2011-097 12 of 15

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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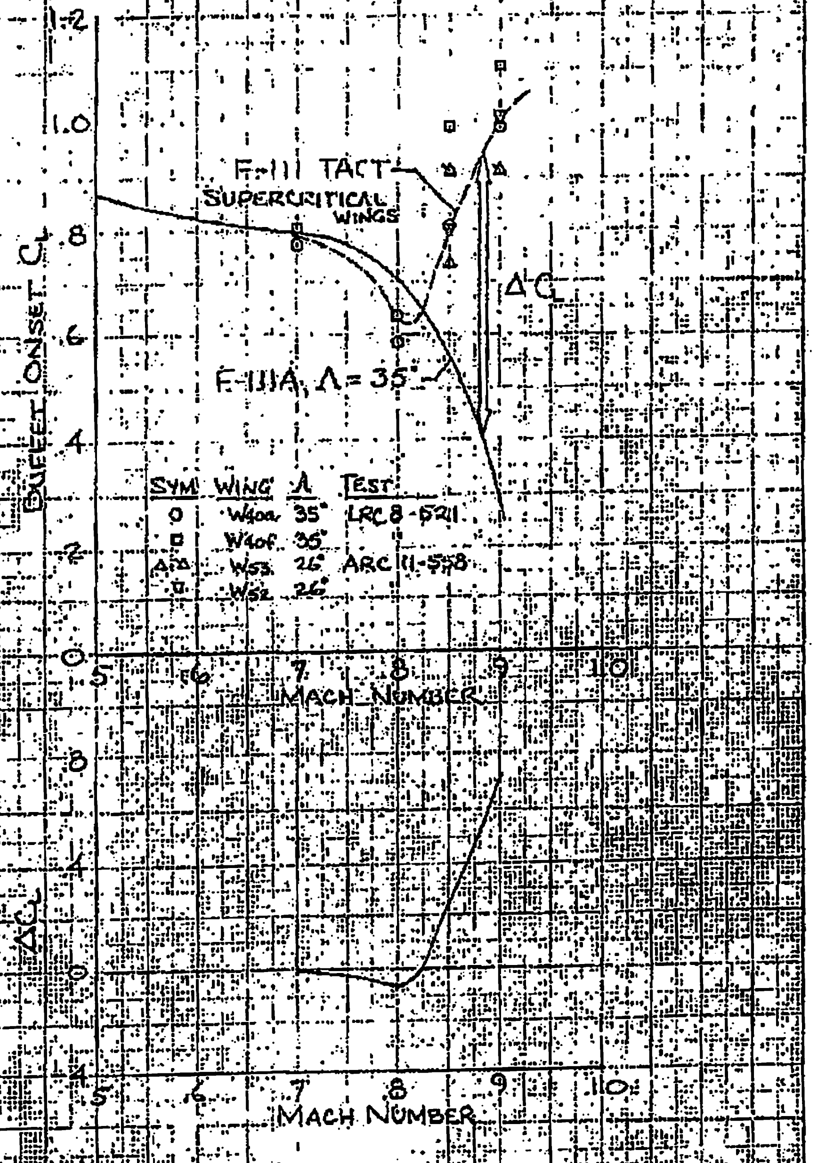

~~(S)~~ Figure 7.3-14 Effect of Supercritical Wing on Buffet Onset C_L for F-111 (U)

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7.4 PERFORMANCE

(U) The performance capabilities of Configuration 401B with the two supercritical airfoils (AR = 3.0 and 3.75) were evaluated for the same missions and ground rules as set forth in Section 3.2. Both wings have a wing loading of 60 psf and a leading-edge sweep of 45 degrees.

~~(S)~~ The LRASM and SRASM mission radius capabilities for the two design concepts are shown below for the 16,800-lb versions described in Section 7.2.

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3
~~(b)(4)~~ (6)(1)
~~1.4(a)(g)~~ 25
SEC 3.3(6)(4)
SEC 1.4(a)(g)

Aspect Ratio	Mission	Radius (n.mi)	$\dot{\theta}$ M0.8 (deg/sec)	$\dot{\theta}$ M1.2 (deg/sec)	Accel. Time (sec)
3.0	LRASM	802	10.65	7.42	56.9
	SRASM	244	11.50	8.10	52.1
3.75	LRASM	726	11.10	7.88	59.9
	SRASM	193	11.93	8.42	55.3

~~(S)~~ After the supercritical designs were evaluated at a fixed design weight of 16,800 lb, both designs were resized to meet the 225-n.mi SRASM radius requirement rather than the 750-n.mi LRASM radius requirement. This was done because of the poor supersonic performance of the supercritical airfoil design, which results in more fuel required for combat. The SRASM does not have enough cruise distance for the better cruise L/D offered by the supercritical wing to compensate for added combat fuel requirement, as is the case with the LRASM.

~~(S)~~ The reference areas of the supercritical wings changed from 280 sq ft to 277.3 sq ft for the aspect-ratio 3.0 wing and to 385.2 sq ft for the aspect ratio 3.75 wing. The following corrections, obtained from the growth data presented in Section 3.3, were added to the basic aerodynamic data of Section 7.3 to account for the change in aircraft size and wing area.

Mach No.	ΔC_D AR 3.0	ΔC_D AR 3.75
0.6	.00008	-.00015
0.8	.00008	-.00015
0.9	.00008	-.00017
1.2	.00034	-.00062
1.5	.00031	-.00056

(U) The weight data presented in Section 7.6 were corrected for change in aircraft size through use of the growth data presented in Section 3.5. A summary of the corrected weight data is presented in Table 7.4-1 for the aspect-ratio 3.0 wing and in Table 7.4-2 for the aspect-ratio 3.75 wing.

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

~~(S)~~ Summaries of the mission capabilities of the resized aircraft are presented in Figures 7.4-1 and -2. A comparison with the basic 401B configuration is presented below:

88th ABW/IPI
~~FOIA (b)(1)~~ FOIA (b)(1)
~~E.O. 13526 SEC. 3.3. (b)(4)~~ 13526
~~1.4(a)(g)~~ SEC. 3.3 (b)(4)
SEC 1.4(a)(g)

Config.	Mission Weight (lb)	LRASM Radius (n.mi)	$\dot{\theta}$ M0.8 (deg/sec)	$\dot{\theta}$ M0.9 (deg/sec)	$\dot{\theta}$ M1.2 (deg/sec)
Basic 401B	17,115	750	9.8	10.2	8.1
AR 3.0	16,640	767	10.6	11.3	7.5
AR 3.75	17,115	794	11.0	11.8	7.7

Config.	Accel. Time (sec)	Max. Mach No.
Basic 401B	35.5	2.35
AR 3.0	55.8	1.79
AR 3.75	62.6	1.77

Mission weight listed above is full-up weight with mission payload and without tanks. This is the SRASM takeoff gross weith and the LRASM weight at start of combat.

(U) The supercritical airfoil design with an aspect ratio of 3.75 is the same-size aircraft as the basic 401B configuration and has a 1.2-deg/sec increase in subsonic turn rate (approximately 10 percent increase). The supersonic design with an aspect ratio of 3.0 is of slightly smaller size than the basic 401B and has an 0.8-deg/sec increase in subsonic turn rate. Both supercritical airfoil configurations perform worse at supersonic speeds than does the basic 401B configuration. This is caused by the increased wave drag associated with the thicker airfoil section and blunter leading edge.

(U) Tabulations of the pertinent data for each segment of the three missions are presented in Tables 7.4-3 through

(U) 7.4-8. General performance data are presented in Figures 7.4-3 through 7.4-22. Sensitivity of mission weight to weight-empty variations is presented in Figure 7.4-23 for the aspect-ratio 3.0 wing and in Figure 7.4-24 for the aspect ratio 3.75 wing.

~~(S)~~ Table 7.4-1 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING WEIGHT SUMMARY

(16,640-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	11,779
Ammunition (500 Rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,228
SRASM Takeoff Gross Weight	16,640
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	21,478
Basic Operating Weight	11,779
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	397
SRASM and LRASM Landing Weight	12,318
2. FERRY MISSION	
Basic Operating Weight	11,779
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	11,940
Internal Fuel	4,228
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	26,825
Zero Fuel Weight	11,940
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	654
Twenty-Minute Sea-Level Loiter	484
Landing Weight	14,892

~~(S)~~ Table 7.4-2 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING WEIGHT SUMMARY

(17,115-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	12,249
Ammunition (500 Rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,233
SRASM Takeoff Gross Weight	17,115
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	21,953
Basic Operating Weight	12,249
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	379
SRASM and LRASM Landing Weight	12,770
2. FERRY MISSION	
Basic Operating Weight	12,249
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	12,410
Internal Fuel	4,233
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	27,300
Zero Fuel Weight	12,410
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	654
Twenty-Minute Sea-Level Loiter	470
Landing Weight	15,348

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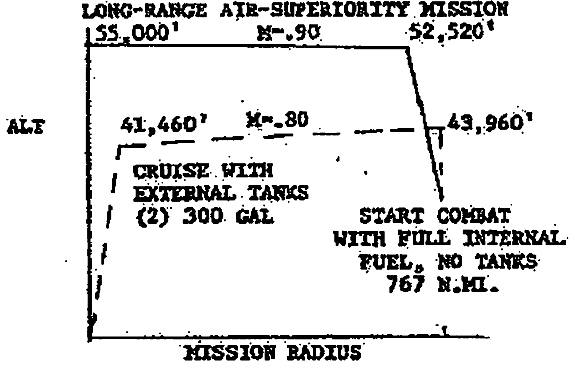
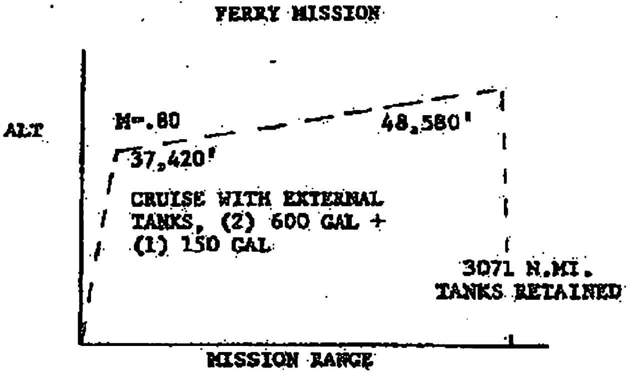
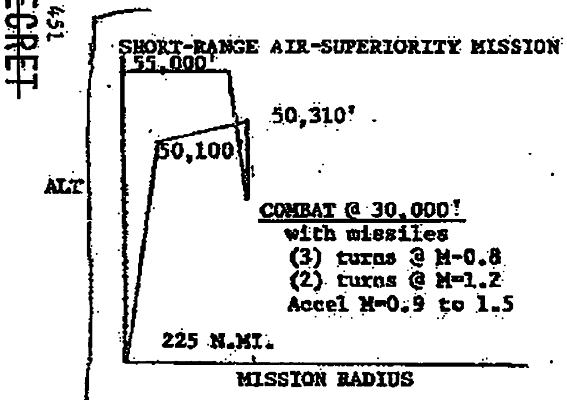
(16,640-lb A/P W/O Tanks)







LONG-RANGE AIR-SUPERIORITY MISSION		
Takeoff Gross Weight	21,478	lb
Takeoff Distance over 50 ft	1,940	ft
Landing Distance over 50 ft	3,300	ft
Accel Time, M=0.9 to 1.5	55.8	sec
Turn Rate @ M=0.8	10.6	deg/sec
Turn Rate @ M=1.2	7.5	deg/sec
SHORT-RANGE AIR-SUPERIORITY MISSION		
Takeoff Gross Weight	16,640	lb
Takeoff Distance over 50 ft	1,310	ft
Landing Distance over 50 ft	3,300	ft
Accel Time, M=0.9 to 1.5	51.1	sec
Turn Rate @ M=20.8	11.4	deg/sec
Turn Rate @ M=1.2	8.2	deg/sec

~~(S)~~ Figure 7.4-1 Configuration 401B with Aspect Ratio 3.0 Supercritical Wing Mission Performance Summary (U)

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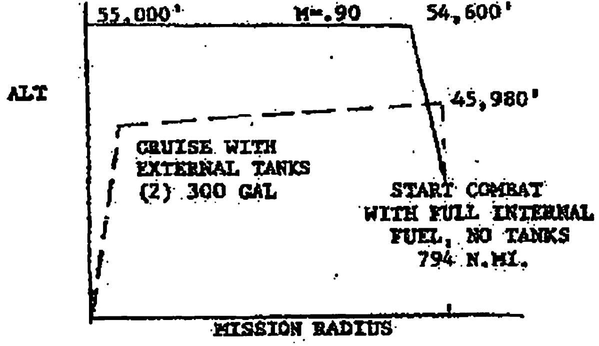
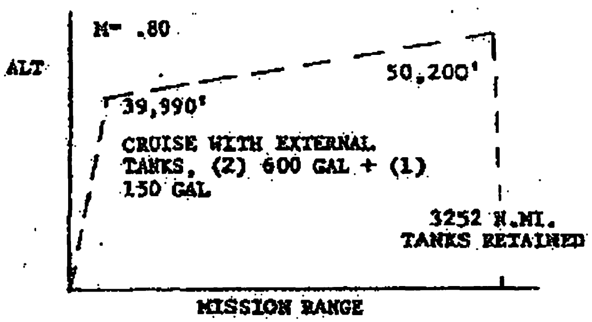
(17,115-lb A/P W/O Tanks)

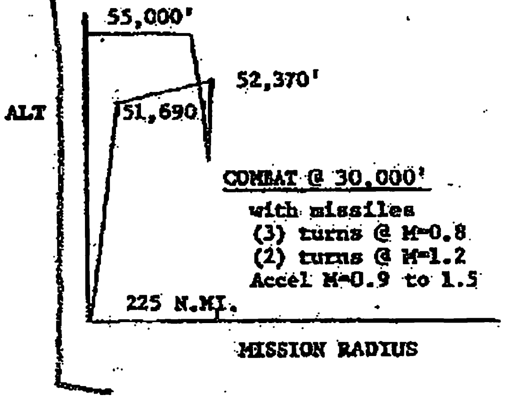
LONG-RANGE AIR-SUPERIORITY MISSION



FERRY MISSION



SHORT-RANGE AIR-SUPERIORITY MISSION



LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	21,953 lb
Takeoff Distance over 50 ft	1,970 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	62.6 sec
Turn Rate @ M=20.8	11.0 deg/sec
Turn Rate @ M=1.2	7.7 deg/sec

SHORT-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	17,115 lb
Takeoff Distance over 50 ft	1,330 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	57.2 sec
Turn Rate @ M=20.8	11.7 deg/sec
Turn Rate @ M=12.	8.3 deg/sec

~~(S)~~ Figure 7.4-2 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Mission Performance Summary (U)

88th ABW/IPI
FOIA (b)(1) a w/ PPT
E.O. 13526 SEC 3.3 (b)(4)
2 (a)(b)
EO 13526 SEC 3.3 (b)(4)
SEC 1.4(a)(2)
PGS 453-480

~~(S)~~ Table 7.4-3 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL 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 C_L	Combat g's
Initial Weight	0	0	21478								
Ground Operation				321	0	0					
	0	0	21157								
Accel to Climb Speed				241	0	.10					
	0.50	0	20916				2520	.875	7.42		
Climb to Cruise Alt.				511	42	.10					
	0.80	41463	20405				1923	.835	10.71		
Outbound Cruise				2397	723	1.59					
	0.80	43961	18008								
Drop Tanks				1368	0	0					
(847#Tank+521#Fuel)	0.80	43961	16640								
Combat				(2145)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		555	0	.02					
(2)M1.2 Turns	1.2	30000		910	0	.02				.432	4.88
(2)M0.8 Turns	0.8	30000		680	0	.03				.917	4.61
	0.90	30000	14495								
Drop Payload				348	0	0					
	0.90	30000	14147								
Drop ½ Ammo				143	0	0					
	0.90	30000	14004				2269	.887	5.89		
Climb to Cruise Alt.				166	32	.06					
	0.90	52517	13838				1275	.886	10.98		
Return Cruise				1520	735	1.42					
	0.90	55000	12318								
Descend				0	0	0					
	0.25	0	12318				1025	1.175	12.07		
Landing Reserves (20-Min. Loiter S.L.)				397	0	.33					
Zero-Fuel Weight			11921								

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3.(b)(4)
1.4. (a)(g)

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~~(S)~~ Table 7.4-4 CONFIGURATION 401B WITH ASPECT RATIO 3.0
SUPERCRITICAL WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (Ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat ε s
Initial Weight	0	0	16640								
Ground Operation				232	0	0					
	0	0	16408								
Accel to Climb Speed				183	0	.10					
	0.50	0	16225				2039	.875	6.50		
Climb to Cruise Alt.				462	49	.11					
	0.90	50097	15763				1466	.872	10.81		
Outbound Cruise				432	176	.34					
	0.90	50312	15331								
Combat				(1970)		(.06)					
Accel M0.9-M1.5	0.9-1.5	30000		505	0	.01					
(2)M1.2 Turns	1.2	30000		845	0	.03				.431	5.28
(3)M0.8 Turns	0.8	30000		620	0	.02				.910	4.94
			13361								
Drop Payload				348	0	0					
	0.90	30000	13013								
Drop ½ Ammo				143	0	0					
	0.90	30000	12870				2253	.876	5.42		
Climb to Cruise Alt.				173	37	.07					
	0.90	55000	12697				1167	.885	10.93		
Return Cruise				379	188	.36					
	0.90	55000	12318								
Descend				0	0	0					
	0.25		12318				1025	1.175	12.07		
Landing Reserves (20 Min. Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			11921								

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4 (a)(g)

~~(S)~~ Table 7.4-5 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Treq	Initial TSFC	Initial L/D	Combat C_L	Combat R's
Initial Weight	0	0	26825								
Ground Operation				387	0	0					
	0	0	26438								
Accel to Climb Speed				307	0	.11					
	0.50	0	26131				2845	.875	8.53		
Climb to Cruise Alt.				627	46	.11					
	0.80	37424	25504				2485	.825	10.37		
Cruise w/(2)Ext.Tanks				10612	3025	6.60					
	0.80	48576	14892								
Descend				0	0	0					
	0.20	0	14892				1315	.973	9.98		
Landing Reserves				(1138)							
(20Min.Loiter S.L.)				484							
(5% Initial Fuel)				654							
Zero-Fuel Weight			13754								

88th ABW/IPI
FOIA (b)(1)
~~E.O 13526 SEC. 3.3 (b)(4)~~
1.4. (a)(g)

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~~(S)~~ Table 7.4-6 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING LRASM MISSION TABULATION(U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	21953								
Ground Operation				327	0	0					
	0	0	21626								
Accel to Climb Speed				247	0	.10					
	0.50	0	21379				2513	0.875	7.65		
Climb to Cruise Alt.				551	48	.11					
	0.80	43499	20828				1794	0.839	11.73		
Outbound Cruise				2315	746	1.44					
	0.80	45980	18513								
Drop Tanks				1398	0	0					
(847#Tank+521#Fuel)	0.80	45980	17115								
Combat				(2179)		(.08)					
Accel M0.9-M1.5	0.9-1.5	30000		635	0	.02					
(2)M1.2 Turns	1.2	30000		895	0	.03				.441	4.97
(2)M0.8 Turns	0.8	30000		649	0	.03				.949	4.75
	0.90	30000	14936								
Drop Payload				348	0	0					
	0.90	30000	14588								
Drop ½ Ammo				143	0	0					
	0.90	30000	14445				2305	0.887	6.00		
Climb to Cruise Alt.				193	40	.08					
	0.90	54606	14252				1198	0.892	11.99		
Return Cruise				1482	754	0					
	0.90	55000	12770								
Descend				0	0	0					
	0.24	0	12770				949	1.213	13.51		
Landing Reserves (20-Min.Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			12391								

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4.(a)(g)

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~~(S)~~ Table 7.4-7 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	17115								
Ground Operation				238	0	0					
	0	0	16877								
Accel to Climb Speed				188	0	.10					
	0.50	0	16689				2054	0.875	6.72		
Climb to Cruise Alt.				493	55	.12					
	0.90	51687	16196				1387	0.878	11.81		
Outbound Cruise				396	170	.33					
	0.90	52372	15800								
Combat				(2004)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		580	0	.02					
(2)M1.2 Turns	1.2	30000		825	0	.02				.440	5.38
(3)M0.8 Turns	0.8	30000		599	0	.03				.929	5.04
			13796								
Drop Payload				348	0	0					
	0.90	30000	13448								
Drop ½ Ammo				143	0	0					
	0.90	30000	13305				2296	0.887	5.53		
Climb to Cruise Alt.				175	37	.07					
	0.90	55000	13130				1107	0.899	11.90		
Return Cruise				360	188	.36					
	0.90	55000	12770				949	1.213	13.51		
Descend				0	0	0					
	0.24	0	12770								
Landing Reserves (20 Min. Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			12391								

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

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~~(S)~~ Table 7.4-8 CONFIGURATION 401B WITH ASPECT RATIO 3.75
SUPERCRITICAL WING FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Treq	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	27300								
Ground Operation				392	0	0					
	0	0	26908								
Accel to Climb Speed				312	0	.11					
	0.50	0	26596				2827	0.875	9.02		
Climb to Cruise Alt.				678	55	.13					
	0.80	39985	25918				2292	0.828	11.28		
Cruise w/(2)Ext.Tanks				10570	3197	6.97					
	0.80	50201	15348								
Descend				0	0	0					
	0.26	0	15348				1301	1.095	11.85		
Landing Reserves				(1124)							
(20Min.Loiter S.L.)				470							
(5% Initial Fuel)				654							
Zero-Fuel Weight			14224								

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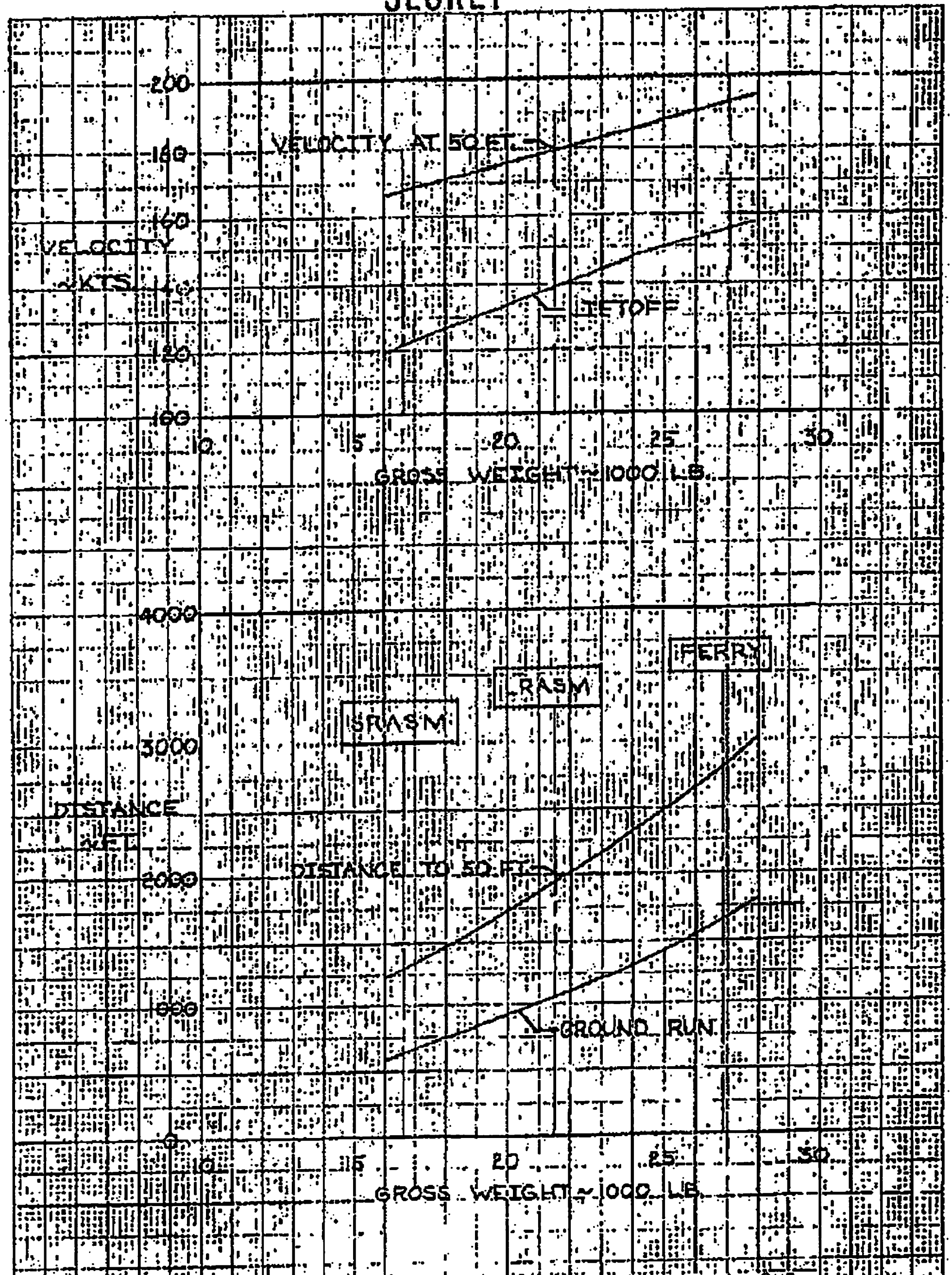
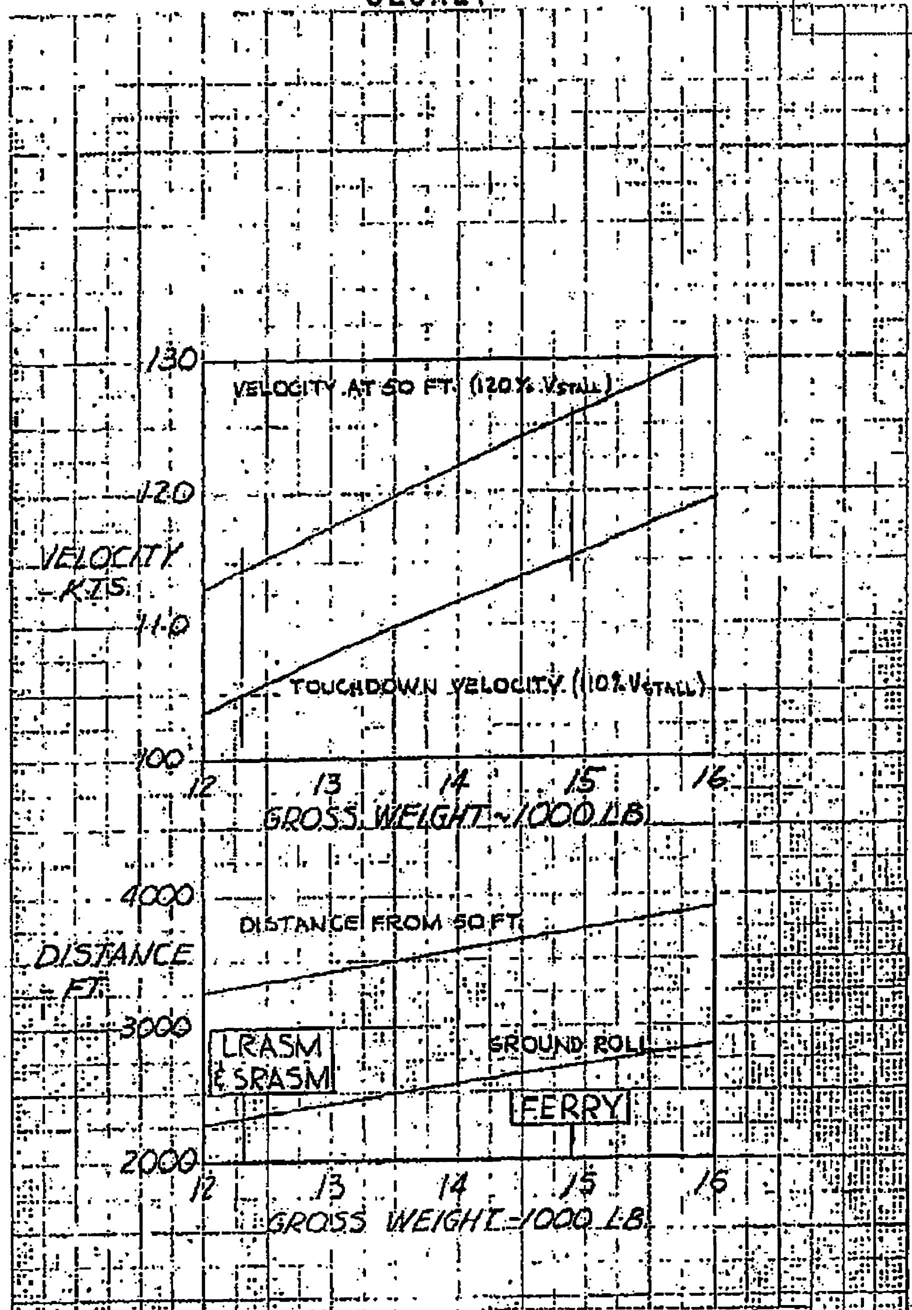
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

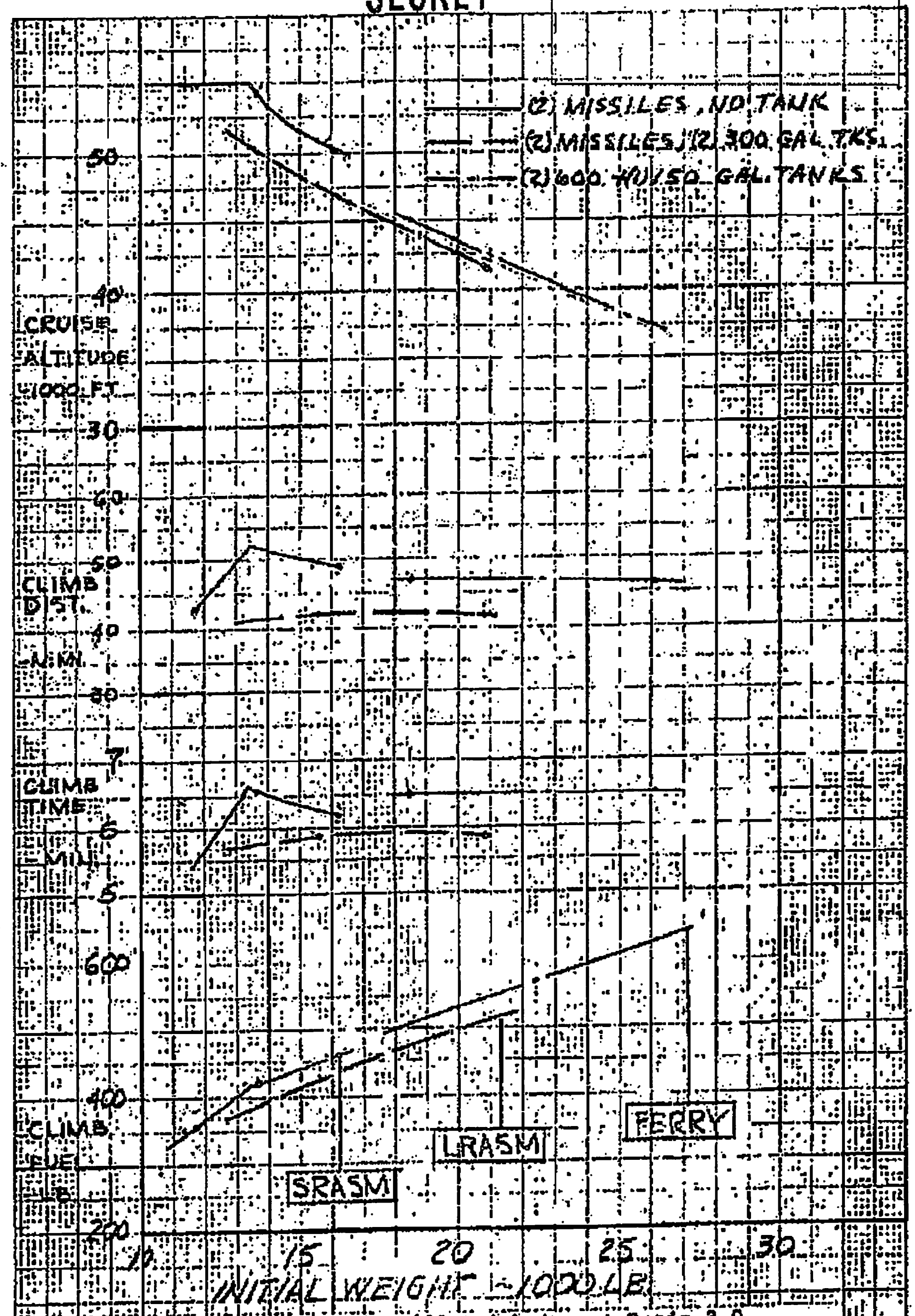


~~(S)~~ Figure 7.4-3 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Takeoff Performance (U)

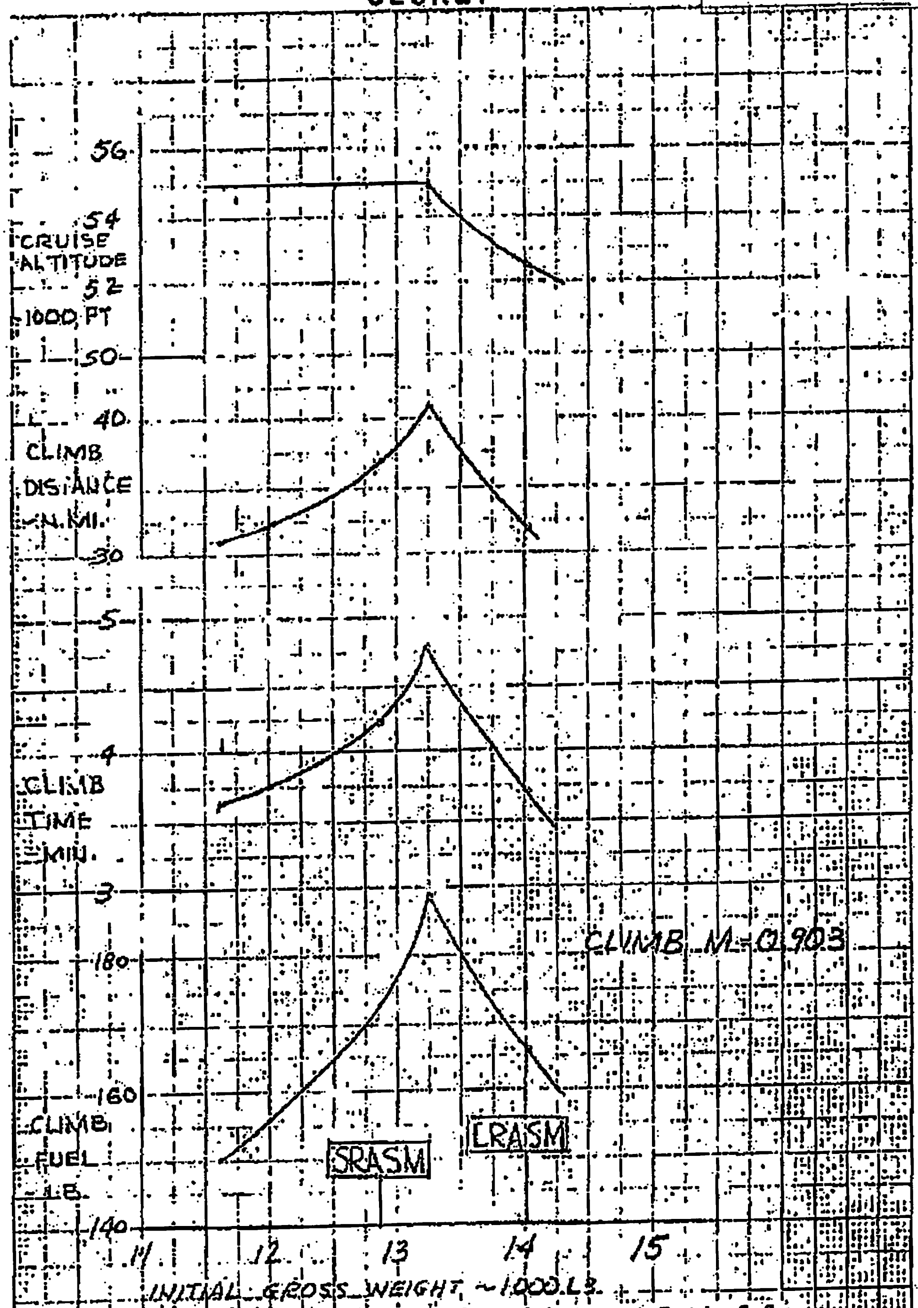


~~(S)~~ Figure 7.4-4 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Landing Performance (U)

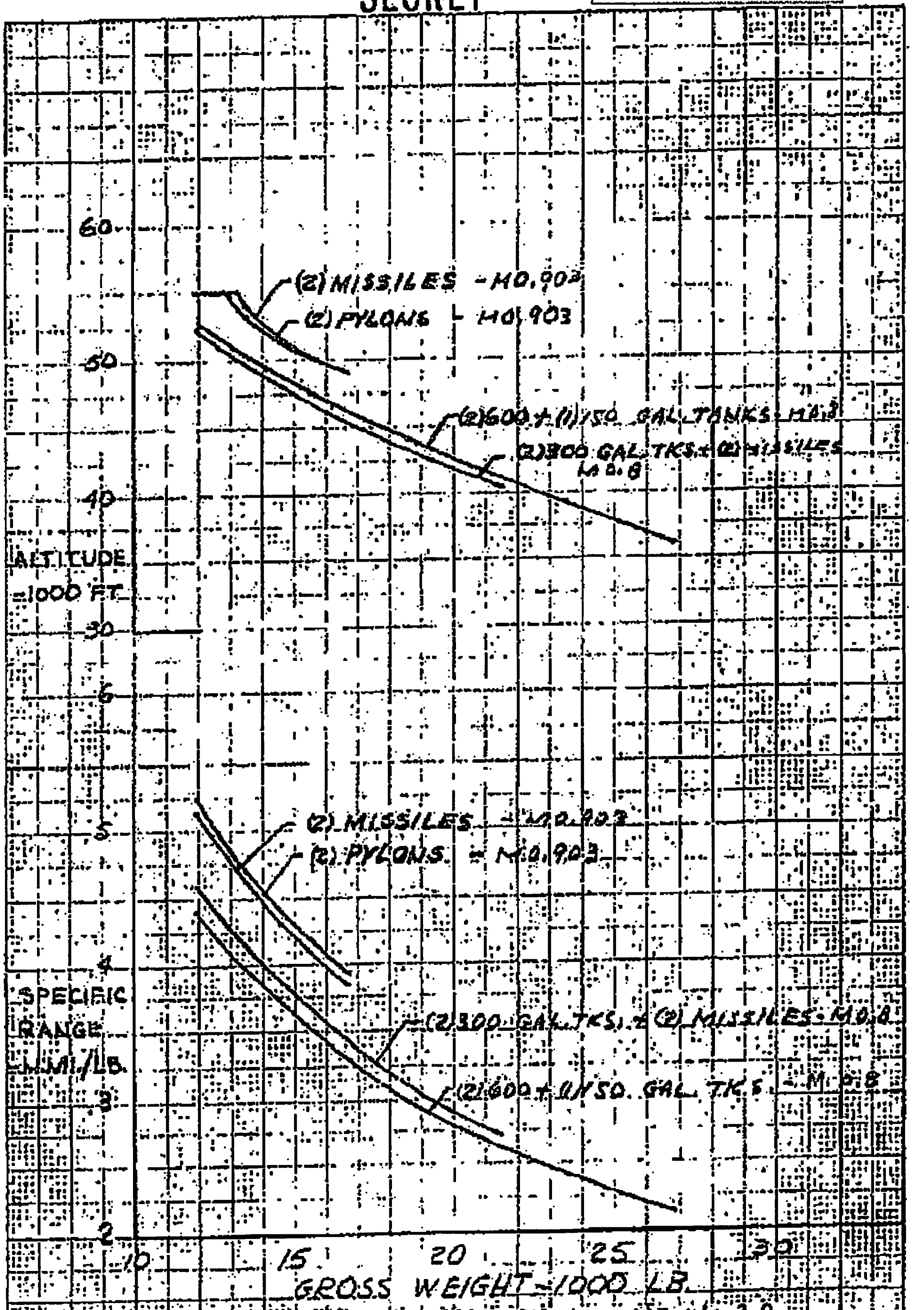
88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



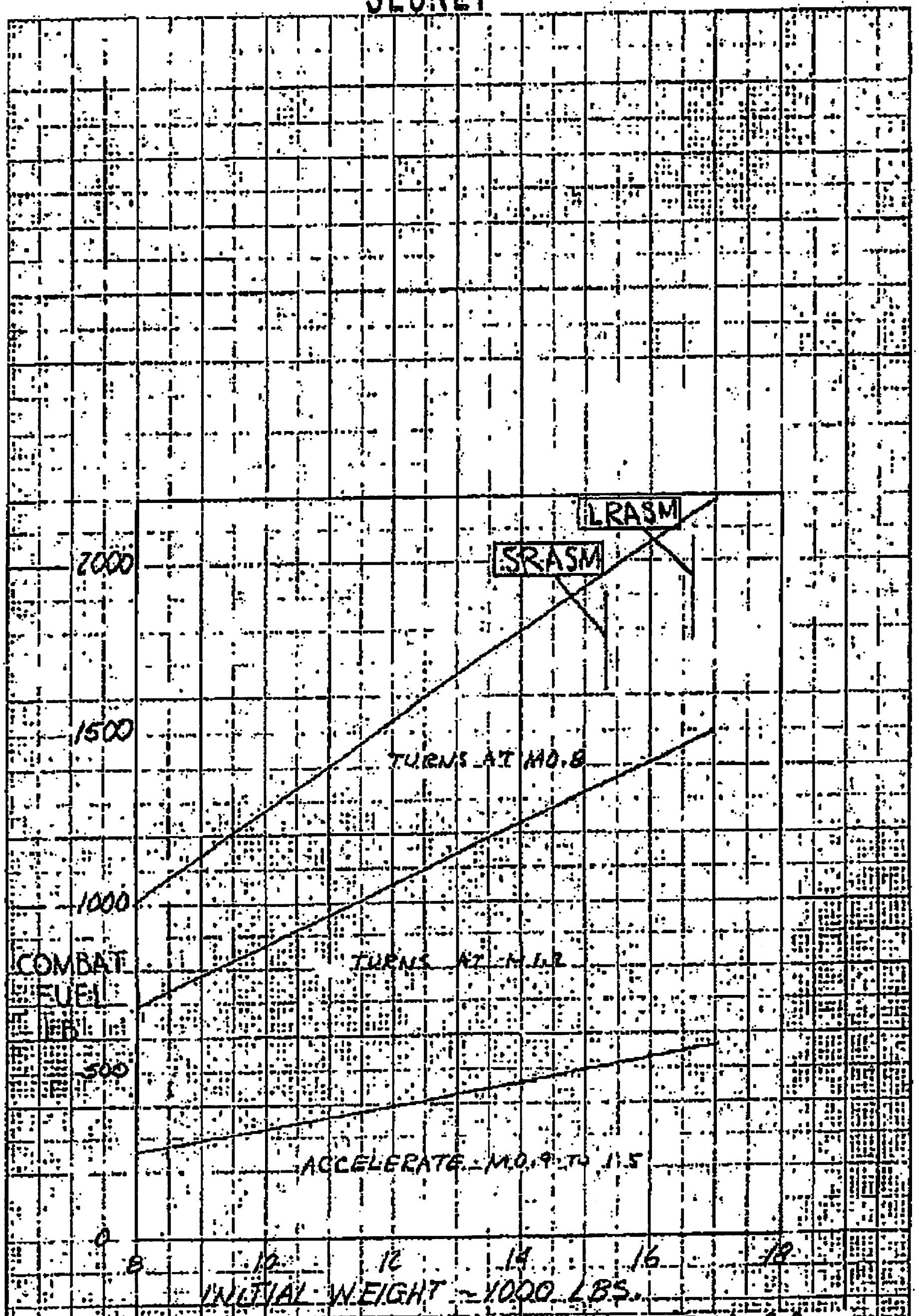
~~(S)~~ Figure 7.4-5 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Initial Climb Performance (U)



~~(S)~~ Figure 7.4-6 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Climb After Combat (U)

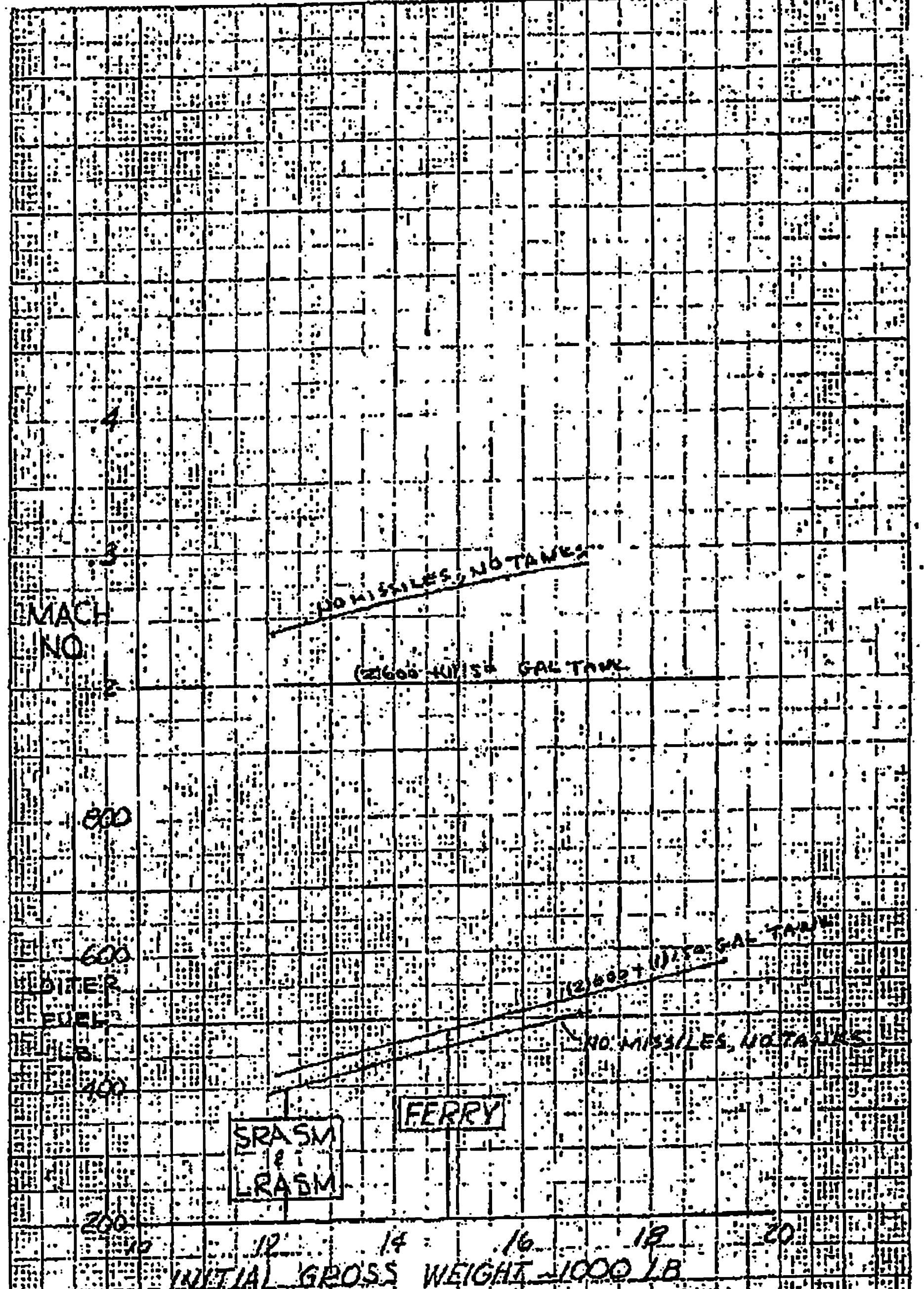


~~(S)~~ Figure 7.4-7 Configuration 401B with Aspect Ratio 3.0 Supercritical Wing Cruise Performance (U)



~~(S)~~ Figure 7.4-8 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Combat Fuel Allowance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-9 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Sea-Level Loiter Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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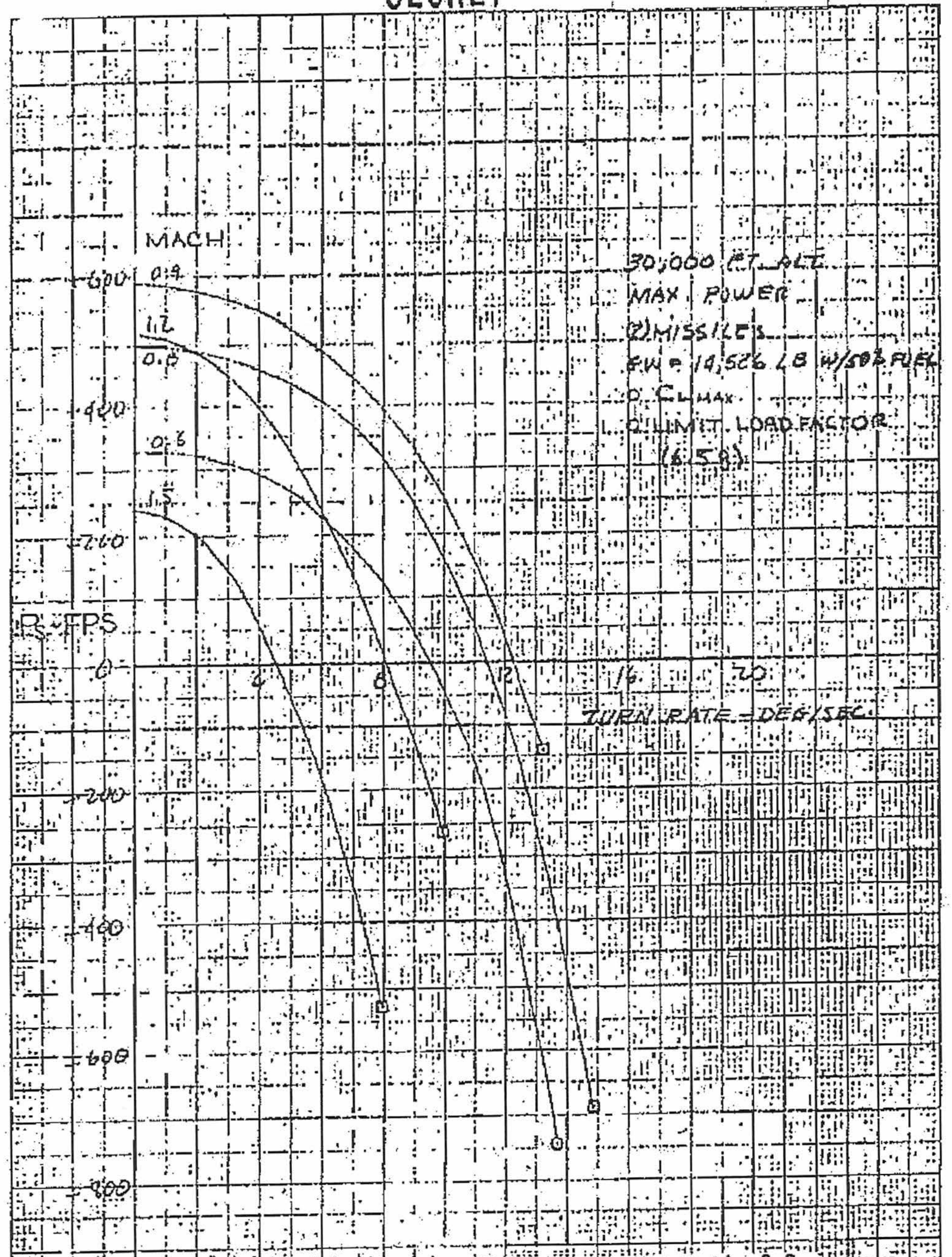

~~(S)~~ Figure 7.4-10 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Turning Performance (U)

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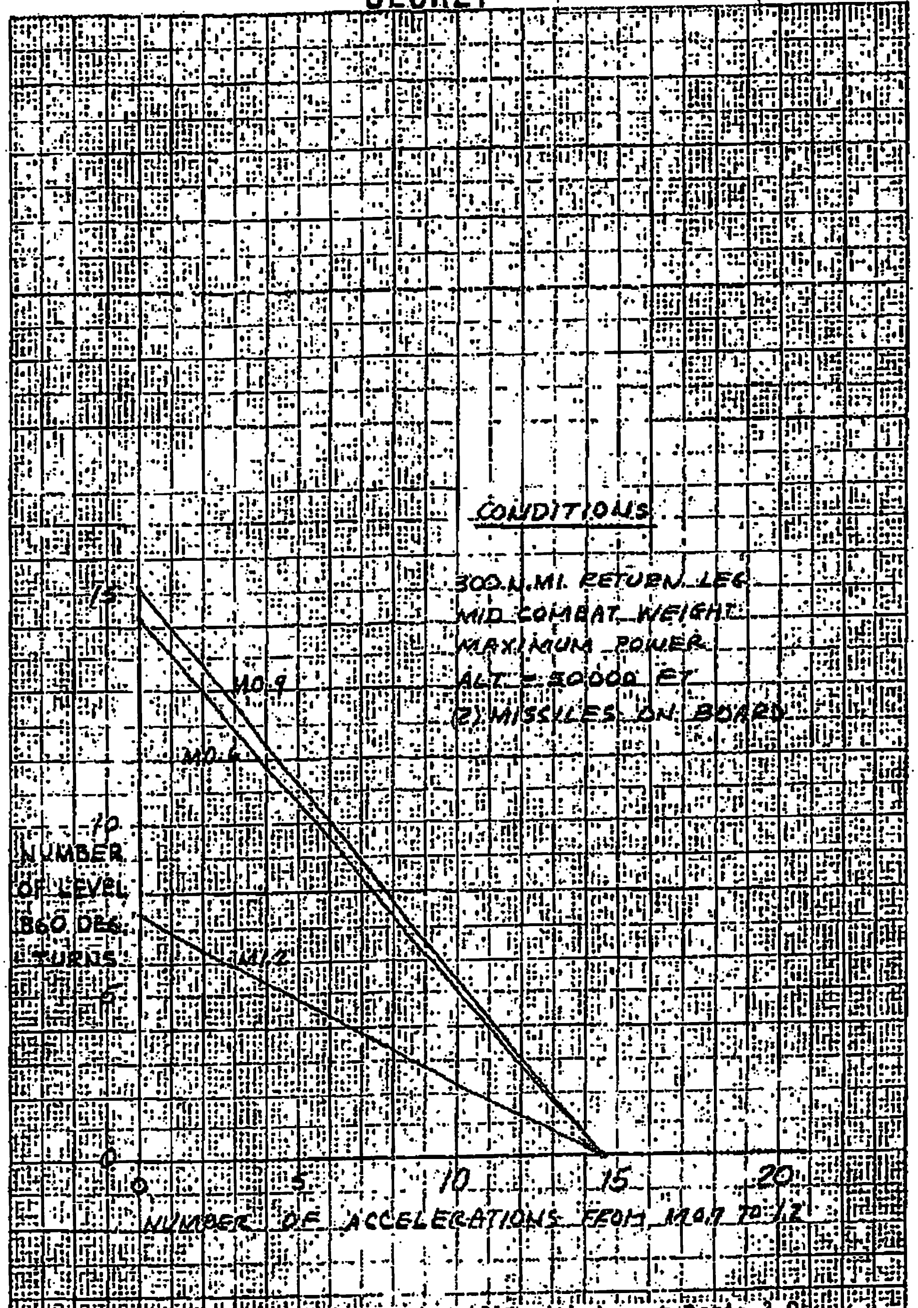

~~(S)~~ Figure 7.4-11 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Persistence Plot (U)

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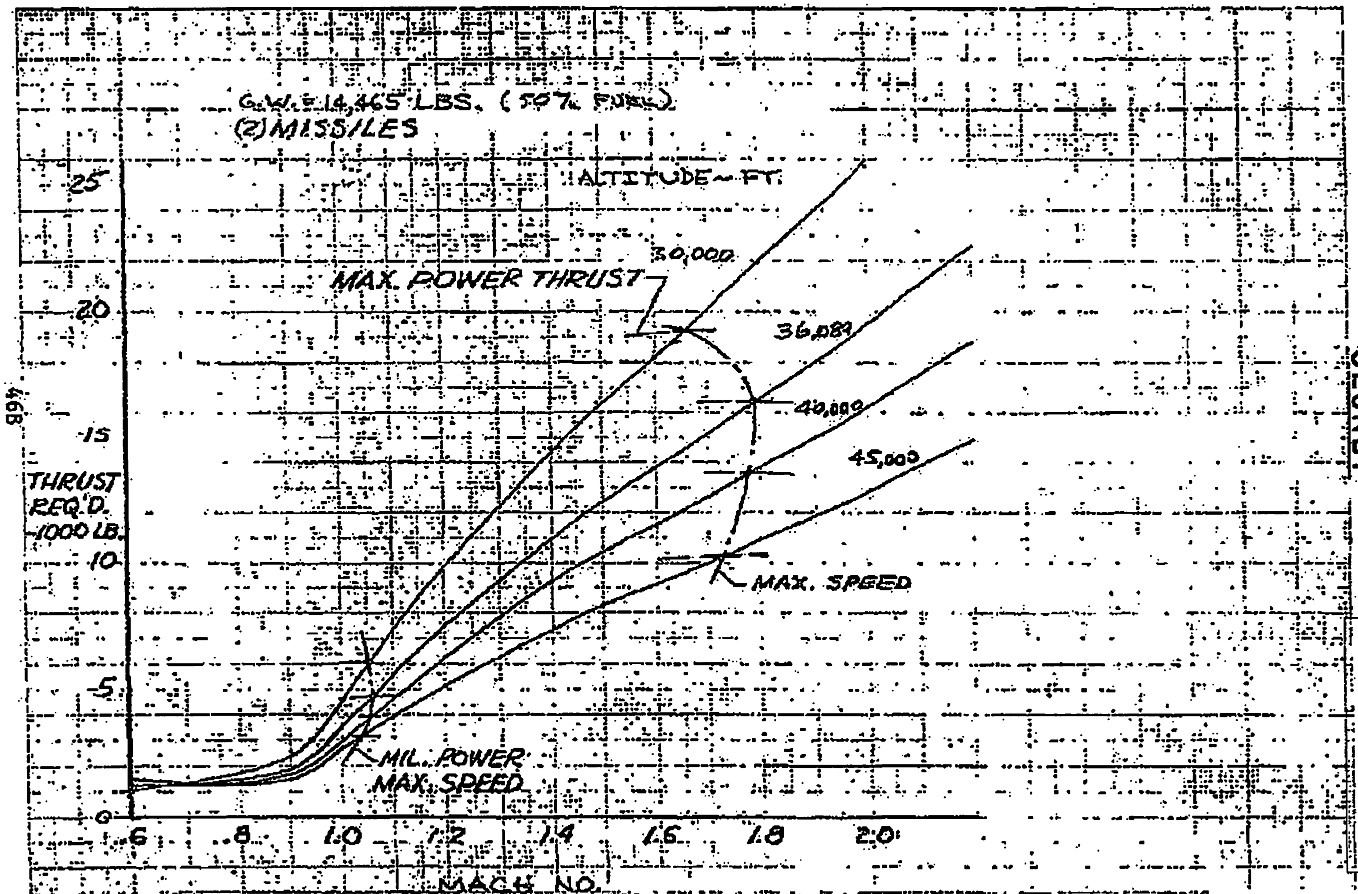

(S) Figure 7.4-12 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Thrust Required (U)

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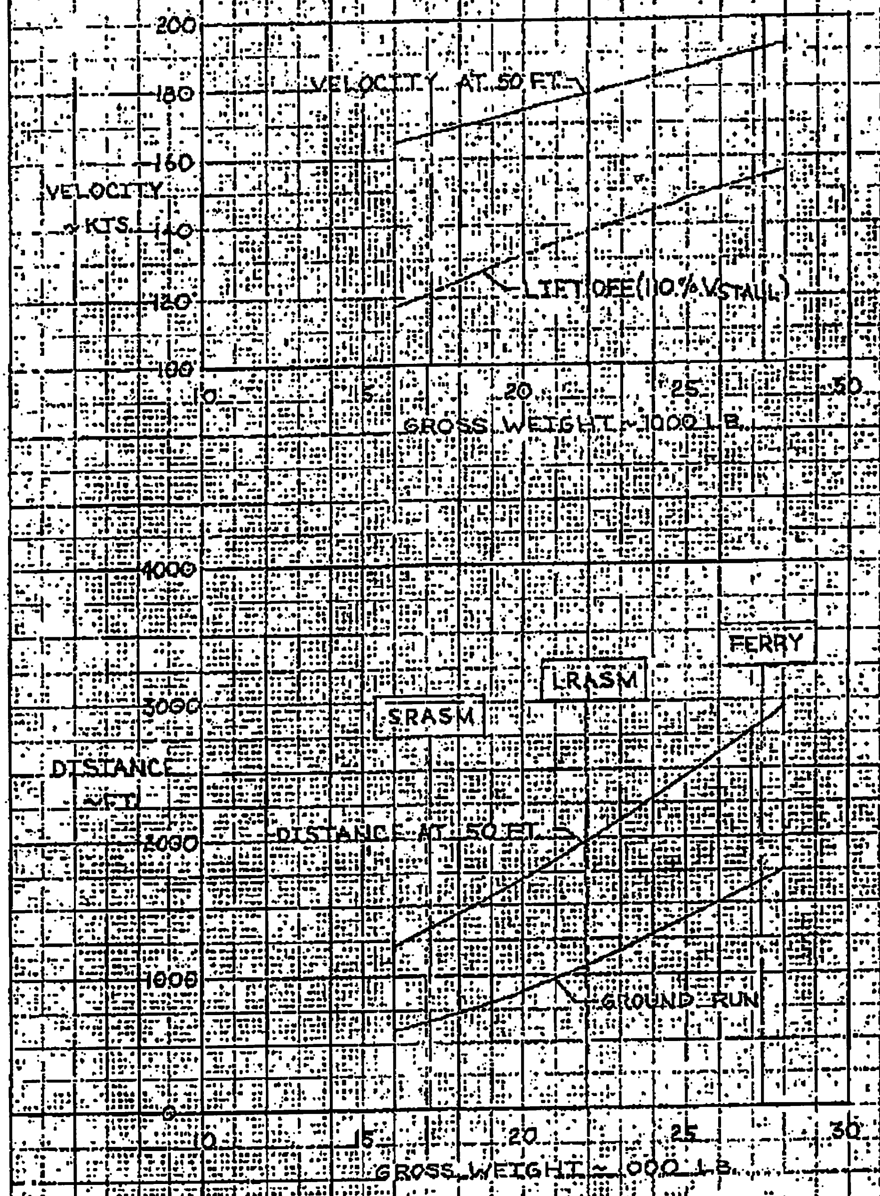
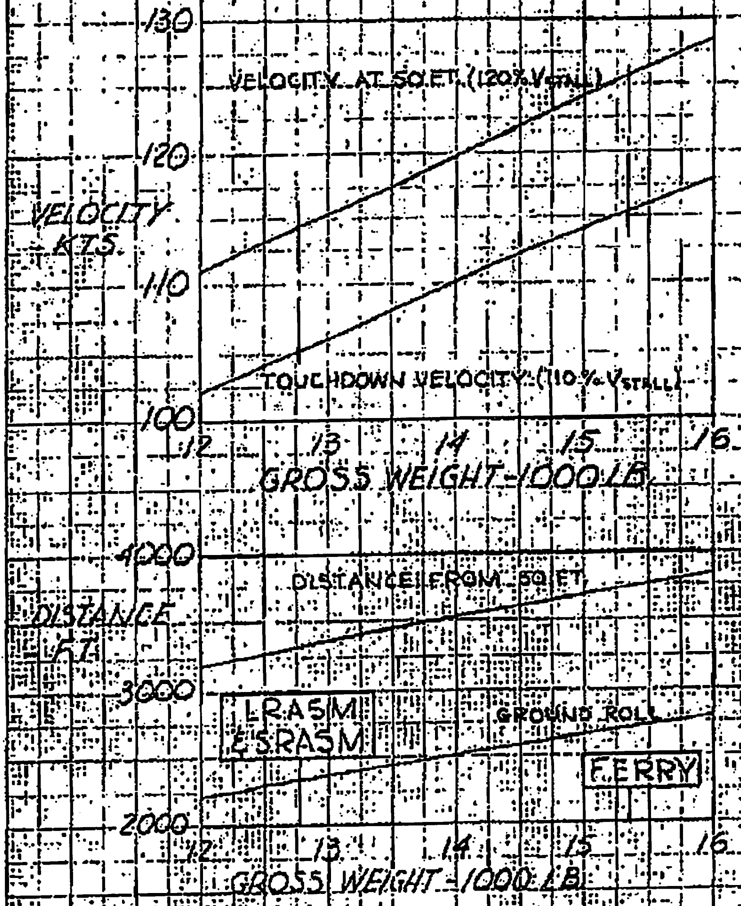
~~88th ABW/IP~~
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



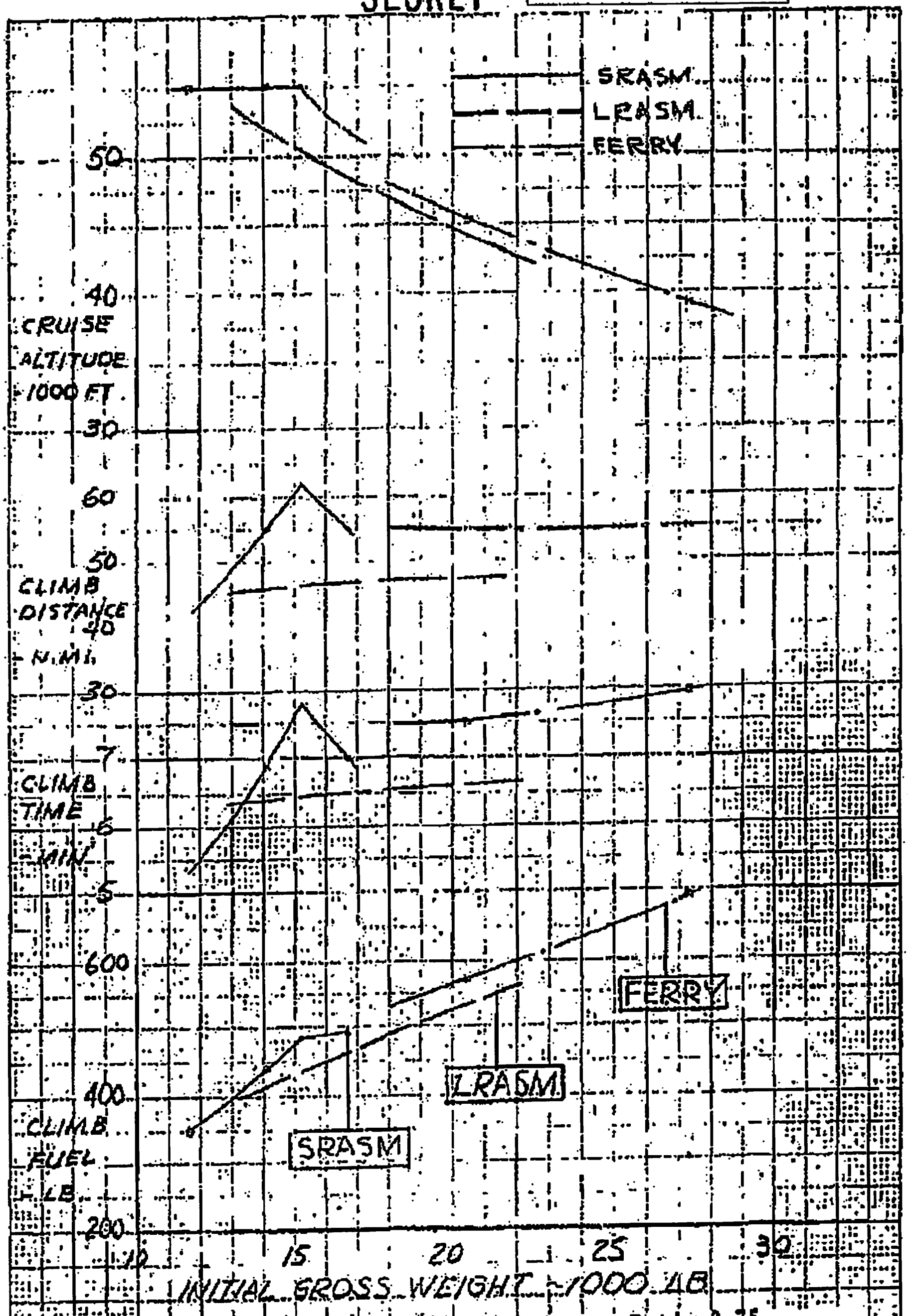
~~(S)~~ Figure 7.4-13 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Takeoff Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



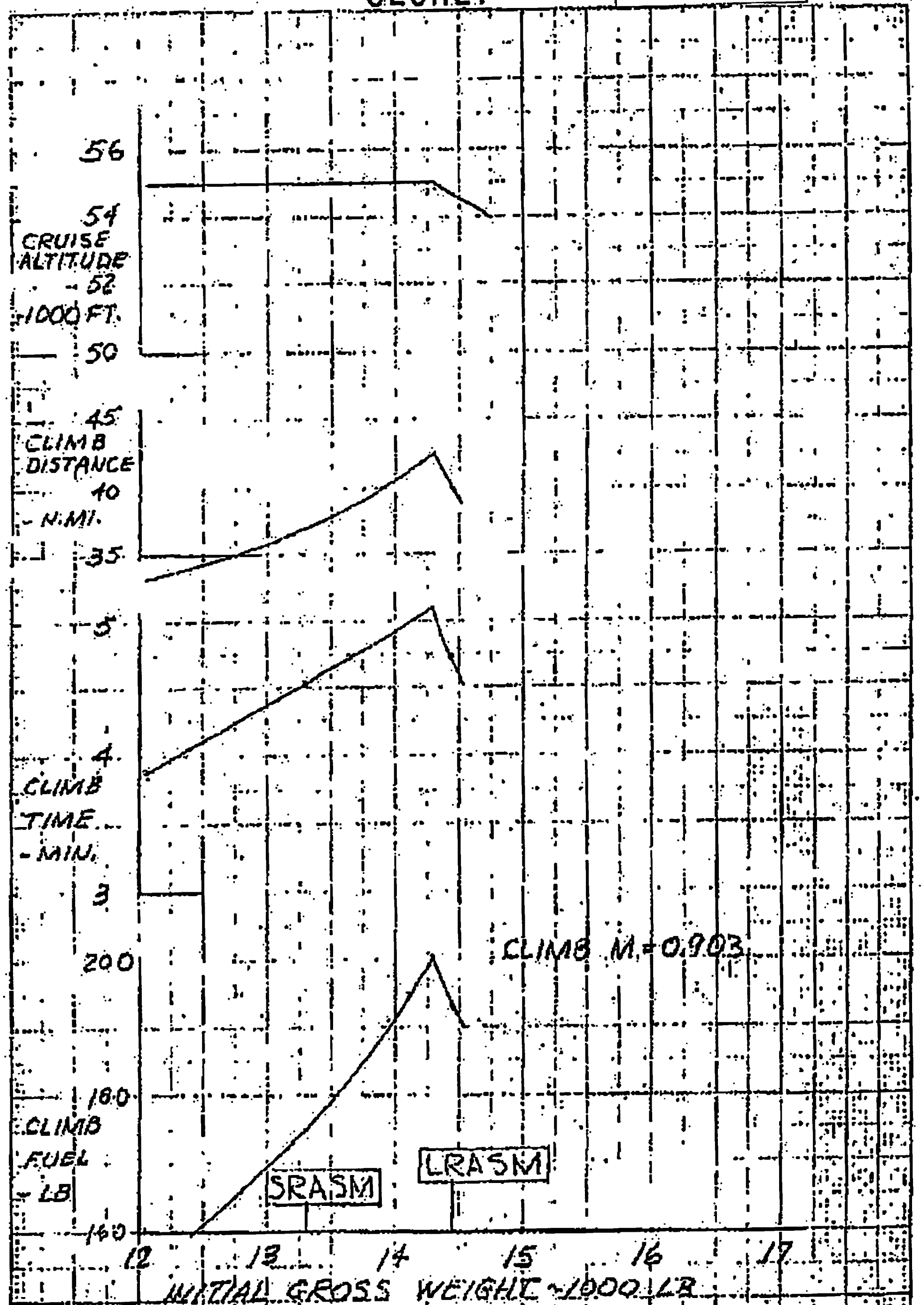
~~(S)~~ Figure 7.4-14 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Landing Performance (U)

88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



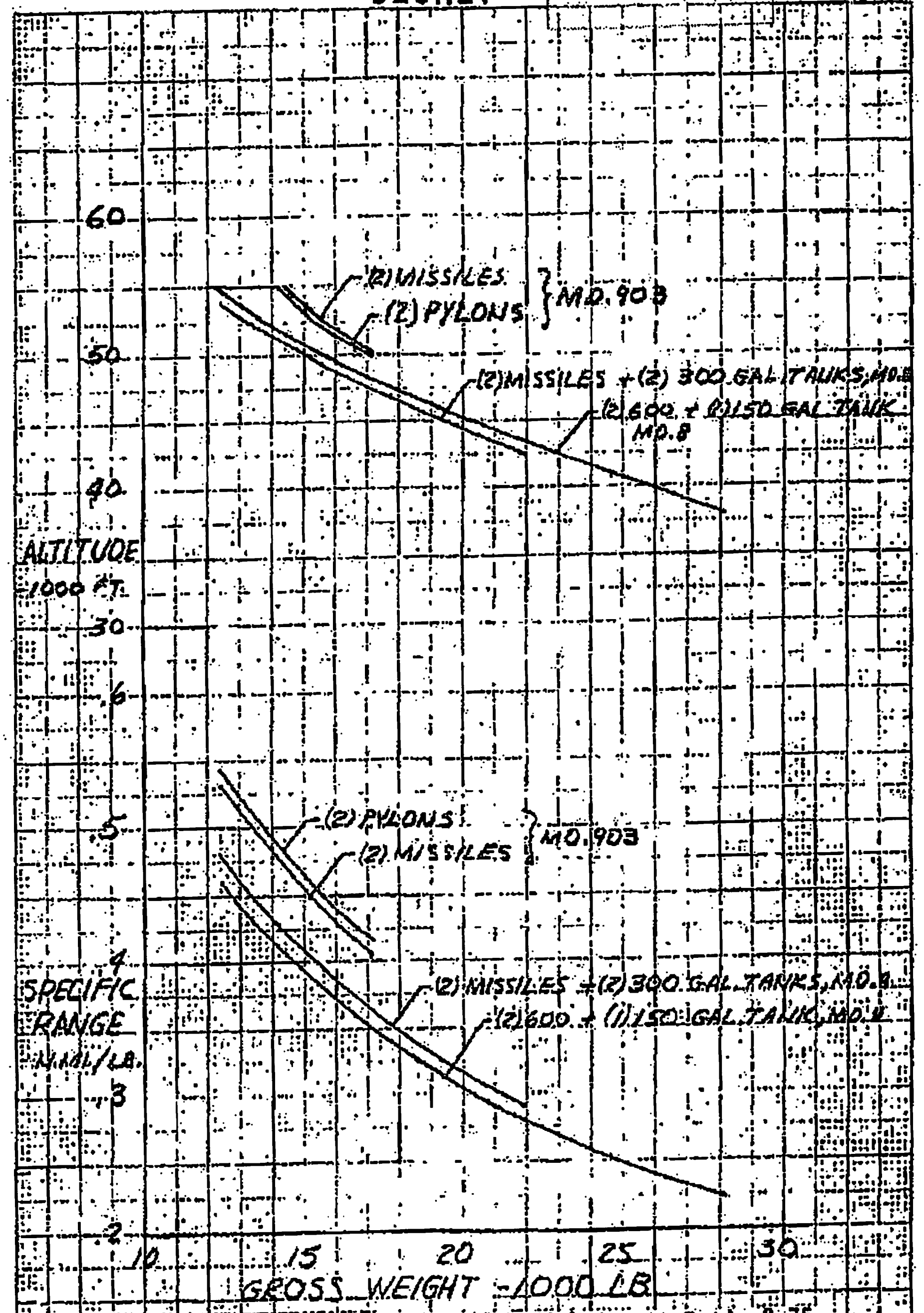
~~(S)~~ Figure 7.4-15 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Initial Climb Performance (U)

~~SECRET~~



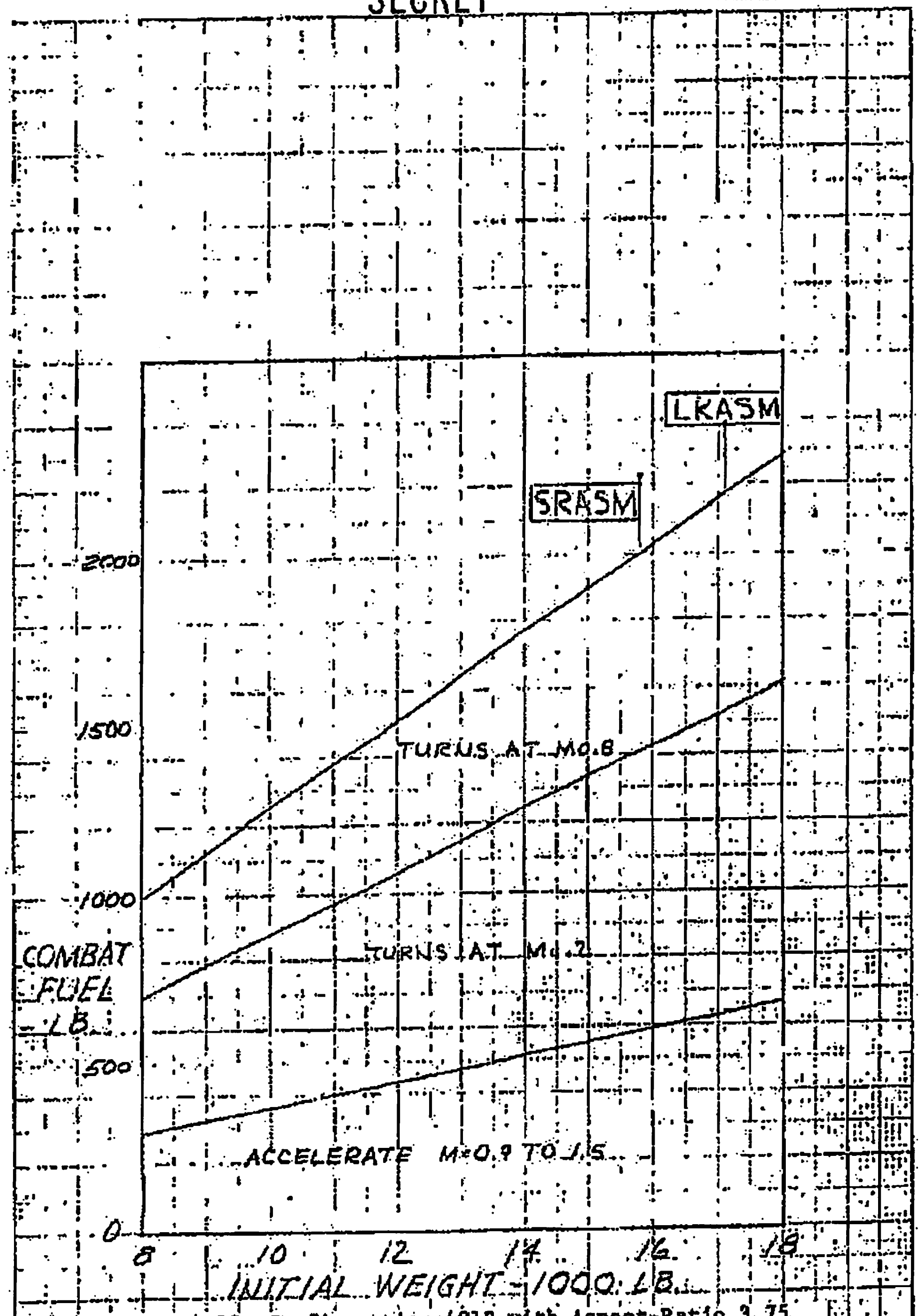
~~(S)~~ Figure 7.4-16 Configuration 4018 with Aspect-Ratio 3.75 Supercritical Wing Climb After Combat (U)

~~SECRET~~



~~(S)~~ Figure 7.4-17 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Cruise Performance (U)

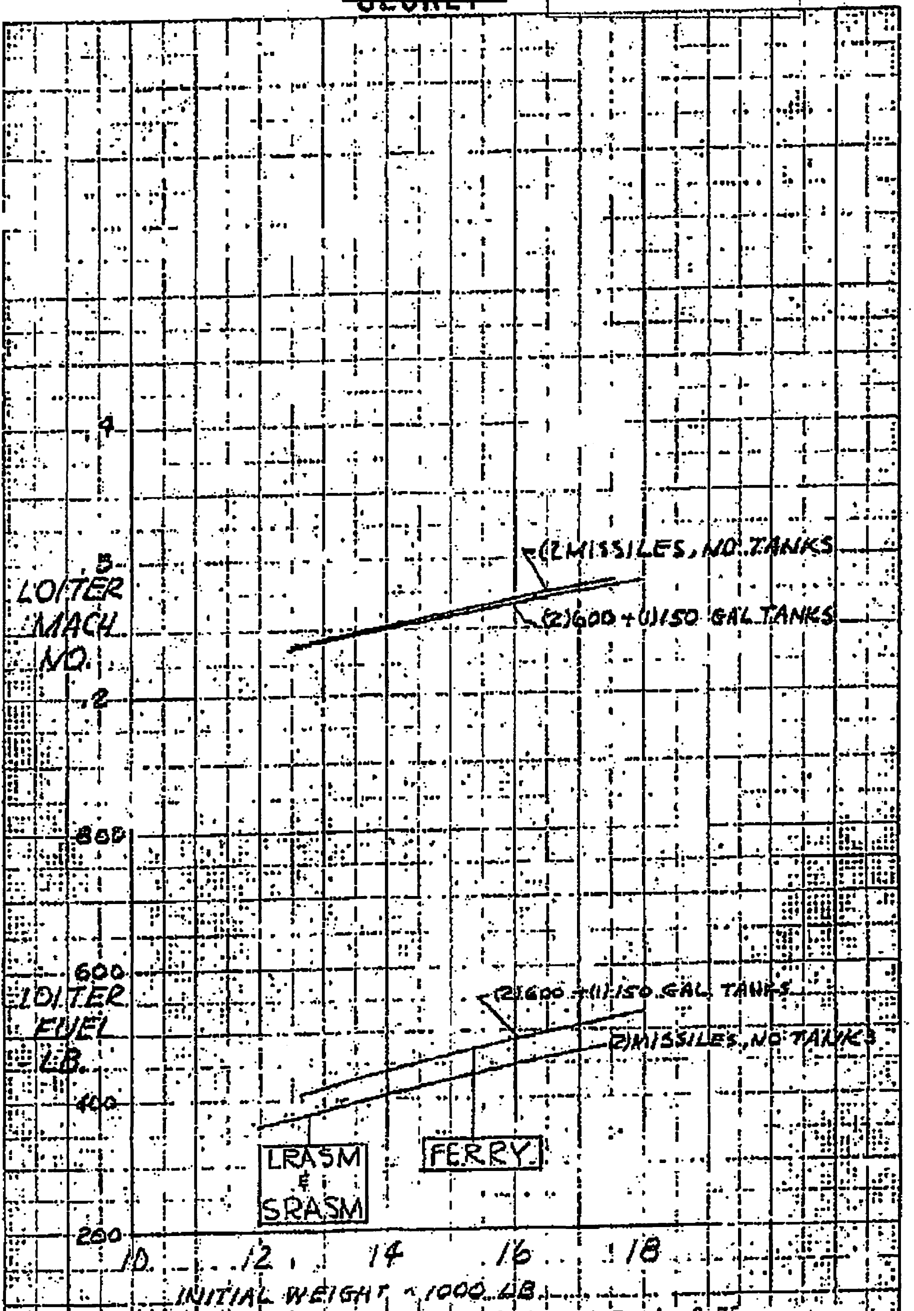
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-18 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Combat Fuel Allowance (U)

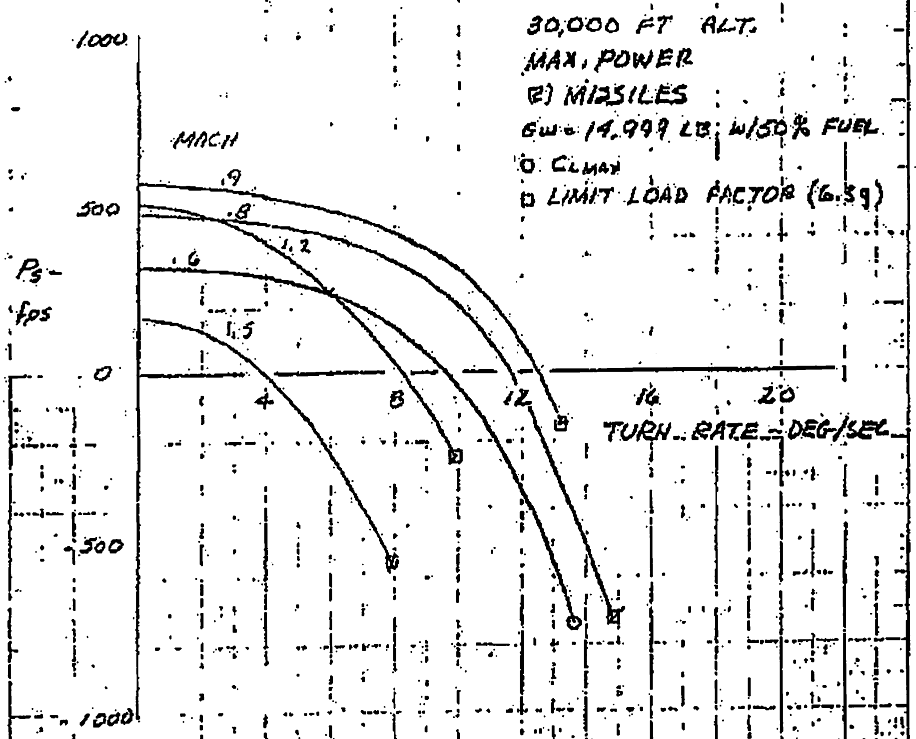
88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC. 3.3.~~
(b)(4)
1.4. (a)(g)

~~SECRET~~



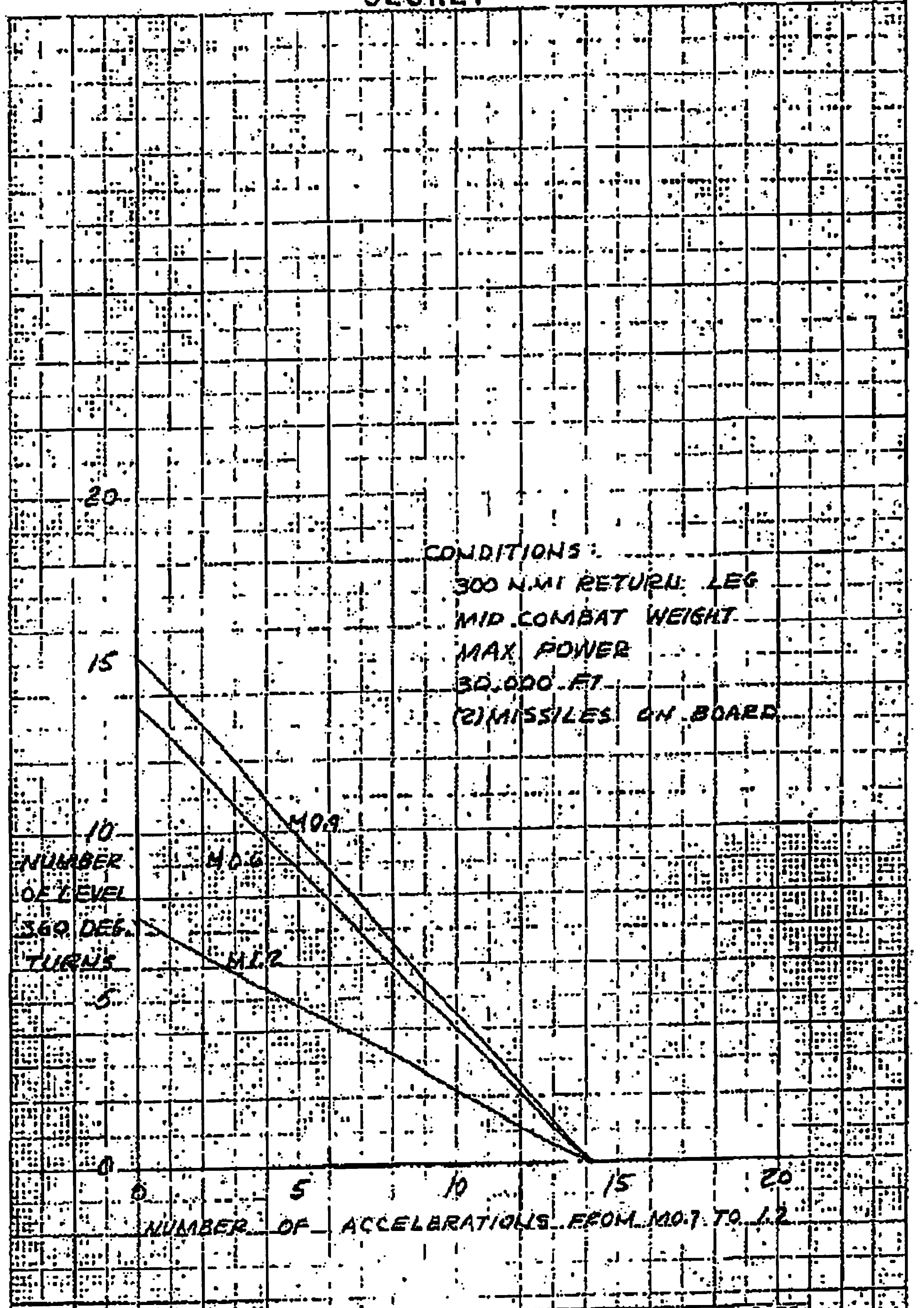
~~(S)~~ Figure 7.4-19 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Sea-Level Loiter Performance (U)

~~SECRET~~



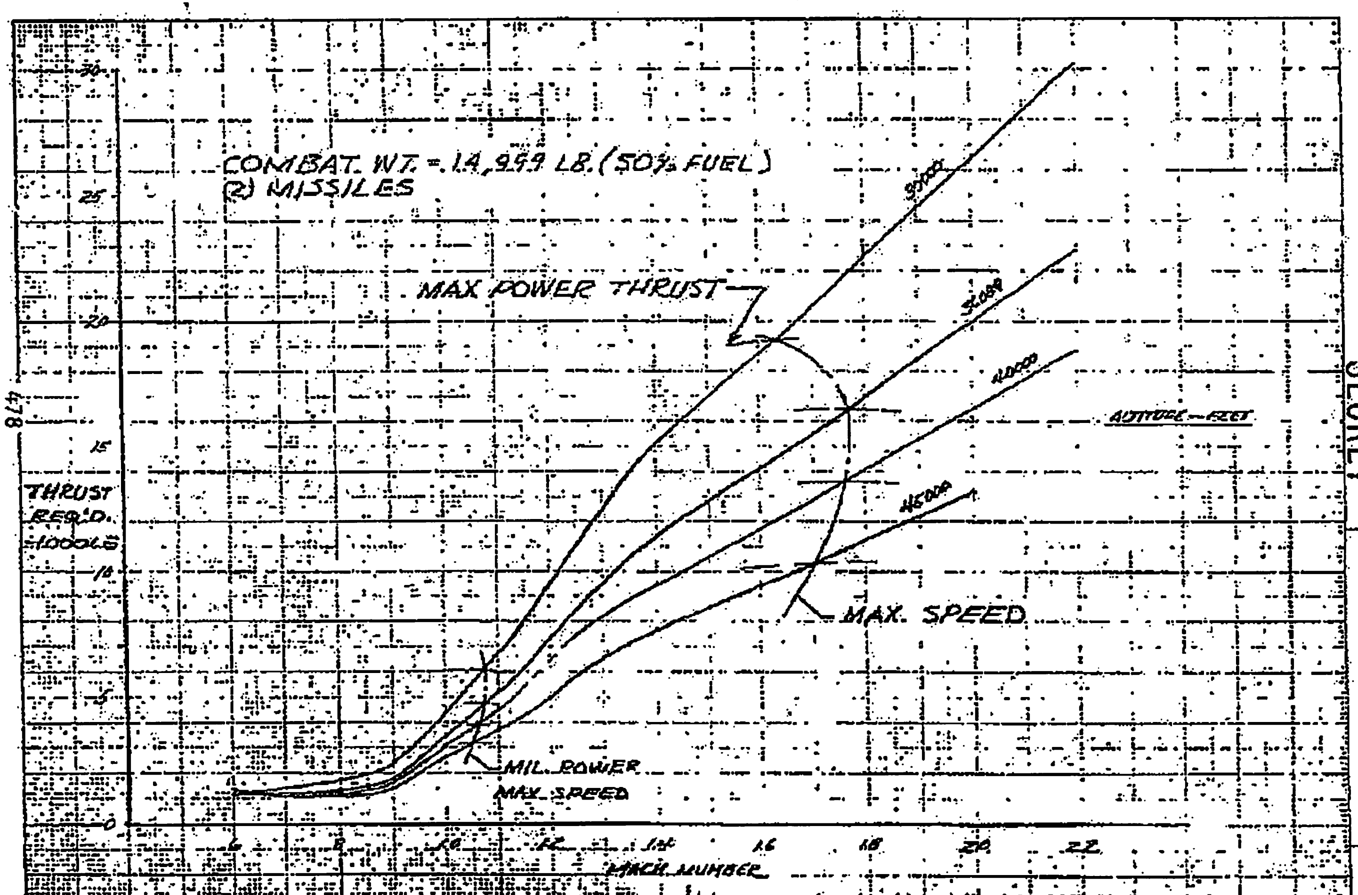
~~(S)~~ Figure 7.4-20 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Turning Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
~~1.4. (a)(g)~~



~~(S)~~ Figure 7.4-21 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Persistence Plot (U)

SECRET

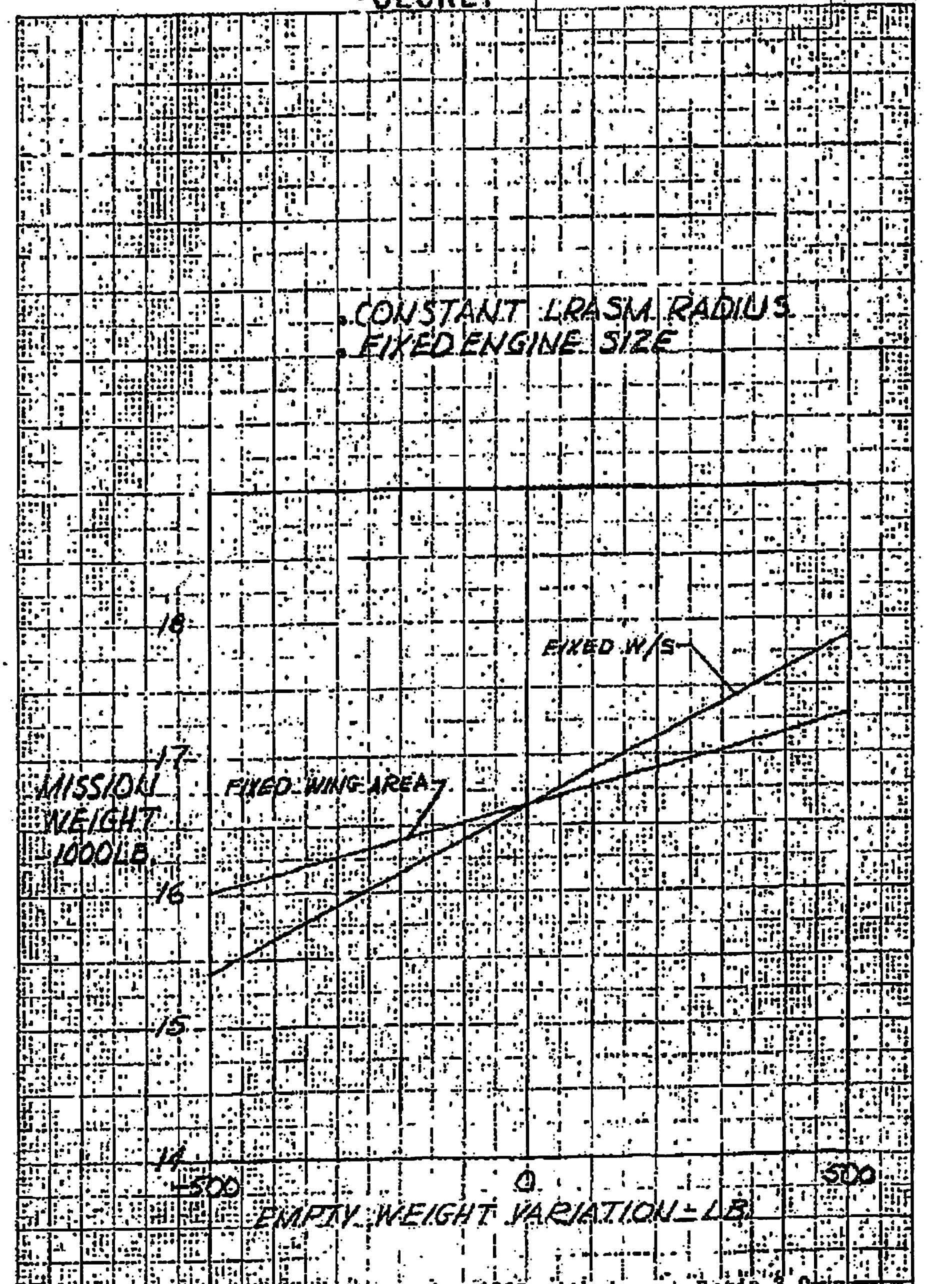


~~(S)~~ Figure 7.4-22 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Thrust Required (U)

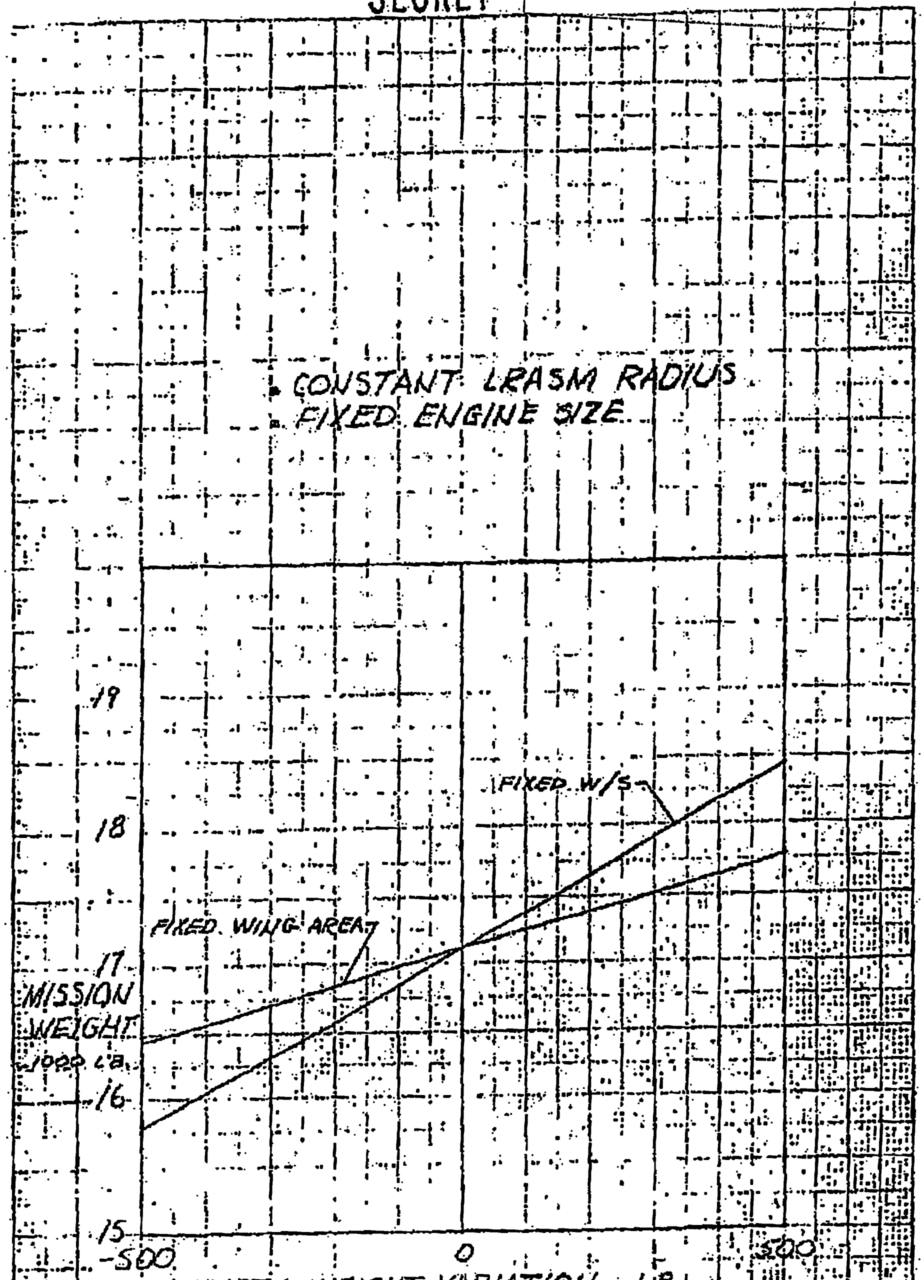
SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-23 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Sensitivity to Weight-Empty Variation (U)

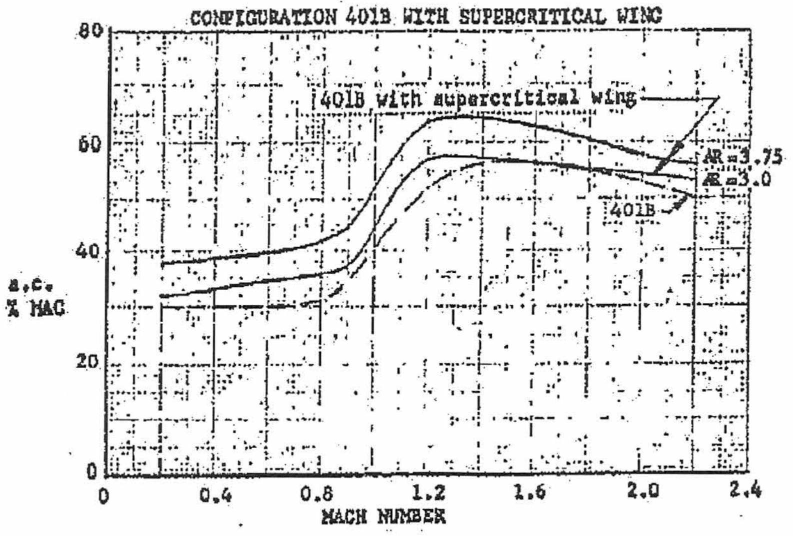


~~(S)~~ Figure 7.4-24 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Sensitivity to Weight-Empty Variation (U)

7.5 STABILITY AND CONTROL

(U) Other than an evaluation of the aerodynamic-center location, since there had been an alteration of wing-sweep angle and aspect ratio, no attempt was made to establish specific stability and control characteristics for the supercritical wing study. The variation of aerodynamic-center location with Mach number is presented in Figure 7.5-1 for the point design airplanes. Also shown in this figure for comparative purposes is the predicted aerodynamic-center location for the basic 401B configuration.

(U) With the exception of the aerodynamic-center location noted above, the basic stability and control parameters for the selected supercritical wing point-design configurations are similar to those presented in Section 3.4 for the 401B configuration.



(U) Figure 7.5-1 Aerodynamic Center Location for Supercritical Point-Design Configurations

7.6 STRUCTURES AND WEIGHTS

~~(S)~~ The two airplanes selected from the parametric study were examined in detail by use of the same techniques discussed in Section 3.5. These airplanes have an aspect ratio of 3.0 and 3.75. Input data for weighing these airplanes were obtained from the design layouts shown in Section 7.2. The resulting weight breakdowns are shown in Table 7.6-1. A summary of the center-of-gravity conditions for the various mission loadings is as follows:

Condition	Basic Operating Weight	Zero Fuel Weight	Gross Weight
AR 3.0			
SRASM			
Weight (lb)	11,835	12,468	16,800
C.G. (% MAC)	26.6	25.8	23.1
LRASM			
Weight (lb)	12,683	13,316	21.638
C.G. (% MAC)	26.7	26.0	24.2
Ferry Mission			
Weight (lb)	13,525	13,810	27,000
C.G. (% MAC)	26.6	25.6	24.8
AR 3.75			
SRASM			
Weight (lb)	12,131	12,764	16,800
C.G. (% MAC)	31.9	31.1	28.9
LRASM			
Weight (lb)	12,979	13,612	21,638
C.G. (% MAC)	31.5	30.8	28.1
Ferry Mission			
Weight (lb)	13,821	14,106	27,000
C.G. (% MAC)	31.2	30.0	27.7

~~(S)~~ Table 7.6-1 WEIGHT SUMMARY: CONFIGURATION 401B WITH SUPERCRITICAL WING WITH 3.0 AND 3.75 ASPECT RATIO (pounds) ~~(S)~~

Item	Weight	
	AR=3.0	AR=3.75
Structure	(5302)	(5561)
Wing	1400	1671
Fuselage	2608	2636
Horizontal Tail	368	336
Vertical Tail	310	302
Landing Gear	616	616
Propulsion	(3530)	(3530)
Engines	2737	2737
Air Induction	322	322
Fuel System	421	421
Engine Controls	22	22
Starting System	28	28
System and Equipment	(2603)	(2641)
Surface Controls	468	481
Landing Gear Controls	115	115
Instruments	94	94
Hydraulics and Pneumatics	271	288
Electrical	362	370
Avionics	460	460
Furnishings	238	238
Air Conditioning	142	142
Armament	453	453
Weight Empty	11,435	11,732
Useful Load	(400)	(399)
Crew	200	200
Unusable Fuel	23	22
Engine Oil	17	17
Missile Racks and Pylons	124	124
Miscellaneous	36	36
Basic Operating Weight	11,835	12,131
Payload	(633)	(633)
Ammo (500 rounds)	285	285
Missiles (2)	348	348
Zero Fuel Weight	12,468	12,764
Fuel	4332	4036
Gross Weight	16,800	16,800

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SECTION 8

COMPOSITE MATERIAL

STUDY ON 401B

~~(S)~~ A design tradeoff study was conducted to determine how the potential weight reduction from the use of composite materials should be used to maximize the maneuver capabilities. The study yielded the following results:

1. The weight reduction should be used to change aspect ratio, wing loading, and aircraft size simultaneously rather than any one variable separately.

2. The degree of change of each variable is dependent upon the degree of composite material usage in the aircraft construction.

3. The best combination of variables is dependent upon the aspect of the maneuver capability that is to be maximized (i.e., increased subsonic turn rate requires increased wing aspect ratio and size, while increased acceleration capability requires the opposite.)

4. The following selection of variables is for the case where turn rate is maximized while acceleration time between Mach 0.9 and 1.5 is held constant. Both turn rate and acceleration are for maximum power and 30,000-ft altitude conditions.

88th ABW/IP/
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
EO 13526 3.3(b)(4)
1.4(a)(g)
SEC 1.4(a)(3)

Parameter	Aluminum	Composite Wing	Composite Wing, Tail, and Inlet	All Composite
Accel Time, sec	35.5	35.5	35.5	35.5
M.8 deg/sec	9.9	11.2	11.8	13.5
Mission Wt, lb	17,115	16,570	16,270	15,600
Aspect Ratio	3.0	3.3	3.4	3.8
W/S psf	60	54	47	45
T/W	1.37	1.42	1.45	1.50

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8.1 STUDY PLAN AND DESIGN DATA

8.1.1 Study Plan

(U) The plan followed in the composite material study on Configuration 401B sought to determine the best way to use the weight reductions resulting from use of composite materials to maximize maneuver capabilities. The first step was the establishment of a matrix of variables to be considered. The second step was the selection of maneuver conditions to use for the evaluation.

8.1.1.1 Matrix of Variables

(U) A matrix of variables was selected to determine whether the weight reductions from the use of composite materials should be used for increased wing aspect ratio (AR), reduced wing loading (W/S), reduced aircraft size, or a combination of the three to maximize the maneuver capabilities. That is,

$$\text{Lower Weight} \longrightarrow \left\{\begin{array}{l}\text{Higher AR}\\ \text{Lower W/S}\\ \text{Smaller Size}\\ \text{(Higher T/W)}\end{array}\right\} \longrightarrow \begin{array}{l}\text{Maximum Turn Rate}\\ \text{Minimize Accel. Time}\end{array}$$

88th ABW/IPZ
FOIA (b)(1)(4)
E.O. 13526 SEC. 3.3.
(b)(4) 35 (6)(X4)
1.4(a)(g) (5)(X4)
SEC 1.4(a)(g)

~~(S)~~ The matrix of variables selected is:

Mission Weight (Aircraft Size), lb	15,600; 16,800; 18,000
Wing Loading, psf	45, 50, 55, 60
Aspect Ratio	3, 4, 5, 6
Composite Material Content	1. None (all aluminum), 2. Wing only, 3. Wing, tail and inlet duct, and 4. Maximum usable

~~(S)~~ The other configuration variables (i.e., wing leading-edge sweep angle, thickness ratio, and taper ratio) are held constant to keep the matrix of variables within a reasonable size; also, the present values are felt to be near optimum. Flying qualities and lift and drag considerations have shown the 35-degree leading-edge sweep to be desirable for an air superiority fighter. The requirement for supersonic operation restricts the wing thickness ratio to a low value. The thickness ratio of 0.04 and the taper ratio of 0.2 were held constant as practical values.

8.1.1.2 Maneuver Conditions

(U) Two conditions were selected for evaluating the maneuver capabilities of the various combination of variables. Both conditions are for maximum power operation at 30,000 feet. One condition is the maximum sustained turn rate at Mach 0.8, which is representative of the high-subsonic-speed turning portion of air-to-air combat. The second condition is a level acceleration from Mach 0.9 to 1.5, which gives an insight into the supersonic capabilities.

~~(S)~~ Maneuver capabilities attained with the various combinations were compared at the mid-combat weight for the Long-Range Air-Superiority Mission (LRASM) with a 750-n.mi radius. The results are presented as plots of turn rate versus acceleration time for each level of composite material usage.

8.1.2 Design Data

(U) In this subsection, the manner in which the design data were derived is described, the ground rules which governed the development of the data are defined, and the geometric data that formed the basis for the analytical studies are summarized.

~~(S)~~ The matrix of 48 airplanes described above in Subsection 8.1.1 was developed around the three growth data points derived in the 401B growth study (Subsection 3.1.1). The data from the three growth data points at mission weights of 15,600, 16,800, and 18,000 pounds were expanded to include the four aspect ratios and four wing loadings to develop the desired matrix for the parametric investigation. Variations in fuselage, wing, and tail surfaces were governed by the list of ground rules, which are summarized briefly as follows:

1. The values $t/c = .04$, $\Lambda_{LE} = 35^\circ$ and $\lambda = 0.2$ remain constant for all wings.

~~(S)~~ 2. The $\bar{c}/4$ of all reference wings is located at a constant fuselage station.

3. The horizontal and vertical tail moment arm (distance from $\bar{c}/4$ wing to $\bar{c}/4$ of the tails) is constant at a given aircraft mission weight.

4. The sizing horizontal tail planform geometry remains constant (AR = 3.0, $\lambda = 0.2$, and $\Lambda_{LE} = 35^{\circ}$).

5. The vertical tail planform geometry remains constant (AR = 1.3265, $\lambda = 0.4$, and $\Lambda_{LE} = 45^{\circ}$).

6. The horizontal tail and vertical tail moment arms vary as aircraft mission weight varies (scaled according to the square root of the aircraft gross-weight ratio).

7. The "d" distances to the exposed wing root chord exposed horizontal tail chord (measured from airplane centerline) remain constant for a given aircraft mission weight. This "d" distance varies as a function of aircraft mission weight (scaled according to the square root of the gross-weight ratio).

8. The ratio of the exposed horizontal tail area to the sizing tail area remains constant at a value of 0.866.

9. The vertical tail size is constant for a given mission weight and is determined by a vertical tail coefficient of 0.037 (per tail) and a wing geometry defined by AR = 3.0 and W/S = 60 psf.

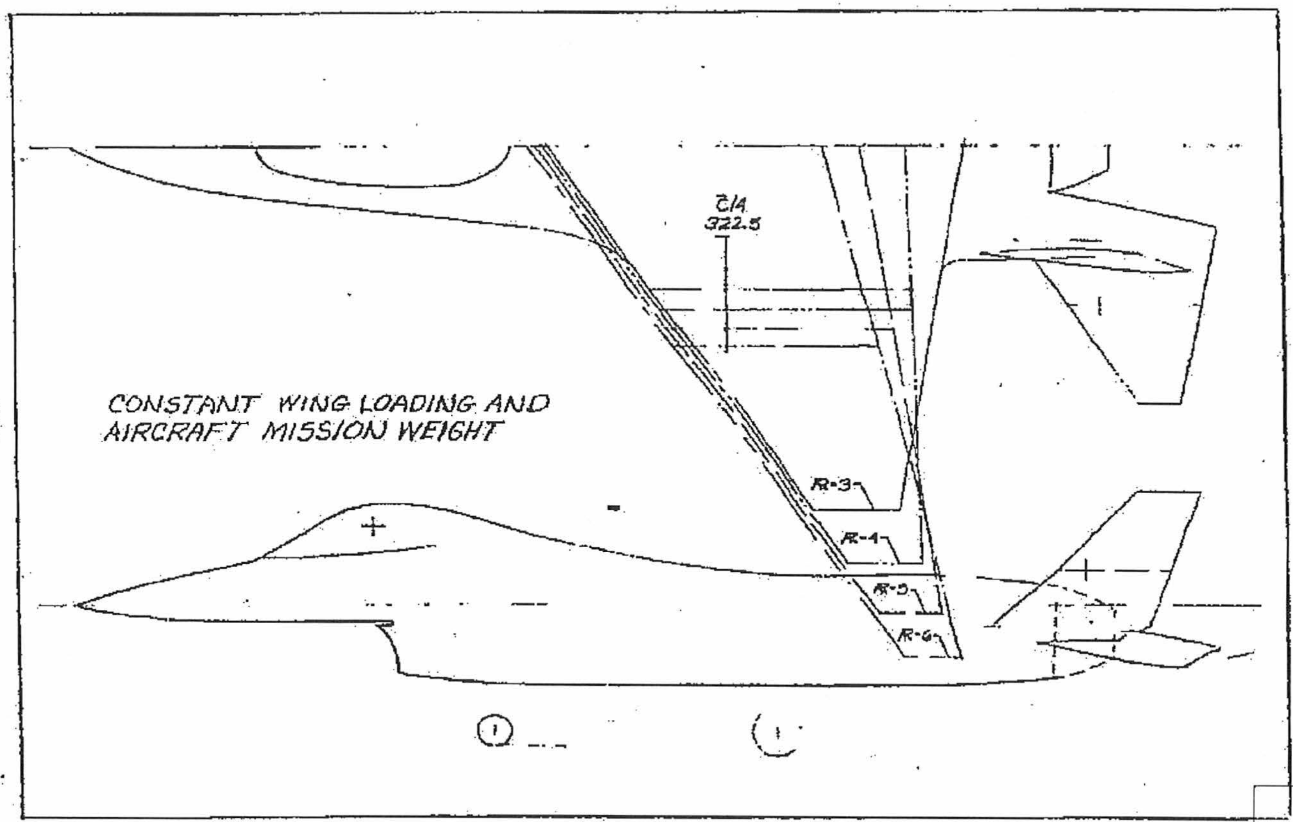
10. For a given aircraft mission weight, an initial sizing horizontal tail is determined by a horizontal tail volume coefficient of 0.26 and a wing geometry defined by AR = 3.0 and W/S = 60 psf. This establishes a horizontal tail area to wing area ratio of 0.202. As wing geometry changes because of corresponding variations in aspect ratio and wing loading, the sizing horizontal tail area is determined by keeping the area ratio of 0.202 constant.

11. Fuselage length is constant for a given aircraft design mission weight. As mission weight is varied, the fuselage length is scaled as a function of the square root of the gross-weight ratio.

(U) External airplane comparisons that indicate the effect of selected variations of the matrix on the airplane arrangement are presented in Figure 8.1-1, -2, and -3. These comparisons show the effect of varying aspect ratio at a constant wing loading and aircraft mission weight (Figure 8.1-1), the effect of varying wing loading at a constant wing aspect ratio and given mission weight (Figure 8.1-2), and effects of varying aircraft mission weight at a constant wing aspect ratio and wing loading (Figure 8.1-3).

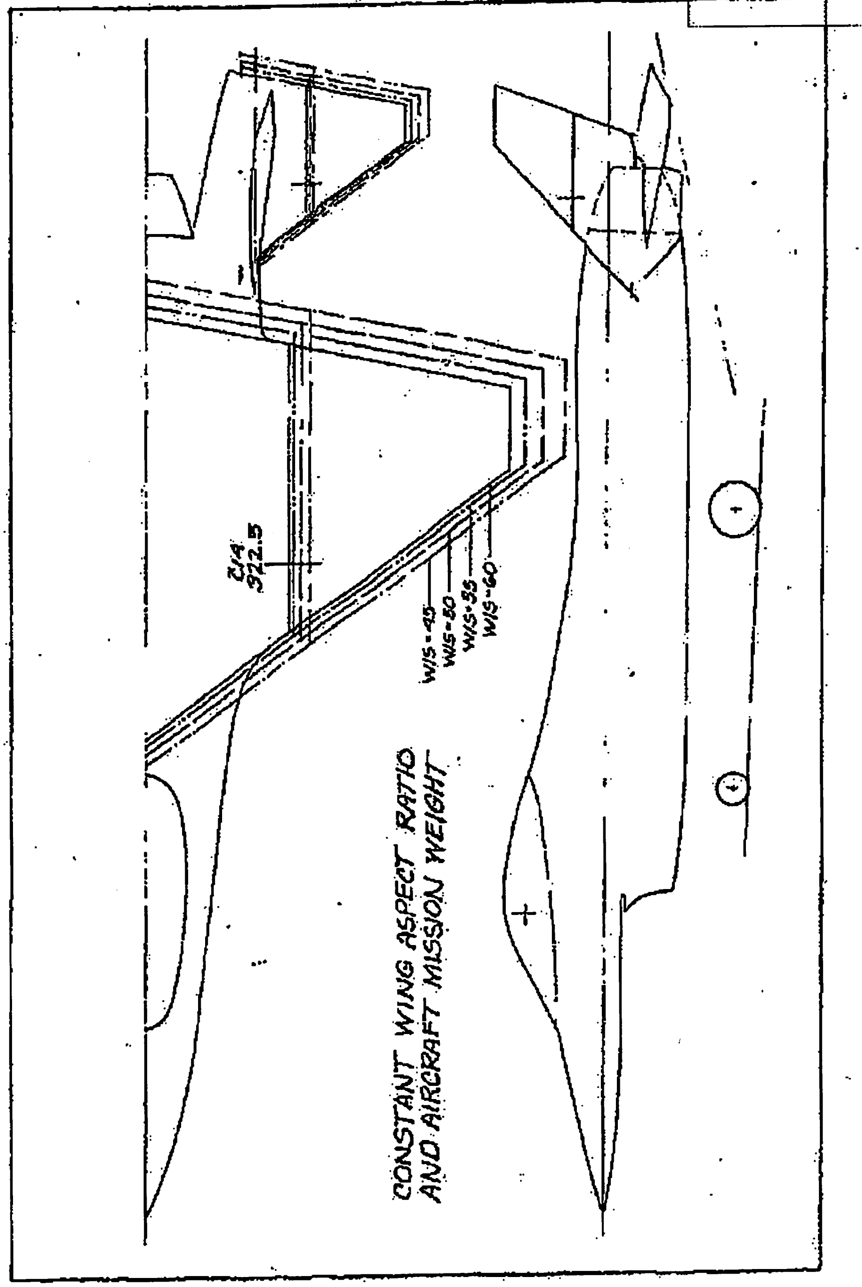
(U) The geometry for each reference wing of the 48-airplane matrix is defined in Figures 8.1-4, -5, and -6. The geometry of each of the sizing horizontal tail planforms utilized in the study is defined in Figure 8.1-7. The geometry for each of the vertical tails and ventral fins of the matrix is defined in Figure 8.1-8.

~~(S)~~ The reference wing area variation is plotted as a function of wing loading for the three mission weights in Figure 8.1-9. The variation of total wetted area for the aircraft configuration is plotted as a function of wing aspect ratio and wing loading in Figures 8.1-10, -11, and -12 for airplane mission weights of 15,600, 16,800, and 18,000 pounds, respectively. Wetted-area variations for the various components in the matrix are shown plotted in Figures 8.1-13 through 8.1-18. Further explanation of the definition of these components as they relate to wetted-area buildup is presented in the growth study approach contained in Subsection 3.1.3.1.

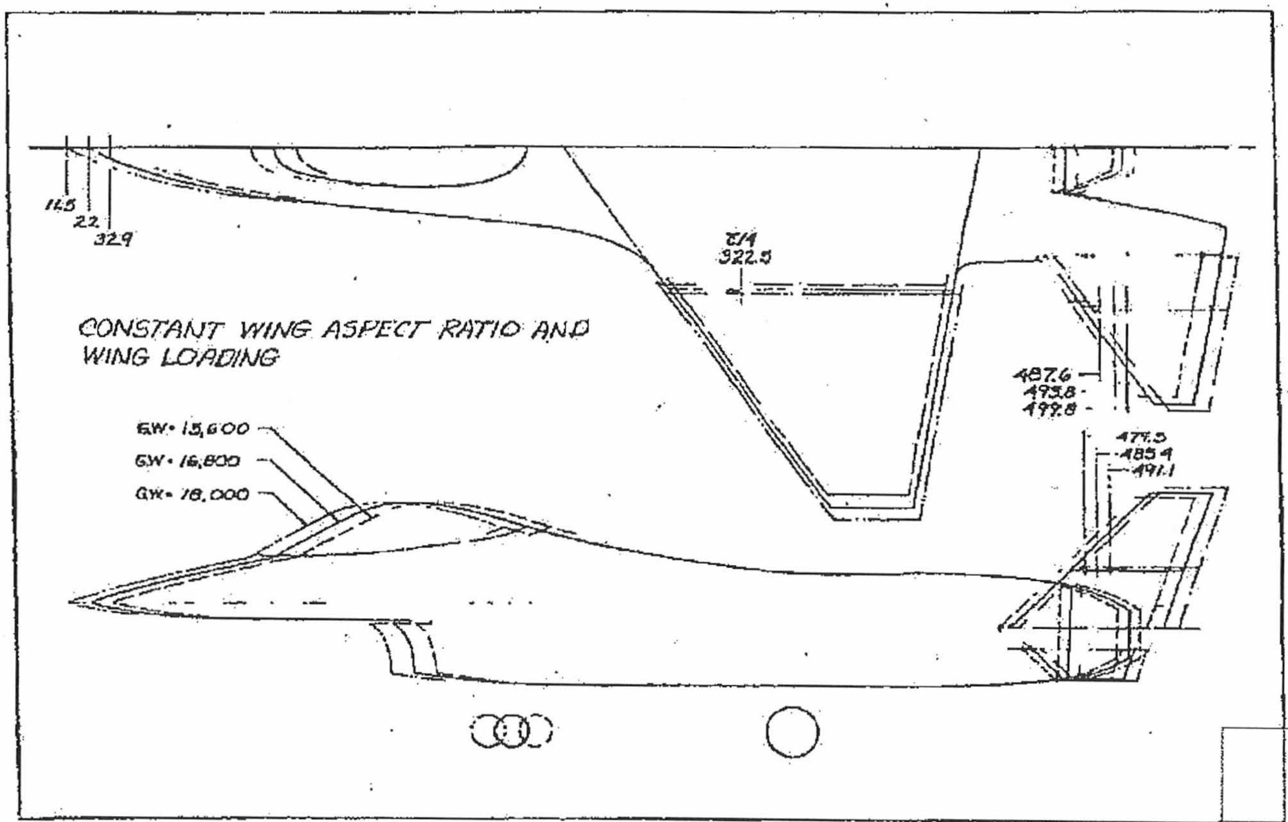


~~(S)~~ Figure 8.1-1 Configuration Comparison - Wing Aspect Ratio Variation (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 8.1-2 Configuration Comparison - Wing Loading Variation (U)



CONSTANT WING ASPECT RATIO AND WING LOADING

~~(S)~~ Figure 8.1-3 Configuration Comparison - Mission Weight Variation (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)