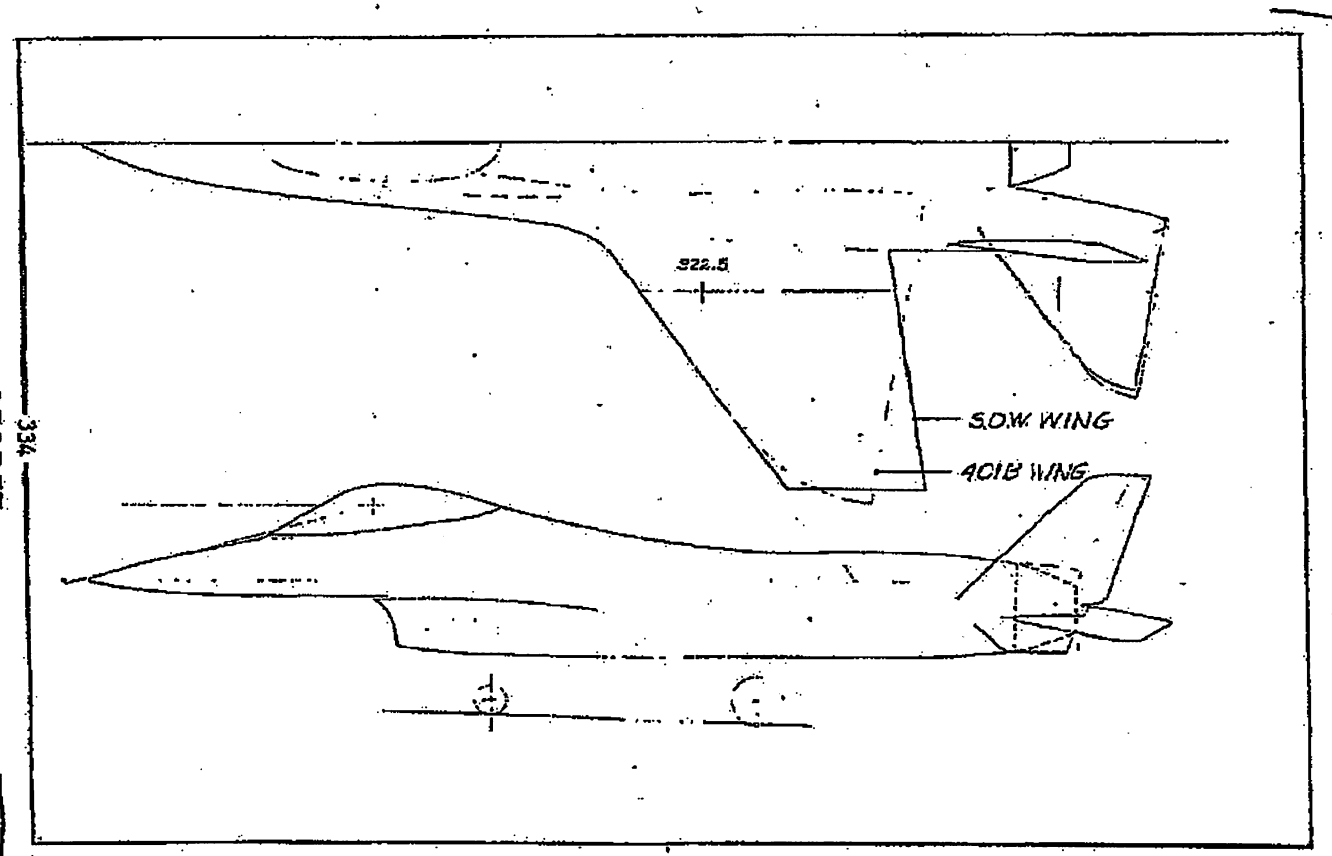
(S) quarter-chord location on the mean aerodynamic chord as the 401B wing planform. Wing thickness ratio was also modified on the S.O.W. wing to provide an offsetting effect to the weight penalty imposed by the difference in taper ratio between the S.O.W. wing (0.40) and the 401B wing (0.20). A biconvex wing with a t/c of .04 RMS (based on exposed planform) was used instead of a constant t/c = .04 to allow the structural weight reduction necessary for minimizing the weight difference between the two wings. This rationale is explained in more detail in subsection 6.5.

(S) The new horizontal tail, which was sized to the same tail volume coefficient as 401B (0.26), is so located that the tail moment arm remains the same as that of the basic 401B horizontal tail. This wing and tail relationship was established to maintain the original balance characteristics of 401B as nearly as possible on the modified configuration. The planform of the original horizontal tail is also retained. A comparison of the two wing planforms superimposed on the airplane is presented in Figure 6.1-2 for a gross weight of 16,800 pounds.

6.1.2 Design Data

(U) A summary of basic configuration data for the S.O.W. aircraft at a mission weight of 16,800 pounds is presented in Figures 6.1-3, -4, and -5. Basic geometric description data are given in Figure 6.1-3. Friction drag design data for the airplane are given in Figure 6.1-4 The normal area distribution for the airplane with the S.O.W. wing is presented in Figure 6.1-5.



SECRET
THIS PAGE CONFIDENTIAL

~~(S)~~ Figure 6.1-2 Planform Comparison - Configuration 401B Wing vs. S.O.W. Wing at 16,800-lb Mission Weight (U)

~~SECRET~~

BASIC DESCRIPTION

G.W. = 16,800 lbs
W/S = 60 lbs/ft.²
T/W = 1.397 (UNINSTALLED)
Engine: P&W JTF 22A-27
(AF Designation F100-PW-100)

PROJECT: ADV. TAC. FIGHTER
CONFIGURATION: ADF-401B/SOLID WING
DATE: 23 JUNE 71

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY W/O CANOPY	* 478.6	0	0	0
FUSELAGE OUTERBODY	421.0	107.0	±40.0	0
CANOPY	143.0	85.0	0	+39.0

* INCLUDES NOZZLE LENGTH (OPEN)

88th ABW/IPI
FOIA(b)(1)(1)(A)
E.O.13526 SEC.
3.3(b)(1)(A)
1.4.(a)(b) 3.3(b)(6)
SEC 1.4(a)(b)

WING REF. AREA (IN.²): 4032.0

SURFACES

	2 IDENTICAL WING PANELS	2 IDENTICAL HORIZ. TAILS	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT^2)	280.00	117.63	22.17	3.65
AR - ASPECT RATIO	3.00	3.93	1.33	0.3733
λ - TAPER RATIO	0.40	0.135	0.40	0.559574
L.E. E_1	+55°	+55	+45°	+45°
E_2(+) E_2	-7.34°	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$				
C_R - ROOT CHORD (IN.)	165.62	123.83	69.91	47.03
C_T - TIP CHORD (IN.)	66.25	16.70	27.96	28.02
b - SPAN (IN.)	347.79	241.06	65.09	14.01
AIRFOIL	4% RMS Biconvex Tip - 2.5% Biconvex 95% SS - 4.84% Biconvex	Tip - 4% Biconvex 35% SS 5% Biconvex	6% @ root 4% @ tip BICONVEX	6% BICONVEX
d (IN.)	54.00	51.887	0	0
x (IN.)	295.50	441.0	422.52	435.52
y (IN.)	0	0	±54.9	± 51.50
z (IN.)	0	-13.80	0	-13.00
	0° DIHEDRAL	3° INCL. DIHEDRAL	75° OUTBD CANT	0° CANT ∥

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point,
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line,
z = Distance up (+) or down (-) from fuselage ref. line WL92 to body or surface ref line.

8061-74

~~(S)~~ Figure 6.1-3 Basic Description Data Sheet - Configuration 401B with S.O.W. Wing (U)

~~SECRET~~

~~SECRET~~

FRICTION DRAG DATA

PROJECT ADV DAY FIGHTER

CONFIGURATION ADE-401B /SUPW WING

DATE 22 JUNE 71

G.W. = 16,800 lbs
W/S = 60 lbs /ft²
T/W = 1.397 (UNINSTALLED)
ENGINE - P&W JTF22A-27

BODIES

BODY	WETTED AREA (FT^2)		LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)
FUSELAGE (CENTERBODY)		405.5	* 476.2	52.0	71.0
FUSELAGE (AFTERBODY)		259.0	421.0	28.0	18.0
CANOPY (INCL FAIRING)		50.7	147.0	40.0	27.0
NOZZLE (CLOSED)		70.8	27.2	43.5 DIA	43.5 DIA
NOZZLE (OPEN)	26.7		28.6	43.5 DIA	43.5 DIA
BODY TOTAL		796.0			

* Length includes nozzle (closed)
Aft cap nozzle shown separately

SURFACES

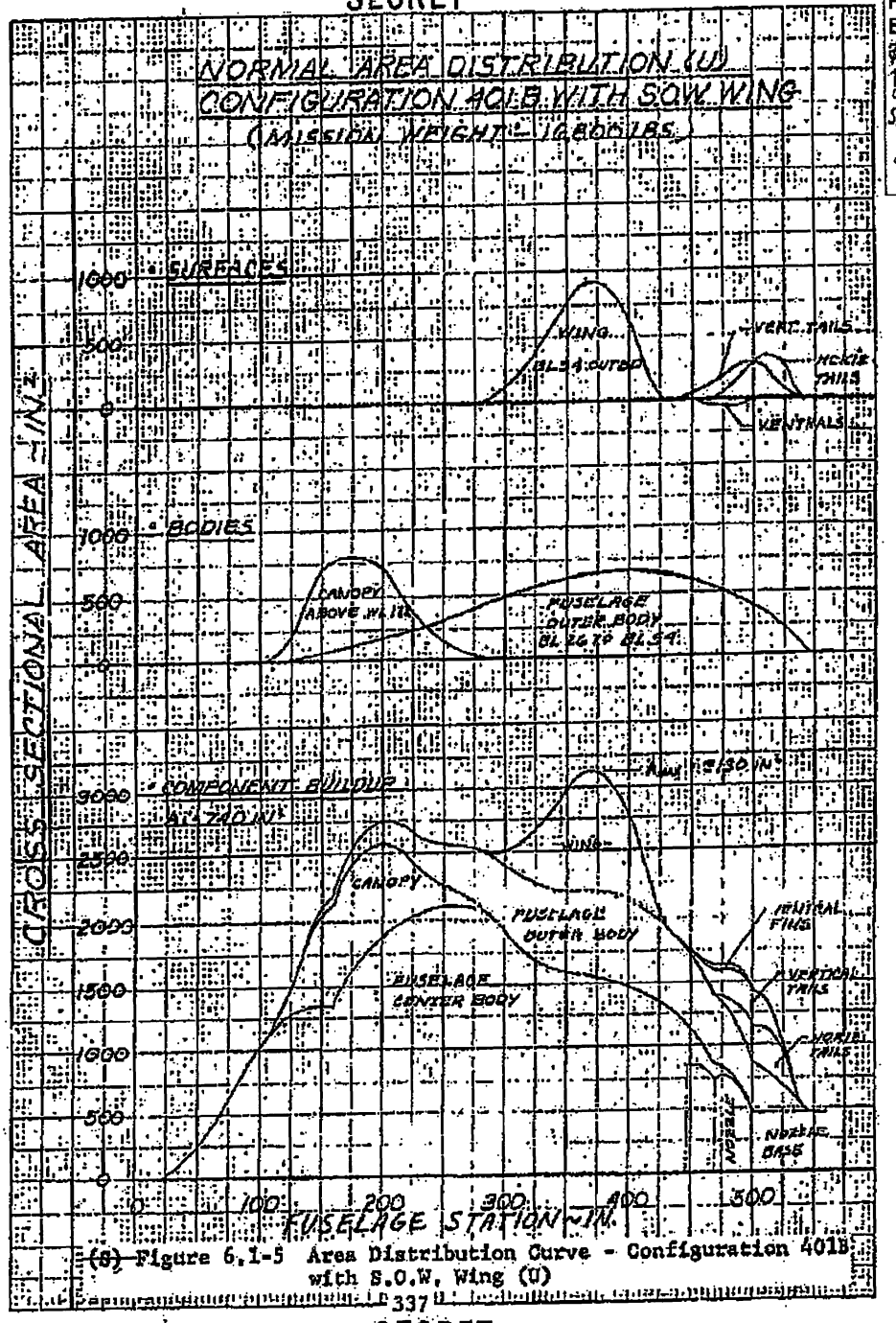
SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		338.7	104.39	14°30'	4% BICONVEX RMS
HORIZ. TAIL		90.0	53.78	14°30'	6% BICONV - ROOT 4% BICONV - TIP
VERT TAIL (2)		88.5	51.93	34°15'	6% BICONV - ROOT 4% BICONV - TIP
VENTRAL FIN (2)		14.6	37.33	17°45'	6% BICONVEX
SURFACE TOTAL		527.8			
AIRPLANE TOTAL		1263.8			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE BASIC REF. WING
AREA (FT^2)	280.84
ASPECT RATIO	3.0
TAPER RATIO	0.4
LEADING EDGE SWEEP (DEG.)	35.

~~(S)~~ Figure 6.1-4 Friction Drag Data Sheet - Configuration 401B with S.O.W. Wing (U) 8061-13

~~SECRET~~



(S) Figure 6.1-5 Area Distribution Curve - Configuration 401B with S.O.W. Wing (U)

6.2 PERFORMANCE

(U) The performance characteristics of Configuration 401B with the 0.4 taper-ratio wing are based on the same mission definitions and performance rules as presented in Section 3.2 for Configuration 401B with the 0.2 taper-ratio wing.

~~(S)~~ The LRASM performance capabilities of Configuration 401B with the 0.4 taper-ratio wing are compared with the basic 401B Configuration in Figure 6.2-1. The comparison is for the 16,800-lb size used for the design layout described in Section 6.1. The mission radius with the 0.4 taper-ratio is 115 n.mi less than that with the basic wing, which has a 0.2 taper-ratio for the theoretical trapezoidal wing (i.e., without curved tips). Approximately one half of the radius loss is due to the 119-lb heavier weight of the 0.4 taper-ratio design. This is a resulting 119-lb loss of fuel when the analysis is made at a constant mission weight, as is the case in this analysis. The remainder of the radius loss is due to the lower L/D of the 0.4 taper-ratio wing.

~~(-)~~ When the 0.4 taper-ratio wing design is sized to meet the 750-n.mi LRASM radius, it is 620-lb heavier than the basic design. (This is the reason for having chosen the baseline design.) The sizing of Configuration 401B with a 0.4 taper-ratio wing to meet the LRASM radius requirements was done by use of corrections obtained from the growth data presented in Sections 3.3 and 3.5.

~~(S)~~ The following corrections, obtained from the Section 3.3 growth data, were added to the basic aerodynamic data of Section 6.3 to account for increased aircraft size and wing area change:

Mach No.	ΔC_D
0.6	-0.00013
0.8	-0.00013
0.9	-0.00015
1.2	-0.00017
1.5	-0.00045

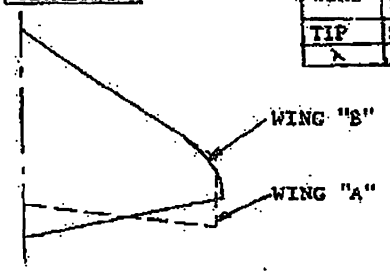
16,800-lb A/F w/o Tanks

Δ WEIGHT: WING "A" - WING "B"

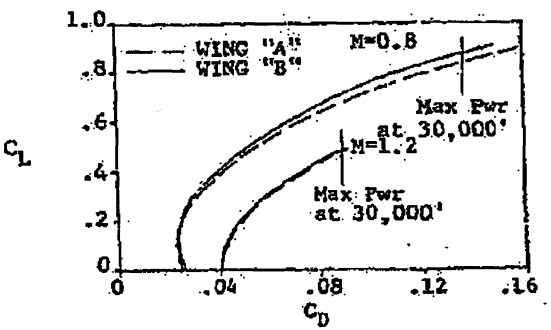
Structure		
- Wing	111	lb
- Fuselage	16	
- Horizontal Tail	-24	
	103	lb
Controls		
- Surface Controls	19	lb
- Hyd & Pneu	-3	
	16	
Total	119	lb

GEOMETRY

WING	A S.O.W.	B 401B
TIP	SQUARE	CURVED
λ	0.4	0.2



AERODYNAMIC COMPARISON



PERFORMANCE COMPARISON FOR LRASM

	WING "A"	WING "B"	EQUIVALENT RAD, N.MI
Combat Fuel	1924	1866	-23
-Accel Time, sec	36.1	34.8	
-Turn Rate @ M=0.8	9.3	9.8	
-Turn Rate @ M=1.2	8.2	8.3	
Climb Dist/Fuel	25/144	25/144	0
Cruise Range Constant	5281	5563	-30
-L/D	9.226	9.823	
-M	.870	.863	
-TSFC	.872	.870	
Reserve Fuel	473	446	-11
Weight	119	0	-51
			-115

~~(S)~~ Figure 6.2-1 Comparison of 0.4 Taper-Ratio Wing and Basic 401B Wing LRASM Performance (U)

~~SECRET~~

339

~~SECRET~~

(S) The reference wing area was changed from 280 sq. ft. to 295.6 sq. ft. to maintain a constant wing loading of 60 psf.

(U) The weight data presented in Section 6.3 were corrected for change in aircraft size. The corrections were made by use of the growth data presented in Section 3.5. A summary of the corrected weight data is presented in Table 6.2-1.

(U) The engine size was maintained fixed, and the propulsion data from Section 3.6 were used without modification.

(U) A summary of the mission capabilities of the resized Configuration 401B with a 0.4 taper-ratio wing is presented in Figure 6.2-2. Tabulations of the pertinent data for each segment of the three missions are presented in Tables 6.2-2 through 6.2-4. General performance data are presented in Figures 6.2-3 through 6.2-12. Sensitivity to weight-empty variation is presented in Figure 6.2-13.

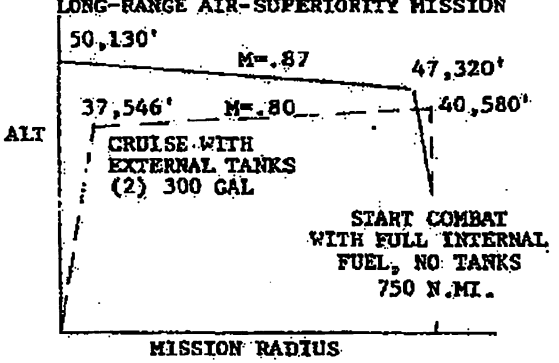
~~(S)~~ Table 6.2-1 CONFIGURATION 401B WITH 0.4 TAPER RATIO WING WEIGHT SUMMARY

(17,735-Lb Airplane Without Tanks)

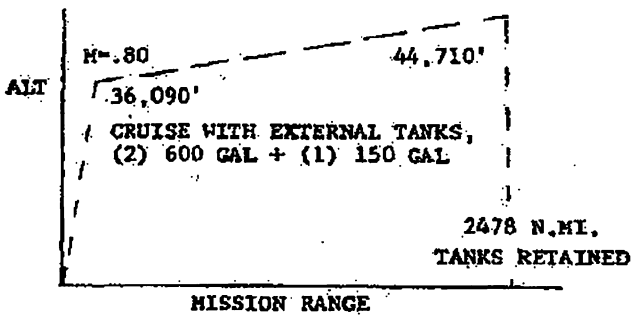
Items	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	12,566
Ammunition (500 rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,536
SRASM Takeoff Gross Weight	17,735
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	22,573
Basic Operating Weight	12,566
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	476
SRASM and LRASM Landing Weight	13,184
2. FERRY MISSION	
Basic Operating Weight	12,566
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	12,727
Internal Fuel	4,536
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	27,920
Zero Fuel Weight	12,727
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	669
Twenty-Minute Sea-Level Loiter	584
Landing Weight	15,794

(17,735-lb A/P w/o Tanks)

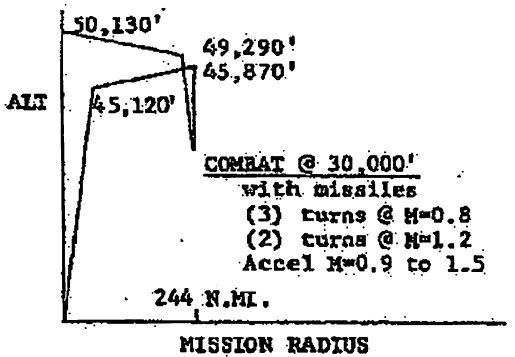
LONG-RANGE AIR-SUPERIORITY MISSION



FERRY MISSION



SHORT-RANGE AIR-SUPERIORITY MISSION



LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	22,573 lb
Takeoff Distance over 50 ft	2,060 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	38.6 sec
Turn Rate @ M=0.8	9.2 deg/sec
Turn Rate @ M=1.2	8.0 deg/sec

SHORT-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	17,735 lb
Takeoff Distance over 50 ft	1,370 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	35.2 sec
Turn Rate @ M=20.8	10.1 deg/sec
Turn Rate @ M=1.2	8.7 deg/sec

~~(S)~~ Figure 6.2-2 Configuration 401B with 0.4 Taper-Ratio Wing Mission Performance Summary (U)

~~(S)~~ Table 6.2-2 CONFIGURATION 401B WITH 0.4 TAPER RATIO
WING LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial T_{REQ}	Initial TSFC	Initial L/D	Combat CL	Combat C_D
Initial Weight	0	0	22573								
Ground Operation				335	0	0					
	0	0	22238								
Accel to Climb Speed				258	0	.11					
	0.50	0	21980				2904	0.875	6.89		
Climb to Cruise Alt.				537	39	.09					
	0.80	37546	21443				2445	0.825	8.84		
Outbound Cruise				2923	711	1.55					
	0.80	40580	18520								
Drop Tanks				785*	0	0					
(847#Tank+ 62#Fuel)	0.80	40580	17735								
Combat				(1997)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		364	0	.01					
(2)M1.2 Turns	1.2	30000		863	0	.03				.470	5.19
(2)M0.8 Turns	0.8	30000		770	0	.03				.822	4.03
	0.87	30000	15738								
Drop Payload				348	0	0					
	0.87	30000	15390								
Drop ½ Ammo				143	0	0					
	0.87	30000	15247				2456	0.876	6.01		
Climb to Cruise Alt.				152	25	.05					
	0.87	47321	15095				1614	0.859	9.36		
Return Cruise				1911	725	1.45					
	0.87	50133	13184								
Descend				0	0	0					
	0.28	0	13184				1295	1.117	10.20		
Landing Reserves				476	0	.33					
(20-Min.Loiter S.L.)											
Zero-Fuel Weight			12708								

*62 Lb. Additional Fuel Needed

SECRET

SECRET

~~(S)~~ Table 6.2-3 CONFIGURATION 401B WITH 0.4 TAPER RATIO
WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial T_R/θ	Initial T_R/δ	Initial L/D	Combat C_L	Combat n's
Initial Weight	0	0	17735								
Ground Operation				246	0	0					
	0	0	17489								
Accel to Climb Speed				198	0	.10					
	0.50	0	17291				2411	0.875	6.09		
Climb to Cruise Alt.				477	44	.10					
	0.87	45117	16814				1838	0.853	9.21		
Outbound Cruise				619	200	.40					
	0.87	45869	16195								
Combat				(1817)		(.06)					
Accel M0.9-M1.5	0.9-1.5	30000		333	0	.01					
(2)M1.2 Turns	1.2	30000		783	0	.02				.466	5.63
(3)M0.8 Turns	0.8	30000		701	0	.03				.819	4.40
	0.87	30000	14378								
Drop Payload				348	0	0					
	0.87	30000	14030								
Drop ½ Ammo				143	0	0					
	0.87	30000	13887				2430	0.876	5.50		
Climb to Cruise Alt.				153	27	.06					
	0.87	49289	13734				1485	0.865	9.32		
Return Cruise				550	217	.43					
	0.87	50133	13184								
Descend				0	0	0					
	0.28	0	13184				1295	1.117	10.20		
Landing Reserves (20 Min. Loiter S.L.)				476	0	.33					
Zero-Fuel Weight			12708								

SECRET

SECRET

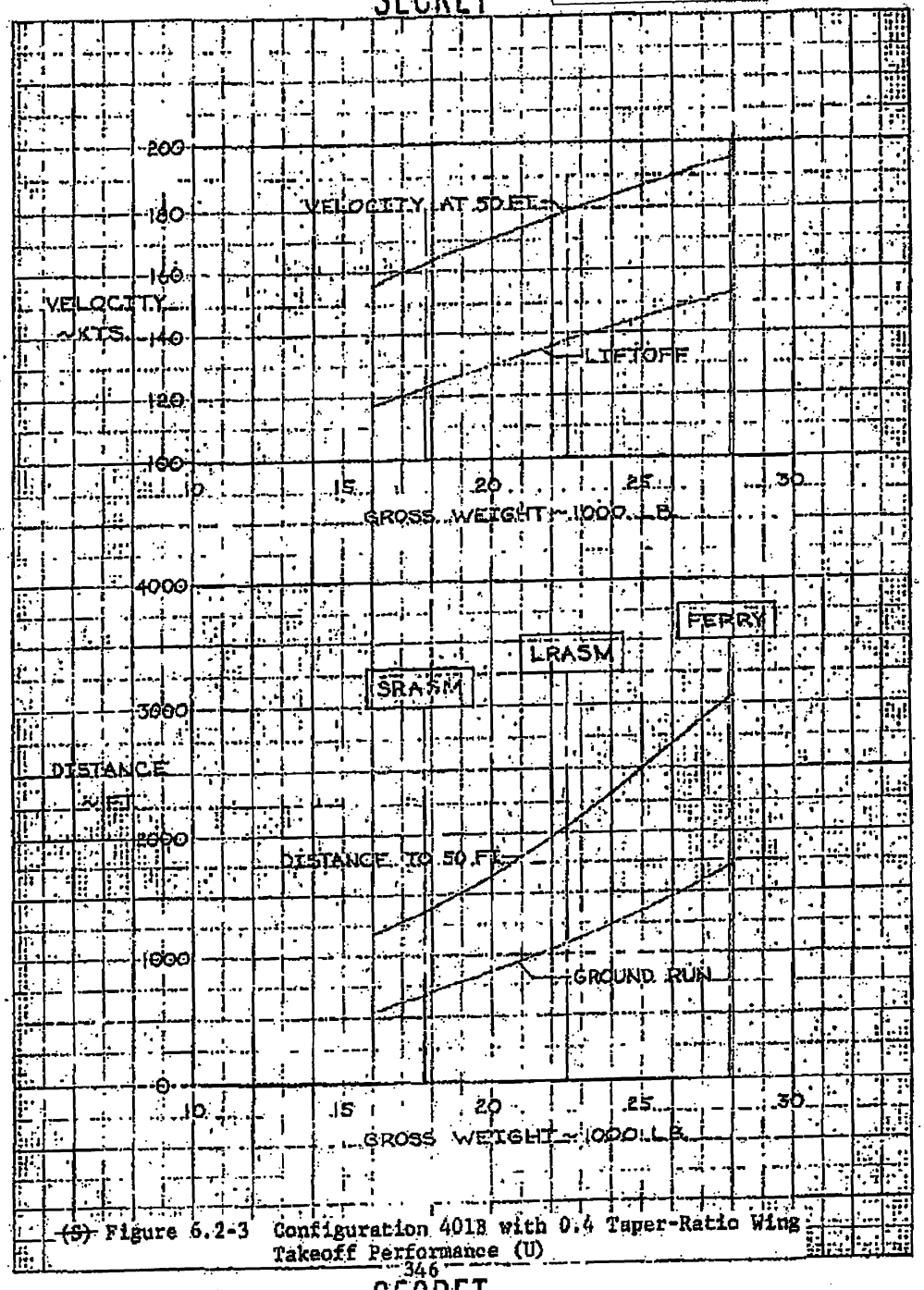
(S) Table 5.4-7 CONFIGURATION A-11 WITH 0.4 TAPER RATIO WING
FERRY MISSION TABULATION (U)

Mission Phase	Alt. (ft)	Mach No.	Segment Weight (lb)	Time (min)	Fuel (lb)	Initial L/D	Initial T/W	Initial W/S	Comments
Initial Weight	0	0	27920						
Ground Operation			403	0	0				
	0	0	27517						
Accel to Climb Speed			326	0	.11				
	0.50	0	27191			3277	0.875	7.80	
Climb to Cruise Alt.			732	55	.12				
	0.80	36089	26459			3236	0.820	8.51	
Cruise w/(2)Ext.Tanks			10665	2423	5.28				
	0.80	44708	15794						
Descend			0	0	0				
	0.27	0	15794			1801	0.987	8.83	
Landing Reserves			(1253)						
(20 Min.Loiter S.L.)			584	0	.33				
(5% Initial Fuel)			669						
Zero-Fuel Weight			14541						

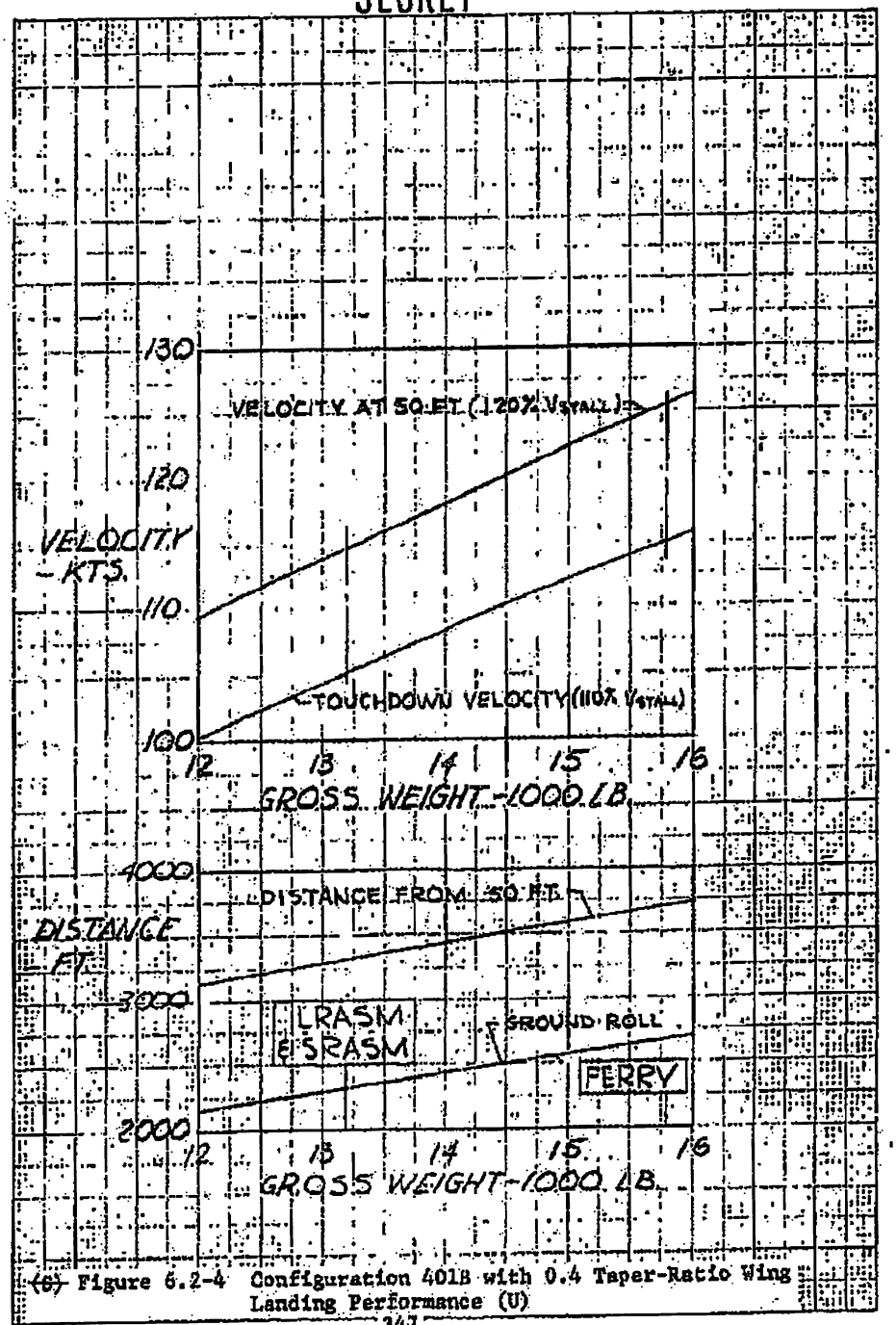
SECRET

345

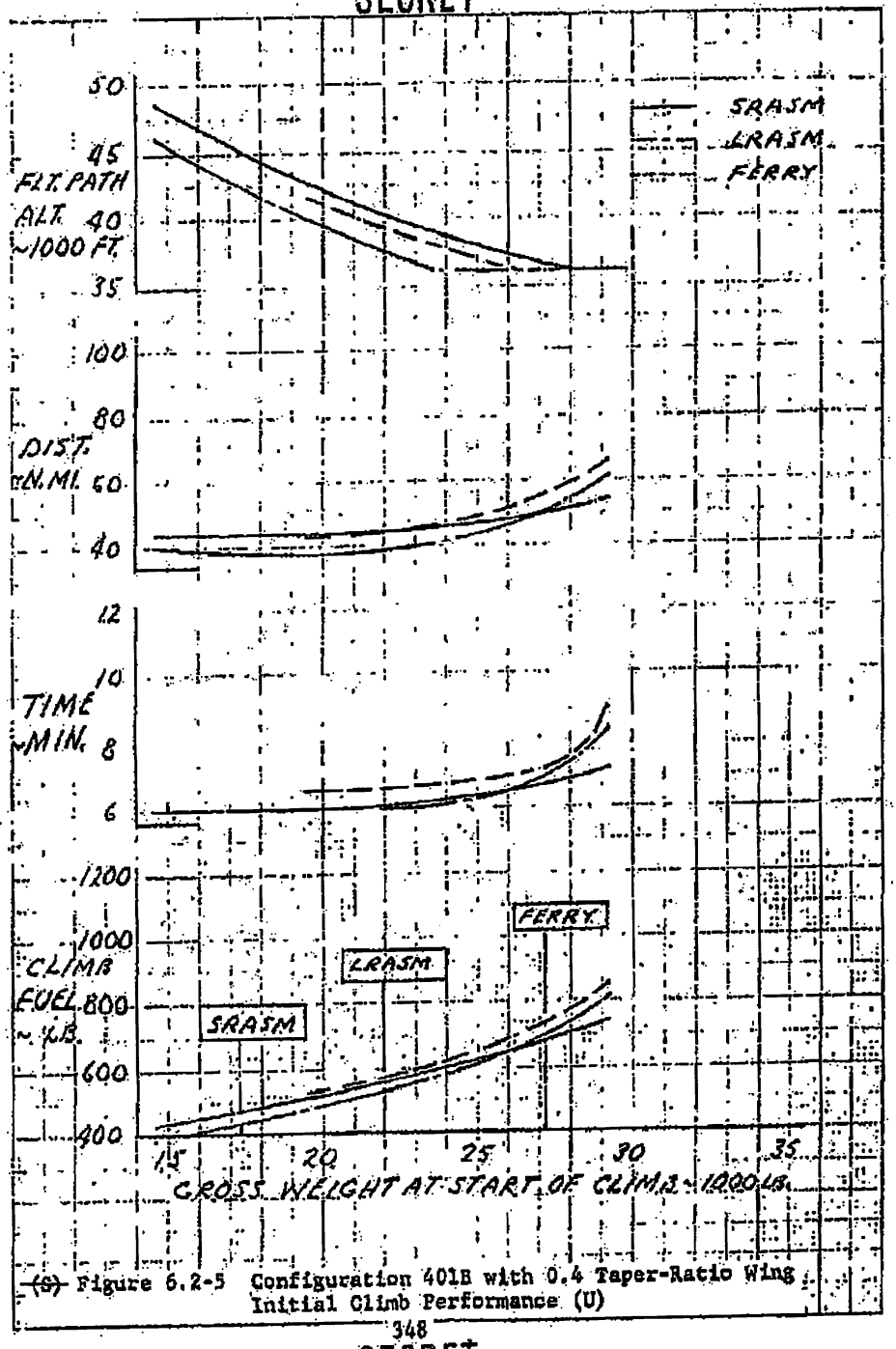
SECRET



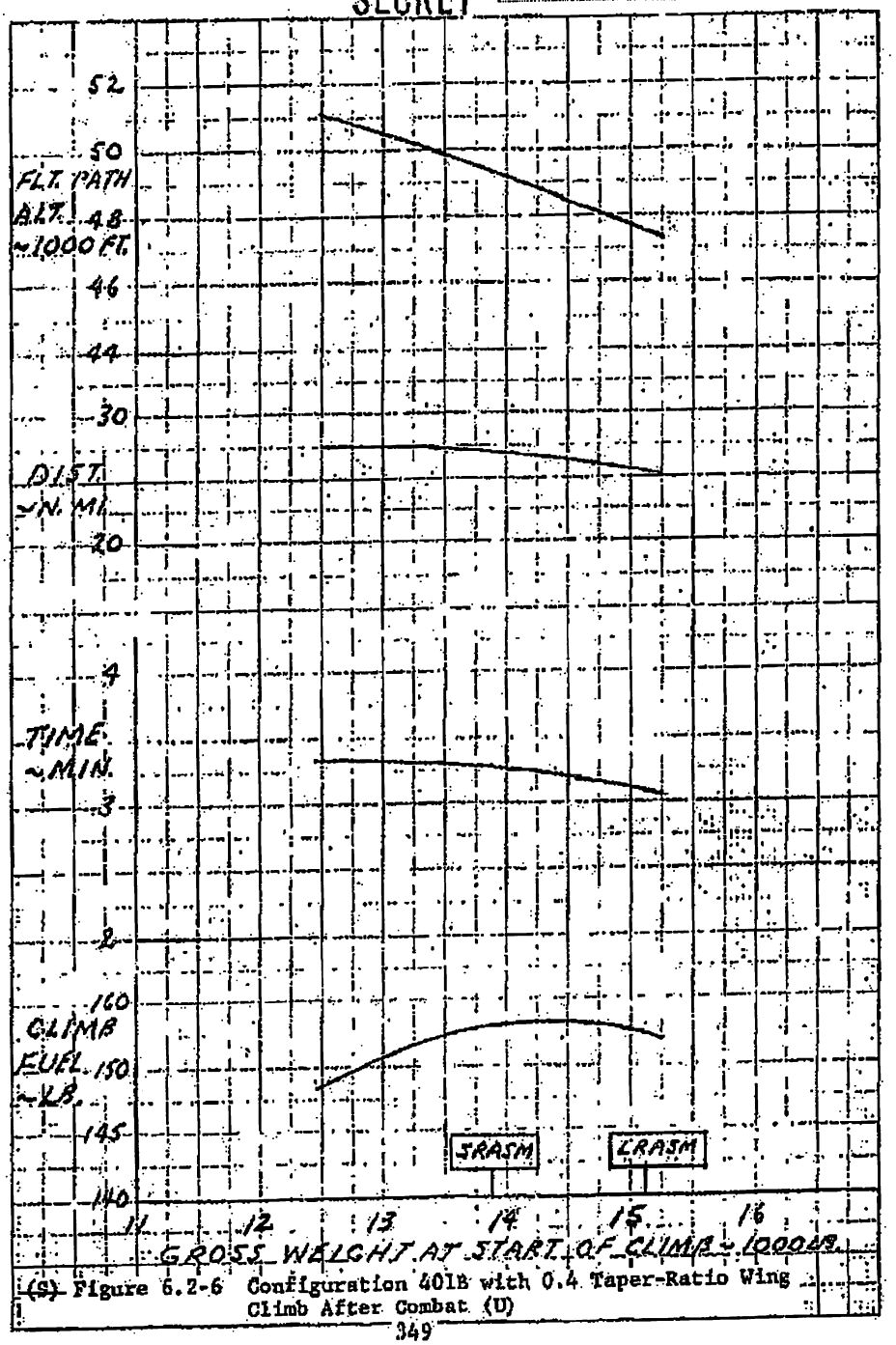
(S) Figure 6.2-3 Configuration 401B with 0.4 Taper-Ratio Wing Takeoff Performance (U)



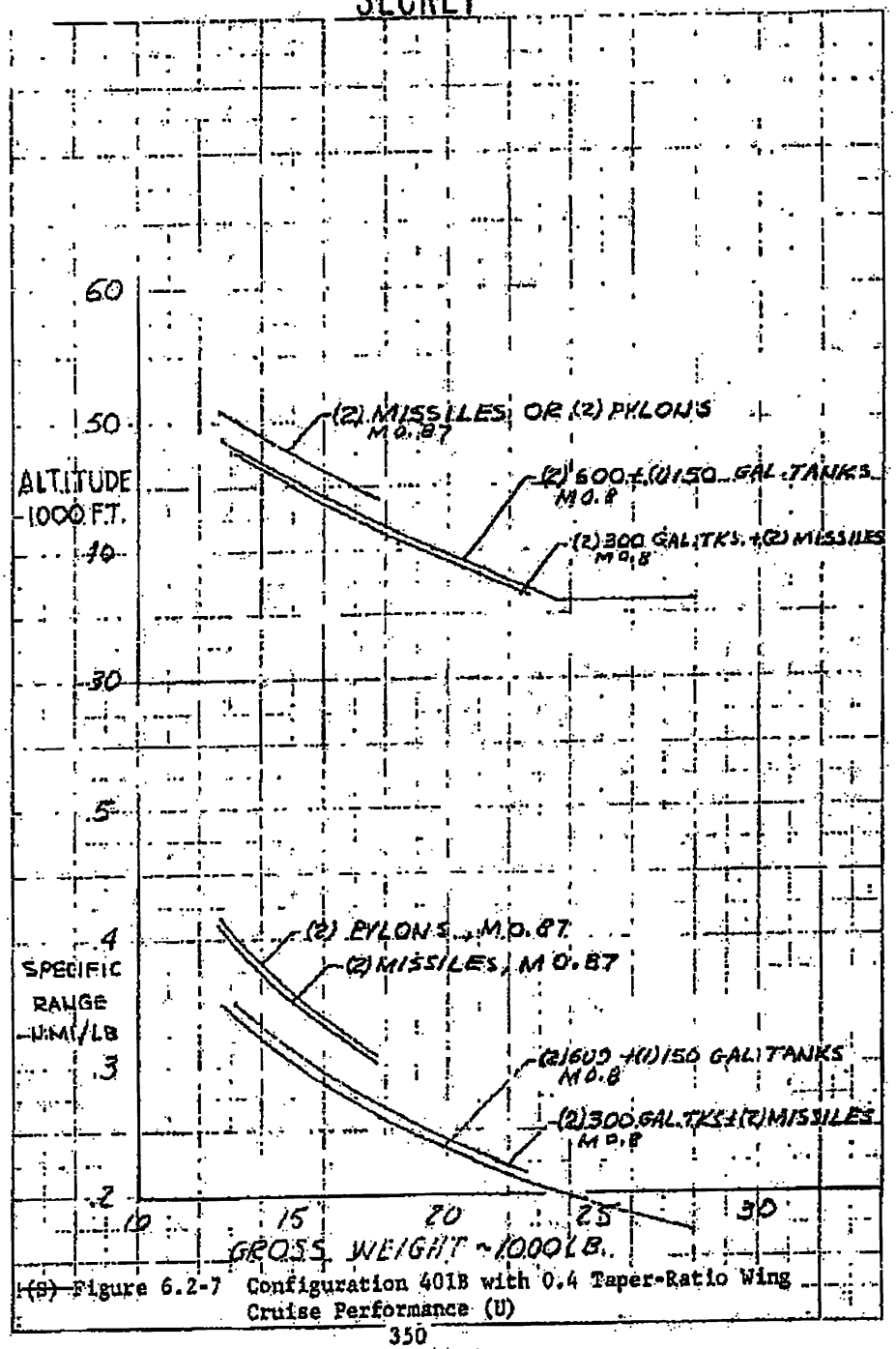
(S) Figure 6.2-4 Configuration 401B with 0.4 Taper-Ratio Wing Landing Performance (U)



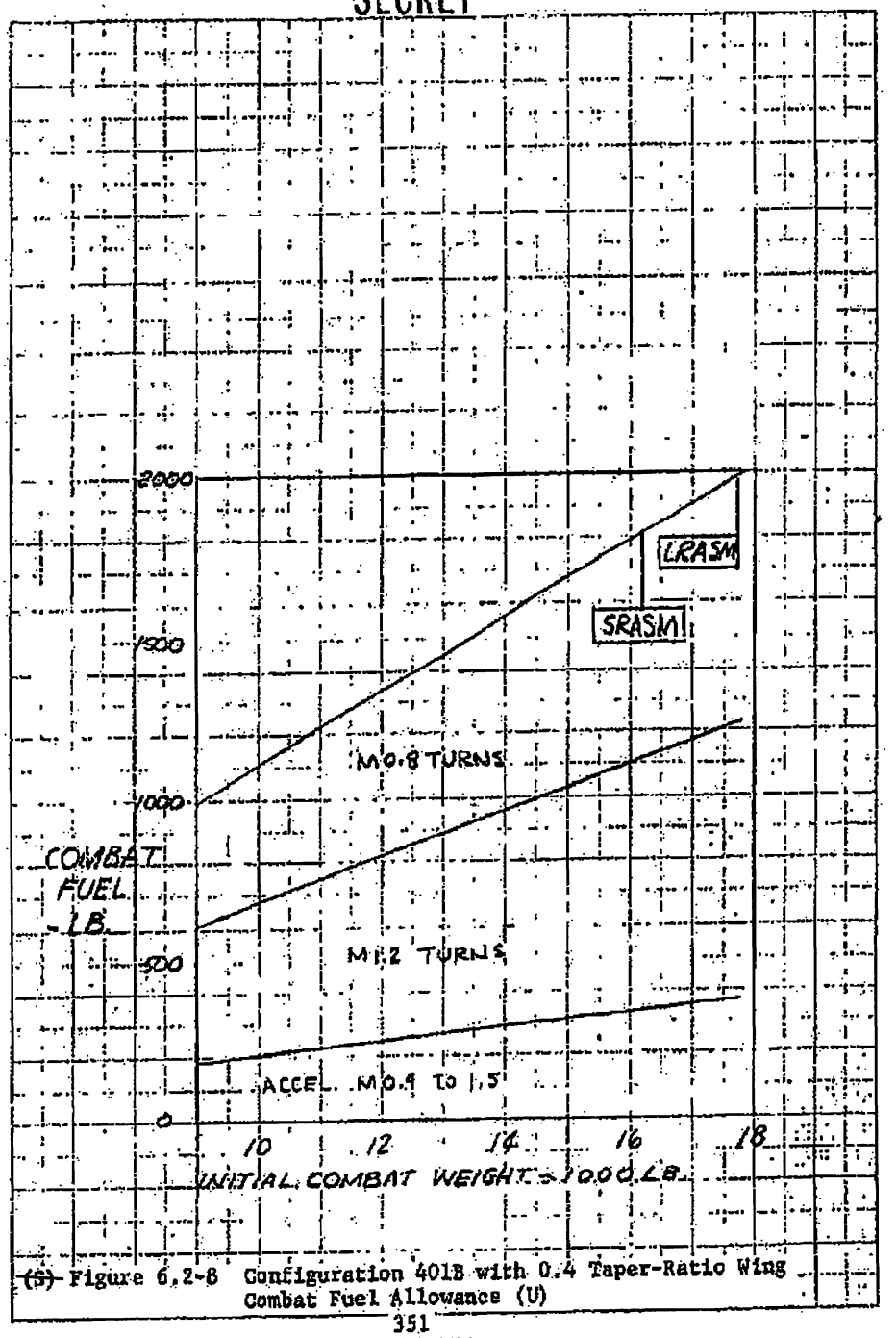
(S) Figure 6.2-5 Configuration 401B with 0.4 Taper-Ratio Wing Initial Climb Performance (U)



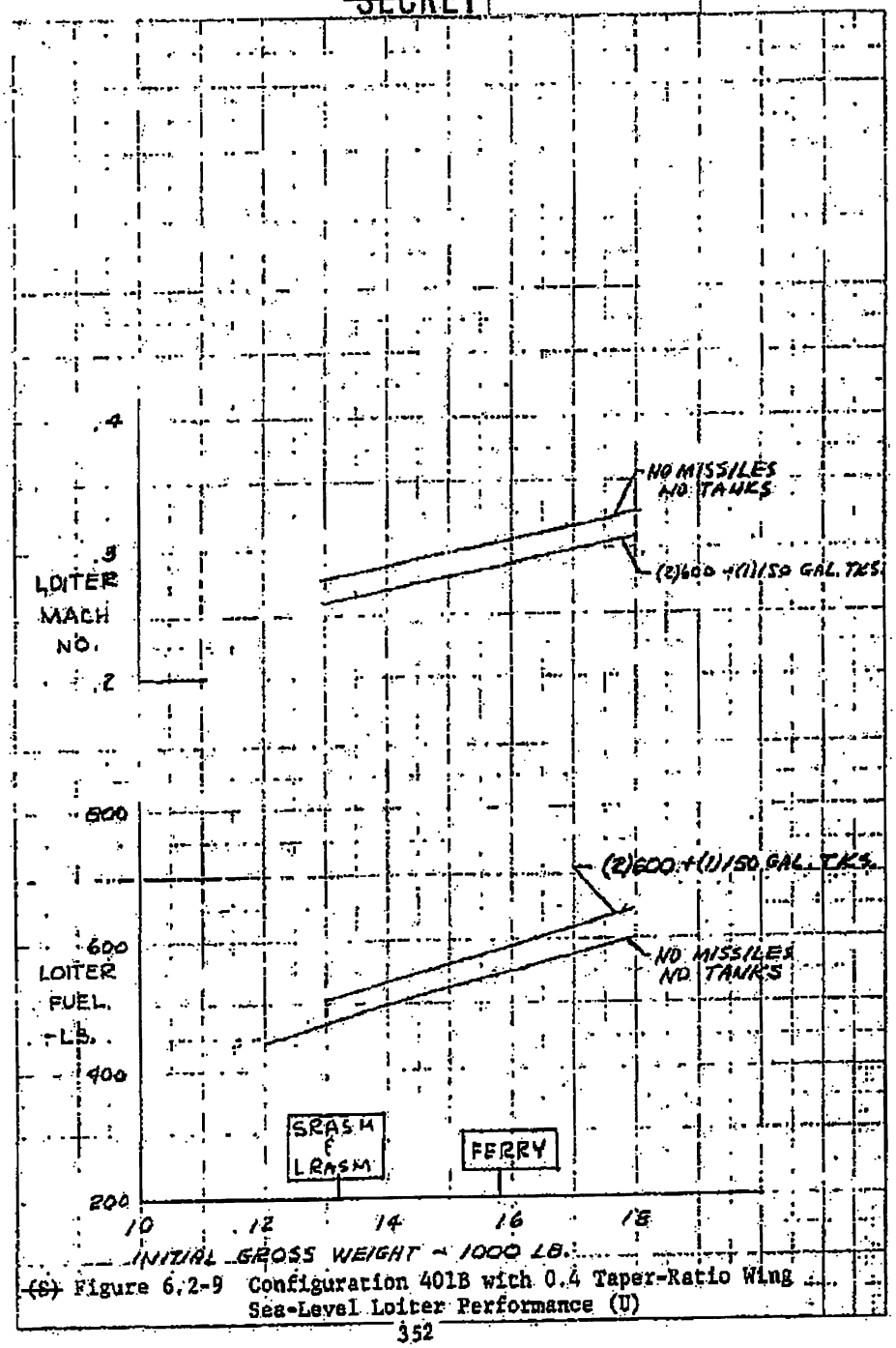
(S) Figure 6.2-6 Configuration 401B with 0.4 Taper-Ratio Wing Climb After Combat (U)



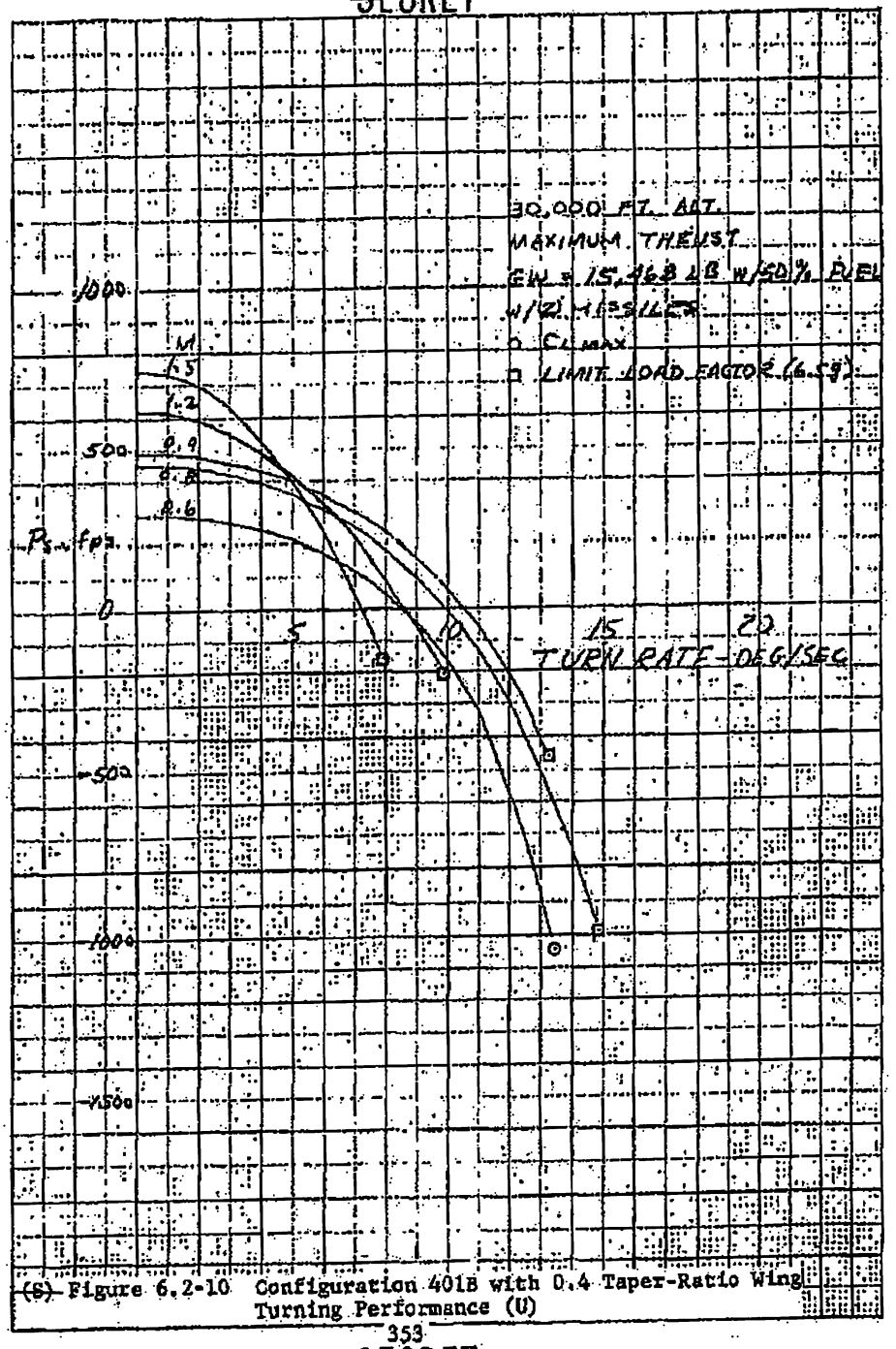
~~(S)~~ Figure 6.2-7 Configuration 401B with 0.4 Taper-Ratio Wing Cruise Performance (U)



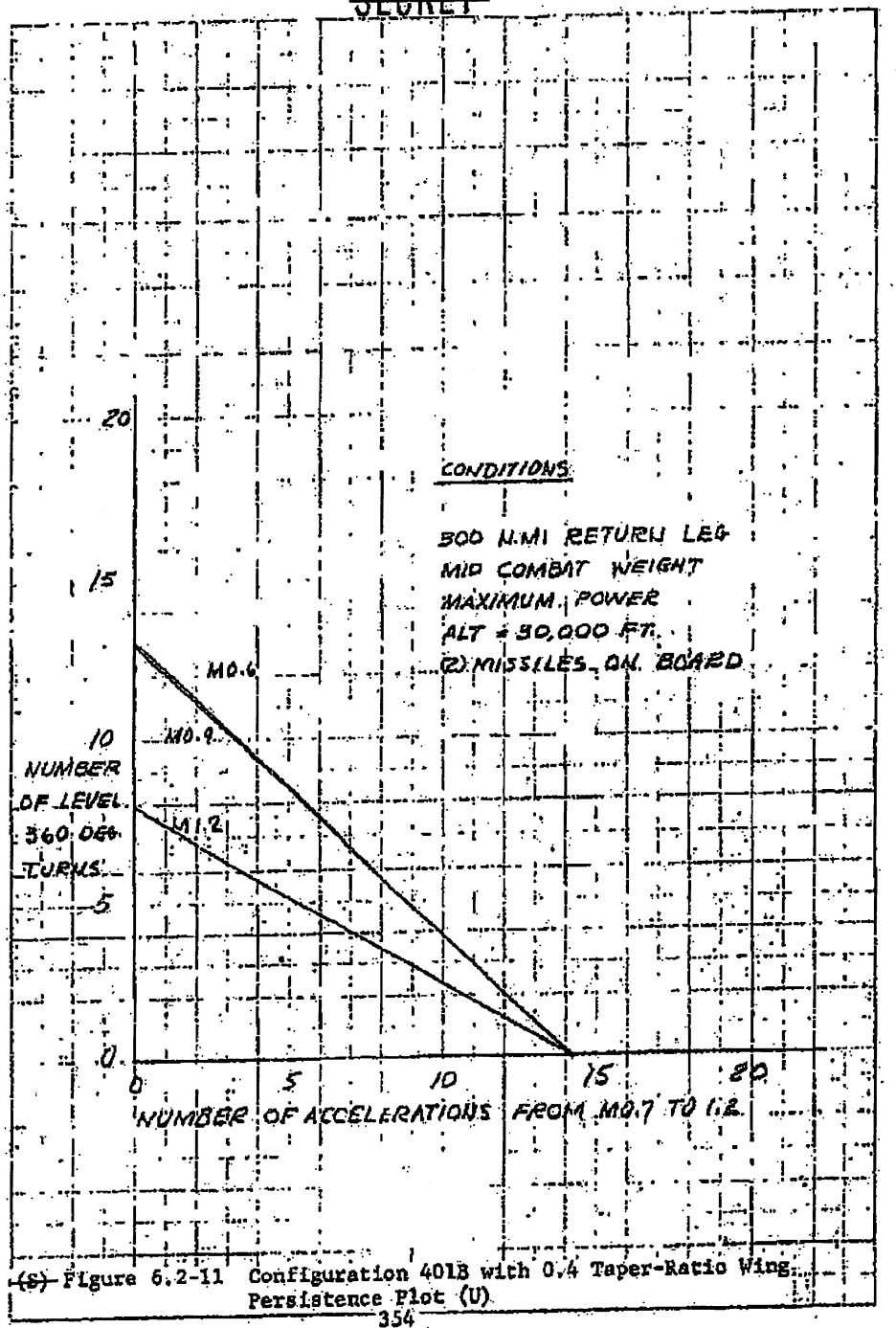
(S) Figure 6.2-8 Configuration 4018 with 0.4 Taper-Ratio Wing Combat Fuel Allowance (U)



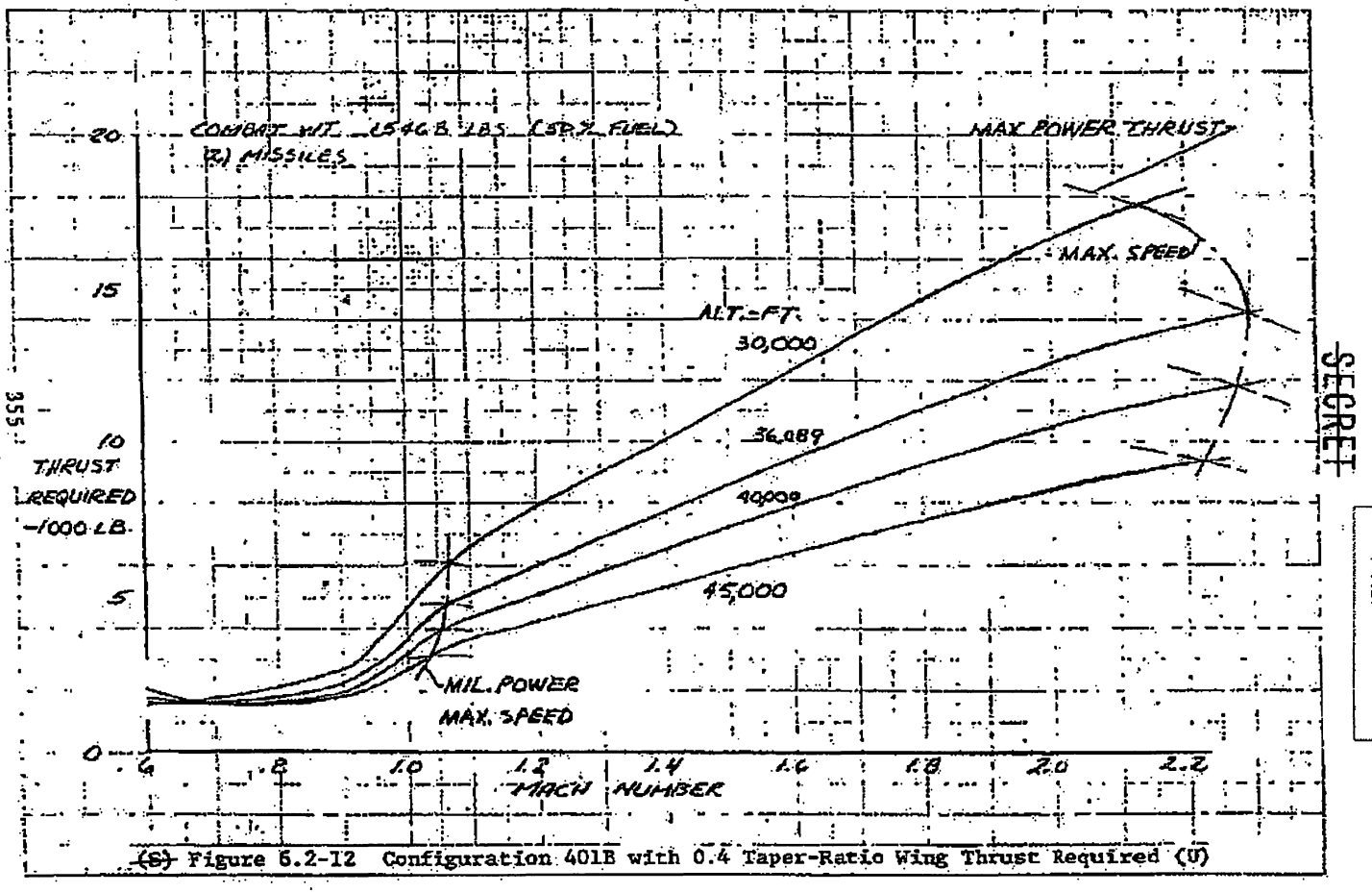
(S) Figure 6.2-9 Configuration 401B with 0.4 Taper-Ratio Wing Sea-Level Loiter Performance (U)



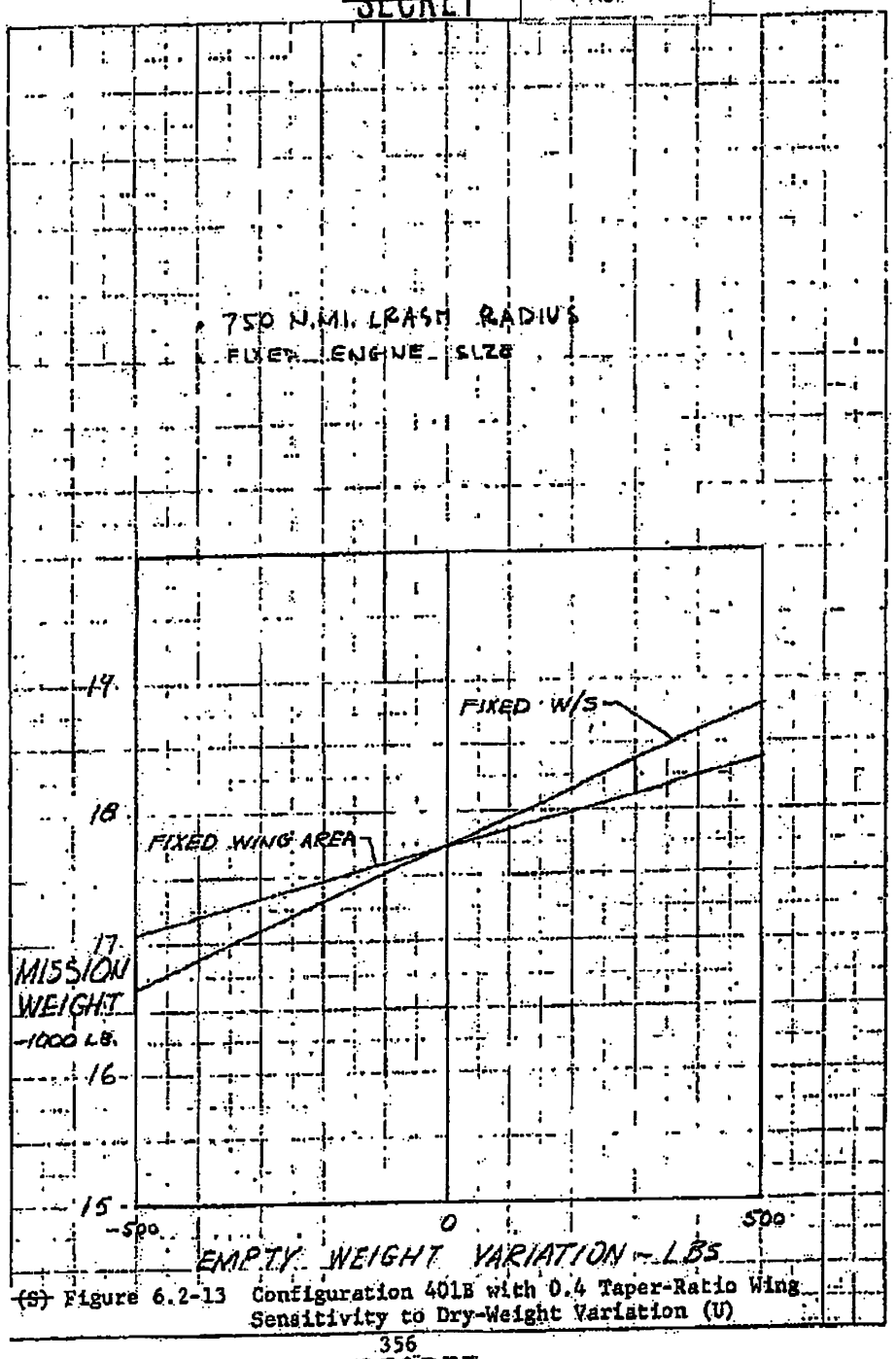
(S) Figure 6.2-10 Configuration 401B with 0.4 Taper-Ratio Wing Turning Performance (U)



(S) Figure 6.2-11 Configuration 401B with 0.4 Taper-Ratio Wing Persistence Plot (U)



(S) Figure 6.2-12 Configuration 401B with 0.4 Taper-Ratio Wing Thrust Required (U)



~~(S)~~ Figure 6.2-13 Configuration 401B with 0.4 Taper-Ratio Wing Sensitivity to Dry-Weight Variation (U)

6.3 AERODYNAMICS

(U) The aerodynamic characteristics for Configuration 401B with the 0.4 taper-ratio wing were generated through use of the same methods and wind tunnel data as were used for the basic 401B configuration of Section 3.

6.3.1 Minimum Drag

(U) The total minimum drag is plotted in Figure 6.3-1 for various altitudes. The minimum drag coefficient is higher at supersonic speeds because of a higher basic wave drag and no drag reduction due to curve tips, as discussed in Subsection 3.3.1. The net wave drag coefficient is .0030 higher at Mach 1.2 and .0043 higher at Mach 1.6.

(U) The drag component and growth curves of Figures 3.3-2 and 3.3-4 are applicable to this configuration.

6.3.2 Drag Due to Lift

(U) The drag due to lift shown in Figures 6.3-2 through 6.3-6 also is derived from the FX wind tunnel tests discussed in Section 3.3. The induced drag for the 0.4 taper-ratio wing is higher for the following reasons:

1. The increased wing cutout (i.e., increased trailing edge sweep) causes a reduction in $C_{L\alpha}$ and therefore a reduction in span efficiency since $1/e \propto 1/C_{L\alpha}$
2. The trapezoidal tips have less span than the curved tips; AR = 3.0 instead of 3.2.

The net result is that the 0.4 taper-ratio wing has about 10-percent higher induced drag at subsonic speeds and at Mach 1.2.

(U) The associated leading-edge-flap drag is plotted in Figure 6.3-7. It is essentially the same as that for the basic 401B airplane.

6.3.3 Trim Drag

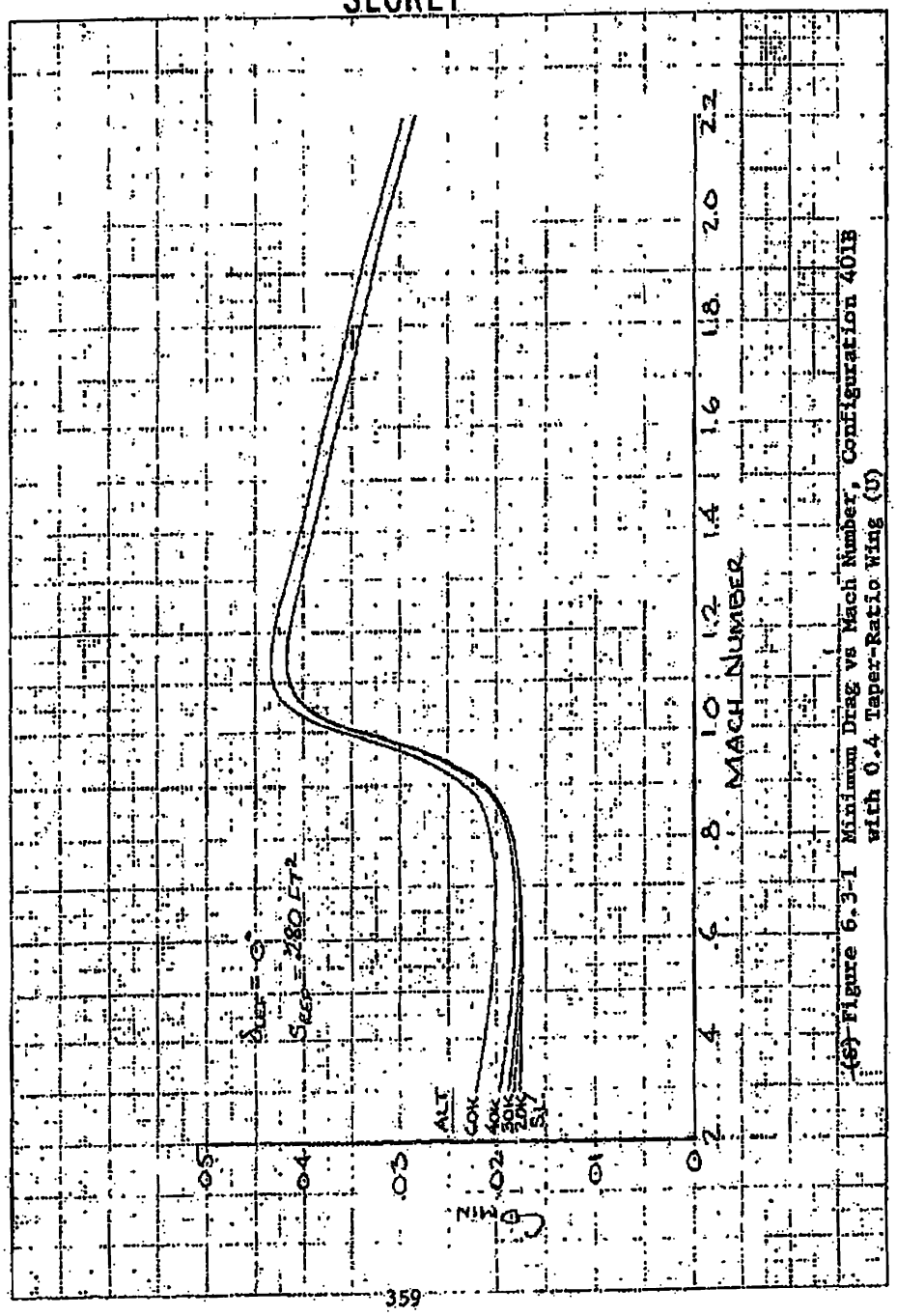
(U) The trim drag shown in Figure 3.3-13 for Configuration 401B also applies to the 0.4 taper-ratio wing.

6.3.4 Trimmed Drag Polars

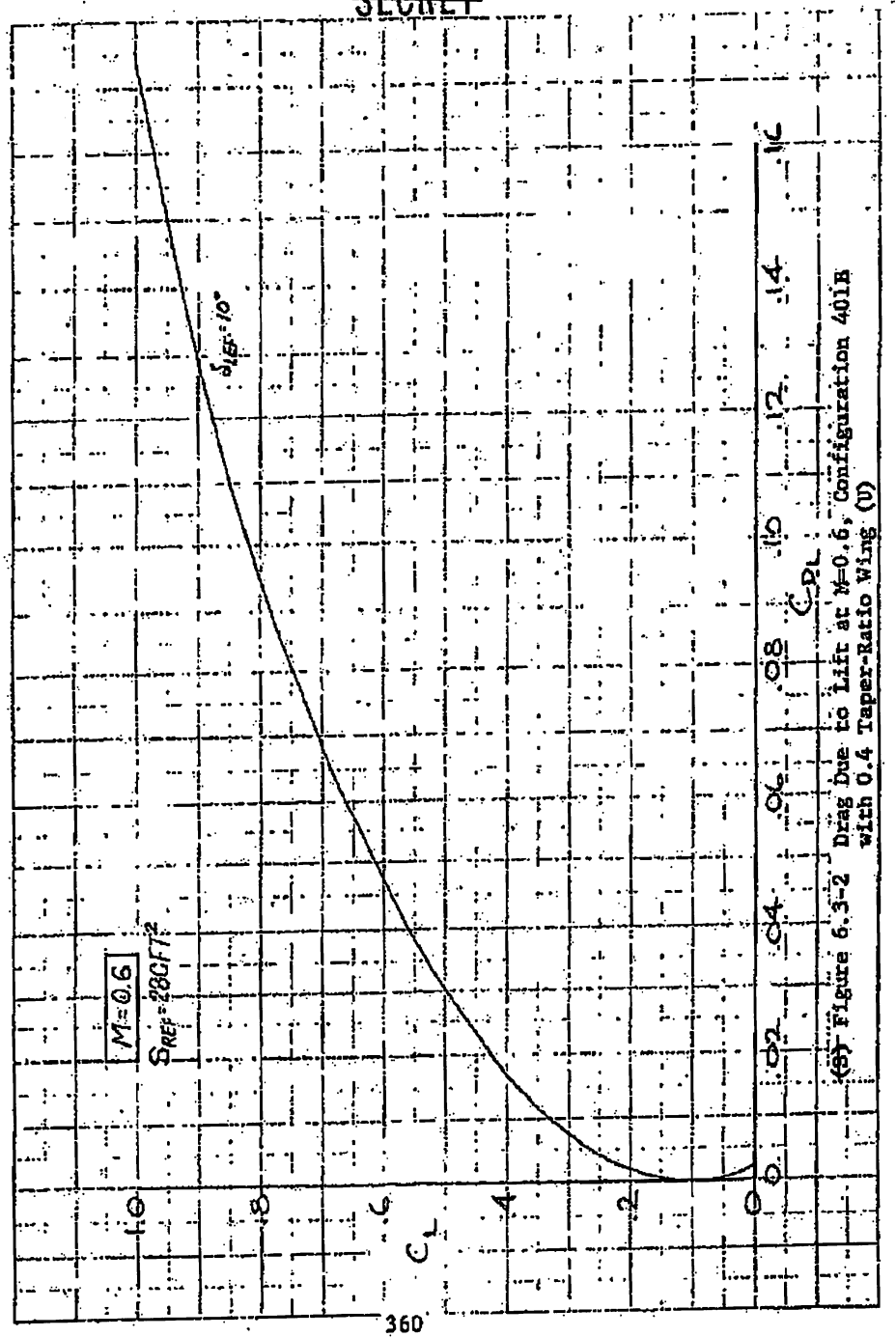
(U) The trimmed drag polars and configuration polars for 401B with the 0.4 taper-ratio wing are given in Figure 6.3-8 through 6.3-17. The $(L/D)_{max}$ data plotted in Figure 6.3-18 are, as expected, lower than similar data for the basic 401B configuration (see Figure 3.3-25).

6.3.5 Lift and Buffet Data

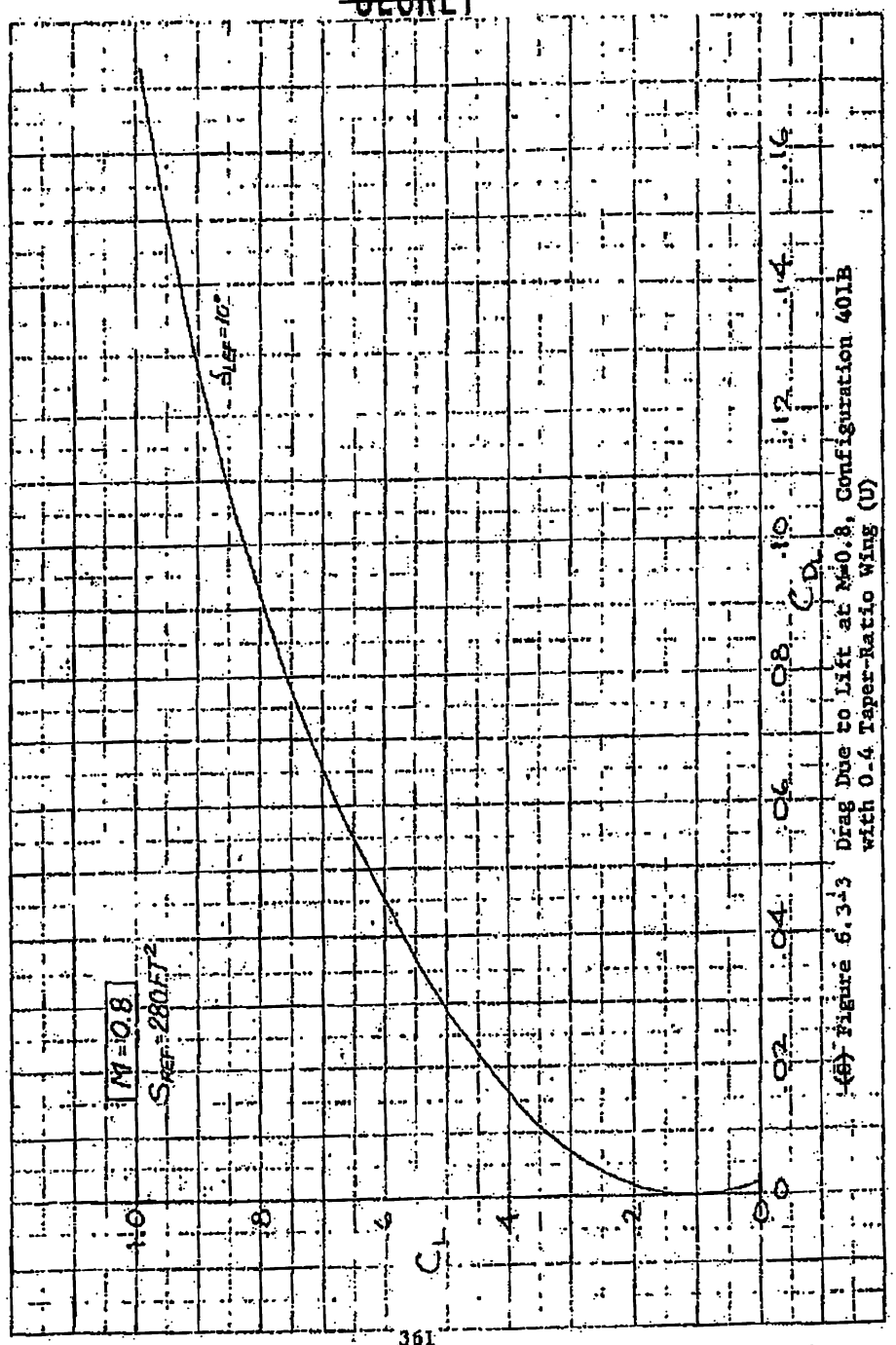
(U) The C_L-vs-α curves, control limit C_L's, and buffet boundaries shown in Figures 6.3-19 through 6.3-23 are derived from the same wind tunnel data as was used for the basic 401B. However, an adjustment for the change in taper ratio was made. This correction is small, since $C_{L\alpha}$ is reduced only about 3-percent from that of the basic 401B.



(S) Figure 6.3-1 Minimum Drag vs Mach Number, Configuration 4018 with 0.4 Taper-Ratio Wing (U)



(S) Figure 6.3-2 Drag Due to Lift at M=0.6, Configuration 401B with 0.4 Taper-Ratio Wing (U)



(U) Figure 6.3-3 Drag Due to Lift at M=0.8, Configuration 401B with 0.4 Taper-Ratio Wing (U)