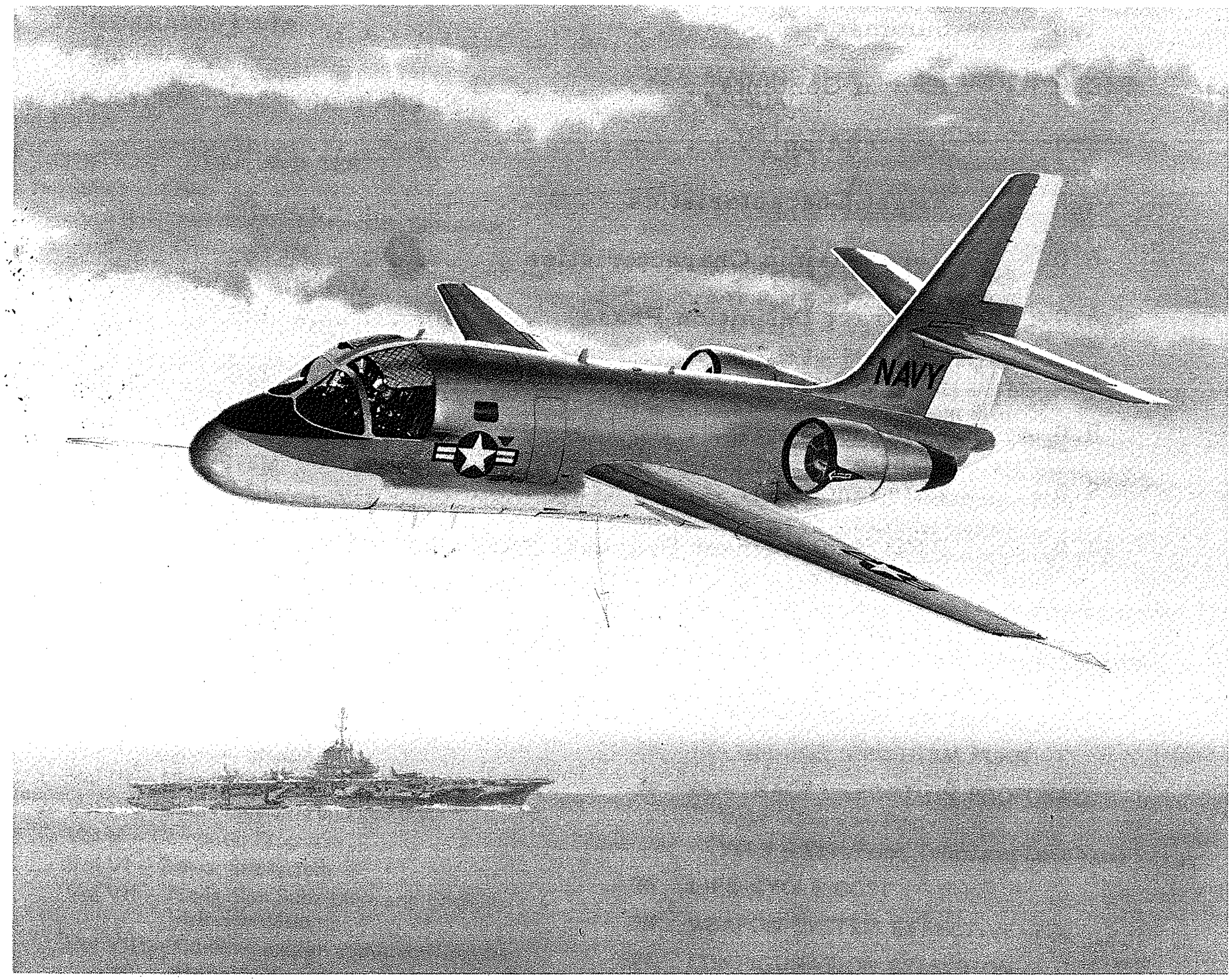

NAVY

1.0 SUMMARY

This report contains the aerodynamic stability and control characteristics and predicted flying qualities of the McDonnell Douglas Model MD-893, proposed as the recommended baseline VS(X) air vehicle. These data are presented in conjunction with applicable requirements to facilitate demonstration of compliance. The aerodynamic and physical descriptions of the air vehicle and major subsystems are sufficiently complete to permit verification of indicated flying qualities and other flight characteristics of interest.

The Model MD-893 is designed to meet general Military Airplane Flying Quality Requirement Specifications, MIL-F-8785(ASG)-4, as modified by VS(X) Type Specifications, TS-160, with a simple manual control system. Inasmuch as the operational flight envelope is completely within the subsonic regime, the critical flying-quality considerations are those normally associated with multiengine carrier-based aircraft operation: single-engine directional control and lateral control response. These considerations, together with expressed requirements for particularly good directional stability, were instrumental in establishing the aft-fuselage engine arrangement and large vertical stabilizer that characterize the design. From a practical viewpoint, fuselage mounting of the engines is essential to meet specified lateral-control requirements at low landing approach speeds and single-engine directional-control requirements at low weights with a margin for increased engine thrust. ?

The airplane meets all specified flying-quality requirements except for three very slight deviations:

a. The frequency of the longitudinal short-period mode falls below the 0.24-cps minimum specified by TS-160. ← less than .15

b. The damping of the longitudinal short-period mode falls very slightly below that specified by MIL-F-8785 at altitudes between 20,000 and 30,000 feet.

c. The take-off flap-retraction trim change exceeds the 20-lb limit of MIL-F-8785 at the structural limit speed, the speed specified by TS-160 for the analysis.

These deviations do not constitute flying-quality deficiencies and will certainly not degrade the tactical utility of the airplane. ?

The design incorporates two significant features the contractor is particularly well qualified to propose:

a. A simple aerodynamically-boosted manual control system.

b. Direct lift control.

also $\frac{1}{T_{\theta_2}}$ = .3 no .50 reqd.

+ $\frac{1}{T_{H_3}}$ = 3.7 no. 4.0

Also 6.84° LE down elevator + balance opening of throttle for waveoff

Recent PD-808, DC-8, and DC-9 experience in the design and development of aerodynamically-boosted manual flight control systems on smaller and larger airplanes operating over larger flight envelopes ensures the feasibility and practicality of the proposed systems. The contractor not only pioneered the development of direct lift control for carrier-landing approach control but also has kept up with all developments in the area and is presently utilizing direct lift control in its latest jet transport, the DC-10. Direct lift control will compensate for the low natural frequency of the longitudinal short-period mode and will provide excellent carrier landing approach control.

3.0 DESCRIPTION

3.1 AIRFRAME

The McDonnell Douglas Model MD-893 is a twin turbo-fan powered airplane, as shown in the Three-View Diagram of Figure 1, with a slightly swept, low mid-wing, aft-fuselage-mounted short-duct turbo-fan engines, and a high fin-mounted horizontal tail. Detailed diagrams of the wing and empennage are given in Figures 2, 3, and 4, and a complete set of dimensional data is presented in Table I.

A few of the more significant wing dimensions are summarized here as follows:

Area	480.00 sq ft
Mean Aero Chord	9.08 ft
Span	58.0 ft
Aspect Ratio	7.00
Taper Ratio	0.30
Sweepback	15.00 deg

Carrier suitability considerations limit the over-all length to 55 feet and folded span to 27.5 feet and make it necessary to fold the fin at a height of 17 feet.

A few of the characteristic horizontal and vertical stabilizer dimensions are tabulated here as follows:

		Horizontal	Vertical
Tail Area	sq ft	170.5	120.0
Tail Area Ratio		0.355	0.250
Tail Length	ft	21.6	19.6
Tail Length Ratio		2.38	0.345
Tail Volume Ratio		0.845	0.0864

The relatively large empennage areas are necessitated by the length limitation in conjunction with conventional longitudinal and directional stability and control considerations.

According to TS-160, the airplane is considered to be in Class II-C as defined by Reference 1.

A center-of-gravity envelope showing the variation of horizontal center-of-gravity location with weight, fuel, and store-loading variations and the recommended forward and aft permissible limits is presented in Figure 5. As shown in these data, the weight varies from a maximum over-load of slightly over 51,000 pounds to minimum flying weight of just over 28,000 pounds. The weights and inertias of specific significant loadings and configurations are presented in Table II and discussed in Paragraph 3.6. The recommended forward and aft permissible center-of-gravity limits are 24 and 37 percent MAC respectively. These limits are for the gear retracted. The corresponding gear-down center-of-gravity positions would be approximately one-percent MAC more aft. The MD-893 is designed to have an actual extreme center-of-gravity travel range of only 7 percent MAC (from 27 to 34 percent). The desired 3-percent MAC forward and aft growth ranges are thus provided.

3.2 CONTROL SYSTEM

3.2.1 Longitudinal Flight Control System

Longitudinal flight control is achieved through a conventional aerodynamically boosted(linked-tab), manually-controlled elevator. The longitudinal control system is discussed and described in detail in Reference 21. All the control-system dimensional data necessary for aerodynamic stability and control analyses are presented in Table I, but some of the more significant data are summarized here as follows:

Elevator Area (Per Side)	S_e	25.55 sq ft
Elevator Chord (MAC)	$\bar{c}_e$	1.95 ft
Tab Volume Ratio	A_e	0.02
Elevator Gearing Ratio (Tab-Fixed)	G_e	0.768 rad/ft
Tab Link Ratio	R_{L_e}	10
Elevator Deflection Range	δ_e	-25 +15 deg

The inboard elevator tabs are linked tabs and thus are an integral part of the control system. The outboard tabs are simple geared tabs with a gearing ratio of -0.60. The longitudinal control system break-out force from a trimmed flight condition is 2.75 pounds, within the 0.5- to 3.0-pound range required by Reference 1. The control system has an effective normal bob-weight effect of 2.5 pounds per g. This effect stems from the push rods in the vertical tail and must be accounted for in control force calculations.

Longitudinal trim is accomplished through variation of horizontal stabilizer incidence. A large stabilizer incidence range, from 4 degrees (TED) to -12 degrees (TEU), is required because of the strong pitching moments due to flap deflection and thrust and for a relatively large center-of-gravity range. In view of the large incidence range, the horizontal stabilizer actuation system is specifically designed to preclude any possibility of a runaway failure of the trim system.

3.2.2 Lateral Flight Control System

Lateral control is achieved through conventional, aerodynamically-boosted (linked-spring tab), manually-controlled ailerons augmented by electrically-commanded, hydraulically-powered slot-lip-aileron type spoilers. The lateral-control system is described fully in Reference 21. A few of the more characteristic lateral-control system dimensional data are summarized as follows:

Aileron Area (Per Side)	S_a	10.80 sq ft
Aileron Chord (MAC)	$\bar{c}_a$	1.33 ft
Tab Volume Ratio	A_a	0.03
Aileron Deflection Total	δ_a	$\pm$ 40 deg
Aileron Gearing Ratio (Tab-Fixed)	G_a	1.92 rad/ft
Tab Link Ratio	R_{L_a}	4.0
Tab Spring Rate	k_t	0.13 lb/deg

The lateral-control spoilers are electrically slaved to aileron deflection as shown in Figure 6. Electrical command of the spoilers is employed to avoid increasing lateral-control system friction and to facilitate a flexible (adaptable) gearing to aileron deflection and mixing of asymmetric (lateral control and Dutch-roll damping) and symmetric (cross-wind landing and landing roll-out lift reduction) commands. The lateral-control system break-out force is 1.75 pounds, as compared to the 0.5- to 2.0-pound range required by Reference 1.

Lateral trim is achieved through a manually-controlled trim tab on the left aileron. The aileron trim tab has a deflection range of $\pm$ 20 degrees.

3.2.3 Directional Flight Control System

Directional flight control is achieved through a conventional, aerodynamically-boosted(linked-tab) rudder. A complete description of the directional control system is given in Reference 21. Characteristic dimensional data are summarized as follows:

Rudder Area (Total)	S_r	32.40 sq ft
Rudder Chord (MAC)	$\bar{c}_r$	3.00 ft
Tab Volume Ratio	A_r	0.025
Rudder Deflection	δ_r	$\pm$ 30.0 deg
Rudder Gearing Ratio (Tab-Fixed)	G_r	2.12 rad/ft
Tab Link Ratio	R_{L_r}	10.0

The directional control system break-out force is 4.0 pounds, as compared to the 1.0- to 7.0-pound range required by Reference 1. Directional trim is achieved through an adjustable trim tab on the upper rudder segment. The directional trim tab is operated manually over a deflection range of $\pm$ 20 degrees.

3.2.4 Deceleration Devices

The deceleration devices consist of a pair of speed brakes on the aft fuselage below the engines, opening out and down to clear the engine wakes, and another pair on the belly of the airplane. A sketch of the speed brakes is presented in Figure 7. The lower brakes close automatically as the gear is extended to preclude their striking the ground on landing.

Although not a part of the in-flight deceleration devices, the wing spoilers are deflected symmetrically during landing roll-outs to reduce roll-out distances and improve the cross-wind landing characteristics. The lateral-control function of the spoilers is retained when the spoilers are deflected symmetrically for landing roll-out. The landing spoilers are electrically commanded, with the master switch in the cockpit, a throttle switch, and landing-gear spin-up switches to prevent inadvertent airborne deflection.

3.2.5 Direct Lift Control System

Direct lift control is achieved through symmetrical deflection of the inboard spoilers. During landing approaches, these spoilers are deflected 5 degrees by activation of the system. Control about this nominal approach position is accomplished through a spring-centered thumb switch on the control stick. Forward (or upward) deflection of this switch opens the inboard spoilers another 5 degrees. Aft (or downward) deflection of this switch closes the inboard spoilers, and releasing the switch returns the spoilers to their nominal approach position. The aerodynamic function and effectiveness of the direct lift control system is discussed in Section 4.1.3.4.

3.3 HIGH LIFT SYSTEM

The high lift system consists of conventional double-slotted trailing-edge flaps extended to 70 percent of the semi-span and full-span leading-edge slats. The flaps and slats are both hydraulically actuated. The slats are extended with the flaps retracted to increase the low-speed maneuvering capability in the "CR_{ASW}" configuration defined in Table II. The flaps and slats are both extended for take-offs and landings.

3.4 PROPULSION SYSTEM

The propulsion system consists of two Allison TF32-A-2 turbo-fan engines. The alternate system consists of two General Electric TF34-GE-2 turbo-fan engines. The stability and control characteristics and handling qualities of the airplane are independent of the choice of engines. The engines have an increased thrust rating for take-offs and, as necessary, for wave-offs, that may be used for 5 minutes. There is also an intermediate increased thrust rating for climbs and accelerations that may be used for 30 minutes. This intermediate increased thrust level corresponds to the "military thrust" rating identified in Table II and Reference 2. The maximum continuous thrust level of the engines corresponds to the "normal-rated thrust" level identified in Table II and Reference 2. There are no provisions for thrust augmentation through after-burning. The variation of net installed thrust with speed and altitude is shown in Figure 8 for various thrust levels.

3.5 HYDRAULIC SYSTEM

The hydraulic system consists of two completely independent systems. A block diagram of the hydraulic system is presented in Figure 9. As shown in the block diagram, both hydraulic systems contain priority valves that give priority to spoiler demands.

There are three spoiler segments on each wing: inboard, center, and outboard. All three are used for lateral control and landing roll-out. The outboard and center spoiler segments are used for Dutch-roll damping. The inboard segments are used for direct lift control. The inboard and center segments are driven by Hydraulic System No. 1 (Left Engine). The outboard spoiler segment is driven by Hydraulic System No. 2 (Right Engine).

The distribution of the hydraulic systems to the spoilers and the functions of the spoilers are summarized in the following table:

Hydraulic System	1 Left Engine	1 Left Engine	2 Right Engine
Spoiler	Inboard	Center	Outboard
Function	Direct Lift Control Lateral Control Landing Roll-out	Dutch-Roll Damping Lateral Control Landing Roll-out	Dutch-Roll Damping Lateral Control Landing Roll-out

This distribution of hydraulic systems and spoiler functions is established to assure adequate lateral control and stability augmentation in the event of a hydraulic system or engine failure.

3.6 CONFIGURATIONS AND LOADINGS

The airplane configurations of significance to flying quality considerations, as defined in Reference 1, as modified by Reference 2, are described in Table II in terms of power level, gear, flap, slat and speed-brake positions, weight, and moments of inertia. These configurations are based on Loading A, Paragraph 3.1.3.2.12a of Reference 2.

Loadings that are more critical than that serving as the basis for the general configuration descriptions of Table II are defined as critical considerations arise. Flight envelopes are shown in the Cruise and Power-on Configurations with four loadings:

a. Loading A as defined by Paragraph 3.1.3.2.12a of Reference 2. (W = 38,900 lb)

b. Loading B as defined by Paragraph 3.1.3.2.12b of Reference 2. (W = 40,540 lb)

c. Loading B with 2 Mk-55 Mines aboard (W = 45,600 lb)

d. Loading A in the CR_{ASW} configuration

The landing, power-approach, and wave-off configurations are based upon a very light weight (30,700 lb) to provide a conservative representation of the flight characteristics where they are critical, at low speeds. The effects of adding 2 externally-mounted Mk-55 mines on the lateral-control response are shown at a corresponding higher weight (35,500 lb). The single-engine directional characteristics in the take-off

(U) and wave-off configurations are shown as a function of gross weight. The single-engine control characteristics in the catapult take-off configuration (which is based on Loading B) are shown at a heavy weight (46,100 lb) and in the cruise configuration at a very light weight (31,100 lb). The catapult take-off characteristics are analyzed at three weights: 39,000 lb, 46,100 lb, and 54,000 lb. Landing approach pull-ups are shown at a weight of 34,500 lb, since this is the weight upon which landing performance in Reference 20 is based. Generally speaking, the longitudinal flying qualities are shown as functions of center-of-gravity position over the entire permissible center-of-gravity range at appropriate weights, although it may be physically impossible for the center of gravity to vary so widely with any particular loading.

3.7 OPERATING ENVELOPE

(C) Operating envelopes for Loading A, Loading B, and Loading B with 2 Mk-55 mines aboard are presented in Figure 10. These envelopes are bounded on the right by the following limitations:

a. A design limit speed, V_L, of 480 knots

b. A maximum operational Mach number, M_M, of 0.78

c. A maximum permissible Mach number, M_D, and design limit Mach number, M_L, of 0.85

d. The design limit speed also serves as a maximum operational speed, V_M, up to 3500 feet and as a maximum permissible speed, V_D, up to 8500 feet

(C) The speed at which high-speed level-flight buffet onset occurs decreases to below M_M at 30,000 feet. Buffet intensity is expected to increase to a tolerable limit at a Mach number of 0.85.

(C) The flight envelopes are bounded on the left by level-flight stall and buffet onset at low altitudes and by available thrust at high altitudes. The flight envelope for the CR_{ASW} configuration, with the slats extended for low-speed maneuvering, is also shown for Loading A. The limit speed with the slats extended is 262 knots, the landing-gear and flap placard speed.

(U) As shown by the data of Figures 10 and 11, 45-degree dives from maximum level flight speeds at 35,000 feet in the Dive configuration remain. within the permissible envelope. A complete envelope of dive profiles and the dive-recovery characteristics are presented in Figures 11 and 28, respectively. Dive recovery characteristics are discussed in Section 4.1.3.6.

(C) The flight characteristics of the MD-893 have been analyzed at and are presented throughout this report for the three altitudes specified by References 1 and 2: Sea level, 15,000 feet, and 30,000 feet.

TABLE I
DIMENSIONAL DATA

WING (Trapezoidal)		
Area (Reference)	S_W	480.0 (sq ft)
Span (Reference)	b_W	58.0 (ft)
Aspect Ratio	A_W	7.0
Mean Aerodynamic Chord (Reference)	MAC, $\bar{c}$	9.08 (ft)
Sweepback of 25-percent Chordline	Λ	15 (deg)
Taper Ratio	λ	.30
Dihedral at 25-percent Chordline	Γ	1.75 (deg)
Geometric Twist		3.5 (deg)
Aerodynamic Twist		1.5 (deg)
Incidence at Root	i_W	4.0 (deg)
Airfoil Sections		
Root		DSMA-482
Tip		DSMA-483
Airfoil Thickness Ratios		
Root	t/c_r	.14
Tip	t/c_t	.11
AILERON (Per Side)		
Area (Aft of Hingeline)	S_a	10.8 (sq ft)
Span	b_a	8.7 (ft)
Mean Aerodynamic Chord	$\bar{c}_a$	1.33 (ft)
Chord Ratio	c_a/c_W	.25
Nose Balance Ratio	c_b/c_a	.35
Aileron Gearing Ratio	G_a	1.92 (rad/ft)
Maximum Deflection	$\delta_{a_{max}}$	±20.0 (deg)
AILERON CONTROL TAB (Per Side)		
Type		Spring
Area	S_t	1.30 (sq ft)
Span	b_t	3.90 (sq ft)
Chord	c_t	.25 (ft)
Volume Ratio	A_a	.030
Link Ratio	R_{L_a}	4.0

Gear Ratio	β	0
Spring Rate Factor	k	.30(lb/sq ft deg)
Spring Rate	k_t	.13(ft lb/deg)
Maximum Deflection	$\delta_{t_{max}}$	±20.0 (deg)

AILERON TRIM TAB (Left Wing Only)

Area	S_T	.375 (sq ft)
Span	b_T	1.50 (ft)
Chord	c_T	.25 (ft)
Maximum Deflection	$\delta_{T_{max}}$	±20.0 (deg)

SPOILER (Per Side)

Type		Slot Lip
Area	S_S	13.8 (sq ft)
Span	b_S	11.7 (ft)
Chord (Inboard)	c_S	1.29 (ft)
Chord (Outboard)	c_S/c_W	.15
Maximum Deflection	$\delta_{S_{max}}$	60.0 (deg)

WING FLAPS (Per Side)

Type		Double-Slotted
Area	S_F	39.9 (sq ft)
Span	b_F	16.3 (ft)
Chord (Inboard)	c_F	2.58 (ft)
Chord Ratio (Outboard)	c_F/c_W	.30
Maximum Deflection	$\delta_{F_{max}}$	40.0 (deg)

WING SLATS

Type		Powered
Span	b_s	24.4 (ft)
Chord Ratio	c_s/c_W	.15
Maximum Deflection	$\delta_{s_{max}}$	21.0 (deg)

HORIZONTAL TAIL		
Area	S_H	170.5 (sq ft)
Area Ratio	S_H/S_W	.355
Span	b_H	27.3 (ft)
Aspect Ratio	A_H	4.36
Mean Aerodynamic Chord	$\bar{c}_H$	6.48 (ft)
Sweepback of 25-percent Chordline	Λ_H	13.0 (deg)
Taper Ratio	λ_H	.50
Dihedral at 25-percent Chordline	Γ_H	4.2 (deg)
Airfoil Sections		
Root	DSMA-485 Inverted	
Tip	DSMA-486 Inverted	
Airfoil Thickness Ratios		
Root	t/c_r	.115
Tip	t/c_t	.085
Range of Adjustable Incidence	i_H	+4.0(TED) -12.0(TEU) (deg)
Tail Length	ℓ_H	21.6 (ft)
Tail Length Ratio	$\ell_H/\bar{c}$	2.38
Tail Volume Ratio	$S_H \ell_H / S_W \bar{c}$	.845
ELEVATOR		
Area (Aft of Hingeline)	S_e	51.1 (sq ft)
Span	b_e	27.3 (ft)
Mean Aerodynamic Chord	$\bar{c}_e$	1.95 (ft)
Chord Ratio	c_e/c_H	.30
Nose Balance Ratio	c_b/c_e	.35
Elevator Gearing Ratio	G_e	.768 (rad/ft)
Maximum Deflection	$\delta_{e_{max}}$	+15.0(TED) -25.0(TEU) (deg)
ELEVATOR CONTROL TAB		
Type		Linked
Area	S_t	4.0 (sq ft)
Span	b_t	8.0 (ft)
Chord	c_t	.50 (ft)
Volume Ratio	A_t	.020
Link Ratio	R_{L_e}	10.0

Gear Ratio	β	0
Maximum Deflection	$\delta_{t_{max}}$	+25.0(TED) -15.0(TEU) (deg)

ELEVATOR GEARED TAB

Type		Geared
Area	S'_t	2.0 (sq ft)
Span	b'_t	4.0 (ft)
Chord	c'_t	.50 (ft)
Volume Ratio	A'_t	.010
Gear Ratio	β'	-.60
Maximum Deflection	$\delta'_{t_{max}}$	+15.0(TED) -9.0(TEU) (deg)

VERTICAL TAIL (To VSBL @ WL 184.2)

Area	S_V	120.0 (sq ft)
Area Ratio	S_V/S_W	.25
Span	b_V	14.9 (ft)
Aspect Ratio	A_V	1.85
Mean Aerodynamic Chord	$\bar{c}_V$	8.72 (ft)
Sweepback of 25-percent Chordline	Λ_V	25.0 (deg)
Taper Ratio	λ_V	.338
Airfoil Sections		
Root		NASA 0011.5
Tip		NASA 0008.5
Tail Length	ℓ_V	20.0 (ft)
Tail Length Ratio	ℓ_V/b_W	.345
Tail Volume Ratio	$S_V\ell_V/S_W b_W$	.0864

RUDDER

Area (Aft of Hingeline)	S_r	32.4 (sq ft)
Span	b_r	11.8 (ft)
Mean Aerodynamic Chord	$\bar{c}_r$	3.0 (ft)
Chord Ratio	c_r/c_V	.35
Nose Balance Ratio	c_b/c_r	.35
Elevator Gearing Ratio	G_r	2.12 (rad/ft)
Maximum Deflection	$\delta_{r_{max}}$	±30.0 (deg)

RUDDER CONTROL TAB

Type		Linked
Area	S_t	3.22 (sq ft)
Span	b_t	4.30 (ft)
Chord	c_t	.75 (ft)
Volume Ratio	A_r	.025
Link Ratio	R_{L_r}	10.0
Gear Ratio	β	0
Maximum Deflection	$\delta_{t_{max}}$	±30.0 (deg)

RUDDER TRIM TAB

Area	S_T	.75 (sq ft)
Span	b_T	1.50 (ft)
Chord	c_T	.50 (ft)
Maximum Deflection	$\delta_{T_{max}}$	±20.0 (deg)

SPEED BRAKES

Number		4
Side Brakes (2)		
Hingeline Location		Sta 442.5
Area, Per Brake	S_B	16.9 (sq ft)
Maximum Deflection	δ_B	50.0 (deg)
Bottom Brakes (2)		
Hingeline Location		Sta 481.0
Area, Per Brake	S_B	7.6 (sq ft)
Maximum Deflection	δ_B	50.0 (deg)

TABLE II

CONFIGURATION DESCRIPTION

Configuration	Thrust	Gear	Flaps	Slats	Speed Brakes	Weight (W) lb	Roll (I_x) slug ft^2	Pitch (I_y) slug ft^2	Yaw (I_z) slug ft^2	Product (I_{xz}) slug ft^2
TO: Take-off	Take-off	Down	Down	Extended	Closed	44,500	51,000	138,000	173,000	10,500
CTO: Catapult Take-off	Take-off	Down	Down	Extended	Closed	46,100	52,000	140,000	175,000	10,600
CR: Cruise	PLF	Up	Up	Closed	Closed	38,900	41,000	134,000	164,000	10,500
CR_{ASW}: Cruise-ASW	PLF	Up	Up	Extended	Closed					
P_{NRP}: Power-on	NRP	Up	Up	Closed	Closed					
P_{MRP}: Power-on	MRP	Up	Up	Closed	Closed					
D: Dive	Idle	Up	Up	Closed	Open					
PA: Power-Approach	PLF	Down	Down	Extended	Closed	30,700	41,000	134,000	162,000	10,800
L: Landing	Idle	Down	Down	Extended	Closed					
WO: Wave-off	Take-off	Down	Down	Extended	Closed					

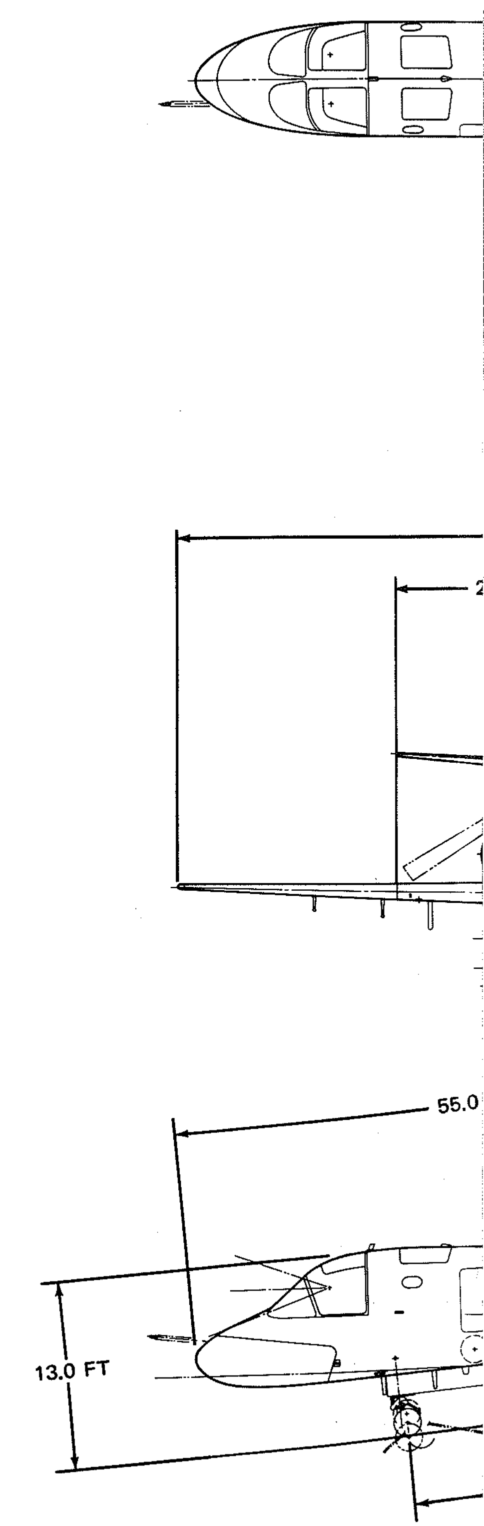


FIGURE 1

MODEL MD-893
THREE-VIEW DIAGRAM

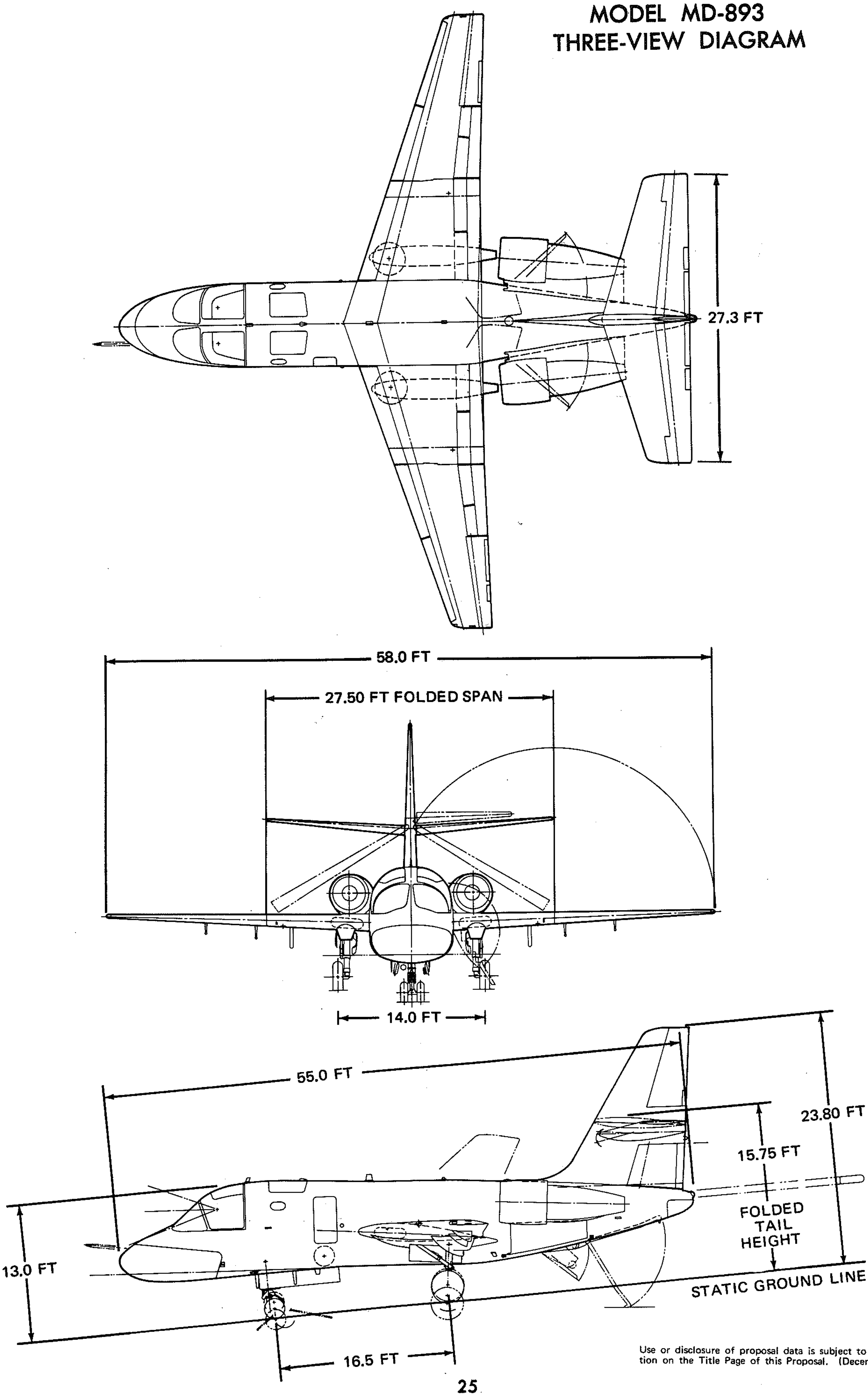
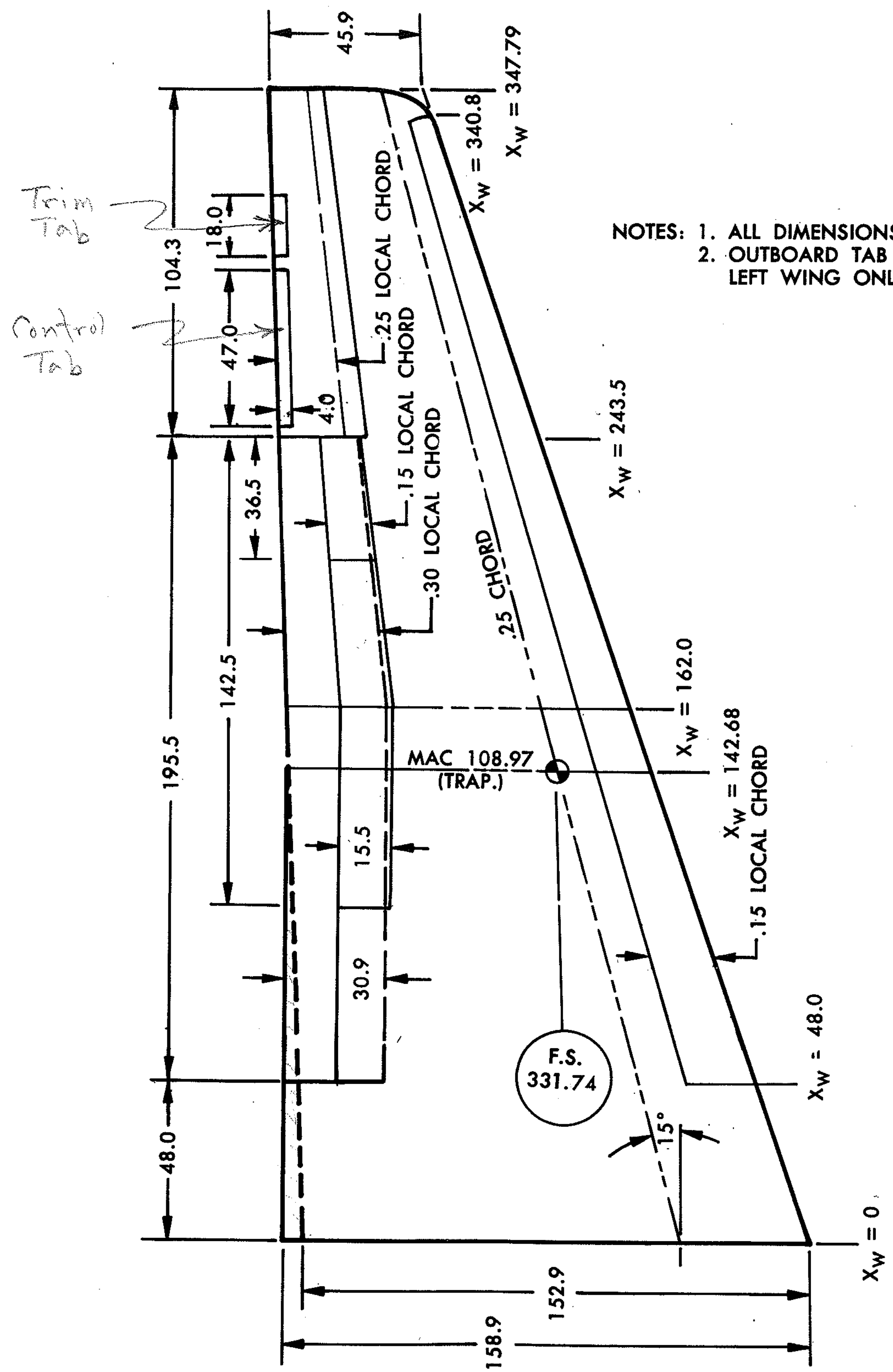


FIGURE 2

MODEL MD-893
WING DIAGRAM



NOTES: 1. ALL DIMENSIONS IN INCHES
2. OUTBOARD TAB (TRIM) ON LEFT WING ONLY

FIGURE 3

MODEL MD-893
HORIZONTAL STABILIZER DIAGRAM

ALL DIMENSIONS IN INCHES

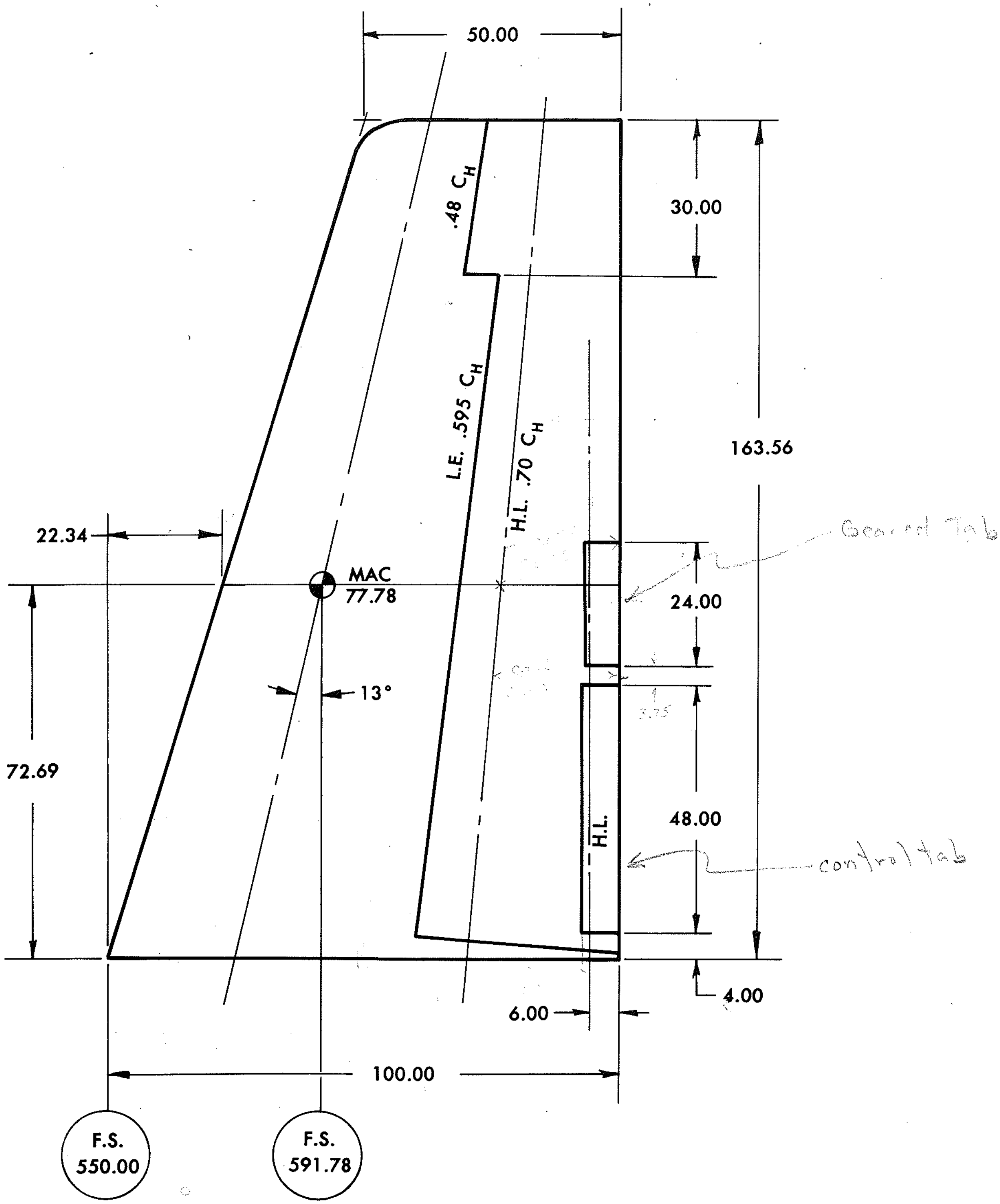
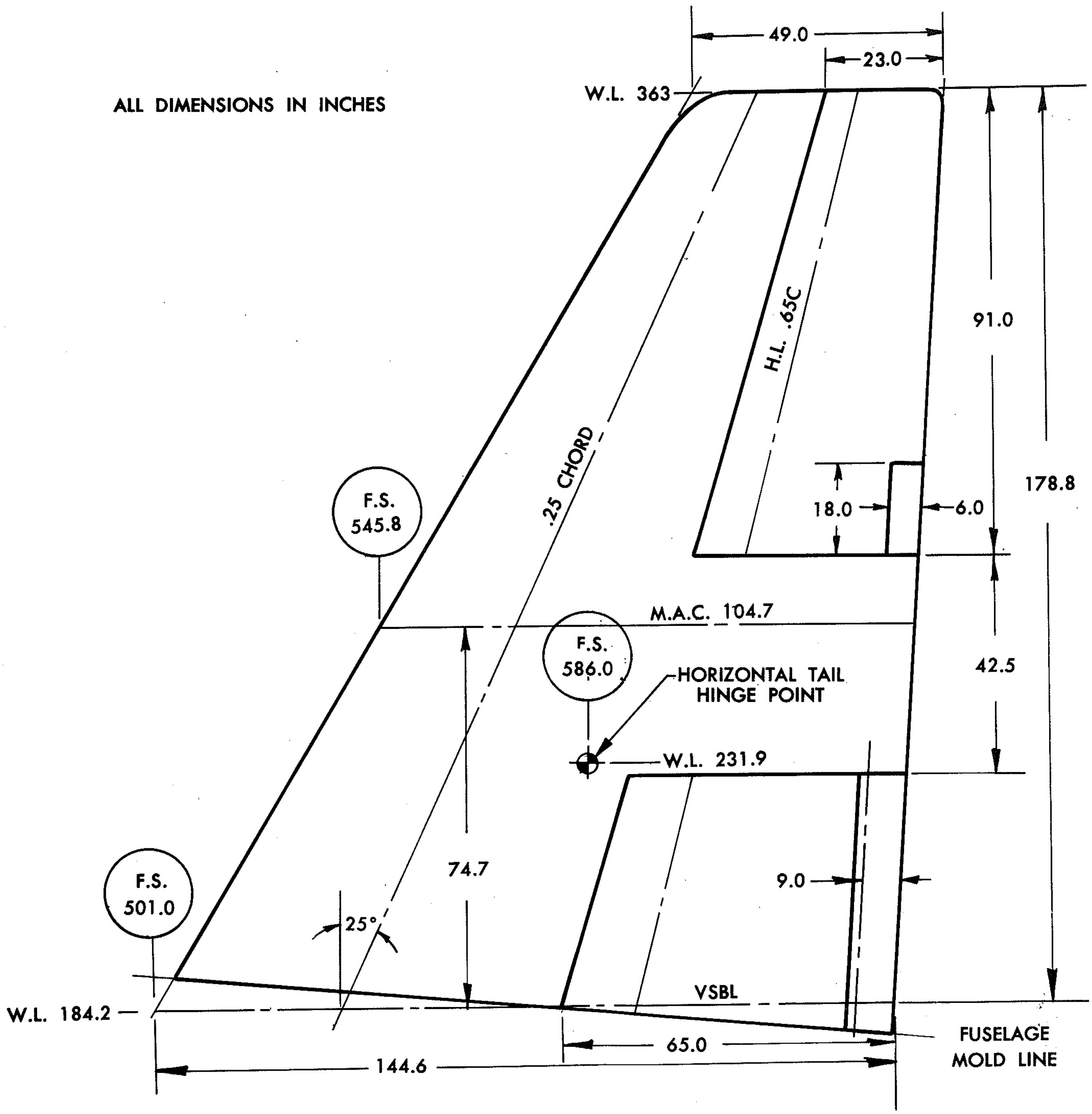


FIGURE 4

MODEL MD-893
VERTICAL STABILIZER DIAGRAM



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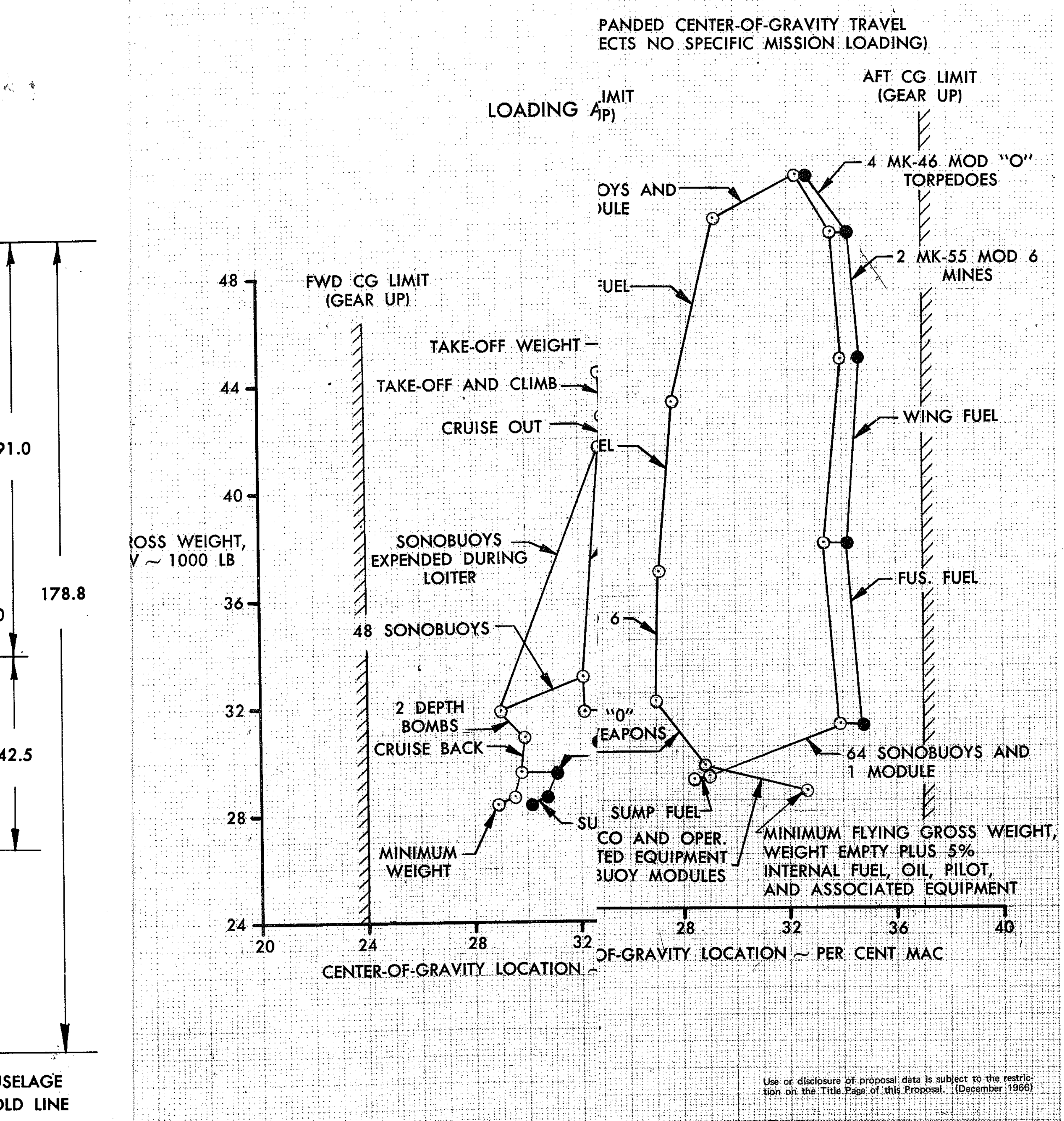

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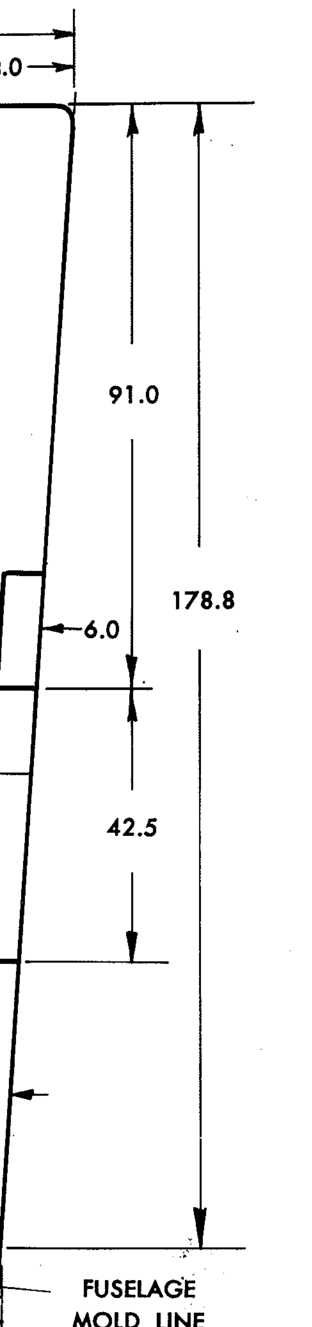

MODEL MD-893
CENTER-OF-GRAVITY ENVELOPES

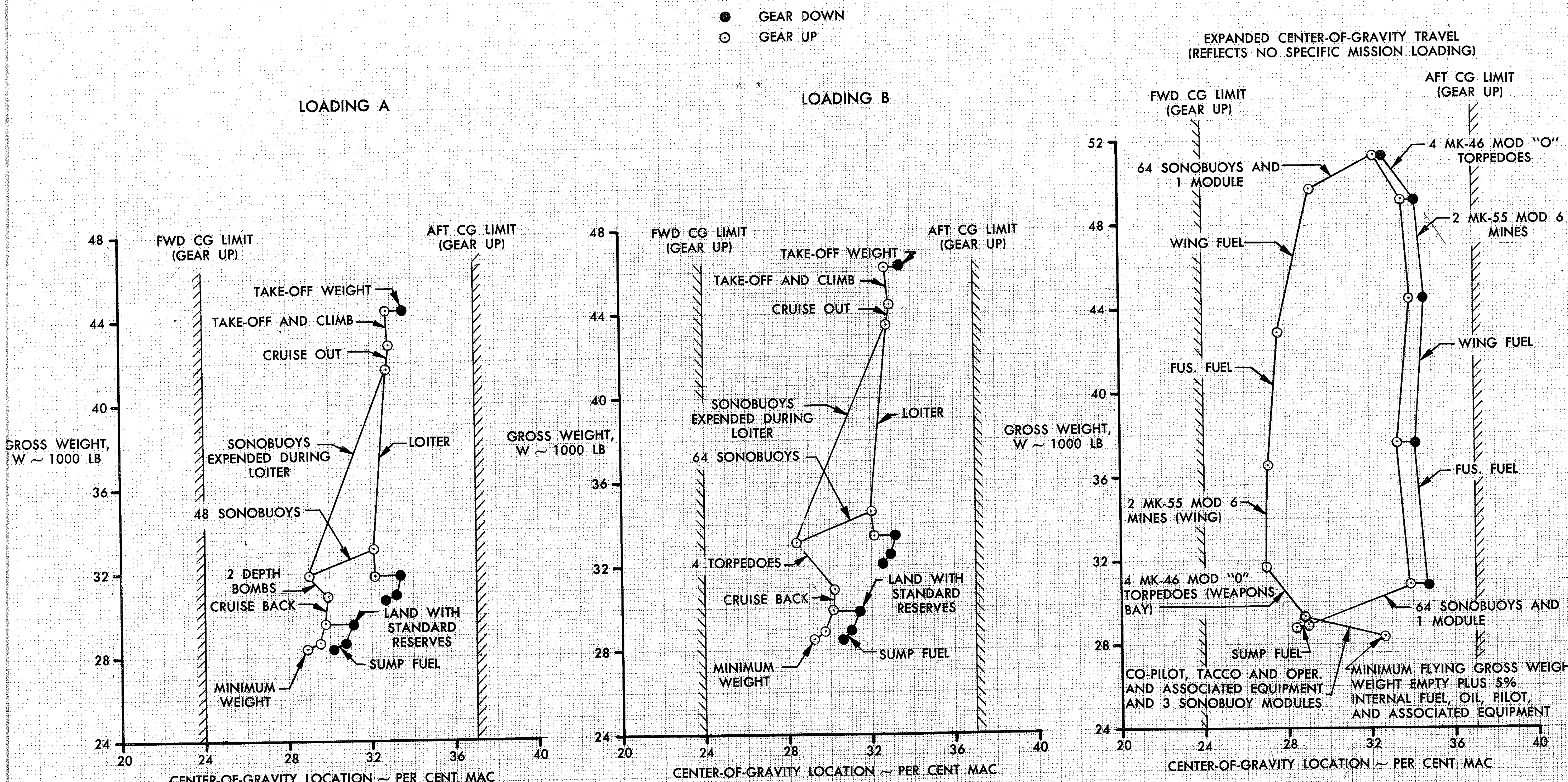

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FIGURE 7

MODEL MD-893
SPEED BRAKE DIAGRAM

TOTAL SPEED BRAKE AREA = 49 SQ FT