use of the ODIN system greatly simplified the handling of analytical data while maintaining compliance with the space shuttle general vehicle requirements and allowed the expedient selection of a desirable wing planform. The analytical aerodynamic estimates obtained by using the ODIN system were in reasonable agreement with experimental results obtained subsequently for the orbiter configuration selected. The analytical study suggested reductions in wing sweep to produce a minimum-wing-area (minimum-weight) configuration. Reductions in wing area and sweep also enhanced the high-angle-of-attack trim capability at hypersonic speeds. This trend, however, was constrained by entry heating considerations to preclude wing-leading-edge sweep angles below 45°. Hypersonic considerations of elevon size effects redirected the study toward unsweeping the wing trailing edge to provide increased trimmed angle-of-attack capability for a 46.8° swept-wing configuration which satisfied the guideline subsonic flight requirements. The analytically selected orbiter configuration required minor experimental wind-tunnel refinements to provide a viable orbiter configuration. The primary refinement

<sup>\*</sup>Aerophysics Research Corporation, Hampton, Va.

was the addition of a small planform fillet to increase lift coefficients at landing attitudes. Significant reductions in lift-drag ratio losses due to the addition of attitude control propulsion system wing-tip pods were attained by tailoring the external shape of pods designed to house the roll-attitude control system. The use of sequentially deflected segmented elevons improved subsonic trimmed lift-drag ratios which may be beneficial to landing-approach glide-slope performance.

### INTRODUCTION

As the space shuttle program has matured, significant effort has been devoted to reductions in system weight resulting, in turn, in a smaller orbiter vehicle. The payload weight and volume requirements remained fixed, however, and the variations in potential payload centers of gravity exert an increased influence on the flight characteristics of the smaller vehicle. In addition to wide center-of-gravity excursions due to the various payloads, other interacting requirements such as a maximum allowable landing speed, acceptable unaugmented low-speed flying qualities, and stable hypersonic trim at high angles of attack present a formidable challenge to aerospace design.

Definition of a near-optimum design solution to these conflicting requirements within a reasonable time frame requires the rapid examination of a large number of configuration variables. Studies of means to automate design problems such as these have resulted in the formulation of an Optimal Design Integration system (ODIN) described in reference 1. The derived system is a unique approach to design synthesis in that it allows interactive operation of existing analysis programs representing the various problem-related technology areas. This paper presents the results of an initial utilization of this approach.

In the present study an existing orbiter design with known weight characteristics but unacceptable aerodynamic performance served as a baseline and the body, tail, and internal arrangement were held constant. The ODIN system was utilized to determine rapidly a wing configuration meeting the system requirements insofar as possible at a minimum weight. The aerodynamic characteristics of the analytically derived configuration were verified by experimental studies at subsonic and hypersonic speeds.

Also included in the subsonic experimental studies were the effects of a wing leading-edge planform fillet, wing twist, and the use of segmented elevons. The effects of wing-tip-mounted attitude-control propulsion system pods were also determined at subsonic speeds.

# **SYMBOLS**

Values are given in both SI and U.S. Customary Units. The measurements and calculations were made in U.S. Customary Units.

- A aspect ratio
- ē mean aerodynamic chord, meters (ft)
- $C_{D}$  drag coefficient,  $\frac{Drag}{q_{\infty}S_{ref}}$
- $C_L$  lift coefficient,  $\frac{Lift}{q_{\infty}S_{ref}}$
- $c_m \qquad \qquad \text{pitching-moment coefficient,} \quad \frac{\text{Pitching moment}}{\mathsf{q}_{\infty} s_{ref} \tilde{\mathsf{c}}}$
- $c_{m_{C_L}}$  static longitudinal stability level based on  $\bar{c}, \ \frac{\partial c_m}{\partial c_L}$
- $C_N$  normal-force coefficient,  $\frac{Normal\ force}{q_{\infty}S_{ref}}$
- $i_{\mbox{wing}}$  incidence angle of wing, deg
- L/D lift-drag ratio
- length of fuselage, meters (ft)
- M Mach number
- ${\rm q}_{\infty}$  free-stream dynamic pressure, newtons per meter  $^2$  (lb/ft  $^2$ )
- $\mathbf{R}_l$  free-stream Reynolds number based on l
- S<sub>elevon</sub> elevon area, meters<sup>2</sup> (ft<sup>2</sup>)
- Sref wing reference area, meters<sup>2</sup> (ft<sup>2</sup>)

 $V_{\rm min,des}$  minimum flying speed at design conditions and  $\alpha$  = 170, knots

x,y coordinates of exposed reference wing planform (origin at exposed root chord

leading edge)

 $x_{cg}$  center-of-gravity location from nose of vehicle

xwing location of exposed wing leading-edge root chord from nose of vehicle,

meters (ft)

XSF scale factor for x-ordinates of exposed wing planform

YSF scale factor for y-ordinates of exposed wing planform

 $\alpha$  angle of attack, deg

 $\delta_{\mbox{\it e}}$  elevon deflection angle, deg

λ taper ratio

 $\Lambda_{le}$  leading-edge sweep angle, deg

 $\Lambda_{ ext{te}}$  trailing-edge sweep angle, deg

Subscripts:

e<sub>1</sub>,e<sub>2</sub>,e<sub>3</sub> inboard to outboard elevon segments

des design conditions

max maximum

min minimum

trim trim conditions

# Abbreviations:

ACPS attitude control propulsion system

BW<sub>P</sub>V<sub>2</sub> body-plane (untwisted) wing-large vertical tail (subsonic model)

 ${\rm BW}_{\rm T}{\rm V}_{\rm 2}{\rm F}$  body-twisted wing-large vertical tail-fillet (subsonic model)

BWpV<sub>1</sub> body-plane (untwisted) wing-small vertical tail (hypersonic model)

Design P/L design payload condition (18 144 kg (40 000 lb) at payload bay centroid)

JSC NASA Johnson Space Center

Mod modified

ODIN Optimal Design Integration system

P<sub>1</sub> semifaired ACPS tip pod design

P<sub>2</sub> fully tailored ACPS tip pod design

P/L out payload-out condition

TPS thermal protection system

 $W_1$  to  $W_{35}$  wing designations

W/40K PL with 18 144 kg (40 000 lb) payload at payload bay centroid

### METHOD OF ANALYSIS

An existing orbiter design, designated the 040A (ref. 2), of known weight characteristics with aerodynamic performance characteristics unacceptable relative to established criteria, was used as a baseline configuration. The body, vertical tail, and internal arrangement were held constant and the ODIN system was utilized to determine a wing geometry and location to meet the system requirements in the longitudinal mode. Use of the ODIN system allowed rapid perturbation of the orbiter wing geometry by directing the sequential execution and data retrieval from a selected group of analytical programs. The specific programs were chosen to provide pertinent information representing the technology areas of subsonic and hypersonic aerodynamics, stability and control, weight, balance, geometry, and graphics.

# Analysis Criteria

The guidelines established for the wing design study (see table I) were in accord with those outlined and/or implied by the general vehicle requirements of the space shuttle program. The orbiter geometry and accompanying weight statement used as a study baseline are indicated in table II and table III, respectively. The design criteria are further depicted on the design envelope of payload loadings for the orbiter shown in figure 1. The requirement of a minimum design speed of 150 knots or less is shown for an 18 144 kg (40 000 lb) payload located at the half-length station of the payload bay. This payload loading represents the maximum return payload anticipated in its most forward location in the payload bay. Minimum design speed ( $V_{\min,des}$ ) is used herein to denote the level flying speed at  $\alpha = 17^{\circ}$  and sea-level standard day conditions for an orbiter having the design payload loading. Additional design criteria included stable subsonic static margin and high-angle-of-attack trim capability ( $\alpha_{\max} = 50^{\circ}$ ) hypersonically over the center-of-gravity range dictated by the payload envelope.

Parameters descriptive of these criteria, along with descriptive weights and geometry data, were output in the ODIN summary reports for each wing design and are included herein as an appendix. Pertinent information for the wings is summarized in the appendix. These summary reports enabled the user to determine the wing having the most desirable characteristics.

# TABLE I. - ANALYSIS CRITERIA

# Baseline orbiter configuration:

JSC-040A geometry (ref. 2) 040A weights (table II)

# Orbiter design criteria:

# Subsonic:

- (a)  $C_m/C_L$  (All payloads)  $\leq 0$ (b)  $V_{\min,des}$  (Design payload)  $\leq 150$  knots at  $\alpha = 17^0$
- (a)  $\alpha_{\rm max,trim}$  (Design payload) =  $50^{\rm O}$ (b)  $\Lambda_{\rm le} \stackrel{>}{\scriptstyle =} 45^{\rm O}$

# TABLE II. - BASELINE GEOMETRY

 $\left[ XSF = YSF = 1.0 \right]$ 

Overall configuration:	
Area, planform, $m^2$ (ft <sup>2</sup> )	(3723.0)
Length, nose to wing leading edge at body, m (in.) 15.765	(620.68)
Length, nose to wing $\bar{c}/4$ , m (in.)	(883.97)
Angle, ground plane, deg	17.00
Fuselage:	
Area, wetted, $m^2$ (ft <sup>2</sup> )	(6307.0)
Length, nose to end of body, m (in.)	(1315.0)
Wing:	
2 ()	(3155.8)
Area, elevon, $m^2$ (ft <sup>2</sup> )	(455.52)
Span, m (in.)	(882.00)
Chord, mean aerodynamic, m (in.) 15.485	(609.63)
Chord, center-line root, m (in.)	(897.14)
Chord, tip, m (in.)	(133.32)
Taper ratio, theoretical	0.14860
Aspect ratio, theoretical	1.7118
Aspect ratio, exposed span	1.5882
Angle, leading-edge sweep, deg	59.998
Angle, trailing-edge sweep, deg	0.0
Angle, dihedral, deg	7.0
Angle, incidence, deg	1.5
Airfoil section, root	0008-64
A. 6.13	0008-64
x <sub>wing</sub> , m (in.)	(720.04)

# TABLE III. - BASELINE WEIGHT STATEMENT

Wing group, kg (lb)
Tail group, kg (lb)
Body group, kg (lb)
Induced environmental protection, kg (lb)
Landing, docking, recovery, kg (lb)
Propulsion - ascent, kg (lb)
Propulsion - cruise, kg (lb)
Propulsion - auxiliary, kg (lb)
Prime power, kg (lb)
Electrical conversion and distribution, kg (lb) 1285.9 (2835)
Hydraulic conversion and distribution, kg (lb) 440.0 (970)
Surface controls, kg (lb)
Avionics, kg (lb)
Environmental control, kg (lb)
Personnel provisions, kg (lb)
Growth/uncertainty, kg (lb) 5305.2 (11 696)
Dry weight, kg (lb)
Personnel, kg (lb)
Payload, kg (lb)
Residual and reserve fluids, kg (lb)
Landing weight, kg (lb)
ACPS propellant (entry), kg (lb)
Entry weight, kg (lb)

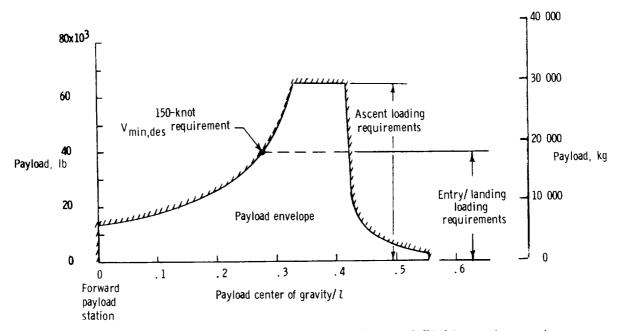
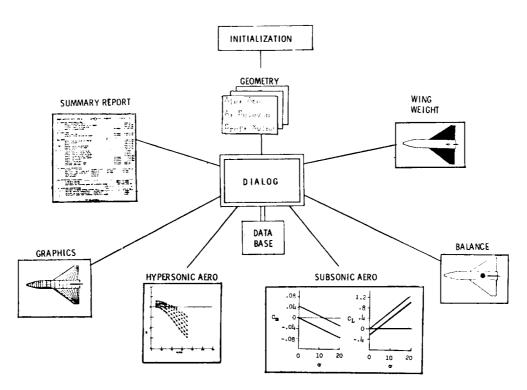


Figure 1.- Payload envelope depicting loading and flight requirements for the space shuttle orbiter.

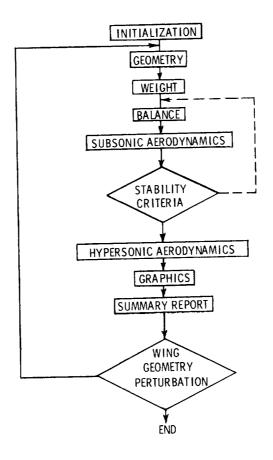
# Method

The general programing arrangement within the ODIN system is shown in figure 2(a), and the detailed programing arrangement for this problem is shown in figure 2(b). After initialization, the geometry program calculated the geometric characteristics of a matrix of wings selected as reasonable perturbations from the baseline shape. This information was stored in the data base by the executive program DIALOG. The calculations then proceeded sequentially for each wing geometry. The necessary information needed to calculate wing weight was retrieved from the data base by utilizing the DIALOG program which also input these values into the weight programs. Weights were assigned to the fuselage structure, to the fuselage-contained components, and to the vertical tail and were held constant during the study. The structural and the thermal protection system weights of the wing were calculated by the methods described in reference 3. This process was repeated through the balance program which calculated the centers of gravity of the vehicle for the payload-in and payload-out conditions. The



(a) General programing arrangement.

Figure 2.- Orbiter wing design problem formulation within the ODIN system.



(b) Programing arrangement. Figure 2.- Concluded.

static margins and trimmed  $\,C_L\,$  were obtained from the subsonic aerodynamics program (ref. 4). Static margins were obtained for payload-out and the design-payload conditions. The payload-out static margin was weighed against a target static margin of  $0.03\bar{c} \pm 0.002$ , which assured longitudinal stability at the guideline subsonic flight conditions. If this condition was not met, the system adjusted the longitudinal position of the wing and performed an iterative looping back through the geometry, balance, and subsonic aerodynamics programs until convergence was attained. After the final subsonic static margin calculation, the hypersonic characteristics were calculated by using the methods outlined in reference 5. The graphics program was then used to depict the vehicle and plot the aerodynamic characteristics. A summary report provided the pertinent information such as wing geometry, the weight of the vehicle, the center-of-gravity locations, the minimum design speed, and the maximum hypersonic trim angle of attack and thereby completed the design calculations for a specific wing.

# Study Variables

The wing study variables were leading-edge sweep angle, aspect ratio, and exposed wing area. These parameters were varied by using x- and y-scale factors (XSF and YSF) to depict the exposed planform of a study wing which is represented by the dashed outline in figure 3 (that is, a wing planform having XSF = 0.9 and YSF = 1.3 has exposed root and tip chords equal to 0.9 times the exposed root and tip chords of the baseline wing and an exposed span equal to 1.3 times the baseline exposed wing span). The trailing-edge sweep angle was fixed ( $\Lambda_{te}$  = 0°) and the taper ratio of the exposed wing was held constant for most of the study. To meet the subsonic static margin requirement, the longitudinal wing position  $x_{wing}$  was varied. For some of the wings considered in this study,  $\Lambda_{te}$  and  $S_{elevon}$  were also varied. Twenty-five different wing planforms were considered in the initial matrix which covered a broad spectrum of possible wing designs. (See fig. 4(a).)

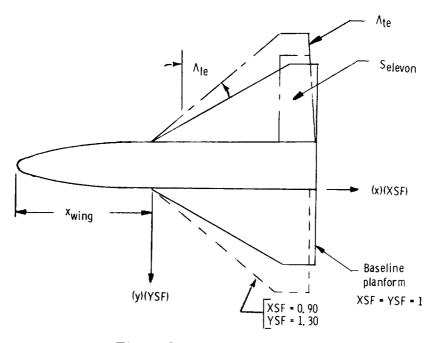
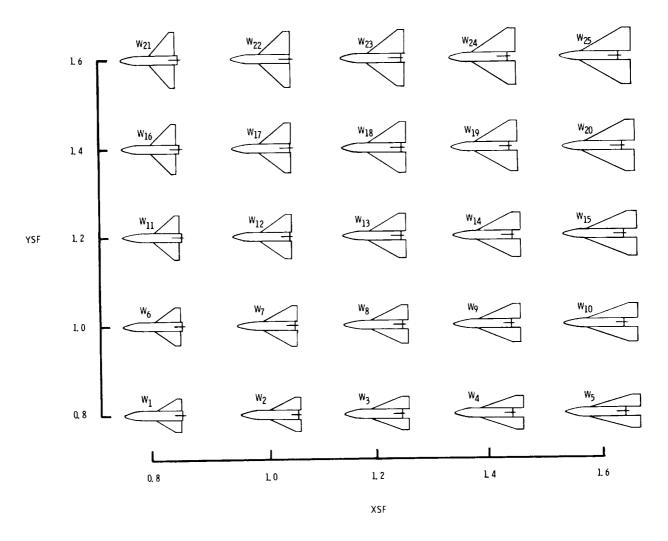


Figure 3.- Study variables.

The results of this matrix calculation were displayed in computer-generated maps of combined design and performance data (figs. 4(b) to 4(d)) which enabled rapid isolation of the effects of design variables. Based on the initial survey, 10 additional matrix points were added to indicate the desired configuration more clearly.



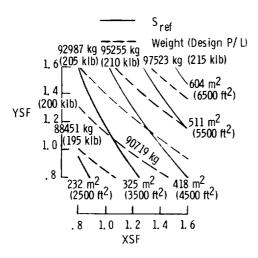
(a) Matrix of wings considered.

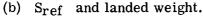
Figure 4.- Summary of geometric, weight, and aerodynamic characteristics.  $\Lambda_{\mbox{te}} = 0^{\mbox{O}}.$ 

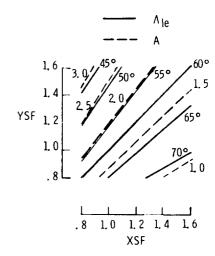
The entire 35 wing matrix calculations required approximately 1 hour of computer time. Individual assessment by conventional means was estimated conservatively to require one-half man-year.

# Verification

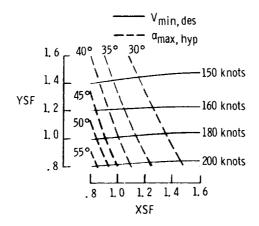
To complete the study cycle, models were constructed of the selected configuration to verify the estimated aerodynamic characteristics at both subsonic and hypersonic speeds. These models were then used to examine minor configuration improvements for







(c)  $\Lambda_{le}$  and A.



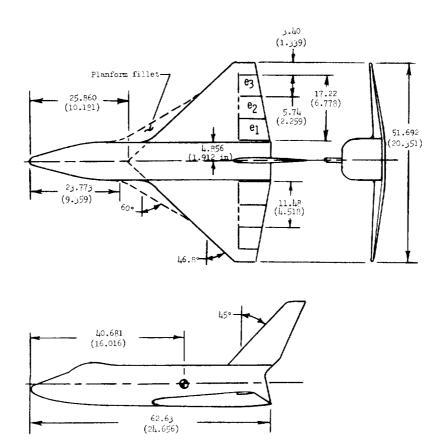
(d)  $V_{min,des}$  and  $\alpha_{max,hyp}$ . Figure 4.- Concluded.

which analytical techniques are inadequate. The following section entitled "Apparatus and Tests" is devoted to the introduction of the experimental aspects of the study.

# APPARATUS AND TESTS

# Subsonic

Model.- Details of the 0.01875-scale model used in the subsonic wind-tunnel design verification investigation are shown in figure 5(a). The model incorporated the analytically selected wing (W<sub>33</sub> (Mod), table IV) mounted on a similarly scaled 040A fuselage. (See ref. 2.) The model wing had a leading-edge sweep angle of 46.8°, a trailing-edge sweep



(a) Subsonic model; 
$$BW_TV_2$$
 (0.01875 scale);  $S_{ref}$  = 0.11067  $m^2$ ;  $\Lambda_{le}$  = 46.8°;  $\Lambda_{te}$  = -11.0°;  $\lambda$  = 0.135.

Figure 5. - Model schematic views. All dimensions are in centimeters (inches) unless otherwise specified.

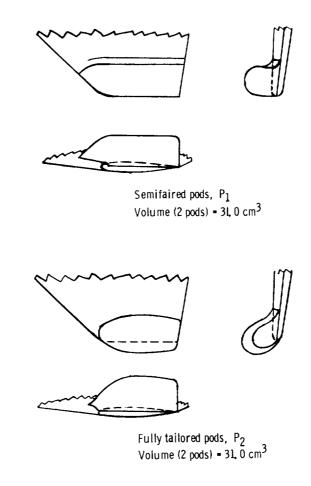
of  $-11.0^{\circ}$ , and an unswept elevon hingeline. The elevon tip chord was equal to 50 percent of the local wing chord. The basic (unfilleted) wing had an NACA 0008-64 airfoil section at the exposed root chord and varied linearly to an NACA 0012-64 section at the wing tip chord. Two basic wings identical in projected planform were utilized: a plane (untwisted) wing Wp with  $1.5^{\circ}$  incidence; and a twisted wing WT having the same incidence at the exposed root chord and  $4.5^{\circ}$  washout. Trisegmented elevons were incorporated for the model wings. A  $60^{\circ}$  swept planform fillet could be added ahead of the wing leading edge. This fillet had a leading-edge radius of about 0.20 cm and a hand-faired section which was tangential with the basic wing section at the local maximum thickness stations. Addition of the wing fillet increased the exposed model wing area by about 8.5 percent.

# TABLE IV. - SUMMARY DATA FOR SELECTED CONFIGURATION

 $\left[ \text{ODIN summary data for } w_{33} \text{ (Mod)} \right]$ 

Overall configuration:					
Area, planform, m $^2$ (ft $^2$ )	. <b></b>			378.0	(4069.3)
Length, nose to wing leading edge at body, cm (in.)	. <b></b> .			1655.32	(651,70)
Length, nose to wing $\bar{c}/4$ , cm (in.)				2267.71	(892,80)
Fuselage:					, ,
Area, wetted, m <sup>2</sup> (ft <sup>2</sup> )				E0E 0	(620T 0)
Length, nose to end of body, cm (in.)					(6307.0)
	• • • • •				(1315.0)
Wing:					
Area, theoretical or total, $m^2$ (ft <sup>2</sup> )		• • • • • • •		314.67	(3387.1)
Area, elevon, $m^2$ (ft <sup>2</sup> )					(678.75)
Span, cm (in.)					(1085.4)
Chord, mean aerodynamic, cm (in.)					(536.52)
Chord, center-line root, cm (in.)					(792.09)
Chord, tip, cm (in.)					(106.66)
Taper ratio, theoretical					
Aspect ratio, theoretical					
Aspect ratio, exposed span					
Angle, leading-edge sweep, deg					
Angle, trailing-edge sweep, deg					
Angle, dihedral, deg					
Angle, incidence, deg					
Airfoil section, root					
Airfoil section, tip				NACA	0008-64
	W	eight		x <sub>cg</sub>	$x_{cg}/l$ ,
Mass properties at flight condition:	kg	(lb)	m	(ft)	percent
Orbiter landing (Design P/L)	90 541	(199 609)	21.7	(71.181)	64.96
Orbiter landing (P/L out)	72 397	(159 609)	22.41	(73.523)	67.096
Wing weight		(16 476.8)			
Thermal protection system weight	12 258.96	(27 926.2)			
Principal parameters:					
x-scale factor, XSF					0.80000
y-scale factor, YSF					1.3000
Distance to leading edge of exposed wing, xwing, cm (					
Landing performance:	. ,				(002110)
Minimum landing speed (Design P/L), knots					
to the second se				• • • • • • • •	150.2
Static margin (subsonic) (Design P/L)	• • • • •			• • • • • • • •	0.0804
Static margin (subsonic) (P/L out)	• • • • •	• • • • • • • •		• • • • • • • •	0.0280
Trim $C_L$ for landing $(\alpha = 17^0)$	• • • • •			• • • • • • • •	0.7715
Hypersonic aerodynamic trim data:					
Trim angle of attack at elevon -45°, deg					
, 2				• • • • • • •	45.59

The vertical tail  $V_2$  (ref. 2) had NACA 0012-64 airfoil sections. Semifaired and fully tailored wing-tip-mounted ACPS pods were included as model configuration variables  $P_1$  and  $P_2$ , respectively. These pods were sized to represent the scaled volumetric requirement of the ACPS roll control. (See fig. 5(b).)



(b) Wing tip roll ACPS pods (0.01875-scale model).

Figure 5.- Continued.

Tunnel.- Subsonic tests were conducted in the Langley low turbulence pressure tunnel which is a variable-pressure, single-return facility with a closed test section 0.914 meter (3.0 feet) wide and 2.29 meters (7.5 feet) high. The tunnel is a low subsonic facility ( $M \le 0.4$ ) with the capability of Reynolds numbers per unit length up to about  $49.2 \times 10^6$  per meter ( $15.0 \times 10^6$  per foot).

<u>Test conditions.</u>- The investigation was conducted at a Mach number of about 0.25 and at Reynolds numbers from about  $12.6 \times 10^6$  to  $21.0 \times 10^6$ , based on the fuselage length. Test angle of attack was varied from approximately -3° to  $20^\circ$  at  $0^\circ$  sideslip.

Measurements and corrections. - An internally mounted six-component strain-gage balance was used to measure aerodynamic forces and moments acting on the model. No base- or chamber-pressure corrections were applied to the data. Corrections have been applied to the angles of attack and sideslip to account for sting and balance deflections produced by aerodynamic load on the model. All pitching-moment coefficient data are presented about the moment reference point location shown in figure 5(a) unless otherwise specified. The subsonic longitudinal aerodynamic coefficients and angles of attack have been corrected for blockage and lift interference in accordance with the techniques outlined in references 6 and 7.

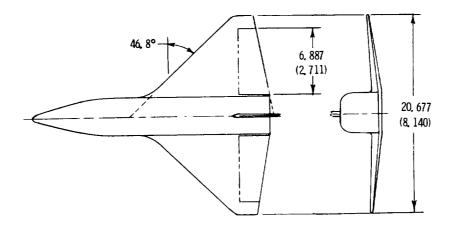
# Hypersonic

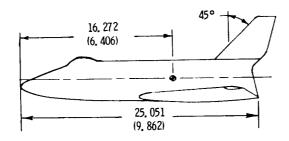
<u>Model.</u>- The hypersonic model was a 0.0075-scale model of the analytically selected configuration and is shown in figure 5(c). The model wing geometric features were similar to the subsonic plane (untwisted) model wing. The vertical tail  $V_1$  was geometrically similar in planform to the 040A vertical tail  $V_1$  (ref. 2) and used NACA 0012-64 airfoil sections.

Tunnel.- The hypersonic tests were made in the Langley continuous-flow hypersonic tunnel, which is designed to operate over a pressure range of 15 to 150 atmospheres (1 atmosphere =  $101\ 325\ N/m^2$ ) at temperatures up to  $1090\ K$  ( $1960^0\ R$ ). Air is heated by an electrical resistance multitube heater prior to entry into a water-cooled contoured nozzle which has a 79-cm-square (31-inch-square) test section. Continuous operation is achieved by recirculating the air flow through a series of compressors. Reynolds number varies from  $1.64\times 10^6$  to  $8.53\times 10^6$  per meter ( $0.5\times 10^6$  to  $2.6\times 10^6$  per foot).

Test conditions.— The hypersonic tests were conducted at a Mach number of about 10.3, a stagnation pressure of about 50 atmospheres, and a test Reynolds number of about  $0.8 \times 10^6$  based on the fuselage length. Data were taken at angles of attack from approximately 15° to 48° at 0° sideslip.

Measurements and corrections. - Aerodynamic force and moment data were measured by an internally mounted six-component strain-gage balance. The balance was strut mounted on an injection system assembly which inserted the model into the airstream.





(c) Hypersonic model; BWpV1 (0.0075 scale); Sref = 0.1771 m²;  $\Lambda_{le} = 46.8^{\circ}; \quad \Lambda_{te} = -11.0^{\circ}; \quad \lambda = 0.135.$ 

Figure 5. - Concluded.

Balance temperatures were continuously monitored to allow model retraction prior to overheating of the components. Angles of attack have been corrected to account for sting and balance deflections produced by aerodynamic loading. No base- or chamber-pressure corrections were applied to the data. The pitching-moment coefficient data are presented about the moment reference point location shown in figure 5(c).

# RESULTS AND DISCUSSION

# Analytical Results

Effect of wing geometry on aerodynamics, weight, and performance. Summary results from the initial 25-wing matrix ( $\Lambda_{te} = 0^{\circ}$ ) are shown in figure 4 and in the appendix.

The resulting configuration geometries, curves of constant landed weight, wing reference area, aspect ratio, leading-edge sweep, minimum design speed, and maximum hypersonic trim angle of attack are presented in figure 4. In order to satisfy the guidelines of the study, a wing is required to have the geometry specified at or above and to the left of the intersection of the 150-knot  $V_{\rm min,des}$  curve with the curve for a hypersonic trimmed  $\alpha_{\rm max}$  of  $50^{\rm O}$ . This projected intersection would occur at values of XSF and YSF of about 0.75 and 1.4, respectively, which represents an A > 3.0 wing configuration having a leading-edge-sweep angle less than 45°. (See fig. 4(b).) Entry heating considerations, however, which were used to establish the 45° minimum wing sweep boundary of table I precluded the further consideration of the aerodynamically desirable wing configurations indicated in figure 4. The nearby region containing wings having leading-edge sweep angles of 45° or greater was then investigated since it should contain the wing configurations most nearly conforming with the established guidelines and constraints. For this purpose 10 additional wing configurations were added to the initial matrix. Summary data for these additional configurations are presented in the appendix.

Effect of elevon size and  $\Lambda_{1e^*}$ - Figure 6 shows the effect of elevon chord increases on the hypersonic trim capability of the orbiter wings included in the study matrix. These results indicate that increasing the elevon area by about 4 percent of the wing area increases the maximum hypersonic trim angle from  $6^{\circ}$  to  $8^{\circ}$  for wings having reference areas between 210 and 330 m<sup>2</sup> (2260 and 3552 ft<sup>2</sup>). Figure 7 shows the effect of leading-edge sweep angle on the subsonic minimum design speed. The lower sweep angles allow the smaller wing areas to meet the subsonic requirement for a minimum design speed of 150 knots. In addition, reduced wing areas yield increased hypersonic trim angle-of-attack capability as indicated in figure 6.

Configuration selection.— Two configurations  $W_{27}$  and  $W_{33}$  (see appendix) were selected from the study matrix for further analysis. These configurations exhibited values of XSF and YSF indicated in figure 4 and would most likely result in wing planforms capable of meeting the subsonic-hypersonic criteria without violating the  $45^{\circ}$  minimum sweep constraint. The configuration  $W_{27}$  is defined in the appendix for values of XSF and YSF of 0.9 and 1.3 and configuration  $W_{33}$  by XSF and YSF values of 0.8 and 1.3. These two configurations were selected since each was considered to be marginally acceptable in satisfying the guidelines of the study regarding hypersonic trim and minimum design speed. As indicated in the index in the appendix (table V),  $V_{\min, des}$  for  $W_{27}$  and  $W_{33}$  were 151 knots and 154 knots, respectively. Also indicated are maximum

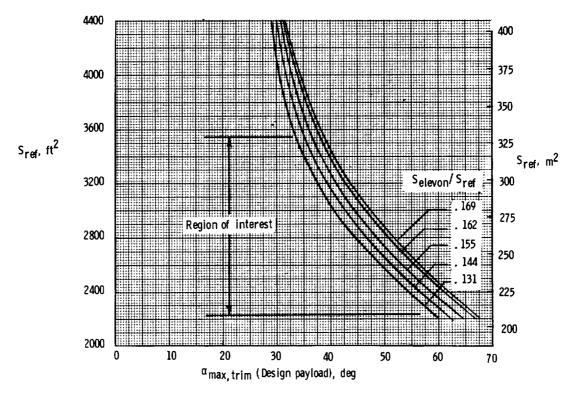


Figure 6.- Analytical effects of elevon size at hypersonic speeds for study wings.  $\Lambda_{te}$  = 00.

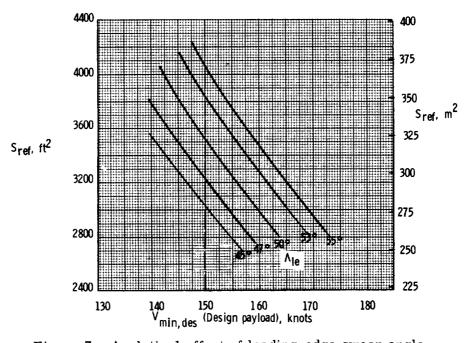
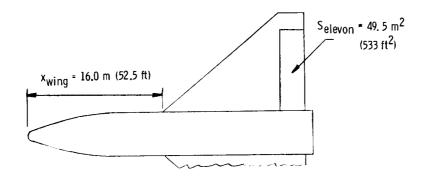


Figure 7.- Analytical effect of leading-edge sweep angle.

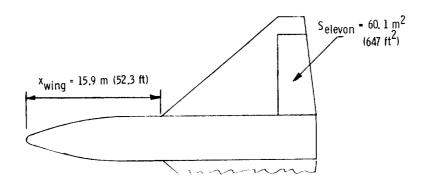
hypersonic trim angles of 40° and 46°, respectively, for the two configurations. At this point in the design cycle, improvements in the analytical aerodynamic characteristics as well as the introduction of empirical or experience factors are required to insure experimental compliance of the selected configurations with the established aerodynamic guidelines. For example, past comparisons with experiment have indicated higher analytical values of subsonic  $C_L$  and hypersonic trim capability (ref. 8) than experimental results for delta wings of moderate aspect ratio and sweep.

Reduction of  $V_{min,des}$  to the 150-knot guideline value requires an increase in wing area for both configurations (W27 and W33); hypersonic trim requirements, on the other hand, dictated a decrease in wing area or that the wing be moved forward to reduce the level of longitudinal stability. The subsonic stability criteria constrained the forward wing movement for both wings and thereby precluded meeting the hypersonic trim guidelines.

A possible solution to these conflicting requirements would be to increase the wing area slightly by using a negatively swept trailing edge and move the wing forward to comply with subsonic stability requirements and to achieve increased hypersonic trim capability. Additional benefits in hypersonic trim might also be realized by retaining the present elevon hingeline locations relative to the exposed wing to provide increased movable elevon areas. The effects of these modifications on wings  $w_{27} \ \text{and} \ w_{33} \ \text{are} \cdot$ shown in figures 8 and 9, respectively. Analytical results for the  $W_{\mathbf{27}}$  modification indicate that the target  $\,V_{\mbox{min,des}}\,\,$  of 150 knots was achieved, whereas the hypersonic  $\alpha_{\rm max, \, trim}$  increased by only 10 to a value of 410. Since the wing-forward movement was very slight, the corresponding increase in hypersonic trim angle was extremely small. (Compare fig. 8(a) with fig. 8(b).) Comparison of figure 9(a) with figure 9(b) shows that these modifications of  $W_{33}$  produced more desirable results. The value of  $V_{\min, \mathrm{des}}$ for the modified wing was reduced to 150 knots whereas hypersonic trim capability was extended to 49°. This wing configuration was selected for the experimental verification with one further modification; the elevon chords were arbitrarily reduced to improve structural integrity of the wing tips. The resulting configuration selected is shown in figure 10 and pertinent summary characteristics are shown in table IV. The analytical results indicated that the selected configuration met all the aerodynamic design requirements outlined in table I with the exception of the maximum angle-of-attack hypersonic trim. Because of the reduced elevon area, the design exhibited a maximum trimmed angle of attack  $4^{\rm O}$  less than the required value (50°). This deficiency could be eliminated



(a)  $\Lambda_{\text{te}} = 0^{\circ}$ ;  $W_{27}$ ;  $V_{\text{min,des}}$  (Design P/L) = 151 knots; hypersonic  $\alpha_{\text{max,trim}}$  (Design P/L) =  $40^{\circ}$ ;  $S_{\text{ref}} = 312 \text{ m}^2$  (3357 ft<sup>2</sup>).



(b)  $\Lambda_{\text{te}} = -7.0^{\circ}$ ;  $W_{27}$  (Mod);  $V_{\text{min,des}}$  (Design P/L) = 150 knots; hypersonic  $\alpha_{\text{max,trim}}$  (Design P/L) = 41°;  $S_{\text{ref}} = 328 \text{ m}^2$  (3535 ft<sup>2</sup>).

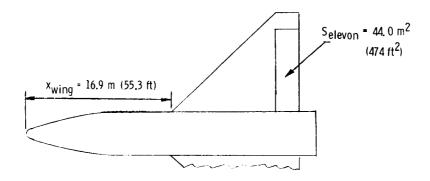
Figure 8.- Effect of trailing-edge sweep angle on wing  $W_{27}$ .  $\Lambda_{le}$  = 50.2°.

by some fuselage nose reshaping (not considered in the wing study) which has been shown to provide a positive increment in pitching moment. (See ref. 9.)

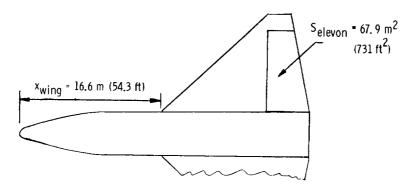
Subsequent experimental wind-tunnel studies using the selected configuration were made to validate these aerodynamic estimates and to demonstrate the aerodynamic development required to produce a satisfactory orbiter design.

### **Experimental Results**

The basic longitudinal aerodynamic data obtained at subsonic and hypersonic speeds for the selected configuration are presented. The subsonic data are shown in figures 11



(a)  $\Lambda_{\text{te}} = 0^{\circ}$ ;  $W_{33}$ ;  $V_{\text{min,des}}$  (Design P/L) = 154 knots; hypersonic  $\alpha_{\text{max,trim}}$  (Design P/L) = 46°;  $S_{\text{ref}} = 315 \text{ m}^2$  (2983 ft<sup>2</sup>).



(b)  $\Lambda_{\rm te}$  = -11.0°; W<sub>33</sub> (Mod); V<sub>min,des</sub> (Design P/L) = 150 knots; hypersonic  $\alpha_{\rm max,trim}$  (Design P/L) = 49°; S<sub>ref</sub> = 315 m<sup>2</sup> (3387 ft<sup>2</sup>).

Figure 9.- Effect of trailing-edge sweep angle on wing  $W_{33}$ .  $\Lambda_{le}$  = 46.8°.

to 17 with hypersonic data in figure 18. The subsonic aerodynamic characteristics of the configuration selected are summarized in figures 19 to 22. Longitudinal aerodynamic characteristics obtained at hypersonic speeds are summarized in figure 23.

Subsonic analytical and experimental comparisons. A comparison of the analytical predictions with subsonic longitudinal aerodynamic characteristics obtained at high Reynolds number ( $R_l \approx 20 \times 10^6$ ) in the Langley low turbulence pressure tunnel is shown in figure 19. The wind-tunnel and analytical data are in good agreement at low to moderate angles of attack. The pitch-down tendency which occurs at high angles of attack in the

$$\Lambda_{le}$$
 = 46.8°  
 $\Lambda_{te}$  = -11.2°  
 $S_{ref}$  = 315 m<sup>2</sup>  
(3387 ft<sup>2</sup>)  
 $S_{elevon}$  = 63.1 m<sup>2</sup>  
(679 ft<sup>2</sup>)  
 $\lambda$  = .135  
 $\Lambda$  = 2.4  
 $i_{wing}$  = 1.5°

# Payload out:

Landed weight = 72398 kg (159609 lb)

x<sub>cg</sub> = 0, 6711 C<sub>mC1</sub> = -0, 028  $\bar{c}$ 

# Design payload:

Landed weight = 90542 kg (199609 lb)

x<sub>cg</sub> = 0.650*l* C<sub>mCL</sub> = -0.080 c

 $V_{min,des} (\alpha = 17^{0}) = 150 \text{ knots}$ 

 $\alpha_{max.trim}$  at hypersonic speeds = 46°

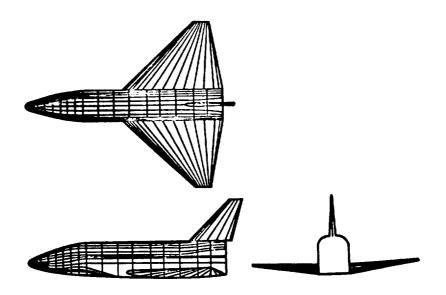


Figure 10. - Configuration selected, W<sub>33</sub> (Mod).

experimental data was not predicted analytically because linear trends were assumed. This tendency reduces trimmed lift coefficient at high angles of attack below the level predicted and would result in an increase in minimum design speed of 12 knots for the design payload condition.

Effect of planform fillet on subsonic characteristics. In an attempt to alleviate the landing lift decrement, a wing leading-edge planform fillet was added to the subsonic model (figs. 5(a) and 20). The fillet provided sufficient lift at the higher angles of attack

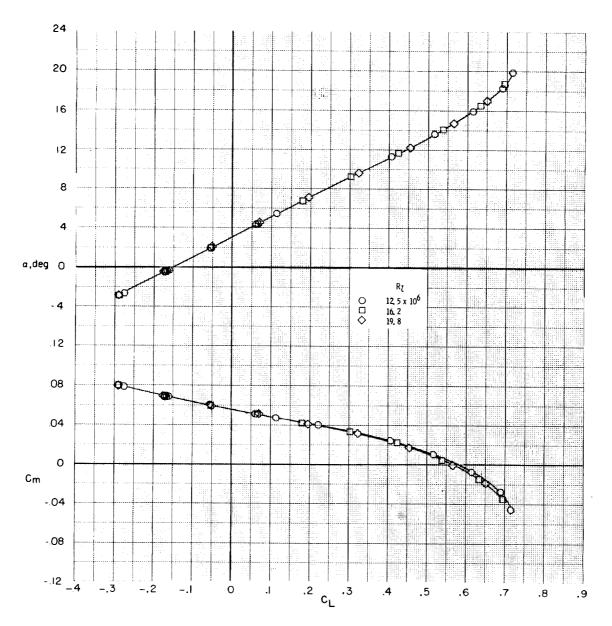


Figure 11.- Effect of Reynolds number on the longitudinal aerodynamic characteristics of the untwisted wing configuration  $BW_{p}V_{2}$ .  $\delta_{e_{1}} = \delta_{e_{2}} = \delta_{e_{3}} = -10^{\circ}$ .

to linearize the trimmed lift curve and provide a minimum design speed of about 150 knots. The addition of the fillet shifted the aerodynamic center of the configuration about  $0.05\bar{c}$  forward and required a rearward shift of the wing of about the same amount to keep the static margin of the configuration (payload out) at  $0.03\bar{c}$ .

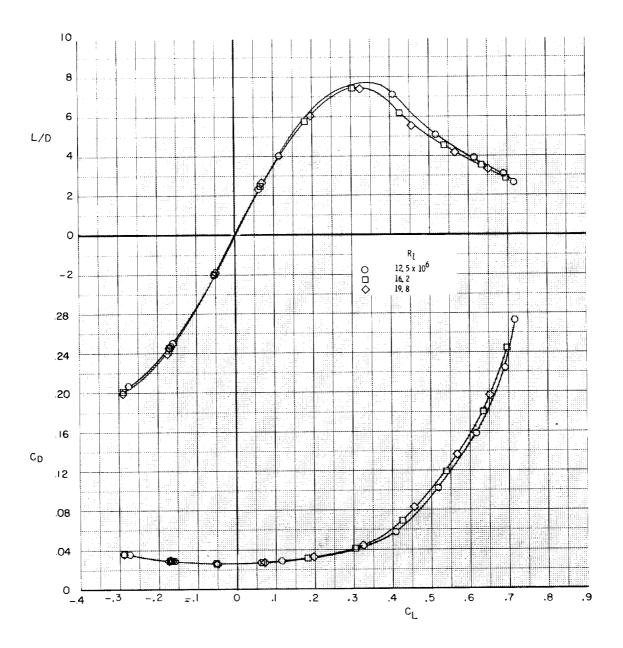


Figure 11.- Concluded.

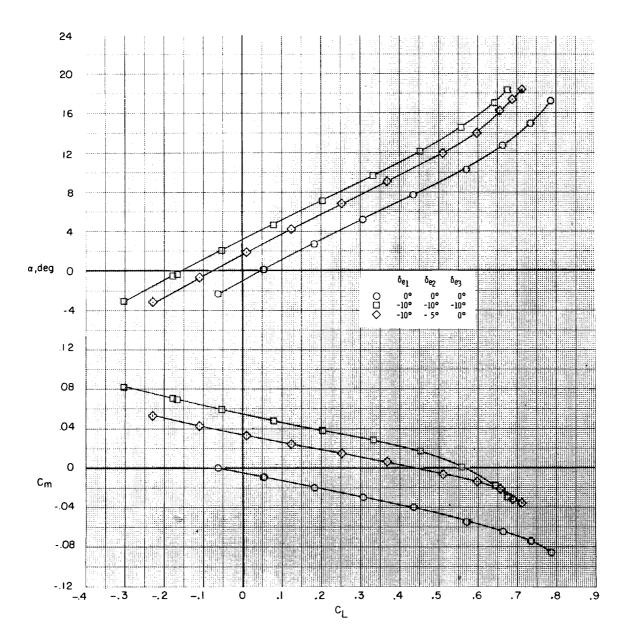


Figure 12.- Comparative longitudinal trim effects of unsegmented and segmented elevons for the untwisted wing configuration  $BW_PV_2$ .  $R_l \approx 20.1 \times 10^6$ .

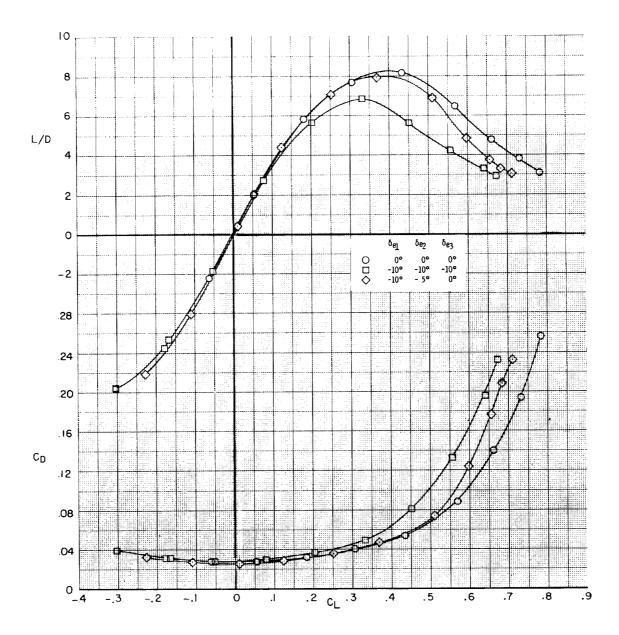


Figure 12.- Concluded.

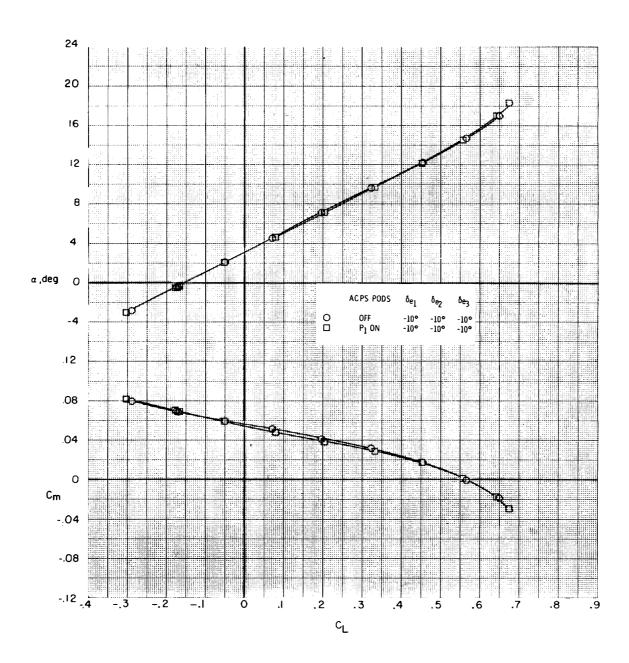


Figure 13.- Effect of adding ACPS pods  $P_1$  on the aerodynamic characteristics of the untwisted wing configuration  $~BW_PV_2.~~R_{l}\approx 20.0\times 10^6.$ 

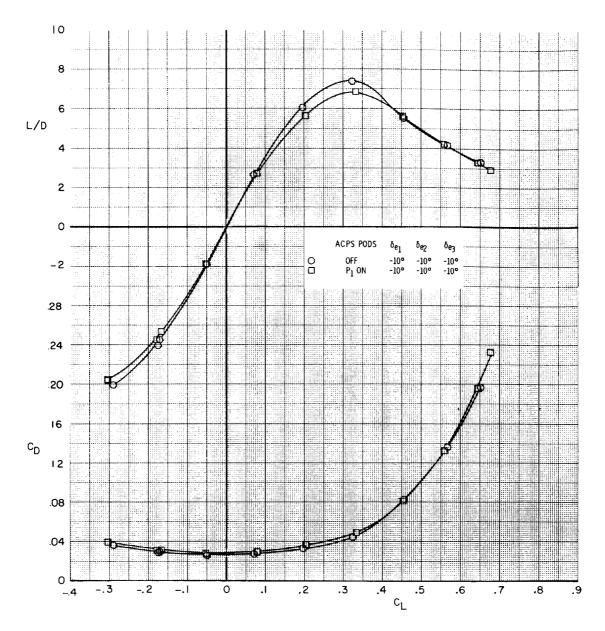


Figure 13.- Concluded.

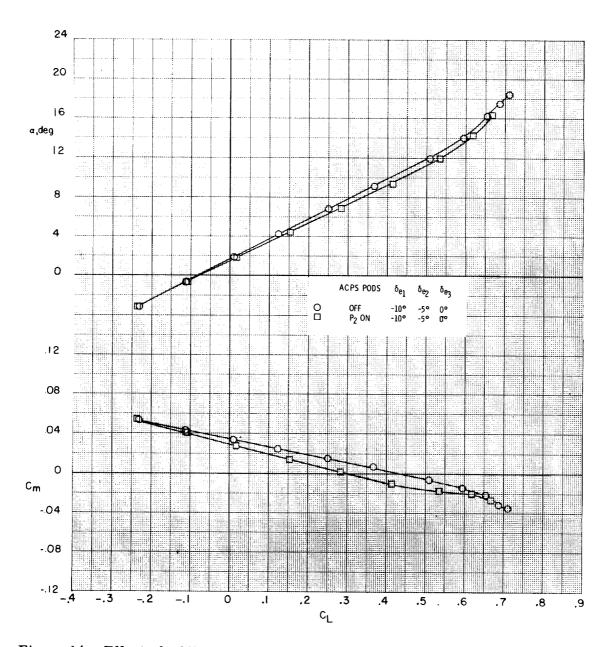


Figure 14.- Effect of adding contoured ACPS pods  $P_2$  on the aerodynamic characteristics of the untwisted wing configuration  $BW_PV_2.\ R_{l}\approx 20.3\times 10^6.$ 

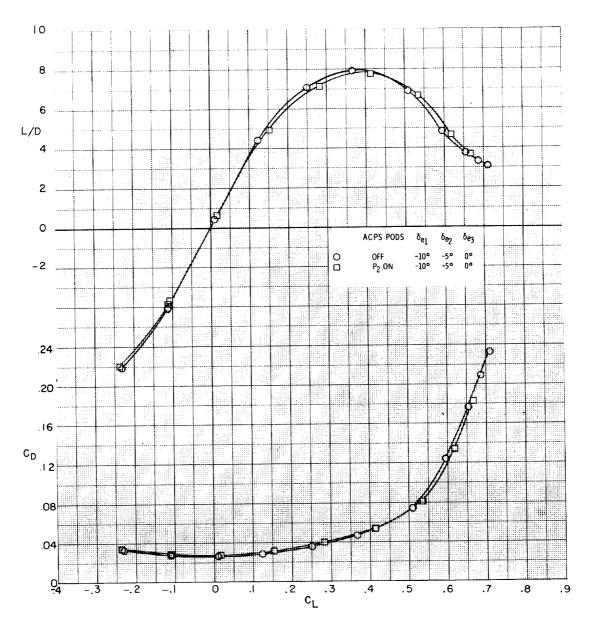


Figure 14.- Concluded.

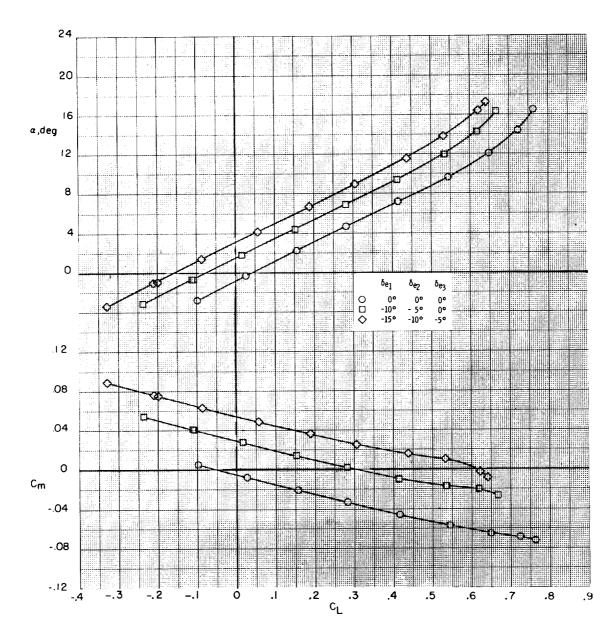


Figure 15.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the untwisted wing configuration with ACPS pods  $\rm P_2$  on.  $\rm BW_PV_2P_2$ ;  $\rm R_{\it l}\approx 20.6\times 10^6$ .

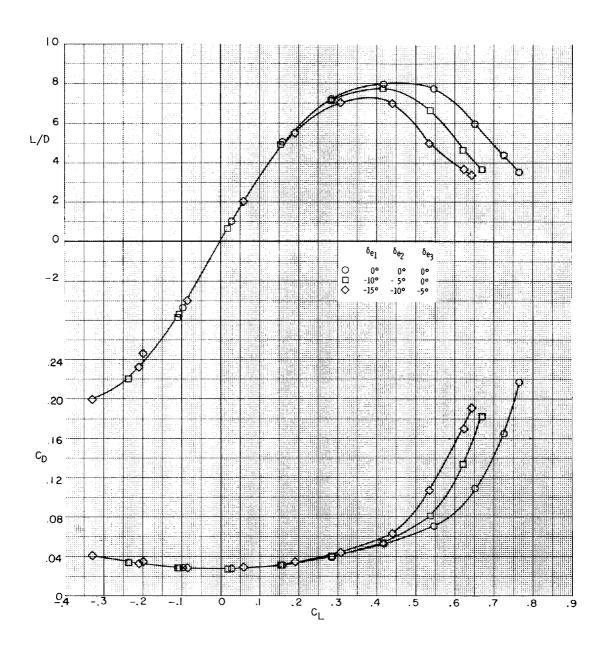


Figure 15.- Concluded.

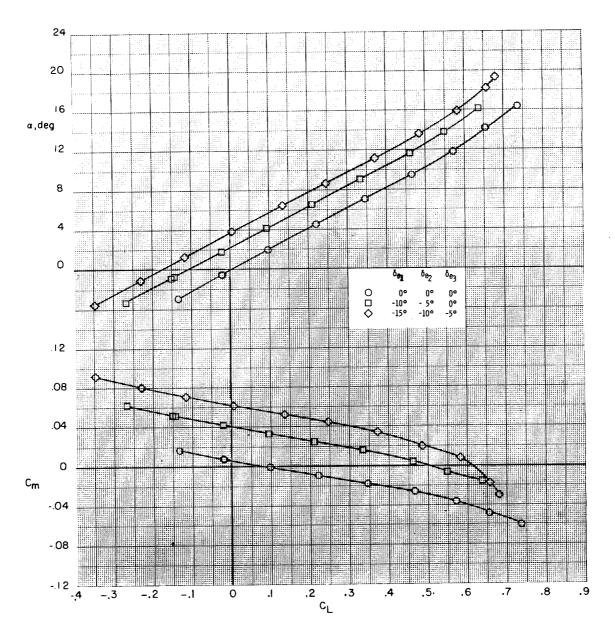


Figure 16.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the twisted wing configuration  $BW_TV_2.\ R_{\slashed l}\approx 20.1\times 10^6.$ 

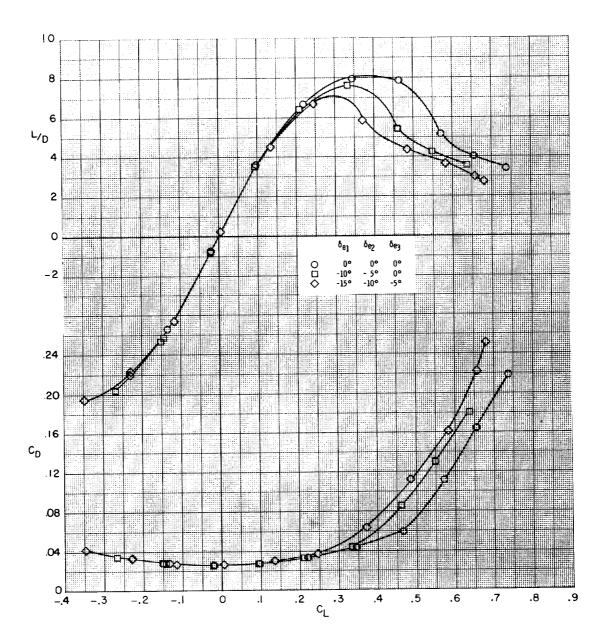


Figure 16.- Concluded.

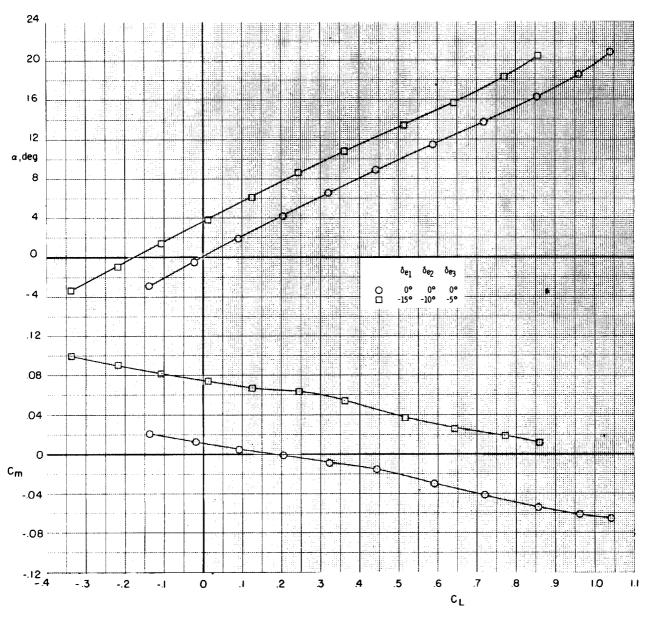


Figure 17.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the twisted wing configuration with a planform fillet. BW $_T$ V $_2$ F;  $R_l \approx 13.4 \times 10^6$ .

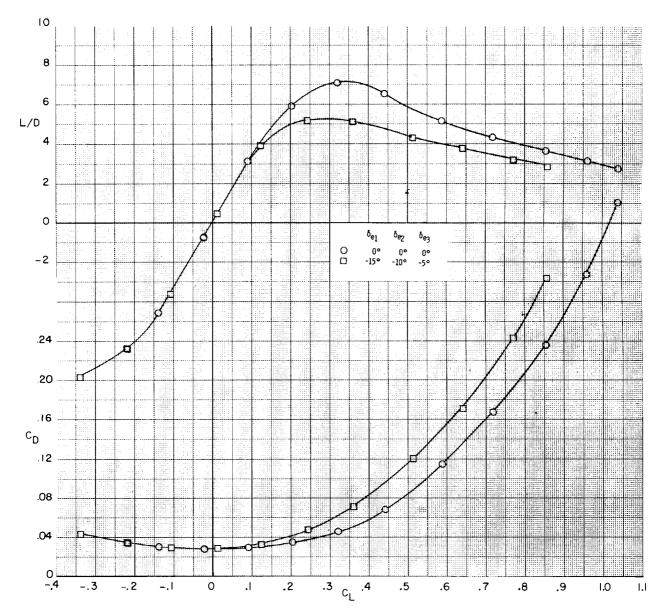


Figure 17.- Concluded.

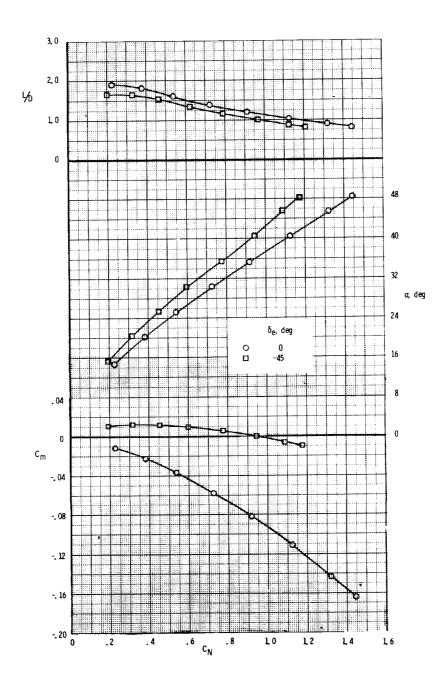
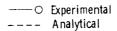


Figure 18.- Hypersonic aerodynamic characteristics for configuration  $BW_{1}V_{1}$ . M=10.33.



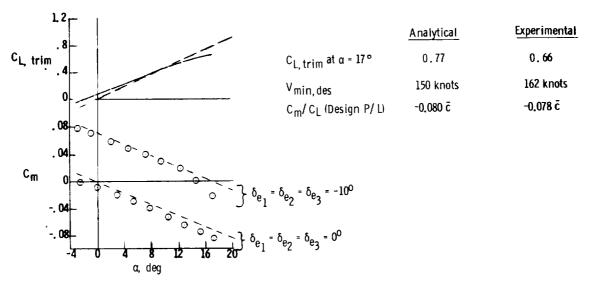


Figure 19.- Comparison of subsonic analytical aerodynamic characteristics with wind-tunnel experimental values for configuration  $BW_{\mathbf{P}}V_{\mathbf{2}}$ .

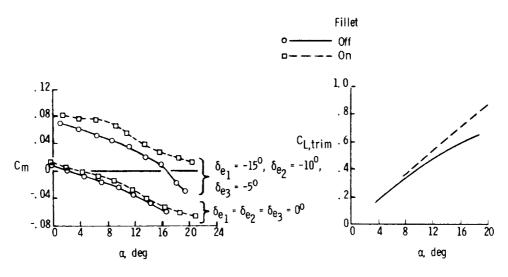


Figure 20.- Effect of the planform fillet on the subsonic aerodynamic characteristics of configuration  $\, {\rm BW}_T {\rm V}_2.$ 

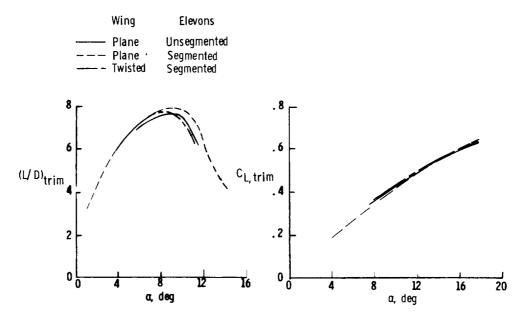


Figure 21.- Some experimental effects of segmented elevons and wing twist on the trimmed subsonic aerodynamic characteristics.

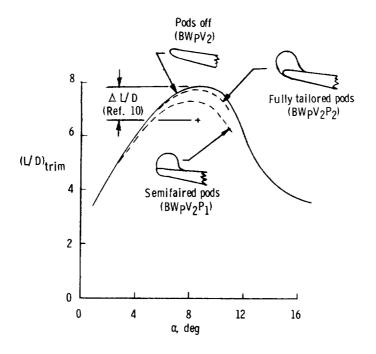


Figure 22.- Experimental subsonic effects of wing-tip-mounted ACPS pods.

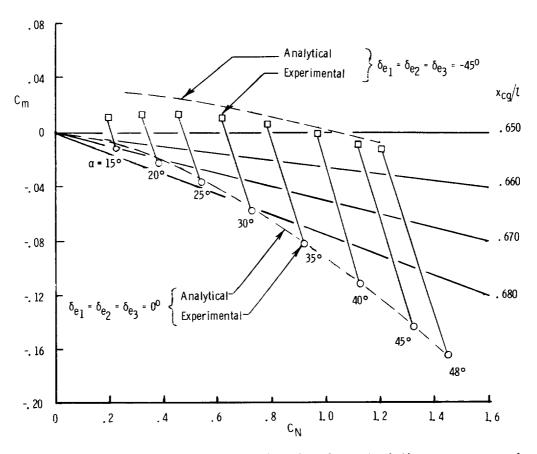


Figure 23.- Experimental hypersonic trim characteristics as compared to analytically obtained values for configuration  $BW_{p}V_{1}$ .

Effects of segmented elevons and wing twist.- The effect of varying spanwise deflections of trisegmented elevons (more negative for the inboard segments) and wing twist on the longitudinal trim characteristics of the configuration is shown in figure 21. Use of variations in spanwise elevon deflections produced little or no increase in trimmed lift coefficients at landing angles of attack ( $\alpha > 15^{\rm O}$ ) for the basic plane wing configuration. However, some increase in trimmed (L/D)<sub>max</sub> was noted for the configuration using variations in spanwise elevon deflection for trim. Only slight changes in trimmed lift coefficients were produced by incorporating linear wing twist (4.5° washout) in the subsonic model although some reductions in L/D are attributed to the introduction of wing twist for angles of attack near and above (L/D)<sub>max</sub>.

Subsonic ACPS tip pod effects. Significant degradations in trimmed lift-drag ratios have been associated with the addition of unfaired wing-tip-mounted ACPS pods to space shuttle orbiters (ref. 10). Figure 22 shows the  $(L/D)_{\rm max}$  decrement from reference 10

to be about 1.2 which would result in an approach glide-slope angle increase somewhat greater than  $1^{\rm O}$ . An attempt was made to assess the effects of tailoring the ACPS pod external shape on L/D ratios. For this purpose, two wing-tip pod configurations were tested on the plane-wing configuration BWpV2 (fig. 5(b)) which fulfilled the volumetric requirements for roll-control ACPS. The two configurations represented semifaired and fully tailored designs. Addition of the semifaired pod to configuration BWpV2 produced a trimmed  $(L/D)_{max}$  decrement of about 0.7 (fig. 22) whereas the fully tailored fairing of the pods resulted in a decrement of only about 0.1.

Hypersonic analytical and experimental comparisons. The basic longitudinal aerodynamic characteristics obtained for configuration BWpV1 at M = 10.33 in the Langley continuous-flow hypersonic tunnel are shown in figure 18. A comparison of these data with the analytically predicted pitch trim characteristics is presented in figure 23. This experimental data comparison indicates a reduction of approximately  $5^{\rm O}$  in maximum trimmed angle-of-attack capability for the configuration with  $\delta_{\rm e1} = \delta_{\rm e2} = \delta_{\rm e3} = -45^{\rm O}$ ; this reduction thereby produces an  $\alpha_{\rm max,trim}$  of about  $40^{\rm O}$  for the design payload condition ( $x_{\rm cg}/l = 0.650$ ). Experimental effects of fuselage widening and of changing the fuselage nose camber (see ref. 9) indicate the necessity of only minor modifications to increase the trimmed hypersonic maximum angle of attack for the present configuration from  $40^{\rm O}$  to  $50^{\rm O}$ . Although no hypersonic data were obtained for configuration BWpV1F (incorporating the planform fillet and the aftward wing movement), estimates of stability and control indicate the possibility of some improvement in hypersonic maximum angle-of-attack trim capability for this configuration.

Summarization of vehicle performance characteristics. During the course of the present analytical and experimental orbiter wing design study, a configuration  $BW_TV_2F$  (incorporating a  $0.03\bar{c}$  aft wing movement) was developed which would essentially satisfy the established design guidelines. Figure 24 summarizes the experimental aerodynamic performance, stability, and control characteristics for this configuration. Stable subsonic static margins were found for the configuration throughout the envelope which are in accord with the preset study guidelines as is the  $V_{min,des}$  value of 148 knots.

Maximum hypersonic trim capability for configuration BWpV1F is estimated at  $\alpha_{\rm max,trim} \approx 40^{\rm O}$  for the design payload condition. This value is approximately  $10^{\rm O}$  less than the guideline value of  $50^{\rm O}$  which might be attained with some fuselage nose reshaping and/or elevon resizing which would not adversely alter the subsonic flight characteristics.

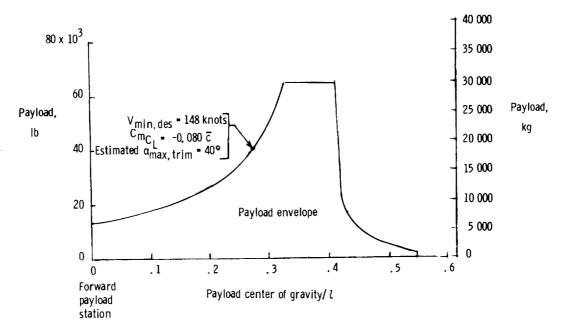


Figure 24.- Summary of experimental performance characteristics for configuration  $BW_TV_2F$  as applied to the various landed payload loadings of the space shuttle.

#### SUMMARY OF RESULTS

An analytical and experimental investigation has been made to define a space shuttle orbiter wing configuration meeting requirements for landing performance, stability, and hypersonic trim for a specified center-of-gravity envelope. The analytical part of the study was facilitated by the use of the Optimal Design Integration system (ODIN). Limited experimental studies were made in the Langley low-turbulence pressure tunnel and the Langley continuous-flow hypersonic tunnel to verify the aerodynamic characteristics of the orbiter configuration selected analytically. Results are summarized as follows:

- 1. Use of the ODIN system greatly simplified the handling of analytical data while maintaining compliance with the space shuttle general vehicle requirements and allowed the expedient selection of a desirable wing planform. The analytical aerodynamic estimates obtained by using the ODIN system were in reasonable agreement with experimental results obtained subsequently for the orbiter configuration selected.
- 2. The analytical study suggested reductions in wing sweep to produce a minimum wing area (minimum weight) configuration. Reductions in wing area and sweep also

enhanced the high-angle-of-attack trim capability at hypersonic speeds. This trend, however, was constrained by entry heating considerations to preclude wing leading-edge sweep angles below 45°. Attempting to meet the hypersonic and subsonic guidelines directed the study toward using a negatively swept wing training edge to provide increased hypersonic trim capability and desirable subsonic flight characteristics.

- 3. The analytically selected orbiter configuration required minor experimental wind-tunnel refinements to provide a viable orbiter configuration. The primary refinement was the addition of a small planform fillet to increase lift coefficients at landing attitudes accompanied by an aft wing movement.
- 4. Significant reductions in lift-drag ratio losses due to the addition of attitude-control propulsion system wing-tip pods were attained by tailoring the external shape of pods designed to house the roll-attitude control system.
- 5. The use of sequentially deflected segmented elevons improved subsonic trimmed lift-drag ratios which may be beneficial to landing-approach glide-slope performance.

Langley Research Center.

National Aeronautics and Space Administration, Hampton, Va., January 18, 1974.

#### APPENDIX

#### ANALYTICAL DATA

The characteristics of the wings investigated are presented in this appendix. An index of these characteristics is presented in table  ${\bf V}.$ 

TABLE V. - INDEX OF CHARACTERISTICS OF WINGS INVESTIGATED

							Subsonic	C <sub>m</sub> C <sub>1</sub>	**	Hypersonic		_		
Wing	$x_{wing}/l$	Sr	ef	Λ <sub>le</sub> , deg	Λ <sub>te</sub> , deg	Α	(based		V <sub>min,des</sub> ,	α <sub>max,trim</sub> , deg	XSF	YSF	Selevon	Page
	.,	m <sup>2</sup>	ft <sup>2</sup>	ueg	ucs		P/L out	40K P/L	(40K P/L)	(40K P/L)			Sref	
$\mathbf{w}_1$	0.5404	207.0	2228	60.0	0.0	1.74	-0.0282	-0.0843	204	59	0.8	0.8	0.131	47
$\mathbf{w_2}^{-}$	.4928	258.7	2785	65.2		1.39	0282	0759	203	45	1.0	.8	.131	48
$\mathbf{w}_{3}$	.4517	310.5	3342	68.9		1.16	0293	0721	204	36	1.2	.8	.131	49
$W_4$	.4152	362.2	3899	71.7		.99	0310	0708	206	31	1.4	.8	.131	50
$\mathbf{w}_{5}$	.3805	414.0	4456	73.9		.87	0316	0696	207	29	1.6	.8	.131	51
$W_6$	.5192	234.5	2524	54.2		2.14	0290	0870	179	53	.8	1.0	.144	52
w <sub>7</sub>	.4718	293.2	3156	60.0		1.71	0275	0770	177	41	1.0	1.0	.144	53
w <sub>8</sub>	.4335	351.8	3787	64.3		1.42	0318	0764	178	33	1.2	1.0	.144	54
w <sub>9</sub>	.3942	410.4	4418	67.6		1.22	0312	0727	178	30	1.4	1.0	.144	55
w <sub>10</sub>	.3586	469.1	5049	70.2		1.07	0317	0712	178	28	1.6	1.0	.144	56
w <sub>11</sub>	.5074	262.9	2830	49.1		2.54	0278	0873	161	48	.8	1.2	.155	57
w <sub>12</sub>	.4627	328.6	3537	55.3		2.03	0288	0798	158	37	1.0	1.2	.155	58
w <sub>13</sub>	.4243	394.3	4244	60.0		1.69	0324	0786	158	31	1.2	1.2	.155	59
w <sub>14</sub>	.3842	460.0	4952	63.7		1.45	0312	0741	157	28	1.4	1.2	.155	60
w <sub>15</sub>	.3486	525.7	5659	66.6		1.27	0316	0725	157	27	1.6	1.2	.155	61
W <sub>16</sub>	.5010	291.6	3139	44.7		2.94	0283	0891	147	44	.8	1.4	.163	62
W <sub>17</sub>	.4563	364.6	3924	51,1		2.35	0277	0800	143	34	1.0	1.4	.163	63
w <sub>18</sub>	.4179	437.5	4709	56.0		1.96	0306	0779	142	30	1.2	1.4	.163	64
w <sub>19</sub>	.3796	510.4	5494	60.0		1.68	0311	0752	141	27	1.4	1.4	.163	65
$W_{20}$	.3431	583.3	6279	63.2		1.47	0314	0735	141	26	1.6	1.4	.163	66
$W_{21}$	.4973	320.7	3452	40.9		3.34	0287	0906	136	40	.8	1.6	.169	67
W <sub>22</sub>	.4554	400.9	4315	47.3		2.67	0287	0821	132	32	1.0	1.6	.169	68
$w_{23}$	.4179	481.0	5178	52.4		2.23	0324	0810	131	28	1.2	1.6	.169	69
W <sub>24</sub>	.3778	561.2	6041	56.6		1.91	0310	0762	129	27	1.4	1.6	.169	70
W <sub>25</sub>	.3422	641.4	6904	60.0		1.67	0312	0745	129	26	1.6	1.6	.169	71
w <sub>26</sub>	.4882	279.7	3011	54.8		2.08	0278	0817	168	44	.9	1.1	.150	72
w <sub>27</sub>	.4791	311.9	3357	50.2		2.44	0254	0806	151	40	.9	1.3	.159	73
W <sub>28</sub>	.4763	344.4	3707	46.1		2,79	0272	0837	139	37	.9	1.5	.166	74
W <sub>29</sub>	.4417	381.2	4103	55.7		1.99	0327	0818	150	32	1.1	1.3	.159	75
$\mathbf{w}_{30}$	.4572	346.5	3730	53.1		2.19	0261	0776	150	36	1.0	1.3	.159	76
$w_{31}^{30}$	.4846	295.7	3183	52.4		2.26	0289	0836	159	42	.9	1.2	.155	77
w <sub>32</sub>	.4773	328.0	3531	48.1		2.62	0261	0819	144	38	.9	1.4	.163	78
w <sub>33</sub>	.5046	277.1	2983	46.8		2.74	0297	0900	154	46	.8	1.3	.159	79
w <sub>34</sub>	.5366	233.1	2509	47.8		2.87	0286	0940	171	59	.7	1.1	.150	80
W <sub>35</sub>	.5320	214.7	2311	45.3		2.71	0289	0949	163	57	.7	1.2	.155	81
W <sub>27</sub> (Mod)	.4773	328.4	3535	50.2	-7.0	2.31	0281	0804	150	41	.9	1.3	.183	82
W <sub>33</sub> (Mod		314.7	3387	46.8	-11.0	2.42	0280	0804	150	49	.8	1.3	.216	83

1	OVERALL CONFIGURATION			
1.	AREA - PLANFORM (SFT)			2999.4
	LENGTH, MUSE TO WING LE	AT BCDY		710.02 IN
	LENGTH NUSE TO WING C/4	.,,		903.27 IN
	ANGLE, GROUND PLANE		*FIXE	D* 17.00 DEG
2	FUSELA;E			
۷.	AKEA . WETTED		*FIXE	C* 6307.0 SFT
	LENGTH, NUSE TO END OF BO	Yטנ	*FIXE	C* 1315.0 IN
3.	w1 NG			
	AREA. THEORETICAL OR TOTA	4L		2228.1 SFT
	AREA . ELEVON			291.53 SFT
	SPAN			746.40 IN
	CHUR C. MEAN AERCDYNAMIC			510.88 IN
	CHORD, CENTERLINE ROOT			753.05 IN
	CHUR D. TIP			106.66 IN
	TAPER RATIO, THEORETICAL			.14163
	ASPECT RATIO, THEORETICAL			1.7364 1.5882
	ASPECT KATIC, EXPUSED SPA			59.598 DEG
	ANGLE, LEADING EDGE SWEER ANGLE, TRAILING EDGE SWEE		*E1YE	
	ANGLE, TRATEING EDGE SWEE	_r	*FIXE *FIXF	C* 7.0 DEG
	ANGLE, INCIDENCE		*FIXE	
	AIRFCIL SECTION, ROUT			C* 008-64
	AIRFOIL SECTION, TIP			C* 008-64
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
	URBITER LNUG (W/40K PL)	191590.2	70.881	04.084
	UKBITER LNDG (W/U PL)		73.208	66.863
	WING WEIGHT TPS WEIGHT	12493.5		
	IPS WEIGHT	22990.7		
خ <del>ز</del>	PRINCIPAL PARAMETERS		5.01	v 04444
	X-SC ALE FACTOR			X= .80000 Y= .80000
	Y-SCALE FACTOR	OF EVENCERA AL		F=710.023 IN
	DISTANCE TO LEADING EDGE	OF EXPUSED MI	NG AG	F=710.023 IN
6.	LANDING PERFERMANCE			
	AINI MUM LANGING SPEED ( .			203.5 KT
	STATIC MARGIN (SUBSONIC)			0843
	STATIC MARGIN (SUBSUNIC)		re1	0282
	TRIM LIFT COEF FOR LANDI	NO (ALPHA=I/ D	E61	.6134
7.	HYPERSUNIC AEROLYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG		58.59 DEG

1	UVERALL CONFIGURATION			
٨.	AREA, PLANFORM (SFT)			3321.0
	LENGTH, NOSE TO ALNO LE	AT BODY		648.44 IN
	LENGTH. NOSE TO WING C/4			890.00 IN
	ANGLE, GROUND PLANE		*F1XED*	17.00 DEG
	ANGLE: GROUND PLANE		TI TACO	1,100 020
2.	FUSELAGE			
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF BO	YUC	*FIXEC*	1315.0 IN
3.	WING			
-	AREA, THEORETICAL OR TOTAL	AL		2785.1 SFT
	AREA. ELEVON			364.42 SFT
	SPAN			746.40 IN
	CHURE. MEAN AERODYNAMIC			638.60 IN
	CHURD, CENTERLINE RUOT			941.31 IN
	CHORD. TIP			133.32 IN
	TAPER RATIO, THEURETICAL			.14163
	ASPECT KATIO, THEORETICAL			1.3891
	ASPECT RATIO, EXPOSED SPA			1.2705
	ANGLE. LEADING EUGE SWEET			65.207 DEG
	ANGLE. TRAILING EDGE SWE	FD	*FIXEC*	0.0 DEG
	ANGLE: DIHEDRAL	<b>-</b> '	*FIXED*	7.0 DEG
	ANGLE, INCILENCE		*FIXED*	
	AIRFUIL SECTION, KOOT			008-64
	AIRFUL SECTION, ROOT		*FIXFC*	
	AIRPUIL SECTION, TIP		VI INCL	1,700 0 1
4.	U40A MASS PROPERTIES			v 60 100 L
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	
	ORBITER ENDG (W/40K PL)		71.624	65.362
	URBITER LNDG (W/U PL)	154150.0	74.165	67.681
		12994.4		
	TPS WEIGHT	25049.5		
5.	PHINCIPAL PARAMETERS			
	X-SCALE FACTOR			: 1.0000
	Y-SCALE FACTOR			.80000
	DISTANCE TO LEADING EDGE	CF EXPOSED WI	NG XOF=	648.442 IN
6.	LANDING PERFICHMANCE			
	MINIMUM LANLING SPEED (W.	/40K PL )		203.3 KT
	STATIC MARGIN (SJUSGNIC)			0759
	STATIC MARGIN (SUBSUNIC)			0282
	TRIM LIFT CLEF FUR LANDI	NG (ALPHA=17 E	DEG)	.4980
7.	HYPERSONIC AERODYNAMIC TRIM	CATA		
. •	TRIM ANGLE OF ATTACK AT		,	45.35 DEG

1 111/15	ERALL CONFIGURATION			
1. 04	AREA, PLANFORM (SFT)			3642.6
	LENGTH. NUSE TO WING LE	AT BODY		594.36 IN
	LENGTH. NOSE TO WING C/4			884.23 IN
	ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
	ANGELY ONCOME TERME			
2. FU	SELAGE			(207 0 CET
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF B	ODY	*F [ X E D *	1315.0 IN
3. W1	NG			
J. "	AREA. THEORETICAL UR TOT	AL		3342.1 SFT
	AREA . ELEVUN			437.30 SFT
	SPAN			746.40 IN
	CHURE, MEAN AERODYNAMIC			766.32 IN
	CHURD, CENTERLINE ROUT			1129.6 IN
	CHURD. [IP			159.98 IN
	TAPER RATIO. THEORETICAL			.14163
	ASPECT RATIO, THEURETICA	L		1.1576
	ASPECT RATIC. EXPUSED SP	AN		1.0588
	ANGLE, LEADING EDGE SWEE			68.947 DEG
	ANGLE, TRAILING EDGE SWE		*FIXFC*	0.0 DEG
	ANGLE, DIHEURAL		*FIXEE*	
	ANGLE. INCIDENCE		*FIXEC*	1.5 DEG
	AIRFUIL SECTION, ROUT		*FIXEC*	008-64
	AIRECIL SECTION, TIP		*FIXED*	008-64
4. 04	UA MASS PROPERTIES			
7. 07	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC 1)
	UPBLITCH LNDG (W/40K PL)	196729-0	72.551	66.208
	UKBITER LNDG (W/J PL)	156729.0	75.286	68.704
	which we fight	13508.6		
	WING WEIGHT TPS WEIGHT	27114.4		
- 15	INCIPAL PARAMETERS			
5. PK	X-SCALE FACTOR		SCIX=	1.2000
				.80000
	Y-SCALE FACTOR DISTANCE TO LEADING EDGE	HE EVENSEN WI		594.360 IN
	DISTANCE TO LEADING EDGE	OF EXPUSED AT	701 -	3718300 IN
6 • LA	NOING PERFERMANCE			204 5 4 7
	MINIMUM LANCING SPEED (W			204.1 KT
	STATIC MARGIN (SUBSCNIC)			0721
	STATIC MAKGIN (SUBSUNIC)	(W/O PL)		0253
	TRIM LIFT CLEF FUR LANDI	NG (ALPHA=17 D	IEG)	.4172
7. HY	PERSONIC AEROCYNAMIC TRIM	LATA		
	TRIM ANGLE OF ATTACK AT		i	36.33 DFG

1.	OVERALL CONFIGURATION			
1.	AREA . PLANFORM (SFT)			3964.2
	LENGTH, NOSE TO WING LE	AT BCDY		546.17 IN
	LENGTH, NOSE TO WING C/4			884.35 IN
	ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
2.	FUSELAGE AREA: WETTEC		****	(207 D CCT
	LENGTH. NOSE TO END OF B	ר יו	*FIXEC* *FIXEO*	
	LENGTH NOSE TO END OF BO	691	TEIXEUT	1313.0 18
٥.	WING			
	AREA. THEORETICAL OR TOTAL	ÁL		3899.1 SFT
	AREA. ELEVON			510.18 SFT
	SPAIN			746.40 IN
	CHURD, MEAN AERCHYNAMIC			894.04 IN
	CHURU, CENTERLINE ROOT			1317.8 IN
	CHURD, TIP			186.65 IN
	TAPER RATIO. THEURETICAL ASPECT RATIO. THEURETICAL			.14163
	ASPECT RATIO, TREURETTCAL ASPECT RATIO, EXPOSED SF			• 99223 • 90753
	ANGLE, LEADING EDGE SWEET			71.740 DEG
	ANGLE: TRAILING EDGE SWEE		*FIXEC*	
	ANGLE TRATETAG EDGE SWEE	L r	*FIXED*	
	ANGLE, INCIDENCE		*FIXED*	
	AIRFOIL SECTION, KUUT			008-64
	AIRFCIL SECTION, TIP			008-64
4.	U40A MASS PROPERTIES			
			X-CG (FT)	
	UNBITER LNDG (W/40K PL)	199310.4		67.217
	ORBITER LNDG (W/U PL)		76.625	69.926
		14021.4		
	TPS WEIGHT	29183.0		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.4000
	Y-SCALE FACTOR		SCL Y=	.80000
	DISTANCE TO LEADING EDGE	CF EXPOSED WI	ING XUF=	546.165 IN
Ċ.	LANDING PERFORMANCE			
	MINIMUM LANDING SPEED (WA	/40K PL)		205.6 KT
	STATIC MARGIN (SUBSUNIC)	(h/40K PL)		0708
	STATIC MARGIN (SUBSUNIC)			0310
	TRIM LIFT COEF FOR LANDIN	NG (ALPHA=17 D	)EG)	.3572
7.	HYPERSUNIC AERULYNAMIC TRIM (	CATA		
	TRIM ANGLE OF ATTACK AT		ì	31.46 DEG
		· ·		

1.	OVERALL CONFIGURATION			
1.	AREA, PLANFORM (SFT)			4285.8
	LENGTH. NOSE TO WING LE	AT ACOV		500.27 IN
	LENGTH. NUSE TO WING C/4			886.77 IN
	ANGLE: GROUND PLANE		*FIXED*	
	ANGLE, GROUND PLANE		TELACUT	ITAGO DEG
2.	FUSELAGE			
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF BO	Yטנ	*FIXEC*	1315.0 IN
3.	WING			
	AREA. THEURETICAL OF TOTA	AL		4456.2 SFT
	AREA . ELEVON			583.07 SFT
	SPAN			746.40 IN
	CHURD, MEAN AERODYNAMIC			1021.8 IN
	CHURD, CENTERLINE RUDT			1506.1 IN
	CHORD. TIP			213.31 IN
	TAPER RATIO, THEORETICAL			.14163
	ASPECT RATIO. THEURETICAL			.86820
	ASPECT RATIC. EXPOSED SPA	-		.79409
	ANGLE. LEADING EDGE SWEET			73.896 DEG
	ANGLE. TRAILING EDGE SWEE		*FIXEC*	
	ANGLE. CIHECRAL	-'	*FIXEC*	
	ANGLE, INCIDENCE		*FIXEC*	
	AIRFCIL SECTION, ROUT			008-64
	AIRFOIL SECTION, TIP		*FIXEC*	
	AIN CIE SECTION TH		A TACO	000 01
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	
	ORBITER LNDG (W/40K PL)		74.906	68.358
	UKBLTER LNDG (W/U PL)	151884.8	78.136	71.305
	WING WEIGHT TPS WEIGHT	14524.8		
	TPS WEIGHT	31254.1		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.6000
	Y-SCALE FACTOR		SCLY=	.80000
	DISTANCE TO LEADING EDGE	CF EXPOSED WI	NG XOF=	500.272 IN
6 -	LANDING PERFERMANCE			
•	AINI MUM LANLING SPEED (WA	ANK PLI		206.9 KT
	STATIC MARGIN (SUBSUNIC)			0696
	STATIC MARGIN (SUBSUNIC)			0316
	TRIM LIFT COEF FOR LANDIN		FG)	•3125
	TRIM ETT COLL TOR EARDT	TO THE THE AT D		4 J L K J
7.	HYPERSONIC AEROCYNAMIC TRIM !	DAT A		
	TRIM ANGLE OF ATTACK AT E	ELEVEN=-45 DEG		28.85 DEG

1.	OVERALL CONFIGURATION			
	AREA. PLANFERM (SFT)			3321.0
	LENGTH, NOSE TO WING LE	AT BEDY		682.59 IN
	LENGTH. NESE TO WING C/4			893.22 IN
	ANGLE, GROUND PLANE		*FIXEC*	17.00 DEG
	ANGELY SHOOTS VEMILE			
2.	FU SEL AGE			
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF B	ODY	*FIXEC*	1315.0 IN
3.	WI NG			
	AREA, THEORETICAL OR TOT	AL		2524.7 SFT
	AREA . ELEVON	_		364.42 SFT
	SPAN			882.00 IN
	CHURD, MEAN AERODYNAMIC			487.70 IN
	CHURD, CENTERLINE ROUT			717.72 IN
	CHORD. TIP			106.66 IN
	TAPER RATIO, THEURETICAL			.14860
	ASPECT RATIO, THEURETICA	L		2.1398
	ASPECT KATIC, EXPUSED SP			1.9852
	ANGLE, LEAUING EDGE SHEE	Р		54.181 DEG
	ANGLE. TRAILING EDGE SWE	EP	*FIXEC*	0.0 DEG
	ANGLE, DIHECRAL		*FIXEC*	7.0 DEG
	ANGLE. INCIDENCE		*FIXEC*	1.5 DEG
	AIRFUIL SECTION, KOOT		*FIXEC*	008-64
	AIRECIL SECTION, TIP		*FIXEC*	008-64
4.	040A MASS PROPERTIES			
4.		METCHT LIBI	X-CG (FT)	Y-CC 10C 11
	OKBITER ENDC (W/40K PL)		70.967	64.763
	OKBITER ENDE (W/4 PL)		73.325	66.915
			13.329	00.717
		14260.4		
	TPS WEIGHT	24592.4		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR			.80000
	Y-SCALE FACTOR		SCLY=	1.0000
	DISTANCE TO LEADING EDGE	UE EXPOSED WI	NG XUF=	682.590 IN
ó.	LANDING PERFERMANCE			
	MINIMUM LANDING SPEED (W	/40K PL)		179.1 KT
	STATIC MARGIN (SUBSUNIC)			0870
	STATIC MARGIN (SUBSUNIC)			0290
	TRIM LIFT CEEF FOR LANDI		DEG)	.7111
-	LAND CONTROL OF AND AND THE	CATA		
1.	HYPERSONIC AERODYNAMIC TRIM			62 21 DEC
	TRIM ANGLE OF ATTACK AT	LLEVIN=-45 DEG	•	53.21 DEG

1	OVERALL CONFIGURATION			
1.	AREA . PLANFORM (SFT)			3723.0
	LENGTH, NOSE TO WING LE A	AT BCDY		620.68 IN
	LENGTH, NESE TO WING C/4			883.97 IN
	ANGLE. GROUND PLANE		*FIXEC*	17.00 DEG
	Ande Ey Grooms ve we			
2.	FUSELAGE		4514504	(207 0 CCT
	AREA. WETTED		*FIXED*	
	LENGTH, NOSE TO END OF EC	Υυ	*FIXEC*	1315.0 IN
3.	WING			
	AREA, THEORETICAL OR FOTA	AL		3155.8 SFT
	AREA, ELEVON			455.52 SFT
	SPAN			882.00 IN
	CHORD. MEAN AERCDYNAMIC			609.63 IN
	CHURD, CENTERLINE ROUT			857.14 IN
	CHORD, TIP			133.32 IN
	TAPER RATIO, THEURETICAL			-14860
	ASPECT KATIO, THEUKETICAL			1.7118
	ASPECT RATIC. EXPUSED SPA			1.5882
	ANGLE: LEADING EDGE SWEET			59.998 DEG
	ANGLE, TRAILING EUGE SWEI	EP .	*F[XEC*	
	ANGLE, CIHECRAL		*FIXEC*	
	ANGLE, INCICENCE			1.5 DEG
	AIRFUIL SECTION, ROOT			008-64
	AIRFOIL SECTION, TIP		*FIXFC*	008-64
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
	UKUITER LINDG (W/40K PL)	197850.1	71.748	65.475
	URBITER LNDG (W/U PL)	157850-1	74.260	67.768
	WING WEIGHT	14703.5		
	TPS WEIGHT	27040.6		
5.	PRINCIPAL PARAMETERS			
	X-SUALE FACTUR			1.0000
	Y-SCALE FACTUR			1.0000
	DISTANCE TO LEADING EDGE	GF EXPOSED WI	NG XOF=	620.678 IN
<b>6</b> •	LANDING PERFORMANCE			
	MINIMUM LANCING SPEED (W.			176.9 KT
	STATIC MARGIN (SUBSUNIC)			0770
	STATIC MARGIN (SUBSUNIC)			0275
	TAIM LIFT COEF FOR LANDI	NG (ALPHA=17 D	EG)	.5917
7.	HYPERSUATO AERODYNAMIO TRIM	UATA		
	TRIA ANGLE OF ATTACK AT	ELEV€N=-45 DEG		40.83 DEG

1.	OVERALE CONFIGURATION			
	ANEA. PLANFERM (SFT)			4125.0
	LENGTH. NOSE TO WING LE	AT BCDY		570.47 IN
	LENGTH. NUSE TO WING C/4			886.42 IN
	ANGLE: GROUND PLANE		*FIXEC*	17.00 DEG
	ANGE EV GROOMS TEAME			
2.	FUSELAGE		i e sue a.	(207.0.057
	AREA. WEITED			6307.0 SFT
	LENGTH, NUSE TO END OF B	Yטט	*FIXEC*	1315.0 IN
3.	WING			
	AREA, THEORETICAL OR TOT	AL		3787.0 SFT
	AREA, ÉLEVEN			546.63 SFT
	SPAN			882.00 IN
	CHURD, MEAN AERCDYNAMIC			731.55 IN
	CHORD, CENTERLINE ROOT			1076.6 IN
	CHURD. TIP			159.98 IN
	TAPER KATIO, THEURETICAL			·14860
	ASPECT RATIO, THEORETICA	L		1.4265
	ASPECT RATIO, EXPUSED SP			1.3235
	ANGLE, LEADING EDGE SWEE	P		64.305 DEG
	ANGLE, TRAILING EDGE SWE	ÉP	*F1XFC*	O.O DEG
	ANGLE. DIHEDRAL			
	ANGLE, INCIDENCE		*FIXEC* *FIXED*	1.5 DEG
	AIRFUIL SECTION, ROOT			008-64
	AIRFUIL SECTION, TIP			008-64
4.	U4UA MASS PROPERTIES		" CC (ET)	V 66 (D6 1)
			X-CG (FT)	X-CG IPC L)
	URBITER LADG (W/+UK PL)	200777.2	72.776	66.413
	OKBITER LNDG (W/J PL)	160777.2	75.498	68.898
	WING WEIGHT	15175.0		
	THS WEIGHT	29456.2		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTUR		SCL X=	1.2000
	Y-SCALE FACTUR			1.0000
	DISTANCE TO LEADING EDGE	UF EXPOSED 41	NG XÚF=	570.473 IN
b	LANDING PERFERMANCE			
•	MINIMUM LANDING SPEED (*	/40K PL)		177.5 KT
	STATIC MARGIN (SUBSUNIC)			0764
	STATIC MARGIN (SUBSUNIC)	(W/O PI)		0318
	THIM LIFT COEF FOR LANDI	NG (ΔΙ ΡΗΔ=17 Ι		• 4969
			- 14 tr <b>*</b>	-,
7.	HYPERSUNIC AERULYNAMIC TRIM	DATA		33 C7 DEC
	TRIM ANGLE OF ATTACK AT	こしとなし ロニーチターリヒし	,	32.97 DEG

1 -	UVERALL CUNFIGURATION			
	AREA . PLANFORM (SET)			4527.0
	LENGTH, NOSE TO WING LE	AT BCDY		518.90 IN
	LENGTH, NOSE TO AING C/4			887.50 IN
	ANGLE, GRUUND PLANE		*FIXED*	17.00 DEG
2.	FU SEL AGE			
	AREA. WETTED		*FIXEC*	
	LENGTH, NOSE TO END UF B	OCY	*F[xeD*	1315.0 IN
3.	wI NG			
	AREA, THEORETICAL UR TOT	AL		4418.1 SFT
	AREA, ELEVON			637.73 SFT
	SPAN Churl, mean Aerodynamic			882.00 IN
	CHUKC, CENTERLINE ROOT			853.48 IN 1256.0 IN
	CHURD, TIP			186.65 IN
	TAPER RATIO, THEURETICAL			.14860
	ASPECT RATIC, THEORETICA			1.2227
	ASPECT RATIC, EXPUSED SP			1.1344
	ANGLE, LEADING EDGE SHEE	ρ		67.588 DEG
	ANGLE: TRAILING EDGE SWE	EP	*F:[XF:[*	0.0 DEG
	ANGLE, DIHEDRAL		*FIXEC*	7.0 DEG
	ANGLE, INCIDENCE		*FIXEC*	
	AIRFCIL SECTION, ROOT			008-64
	AIRFCIL SECTION, TIP		*FIXED*	008-64
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	
	ORBITER LNDG (W/4UK PL)	203721.8		67.451
	URBITER LADG (W/J PL)	15659.4	76.864	70.144
	WING WEIGHT TPS WEIGHT	31950.4		
		3193014		
٥.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR			1.4000
	Y-SC ALE FACTOR		SCLY=	1.0000
	DISTANCE TO LEADING EDGE	OF EXPOSED WIT	NG XEF=	518.903 IN
6.	LANDING PERFERMANCE			
	MINIMUM LANCING SPEED ( )			177.5 KT
	STATIC MARGIN (SUBSUNIC)			0727
	STATIC MARGIN (SUBSONIC)		C ( )	0312
	TRIM LIFT COEF FUR LANDI		E61	•4323
7.	HYPERSUNIC AEROCYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVCN=-45 DEG		29.60 DEG

## ODIN Wing $w_{10}$

1.	OVERALL CONFIGURATION			
••	AREA, PLANFERM (SFT)			4929.0
	LENGTH, NOSE TO WING LE A	AT BCDY		472.06 IN
	LENGTH. ACSE TO WING C/4			893.31 IN
	ANGLE, GROUND PLANE		*FIXFC*	17.00 DEG
2.	FUSELAGE		1514551	(207 0 CET
	AREA, WETTED	224		6307.0 SFT
	LENGTH. NOSE TO END OF BO	ΙU <b>Y</b>	#F1XFU#	1315.0 IN
3.	WING			
	AREA, THEORETICAL OR TOTA	4L		5049.3 SFT
	AREA, ELEVON			728.84 SFT
	SPAIN			882.00 [N
	CHURE, MEAN AERODYNAMIC			975.40 IN
	CHORD, CENTERLINE ROOT			1435.4 IN
	CHURE, TIP			213.31 IN
	TAPER RATIO, THEORETICAL			.14860
	ASPECT RATIO, THEORETICAL			1.0699
	ASPECT RATIO, EXPUSED SPA			.99261
	ANGLE, LEADING EDGE SWEET			70.157 DEG
	ANGLE, TRAILING EUGE SWE	<u>-</u> P	*FIXEC*	0.0 DEG
	ANGLE, CIHEERAL		*FIXED*	0.0 DEG 7.0 DEG 1.5 DEG
	ANGLE, INCIDENCE		*FIXEC*	1.5 DEG
	AIRFOIL SECTION, ROUT			008-64
	AIRFOIL SECTION, TIP		*FIXEC*	008-64
4.	04 OA MASS PROPERTIES			
. •		WEIGHT (LB)	X-CG (FT)	X-CG (PC I)
	DURITED INDC /W/ANK DI 1	206672.3	75.231	68.654
	URBITER LNDG (W/J PL)	166612.3	78.446	71.588
	WING WEIGHT	16146.7 34419.6		
	WING WEIGHT TPS WEIGHT	34419.6		
5.	PRINCIPAL PARAMETERS			
•	X-SCALE FACTUR		SCL X=	1.6000
	Y-SCALE FACTOR		SCLY=	1.0000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI		
_	LANDING PERFERMANCE			
0.	<u></u>	/40K PL)		178.2 KT
	MINIMUM LANDING SPEED (W. STATIC MARGIN (SUBSCNIC)	(W/40K PL)		0712
	STATIC MARGIN (SUBSUNIC)			0317
	TRIM LIFT CLEF FUR LANDI	νι. (ΔΙ PHΔ=17 C	(FG)	.38C8
	TREM ETT CEET TOR EARD!	TO THE THE T	. L u f	
7.	HYPERSONIC AERCCYNAMIC TRIM	CATA		
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG	•	27.57 DEG

# ODIN Wing $w_{11}$

1	ONE CONTRACTOR AND ARTICLE			
1.	OVERALL CONFIGURATION  AREA, PLANFORM (SHT)			2442
	LENGTH, NUSE TO WING LE	AT BCDV		3642.6
	LENGTH, NOSE TO WING CA			667.15 IN
	ANGLE, GROUND PLANE	•	*FIXEC	889.36 IN
			TINED	* 17.00 DEG
2.	FUSELAGE .			
	AREA, WETTED		*FIXED:	* 6307.0 SFT
	LENGTH. NOSE TO END OF E	BUDY		* 1315.0 IN
3.	wl NG			
	AREA, THEORETICAL OR TOT	ľΔI		2829.6 SFT
	AMEA . ELEVON			437.30 SFT
	SFAN			1017.6 IN
	CHURL, MEAN AERCDYNAMIC			472.27 IN
	CHURL, CENTERLINE ROOT			694.16 IN
	CHOKO, TIP			106.66 IN
	TAPÉK KATIO, THEOKÉTICAL			•15365
	ASPECT RATIO, THEORETICA			2.5414
	ASPECT RATIO, EXPUSED SE	AN		2.3823
	ANGLE, LEADING EDGE SWEE			49.105 DEG
	ANGLE, TRAILING EDGE SWE	EP	*FIXEC*	
	ANGLE, CIMEDRAL		*FIXED*	7.0 DEG
	ANGLE, INCIDENCE		#FTXED#	
	AIRFOIL SECTION, KUUT		*FIXEC*	008-64
	AIRFOIL SECTION, TIP		*FIXEC*	008-64
4.	U4 0A MASS PROPERTIES			
		WEIGHT (LB)	Y-CC (FT)	X-CG (PC L)
	UKBITER LNDG (W/4UK PL)	198306.2		64.887
	ORBITER ENDS (W/U PL)	138306.2	73.446	67.025
	WING WEIGHT	15588.4	73.440	07.025
	WING WEIGHT TPS WEIGHT	20211.9		
<b>n</b> .	PRINCIPAL PARAMETERS			
•	X-SCALE FACTUR		CCLV	00000
	Y-SCALE FACTER			.80000
	DISTANCE TO LEADING EDGE	DE EVENCED MEN	_	1.2000
	STSTANGE TO EFACTIVE EDGE	OF EXPOSED WIN	NUF=	667.154 IN
<b>U</b> •	LANDING PERFORMANCE			
	MINIMUM LANDING SPEED (W	/40K PL)		160.7 KT
	STATIC MARGIN (SUBSONIC)	(W/40K PL)		0873
	STATIC MARGIN (SUBSENIC)	(W/O PL)		0278
	TRIM LIFT COEF FUR LANDI	NG (ALPHA=17 DE	6)	.8017
7.	HYPERSUNIC AEROCYNAMIC TRIM	ΓΛΤΛ		
. •	TRIM ANGLE OF ATTACK AT	ELEVIN=-45 DEC		46 43 DCC
	The second of th	CCC4CH= 42 0C0		48.43 DEG

### ODIN Wing $W_{12}$

	OVERALL CONFIGURATION			
1.	AREA, PLANFORM (SFT)			4125.0
	LENGTH, NOSE TO WING LE A	T BCDY		608.36 IN
	LENGTH, NOSE TO WING C/4			886.12 IN
	ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
	ANGLE ORGOND TEAME			
2.	FUSELAGE		AP 1 4 5 5 4	(207 0 SET
	AREA. WETTED			6307.0 SFT 1315.0 IN
	LENGTH, NOSE TO END OF BU	ACI	4F 1XEU7	1313.0 IN
3.	WING			
	AREA, THEORETICAL UK TOTA	ıL.		3537.0 SFT
	AREA. ELEVON			546.63 SFT
	SPAN			1017.6 IN
	CHURE, MEAN AERCOYNAMIC			590.33 IN
	CHURG. CENTERLINE ROOT			867.70 IN
	LHURD. TIP			133.32 IN
	TAPER RATIO, THEUKETICAL			.15365
	ASPECT RATIC, THEORETICAL			2.0331
	ASPECT RATIO, EXPUSED SPA	AN		1.9058
	ANGLE, LEADING EDGE SWEEP	•	4514554	55.283 DEG
	ANGLÉ, TRAILING EUGE SWEE	P	*FIXEC* *FIXEC*	0.0 DEG
	ANGLE, CIHECRAL			
	ANGLE, INCILENCE		*FIXED*	008-64
	AIRFOIL SECTION, ROOT			
	AIRFUIL SECTION, TIP		# F 1 X E U #	008-64
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)		
	ORBITER LNDG (W/40K PL)	201537.7		65.675
	UKBITER LADG (W/U PL)		74.476	67.565
	WING WEIGHT	16378+3		
	TPS WEIGHT	29053.4		
	PRINCIPAL PARAMETERS			
•	X-SCALE FACTUR			1.0000
	Y-SCALE FACTOR			1.2000
	DISTANCE TO LEADING EDGE	OF EXPOSED WIN	G XOF=	608.363 IN
6	LANDING PERFORMANCE			
•	MINIMUM LANDING SPEED (W	/40K PL)		158.0 KT
	STATIC MARGIN (SUBSCRIC)	(W/40K PL)		0798
	STATIC MARGIN (SUBSUNIC)	(W/G PL)		0288
	TRIM LIFT COEF FOR LANDI	NG (ALPHA=17 DE	G )	.6738
7.	HYPERSONIC AERODYNAMIC TRIM	CATA		
• •	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG		36.79 DEG
	• • • • • • • • • • • • • • • • • • • •	*		

### ODIN Wing $W_{13}$

1.	OVERALL CONFIGURATION			
	AREA, PLANFORM (SFT)			4607.4
	LENGTH, NUSE TO WING LE A	AT BCDA		557.64 IN
	LENGTH, NOSE TO WING C/4			890.95 IN
	ANGLE, GROUND PLANE		*FIXEC*	17.00 DEG
2.	FUSELAJE			
	AREA, WETTED		*FIXEC*	6307.0 SFT
	LENGTH. NOSE TO END OF BU	YOU	*F1XED*	1315.0 TN
3.	NI NG			
	AREA, THEORETICAL OR TOTA	AL .		4244.4 SFT
	AREA . ELEVON			655.95 SFT
	SPAN			1017.6 IN
	CHURC. MEAN AEREDYNAMIC			708.40 IN
	CHORD, CENTERLINE ROOT			1041.2 IN
	CHURD, TIP			159.98 IN
	TAPER RATIO, THEORETICAL			.15365
	ASPECT RATIC. THEURETICAL			1.6943
	ASPECT RATIO, EXPUSED SPA			1.5882
	ANGLE. LEADING EDGE SWEET			59.998 DEG
	ANGLE. TRAILING EDGE SWE	EP	*FIXEC*	0.0 DEG
	ANGLE, DIHECRAL		*FIXED*	7.0 DEG
	ANGLE. INCIDENCE		*FIXFC*	
	AIRFUIL SECTION, ROOT		*FIXFC*	008-64
	AIRFOIL SECTION. TIP		*FIXEC*	008-64
4.	U40A MASS PECPERTIES			
	FLIGHT CUNDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W/40K PL)	204814.6	73.055	66.668
	UNBITER LNDG (W/U PL)		75.779	69.154
	WING WEICHT	16804.9		
		31903.7		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.2000
	Y-SCALE FACTUR		SCLY=	1.2000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	ING XOF=	557.644 IN
٥.	LANDING PERFORMANCE			
	MINIMUM LANCING SPEED (W.			157.7 KT
	STATIC MARGIN (SUBSGNIC)	(W/40K PL)		0786
	STATIC MARGIN (SUBSONIC)	(W/O PL)		0324
	TRIM LIFT COLF FUR LANDI	NG (ALPHA=17 C	DEG)	.5733
7.	HYPERSUNIC AERODYNAMIC TRIM	CATA		
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG	•	30.86 DEG

# ODIN Wing $w_{14}$

1.	OVERALL CONFIGURATION			
	AREA, PLANFORM (SFT)			5089.8
	LENGTH, NESE TO WING LE	AT BCDY		505.20 IN
	LENGTH, NOSE TO WING C/4			894.06 IN
	ANGLE, GROUND PLANE		*FIXEC*	17.00 DEG
2.	FUSELAGE			
	AREA, WETTED		*FIXFD*	
	LENGTH, NOSE TO END OF B	ODY	*FIXEC*	1315.0 IN
3.	wlNG			
<b>J.</b>	AREA, THECKETICAL OR TOT	AL		4951.7 SFT
	AREA, ELEVON			765.28 SFT
	SPAN			1017.6 IN
	CHURD, MEAN AERODYNAMIC			826.47 IN
	CHURD, CENTERLINE ROOT			1214.8 IN
	CHURD, TIP			186.65 IN
	TAPER RATIO, THEORETICAL			.15365
	ASPECT RATIO, THEORETICA			1.4522
	ASPECT RATIO, EXPOSED SF			1.3613
	ANGLE. LEADING EDGE SWEE			63.669 DEG
	ANGLE, TRAILING EDGE SWE	EΡ	*FIXEC*	
	ANGLE, CIHECRAL		*FIXED*	
	ANGLE, INCILENCE		*FIXED*	
	AIRFOIL SECTION, RJOT		*FIXED*	
	AIRFOIL SECTION, TIP		*FIXED*	008-64
4.	040A MASS PROPERTIES			
		WEIGHT (LA)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W/40K PL)	208119.6	74.249	67.758
	UKBITER LNOG (W/U PL)		77.203	70.454
		17254.2		
	TPS WEIGHT	34759.4		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.4000
	Y-SCALE FACTOR		SCLY=	1.2000
	DISTANCE TO LEADING EDGE	OF EXPUSED WI	NG XCF=	505.200 IN
6 -	LANDING PERFERMANCE			
•	MINIMUM LANDING SPEED &	/ANK DIT		157.0 KT
	STATIC MARGIN (SUBSUNIC)			0741
	STATIC MARGIN (SUBSENIC)			0312
	TRIM LIFT CCEF FUR LANDI		EG)	.5037
				·
7.	HYPERSONIC AERODYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVEN=-45 DEG		28.33 DEG

### ODIN Wing $W_{15}$

1.	UVERALL CONFIGURATION			
	AREA, PLANFORM (SFT) LENGTH, NOSE TO WING LE	AT ACDY		5572.2
	LENGTH, NOSE TO WING C/4			457.88 IN
	ANGLE. GROUND PLANE		*FIXEO*	902.29 IN
	ANDERY ONDONO TEAME		TEIAEUT	17.00 DEG
2.	FUSELAGE			
	AREA, WEITED		*FIXEC*	6307.0 SFT
	LENGTH, NUSE TO END OF E	CDY	*FIXEC*	
3.	WING			
	AREA. THEORETICAL OR TOT	AL		5659.1 SFT
	AREA, ELEVON			874.60 SFT
	SPAN			1017.6 IN
	CHURE, MEAN AERCHYNAMIC			944.53 IN
	CHURD, CENTERLINE ROOT			1388.3 IN
	CHURD, TIP			213.31 IN
	TAPER RATIO. THEURETICAL			.15365
	ASPECT RATIO, THELKETICA	L		1.2707
	ASPECT RATIO, EXPUSED SP	AN		1.1911
	ANGLE, LEADING EUGE SWEE	•		66.585 DEG
	ANGLE, TRAILING EDGE SWE	EP	*FIXED*	0.0 DEG
	ANGLE, CIHETRAL		*FIXEC*	7.0 DEG
	ANGLE. INCIDENCE		*FIXEC*	1.5 DEG
	AIRFOIL SECTION, ROOT		*FIXEC*	
	AIRFUIL SECTION, TIP		*FIXEC*	008-64
4.	040A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LP)	X-CG (FT)	X-CG (PC L)
	UKBITER LINDG (W/40K PL)		75.64)	69.027
	OKBITER LAUG (W/J) PL1	171440-1	78.861	71.967
	wing weight	17715.5		
	FPS WELGHT	37618.6		
5.	PRINCIPAL PARAMETERS			
	X-SC ALE FACTOR		SCI Y=	1.6000
	Y-SCALE FACTUR			1.2000
	DISTANCE TO LEADING EUGE	OF EXPOSED AT		457.883 IN
_	LANDING PERFERMANCE			
٠.	HINIMUM LANDING SPEED (h	740K 01 1		163 3 45
	STATIC MARGIN (SUBSUNIC)			157.2 KT
	STATIC MARGIN (SUBSUNIC)			0725
	TRIM LIFT CUEF FUR LANDI		FC)	0316
	THE ETT COLL FOR EARDS	NO IMERNATION		• 4462
7.	HYPERSONIC AERODYNAMIC TRIM	CATA		
	TRIM ANGLE OF ATTACK AT	ELEVEN=-45 DEG		26.74 DEG

## ODIN Wing $w_{16}$

	UVERALL CONFIGURATION  AREA, PLANFLRM (SET)  LENGTH, ACSE TO WING C/4  ANGLE, GROUND PLANE  FUSELAGE  AREA, WETTED  LENGTH, ACSE TO END UF BC		*F1	XED*	3964.2 658.86 889.32 17.00 0	IN IN DEG
3.	WING  AREA, THEORETICAL OR TOTAL AREA, ELEVON SPAN CHURG, MEAN AERODYNAMIC CHURD, TIP TAPÉR RATIO, THEURETICAL ASPECT RATIC, THEORETICAL ASPECT RATIC, EXPOSED SPANGLE, LEADING EDGE SWEED ANGLE, TRAILING EDGE SWEED ANGLE, CIHECRAL ANGLE, INCICENCE AIRFOIL SECTION, ROUT AIRFUIL SECTION, TIP	. N	*FI *FI *FI		7.0	SFT IN IN IN DFG DEG DEG
4.	ORBITER LNDG (W/40K PL) ORBITER LNDG (W/U PL) WING WEIGHT		X-CG (FT) 71.277 73.614	6	(-CG (PC 55.046 57.179	L
٥.	PRINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  DISTANCE TO LEADING EDGE	GF EXPGSED WING	9	SCLX= . SCLY= I XCF=6!		N
6.	LANUING PERFERMANCE MINIMUM LANDING SPEED (W. STATIC MARGIN (SUBSENIC) STATIC MARGIN (SUBSENIC) TRIM LIFT COEF FUR LANDIN	(W/4OK PL) (W/O PL)		-	147.0 KT 0891 0283 .8772	
7.	HYPERSONIC AERODYNAMIC TRIM E TRIM ANGLE CF ATTACK AT E	CATA ELEVEN=-45 DEG		•	43.87 C	EG

# ODIN Wing $w_{17}$

1.	OVERALL CONFIGURATION			
•	AKEA . PLANFORM (SFT)			4527.0
	LENGTH. NOSE TO WING LE	AT BODY		600.61 IN
	LENGTH. NOSE TO WING C/4			888.69 IN
	ANGLE, GREUNE PLANE		*FIXEG*	
	ANGE EV GAGONS TEAME		TO TALLO.	Trace or G
2.	FUSELAGE			
	AKEA: WETTED		*FIXEO*	
	LENGTH. NOSE TO END UP BO	Ου <b>Υ</b>	*FIXEC*	1315.0 IN
3.	WING			
	AREA, THEURETICAL UR TUT	AL		3924.1 SFT
	AREA, ELEVON	· <del>-</del>		637.73 SFT
	SPAN			1153.2 IN
	CHUR D. MEAN AERCDYNAMIC			576.57 IN
	CHURC, CENTERLINE RUGT			846.67 IN
	CHORD. TIP			133.32 IN
	TAPER RATIO, THEURETICAL			.15746
	ASPECT KATIL, THEURETICAL	<b>\</b>		2.3535
	ASPECT RATIL, EXPUSED SP			2.2235
	ANGLE, LEADING EUGE SKEEP			51.050 DEG
	ANGLE: TRAILING EDGE SWEE		*FIXEC*	
	ANGLE: TRATEING EDGE SWEE	Er	*F[XEC*	**
	ANGLE: DIRECTAL ANGLE: INCIDENCE		*FIXEC*	
	AIRFOIL SECTION, ROOT			
	AIRFOIL SECTION, ROUT		*FIXEC* *FIXFC*	
	AIRPUIE SECTION, TIP		*FIXEL*	008-64
4.	040A MASS PROPERTIES			
			X-CG (FT)	X-CG (PC L)
	UKBITEK LNDG (W/40K PL)		72.199	65.887
	DABLITER LNCG (W/O PL)	165210.0	74.709	68.178
	WING WEIGHT	10023.7		
	TPS WEIGHT	31080.3		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.0000
	Y-SCALE FACTOR		SCLY=	1.4000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	NG XOF=	600.614 IN
<u>ت ـ</u>	LANDING PERFORMANCE			
	MINIMUM LANCING SPEED ( N.	/40K PL1		143.2 KT
	STALIC MARGIN (SUBSCNIC)	=		0800
	STATIC MARGIN (SUBSUNIC)	•		0277
	TAIM LIFT CLEF FUR LANDIN		eg)	•7534
	TAIN ETT GEET FOR EANDT	TO THEFTIA-17 D	LUI	• 1 > ) 7
7.	HYPERSONIC AERODYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT E	=LEVON=-45 DEG		34.12 DEG

### ODIN Wing $W_{18}$

	SUCCESS CONCRETEDA			
1.	OVERALL CONFIGURATION			5089.8
	AREA, PLANFERM (SFT)	AT DOOM		549.15 IN
	LENGTH, NUSE TO WING LE			
	LENGTH, NOSE TO WING C/4		4514504	854.84 IN
	ANGLE. GRUUND PLANE		*FIXEC*	17.00 DEG
2.	FUSELAGE			
	AREA, WETTED			6307.0 SFT
	LENGTH. NUSE TO END OF BO	ODY	*FIXEC*	1315.0 IN
3.	WLNG			
	AREA, THEORETICAL OR TOTA	AL		4708.9 SFT
	AREA, ELEVON			765.28 SFT
	SPAN			1153.2 IN
	CHURE, MEAN AERUDYNAMIC			691.88 IN
	CHURD, CENTERLINE ROOT			1016.0 IN
	CHURE, TIP			159.98 IN
	TAPER RATIO, THEORETICAL			.15746
	ASPECT RATIO, THEORETICAL	L		1.9612
	ASPECT RATIC, EXPUSED SF	AN		1.8529
	ANGLE. LEADING EDGE SWEET			56.035 DEG
	ANGLE. TRAILING EDGE SWEE		*FIXEC*	0.0 DEG
	ANGLE, CIMECRAL		*FIXEC*	7.0 DEG
	ANGLE, INCIDENCE		*FIXEC*	
	AIRFOIL SECTION, KJOT		*F1XE0*	008-64
	AIRFUIL SECTION, TIP		*FIXEC*	008-64 008-64
4.	040A MASS PREPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
	DRBITER LNDG (W/4UK PL)		73.343	66.931
	ORBITÉR LNUG (W/U PL)	168841.9	76.069	69.419
	WING WEIGHT	18408.3		
	TPS WEIGHT	34327.6		
5.	PRINCIPAL PAKAMETERS			
	A-SCALE FACTOR		SCL X=	
	Y-SCALE FACTOR			1.4000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	NG XOF=	549.145 IN
6.	LANUING PERFORMANCE			
	MININUM LANCING SPEED (W.	/40K PL)		142.1 KT
	STATIC MARGIN (SUBSUNIC)	(W/40K PL)		0779
	STATIL MARGIN (SUBSCRIC)	(W/O PL)		0306
	TRIM LIFT LOEF FUR LANDI	NG (ALPHA=17 C	DEG)	•6490
7.	HYPERSONIC AERODYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVEN=-45 DEG		29.53 DEG

# ODIN Wing $W_{19}$

1.	OVERALL CONFIGURATION			
-	AREA, PLANFERM (SET)			5652.6
	LENGTH, NOSE TO WING LE	AT BCDY		498.90 IN
	LENGTH. NUSE TO WING C/4			902.21 IN
	ANGLE, GROUND PLANE		*FIXEC*	17.00 DEG
2.	FUSELAGE			
	AKEA, WETTED		*FIXEC*	
	LENGTH. NOSE'TO END OF B	ODY	*FIXED*	1315.0 IN
3.	WING			
-	AREA, THEURETICAL OR TOT	Δ1		5493.7 SFT
	AREA, ELEVON			892.82 SFT
	SPAV			1153.2 IN
	CHURD, MEAN AERUDYNAMIC			807.19 IN
	CHURE, CENTERLINE ROOT			1185.3 IN
	CHUKU, TIP			186.65 IN
	TAPER RATIO. THEORETICAL			.15746
	ASPECE RATIO, THEORETICA	L		1.6811
	ASPECT KATIC, EXPUSED SP	AN		1.5882
	ANGLE, LEADING EUGE SWEET	P		59.998 DEG
	ANGLE, TRAILING EDGE SWE	<b>EP</b>	*FIXED*	0.0 DEG
	ANGLE, CIHECKAL		*FIXED*	7.0 DEG
	ANGLE: INCILENCE		*FIXED*	1.5 DEG
	AIRECIL SECTION, ROUT			008-64
	AIRFCIL SECTION, TIP		*FIXEC*	008-64
4.	U4UA MASS PROPERTIES			
•		WEIGHT (18)	x-CG (FT)	X-CG (PC L)
	URBITER LNDG (W/4UK PL)		74.636	68-111
	ORBITER ENDG (W/J PL)		77.605	70.820
		18821.4		
	ning neight TPS height	37581.2		
h	DE TAIL TO ALL D'ACAMET LE C			
٠,	PRINCIPAL PARAMETERS  X-SCALE FACTOR		SCI V-	1.4000
	Y-SCALE FACTOR			1.4000
	DISTANCE TO LEADING EDGE	HE EYBOCEN WI		498.903 IN
	DISTANCE TO ELADINO EDGE	Of EXPESSION AT	NO NO - 1	4:04:007 114
٥.	LANDING PERFERMANCE			
	MINIMUM LANCING SPEED (W	/+OK PL)		141.4 KT
	STATIC MARGIN (SUBSUNIC)	(W/40K PL)		0752
	STATIL MARGIN (SUBSUNIC)	(W/O PL)		0311
	TRIM LIFT CLEF FOR LANDID	NG (ALPHA=17 D	EG)	.5711
7.	HYPERSUNIC AEROCYNAMIC TRIM I	CATA		
	TRIM ANGLE OF ATTACK AT I			27.36 DEG

#### ODIN Wing $W_{20}$

,	OVERALL CONFIGURATION			
1.	AKEA, PLANFORM (SFT)			6215.4
	LENGTH, NOSE TO WING LE A	T RCDV		451.62 IN
	LENGTH, NUSE TO WING CLA	11 001/1		912.54 IN
			#EIYEC#	17.00 DEG
	ANGLE, GROUND PLANE		VI IACE	11100 010
2.	FUSELAGE			(202 0 CET
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF BO	DDY	*FIXEC*	1315.0 IN
3.	WING			
-	AREA, THEURETICAL UR TOTA	\L		6278.5 SFT
	AREA. ELEVUN			1020.4 SFT
	SPAN			1153.2 IN
	CHORD, MEAN AERODYNAMIC			922.51 IN
	CHURD. CENTERLINE ROCT			1354.7 IN
	CHOKC, TIP			213.31 IN
	TAPER RATIO. THEORETICAL			.15746
	ASPECT RATIC. THEURETICAL	_		1.4709
	ASPECT KATIO, EXPUSED SE	- AN		1.3897
	ANGLE, LEADING EUGE SWEET			63.196 DEG
	ANGLE. TRAILING EDGE SWEE	P	*FIXED*	0.0 DEG
	ANGLE, DIHECRAL	<del>,</del> ,	*FIXED*	7.0 DEG
	ANGLE, INCICENCE		*FIXEC*	1.5 DEG
	AIRFOIL SECTION, ROUT		*FIXEC*	008-64
	AIRFUL SECTION. TIP		*FIXEC*	008-64
	000000000000000000000000000000000000000			
4.	U40A MASS PROPERTIES	UE YOUT 1101	x-CG (FT)	Y-CC (DC 1)
			76.106	69.453
	ORBITER LNDG (W/40K PL)	210198.1	79.346	72.410
	URBITER LNDG (W/U PL)	1/01/01	77.340	120710
	W. 110 W. 11 2 0 1 1 1	19253.1		
	TPS WEIGHT	40839.0		
۶.	PRINCIPAL PARAMETERS		661	= 1.6000
	X-SCALE FACTOR			= 1.4000
	Y-SCALE FACTOR			= 1.4000 =451.616 [N
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	ING AUF	431.CIC IN
υ.	LANDING PERFORMANCE			1/1 / 47
	MINIMUM LANCING SPEED (W	/40K PL)		141.4 KT
	STATIC MARGIN (SUBSONIC)	(W/40K PL)		0735
	STATIC MARGIN (SUBSCNIC)	(W/O PL)		0314
	TRIM LIFT COEF FUR LANDI	NG (ALPHA=17 (	DEG)	.5086
7.	HYPERSONIC AERBEYNAMIC TRIM	CATA		
. •	TRIM ANGLE OF ATTACK AT	ELEVEN=-45 DEC	;	26.10 CEG
	· · · · · · · · · · · · · · · · · · ·			

## ODIN Wing $w_{21}$

1.	OVERALL CONFIGURATION AREA, PLANFORM (SFT)				4285.8	
	LENGTH. NOSE TO WING LE A	AT BODY			654.40	
	LENGTH, NOSE TO WING C/4				891.05	
	ANGLE, GROUND PLANE		:	*FIXEC*	17.00	DEG
2.	FUSELAGE			*E! AEU*	6307.0	SET
	AREA, WEITED	1 .W		*	1315.0	TAI
	LENGTH, NUSE TO END OF BO	101		******	131300	1 14
3.	dI NG					
	AREA, THEORETICAL OR TOTA	\L			3451.9	SFT
	AREA, ELEVON				583.07	
	SPAN				1288.8	
	CHORD, MEAN AERODYNAMIC				453.00	
	CHURD, CENTERLINE RUOT				664.72	
	CHURE, TIP				106.66	
	TAPER RATIO, THEORETICAL				.16045	
	ASPECT KATIC, THEURETICAL	-			3.3416	
	ASPECT RATIO, EXPUSED SPA	AN .			3.1764	
	ANGLE, LEADING EDGE SWEER				40.892	DEG
	ANGLE. TRAILING EDGE SWEE			*FIXEC* *FIXEC*	0.0	
	ANGLE, CIHEDRAL					DEG
	ANGLE, INCILENCE			*FIXFC*		DEG
	AIRFOIL SECTION, RUOT				008-64	
	AIRFUIL SECTION. TIP			*F [XEI)*	008-64	
,	U40A MASS PECPERTIES					
4.	FLIGHT CONDITION	WEIGHT (LB)	X-CG IF	T)	X-CG IPC	1.3
	ORBITER ENDG (W/40K PL)	WEIGHT (LB)	71.471	• •	65.223	. ,
	URBITER ENDS (W/40K PL)	164024 5			67.356	
		10476 Te J	13460)		01.330	
	WING WEIGHT IPS WEIGHT	19336.9 29481.6				
	IPS WEIGHT	29401.50				
5.	PKINCIPAL PARAMETERS					
	X-SCALE FACTOR				.80000	
	Y-SCALE FACTOR			SCLY=	1.6000	
	DISTANCE TO LEADING EDGE	CF EXPOSED WIN	iG	XCF=6	54.398 I	N
_	LANDING PERFERMANCE					
0.	MINIMUM LANCING SPEED (W.	/40K PL)			136.3 KT	
	STATIC MARGIN (SUBSGNIC)				0906	
	STATIC MARGIN (SUBSCNIC)				0287	
	TRIM LIFT COEF FUR LANDI	NG (ALPHA=17 DE	G )		9438	
	TATH ETT COEF FOR EAROT	10 TECTION TO IVE	•			
7.	HYPERSONIC AEROLYNAMIC TRIM					
	TRIM ANGLE LE ATTACK AT I	ELEVEN=-45 DEG			39.93 D	ŒG

## ODIN Wing $W_{22}$

1.	OVERALL CONFIGURATION					
	AKEA. PLANFORM (SET)				4929.0	
	LENGTH. NUSE TO WING LE	AT BCDY			558.27	IN
	LENGTH, NOSE TO WING C/4				894.09	IN
	ANGLE, GRUUND PLANE		*	FIXEC*	17.00	DEG
2.	FUSELAGE		.4.	EIVEDA	(207.0	
	AREA, WETTED				6307.0	
	LENGTH, NOSE TO END OF BU	אטר	*	FIXEC*	1315.0	1 N
3.	WING					
	AREA, THECRETICAL OR TOTAL	AL .			4314.9	
	AREA, ELEVON				728.84	SFT
	SPAN				1288.8	IN
	CHORU, MEAN AERUDYNAMIC				566.25	
	CHURE, CENTERLINE RUGT				830.89	
	CHORD. TIP				133.32	
	TAPÉR RATIO, THEURETICAL				.16045	
	ASPECT KATIC, THEURETICAL				2.6732	
	ASPECT' RATIO, EXPUSED SPA				2.5411	
	ANGLE, LEADING EDGE SWEET				47.268	
	ANGLE, THAILING EDGE SWE	EP	*	FIXEC*	0.0	
	ANGLE, DIHEDFAL		•	FIXEUT	7 • 0	DEG
	ANGLE. INCILENCE				1.5	
	AIRFUIL SECTION, ROUT				008-64	
	AIRECIL SECTION, TIP		*	FIXED*	008-64	
4.	040A MASS PREPERTIES					
	FLIGHT CENDITION	WEIGHT (LB)	X-CG (FT	1	X-CG (PC	( )
	UKBITËR LNDG (W/40K PL)	208864.9	72.478		66.141	
	UKBLIEK LNDG (W/U PL)	168864.9	74.999		68.442	
	wing weight	19642.3				
	TPS WELGHT	33116.7				
5.	PRINCIPAL PARAMETERS					
-	X-SCALE FACTUR			SCLX=	1.0000	
	Y-SCALE FACTOR			SCLY=	1.6000	
	DISTANCE TO LEADING EDGE	OF EXPOSED WIN	ıG	X0F=5	598.269 I	N
6-	LANDING PERFORMANCE					
••	MINIMUM LANCING SPEED (N.	/40K PL)			132.0 KT	
	STATIC MARGIN (SUBSUNIC)				0821	
	STATIC MARGIN (SUBSUNIC)				0287	
	TRIM LIFT COEF FOR LANDII		(G)		.8204	
7 -	HYPERSONIC AEROEYNAMIC TRIM	1) Δ <b>Τ Δ</b>				
. •	TRIM ANGLE OF ATTACK AT				31.79 D	F G
	INTH AROCE OF ATTACK AT	EEE 4614: 47 DEG			J	- **

### ODIN Wing $W_{23}$

1. UVERALL CCRFIGURATICN  AREA, PLANFORM (3FT)  LENGTH, MUSE TO WING C/4  ANGLE, GROUND PLANE  2. FUSELAGE  AREA, METTEL  LENGTH, NUSE TO END OF BUDY  3. WING  AREA, THEORETICAL OR TOTAL  AREA, ELEVOR  SPAN  CHURG, MEAN AERCOYNAMIC  CHURG, CENTERLING ROOT  CHURG, CENTERLING ROOT  ASPECT RATIC, THEORETICAL  ASPECT RAT		AVECALL CONSTCUENTICAL					
LENGTH, NOSE TO WING C/4  LENGTH, NOSE TO WING C/4  ANGLE, GROUND PLANE  2. FUSELAGE  AREA, WETTEL  LENGTH, NUSE TO END OF BUDY  3. WING  AREA, THEORETICAL UR TOTAL  AREA, ELEVOR  SPAN  CHUMD, MEAN AERCOYNAMIC  CHUMD, CENTERLINE ROOT  CHURC, TP  1APER RATIL, THEORETICAL  ASPECT RATIL, THEORET CAL  ANGLE, LEADING EDGE SHEEP  ANGLE, LINETRAL  ASPECT RATIL, THEORET CAL  AS	1.	ABEA DIAGETOM (SET)				5572.2	
LENGTH, NCSE TO WING C/4  ANGLE, GREUND PLANE  2. FUSELAGE  AREA, WETTEL LENGTH, NUSE TO END OF BUDY  3. WING  3. WING  AREA, THEORETICAL UR TOTAL AREA, ELEVON SPAN CHUR D. MEAN AERODYNAMIC CHUR D. CENTERLINE ROOT CHUR D. CENTERLINE ROOT CHUR D. TIP TAPER RATIO. THEORETICAL ASPECT RATIC. TREDRETICAL ASPECT RATIC. EAPOSED SPAN ANGLE. LEDING EDGE SHEEP ANGLE. THAILING EDGE SHEEP ANGLE. TRAILING EDGE SHEEP ANGLE. TO DEG ART CIL SECTION, TIP  4. OHOA MASS PHUPERTIES FLIGHT CONDITION DRBITER UNDO (W/40K PL) 212888.0 76.475 WING WEIGHT TPS WEIGHT TO SCLY= 1.0000 DISTANCE TG LEADING EDGE UF FXPCSED WING  6. LANDING PERFERMANCE MINIMOM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) THIM LIFT CCLEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA		AREA, PLANEURIN ISLIT	T REDV				
2. FUSELAGE     AREA, WETTEL     LENGTH, NUSE TO END OF BUDY  3. WING     AREA, THEORETICAL UR TOTAL     AREA, ELEVOR     SPAN     CHURCH, MASE TO END OF BUDY  3. WING     AREA, THEORETICAL UR TOTAL     AREA, ELEVOR     SPAN     CHURCH, MEAN AERODYNAMIC     CHURCH, TIP     IAPPER RATILL, THEORETICAL     ASPECT RATIC, EXPUSED SPAN     ARGEL, LEADING EDGE SHEEP     ANGLE, LEADING EDGE SHEEP     ANGLE, LEATING, ROUT     ARGUE, LEADING EDGE SHEEP     ANGLE, LINEIRAL     ARGUE, LEATING, ROUT     ARGUE, LEADING EDGE SHEEP     ANGLE, LINEIRAL     ARGUE, LINEIRA     ARGUE, LINEIRA     ARGUE, LINEIRA     ARGUE, LINEIRAL     ARG		LENGTH ACCUTO WING CAA	i, beni				
2. FUSELAGE  AREA. WETTEL  LENGTH, NUSE TO END OF BUDY  3. WING  AREA. THEORETICAL OR TOTAL  AREA. ELEVOR  SPAN  CHUR D. MEAN AERCOYNAMIC  CHUR D. MEAN AERCOYNAMIC  CHUR D. MEAN AERCOYNAMIC  CHUR D. TIP  IAPER RATIL., THEORETICAL  ASPECT RATIL., THEORET ASPECT RATIC.  ASPECT RATIL., THEORETICAL  ASPECT RATIL., THEORETICAL  ASPECT RATIL.				*£	TYED*		
AREA, WETTEL LENGTH, NUSE TO END OF BUDY  3. WING  AREA, THEORETICAL OR TOTAL AREA, ELEVGN SPAN CHURCH, MEAN AERCHYNAMIC CHURCH, TIP TAPER RATIU, THEORETICAL ASPECT RATIC, THEORET TO A CO. DEG ANGLE, LIMITING BUGE SWEEP ANGLE, THAILING BUGE SWEEP ANGLE, TRAILING BUGE SWEEP ANGLE, TRAILING BUGE SWEEP ANGLE, TRAILING BUGE SWEEP ANGLE, TRAILING BUGE SWEEP ANGLE, TOO DEG ANGLE, THEORET BUGE SWEEP ANGLE, THEOR		ANGLE, GROUND PLANE		71	I AT U"	17.00	71. 0
### 1315.0 IN  3. WING  AREA. THEORETICAL UR TOTAL AREA. ELEVOR  SPAN  CHUR D. MEAN AERCOYNAMIC  CHUK D. CENTERLINE ROOT  CHUK D. CENTERLINE ROOT  CHUK C. TIP  IAPER RATIO. THEORETICAL ASPECT RATIC. EXPUSED SPAN  ANOLE. LEADING EDGE SWEEP ANOLE. THAILLING EDGE SWEEP ANOLE. THAILLING EDGE SWEEP ANOLE. THAILLING EDGE SWEEP ANOLE. THAILLING EDGE SWEEP ANOLE. THEORETICAL AIR CIL SECTION. TIP  4. 040A MASS PHOPERTIES FLIGHT CUNDITION WEIGHT (LB) X-CG (FT) CRBITER LNDG (W/40K PL) 21288.0 73.773 67.278 CHAILTER LNDG (W/40K PL) 172878.0 76.475 CHAILTER LNDG (W/0K PL) 172878.0 TO THEORETICAL  CHUKH LANDING (W/0K PL) 172878.0 TO THEORETICAL  CHUKH	2.	FUSELAGE					^
3. WING  AREA, THEORETICAL UR TOTAL  AREA, CLEVON  SPAN  CHURC, MEAN AERCOYNAMIC  CHURC, MEAN AERCOYNAMIC  CHURC, TIP  IAPER RATIO, THEORETICAL  ASPECT KATIC, THEORETICAL  ASPECT KATIC, EXPUSEU SPAN  ANOLE, LEADING EDGE SWEEP  ANOLE, TRAILING EUGE SWEEP  ANOLE, TRAILING EUGE SWEEP  ANOLE, INCIDENCE  AIRFCIL SECTION, MUUT  AIRFCIL SECTION, MUUT  AIRFCIL SECTION, TIP  4. 040A MASS PHUPERTIES  FLIGHT CUNDITION  WEIGHT (LB)  WEIGHT (LB)  WEIGHT (LB)  WEIGHT (LB)  WEIGHT (LB)  SCLY= 1.2000  MING WEIGHT  JORGLEFA  A-SCALE FACTOR  Y-SCALE FACTOR  Y-SCALE FACTOR  MINI MUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSONIC)  SCLY= 1.6000  MOF-549.090 IN  7. HYPERSUNIC AERULYNAMIC TRIM DATA  7. HYPERSUNIC AERULYNAMIC TRIM DATA							
AREA, THEURETICAL UR TOTAL  AREA, ELEVON  SPAN  CHUK D. MEAN AERODYNAMIC  CHUR D. TIP  IAPER RATIC, THEURETICAL  ASPECT RATIC, THEURETICAL  ASPECT RATIC, TREUBETICAL  ASPECT RATIC, EXPUSED SPAN  ANGLE, LEADING EDGE SWEEP  ANGLE, THAILING EDGE SWEEP  ANGLE, THAILING EDGE SWEEP  ANGLE, LINEERAL  ANGLE, LINEERAL  ANGLE, LINEERAL  ANGLE, LINEERAL  ANGLE, THEURETICAN  ANGLE, CONTROL EDGE SWEEP  ANGLE, THEIR DEGE STATE  ANGLE, THEIR DEGE SWEEP  ANG		LENGTH, NUSE TO END OF BU	YOY	*F	I XED*	1315.0	I N
AREA, ELEVON  AREA, ELEVON  SPAN  CHUK D. MEAN AERODYNAMIC  CHORD. CENTERLINE ROUT  CHURD. TIP  IAPER RATIU, THEORETICAL  ASPECT RATIC. EXPUSED SPAN  ANGLE. LEADING EJGE SWEEP  ANGLE. THAILING EDGE SWEEP  ANGLE. THAILING EDGE SWEEP  ANGLE. INCIDENCE  AIRCIL SECTION, NOUT  AIRCIL SECTION, TIP  4. 040A MASS PHOPERTIES  FLIGHT CONDITION  URBITER LNDG (W/40K PL) 212858.0  TO ARTIC LNDG (W/40K PL) 172788.0  TO SCHOOL  THOSE PACED TO SCHOOL  AIRCIL SECTION  WING WEIGHT  19989.2  TO SWEIGHT  36762.6  5. LANDING PERFORMANCE  MINIMOV LANDING SUPED WING  MINIMOV LANDING SUPED WING  C. LANDING PERFORMANCE  MINIMOV LANDING SUPED (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  THIN LIFT CCEF FUN LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AEROLYNAMIC TRIM CATA	<b>3.</b>	WENG					
1288.8 IN   1288.8 IN   679.50 IN   679.		AREA, THEORETICAL OR TOTA	AF.				
CHUR D. MEAN AERCOYNAMIC  CHUR D. CENTERLINE ROOT  CHUR D. CENTERLINE  LIPERLINE CENTERLINE  ASPECT RATIC. FRANCE  ANGLE. CHADITIC EXPOSED SPARN  ANGLE. CHADITIC BEDGE SWEEP  ANGLE. THAILING EDGE SWEEP  ANGLE. THAILING EDGE SWEEP  ANGLE. THAILING EDGE SWEEP  ANGLE. CHACLENCE  AIRFULL SECTION, ROOT  AIRFULL SECTION, ROOT  AIRFULL SECTION, TIP  4. 040A MASS PHEPERTIES  FLIGHT CUNDITION  WEIGHT (LH) X-CG (FT) X-CG (PC L)  CHADITICR LNDG (W/O PL) 172F58.0 76.475 65.789  WING WEIGHT 19989.2  TPS WEIGHT 19989.2  TPS WEIGHT 36762.E  5. PHINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  Y-SCALE FACTOR  SCLX= 1.2000  SCLY= 1.6000  DISTANCE TO LEADING EDGE UF FXPCSED WING XOF=549.090 IN  6. LANDING PERFORMANCE  MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  STATIC MARGI		AREA. ELEVON					
CHURCH, TIP  CHURCH, TIP  LAPER RATIU, THEORETICAL  ASPECT RATIC, EXPUSED SPAN  ANDLE, LEADING EDGE SMEEP  ANDLE, LEADING EDGE SMEEP  ANDLE, LIMETRAL  ANDLE, LIMETRAL  ANDLE, LIMETRAL  ANDLE, LIMETRAL  ANDLE, INCILENCE  AIRFOLL SECTION, RUUT  AIRFOLL SECTION, RUUT  AIRFOLL SECTION, RUUT  WEIGHT (LB)  CRBITER LNDG (W/40K PL)  WING WEIGHT  JOBANAL TO LEADING EDGE UF FXPCSED WING  CLYSTANCE TO LEADING EDGE UF FXPCSED WING  CLANDING PERFERMANCE  MINIMUM LANLING SPEED (W/40K PL)  STATIC MARGIN (SJBSONIC) (W/40K PL)  STATIC MARGIN (SJBSONIC) (W/40K PL)  STATIC MARGIN (SJBSONIC) (W/40K PL)  TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA		SPAN					
CHUKD, CENTERLINE REGOT		CHURD, MEAN AERODYNAMIC					
CHUNC, TIP		CHURD. CENTERLINE ROOT					
IAPER RATIO, THEORETICAL   16045   1							
ASPECT RATIC, THEURETICAL  ASPECT RATIC, EXPUSED SPAN  ANGLE, LEADING EUGE SWEEP  ANGLE, THAILING EUGE SWEEP  ANGLE, LIHEERAL  ANGLE, LIHEERAL  ANGLE, INCICENCE  AIRHOIL SECTION, NOUT  AIRHOIL SECTION, TIP  4. 040A MASS PHOPERTIES  FLIGHT CONDITION  URBITER UNDG (W/40K PL) 212838.0 73.723 67.278  URBITER UNDG (W/40K PL) 172858.0 76.475 65.789  WING WEIGHT 19989.2  TPS WEIGHT 36762.8  5. PHINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  UISTANCE TO LEADING EDGE UF FXPCSED WING  6. LANDING PERFORMANCE  MINIMUM LANGING SPEED (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  THIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA						.16045	
ASPECT RATIC, EXPUSED SPAN ANGLE, LEADING EDGE SWEEP ANGLE, THAILING EDGE SWEEP ANGLE, THAILING EDGE SWEEP ANGLE, LIMETRAL ANGLE, INCICENCE ARGUE, SECTION, ROUT ARGUER SECTION, TIP  4. 040A MASS PHEPERTIES FLIGHT CUNDITION WEIGHT (LB) X-CG (FT) X-CG (PC L) URBITER LNDG (W/40K PL) 212858.0 73.723 67.278 URBITER LNDG (W/40K PL) 172858.0 76.475 65.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS X-SCALE FACTOR Y-SCALE FACTOR Y-SCALE FACTOR Y-SCALE FACTOR SCLY= 1.2000 SCLY= 1.6000 DISTANCE TO LEADING EDGE UF FXPCSED WING  5. LANDING PERFORMANCE MINIMUM LANGUING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) TTIM LIFT COEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA			=			2.2217	
ANGLE, LEADING EDGE SHEEP  ANGLE, THAILING EDGE SWEEP  ANGLE, CHEERAL ANGLE, INCICENCE  ANGLE, INCICENCE  ANGLE, INCICENCE  AIRFOIL SECTION, ROUT AIRFOIL SECTION, TIP  4. 040A MASS PHOPERTIES FLIGHT CONDITION  WEIGHT (LB) X-CG (FT) X-CG (PC L)  URBITER LNDG (M/40K PL) 212858.0 73.723 67.278  URBITER LNDG (M/9 PL) 172858.0 76.475 65.789  WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS  X-SCALE FACTOR Y-SCALE FACTOR UISTANCE TO LEADING EDGE UF FXPCSED WING  6. LANDING PERFORMANCE MINI MUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (M/40K PL) STATIC MARGIN (SUBSONIC) (M/40K PL) THIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA		ASPECT RATIC. EXPUSED SPA	AN			2.1176	
# NOLE, THAILING EDGE SWEEP ANOLE, CHEERAL ANOLE, CHEERAL ANOLE, CHEERAL ANOLE, INCIDENCE A		ANGLE. LEADING EDGE SHEEF	)			52.409	DEG
ANGLE, CHECRAL ANGLE, (NOTICENCE ANGLE, CHECK, NOTE ANGLE, CONTINE  WEIGHT (LB) X-CG (FT) X-CG (PC L) WEBITER LNDG (W/40K PL) 212858.0 73.723 67.278 UNGSTER LNDG (W/4) PL) 172858.0 76.475 65.789 WING WEIGHT 19989.2 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PHINCIPAL PARAMETERS X-SCALE FACTOR Y-SCALE FACTOR V-SCALE FACTOR V-CATOR		ANGLE. THAILING EDGE SHEE	ĒΡ	*F	IXEC*		DEG
ANGLE, INCIDENCE AIRHOIL SECTION, ROUT AIRHOIL SECTION, ROUT AIRHOIL SECTION, TIP  4. 040A MASS PHOPERTIES FLIGHT CONDITION WEIGHT (LB) X-CG (FT) X-CG (PC L) URBITER LNDG (W/40K PL) 212858.0 73.773 67.278 URBITER LNDG (W/0) PL) 172858.0 76.475 65.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS X-SCALE FACTOR Y-SCALE FACTOR UISTANCE TO LEADING EDGE OF FXPCSED WING XOF=549.090 IN  6. LANDING PERFORMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA		ANGLE. CIHETRAL		*F	IXEC*	7.0	DEG
AIRHCIL SECTION, ROUT AIRFOIL SECTION, TIP  4. 040A MASS PHOPERTIES FLIGHT CUNDITION WEIGHT (LB) X-CG (FT) X-CG (PC L) URBITER LNDG (W/40K PL) 212858.0 73.723 67.278 URBITER LNDG (W/40K PL) 172858.0 76.475 65.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS X-SCALE FACTOR Y-SCALE FACTOR UISTANCE TO LEADING EDGE OF EXPOSED WING XOF=549.090 IN  6. LANDING PERFORMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) THIM LIFT COEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSONIC AERULYNAMIC TRIM DATA		ANGLE. INCICENCE					
#FIXEC* 008-64  4. 040A MASS PHEPERTIES  FLIGHT CENDITION WEIGHT (LH) X-CG (FT) X-CG (PC L)  URBITER LNDG (W/40K PL) 212858.0 73.723 67.278  URBITER LNDG (W/40K PL) 172858.0 76.475 69.789  WING WEIGHT 19989.2  TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  UISTANCE TO LEADING EDGE OF EXPOSED WING XOF=549.090 IN  6. LANDING PERFORMANCE  MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  STATIC MARGIN (SUBSONIC) (W/40K PL)  TEIM LIFT COEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA				*F	IXEC*	008-64	
FLIGHT CUNDITION WEIGHT (LB) X-CG (FT) X-CG (PC L) URBITER LNDG (W/4UK PL) 212858.0 73.723 67.278 URBITER LNDG (W/4UK PL) 172858.0 76.475 69.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS X-SCALE FACTUR SCLY= 1.6000 DISTANCE TO LEADING EDGE UF FXPCSED WING XOF=549.090 IN  6. LANDING PERFERMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) TELM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA				*F	IXFC*	008-64	
FLIGHT CUNDITION WEIGHT (LB) X-CG (FT) X-CG (PC L) URBITER LNDG (W/4UK PL) 212858.0 73.723 67.278 URBITER LNDG (W/4UK PL) 172858.0 76.475 69.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS X-SCALE FACTUR SCLY= 1.6000 DISTANCE TO LEADING EDGE UF FXPCSED WING XOF=549.090 IN  6. LANDING PERFERMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) TELM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA	4.	040A MASS PROPERTIES					
URBITER LNDE (W/40K PL) 212858.0 73.773 67.278  ORBITER LNDE (W/0) PL) 172858.0 76.475 69.789  WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS  X-SCALE FACTOR SCLX= 1.2000 Y-SCALE FACTOR SCLY= 1.6000 DISTANCE TO LEADING EDGE UF FXPCSED WING XOF=549.090 IN  6. LANDING PERFERMANCE MINIMUM LANGING SPEED (W/40K PL) 130.6 KT STATIC MARGIN (SUBSONIC) (W/40K PL)0810 STATIC MARGIN (SUBSONIC) (W/40K PL)0324 THIM LIFT CCEF FUR LANDING (ALPHA=17 DEG) .7113	•••	FLIGHT CONDITION	WEIGHT (LR)	X-CG (FT)		X-CG (PC	L)
ORBITER ENDG (W/O PL) 172858.0 76.475 65.789 WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS  X-SCALE FACTOR Y-SCALE FACTOR OUTSTANCE TO LEADING EDGE UP PXPCSED WING SCLY= 1.2000 XOF=549.090 IN  6. LANDING PERFORMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSONIC) (W/40K PL) TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM CATA						67.278	
WING WEIGHT 19989.2 TPS WEIGHT 36762.8  5. PRINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  DISTANCE TO LEADING EDGE OF FXPCSED WING  6. LANDING PERFERMANCE  MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/40K PL)  TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPEKSUNIC AERULYNAMIC TRIM DATA		DRBLTER LNDG (W/B PL)	172858.0	76.415		69.789	
5. PRINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  DISTANCE TO LEADING EDGE OF FXPCSED WING  6. LANDING PERFERMANCE  MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/0 PL)  TELM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA		WING WEIGHT	19989.2				
X-SCALE FACTOR Y-SCALE FACTOR SCLX= 1.2000 SCLY= 1.6000 SCLY= 1.6000 XOF=549.090 IN  6. LANDING PERFERMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA		TPS WELGHT	36762.8				
X-SCALE FACTOR Y-SCALE FACTOR SCLX= 1.2000 SCLY= 1.6000 SCLY= 1.6000 XOF=549.090 IN  6. LANDING PERFERMANCE MINIMUM LANDING SPEED (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA	5.	PHINCIPAL PARAMETERS					
Y-SCALE FACTUR DISTANCE TO LEADING EDGE UF FXPCSED WING  6. LANDING PERFERMANCE MINIMUM LANDING SPEED (W/40K PL) STATIL MARGIN (SUBSUNIC) (W/40K PL) STATIC MARGIN (SUBSUNIC) (W/40K PL) TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIL TRIM DATA		X-SCALE FACTOR					
6. LANDING PERFERMANCE  MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/0 PL)  THIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA		Y-SCALE FACTOR					
MINIMUM LANDING SPEED (W/40K PL)  STATIL MARUIN (SUBSUNIC) (W/40K PL)  STATIC MARUIN (SUBSUNIC) (W/0 PL)  TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIL TRIM DATA		DISTANCE TO LEADING EDGE	UF EXPOSED WIN	G	X() F = 3	549.090 I	N
MINIMUM LANDING SPEED (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/40K PL)  STATIC MARGIN (SUBSUNIC) (W/0 PL)  TEIM LIFT CCEF FUR LANDING (ALPHA=17 DEG)  7. HYPERSUNIC AERULYNAMIC TRIM DATA	6.	LANDING PERFERMANCE					
STATIC MARGIN (SUBSCRIC) (N/O PL)0324 TELM LIFT CCEF FUR LANDING (ALPHA=17 DEG) .7113  7. HYPERSUNIC AERULYNAMIC TRIM DATA		MINIMUM LANGING SPEED (W	/40K PL)				•
TELM LIFT COME FUR LANDING (ALPHA=17 DEG) .7113  7. HYPERSUNIC AMERULYNAMIU TRIM DATA		STATIC MARGIN (SUBSUNIC)	(h/40K PL)				
7. HYPEKSUNIC AÉKULYNAMIL TRIM DATA		STATIC MARGIN (SUBSUNIC)	(W/O PL)				
7. HYPEKSUNIC AËKULYNAMIU TRIM DATA TRIM ANGLE OF ATFACK AT ELEVON=-45 DEG 28.05 DEG		TRIM LIFT COEF FUR LANDI	NG (ALPHA=17 DE	G)		.7113	
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG 28.05 DEG	7.	HYPEKSUNIC AERULYNAMIL TRIM	CATA				
		TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG			28 <b>.0</b> 5 D	EG

## ODIN Wing $W_{24}$

1.	OVERALL CUNFIGURATION					
	AREA. PLANEURM (SET)				6215.4	
	LENGTH, NOSE TO WING LE	AT ECDY			497.01	
	LENGTH, NOSE TO WING C/4				911.15	
	ANGLÉ. GROUND PLANE		*F I	XEC*	17.00	DEG
2.	FUSELAGE					
	AKEA . WETTED				6307.0	
	LENGTH. NOSE TO END OF BI	UDY	*+1	XEC*	1315.0	IN
١.	WING					
	AREA: THEORETICAL OR TOTA	AL			6040.8	SFT
	AREA, ELEVON				1020.4	SFT
	SPAN				1288.8	
	CHURE, MEAN AERODYNAMIC				792.75	IN
	CHORD, CENTERLINE ROUT				1163.3	ΙN
	CHÚR D. TIP				186.65	IN
	TAPER RATIO. THEUKETICAL				.16045	
	ASPECT RATIO. THEORETICAL				1.9095	
	ASPECT KATIC, EXPUSED SP	AN			1.8151	
	ANGLE, LEADING EDGE SWEEK	o c			56.580	DEG
	ANGLE, TRAILING EDGE SWEE	EΡ	<b>*F</b> ]	X E D#	0.0	DEG
	ANGLE: DIHEEKAL		<b>#</b> FI	XEC*	7. C	DEG
	ANGLE: INCIDENCE		*FI	XEC*	1.5	DEG
	AIRFCIL SECTION, ROOT				008-64	
	AIRFOIL SECTION, TIP		*FI	XEC*	008-64	
4.	040A MASS PROPERTIES					
	FLIGHT CENDITION	WEIGHT (LE)	X-CG (FT)	χ-	-CG (PC	()
	URBITER LNDG (W/+UK PL)		75.059	68	3.497	
		176889.8	78.050	7	1.226	
		20367.7				
		40416.0				
<b>5.</b>	PRINCIPAL PARAMETERS					
•	X-SCALE FACTUR		S	CLX= 1.	4000	
	Y-SCALE FACTOR			CLY= 1.		
	DISTANCE TO LEADING EDGE	CF EXPUSED WIN			7.008 1	N
6.	LANDING PERFERMANCE					
•	MINIMUM LANDING SPEED (W.	740K PL)		1 3	29.3 KT	
	STATIC MARGIN (SUBSUNIC)				.0762	
	STATIC MARGIN (SUBSUNIC)				.0310	
	TRIM LIFT COEF FUR LANDIN		G)		6343	
	TATA ETT COULTON EAROT	NO THILLM-IL OF	·	• `	,	
7.	HYPERSUNIC ALROCYNAMIC TRIM					
	TRIM ANGLE OF ATTACK AT I	ELEVEN=-45 DFG		26	5.57 D	Ŀ G

## ODIN Wing $W_{25}$

1.	OVERALL CONFIGURATION			
• •				6858.6
	AREA, PLANFORM (SFT) LENGTH, NOSE TO WING LE A	AT BODY		450.04 IN
	LENGTH. NOSE TO WING C/4			923.35 IN
	ANGLE, GROUND PLANE		*FIXEC*	17.00 DEG
	Andrew Verme			
2.	FUSELAGE			
	AREA. WETTED			6307.0 SFT
	LENGTH, NUSE TO END OF BO	YUU	*FIXEC*	1315.0 IN
3.	WING			
	AREA, THEORETICAL OR TOTAL	AL		6903.8 SFT
	AREA. ELEVON			1166.1 SFT
	SPAN			1288.8 IN
	CHORC, MEAN AERODYNAMIC	-		906.00 IN
	CHORD, CENTERLINE RUOT			1329.4 IN
	CHOOL 110			213.31 IN
	TAPER RATIO, THEORETICAL			.16045
	ASPECT RATIL, THEORETICAL			1.6708
	ASPECT RATIO, EXPUSED SPA	AN		1.5882
	ANGLE, LEADING EDGE SWEET	D		
	ANGLE, TRAILING EDGE SWE	EΡ	*F1XEC* *F1XEC*	0.0 DEG
	ANGLE, DIHECRAL		*FIXEC*	7.0 DEG
	ANGLE, INCIDENCE		*FIXEC*	7.0 DEG 1.5 DEG
	AIRFCIL SECTION, ROOT			008-64
	AIRFUIL SECTION, TIP		*FIXED*	008-64
4.	04 0A MASS PRUPERTIES			
			X-CG (FT)	
	DRBLIER LNDG (W/40K PL)	220949.2	76.612	69.514
	ORBITER LNDG (W/O PL)	180949-2	75.879	72.896
	WING WEIGHT	20769.3		
	WING WEIGHT TPS WEIGHT	44073.9		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR		SCL X=	1.6000
	Y-SCALE FACTUR		SCLY=	1.6000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	NG XOF=	450.039 IN
6.	LANDING PERFORMANCE			
•	MINIMUM LANGING SPEED (W.	/40K PL)		129.0 KT
	STATIC MARGIN (SUBSUNIC)			0745
				0312
	TRIM LIFT COEF FOR LANDI	NG (ALPHA=17 D	IFG)	.5678
	THE EXIT OF THE ENTER	is tractor at 0	- <del></del>	
7.	HYPERSONIC AERODYNAMIC TRIM			25 52 252
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG		25.58 DEG

## ODIN Wing $W_{26}$

	ERALL CONFIGURATION AREA. PLANFORM (SFT)			3702.9
	LENGTH, NOSE TO WING LE	AT BODY		642.36 IN
	LENGTH, NOSE TO WING C/4			886.42 IN
	ANGLE + GROUND PLANE		#FIXE	D* 17.00 DEG
• FU	SELAGE			
	AREA. WETTED		*FIXE	
	LENGTH NOSE TO END OF B	ODY	*FIXE	D# 1315.0 IN
. WI	NG			
	AREA. THEORETICAL OR TOT	AL		3010.9 SFT
	AREA. ELEVON			450.97 SFT
	SPAN			949.80 IN
	CHORD, MEAN AERODYNAMIC			539.19 IN
	CHORD CENTERLINE ROOT			792.98 IN
	CHORD. TIP			119.99 IN
	TAPER RATIO, THEORETICAL			.15131
	ASPECT RATIO, THEORETICA	L'		2.0807
	ASPECT RATIO, EXPOSED SP	AN		1.9411
	ANGLE . LEADING EDGE SWEE	P		54.790 DFG
	ANGLE + TRAILING EDGE SWE	<u>EP</u>	*FIXÉ	
	ANGLE + DIHEDRAL		#FIXE	
	ANGLE. INCIDENCE		#FIXE	
	AIRFOIL SECTION, ROOT		*FIXE	
	AIRFOIL SECTION, TIP		*FIXE	D* 008-64
. 04	DA MASS PROPERTIES			/ 06 /D6
	FLIGHT CONDITION	WEIGHT (L→)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W740K PL)	198158.8	71.412	65.169
	ORBITER LNDG (W/O PL)	158158.8	73.835	67.380
	WING WEIGHT	15331.4		
	TPS WEIGHT	26721.3		y
5. PR	RINCIPAL PARAMETERS		521	V = 0.0000
	X-SCALE FACTOR			X= •90000 Y= 1•1000
	Y-SCALE FACTOR	AF FVDACE. U		F=642.360 IN
	DISTANCE TO LEADING FDGE	UP EXPUSED W	LING AC	-045 - 200 IN
5. LA	NDING PERFORMANCE			147 4 7
	MINIMUM LANDING SPEED (W			167.6 KT
	STATIC MARGIN (SURSONIC)	(W/40K □L)		0817 0278
	STATIC MARGIN (SURSONIC)	(W/O PL)	)FET	
	TRIM LIFT COEF FOR LANDI	NO TALPHATI	JEU1	•6916
 7. нү	PERSONIC AERODYNAMIC TRIM	DATA		44.09 DEG

## ODIN Wing $W_{27}$

AREA. PLANFORM (SFT)		4064.7
LENGTH, NOSE TO WING LE AT	BODA	630.36 IN
LENGTH, NOSE TO WING C/4	. , , , , , , , , , , , , , , , , , , ,	885.34 IN
ANGLE + GROUND PLANE	#FIXE	
2. FUSEL AGE		
AREA. WETTED	*F IXE	D# 6307.0 SFT
ENGTH, NOSE TO END OF BOD		
TENOTIN NOOL TO END OF BOD	·	
3. WING		
AREA, THEORETICAL OR TOTAL	The second secon	3356.9 SFT
AREA, ELEVON		532.96 SFT
SPAN		1085.4 IN
CHORD. MEAN AERODYNAMIC	The second secon	524.63 IN
CHORD + CENTERLINE ROOT		770.74 IN
CHORN TIP		119.99 IN
TAPER RATIO, THEORETICAL		•15568
ASPECT RATIO, THEORETICAL		2.4371
ASPECT PATIO, EXPOSED SPAN	<u> </u>	2.2940
ANGLE LEADING EDGE SWEEP		50.172 DEG
ANGLES TRAILING EDGE SWEEP	*FIXE	
ANGLE DIHEDRAL	*FIXE	
ANGLE INCIDENCE	*FIXE	
AIRFOIL SECTION, ROOT AIRFOIL SECTION, TIP	#FIXE	
AIRPOIL SECTIONS ITP	#FIXE	008-64
4. 040A MASS PROPERTIES		
	EIGHT (La) X-CG (FT)	X-CG (PC L)
	01665.9 71.584	65.326
· · · · · · · · · · · · · · · · · · ·	73.996	67.527
,	7015.6	
	3544.3	
, S 7/21(///		
5. PRINCIPAL PARAMETERS		
X-SCALE FACTOR	5CL.	X= •90000
Y-SCALE FACTOR	SCL.	Y= 1.3000
NISTANCE TO LEADING EDGE OF		F=630.360 IN
C LAND-NC DEBROUNANCE		
6. LANDING PERFORMANCE	NP 50 \	
MINIMUM LANDING SPEED (W/4)		150.8 KT
STATIC MARGIN (SURSONIC)	(W/40K PL)	0806
STATIC MARGIN (SURSONIC)	(W/O PL)	0254
TRIM LIFT COEF FOR LANDING	(ALPHA=17 DEG)	•7799
7. HYPERSONIC AEBODYNAMIC TRIM DA	ΤΔ	
TRIM ANGLE OF ATTACK AT ELI		40 36 556
INTER ANGLE OF ATTACK AT ELI	- VUN45 UEU	40.36 DEG

## ODIN Wing $W_{28}$

1.	OVERALL CONFIGURATION			
	APEA. PLANFORM (SFT)		The second of the second of the second of	4426.5
	FENGTH. NOSE TO WING LE AT BUD	Y		626.27 IN
	I FNGTH . NOSE TO WING C/4			889.25 IN
	ANGLE . GROUND PLANE		*FIXED*	17.00 DEG
2.	FUSEL AGE			•
•	AREA. WETTED		#FIXED#	6307.0 SFT
	FENGTH. NOSE TO END OF BODY		#FIXED#	1315.0 IN
3.	M I NG			,
- •	AMEA. THEORETICAL OR TOTAL			3707.2 SFT
	ARÉA. ELEVON			614.95 SFT
-	SPAN	· · · · · · · ·		1221.0 IN
	CHORD. MEAN AERODYNAMIC			513.96 IN
	UHOBUT CFÜLEKFINE KOUL			754.43 IN
	CHORG• TIP			119.99 IN
	TAPEH_RATIO+ THEOMETICAL			•15904
	ASPECT PATIO, THEORETICAL			2.7927
	SPECT PATIO. EXPOSED SPAN			2.6470
	ANGLE + LEADING EDGE SWEEP			46.101 DEG
	ANGLE + TRAILING EDGE SWEEP		#FIXED#	0.0 DEG
	AMGLE . DIHEDRAL		#FIXED#	7.0 DEG
	AMGLE . INCIDENCE		#FIXED#	1.5 DEG
	ATREALL SECTION. ROOT		#FIXED#	
	ATREAL SECTION, TIP		#FIXED#	008-64
4.	643A MASS PROPERTIES			
	FLIGHT CONDITION WEIGH	iT (L∞)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W/40K PL) 20515	2.2	71.819	65.540
	NABITER LNDG (WZO PL) 16515	2.2	74.238	67.747
	aTNG WEIGHT 18668	4	• •	
	TPS .ETGHT 30377	• 7		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR			•90000
	Y-SCALE FACTOR			1.5000
	NISTANCE TO LEADING EDGE OF EX	POSEN WIN	G XUF=6	26.268 ÎN
6.	LANDING WERFORMANCE			
	MINIMUM LANDING SPEED (W/40K P	L)		138.7 KT
	STATIC MARGIN (SURSOMIC) (W/			0837
	STATIC MARGIN (SURSOMIC) (#/			0272
	THIM LIFT COEF FOR LANDING (AL	PHA=17 DE	G)	•8492
7.	HYPEUSONIC MEROBYNAMIC TRIM DATA			
	THIM ANGLE OF ATTACK AT ELEVON	I=-45 DEG		36.55 DEG

### ODIN Wing W<sub>29</sub>

1. OVERALL CONFIGURATION					
AREA, PLANFORM (SFT)				4587.3	
LENGTH, NOSE TO WING LE A	T BODY			580.70	IN
LENGTH, NOSE TO WING C/4				892.35	IN
LENGTH, NOSE TO WING LE A' LENGTH, NOSE TO WING C/4 ANGLE, GROUND PLANE				17.00	EG
2. FUSELAGE					
AREA. WETTED			*FIXED*	6307.0	SF T
AREA, WETTED LENGTH, NOSE TO END OF BO	DY		*FIXED*		IN
3. WING AREA. THEORETICAL OR TOTAL	1			4102.9	SET
AREA: ELEVON				651.40	
SPAN					
CHORD, MEAN AERCOYNAMIC CHORD, CENTERLINE ROOT				641.21	
CHORD, CENTERLINE ROOT				942.01	
CHCRD. TIP				146.65	
TAPER RATIO. THEORETICAL				.15568	
ASPECT RATIO, THEORETICAL					
ASPECT RATIO, THEORETICAL ASPECT RATIO, EXPOSED SPA	N			1.8769	
ANGLE. LEADING FORE SWEEP				55.692	DEG
ANGLE, LEADING EDGE SWEEP ANGLE, TRAILING EDGE SWEE	P	,	*FIXED*	0.0	DEG
ANGLE, DIHECRAL		-	*FIXED*	7.0	DEG
ANGLE. INCIDENCE					DEG
ANGLE, INCIDENCE AIRECIL SECTION, ROOT			*FIXED*	008-64	
AIRECIL SECTION, ROUT AIRECIL SECTION, TIP	e e e e e e e e e e e e e e e e e e e		*FIXED*	008-64	
A DADA WASS DOODSDITES					
4. 040A MASS PROPERTIES  FLIGHT CONDITION	UETCHT ALDS	v cc 11	· <b>T</b> )	X-CG (PC	
FLIGHT CONDITION	MEIGHT (FD)	7-00 tr			LI
ORBITEP LNDG (W/40K PL)	205097.8	72.652		66.301	
ORBITER LNDG (W/Q PL)	100091-8	15.214		68.693	
WING WEIGHT TPS WEIGHT	31588.8	******			
11 0 PC 2 0111					•
5. PRINCIPAL PARAMETERS					
X-SCALE FACTOR				1.1000	
Y-SCALE FACTOR			SCL Y=	1.3000	
DISTANCE TO LEADING EDGE	OF EXPOSED WING		X0F=5	80.704 IN	<u> </u>
6. LANDING PERFORMANCE					
MINIMUM LANCING SPEED (M/	40K P1 1		•	150.3 KT	
MINIMUM LANDING SPEED (W/ STATIC MARGIN (SUBSONIC)	(W/40K PL)			0818	
STATIC MARCIN (SUBSONIC)	(MAU DI)			- 0327	
TRIM LIFT COEF FOR LANDIN	G (ALPHA=17 DEG	)		.6537	
7. HYPERSCNIC AERODYNAMIC TRIM D					
TRIM ANGLE OF ATTACK AT E	LEVON=-45 DEG			31.84 DE	E G

#### ODIN Wing W<sub>30</sub>

<u> </u>	ERALL CONFIGURATION AREA, PLANFORM (SFT)			4326.0
	LENGTH, NOSE TO WING LE	AT BODY		601-69 IN
	LENGTH, NOSE TO WING C/4			885.01 IN
	ANGLE, GROUND PLANE		*FIXED	17.00 DEG
	ANGLET GROOMS TEAME	* *	*FIXED	
2. FI	SELAGE	•		
. = ! - ! - `	ADEA. WETTED		*FIXED	6307.0 SFT
	LENGTH, NOSE TO END OF B	ODY	*FI XED	* 1315.0 IN
3. W1	ING			
	AREA. THEORETICAL OR TOT	AL		3729.9 SFT
	ADEA. ELEVON			592.18 SFT
-	SPAN			1085.4 IN
	CHORD, MEAN AERCDYNAMIC			7.2.0
-	CHCRD, CENTERLINE ROOT			856.38 IN
	CHORD, TIP			133.32 IN
	TAPER RATIO, THEORETICAL			.15568
	ASPECT RATIO, THEORETICA			2.1934
	ASPECT RATIO, EXPOSED SP	ΔN		2.0646
	ANCIE LEACTNE EPCE SHEE	D		53.108 DEG
	ANGLE, LEADING EDGE SWEE ANGLE, TRAILING EDGE SWE ANGLE, DIHECRAL	r ED	*FT XFD	* 0.0 DEG
	ANGLE TRAILING EDGE SWE	EF	*FT YED	* 7-0 DEG
	ANGLE, DIHECRAL		*FIXED	* 1.5 DEG
	ANGLE, INCIDENCE		*E1 AED	* 008-64
	AIRECIL SECTION, ROOT			
	AIRFOIL SECTION, TIP		TELACO	7 000-07
	40A MASS PROPERTIES			
4. 0	FLIGHT CONDITION	WEIGHT (IR)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W/40K PL)	202275 0	72-052	65.753
	URBITER LNDG (W/40K PL)	142275 0	74.553	68.036
	ORBITER LNDG (W/O PL)	10001007	14.333	0000
	WING WEIGHT	17204.5		
	TPS WEIGHT	30065.4		
5 D	RINCIPAL PARAMETERS			
J. F	X-SCALE FACTOR		SCLX	= 1.0000
	W CCALE CACTOD		SCL Y	= 1.3000
	DISTANCE TO LEACING EDGE	OF EXPOSED WI	ING XOF	=601.694 IN
	DISTANCE TO LEACTING EDGE	OF EXPOSED W		
6. 1	ANDING PERFORMANCE			
00 -	MINIMUM LANCING SPEED (W	1/40K PL)		149.6 KT
	STATIC MARGIN (SUBSONIC)	(W/40K PL)		0776
	MINIMUM LANCING SPEED (W STATIC MARGIN (SUBSONIC) STATIC MARGIN (SUBSONIC)	(W/O PL)		0261
	TRIM LIFT COEF FOR LAND	ING (A) PHA=17	DEG )	.7195
	TRIM LIFT CLET TOR LAND.	THE THE AT		Lui⊤ wai≖ no
7. H	MPERSONIC AERODYNAMIC TRIM	DATA		
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG	G	35.82 DEG
	THE MITTER ST. P. L. HOIL M.	<del></del>		

## ODIN Wing $w_{31}$

1.	OVERALL CONFIGURATION AREA, PLANFORM (SFT) LENGTH, NOSE TO WING LE LENGTH, NOSE TO WING C/4 ANGLE, GROUND PLANE		*F1XE	3863.8 637.56 IN 887.54 IN 17.00 DEG
2.	FUSELAGE			
	AREA, WETTED LENGTH, NOSE TO END OF B	ODY		0* 63C7.0 SFT 0* 1315.0 IN
3.	AREA, THEORETICAL OR TOT AREA, ELEVON SPAN CHORD, MEAN AERODYNAMIC CHORD, CENTERLINE ROCT CHORD, TIP TAPER RATIO, THEORETICAL ASPECT RATIO, THEORETICAL ASPECT RATIO, EXPOSED SPANGLE, LEADING EDGE SWEE ANGLE, TRAILING EDGE SWE ANGLE, DIHEDRAL ANGLE, INCIDENCE AIRFOIL SECTION, ROOT	L An	*FIXE0 *FIXE0 *FIXE0 *FIXE0	1.0 0.0
	AIRFOIL SECTION, TIP		*F [ XE[	)* 00E-64
4.	O40A MASS PROPERTIES FLIGHT CONDITION OPBITER LNCG (W/40K PL) OPBITER LNCG (W/0 PL) WING WEIGHT TPS WEIGHT	199915.0 159915.0	X-CG (FT) 71.517 73.940	X-CG (PC L) 65.265 67.476
5.	PRINCIPAL PARAMETERS  X-SCALE FACTOR  Y-SCALE FACTOR  DISTANCE TO LEADING EDGE	OF EXPOSED WI		K= .900CC K= 1.20CO F=637.561 IN
6.	LANDING PERFORMANCE MINIMUM LANDING SPEED (W STATIC MARGIN (SUBSONIC) STATIC MARGIN (SUBSONIC) TPIM LIFT COEF FOR LANDI	(W/40K PL)	EG)	159.2 KT 0836 0289 .7314
7.	HYPERSONIC AERODYNAMIC TRIM TRIM ANGLE OF ATTACK AT			41.53 DEG

### ODIN Wing $W_{32}$

ODIN SUMMARY DATA. 040 A	PITCH.TRIM PROBLEM .90000 1.4000 52.322	CY	CLE 1 27/72
1. OVERALL CONFIGURATION AREA, PLANFORM (SFT)			4245.6
LENGTH, NOSE TO WING LE	AT BODY		627.66 IN
LENGTH, NOSE TO WING C/4		45 T V FD +	887.14 IN
ANGLE, GROUND PLANE		*FIXEU*	17.00 DEG
2. FUSELAGE	<del>-</del>		-
AREA, WETTED			6307.0 SFT
LENGTH. NOSE TO END OF BI	DDY	*FIXED*	1315.0 IN
2 NAMO			
3. WING AREA, THEORETICAL OR TOTAL	Δ (		3531.7 SFT
AREA, ELEVEN	• • • • • • • • • • • • • • • • • • •		573.96 SFT
SPAN			1153.2 IN
CHORD, MEAN AERODYNAMIC			518-S1 TN
CHORD, CENTERLINE ROCT			762.00 IN
CHOOS TIS	the state of the s		119.99 IN
TAPER RATIO, THEORETICAL			.15746
ASPECT RATIO, THEORETICAL	1		.15746 2.6150
ASPECT RATIC, EXPOSED SP			2.4705
ANGLE, LEADING EDGE SWEE	P '' '		48.U/1 DEG
ANGLE, TRAILING EDGE SWE	F P	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL		*FIXED*	7.0 DEG
ANGLE, INCIDENCE		*FIXED*	
AIRFOIL SECTION, ROOT		*FIXED*	008-64
AIRFOIL SECTION, TIP	• • • • • • • • • • • • • • • • • • •	*FIXED*	008-64
4 A4A4 W466 BBBBBBBBB			-
4. 040A MASS PROPERTIES FLIGHT CONDITION	WEIGHT (LB) X-CG	FT)	X-CG (PC 1)
DRBITER LNDG (W/40K PL)			65.430
ORBITER LNDG (W/O PL)			67.634
WING WEIGHT	17845.8		
TPS WEIGHT	29460.0		
(PS WEIGHT	<u> </u>		
5. PRINCIPAL PARAMETERS			00000
X-SCALE FACTOR		20FX=	.90000
Y-SCALE FACTOR		20L1=	1.4000
DISTANCE TO LEADING EDGE	DF EXPOSED WING	XUF=	627.864 IN
6. LANDING PERFORMANCE			
MINIMUN LANDING SPEED (W	/40K PL)		144.3 KT
STATIC MARGIN (SUBSONIC)			0819
STATIC MARGIN (SUBSONIC)			0261
TRIM LIFT COEF FOR LANDI			-8164
7. HYPERSONIC AERCDYNAMIC TRIM	DATA		
TRIM ANGLE OF ATTACK AT			38.33 DEG
INTH WHOLL OF WITHOU ME	7.1		100

## ODIN Wing $W_{33}$

1. 0	VERALL CONFIGURATION				-
	AREA. PLANFORM (SFT)				3803.4
	LENGTH, NOSE TO WING LE				663.70 IN
	LENGTH, NOSE TO WING C/4	•			890.35 IN
	ANGLE + GROUND PLANE			#FIXED#	17.00 DEG
2. FU	SELAGE				
	AREA, WETTED			*FIXED*	6307.0 SF1
	LENGTH, NOSE TO END OF E	RODY		*FIXED#	, ,
3. WI	NG				
	AREA, THEORETICAL OR TOT	AL			2984.0 SF1
	AREA. ELEVON				473.74 SFT
	SPAN				1085.4 IN
	CHORD, MEAN AERODYNAMIC				466.34 IN
	CHORD, CENTERLINE ROOT				685.10 IN
	CHORD, TIP				106.66 IN
	TAPER RATIO, THEORETICAL				.15568
	ASPECT RATIO, THEORETICA				2.7417
	ASPECT RATIO, EXPOSED SP				2.5808
	ANGLE + LEADING EDGE SWEE				46.825 DEG
	ANGLE + TRAILING ENGE SWE	EP		#FIXED#	0.0 DFG
	ANGLE DIHEDRAL			#FIXED#	7.0 DEG
	ANGLE INCIDENCE			*FIXED*	1.5 DFG
	AIRFOIL SECTION, ROOT			#FIXED#	008-64
~	AIRFOIL SECTION, TIP			*FIXED*	008-64
4. 04	OA MASS PROPERTIES				
	FLIGHT CONDITION	WEIGHT (La)	X-CG (	7)	X-CG (PC L)
	ORBITER LNDG (W/40K PL)	199970.6	71.202		64.977
	ORBITER LNDG (W/O PL)	159970.6	73.545		67.115
	WING WEIGHT	16838.4			1984
	TPS WEIGHT	27026.2			
5. PR	INCIPAL PARAMETERS		194	<del></del>	
	X-SCALE FACTOR			SCL X=	.80000
	Y-SCALE FACTOR				1.3000
	DISTANCE TO LEADING EDGE	OF EXPOSED WIN	G		63.696 IN
6. LA	NDING PERFORMANCE				
	MINIMUM LANDING SPEED (W.	/40K PL)			153.8 KT
	STATIC MARGIN (SURSONIC)	(W/40K DI)			0900
	STATIC MARGIN (SURSONIC)	(W/O PL)			0297
	TRIM LIFT COEF FOR LANDII	NG (ALPHA=17 DEC	3)		•8366
7. HYF	PERSONIC AEBODYNAMIC TRIM (	DATA			
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG			45.66 DEG

## ODIN Wing $W_{27}$ (Modified)

1. OVERALL CONFIGURATION			
AREA, PLANFORM (SFT)			4182.2
LENGTH, NOSE TO WING LE A	T BODY		628.13 IN
LENGTH, NOSE TO WING C/4			889.39 IN
ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
Allocation and the second seco			
2. FUSELAGE		10 TUED 4	(207 0 CET
AREA, WETTED			6307.0 SFT
LENGTH, NOSE TO END OF BO	IDY	#F1XED#	1315.0 IN
3. WING		and the second second second second second	
AREA, THEORETICAL OR TOTAL	\L		3535.1 SFT
AREA. ELEVON			646.66 SFT
SPAN			1085.4 IN
CHORD, MEAN AERODYNAMIC		•	555.61 IN
CHORD. CENTERLINE ROOT			818.02 IN
			119.99 IN
TAPER RATIO. THEORETICAL			.14668
CHORD, TIP TAPER RATIO, THEORETICAL ASPECT RATIO, THEORETICAL	_		2.3143
ASPECT RATIO, EXPOSED SPA			2.1747
ANGLE, LEADING EDGE SWEER	)		50.172 DEG
ANGLE, TRAILING EDGE SWEI	FΡ	_	-7.0 DEG
ANGLE, DIHEDRAL		*FIXED*	7.0 DEG
ANGLE, INCIDENCE		*F I XED*	1.5 DEG
AIRFOIL SECTION, ROOT		*FIXED*	008-64
AIRFUIL SECTION, TIP		*FIXED*	008-64
•			
4. U4UA MASS PROPERTIES		V CC 15T1	V.CC (DC 1)
FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC.CI
ORBITER LNDG (W/40K PL)	201478.4	71.606	65.346
URBITER LNOG (W/O PL)	161478.4	14-021	67.555
WING WEIGHT TPS WEIGHT	16828.1		
TPS WEIGHT	28544.3		
5. PRINCIPAL PARAMETERS			
X-SCALE FACTOR			• .90000
Y-SCALE FACTOR			1.3000
DISTANCE TO LEADING EDGE	UF EXPOSED WI	ING XOF:	=628.134 IN
6. LANDING PERFORMANCE			
MINIMUM LANDING SPEED (W	/40K PL)		150.0 KT
STATIC MARGIN (SUBSUNIC)	(W/40K PL)		0804
STATIC MARGIN (SUBSONIC)	(W/O PL)		0281
TRIM LIFT COEF FOR LANDI	NG (ALPHA=17	DEG)	.7480
7. HYPERSONIC AERODYNAMIC TRIM	DATA		
TRIM ANGLE OF ATTACK AT	ELEVUN=-45 DE	<b>G</b>	40.81 DEG

## APPENDIX - Concluded

# ODIN Wing $W_{33}$ (Modified)

1. OVERALL CONFIGURATION		4069.3
		651.70 IN
LENGTH NOSE TO MING LE AL DOG.		892.80 IN
LENCTH NOSE IN WING CAT	*FIXED*	17.00 DEG
ANGLE. GROUND PLANE		
AITOLL 7		
2. FUSELAGE	*FIXED*	6307.0 SFT
	*FIXED*	1315.0 IN
LENGTH, NOSE TO END OF BODY		
THE WINC		3387.1 SFT
AREA, THEORETICAL OR TOTAL		731.03 SFT
AREA, ELEVON		1085.4 IN
COAN		536.52 IN
CHORD, MEAN AERCDYNAMIC		792.09 IN
CHORD, CENTERLINE ROOT		106.66 IN
CHORD, CENTERLINE ROOT	and there are part to the contract of	. 13465
CHORD, TIP TAPER RATIO, THEORETICAL		2.4154
ASPECT RATIO, THEORETICAL		2.2896
ASPECT RATIO, EXPOSED SPAN		46.825 DEG
ASPECT RATIO, EXCESSED ANGLE, LEADING EDGE SWEEP		-11.0 DEG
ANGLE, TRAILING EDGE SWEEP	#ETVEN#	7.0 DEG
ANGLE. DIHEDRAL	*FIXED*	7.0 DEG 1.5 DEG
ANGLE, DIHEDRAL	*FIXEU*	008-64
ANGLE, INCIDENCE	*F1XEU*	008-64
AIRFUIL SECTION, ROOT	*F1 XEU+	000 01
AIRFOIL SECTION, TIP		
4. 040A MASS PROPERTIES WEIGHT (LB) X-0	G (FT)	X-CG (PC L)
FLIGHT CONDITION WEIGHT LEDY		
CORTTER INDO (W/40K /L)	523	67.096
	,,_,	
10410.0		
TPS WEIGHT 27026.2		
5. PRINCIPAL PARAMETERS	SCLX=	.80000
X-SCALE FACTOR	SCLY=	: 1.3000
Y-SCALE FACTOR	XOF =	651.696 IN
Y-SCALE FACTOR DISTANCE TO LEADING EDGE OF EXPOSED WING	,	
TO STORY MANUSE		149.9 KT
6. LANDING PERFURMANCE MINIMUM LANDING SPEED (W/40K PL)	grammers of the second second	0804
MINIMUM LANDING SPEED TO WAY ON PL) STATIC MARGIN (SUBSONIC) (W/40K PL)		0280
STATIC MARGIN (SUBSONIC) (M/O PL) STATIC MARGIN (SUBSONIC) (A/O PL)		.1742
STATIC MARGIN (SUBSURIE) TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)		• • • • •
TOTAL DATA		48.90 DEG
7. HYPERSONIC AERODYNAMIC TRIM DATA TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG		40.00

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### ODIN Wing $W_{33}$

	REA. PLANFORM (SFT)		3803.4
<u> </u>	ENGTH, NOSE TO WING LE AT BODY		663.70 IN
	ENGTH, NOSE TO WING C/4		890.35 IN
14	NGLF. GROUND PLANE	#FIXED#	17.00 DEG
2. FUSEL	AGE		
	REA, WETTED	*FIXED*	6307.0 SF
LE	ENGTH, NOSE TO END OF BODY	*FIXED*	
3. WING			
	REA, THEORETICAL OR TOTAL		2984.0 SF
	REA, ELEVON		473.74 SF
SF	PAN		1085.4 IN
C <sub>F</sub>	HORD, MEAN AERODYNAMIC		466.34 IN
	HORD + CENTERLINE ROOT		685.10 IN
	IORD, TIP		106.66 IN
	APER RATIO, THEORETICAL		.15568
	SPECT RATIO, THEORETICAL		2.7417
	SPECT RATIO, EXPOSED SPAN		2.5808
	NGLE + LEADING EDGE SWEEP		46.825 DE
	NGLE + TRAILING ENGE SWEEP	#FIXED#	0.0 DE
	IGLE + DIMEDRAL	#FIXED#	7.0 DE
	IGLF INCIDENCE	#FIXED#	1.5 DF
	REFOIL SECTION, ROOT	#FIXED#	008-64
Δ Ι	REFOIL SECTION, TIP	#FIXED#	008-64
	ASS PROPERTIES		* * *
		(FT)	X-CG (PC L)
	RBITER LNDG (W/40K PL) 199970.6 71.2		64.977
	BITER LNDG (W/O PL) 159970.6 73.5	45	67.115
	NG WEIGHT 16838.4		
TP	S WEIGHT 27026.2		
	PAL PARAMETERS		
	SCALE FACTOR	SCLX=	.80000
	SCALE FACTOR	SCLY=	1.3000
<u>n I</u>	STANCE TO LEADING EDGE OF EXPOSED WING	XOF=6	63.696 IN
	G PERFORMANCE		
MI	NIMUM LANDING SPEED (W/40K PL)		153.8 KT
ST	ATIC MARGIN (SURSONIC) (W/40K DL)		0900
<u>SI</u>	ATIC MARGIN (SURSONIC) (W/O PL)		0297
TR.	IM LIFT COEF FOR LANDING (ALPHA=17 DEG)		•8366
. HYPERS	ONIC AEBODYNAMIC TRIM DATA		
TR	IM ANGLE OF ATTACK AT ELEVON=-45 DEG		45.66 NEG

### ODIN Wing $W_{34}$

	OVER ALL CONFICER ATTON			
1 •	OVEFALL CONFIGURATION AREA, PLANFORM (SFT)			3260.7
	LENGTH, NOSE TO WING LE A	T ROLY		706.16 IN
	LENGTH, NOSE TO WING C/4	. 5001		895.99 IN
	ANGLE, GROUNE PLANE		*FIXED*	17.00 DEG
	ANGLE, GROUNT FLANC			
2.	FUSELAGE		+E ! VED +	63C7.0 SFT
	AREA, WETTED	5.v	*FIXEU*	1315.0 IN
	LENGTH, NOSE TO END CF BO	UY	+FIXEU+	131340 IN
3.	WING			22/1 9 557
	AREA, THEORETICAL CR TOTA	L		2341.8 SFT 350.75 SFT
	AREA, ELEVON			949.80 IN
	SPAN			419.37 IN
	CHCRD, MEAN AERODYNAMIC			616.76 IN
	CHERD, CENTERLINE ROOT			93.324 IN
	CHORD, TIP			.15131
	TAPER RATIC. THEORETICAL			2.6752
	ASPECT RATIO, THEORETICAL	, At		2.4957
	ASPECT RATIO, EXPOSED SPA	1 <b>17</b> 1		47.782 DEG
	ANGLE, LEACING EDGE SWEEP ANGLE, TRAILING EDGE SWEE	:D	*FIXED*	
		; <b>r</b>	*FIXED*	
	ANGLE, DIHEDRAL ANGLE, INCIDENCE		*FIXED*	1.5 DEG
	AIRFOIL SECTION, ROOT		*FIXED*	0CE-64
	AIRFOIL SECTION, TIP		*FIXED*	008-64
	AINTOIL SECTION, VI			
4.	C40A MASS PROPERTIES			
			X-CG (FT)	X-66 (P6 E7
	CRBITER LNDG (W/40K PL)	195128.5	70.687 72.970	64.5C1
	ORBITER LNDG (W/O PL) WING WEIGHT	155128.5	72.970	00. 7.1
	WING WEIGHT TPS WEIGHT	14939.0		
	TPS WEIGHT	24082.0		
5.	PRINCIPAL PARAMETERS		CC1 V-	70000
	X-SCALE FACTOR			.70000
	Y-SCALE FACTER			: 1.1000 :706.163 IN
	DISTANCE TO LEADING EDGE	CH EXPOSED WIN	IG XUF=	108.103 IN
6.	LANDING PERFCREANCE			171 / 47
	MINIMUM LANDING SPEED (N	/40K FL)		171.4 KT 0940
	STATIC MARGIN (SUBSONIC)	(W/4CK PL)		0286
	SIAIIL MARGIN LOUDOUNIU/	1876 167		U286 .838C
	TRIM LIFT COEF FOR LANDI	NG (ALPHA=I/ DI	: G <i>1</i>	• 03 0 0
7 .	HYPERSONIC AERODYNAMIC TRIM	CATA		44
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG		59.1C DEG

### ODIN Wing $W_{35}$

1	OVERALL CONFIGURATION			
1.	AREA, PLANFORM (SFT)			3401.4
	LENGTH, NOSE TO WING LE	AT BCCY		699-20 IN
	LENGTH, NOSE TO WING C/4			893.63 IN
	ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
	ANGELY GREENS TERMS			
2.	FUSELAGE AREA, WETTED		*FIXED:	6307.0 SFT
	LENGTH, NOSE TO END OF BO	עתר		1315.0 IN
	LENGIP, NUSE TO END CF BO	301	TI I ALD	131200 11
3.	WING	<b>A</b> 1		2475.9 SFT
	APEA, THEORETICAL CR TOTA	4 L		382.64 SFT
	AREA, ELEVON			1017.6 IN
	SPAN			413.23 IN
	CHORD, MEAN AERODYNAMIC			6C7.39 IN
	CHORD, CENTERLINE ROCT			93.324 IN
	CHORD, TIP			•15365
	TAPER RATIO, THEORETICAL			2.9044
	ASPECT RATIO, THEORETICAL ASPECT RATIO, EXPOSED SPA			2.7226
	ANGLE, LEADING EDGE SWEEF			45.294 DEG
	ANGLE, TRAILING EDGE SWEE		*FIXED*	▶ 0.0 DEG
	ANGLE, DIHEDRAL	Lr	*FIXED	7.0 DEG
	ANGLE, INCIDENCE		*FIXED	
	AIRFOIL SECTION, ROOT			<b>▶</b> 008-64
	AIRFOIL SECTION, TIP			▶ 008-64
	Almost Scotter, Ti			
4.	040A MASS PROPERTIES			
			X-CG (FT)	X-CG (PC L)
	CPBITER LNCG (W/40K PL)	196714.8	70.746	64.561
	CPBITER LNDG (W/C PL)	156714.8	73.021	66.637
	WING WEIGHT TPS WEIGHT	15812.6		
	TPS WEIGHT	24796.1		
5.	PRINCIPAL PARAMETERS			
	X-SCALE FACTOR			= .700C0
	Y-SCALE FACTOR		:	= 1.2000
	DISTANCE TO LEADING FOGE	OF EXPOSED WIN	IG XOF:	=699.158 IN
6.	LANDING PERFORMANCE			
	MINIMUM LANDING SPEEC (W.			163.4 KT
	STATIC MARGIN (SUBSONIC)			0949
	STATIC MARGIN (SUBSENIC)			0289
	TRIM LIFT COEF FOR LANDI	NG (ALPHA=17 DE	:G )	.8787
7.	HYPERSONIC AERODYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVON=-45 DEG		56.69 DEG

### ODIN Wing W<sub>27</sub> (Modified)

1. OVE	RALL CONFIGURATION			
	AREA. PLANFORM (SFT)			4182.2
	LENGTH, NOSE TO WING LE	AT BODY		628.13 IN
	LENGTH, NOSE TO WING C/4			889.39 IN
	ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
	The second secon			
2. FUS				
	AREA, WETTED			6307.0 SFT
	LENGTH, NOSE TO END OF BO	DDY	*FIXED*	1315.0 IN
3. WIN	G			
	AREA, THEORETICAL OR TOTAL	4 L		3535.1 SFT
	AREA, ELEVON			646.66 SFT
	SPAN			1085.4 IN
	CHORD. MEAN AERODYNAMIC		•	555.61 IN
	CHURD, CENTERLINE ROOT			818.02 IN
	CHORD, TIP			119.99 IN
<u> </u>	TAPER RATIO, THEORETICAL			.14668
	ASPECT RATIO, THEORETICAL			2.3143
	ASPECT RATIO, EXPOSED SP			2-1747
	ANGLE, LEADING EDGE SWEET			50-172 DEG
	ANGLE. TRAILING EDGE SWE			-7.0 DEG
	ANGLE, DIHEDRAL	<b>L</b> 1	*F1XFD*	-7.0 DEG 7.0 DEG 1.5 DEG
	ANGLE, INCIDENCE		*FIXED*	1.5 DEG
	AIRFOIL SECTION, ROOT			
	AIRFUIL SECTION, TIP		*FIXED*	008-64 008-64
	AIR GIE SECTION III		- TARES	
4. 040	A MASS PROPERTIES			
	FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
	ORBITER LNDG (W/40K PL)		71.606	65.346
	URBITER LNDG (W/O PL)		74.027	67.555
	WING WEIGHT TPS WEIGHT	16828.1		
	TPS WEIGHT	28544.3		
5. PR1	NCIPAL PARAMETERS			
er marina	X-SCALE FACTOR		SCLX=	.90000
	Y-SCALE FACTOR		SCLY=	: 1.3000
	DISTANCE TO LEADING EDGE	OF EXPOSED WI	NG XOF=	628.134 IN
∠ I A A	DING PERFORMANCE			
O. LAN	MINIMUM LANDING SPEED (W	140K 911		150.0 KT
	STATIC MARGIN (SUBSUNIC)			0804
				0281
	STATIC MARGIN (SUBSONIC) TRIM LIFT COEF FOR LANDI		661	0281 -7480
	IKIM LIFT CUEF FUR LANUI	NO IMERIATIFU	EUI	• 1 700
7. HY	ERSONIC AERODYNAMIC TRIM			
	TRIM ANGLE OF ATTACK AT	ELEVUN=-45 DEG		40.81 DEG

#### APPENDIX - Concluded

## ODIN Wing $W_{33}$ (Modified)

1.	OVERALL CONFIGURATION					
	AREA, PLANFORM (SFT)				4069	. 3
	LENGTH, NOSE TO WING LE .	AT BODY			651.	70 IN
	LENGTH, NOSE TO WING C/4					80 IN
	ANGLE, GROUND PLANE		·	*FIXED*	17.0	O DEG
2.	FUSELAGE					
	AREA, WETTED			*FIXED*	6307	.0 SFT
	LENGTH, NOSE TO END OF B	OUY		*FIXED*		-0 IN
3.	WING					
-	AREA, THEORETICAL OR TOT	AL			3387	·1 SFT
	AREA, ELEVON					03 SFT
	SPAN				1085	.4 IN
	CHORD, MEAN AERCDYNAMIC				536.	52 IN
	CHORD, CENTERLINE ROOT					09 IN
	CHORD, TIP				106.	66 IN
	TAPER RATIO, THEORETICAL				. 134	65
	ASPECT RATIO, THEORETICAL				2.41	
	ASPECT RATIO, EXPOSED SP ANGLE, LEADING EDGE SWEET				2.28	-
	ANGLE, LEADING EDGE SWEE					25 DEG
	ANGLE, TRAILING EDGE SWE			<b>451</b> 4504		• O DEG
	ANGLE, INCIDENCE		· · · · · · · · · · · · · · · · · · ·	*FIXED*	!	
	AIRFUIL SECTION, ROOT			*FIXED*	000-	•5 DEG
	AIRFOIL SECTION, TIP			*FIXED*		
4.	040A MASS PROPERTIES					
	FLIGHT CONDITION	WEIGHT (LB)	X-CG LE	Ti	X-CG 1	וו אפ
	ORBITER LNDG (W/40K PL)	199609.0	71.181		64.958	·· <u>·····</u>
	URBITER LNDG (W/O PL)		73.523		67.096	
	WING WEIGHT				0,,0	
	TPS WEIGHT	27026.2				
5.	PRINCIPAL PARAMETERS					
	X-SCALE FACTOR			SCLX=	.80000	
	Y-SCALE FACTOR				1.3000	
	DISTANCE TO LEADING EDGE	OF EXPOSED WIN	G	XOF = 6	551.696	IN
6.	LANDING PERFORMANCE	•	-			
	MINIMUM LANDING SPEED (W.	/40K PL)			149.9	ΚŢ
	STATIC MARGIN (SUBSONIC)	(W/40K PL)			0804	
	STATIC MARGIN (SUBSONIC)	[ (W/O PL)			0280	
	TRIM LIFT COEF FOR LANDIN	NG (ALPHA=17 DE	G)		.7742	
7.	HYPERSONIC AERODYNAMIC TRIM					
	TRIM ANGLE OF ATTACK AT L	LEVON=-45 DEG			48,90	DEG

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