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Multiple-Purpose Subsonic Naval Aircraft (MPSNA) - Multiple Application Propfan Study (MAPS)

R. M. Engelbeck, C. T. Havey, A. Klamka, C. L. McNeil, M. A. Paige

BOEING MILITARY AIRPLANE COMPANY
A Division of The Boeing Company
Wichita, Kansas 67277-7730

Contract No. NAS 3-24529

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UTTL: Multiple-Purpose Subsonic Naval Aircraft (MPSNA): Multiple Application Propfan Study (MAPS) TLSP: Final Report
AUTH: A/ENGELBECK, R. M.; B/HAVEY, C. T.; C/KLAMKA, A.; D/MCNEIL, C. L.; E/PAIGE, M. A.
CORP: Boeing Military Airplane Development, Wichita, KS.
SAP: Avail: NTIS HC A10/MF A02
CIO: UNITED STATES
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MINS: / ANTISUBMARINE WARFARE/ SHORT TAKEOFF AIRCRAFT/ VERTICAL LANDING
ABA: Author
ABS: Study requirements, assumptions and guidelines were identified regarding carrier suitability, aircraft missions, technology availability, and propulsion considerations. Conceptual designs were executed for two missions, a full multimission aircraft and a minimum mission aircraft using three different propulsion systems, the UnDucted Fan (UDF), the Propfan and an advanced Turbofan. Detailed aircraft optimization was completed on those configurations yielding gross weight performance and carrier spot factors. Propfan STOVL conceptual designs were exercised also
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LIST OF ACRONYMS

AAM	Air-Air Missile
AAW	Anti-Air Warfare
ACLS	Automatic Carrier Landing System
AELW	Airborne Electronic Warfare
AEW	Airborne Early Warning
ALT	Altitude
ALWT	Advanced Lightweight Torpedo
AMAD	Airframe Mounted Accessory Drive
AMPR	Aeronautical Manufacturers Planning Report
AOA	Angle Of Attack
APET	Advanced Propfan Engine Technology
APU	Auxiliary Power Unit
AR_e	Exposed Aspect Ratio
ASAMP	Airplane Synthesis and Mission Program
ASM	Air-to-Surface Missile
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATACM	Advanced Technology Airframe Cost Model
BMAC	Boeing Military Airplane Company
b_v	Span of Vertical Tail
C^3I	Command, Control, and Communication Information
CAP	Combat Air Patrol
CAT	Clear Air Turbulence
CG,C.G.	Center of Gravity
C_L	Lift Coefficient
C_{L_A}	Lift Coefficient of Airplane
C_{LMAX}	Maximum Lift Coefficient
CN, C_N	Yaw Moment Coefficient
CN_β , C_{N_β} , C_{n_β}	$dC_N/d\beta$ Variation of Yawing Moment with Sideslip Angle
COD	Carrier Onboard Delivery
CONUS	Continental United States
CTOL	Conventional Takeoff and Landing
CV	Aircraft Carrier
CVBG	Carrier Battle Group
$C/4_{sweep}$	Quarter Chord Sweep
DEG	Degree
DIA	Diameter
DLI	Deck-Launched Interceptor
DoD	Department of Defense
EBU	Engine Buildup
ECM	Electronic Countermeasures
EFH	Engine Flight Hours

LIST OF ACRONYMS

ELW	Electronic Warfare
EMAD	Engine Mounted Accessory Drive
EW	Electronic Warfare
F_{NT}	Total Net Thrust
FPS	Feet Per Second
FT, Ft, ft	Feet
GAL	Gallon
GE	General Electric Company
GW	Gross Weight
IDG	Integrated Drive Generator
IFF	Identification Friend or Foe
ILS	Instrument Landing System
IN, in	Inch
INS	Inertial Navigation System
IPU	Integrated Power Unit
IR	Infra Red
ISAR	Inverse Synthetic Aperture Radar
JBD	Jet Blast Deflector
JTIDS	Joint Tactical Information Distribution System
KEAS	Knots Equivalent Airspeed
KTAS	Knots True Airspeed
KTS, kts	Knots
KVA	Kilovolt Amperes
L	Lift
LB., Lb., lb.	Pounds
LCC	Life Cycle Cost
l_V	Distance Along X-Axis from C.G. to Aerodynamic Center of Vertical Surface
M	Mach Number
MAC	Mean Aerodynamic Chord
MAD	Magnetic Anomaly Detector
MAPS	Multiple Applications Program Study
MFHBF	Mean Flight Hours Between Failure
MIL-STD	Military Standard
MIW	Mine Warfare
MK	Model Number
MMH	Maintenance Man Hours
MOD	Modification Number
MPSNA	Multi-Purpose Subsonic Naval Aircraft
MTBF	Mean Time Between Failure

LIST OF ACRONYMS

MTBM	Mean Time Between Maintenance
MTTR	Mean Time To Repair
NAEC	Naval Air Engineering Center
NAVAIR	Naval Air System Command
NAM	Nautical Air Miles
NM	Nautical Miles
NNEP	Navy/NASA Engine Program
O&S	Operating and Support
PF	Propfan
P/L	Payload
P&W	Pratt and Whitney
PSF, psf	Pounds per Square Foot
Q,q	Dynamic Pressure, $\frac{1}{2} \rho V^2$
R&M	Reliability and Maintainability
R_e	Reynolds Number
ROM	Rough Order of Magnitude
S&C	Stability and Control
SF, S.F.	Scale Factor
S_H	Horizontal Tail Area
SL	Sea Level
S.P.	Short Period
S_{ref}	Wing Reference Area
STOVL	Short Takeoff Vertical Landing
S_V	Vertical Tail Area
TACAN	Tactical Air Navigation
TF	Turbofan
TKR	Tanker
TOS	Time On-Station
TSFC	Thrust Specific Fuel Consumption
TOGW	Takeoff Gross Weight
T/C	Thickness/Chord
T/W	Thrust to Weight Ratio
TYP	Typical
UDACS	Universal Display and Control System
UDF	Unducted Fan (G.E. Copyrighted name for gearless propfan)
USN	United States Navy

LIST OF ACRONYMS

V_{APR}	Approach Velocity
V_{LOF}	Velocity at Liftoff
V_{MCA}	Air Minimum Control Speed
VSTOL, V/STOL	Vertical & Short Takeoff and Landing
VTOL	Vertical Takeoff and Landing
W	Weight
WOD	Wind Over Deck
α	Angle of Attack
β	Sideslip Angle
δ_e	Elevator Deflection
δ_f	Flap Deflection
δ_R	Rudder Deflection
$\Lambda_{c/4}$	Sweep Angle of Wing Quarter Chord Line
λ	Vertical Tail Taper Ratio
θ	Roll Attitude Angle
τ	Change in zero life angle of attack with flap deflection ($\Delta\alpha / \Delta\delta$)

1.0 SUMMARY

A total of eight aircraft configurations were generated to identify effects of propfan/UDF vs. turbofan propulsion system and the effects of STOVL vs. CTOL propfans on gross weight, fuel usage and LCC.

The ten MPSNA missions were analyzed to determine the primary design missions, which were found to be AEW, ASW, EW, Tanker and COD. The Multimission CTOL configurations meet all of the primary mission requirements. The Minimum AEW/ASW configurations were sized to do the AEW mission. All the minimum mission vehicles fall approximately half an hour short of the ASW design loiter time of six hours, even with a reduced payload.

VTOL was deleted from the study because preliminary analysis showed it far exceeds the 80,000 lb. elevator limit. The STOVL configurations were analyzed for the propfan engine. A bleed and burn reaction control system was used for pitch and roll control. Yaw control was achieved through the use of tilt nacelles.

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2.0 INTRODUCTION

A number of previous studies have determined the potential benefits of propfan technology applied to commercial and military transports with fuel savings from 15 to 25 percent and a reduction in operating costs from 7 to 12 percent using identical engine and aircraft technology levels.

This study investigated the potential application of counter-rotating propfan propulsion systems to carrier-based conventional take-off and landing (CTOL), MPSNA type aircraft. The MPSNA aircraft are designed to satisfy projected mission requirements for airborne early warning (AEW); anti-submarine warfare (ASW); anti-surface warfare (ASUW); mine warfare (MIW); cargo (COD); anti-air warfare (AAW); tanker; electronic warfare (EW); and associated surveillance, communication, command and control missions. One MPSNA vehicle configuration is used in more than one role much as the S-3A is used for ASW, ASUW, MIW and surveillance today. The technology level is consistent with a mid 1990's introduction into service and is consistent with the mission requirements and overall benefits to the aircraft weapons system and the carrier battle group. The market potential for this type of aircraft is significant in that it could potentially replace the E-2, S-3, C-2, KA-6 and EA-6 aircraft.

The objectives of this study were to:

1) identify the cost/program benefits of the propfan propulsion system relative to a comparable technology turbofan system and those elements of the mission requirements which influence this comparison.
2) identify propulsion system technology requirements for the proposed MPSNA configuration.
3) propose a recommended technology research and development plan.

The data resulting from the CTOL work done in this study became the baseline data for a concise study of propfan short take-off and vertical landing (STOVL) MPSNA aircraft. Data from the CTOL study was extrapolated for the STOVL studies, to the extent possible.

In order to be compatible with carrier based operation, limits of 80,000 lb. gross weight, 80 ft. span, and 25 ft. maximum height were imposed on all the CTOL configurations. All the CTOL configurations remain within the catapult and arresting gear limits.

The engines for each configuration were sized for the most demanding of the following criteria:

1) Sea level takeoff thrust to weight ratio of .4.
2) AEW cruise speed of 400 kts at 40,000 ft.
3) Air refueling condition of 400 kts at 25000 ft.

The multimission configurations were designed to provide full up capability on all missions. The minimum AEW/ASW configurations were sized to accomplish the full AEW mission and a less stringent ASW mission. The minimum AEW/ASW configurations were also designed so that the only difference between the configurations was the type of engines installed. This would provide a direct comparison between the powerplant types that would not be complicated by differences in configuration geometry.

3.0 TASK I: STUDY REQUIREMENTS, ASSUMPTIONS, AND GUIDELINES

3.1 CARRIER CONSTRAINTS TO AIRCRAFT DESIGN

Operation of aircraft from a carrier has a significant impact on the design of navy aircraft. The following sections highlight some of the major weight and geometry limitations affecting the service, storage and operation of aircraft aboard a carrier.

3.1.1 ELEVATOR WEIGHT LIMITS

The newly revised aircraft carrier chart specification is SI Chart 1134C, 1 May 1985, superceding SI 1134B, 1 January 1981. It should be noted that the 80,000 lb. maximum elevator limit has been raised to 110,000 lb. for the Forrestal class carriers. This resulted from the operational need to accommodate a full F-14 and an ordnance tug simultaneously. This limit includes the weight of the tow tractor. This study is based on the old 80,000 lb elevator limit.

3.1.2 OPERATIONAL PARK LINE

The operational park line for any catapult in use is 42 ft. to either side of the catapult centerline. The 42 ft. limit is derived from the 40.3 ft. semispan of an E-2C. The reduced wing span of an E-2C replacement aircraft could allow more operational parking space. The next largest wingspan in the current wing is the S-3A at 68.7 ft.

3.1.3 HANGAR BAY DOOR HEIGHT

The 25 ft. height of the carrier hangar deck is not uniform. There are clearance areas greater than 25 ft. However, due to fuel tanks, etc., stored in overhead racks, some areas have a clearance less than 25 ft. The hangar door ramps affect the allowable tail height as a function of the various wheelbases and nose gear-to-tail distances. This study uses the hangar bay door height of 25 ft. as the limit.

3.1.4 GROUND OR DECK CLEARANCES

The conditions for minimum clearances of 6 in. are given in SD-24L. These clearance components include propellers, control surfaces, flaps, speed brakes, and external stores. Figure 3.1.4-1 (from SD-24L) presents a composite clearance envelope to be maintained during all catapulting operations.

3.1.5 PROPELLER CLEARANCES

Engine placement is dependent upon maintaining a minimum 12 in. clearance between tips of propellers and the fuselage, landing gear, or any other structural members. Deflections of engines and supporting structure is considered in maintaining those clearances. SD-24L, Paragraph 3.12.13.7, elaborates on this requirement.

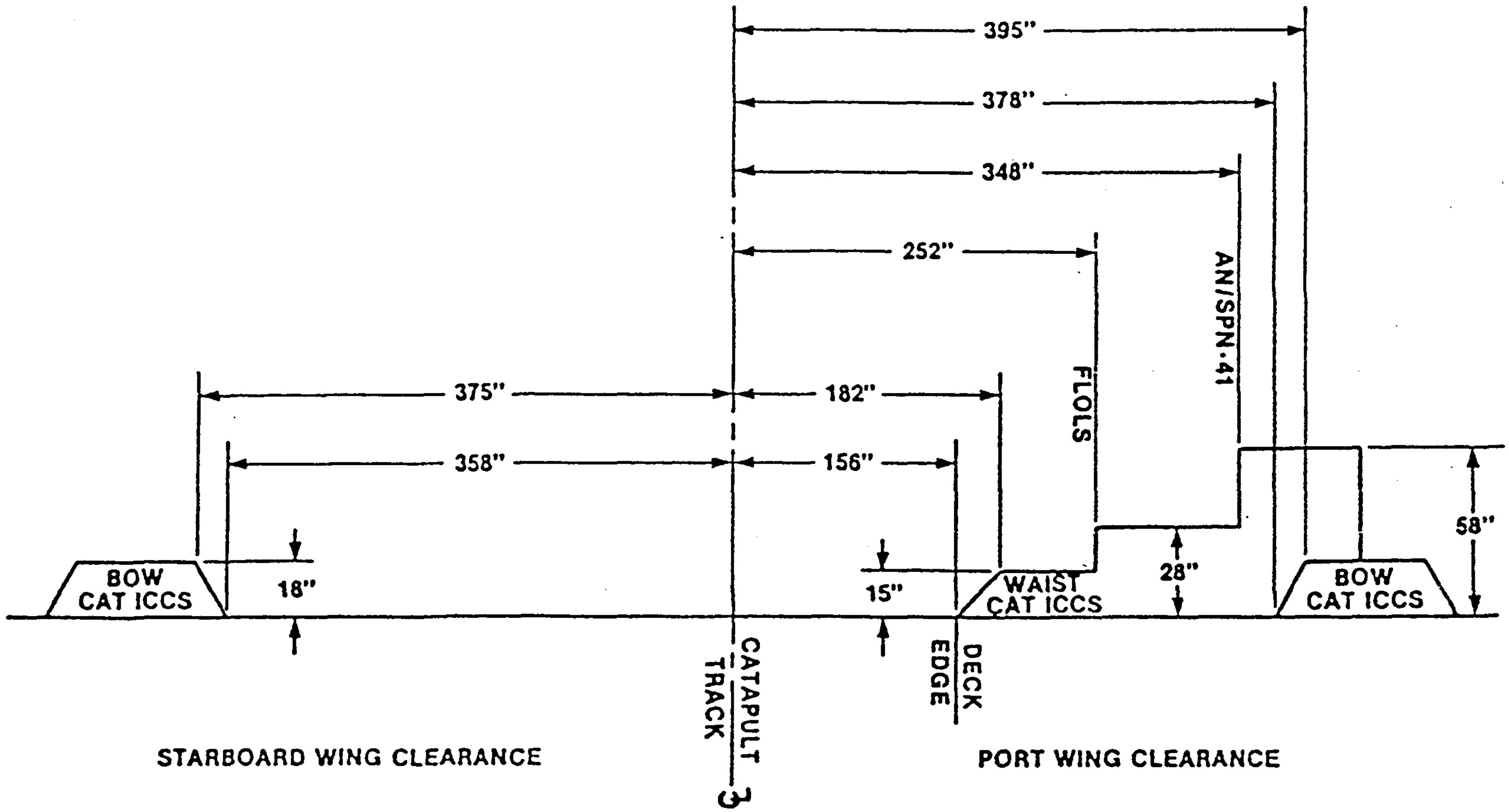


FIGURE 3.1.4-1 COMPOSITE CLEARANCE ENVELOPE FOR CATAPULT OPERATIONS

3.1.6 CATAPULT/ARRESTING GEAR/BARRICADE

The C7 catapult characteristics guide the design of new aircraft nose gear and structure. Reference NAEC MISC, 0A136, "Shipboard Catapult Minimum Performance and Load Factors," provides catapult performance and load factors for aircraft design. NAEC MISC, 0A114, "C7 Minimum Performance," presents the CV62 bow catapult weight versus end speed curves.

MIL-L-22589C(AS) provides nose gear design for launching system guidelines while MIL-STD-2066(AS) presents catapult forcing functions for structural design.

The arresting hook design must conform to criteria found in MIL-A-18717B(AS) concerning arresting hook installation as well as MIL-STD-2066(AS) for arresting gear forcing functions for structural design. In addition, NAEC MISC, 08744, provides MK 7 MOD 3 arresting gear performance.

The MK 7 MOD 2 barricade performance is provided by NAEC MISC, 08784.

3.1.7 TOWING AND TURNING

Ease of maneuvering of aircraft onboard ship is extremely important for aircraft powered taxiing, towing with the tow-tug, or manually steering with a tow bar.

Taxiing or towing of the aircraft must not be restricted in any configuration. All aircraft designs must be able to pivot about either main gear while being towed. Table 3.1.7-I presents a summary of turning radii for selected aircraft.

All aircraft must have provisions for and be able to be towed from the rear as well as the front. One way this can be accomplished is by having tow fittings on both main gear strut for aft towing while the nose gear is steered manually. Discussion of tow fittings and provisions is found in MIL-STD-805A.

3.1.8 ACCESS TO AIRCRAFT

Carrier-based aircraft are often parked near the deck edge with either tail or nose out over the water. The main or nose gear may be as close as 18 in. from the deck edge in the parked position.

Some of the current inventory aircraft parked in this fashion restrict or prevent access to various areas of the aircraft. For example, the S-3A sonobuoy chutes cannot be rearmed while the aircraft is parked tail over water. It is desirable to maximize accessibility to the aircraft systems for provisioning and maintenance.

AIRCRAFT	PIVOT POINT	NOSE GEAR TURN LIMIT TAXI/TOW	MAIN GEAR RADIUS	NOSE GEAR RADIUS	WING FOLDED RADIUS	WING EXTENDED RADIUS
E-2C	MAIN GEAR	63°/360° (1)	19' 6"	25' 4"	38' 1"	50' 0"
S-3A	MAIN GEAR	?/110°	13' 9"	20' 9"	26' 1"	41' 2"
EA-6B	MAIN GEAR	60°/72° (2)	11' 3"	18' 0"	18' 9"	33' 0"
F-14	CENTERLINE BETWEEN MAIN GEAR	?/90°	8' 5"	23' 1"	26' 8"	32' 1"

(1) MECHANICAL STOPS MOUNTED ON STRUT MAY BE EXCEEDED FOR TOWING, ALLOWING 360° NOSE GEAR ROTATION.

(2) ANGLE THROUGH WHICH AIRCRAFT CAN BE PIVOTED ABOUT MAIN GEAR.

TABLE 3.1.7-I AIRCRAFT TAXI/TOW MANEUVERING DATA

3.1.9 LANDING GEAR DIMENSIONAL LIMITATIONS

The maximum distance from the nose of the aircraft to the main gear or bumper (if any) is limited to 52 ft. due to the desired nose-inboard parking of the aircraft on any elevator. The elevator lowers along a slight inboard angle in order to follow the ship's hull. Thus, the aircraft nose cannot be allowed to contact the flight deck as the elevator is either raised or lowered.

The distance from the nose wheel catapult position to the forward mounted hinge line of the Jet Blast Deflector (JBD) of the No. 1 catapult for several carriers is approximately 58 ft. Since the JBD hinge line is not perpendicular to the catapult, this limits the distance from the nose gear fuselage station to the most aft empennage planview station to about 56 ft. The JBD is raised for all takeoffs including propeller-driven aircraft. NAEC 06900 shows the JBD data chart for all carriers and various JBD dimensional parameters. NAEC 06900 Section III should be referred to for the various carrier planform relationships of JBD to catapults.

3.1.10 CATALOG OF DATA

Several aircraft dimensions affect the carrier suitability of the configuration. Some of these have been discussed in the previous sections. A summary of parameter definitions and operational limitations are presented in Table 3.1.10-I and are graphically depicted in Figure 3.1.10-1. The catalog of current carrier aircraft suitability data is then summarized in Table 3.1.10-II.

3.2 MISSION REQUIREMENTS

This section addresses the development of aircraft mission requirements for a mid- 1990's carrier-based multi-purpose subsonic Naval aircraft (MPSNA). Requirements were developed for the ten basic MPSNA missions (airborne early warning (AEW), anti-submarine warfare (ASW), electronic warfare (EW), anti-surface warfare (ASUW), mine warfare (MIW), cargo (COD), anti-air warfare (AAW), tanker, electronic support measures (ESM), and communication, command, and control (C^3I)) using the following operational parameters as applicable: detection range, time on-station, overall aircraft reliability, utilization rates, and cruise velocity. The AEW, ASW, EW, COD, and tanker missions were selected as primary missions, where the remaining missions were determined to be derivatives of these primary missions. Table 3.2-I summarizes the mission requirements for the ten basic missions. Mission profiles for the primary missions are presented in Figure 3.2-1. These were approved under Task I of this contract.

3.2.1 AEW MISSION

The primary contribution an AEW aircraft makes to the survivability of the carrier battle group is to provide sufficient threat warning to effectively utilize CVBG aircraft assets to kill cruise missile carriers

W	MAX GROSS WEIGHT & TAKEOFF	80000 LB ELEVATOR LIMITATION
L	OVERALL LENGTH OF AIRCRAFT	SPOT FACTOR/HANDLING
b.	WINGSPAN	CATAPULT CLEARANCE (80.6 FT LIMIT)
b_f	WINGSPAN, FOLDED	SPOT FACTOR/HANDLING
h	OVERALL HEIGHT	ELEVATOR DOOR/MAINTENANCE OPERATIONS (25 FT LIMIT)
h_f	HEIGHT FOLDED	HANGAR BAY PARKING, TAXIING
h_1	HEIGHT TO TOP OF FORWARD FUSELAGE	OPTICAL LANDING SYSTEM INTERFERENCE
A	NOSE GEAR TO TAIL DISTANCE	JBD CLEARANCE ON CATAPULT (56+ FT LIMIT)
B_1	NOSE TO MAIN GEAR DISTANCE	INBOARD ELEVATOR TO DECK EDGE CLEARANCE (52 FT LIMIT)
B_2	NOSE TO BUMPER DISTANCE	
C	WHEELBASE	TIP OVER ANGLE (SD-24L)
T	WHEEL TREAD	TIP OVER ANGLE (SD-24L) (20 FT CATAPULT LIMIT)
D	MAX TURNING ARC ABOUT MAIN GEAR	OPERATIONAL HANDLING
γ	AFT TIP OVER ANGLE	SD-24L (AFT C.G. LIMIT IS 15° FORWARD OF MAIN GEAR)
α	TIP BACK ANGLE	TOUCHDOWN/ARRESTMENT ANGLE OF ATTACK
SF	MAX DENSITY SPOT FACTOR	OPERATIONAL HANDLING FLEET MIX

TABLE 3.1.10-I CARRIER AIRCRAFT PARAMETER DEFINITIONS AND LIMITATIONS

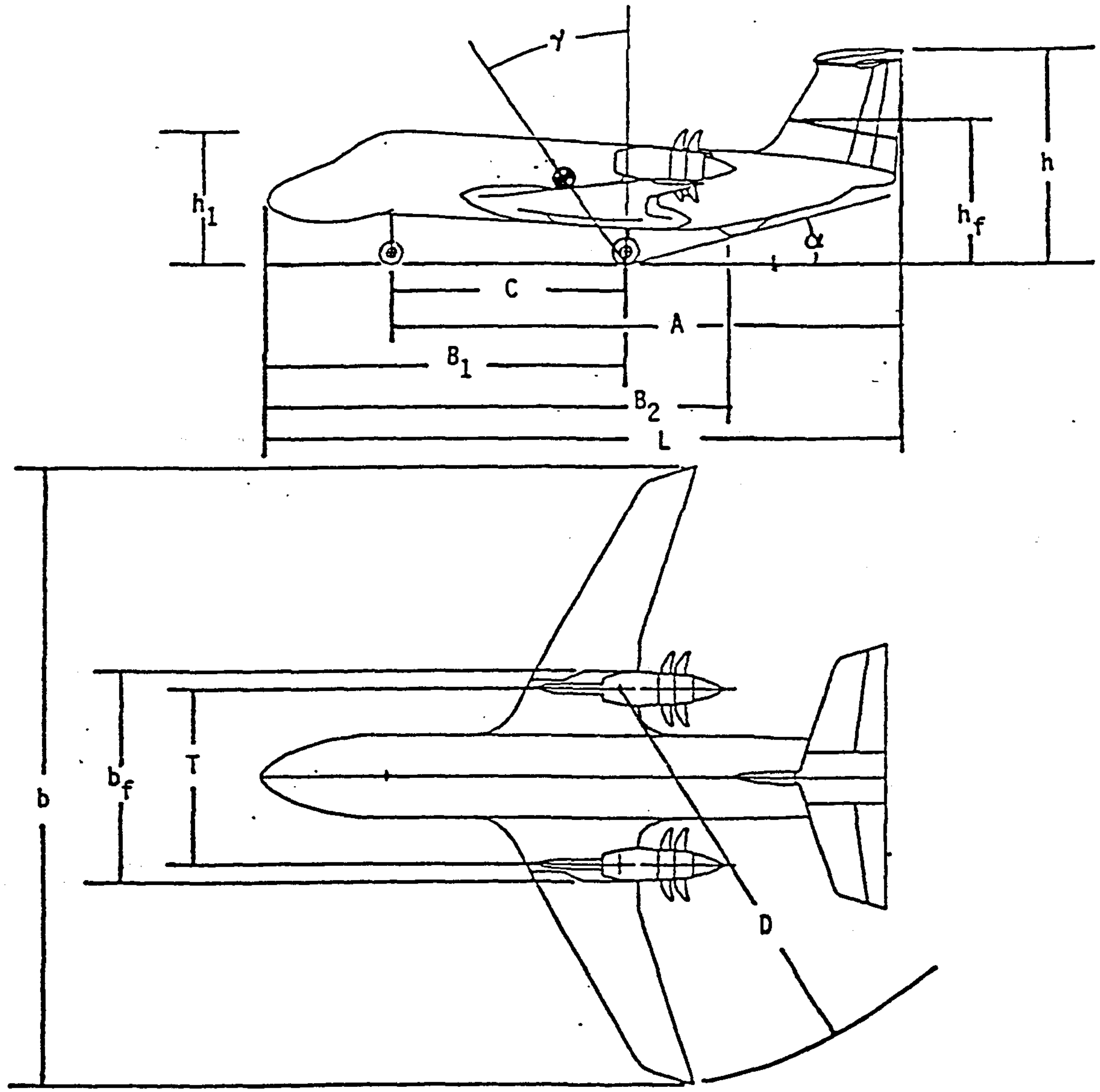


FIGURE 3.1.10-1 CARRIER AIRCRAFT PARAMETER DEFINITIONS DIAGRAM

CATALOG OF CURRENT CARRIER AIRCRAFT SUITABILITY DATA

AIRCRAFT	GROSS TAKEOFF WEIGHT W (LBS)	LENGTH (TAIL NOT FOLDED) (FEET) L	WINGSPAN NO WINGTIP MISSILES (FEET) b	FOLDED SPAN (FEET) b_f	OVERALL HEIGHT (FEET) h	FOLDED HEIGHT (FEET) h_f	FOLDING HEIGHT (FEET)	FORWARD FUSELAGE HEIGHT (FEET) h_1	MAXIMUM HEIGHT ON JACKS (1) (FEET)	DISTANCE NOSE TO NOSE GEAR (FEET)	DISTANCE NOSE GEAR TO TAIL (FEET) A	DISTANCE NOSE TO MAIN GEAR (FEET) B_1	DISTANCE NOSE TO BUMPER (FEET) B_2	WHEEL BASE (FEET) C	WHEEL TREAD (FEET) T	TURNING RADIUS ABOUT MAIN GEAR (FEET) D	TIP OVER ANGLE (AFT C.G) γ (DEG)	TIP BACK ANGLE α (DEG)	SPOT FACTOR
E-2C	52000	57.6	80.6	29.3	18.3	16.5	22.9	9.7	18.7	4.6	53.0	27.9	47.0	23.3	19.5	50.0	17.3	9	2.01
C-2A	54830	56.6	80.6	29.3	16.9	16.9	22.4	11.1	19.1	1.4	55.2	24.6	45.6	23.2	19.5	50.0	14.2	8	1.97
S-3A	52539	53.3	68.7	29.5	22.8	15.3	31.1	11.6	17.0	7.0	46.3	25.8	NA	18.8	13.8	41.2	21.1	16	1.49
A-6E	58600	54.8	53.0	25.2	16.3	16.3	21.1	13.6	18.7	6.4	48.4	23.5	54.2	17.1	11.0	33.0	17.8	10	1.42
EA-6B	65000	59.4	53.0	25.2	16.7	16.7	21.1	14.1	20.3	11.0	48.4	28.2	59.4	17.2	10.8	33.0	19.9	10	1.46
F-14A	69800	61.9	64.1	33.3	16.0	NA	NA	12.4	18.9	16.7	45.2	39.7	NA	23.0	16.4	39.6	24.0	9	1.55
F/A-18	50060	56.0	37.5	27.5	15.1	15.1	15.1	10.4	17.6	17.9	38.1	35.8	NA	17.9	10.2	38	22.7	18	1.18
A-7E	42000	46.1	38.7	23.8	16.1	16.1	17.1	10.7	17.8	9.3	36.8	25.0	37.5	15.7	9.5	29	12.0	10	1.00
EA-3B (2)	73000	80.0	72.5	48.2	22.8	16.6	27.3	12.0	18.5	16.3	63.7	43.0	58.0	26.7	10.5	45	25.4	12	2.94

(1) GEAR EXTENDED AND TWO INCH TIRE CLEARANCE. TAIL & WINGS FOLDED.
(2) BRIDLE LAUNCHED

N85007-55

TABLE 3.1.10-II CATALOG OF CURRENT CARRIER SUITABILITY DATA

CONSIDERATIONS	AEW	ASW	ASUW	MIW	COD	AAW	EW	TANKER	ESM	C^3I
BASING MODE	CARRIER	CARRIER	LAND/CARRIER	LAND/CARRIER	LAND/CARRIER	CARRIER	CARRIER	CARRIER	CARRIER	CARRIER
MISSION RANGE (NM) WITH MAXIMUM PAYLOAD	—	—	—	—	2,100	—	—	DICTATED BY OFFLOAD REQUIREMENT	—	—
PAYLOAD (LBS)	MISSION EQUIPMENT AND ARMAMENT	MISSION EQUIPMENT AND ARMAMENT	MISSION EQUIPMENT AND ARMAMENT	MISSION EQUIPMENT AND ARMAMENT	15,000	MISSION EQUIPMENT AND ARMAMENT	MISSION EQUIPMENT AND ARMAMENT	25,000 LB FUEL OFFLOAD AT 200 NM	MISSION EQUIPMENT AND ARMAMENT	MISSION EQUIPMENT AND ARMAMENT
LOITER TIME ON STATION	6.0 HOUR* HOLD AT 40,000 FT AT 350 NM	6.0 HOUR* HOLD AT 5,000 FT AT 350 NM	6.0 HOUR* HOLD AT 5,000 FT AT 350 NM	3.0 HOUR HOLD AT 5,000 FT AT 800 NM	NO REQUIREMENT	6.0 HOUR* HOLD AT 40,000 FT. AT 350 NM	2.0 HOUR HOLD AT 35,000 FT AT 650 NM	2.5 HOUR HOLD AT 25,000 FT AT 200 NM	6.0 HOUR* HOLD AT 40,000 FT AT 350 NM	6.0 HOUR* HOLD AT 40,000 FT AT 350 NM
MISSION ALTITUDE REQUIREMENT	40,000 FT	5,000 FT	5,000 FT	5,000 FT	ABOVE 25,000 FT	40,000 FT	35,000 FT	25,000 FT	40,000 FT	40,000 FT
MISSION SPEED (KTAS) CRUISE	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT	400 AT OPTIMUM ALT
MISSION SPEED (KTAS) LOITER	BEST ENDURANCE AT 40,000 FT	BEST ENDURANCE AT 5,000 FT	BEST ENDURANCE AT 5,000 FT	BEST ENDURANCE AT 5,000 FT	—	BEST ENDURANCE AT 40,000 FT	BEST ENDURANCE AT 35,000 FT	—	BEST ENDURANCE AT 40,000 FT	BEST ENDURANCE AT 40,000 FT
MISSION SPEED (KTAS) REFUEL	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT	400 AT 25,000 FT
REFUELING CAPABLE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
CREW SIZE	5/6	4	4	2	3	2	4/5	2	3/4	3/4

*LOITER TIME ON STATION IS TRADEABLE FOR INCREASED NUMBER OF AIRCRAFT REQUIRED.

TABLE 3.2-I MISSION REQUIREMENTS SUMMARY

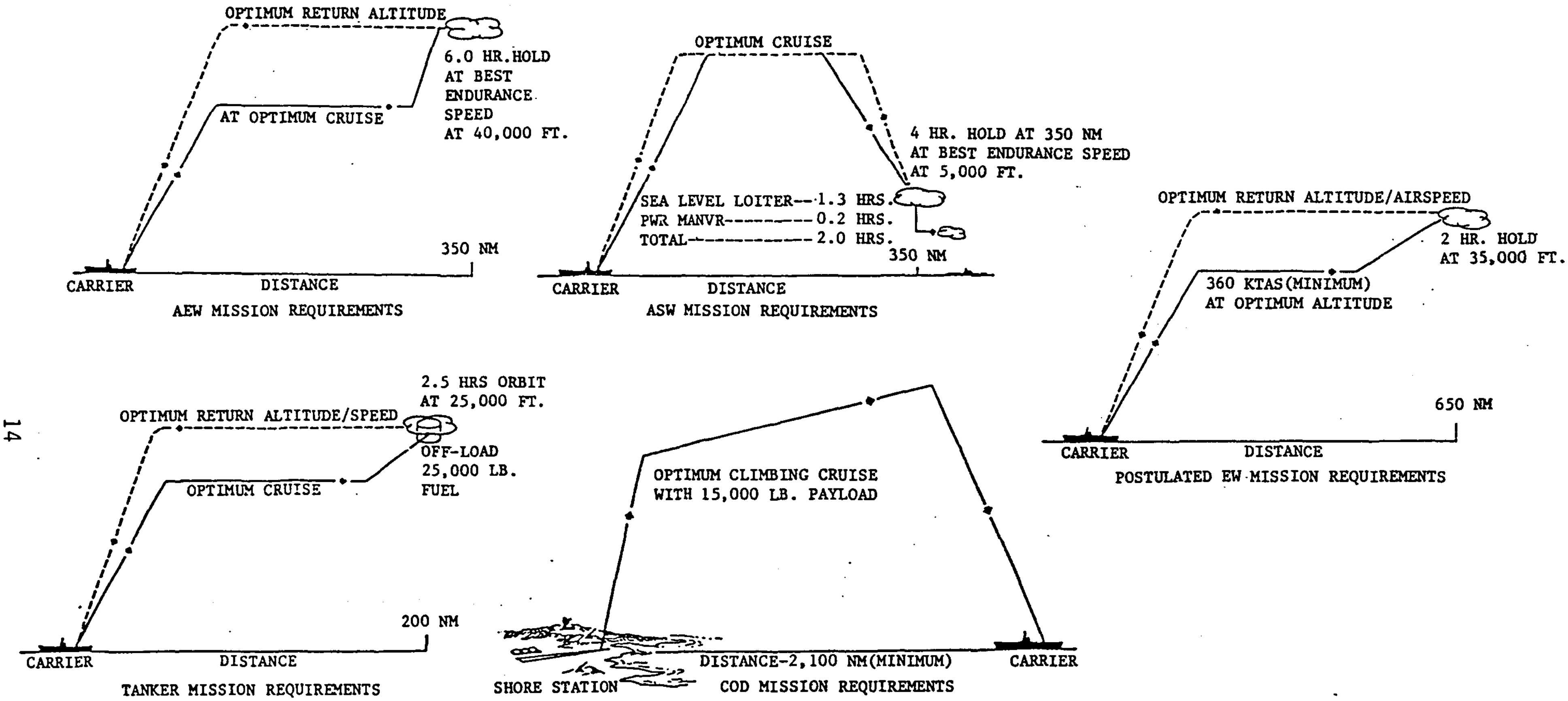


FIGURE 3.2-1 MISSION PROFILES

prior to the time they reach their missile launch point. Projected increases in both Soviet bomber speed and cruise missile launch ranges will require an increase in the minimum threat warning distance even when projected improvements in carrier fighter and air-to-air missile performance are incorporated in the analysis.

In order to provide increased warning over a larger threat sector, a combination of improved radar detection range and/or increased orbit number and radius is required. As shown in Figure 3.2.1-1, there is a definite design advantage in employing an operating altitude of approximately 40,000 ft. which increases the radar line of sight against a target at 1,000 ft. to 285 NM. When the expected target altitude is considered, a minimum of three orbits at 350 NM are required to provide sufficient warning over the threat sector.

Continuous maintenance of an increased number of orbits at longer ranges with the same number of aircraft requires an increase in overall reliability, utilization rate, cruise velocity, and endurance.

With an overall mission reliability of .85 and a reserve factor of 10%, six mission capable aircraft will be available to maintain the three AEW orbits. With projected technological advances, these aircraft should have a cruise velocity of at least 400 knots and be available on an average of 16 hours/day. As shown in Figure 3.2.1-2, these improvements in utilization rate and cruise velocity result in a minimum requirement of six hours on-station endurance.

The AAW, ESM, and C^3I missions were determined to be logical derivatives of the AEW mission because of the position of the AEW aircraft. These missions, which were approved as part of Task I, require no additional performance from the AEW aircraft.

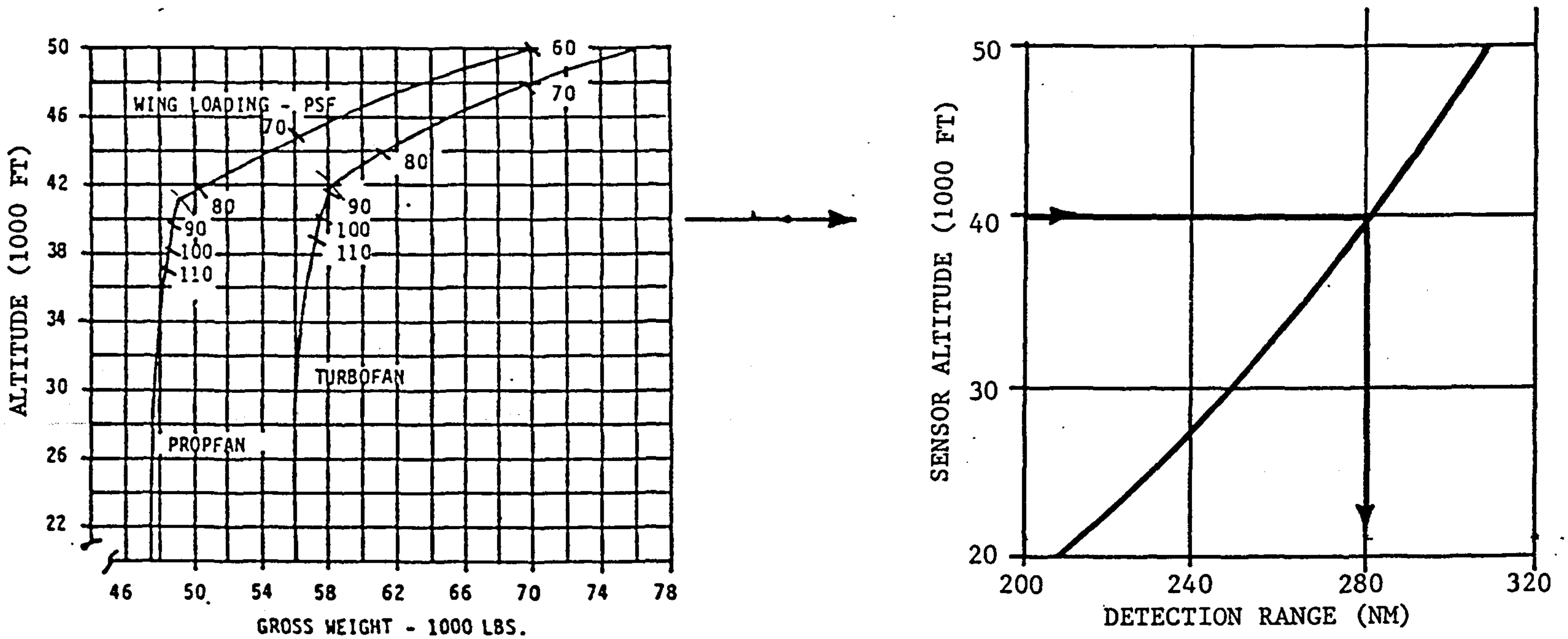
3.2.2 ASW MISSION

ASW aircraft contribute to the survival of the carrier battle group by providing initial detection and prosecution of submarine threats and by acting in a pouncer role where deck-launched ASW aircraft assist other ASW units in the prosecution of submarine contacts. The projected increase in cruise missile launch range requires a commensurate increase in the range at which these submarines must be detected and prosecuted.

To provide this extended ASW coverage, an increased number of orbits will be required even if the threat sector is not expected to increase. With the expected detection performance of the ASW sensors, a minimum of five orbits at 350 NM will be required to provide sufficient coverage using projected Naval ASW tactics and screen spacings. In addition to these station keeping requirements, three reserve aircraft are required in the reactive pouncer role to enhance the total ASW screen performance.

Improved aircraft performance will be required to meet these increased requirements without increasing the number of available aircraft. Of

- ALTITUDE AND RADAR DETECTION CAPABILITY MUST BE MATCHED
  - TARGET CHARACTERISTICS
  - RADAR PERFORMANCE
  - RADAR HORIZON
  - ORBIT SEPARATION



* 1000 FT. TARGET ALTITUDE

FIGURE 3.2.1-1 ALTITUDE AND DETECTION REQUIREMENTS

	NEW AEW
MAXIMUM AIRCRAFT	10
RESERVE AIRCRAFT (10%)	1
POOL AIRCRAFT	9
RELIABILITY (95% CONFIDENCE)	.85
MISSION CAPABLE AIRCRAFT	6
UTILIZATION RATE (HRS/DAY)	16
CRUISE SPEED (KTS)	400
BLOCK SPEED (KTS)	350
ALTITUDE (FT)	40000
RADAR DETECTION RANGE (NM)	280
THREAT DETECTION (NM)	555
STATION RANGE (NM)	350
ORBITS	3
MINIMUM TIME ON STATION (HRS)	6.0

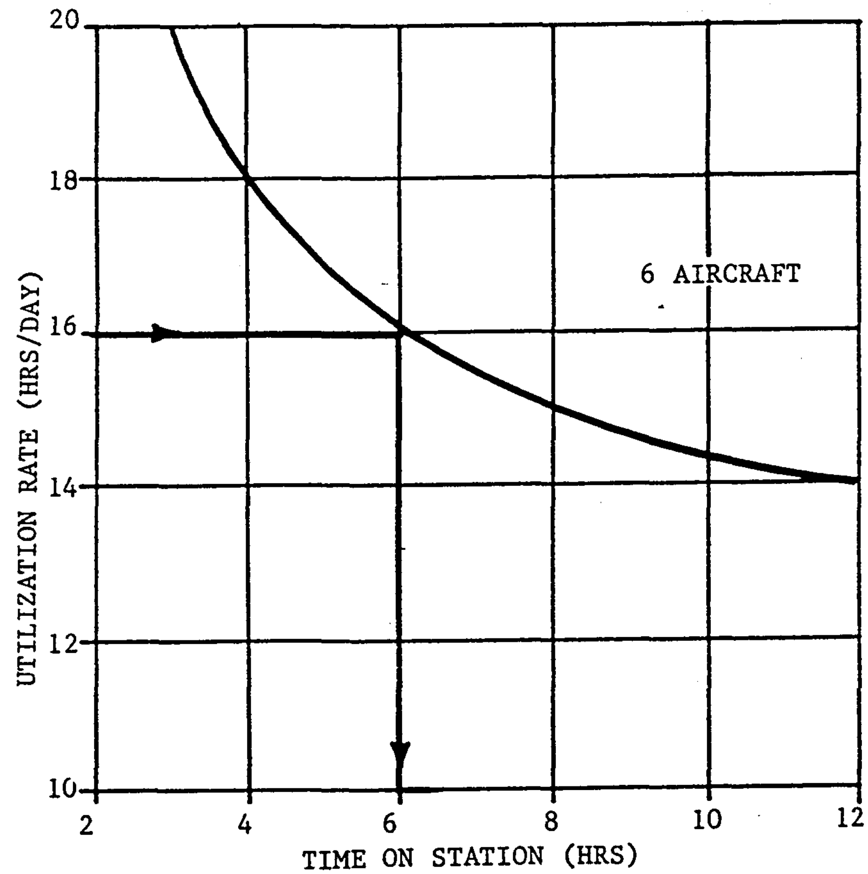


FIGURE 3.2.1-2 AEW TIME ON STATION DETERMINATION

the 20 ASW aircraft available aboard a two carrier battle group, 13 mission capable aircraft will be continuously available when the expected aircraft reliability of 0.85 is achieved at a 95% confidence level and 10% of the total aircraft available (2 in this case) are held in reserve. With three of those aircraft reserved for pouncer duty, ten aircraft will be available to provide continuous ASW barrier coverage. As shown in Figure 3.2.2-1, the ASW aircraft will require a minimum of six hours endurance even with the projected improvement in utilization rate and cruise velocity.

The ASUW and MIW mission requirements are derivative missions for today's ASW variants. Since the requirements for these missions were less stringent than the ASW requirement, it was assumed that they would continue to be derivative missions.

3.2.3 EW MISSION

The EW aircraft contribute to the effectiveness of the carrier battle group by providing ECM coverage for both offensive missions and fleet defense postures. Of these two areas, the offensive mission support was found to be the most stringent in terms of mission requirements. For effective participation in the 1990's carrier strike group, the EW aircraft should be compatible with other strike aircraft in terms of cruise speed, cruise altitude, and mission radius. The projected attack aircraft will have a mission radius of over 800 NM and cruise at over 35,000 ft. with a high subsonic cruise speed. To support this mission the EW aircraft should have as a minimum an unrefueled capability of holding for two hours at 650 NM and have cruise profiles similar to the attack aircraft.

3.2.4 TANKER MISSION

The role of the future tanker aircraft in supporting carrier battle group operations should remain much the same as that of today. However, the extended AAW posture will increase the offload requirements by as much as two to three times. A single tanker will be required to keep as many as three F-14s on extended CAP station for over six hours. This will require a 2.5 hour hold at 200 NM with a 25,000 lb. offload. Tanking operations should be conducted at over 25,000 ft. with a minimum refueling speed of 400 knots. Since all MPSNA variants will be refueling capable, they will also be required to maintain this speed and altitude for refueling.

3.2.5 COD MISSION

The COD aircraft improves carrier effectiveness and efficiency by delivering time sensitive cargo and personnel to a carrier battle group operating in any location worldwide. Based on island hopping and distance requirements in the Indian Ocean area, a mission range of approximately 2,100 NM with a 15,000 lb. payload is required. In order to remain compatible with refueling aircraft, an operating altitude of over 25,000 ft. with a cruise speed of 400 knots is required. High

	NEW ASW
MAXIMUM AIRCRAFT	20
RESERVE AIRCRAFT (10%)	2
POOL AIRCRAFT	18
RELIABILITY (95% CONFIDENCE)	.85
MISSION CAPABLE AIRCRAFT	13
POUNCER AIRCRAFT	3
STATION-KEEPING AIRCRAFT	10
UTILIZATION RATE (HRS/DAY)	16
CRUISE SPEED (KTS)	400
BLOCK SPEED (KTS)	350
ALTITUDE (FT)	5000
STATION RANGE (NM)	350
ORBITS	5
MINIMUM TIME ON STATION (HRS)	6.0

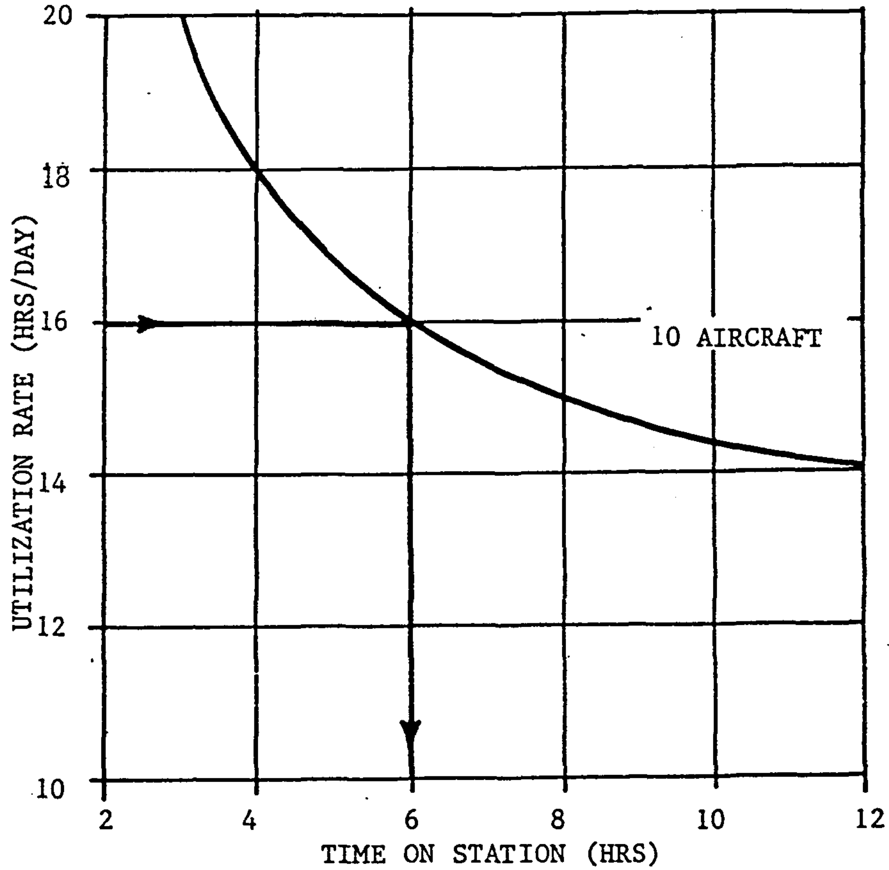


FIGURE 3.2.2-1 ASW TIME ON STATION DETERMINATION

cruise speeds and cruise altitudes will also reduce transit time, extend range, and increase efficiency.

3.2.6 RELATIVE MISSION RANKING

The ten approved MPSNA missions were ranked according to three criteria to identify the most critical mission areas. Those missions which directly support the offensive role of the carrier battle group were ranked highest. Next in importance were the missions which contribute to defensive postures. The lowest priority was assigned to those missions which are neither offensive nor defensive but which help to support the carrier in terms of effectiveness and efficiency.

Table 3.2.6-I shows the relative ranking of the MPSNA missions. The AEW mission area was chosen as the most critical because of the number of mission areas in which it has a significant role and because of the increases in performance over current aircraft which would be gained through a new design.

3.2.7 CONFIGURATION OPTIONS

Two configurations for the MPSNA were to be considered as part of this study. The first configuration was to be a full multimission airplane capable of performing a diverse set of missions. The second design option was to use the most critical mission area as the primary design driver and assess the resulting aircraft performance capabilities in the other mission areas. Table 3.2.7-I shows an initial qualitative assessment of these configurations.

3.2.8 FIGURES OF MERIT

The primary figures of merit selected for this study were takeoff gross weight, deck spot size per aircraft, and number of aircraft required. The first two parameters were chosen for design level evaluation where takeoff gross weight is indicative of the cost of aircraft, and deck spot size per aircraft is a measure of the amount of carrier deck space utilized. Additional first order functions of takeoff gross weight and propulsion system selection are fuel burn, acquisition, and life cycle cost per aircraft. The number of aircraft required is used to make an overall system level evaluation of total systems cost and deck space requirements.

3.2.9 MARKET POTENTIAL

The market potential for the MPSNA aircraft is shown in Table 3.2.9-I and includes the aircraft required for the operational deployment of 15 carriers plus the anticipated requirements for replacement air groups and attrition. As discussed in the mission requirements section, the ASUW, MIW, ESM, C^3I, and AAW missions are considered derivatives of the primary support missions and do not produce additional aircraft requirements. As a point of departure, a one-for-one replacement was assumed. The final market potential for each configuration will be

MISSION	PRIORITY 1 DIRECTLY SUPPORTS CARRIERS OFFENSIVE ROLE	PRIORITY 2 ENHANCES PRESERVATION OF RESOURCES	PRIORITY 3 IMPROVES CARRIER EFFECTIVENESS AND EFFICIENCY
AEW	X	X	
ASW	X	X	
ASUW	X	X	
MIW		X	
COD			X
AAW		X	
EW	X		
TANKER	X		
ESM		X	
C^3I	X		

ALL MISSIONS LISTED ARE ESSENTIAL TO EFFECTIVE CARRIER BATTLE GROUP OPERATION.

TABLE 3.2.6-I RELATIVE MISSION RANKING

	CURRENT AIRCRAFT					REPLACEMENT AIRCRAFT	
MISSIONS	E-2C	S-3A	C-2A	EA-6B	KA-6D	MULTI-MISSION AIRCRAFT (MPSNA)	DERIVATIVE CONFIGURATION 1
AEW	X					X	X
ASW		X				X	LIMITED
ASUW		X				X	LIMITED
MIW		X				X	LIMITED
COD		X	X			X	LIMITED
AAW	X					X	X
EW				X		X	X
TANKER		X			X	X	LIMITED
ESM	X	X		X		X	X
C^3I	X	X		X		X	X

TABLE 3.2.7-I NAVY SUPPORT AIRCRAFT MISSION CAPABILITIES

MISSION	OPERATIONAL DEPLOYMENT (1)	REPLACEMENT AIR GROUP (RAG) (2)	PIPELINE (3)	ATTRITION (4)	TOTAL LIFE CYCLE PROCUREMENT
AEW	75	19	11	34	139
TANKER	82	21	12	37	152
ASW	128	32	19	58	237
EW	60	15	9	27	111
COD	15	4	2	7	28
TOTAL	360	91	53	163	667

(1) 15 CARRIER FLEET
(2) 25% OF OPERATIONAL DEPLOYMENT
(3) 15% OF OPERATIONAL DEPLOYMENT
(4) 45% OF OPERATIONAL DEPLOYMENT BASED ON 3% ATTRITION PER YEAR FOR 15 YEARS

NOTES:

- THE ASUW, MIW, ESM, C^3I, AND AAW MISSIONS ARE CONSIDERED DERIVATIVES OF THE PRIMARY SUPPORT MISSIONS
- INCLUDES ONLY U.S. NAVY PROCUREMENT
- SOME FOREIGN POTENTIAL FOR V/STOL
- AIRCRAFT REPLACED ON A ONE-FOR-ONE BASIS. QUANTITIES WILL BE ADJUSTED BASED ON FINAL PERFORMANCE DATA.

TABLE 3.2.9-I MARKET POTENTIAL - 1993 FLEET PROJECTION

adjusted to account for differences in aircraft performance among the six candidate configurations. For instance, a higher performance aircraft will require fewer acquisitions.

3.3 ASSUMPTIONS AND GUIDELINES

The following sections present some of the aircraft design parameters and propulsion selection considerations appropriate to the technology level that should be available in the mid- 1990's.

3.3.1 TECHNOLOGY AVAILABILITY

The aerodynamic technology level used in this study is consistent with the mid- 1990's introduction of this aircraft into naval service. Use of supercritical airfoil technology and the projected gains in drag divergence mach number are presented in Figure 4.4-1. Advances in laminar flow research will allow aircraft to be designed with transition to turbulent flow delayed past the 50% chord point. For this study a transition location of 30% was assumed. The level of excrescence drag used is 12% to 16%, including antennas. Conformal radar antennas are also used.

A technology availability date of 1990 allows use of advanced composite materials for primary structural components, with an estimated structures weight reduction of 17 to 19% compared to conventional aluminum construction.

3.3.2 AIRCRAFT DESIGN PARAMETERS

All aircraft performance computations are consistent with normal conceptual design practice. Figure 3.3.2-1 lists the major groundrules and assumptions used in aircraft sizing and performance calculations. Takeoff and landing criteria used in sizing the configurations is presented in Figures 3.3.2-2 and 3.3.2-3, respectively.

3.3.3 PROPULSION SELECTION CONSIDERATIONS

An initial engine survey, which was generated prior to starting the MPSNA-MAPS effort, is presented in Figure 3.3.3-1. From other information it was obvious that the Allison and Rolls Royce engines were not of competitive state of the art. Therefore, the initial conclusions were that the General Electric UDF and Pratt and Whitney/Hamilton Standard counter rotating propfans were competitive propfan engines and that the Pratt and Whitney turbofan engine was representative of turbofan state of the art.

- RESERVE FUEL: 20 MINUTES SEA LEVEL ENDURANCE PLUS 5 PERCENT OF INITIAL FUEL
- 5 PERCENT FUEL FLOW CONSERVATISM
- FUSELAGE SHAPE PARAMETERS
  - NOSE FINENESS RATIO: 1.5 TO 1
  - TAIL FINENESS RATIO: 3 TO 1
  - MAIN BODY - CONSTANT CIRCULAR CROSS-SECTION
- SUPERCRITICAL AIRFOIL TECHNOLOGY
- EXCRESCENCE DRAG FACTOR: 12 TO 16 PERCENT (INCLUDES ANTENNAS)
- NATURAL LAMINAR FLOW: 30 PERCENT CHORD
- CONFORMAL RADAR

FIGURE 3.3.2-1 SIZING GROUND RULES AND ASSUMPTIONS

ATMOSPHERIC CONDITIONS:	- 90°F/95 PERCENT RELATIVE HUMIDITY AT SEA LEVEL
WIND OVER DECK:	- ZERO WIND
CATAPULT CAPABILITY:	- MINIMUM C-7 AS ON CV61 AND CV62 (NOMINAL STROKE 253 FEET).
LIFTOFF SPEED:	- NOT LESS THAN 110 PERCENT OF THE SPEED FOR LEVEL FLIGHT AT 90 PERCENT $C_{L_{MAX}}$, POWER ON, IN GROUND EFFECT (MIL-M-85025A).
	- NOT LESS THAN V_{MU} (MIL-M-85025A)
	- NOT LESS THAN 105 PERCENT V_{MCA} (MIL-M-85025A).
	- NOT LESS THAN SPEED FOR 0.5 PERCENT CLIMB GRADIENT IN THE TAKEOFF CONFIGURATION, OUT OF GROUND EFFECT WITH CRITICAL ENGINE INOPERATIVE (MIL-C-005011B).
CLIMBOUT SPEED:	- BEST CLIMB GRADIENT SPEED OUT OF GROUND EFFECT WITH CRITICAL ENGINE INOPERATIVE (PROPELLER FEATHERED IF APPLICABLE) (MIL-M-85025).
	- NOT LESS THAN 120 PERCENT POWER-OFF STALL SPEED (MIL-M-85025A).
	- NOT LESS THAN 110 PERCENT V_{MCA} (MIL-M-85025A)
CLIMBOUT GRADIENT:	- NOT LESS THAN 2.5 PERCENT WITH GEAR UP, FLAPS IN TAKEOFF SETTING, OUT OF GROUND EFFECT WITH CRITICAL ENGINE INOPERATIVE (MIL-C-005011B).
	- NOT LESS THAN 0.5 PERCENT WITH GEAR IN TRANSIT, FLAPS IN TAKEOFF SETTING, OUT OF GROUND EFFECT WITH CRITICAL ENGINE INOPERATIVE (MIL-C-005011B).

FIGURE 3.3.2-2 PERFORMANCE REQUIREMENTS (TAKEOFF)

ATMOSPHERIC CONDITIONS:	- 90°F/95 PERCENT RELATIVE HUMIDITY AT SEA LEVEL.
WIND OVER DECK:	- ZERO WIND
APPROACH GRADIENT:	- 4 DEGREES DESCENT PATH GRADIENT
APPROACH SPEED:	- NOT LESS THAN 105 PERCENT $V_{PA_{MIN}}$ ($V_{PA_{MIN}}$ IS 110 PERCENT V_{SPA} AND NOT LESS THAN V_{SPA} + 10 KEAS) (MIL-M-85025A, MIL-F-8785C).
	- NOT LESS THAN V_{MCA} AT WAVEOFF POWER.
TOUCHDOWN SPEED:	- SAME AS APPROACH SPEED.
LANDING WEIGHT:	- GREATER THAN OEW AND PAYLOAD PLUS FUEL RESERVE.
	- MUST NOT EXCEED ARRESTING GEAR ENERGY LIMITS.
WAVEOFF CAPABILITY:	- MAINTAIN AT LEAST 2.1 CLIMB GRADIENT POTENTIAL AT APPROACH SPEED, LANDING CONFIGURATION, CRITICAL ENGINE INOPERATIVE.
ARRESTING GEAR:	- TYPE MK7-3
BARRICADE:	- TYPE MK7-2

FIGURE 3.3.2-3 PERFORMANCE REQUIREMENTS (LANDING)

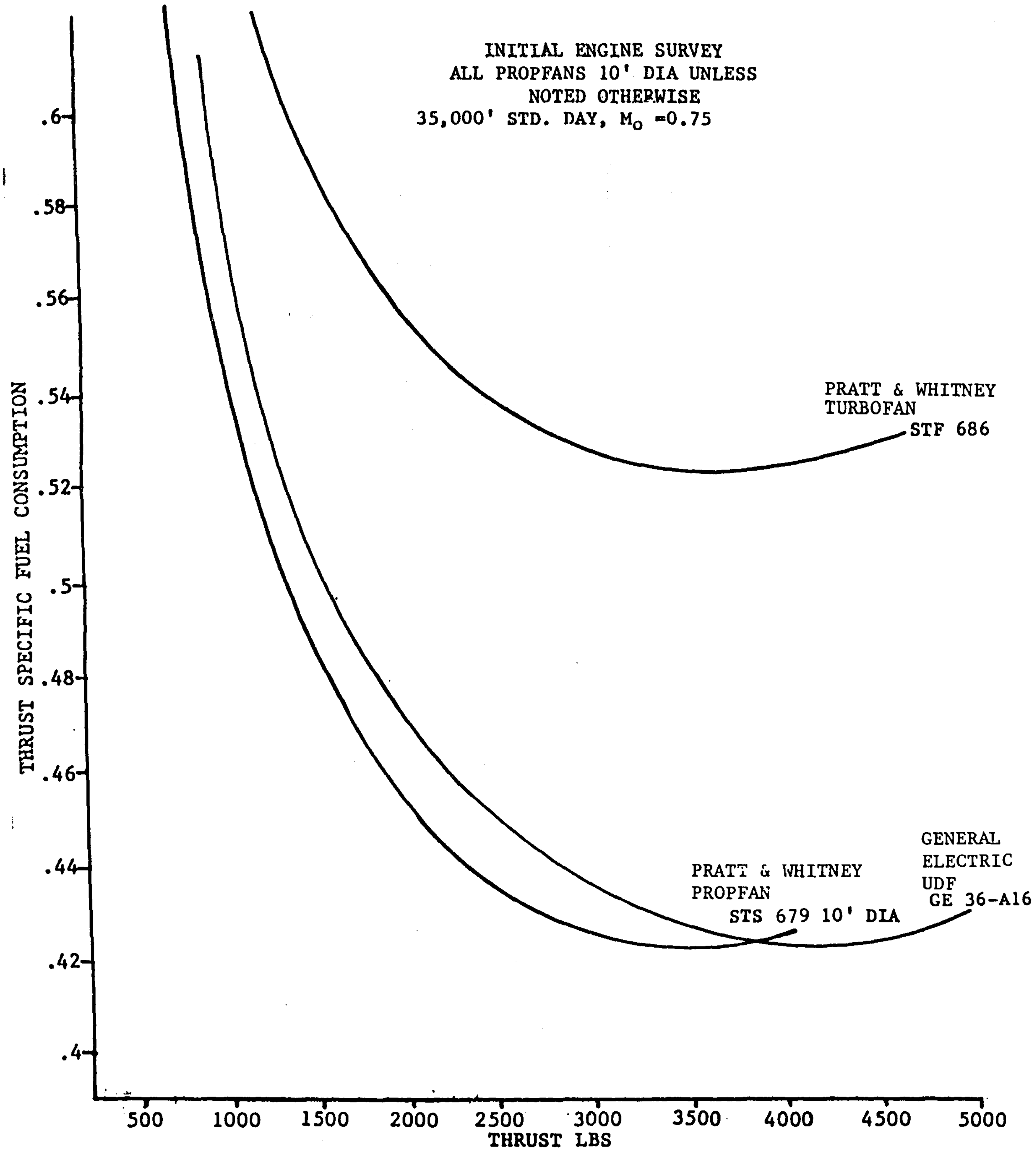


FIGURE 3.3.3-1 **INITIAL ENGINE SURVEY**

3.3.3.1 PROPULSION SELECTIONS

As noted above, the GE-36-A16 unducted fan was selected as a propfan along with the Pratt and Whitney STS 742/ 743* propfan with an inline differential planetary counter rotational gearbox. Both engines were examined in the study to find if there were significant differences between the unconventional UDF and the conventional Propfan. The Pratt and Whitney STF 686 turbofan was used as representative of turbofans with the same state of the art as the propfans chosen. Table 3.3.3.1-I presents the cycle characteristics of these engines along with the NASA/GE E^3 engine characteristics as a point of comparison. Figure 3.3.3.1-1 presents these cycle parameters on a figure adopted from the Pratt and Whitney Advanced Propfan Engine Technology report. This figure relates the overall pressure ratio and combustion exit temperature to thrust specific fuel consumption if all the cores were configured for the same class of turbofan.

3.3.3.2 PROPULSION WEIGHTS AND SCALING

Table 3.3.3.2-I presents a summary of the unscaled weights for use in the MPSNA-MAPS study. The only modifications made to engine company supplied data was through use of 8.5 ft. propellers on the scaled STS 742/743 engines. The information used in scaling engines are presented in Figures 3.3.3.2-1 through 3.3.3.2-3. Figure 3.3.3.2-1 presents the General Electric UDF scaling factors and figure 3.3.3.2-2 presents Pratt and Whitney/Hamilton Standard propfan scaling factors. Figure 3.3.3.2.3 presents the Pratt and Whitney turbofan scaling factors.

3.3.3.3 PROPULSION SYSTEM INSTALLATION

Figures 3.3.3.3-1 thru 3.3.3.3-5 present potential propfan/UDF and turbofan installation configurations. Specifically they are:

- o Wing Mounted Turbofan, (Figure 3.3.3.3-1)
- o Body Pylon Mounted Turbofan, (Figure 3.3.3.3-2)
- o Body Pylon Mounted UDF, (Figure 3.3.3.3-3)
- o Propfan (Pusher), Wing Mounted and Body Pylon Mounted, (Figure 3.3.3.3-4)
- o Propfan (Tractor), Wing Mounted and Body Pylon Mounted, (Figure 3.3.3.3-5)

Engine installed performance is based on the constant built in bleed rate of 3.77% in the STS 742 and STS 743 engines; a constant inlet recovery of 99.8% for both engines with the STS-742 also reflecting the tractor

*The initial screening was done using the STS679 which is the same cycle as the STS 742/743. The latter uses a dedicated continuous bleed for aircraft systems, thereby minimizing the effects on aircraft performance.

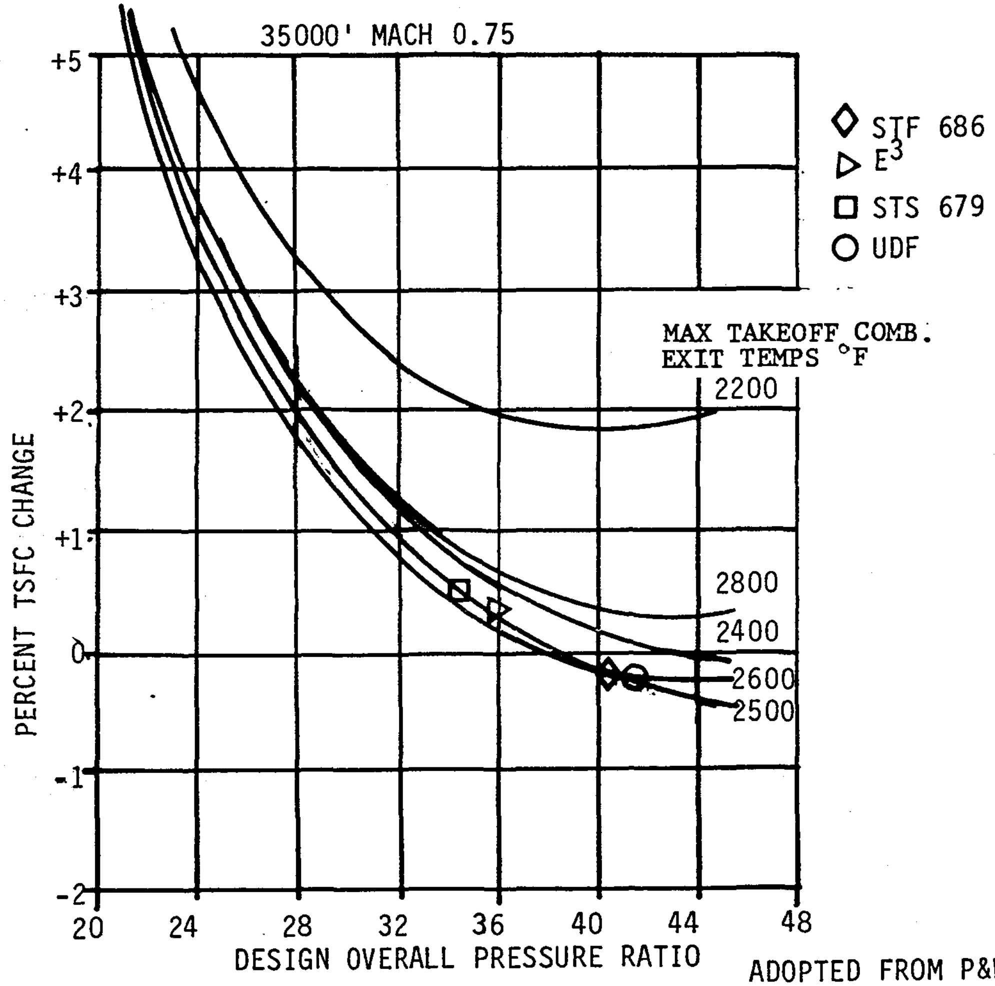
MXCR 35K'

SLS THRUST CLASS KN (LB)	NASA E^3 (G.E.)	STF 686*	GE-36 UDF	STS-679**
	162.4 (36.5K)	84.5 (19K)	87.2(19.6K)	89.4 (20.1K)
OVERALL PRESSURE RATIO	35.8	40.8	42.4	34.2
LP COMPRESSOR RATIO	1.61	2.2	6.68	5.4
HP COMPRESSOR RATIO	22.3	17.0	6.43	6.43
BY-PASS RATIO	6.9	7.0	N/A	N/A
FAN PRESSURE RATIO	1.61	1.66	N/A	N/A
COMB.EXIT TEMP °C (°F)	1246 (2274)	1206 (2203)	1226 (2240)	1274 (2326)

*90% MXCR

**REPRESENTATIVE OF STS-742/-743

TABLE 3.3.3.1-I ENGINE CYCLE SUMMARY



ADOPTED FROM P&W APET REPORT
FIGURE 4.2-3

FIGURE 3.3.3.1-1 ENGINE STATE OF THE ART COMPARISON

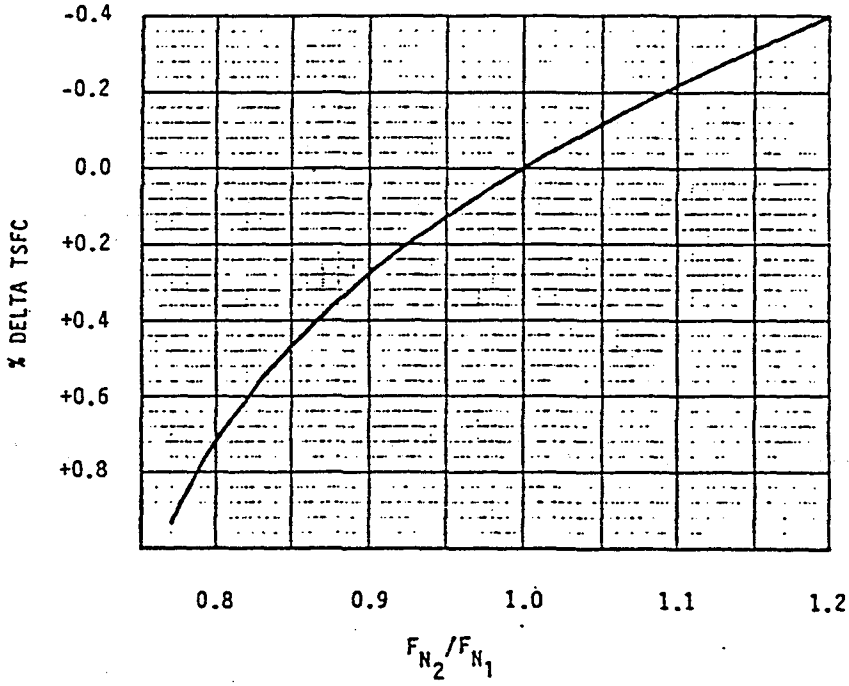
KG (LBS)

ENGINE DESTINATION	STS 686	STS 742 TRACTOR	STS 743 PUSHER	UDF
SIZE (THRUST @ SLS STD)	8776 (19347)	9550 (21055)	9625 (21219)	8366 (18444)
ENGINE WEIGHT	1678 (3700)	1041 (2295)	1116 (2460)	856 (1887)
GEAR BOX WEIGHT	-----	415 (915)	429 (945)	-----
PROPELLER WEIGHT	-----	393 (867)	599 (1320)	958 (2111)
PROPELLER DIA	-----	9.75 FT **	11.6 FT **	10 FT
NACELLE WEIGHT *	794 (1750)	440 (970)	410 (905)	518 (1141)
TOTAL WEIGHT	2472 (5450)	2289 (5047)	2554 (5630)	2332 (5139)

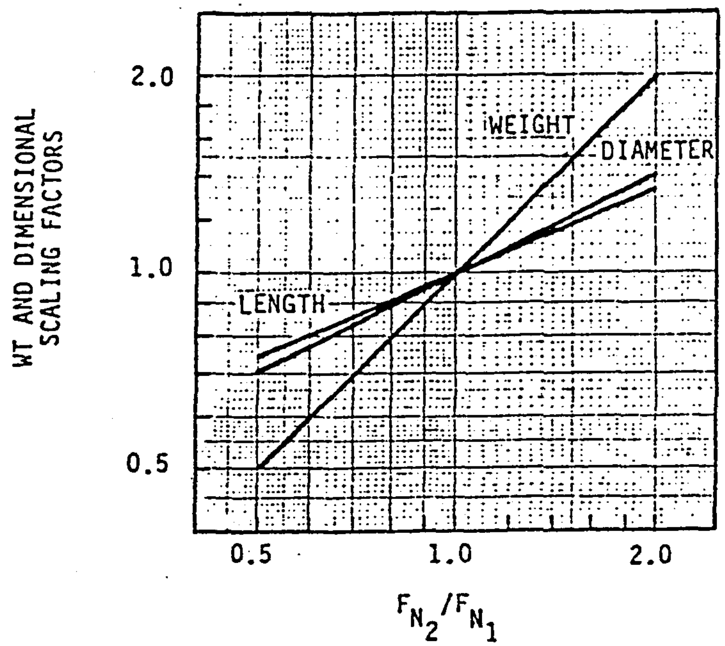
* INCLUDING EBU, MOUNTS AND CONTINGENCY

** DIA. REQUIRED TO OBTAIN 8.5' DIA. AT SCALED SIZE

TABLE 3.3.3.2-I PROPULSION SYSTEM WEIGHT (UNSCALED)



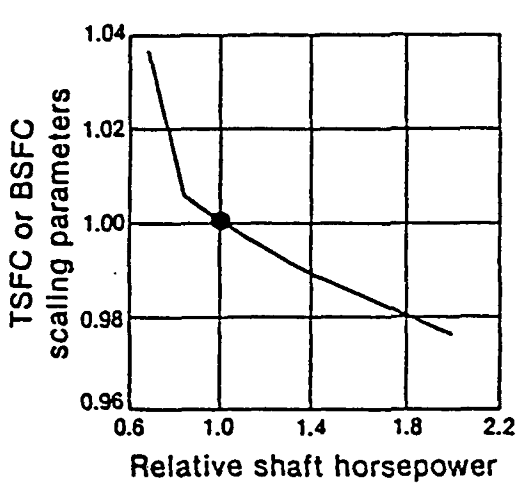
UDF TSFC SCALING



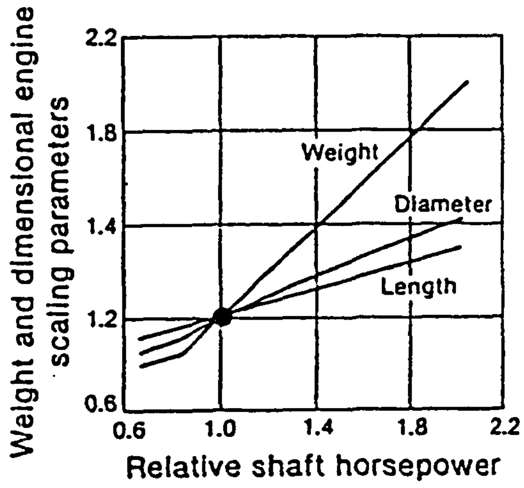
UDF WEIGHT AND
DIMENSIONAL SCALING

FIGURE 3.3.3.2-1 UDF SCALING FACTORS

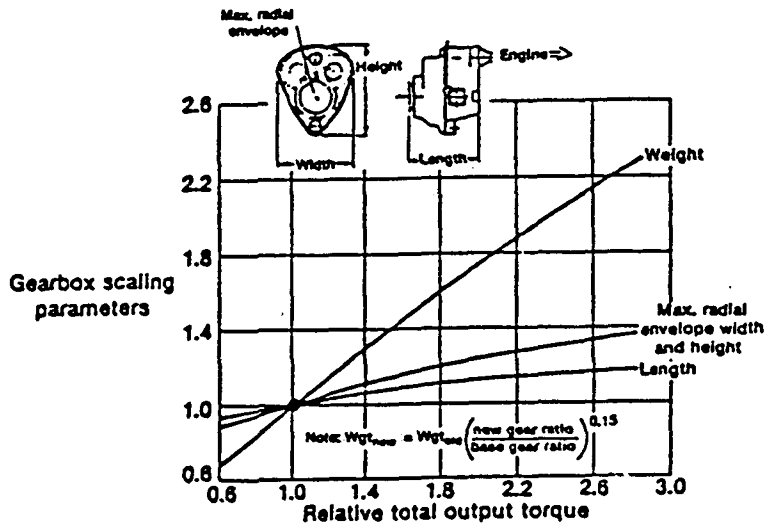
Scaling curve for BSFC and TSFC



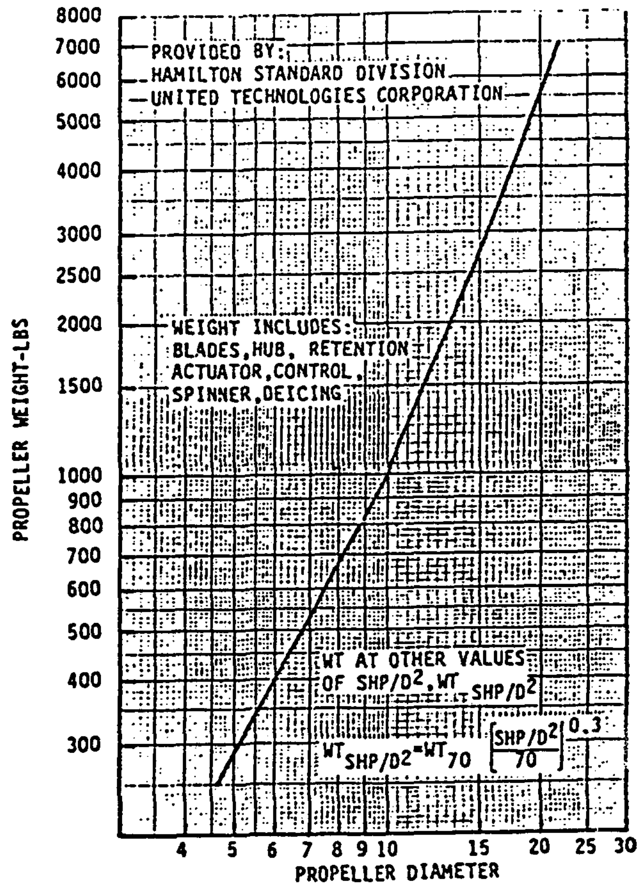
Scaling curve for engine weight and dimensions



*Base engine power to gearbox = 12123 HP @ sea level, 0.3 MN, takeoff rating, STD −13°C (+25°F) day.

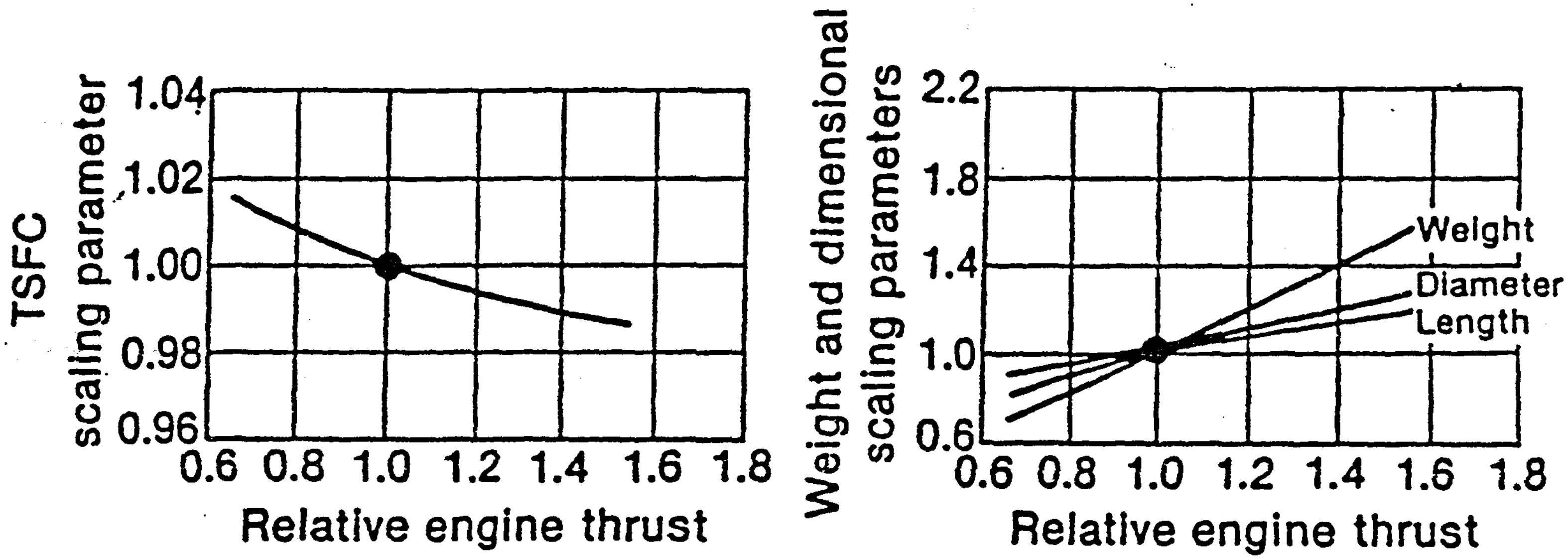


Base size gearbox output torque @ sea level takeoff power STD. −13°C (+25°F) day, Mach 0.3 = 74,662 newton-meters (55,068 ft-lb) for single rotation and 74,492 newton-meters (54,943 ft-lb) for counter rotation



6x6 COUNTER ROTATION PROPFAN WEIGHT
70 SHP/D2-180 AF-750 FPS TIP SPEED
0.18D SPACING BETWEEN BLADE ROWS

FIGURE 3.3.3.2-2 PROPFAN SCALING FACTORS



*Base engine takeoff thrust = 86069 N (19350 lb) @ SLS −13°C (+25°F) day

FIGURE 3.3.3.2-3 TURBOFAN SCALING FACTORS

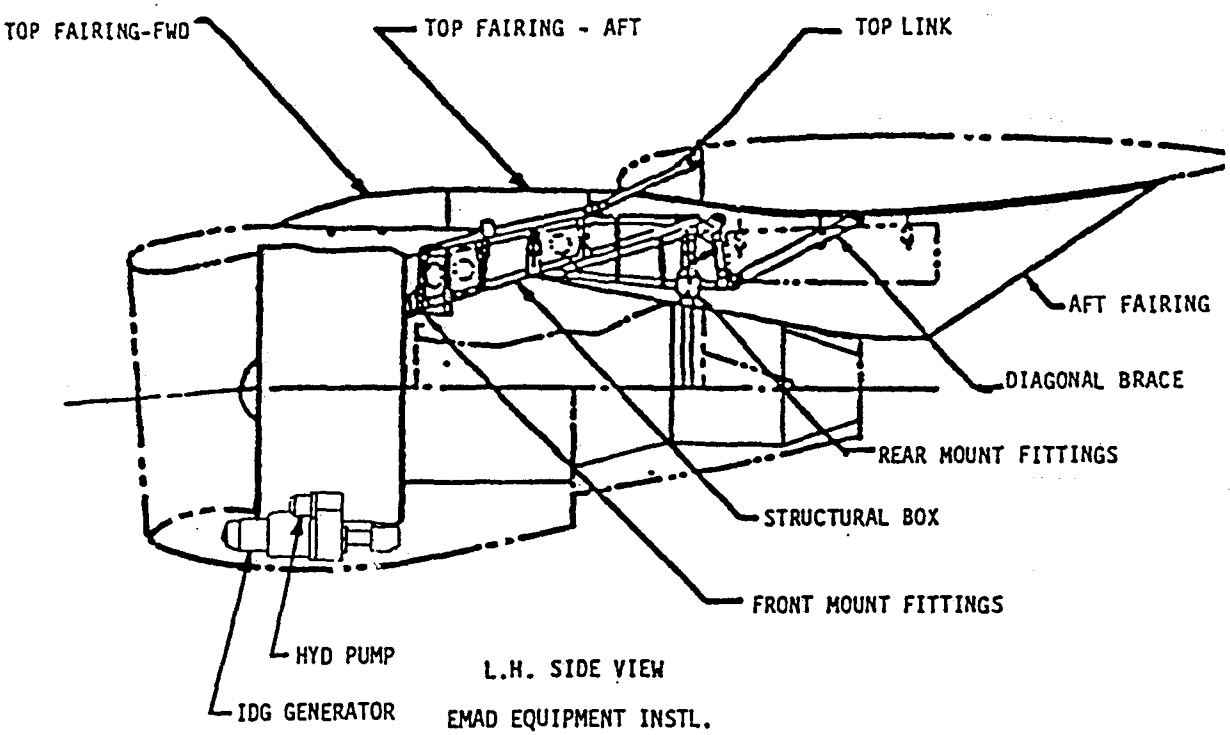


FIGURE 3.3.3.3-1 WING MOUNTED TURBOFAN

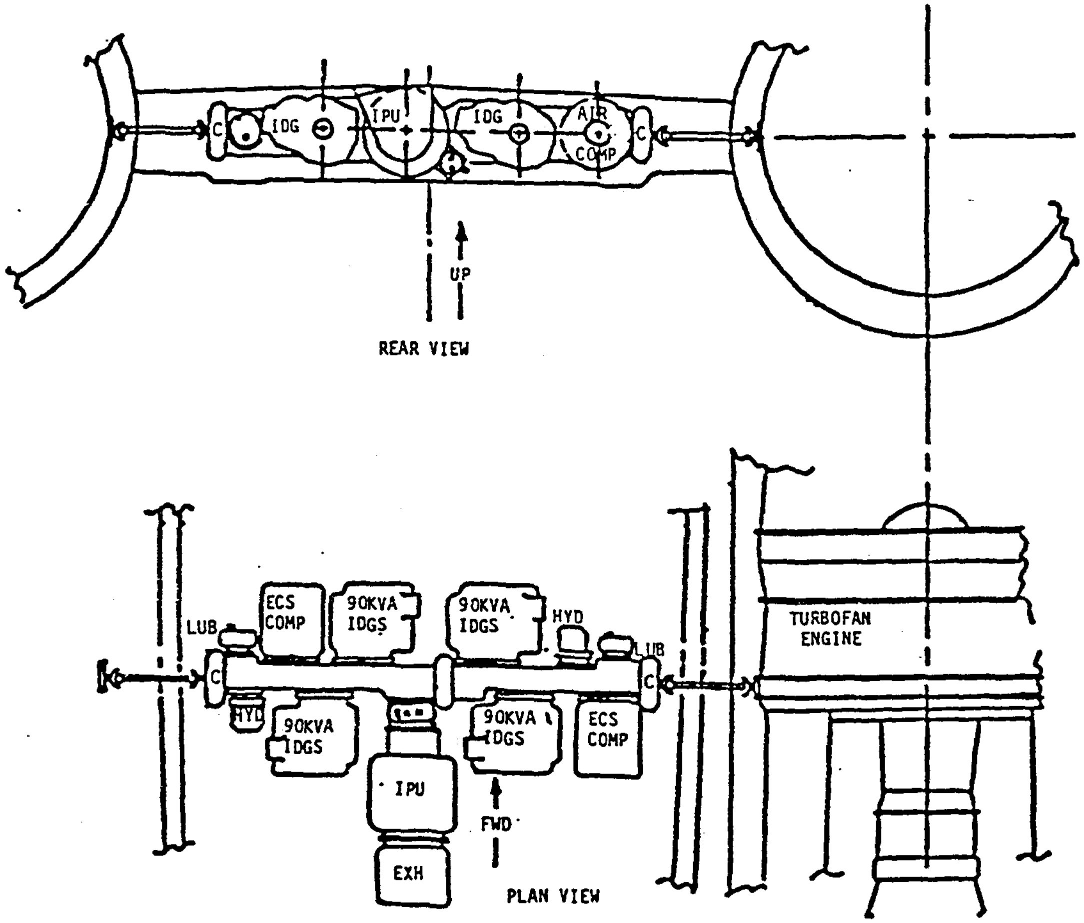


FIGURE 3.3.3.3-2 BODY PYLON MOUNTED TURBOFAN

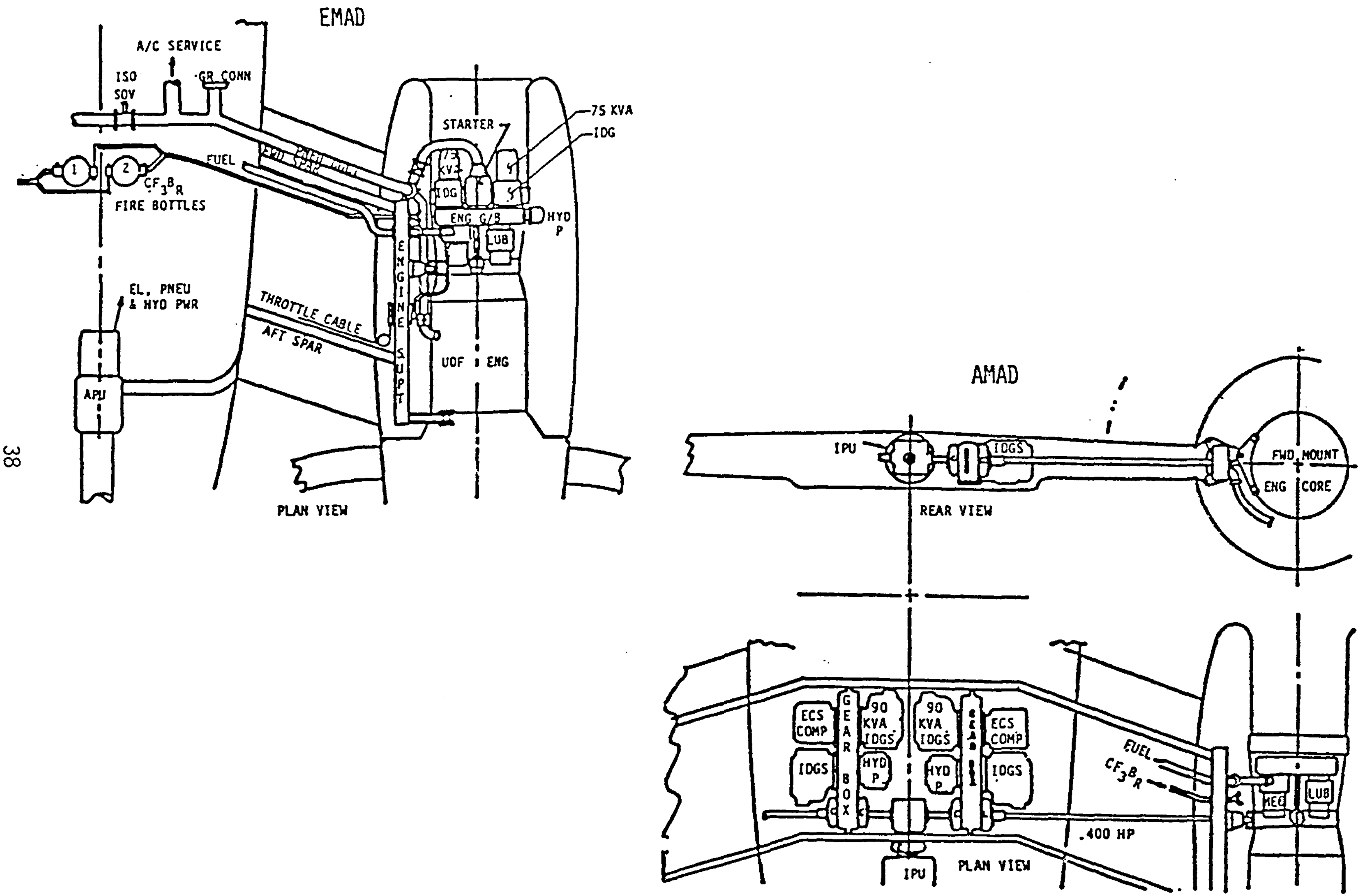


FIGURE 3.3.3.3-3 BODY PYLON MOUNTED UDF

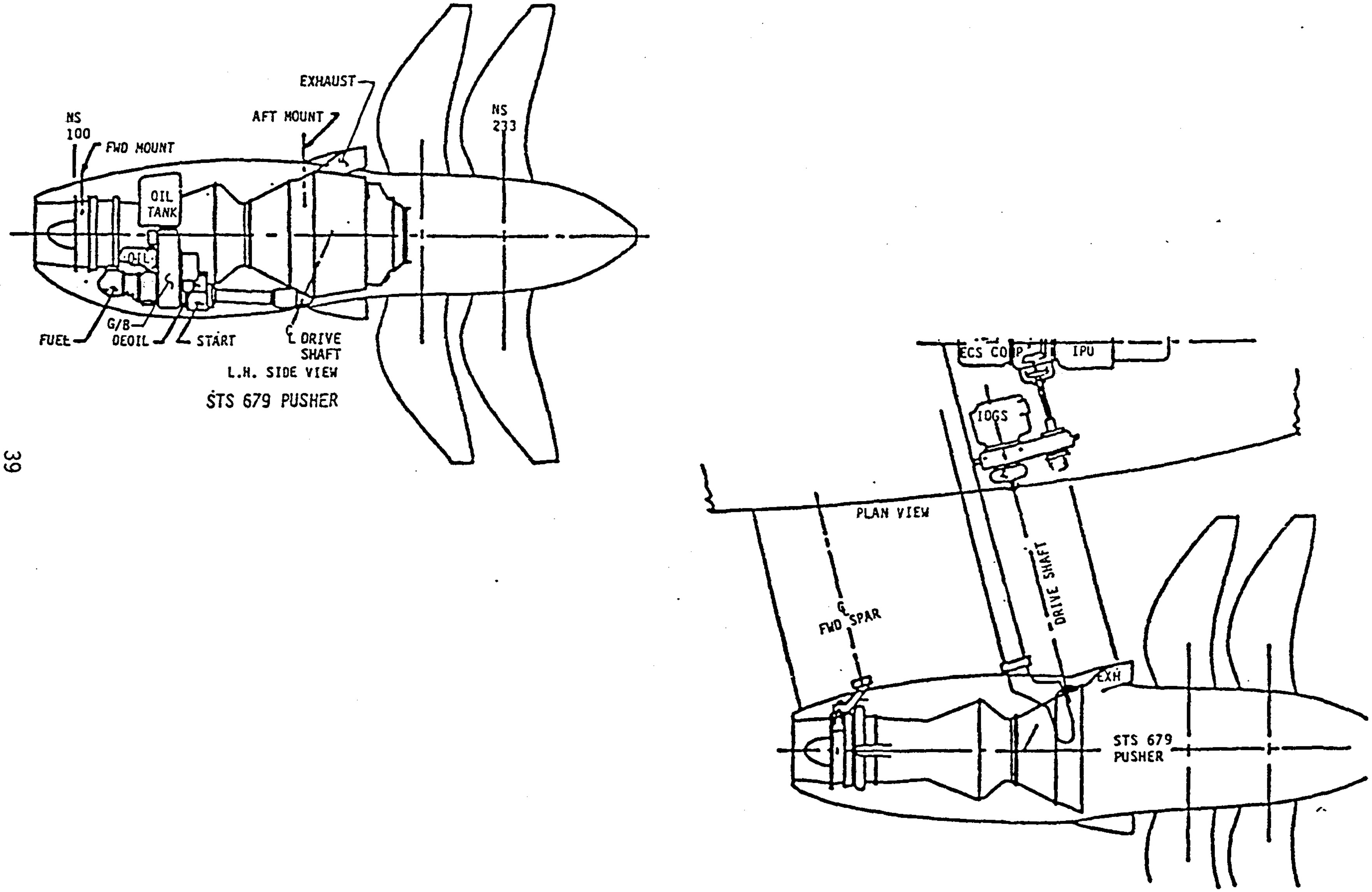
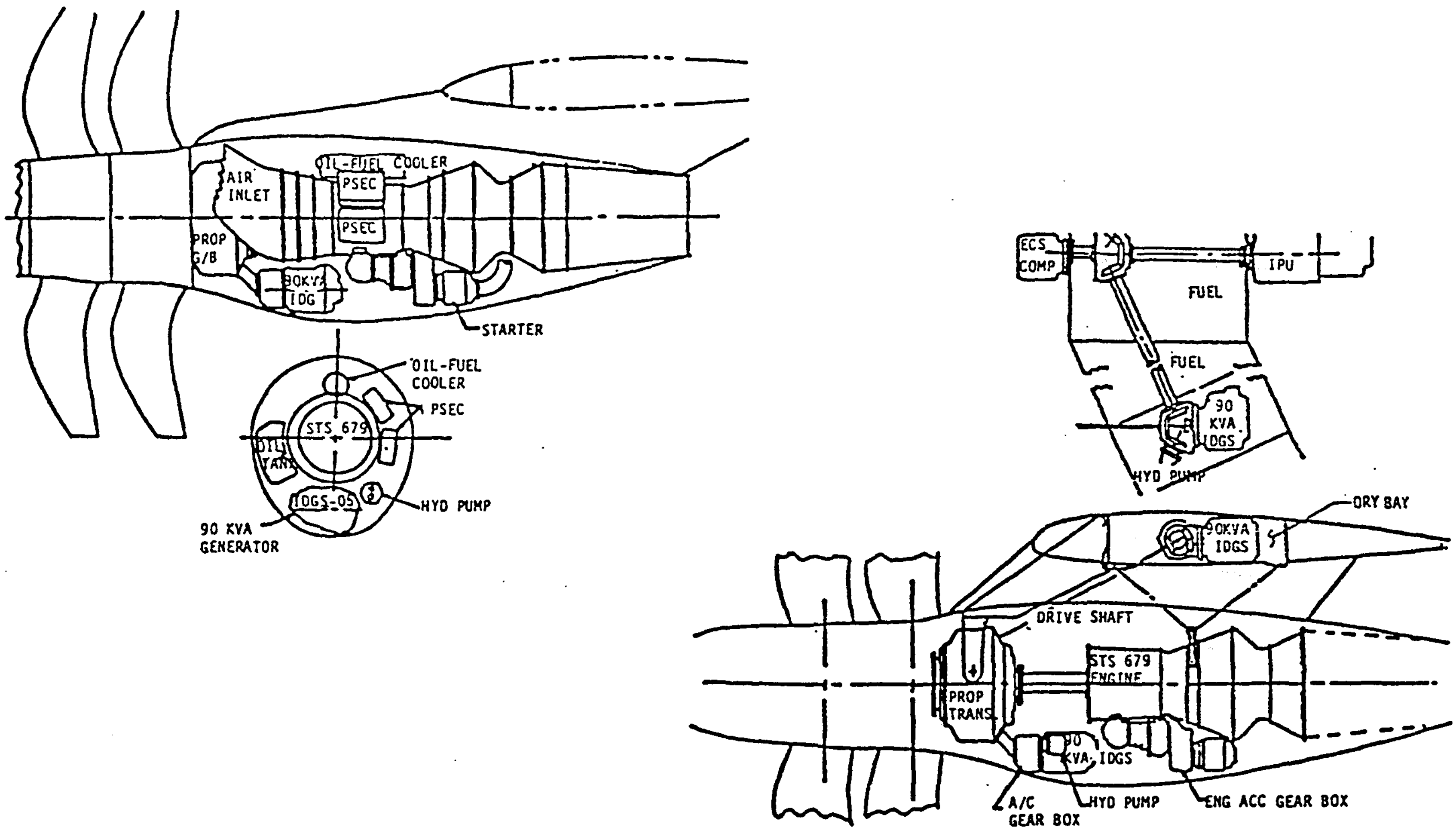


FIGURE 3.3.3.3-4 PROPFAN (PUSHER), WING MOUNTED AND BODY PYLON MOUNTED



L.H. SIDE VIEW

FIGURE 3.3.3.3-5 PROPFAN (TRACTOR), WING MOUNTED & BODY PYLON MOUNTED configuration inlet propeller boost as built into the STS-742 computer deck; and all engines, regardless of scale, had shaft power extraction as follows:

Rating Code	Altitude	Horsepower Extraction/eng
50	SL	181.5
50	5000 & 10000	169.0
40, 35, power hooks	SL	126
40, 35, power hooks	5000	135
40, 35, power hooks	10000-45000	145

The STF686 and the GE-36-22B UDF engines had full scale bleed rates of 0.333 lb/sec, the inlet/ram recovery of 99.8% constant and the same horsepower extraction as the STS 742/743 engines.

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4.0 TASK II: CONCEPTUAL DESIGN

Task II of the Multiple Purpose Subsonic Naval Aircraft (MPSNA) Multiple Applications Program Study (MAPS) was concerned with the following aspects:

- Takeoff and landing limitations
- Engine sizing criteria
- Loiter altitude sensitivity
- Wing sweep selection
- Breakdown of weights of the major systems
- Aircraft sizing
- Configuration selections for vehicle optimization and propulsion trades
- Base weight breakdown for each mission and type of propulsion
- Key figures of merit

4.1 TAKEOFF AND LANDING LIMITATIONS

The minimum deadload endspeeds as a function of gross weight that were used in the analysis were defined by the C-7 catapult capabilities. These data were used to determine required takeoff lift coefficients as a function of wing loading and gross weight. A takeoff lift coefficient of 1.85 was selected as attainable with a moderately complex flap system (double-slotted trailing edge flap with a leading edge device). Figure 4.1-1 presents takeoff speeds for various wing areas and gross weights at a takeoff lift coefficient of 1.85. The C-7 catapult's capability at several wind over deck (WOD) levels is also shown. From this figure, the limiting wing loading to meet the zero wind over deck capability can be obtained, as shown in Figure 4.1-2.

Approach and landing speeds are limited by the arresting gear energy limits of the type MK7-3 arresting gear. The limiting speeds as a function of gross weight are shown in Figure 4.1-3. An approach velocity of 110 knots true airspeed was selected. This allows an 80,000 lb. maximum gross weight aircraft to land at 80% of maximum gross weight (64,000 lb.) with zero WOD and also provides more reasonable vertical tail size requirements for an engine-out waveoff.

4.2 ENGINE SIZING CRITERIA

For the purpose of aircraft sizing, engine data (thrust level and TSFC) and physical engine size were scaled for the worst case of either takeoff or a mission dependent cruise condition. For takeoff, an airplane thrust/weight ratio was determined that enabled the aircraft to climb, flaps down, with one engine inoperative at a climb gradient of at least 2.5%. Figure 4.2-1 shows the single engine thrust/weight ratio required for 2.5% and 3% climb gradients. Since flaps down drag and control drag are very preliminary estimates, an airplane thrust/weight ratio of 0.4 was selected to provide conservatism. The mission dependent cruise conditions used for sizing were 360 KTAS at 40,000 ft. (AEW requirement) and 400 KTAS at 25,000 ft. (Tanker requirement). Five

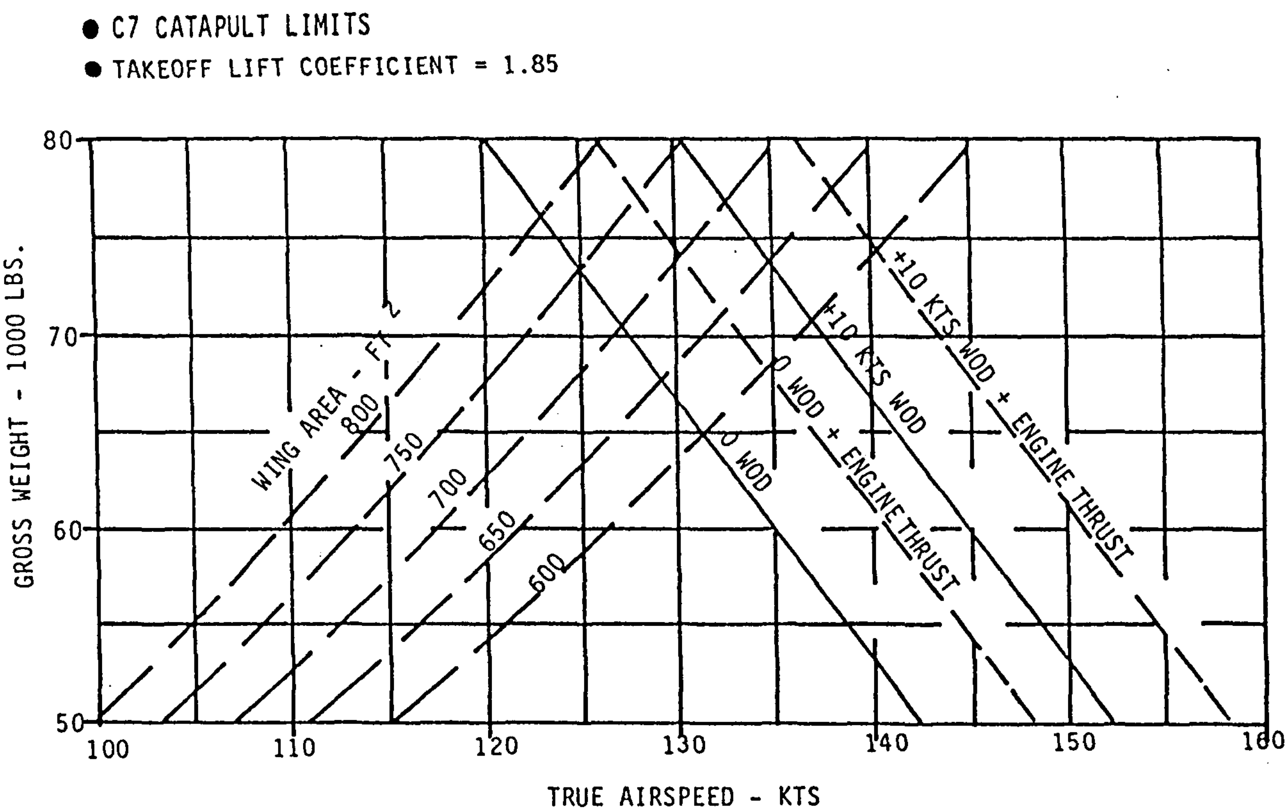


FIGURE 4.1-1 TAKEOFF SPEEDS AT TAKEOFF LIFT COEFFICIENT OF 1.85

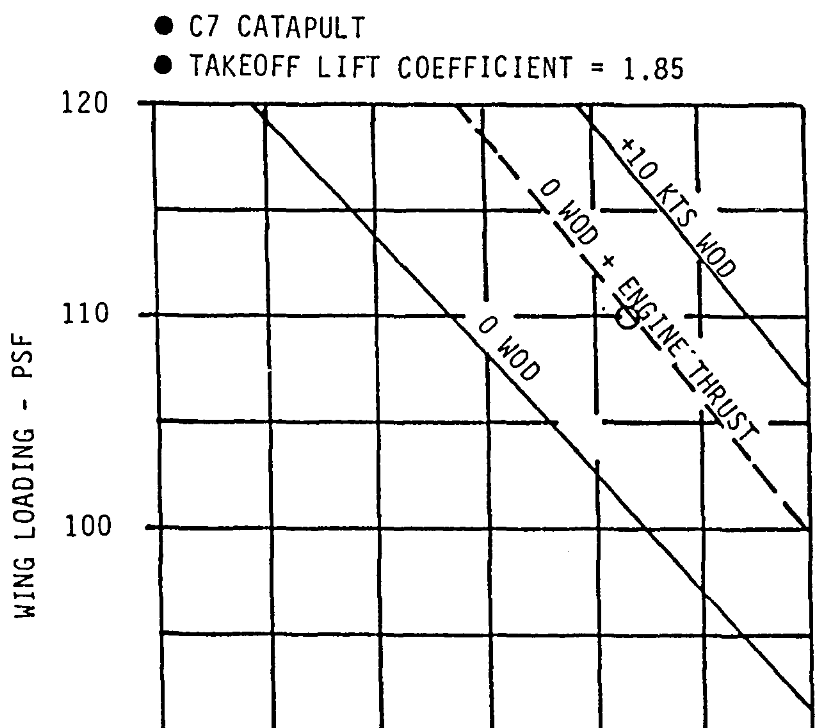
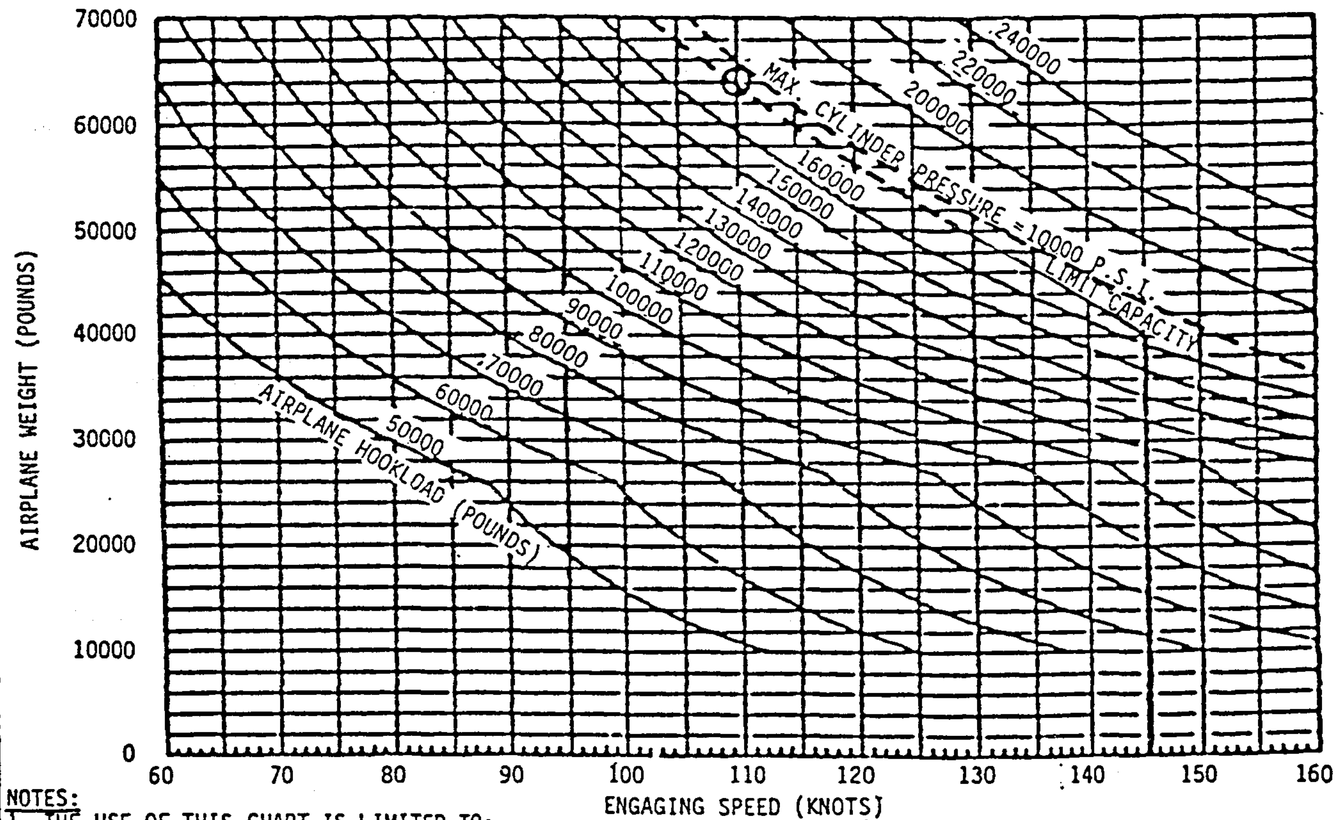


FIGURE 4.1-2 WING LOADING LIMITS FOR CATAPULT TAKEOFF

APPROACH AND LANDING SPEED SELECTION

- CRITERIA

ZERO WIND OVER DECK
MAXIMUM LANDING WEIGHT = 80% OF GROSS WEIGHT
(MAXIMUM ALLOWABLE GROSS WEIGHT = 80,000 LBS.)



NOTES:
1. THE USE OF THIS CHART IS LIMITED TO:
   a. RANGES OF WT & VELOCITY AS INDICATED BY LIMIT CAP. LINE.
   b. MARK & MOD 3 ENGINE WITH CONSTANT RUNOUT VALVE P/N 611037 AND CAM P/N 502715-15P.
   c. ON AND OFF-CENTER ENGAGEMENTS WITH A DECK SPAN OF 115-125 FT
2. CAP. LINE IS BASED ON 95000 LBS MAX ALLOWABLE CABLE TENSION FOR 1 3/8 IN. CABLE.
3. CHART IS BASED ON AIRCRAFT CALIBRATION TESTS AT NATF, LAKEHURST, N.J.

ARRESTING WIRES
PERFORMANCE CHART
(HOOKLOAD)
MARK 7 MOD 3 ARRESTING GEAR
EQUIPPED WITH DECK SHEAVE AND
ANCHOR DAMPERS

NAEC MISC. 08744

FIGURE 4.1-3 ARRESTING GEAR LIMITS

hundred KTAS sea level dash was considered a desirable condition but not a sizing requirement.

4.3 LOITER ALTITUDE SENSITIVITY

The sensitivity of aircraft gross weight and size to loiter altitude was determined by sizing aircraft to the AEW mission. Wing loadings were optimized at each loiter altitude in order to obtain a minimum gross weight. The engines were sized based on the worst case of either 0.4 thrust/weight at takeoff or 360 KTAS at the loiter altitude. The results are shown in Figure 4.3-1. The break in the curves occurs where the engine sizing constraint changes from takeoff to cruise. There is a minimal gross weight penalty for loiter altitudes up to 41,000 ft. for the propfan and 42,000 ft. for the turbofan. Above these altitudes the gross weight penalty is severe. A design loiter altitude of 40,000 ft. can be achieved with a minimal gross weight penalty for both engine types.

4.4 WING SWEEP SELECTION

Representative values of camber (1.5%) and taper ratio (0.4) were selected for the MPSNA study. Wing thickness ratio was set at 15% at the root and 12% at the tip. The spanwise thickness distribution is assumed to vary in a manner such that the wing critical Mach number can be defined based on a thickness ratio of 12%. Supercritical airfoil technology was used in order to push critical Mach numbers beyond the airspeed and altitude ranges of the design missions. Critical Mach number as a function of lift coefficient is presented for various wing sweep angles in Figure 4.4-1. Also shown are the speeds required at lift coefficients representative of the various flight regimes. A wing quarter chord sweep of 20^{o} was chosen for the design study to meet speed requirements and maintain conservatism.

4.5 DISPLAY AND CONTROL SYSTEM

An aid used in sizing the operator work station was the Boeing "Universal Display and Control System" (UDACS) crew station, as shown in Figure 4.5-1. The MPSNA MAPS aircraft ASW/AEW mission performance is enhanced by the use of this console. Advanced integrated panel display devices are used in conjunction with high technology integrated circuits and systems in the console. Each individual UDACS station can be electronically reconfigured in real time for full display and control of any mission function. Operator controls, display formats, and symbology are programmable, and the image displays are compatible with all sensor video formats.

4.6 FUSELAGE SIZING

Considerations used in determining the required fuselage cross section dimensions for the six configurations are discussed below.

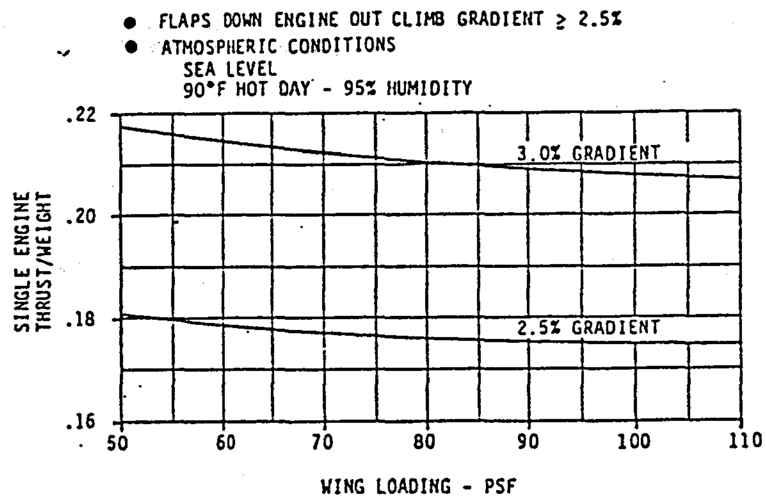


FIGURE 4.2-1 ENGINE SIZING CRITERIA

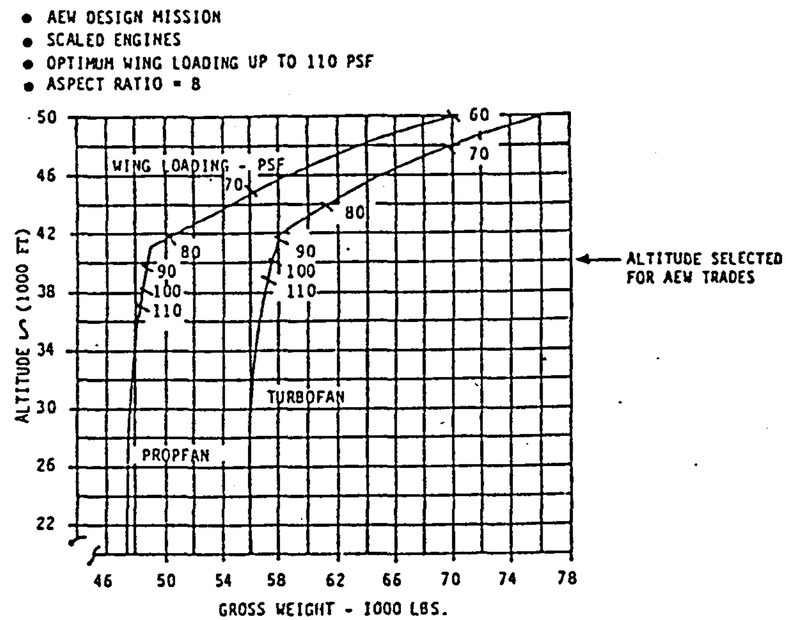


FIGURE 4.3-1 LOITER ALTITUDE SENSITIVITY

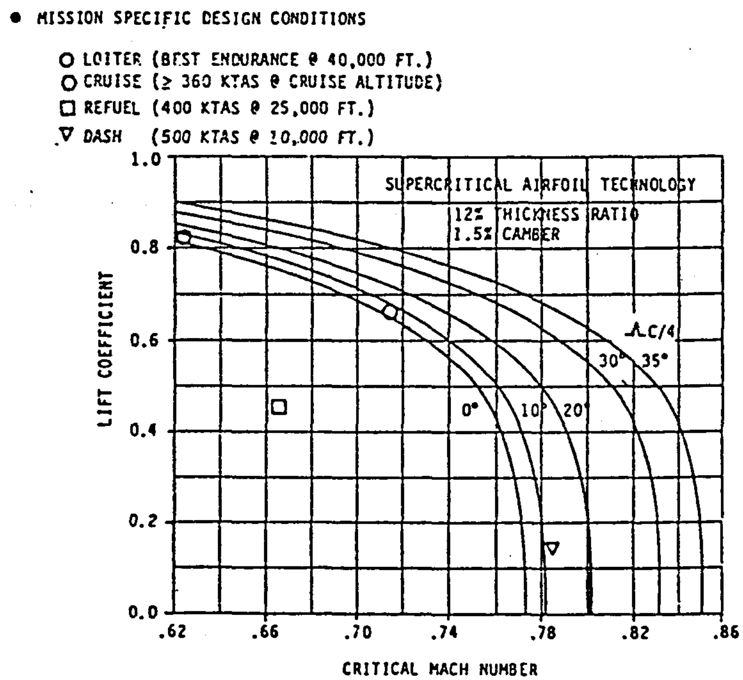


FIGURE 4.4-1 WING SWEEP SELECTION

4.6.1 ASW/AEW MISSION

For aircraft performing ASW/AEW missions, a fuselage cross section of 8.5 ft. diameter was selected. A comfortable standing overhead clearance for crew members is provided with a 78 in. aisle height to reduce fatigue on long endurance missions. Freedom of movement for the crew during mission rest periods and entry or egress is a result of an aisle width of 18 to 20 in. Using the UDACS console, a minimum crew compartment cross section was determined assuming a pressurized circular contour with 4 in. frame thickness, as shown in Figure 4.6.1-1.

4.6.2 COD/TANKER MISSION

For aircraft performing the COD mission, a 9.5 ft. diameter was selected based upon the standardized 463L cargo pallet. Figure 4.6.2-1 presents a fuselage cross section. Commonality between the crew compartment and cargo compartment flooring is maintained by assuming a floor to ceiling height of 6.5 ft.

4.7 EQUIPMENT AND PAYLOAD

The equipment and payloads used for each mission variant to accomplish the projected mission functions is presented. A comparison with current Navy systems is also shown.

4.7.1 MAJOR SYSTEM CHANGES

In order to provide updated capability, equipment was added to the MPSNA-MAPS vehicle that is not presently on the E-2 vehicle. Table 4.7.1-I summarizes the major system changes assumed for the MPSNA vehicle and the additional weight to accommodate a six-man crew with work stations.

4.7.2 FIXED EQUIPMENT/NON-EXPENDABLE USEFUL LOAD

Table 4.7.2-I presents a listing of common core weights, the fixed equipment, and the non-expendable useful load that is common to all missions.

4.7.3 MISSION SPECIFIC EQUIPMENT AND PAYLOADS

Table 4.7.3-I lists the mission specific weights. These weights consist of the fixed equipment and payloads which were taken into consideration when sizing the aircraft.

4.7.4 PAYLOAD REQUIREMENTS

A summary of the previous charts is presented in Table 4.7.4-I. Payloads are defined for each mission based on projected mission requirements and past studies. Improved payload and mission capability is noted for the MPSNA-MAPS designs over the existing aircraft they replace. Payload is defined to include mission specific equipment,

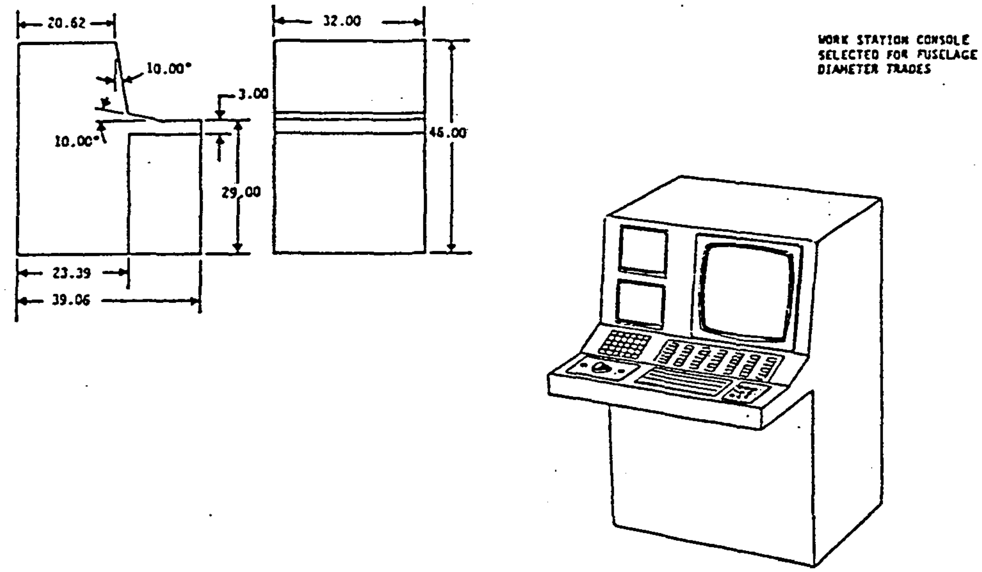


FIGURE 4.5-1 DISPLAY AND CONTROL SYSTEM

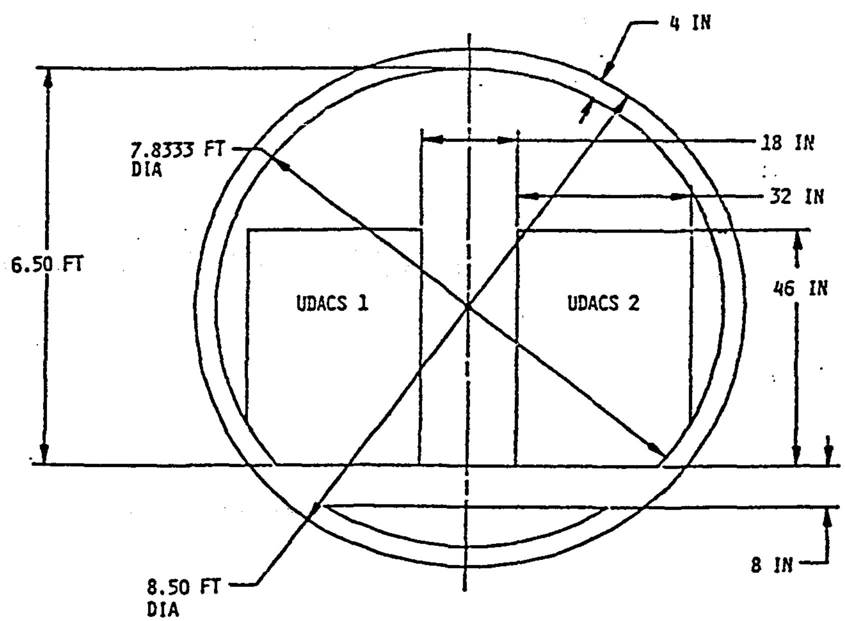


FIGURE 4.6.1-1 CROSS-SECTION OF THE 8.5 FT DIAMETER FUSELAGE

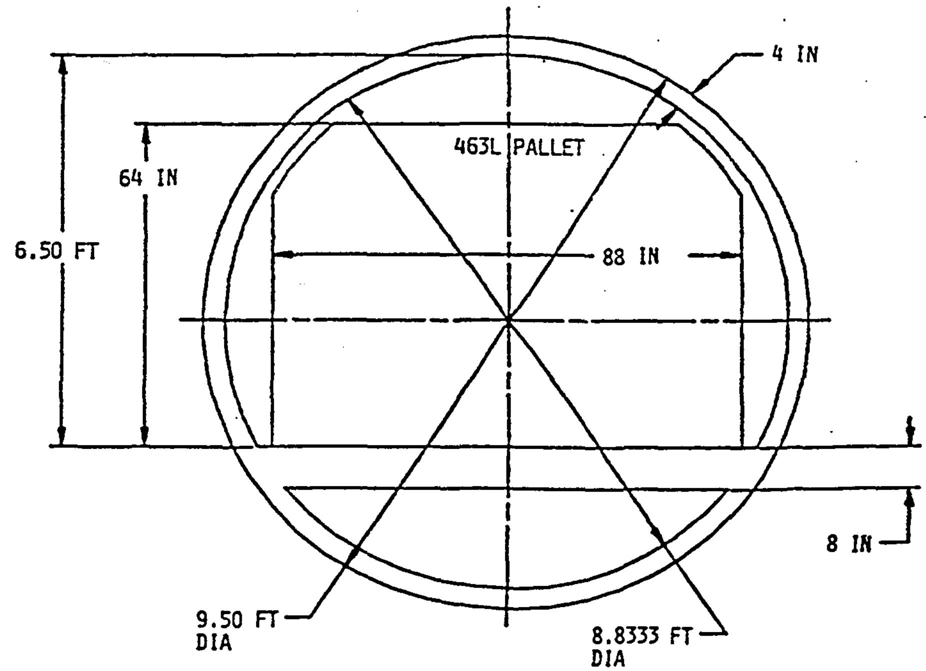


FIGURE 4.6.2-1 CROSS SECTION OF THE 9.5 FT DIAMETER BODY

	WEIGHTS, LBS		
	E-2	MPSNA	Δ
COMPUTER / PROCESSORS	2050	1500	-550
DISPLAY GROUP (1)	1029	1200	+ 171
FURNISHINGS & SEATS (2)	846	1680	834
AIR CONDITIONING & COOLING	804	1125	321
CREW & EQUIPMENT	1043	1500	457
MISSILE LAUNCHERS & MISSILES	--	1120	1120
MPSNA UNIQUE AVIONICS & EQUIPMENT		(2410)	2410
IR / VISUAL / K_uBAND		550	
WEAPONS DELIVERY		200	
FLEET SATELLITE COMMUNICATIONS		70	
JTIDS		95	
MILSTAR		700	
FLIGHT DATA RECORDER		20	
VOR / ILS / MARKER BEACON		125	
GLOBAL POSITIONING SYSTEM		25	
INSTALLATION		625	
SEARCH AND TRACK RADAR (3)	6326	2970	-3356
TOTAL			+ 1407

(1) E-2: THREE RADAR STATIONS
MPSNA: FOUR INTEGRATED DISPLAY SYSTEMS

(2) MPSNA: SIX-MAN CREW WITH EJECTION SEATS

(3) ROTODOME UHF (E-2)
S-BAND CONFORMAL (MPSNA)

TABLE 4.7.1-I MAJOR SYSTEM CHANGES FOR IMPROVED CAPABILITY AEW

MPSNA MAPS 1 25

	WEIGHT LBS
FIXED EQUIPMENT	
AVIONICS	
UHF / VHF RADIOS & DATA LINK	36
HF RADIOS & DATA LINK	263
INTERCOMMUNICATIONS SET	29
SECURE SPEECH & DATA SET	50
FLEET SATELLITE COMMUNICATIONS	70
JTIDS	95
FLIGHT DATA RECORDER	20
RADAR ALTIMETER / ALTITUDE WARNING	28
TACAN	38
AUTOMATIC CARRIER LANDING SYSTEM	20
HEADING ATTITUDE REFERENCE SYSTEM	18
CARRIER AIRCRAFT INERTIAL NAV SYSTEM	96
AIR DATA COMPUTER	16
IFF TRANSPONDER & INTERROGATOR	105
DOPPLER RADAR	85
MARKER BEACON	125
AUTOMATIC DIRECTION FINDER (UHF / VHF)	8
COMPUTER - PROCESSOR	253
GLOBAL POSITIONING SYSTEM	25
INSTALLATION PROVISIONS	483
(AVIONICS SUBTOTAL)	(1863)
FLIGHT CONTROLS	1174
AUXILIARY POWER PLANT	330
HYDRAULICS & PNEUMATICS	224
ELECTRICAL	2630
FURNISHINGS & EQUIPMENT (PILOT / COPILOT EJECTION SEATS, ETC.)	560
AIR CONDITIONING & ANTI-ICING	1437
LOADING & HANDLING	20
PILOT & COPILOT CONSOLES	315
NON-EXPENDABLE USEFUL LOAD	
PILOT & COPILOT & EQUIPMENT	500
UNUSABLE FUEL	56
OIL	125
TOTAL	9234

TABLE 4.7.2-I FIXED EQUIPMENT/NON-EXPENDABLE USEFUL LOAD (COMMON TO ALL MISSIONS)

MPSNA MAPS 1 26

	WEIGHT-LBS				
	AEW	ASW	TANKER	COD	ECM
STRUCTURE					
CARGO RAMP				960	
SONOBUOY STRUCTURE MODULE		1232			
WEAPONS BAY "DOG HOUSE"		400			
SUBTOTAL - STRUCTURE	0	1632	0	960	0
FIXED EQUIPMENT					
AVIONICS					
DEFENSIVE ACTIVE COUNTERMEASURES	650	650			650
SEARCH & TRACK RADAR & PROVISIONS	2970				
INFRARED RADAR SYSTEM	550	550			
WEATHER RADAR SYSTEM		200	200	200	200
MAGNETIC ANOMALY SYSTEM		250			
SONOBUOY REFERENCE SYSTEM		100			
WEAPONS DELIVERY SYSTEM	40	40			40
INTERFACE UNITS	160	160			160
MILSTAR	700	700			700
(AVIONICS SUBTOTAL)	(5070)	(2650)	(200)	(200)	(1750)
CREW CONSOLE #1	300				300
CREW CONSOLE #2	300				300
CREW CONSOLE #3	300	300			300
CREW CONSOLE #4	300	300			
EJECTION SEATS & PROV-CREW (200 LBS EA)	800	400			600
MISC FURNISHINGS - CREW (80 LBS EA)	320	160			240
CARGO HANDLING EQUIPMENT				850	
SUBTOTAL - FIXED EQUIPMENT	7390	3810	200	1050	3490
NON-EXPENDABLE USEFUL LOAD					
CREW & EQUIPMENT (250 LBS EA)	1000	500			750
AAM LAUNCHERS	344				344
HARPOON MISSILES MOUNTING PROVISIONS		85			
INTERNAL WEAPONS MOUNTING PROVISIONS		170			
WEAPONS BAY FUEL TANKS & PROVISIONS			1500		
EXTERNAL REFUEL POD			900		
SUBTOTAL - NON-EXPENDABLE USEFUL LOAD	1344	755	2400	-	1094
TOTAL - MISSION SPECIFIC EQUIPMENT	8734	6197	2600	2010	4584
PAYLOAD					
4 AIR-TO-AIR MISSILES	776				776
4 MK-46 TORPEDOES		3200			
60 SONOBUOYS		1515			
CARGO				(3)	
TRANSFERABLE FUEL			(2)		
SUBTOTAL - PAYLOAD	776	4715(1)	(2)	(3)	776
TOTAL MINIMUM MISSION SPECIFIC EQUIP & P/L	9510	10912	2600+ FUEL OFFLOAD	VAR	5360
TOTAL - FULL CAPABILITY MISSION SPECIFIC EQUIP & P/L	9510	14780	27600	17010	5360

(1) INCLUDING 4 MK-50 TORPEDOES. FOR MAX ASW PHASE II STUDY, P/L=8583 LBS (2 MK-60 MINES + 2 HARPOON MISSILES + 60 SONOBUOYS)

(2) VARIABLE FOR MINIMUM VEHICLE; 25000 LBS FOR FULL TANKER MISSION

(3) VARIABLE FOR MINIMUM VEHICLE; 15000 LBS FOR FULL COD MISSION

TABLE 4.7.3-I. MPSNA ESTIMATED MINIMUM MISSION SPECIFIC EQUIPMENT & PAYLOADS

MISSION	TYPE PAYLOAD	COMMON FIXED EQUIPMENT	MISSION SPECIFIC EQUIPMENT (EQUIPMENT & AVIONICS & CREW)	TOTAL EQUIPMENT	EXPENDABLE PAYLOAD	TOTAL EQUIPMENT PLUS PAYLOAD
AEW AAW ASM C^3I	EQUIPMENT TO HAVE INCREASED CAPABILITY OVER E-2C. DEFENSIVE CAPABILITY TO BE PROVIDED.	9,234	8,734	17,968	776	18,744
ASW ASUW MIW	EQUIPMENT TO HAVE INCREASED CAPABILITY OVER S-3A. ARMAMENT PROVISIONS INCREASED.	9,234	6,197	15,431	8,580 (1) 4,715 (2)	24,011 20,146
COD	IMPROVED C-2 CAPABILITY. (MAX. CARGO)	9,234	2,010	11,244	15,000	26,244
EW	EQUIPMENT TO HAVE INCREASED CAPABILITY OVER EA-6B. ARMAMENT PROVISIONS INCREASED.	9,234	4,584	13,818	776 (3)	14,594
TANKER	MAX. FUEL OFFLOAD, IMPROVED KA-6D CAPABILITY.	9,234	2,600	11,834	25,000	36,834

* THESE PAYLOADS INCLUDE MISSION SPECIFIC EQUIPMENT, EXPENDABLE STORES AND INSTALLATION PROVISIONS, MISSION SPECIFIC CREW AND FURNISHINGS REQUIREMENTS. ALL UNITS SHOWN ARE POUNDS.

(1) FULL MULTI-MISSION 2 MK 56 MINES + 2 HARPOONS + 5 SONOBUOYS

(2) PARTIAL MULTI-MNISSION 4 TORPEDOES + SONOBUOYS

(3) AIR-TO-AIR MISSILES

TABLE 4.7.4-I SUMMARY OF EQUIPMENT & PAYLOAD WEIGHTS VERSUS MISSION

expendable stores and installation provisions, and mission specific crew and furnishings requirements.

4.8 PRELIMINARY ESTIMATE - VEHICLE SIZE VS. PAYLOAD

Preliminary estimates of aircraft size variation with payload carried is used to match vehicle size with operational needs. The discussion for the turbofan and the propfan aircraft matching is presented below.

4.8.1 ADVANCED PROPFAN

For the advanced propfan, a total equipment and payload weight of 18,700 lb. representative of an AEW Mission was used. From Figure 4.8.1-1a, an approximation of a minimum vehicle size of 50,000 lb. for the 8.5 ft. diameter fuselage is obtained. Such a weight would permit approximately a 3,300 lb. expendable payload for the ASW mission, assuming an equipment weight of 15,500 lb. A 6.5 ft. diameter fuselage is shown in Figure 4.8.1-1a to show results of previous studies that were conducted.

Figure 4.8.1-1b shows the results of the COD sizing. The chart shows the estimated effect of increasing the fuselage to the 9.5 ft. diameter. A total range of 2,100 NM is used in the COD sizing.

Figure 4.8.1-1c shows the results of the tanker sizing. In order to provide a 25,000 lb. offload, a vehicle of approximately 70,000 lb. will be required. The tanker is sized with a 200 NM radius and a 2.5 hour loiter. The 50,000 lb. tanker aircraft offloads 11,500 lb. of fuel.

The minimum weights for each mission are taken from Figure 4.7.4-1.

4.8.2 ADVANCED TURBOFAN

Using the same guidelines and requirements as used in Section 4.8.1, the aircraft are sized for the advanced turbofan. Figure 4.8.2-1a shows that for the assumed 18,700 lb. of total equipment and payload weight, a vehicle of approximately 57,000 lb. is required for the AEW mission. Figure 4.8.2-1b shows the COD mission sizing. Figure 4.8.2-1C shows that for any given TOGW the larger fuselages will carry less fuel offload than a smaller one. This is due to the larger fuselage being penalized by weight and drag. However, for the smaller fuselage (i.e. 6.5 ft. dia), the maximum fuel capacity limits the TOGW to 50,000 lb. The maximum fuel capacity limits for the 8.5 ft. diameter fuselage allows a maximum TOGW of 80,000 lb. which implies a 77,000 lb tanker will allow the 25,000 lb. offload.

The reasons for the increase in gross weight as the airplane is sized from propfan to turbofan are twofold:

- o Increase in fuel burn rate
- o Weight spiral

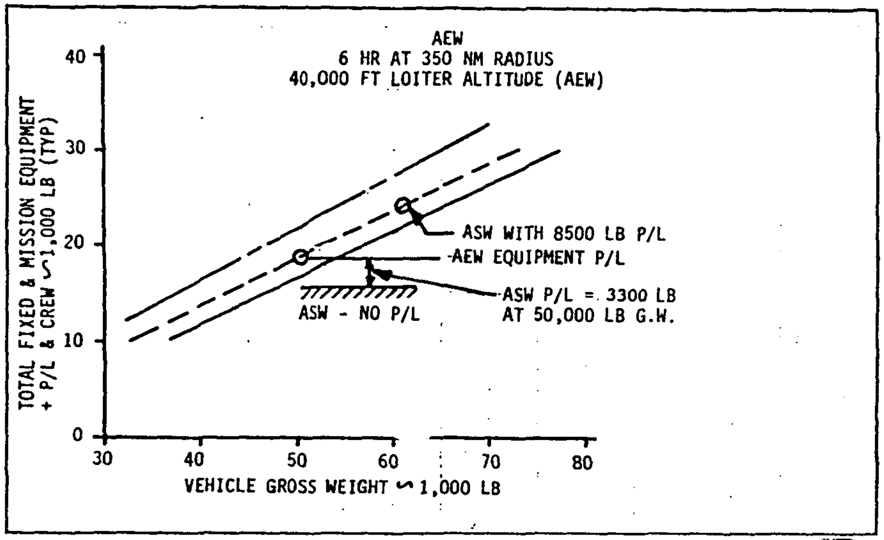


FIGURE 4.8.1-1a

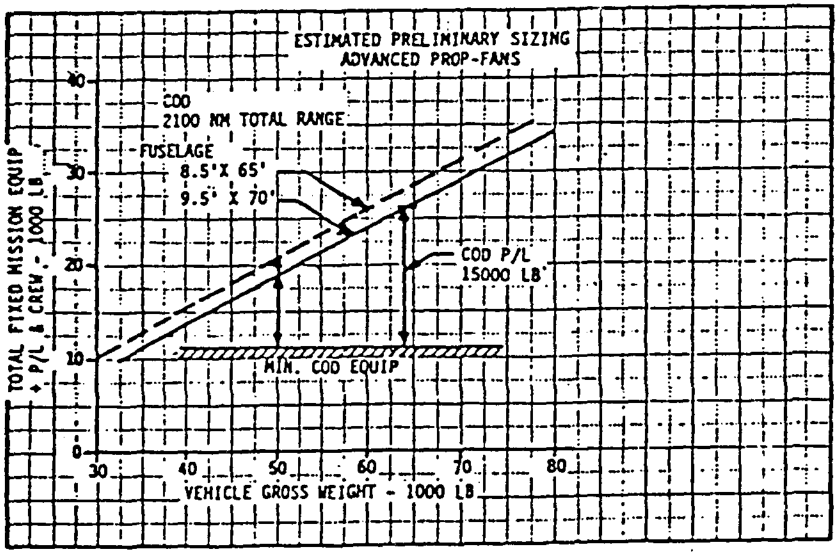


FIGURE 4.8.1-1b

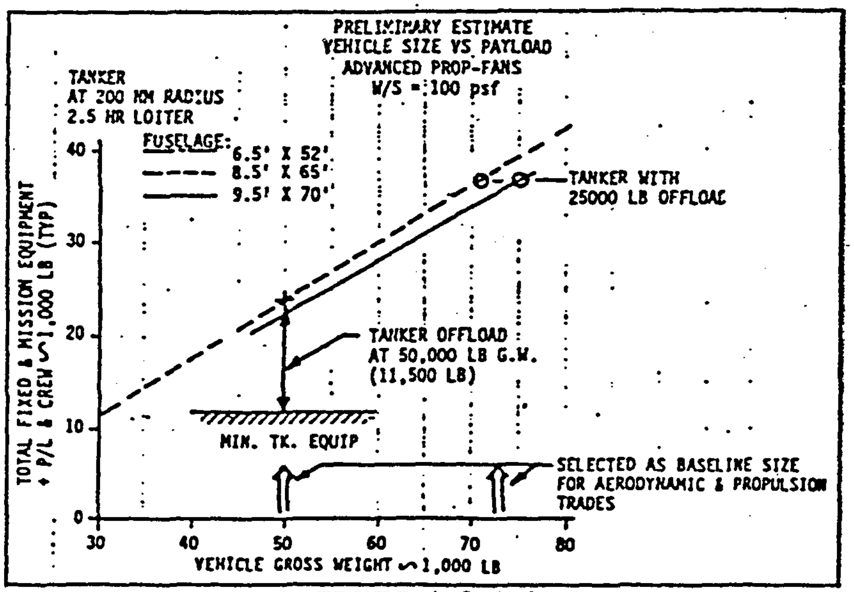


FIGURE 4.8.1-1c

FIGURE 4.8.1-1 PRELIMINARY ESTIMATE - VEHICLE SIZE VS. PAYLOAD - ADVANCED PROPFANS - W/S = 100 PSF

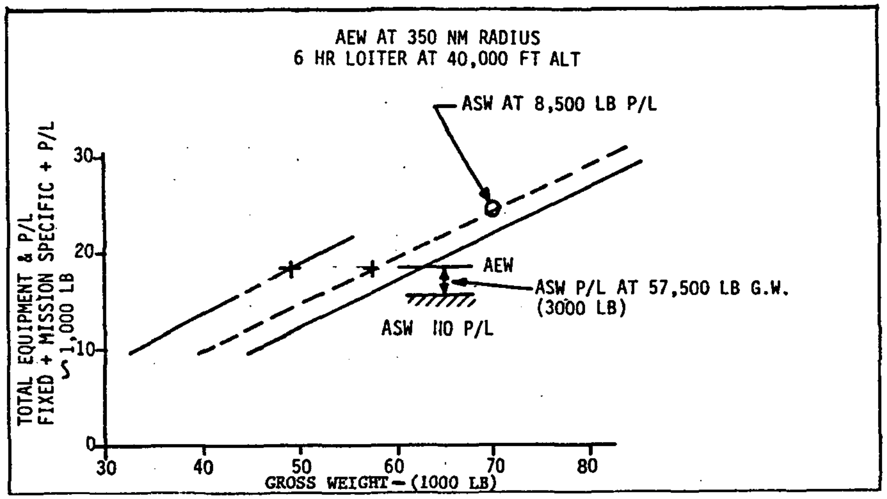


FIGURE 4.8.2-1a

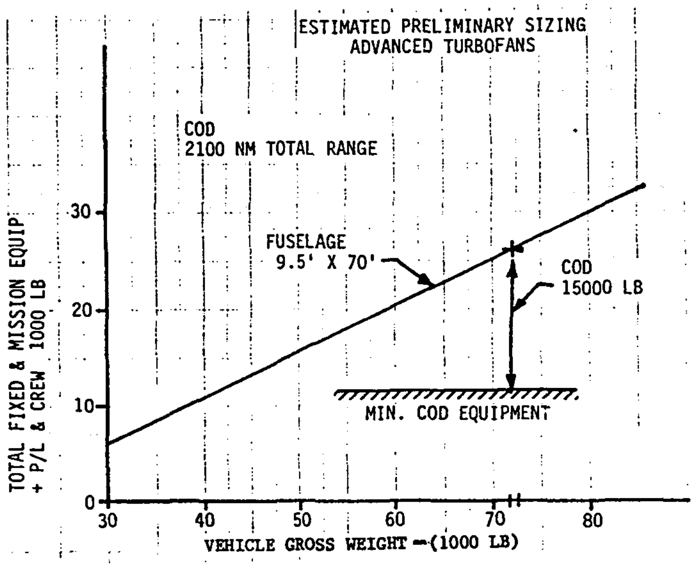


FIGURE 4.8.2-1b

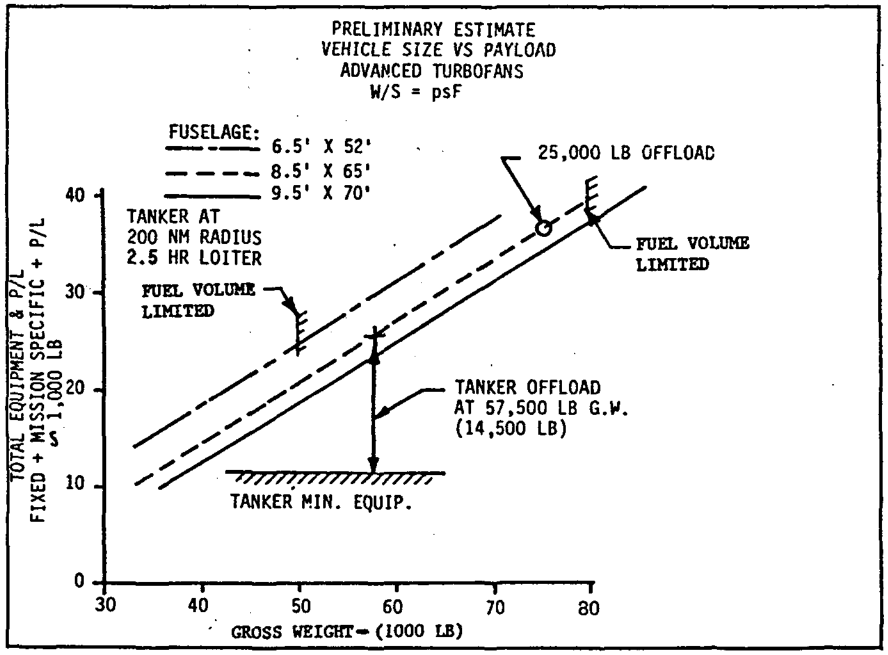


FIGURE 4.8.2-1c

FIGURE 4.8.2-1 PRELIMINARY ESTIMATE-VEHICLE SIZE VS. PAYLOAD - ADVANCED TURBOFANS - W/S =100 PSF

4.9 ALTERNATE MISSION CAPABILITY

Using preliminary estimates, alternate mission capabilities were determined. Both turbofans and propfans were used as well as either an 8.5 ft. or a 9.5 ft. diameter fuselage. Data from Figures 4.9-1b and 4.9-1c for both a 56,000 and a 77,000 lb. aircraft equipped with turbofans was extracted and plotted on Figure 4.9-1a as loiter vs. radius.

Propfan data was extracted from Figure 4.9-2b and 4.9-2c and plotted on Figure 4.9-2a. All configurations were based on an AEW payload which includes 18,700 lb. of equipment.

4.10 CONFIGURATION SELECTION

The process by which the initial configuration matrix was narrowed down to the final six configurations is presented in the following sections.

4.10.1 CONFIGURATION EVALUATION SUMMARY

The configuration design in Task II of the MPSNA-MAPS study addressed the following configuration concepts:

- o Full multimission configurations
- o Partial multimission configurations

A matrix of 35 potential configurations was evaluated. Primary considerations during final selection of both full and partial multimission configurations were as follows:

- o Wing and propulsion location vs. aerodynamic static margin
- o Crew ejection restraints (zero altitude/zero speed ejection for all crew members)
- o Bomb bay and wing box location

The full multimission bomb bay requirements tends to drive the configuration to a high wing in order to avoid wing box/bomb bay interference. This resulted in special problems for the UDF configuration; i.e. the pusher propeller. Sting-wing mounted UDF was considered, however, this results in a forward location of the wing to achieve static balance. The forward location results in the engines extending alongside the pilot station and obstructing pilot visibility. A high wing canard configuration with a sting mounted UDF could meet all multimission requirements but was eliminated due to possible spotting factor problems and high technical risks. A high wing, aft fuselage-mounted UDF was considered but discarded due to wing wake/propeller interference. Low wing configurations were considered but to avoid wing box/bomb bay interference, the wing box must be positioned forward of the bomb bay. With the bomb bay positioned near the C.G., the wing box must be considerably forward of the C.G. to keep the wing aerodynamic center near the C.G. The wing sweep must be more than was judged desirable. The resolution of all these considerations and conflicts

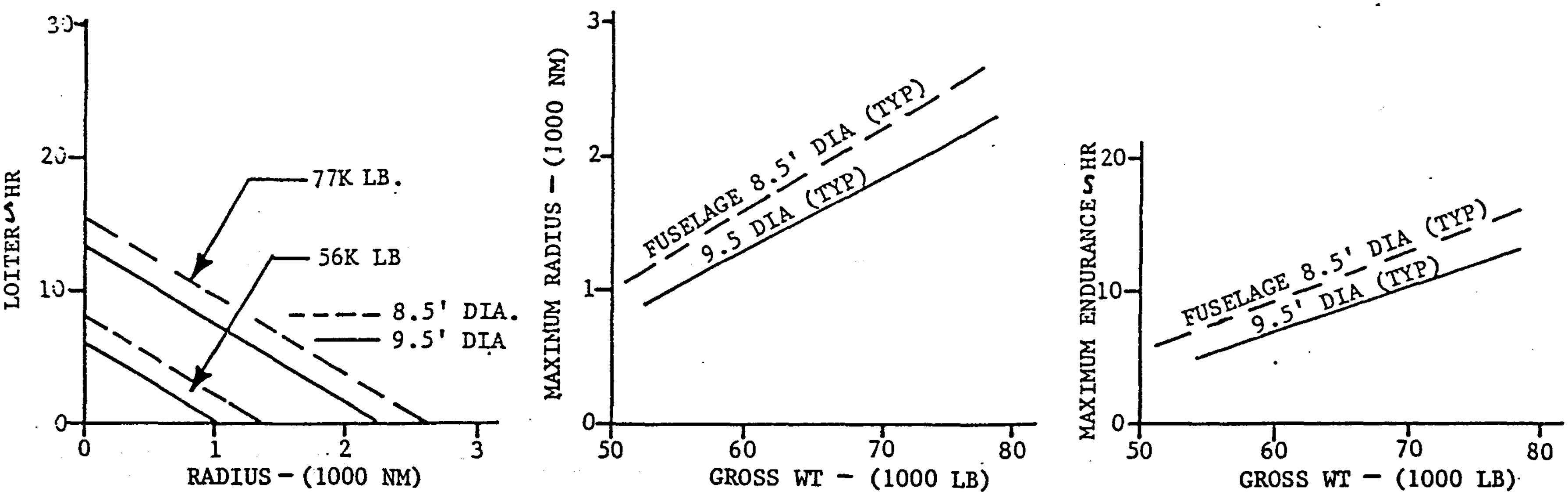


FIGURE 4.9-1a

FIGURE 4.9-1b

FIGURE 4.9-1c

FIGURE 4.9-1 EXAMPLE ALTERNATE MISSION CAPABILITY - TURBOFANS

PROPFANS

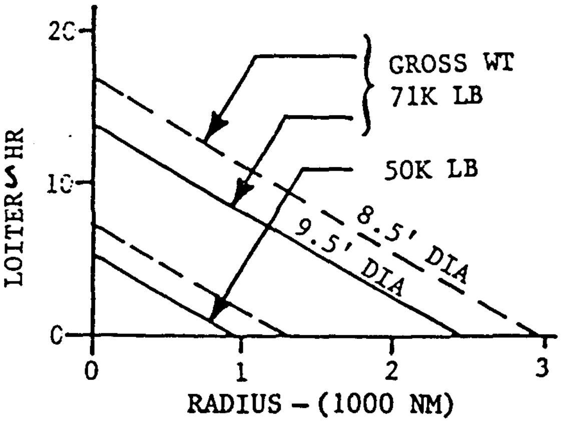


FIGURE 4.9-2a

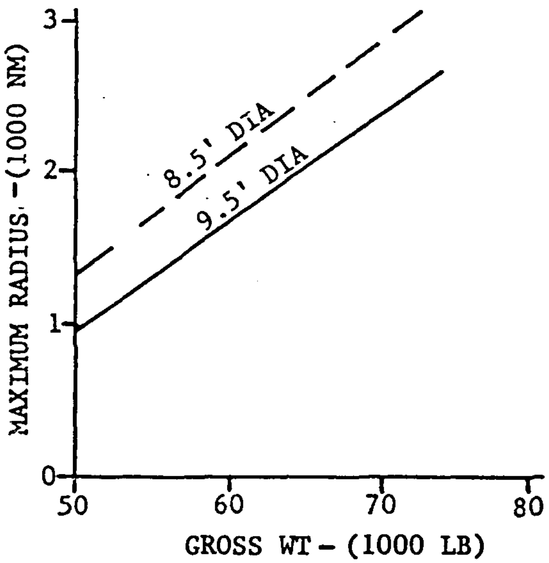


FIGURE 4.9-2b

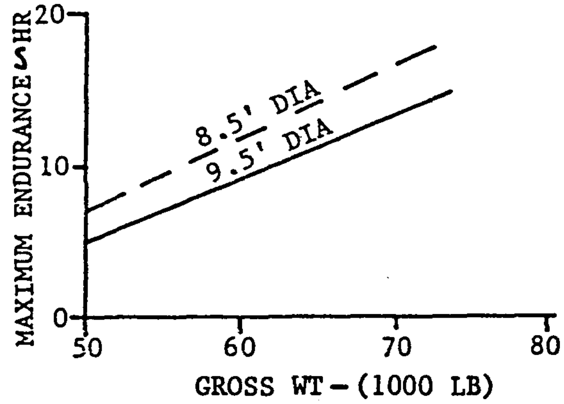


FIGURE 4.9-2c

FIGURE 4.9-2 EXAMPLE ALTERNATE MISSION CAPABILITY – PROPFANS – AEW P/L (18700 LB EQUIPMENT PLUS PAYLOAD) would be required before a final UDF configuration could be synthesized. However, due to time restraints a low wing UDF configuration with the wing box located in front of the bomb bay was used to conduct the trade studies. For the high wing configurations, the crew must be located either forward or aft of the wing box to allow zero speed/zero altitude ejection. For the turbofan configuration, the crew was located forward of the wing box. For the propfan configuration the crew was located aft of the wing box. The aft crew location was due to the danger of propeller alignment with the crew and not wing box crew ejection interference.

The partial multimission bomb bay requirements allowed the wing box to be moved higher to provide an under-the-wing bomb bay which permits the bomb bay to be near the center of gravity. The aft engine location for all engines allowed a common propulsion location for performing the propulsion trades.

Based upon these considerations yet still trying the maintain configuration commonality for the propulsion trades, the following configurations were selected:

o For AEW/ASW with limited bomb bay and COD capabilities, a low wing with common propulsion location for all engines.

o For the full multimission with large bomb bay and rear loading COD: either a) a conventional high wing for turbofan and tractor propfans, or b) a low wing for UDF.

4.10.2 MULTIMISSION CONFIGURATIONS

Presented here are the composite views of the multimission configurations for the UDF, propfan, and turbofan engines. All three configurations feature a 9.5 ft. diameter fuselage with accommodations for a six-man crew. The AEW mission will use a six-man crew while the ASW will use a four-man crew. AEW antenna accommodations are for 2 ft. x 8 ft. S-band phase arrays in the nose, tail, and both sides of the forward fuselage. The ASW bomb bay is adapted by modifying the COD floor with inverted bomb bay assemblies. Figures 4.10.2-1a through 4.10.2-1c, show multimission UDF, propfan, and turbofan configurations, respectively. Cross-hatched lines on the side view are the 25 ft. hangar bay door height limit. Payloads shown are MK-56 or MK-60 mines internally and with Harpoon missiles and fuel tanks externally. The bomb bay length is sized to accommodate two Harpoon missiles or two MK-56 mines. In the COD configuration, an 88 in. wide by 33 ft. long floor will accommodate three MIL 463L pallets.

4.10.3 PARTIAL MULTIMISSION CONFIGURATIONS

For the AEW/ASW minimum configurations, the 8.5 ft. diameter fuselage is used with accommodations for a four-man crew in ASW configuration and six-man crew for AEW configuration. Figures 4.10.3-1a through 4.10.3-1c show the ASW configurations in which the bomb bay is sized to carry four

GENERAL DIMENSIONS

FUSELAGE LENGTH	70.0 FT
FUSELAGE DIAMETER	9.5 FT
WING SPAN	71.3 FT

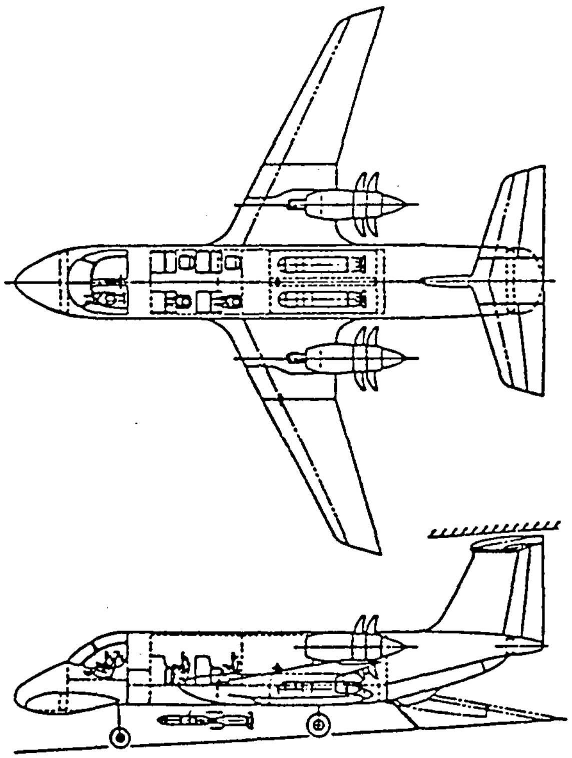


FIGURE 4.10.2-1a UDF MULTI-MISSION CONFIGURATION

GENERAL DIMENSIONS

FUSELAGE LENGTH	70.0 FT
FUSELAGE DIAMETER	9.5 FT
WING SPAN	69.8 FT

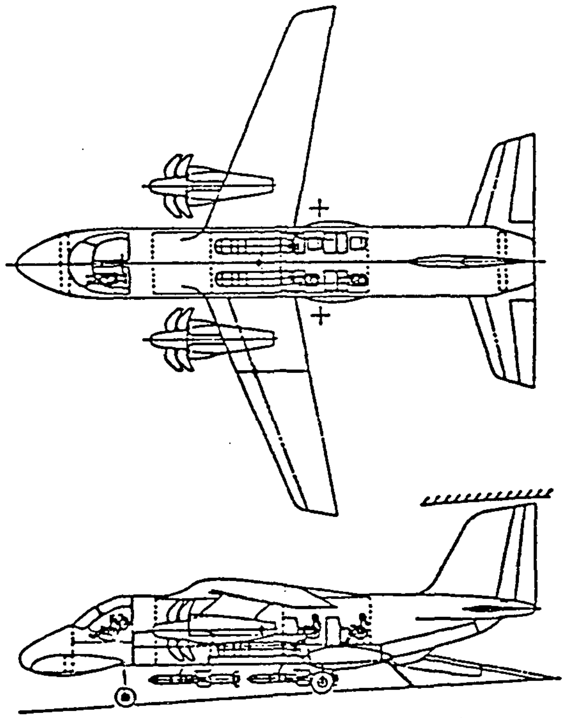


FIGURE 4.10.2-1b PROPFAN MULTI-MISSION CONFIGURATION

GENERAL DIMENSIONS

FUSELAGE LENGTH	70.0 FT
FUSELAGE DIAMETER	9.5 FT
WING SPAN	74.8 FT

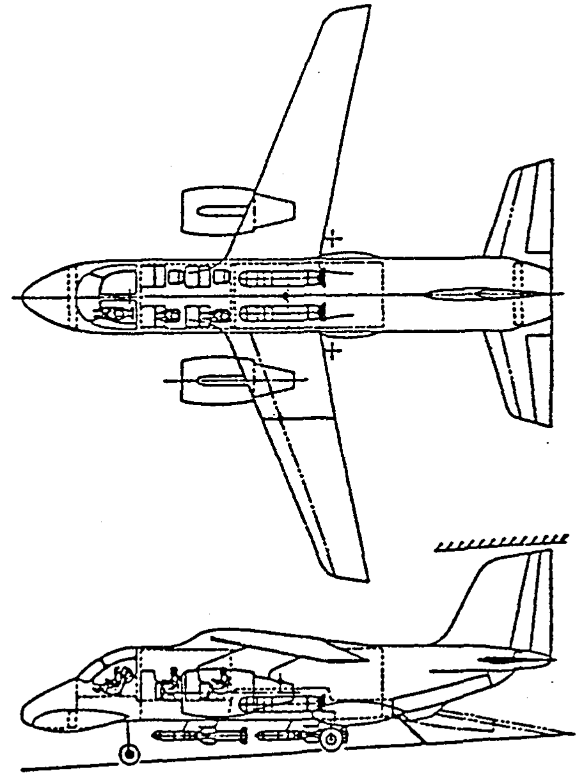


FIGURE 4.10-2-1c TURBOFAN MULTI-MISSION CONFIGURATION

GENERAL DIMENSIONS

FUSELAGE LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING SPAN	62.33 FT

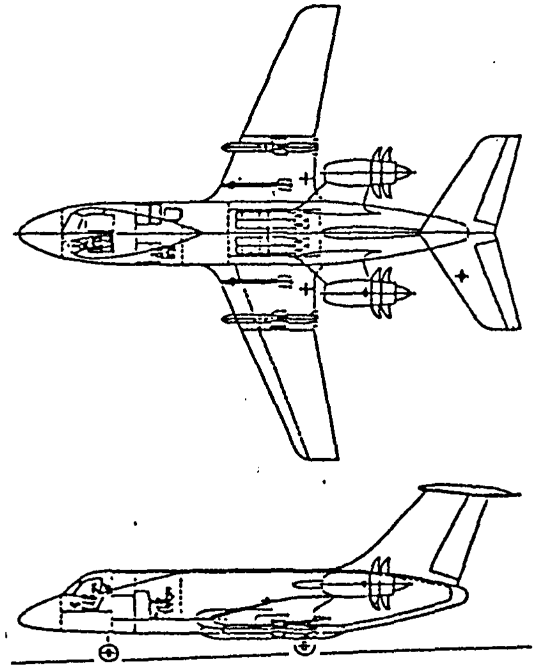


FIGURE 4.10.3-1a UDF ASW (MINIMUM) CONFIGURATION

GENERAL DIMENSIONS

FUSELAGE LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING SPAN	62.33 FT

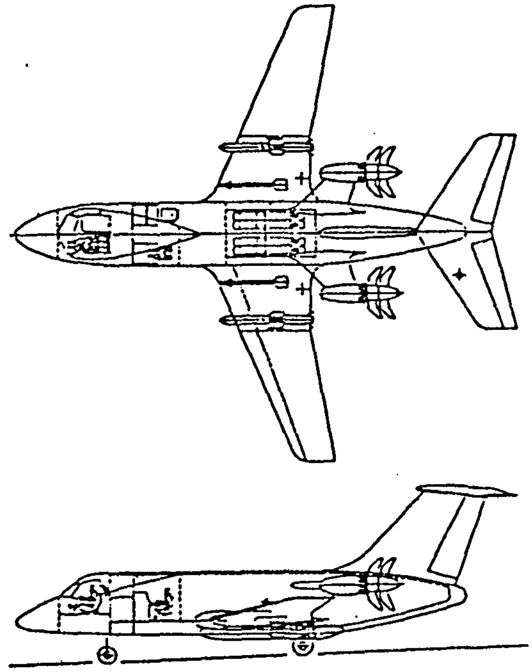


FIGURE 4.10.3-1b PROPFAN ASW (MINIMUM) CONFIGURATION

WING SPAN
66.6 FT

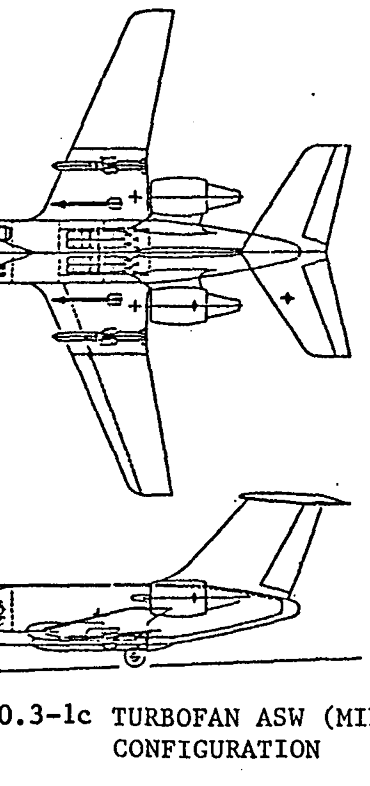


FIGURE 4.10.3-1c TURBOFAN ASW (MINIMUM) CONFIGURATION

WING SPAN
62.33 FT

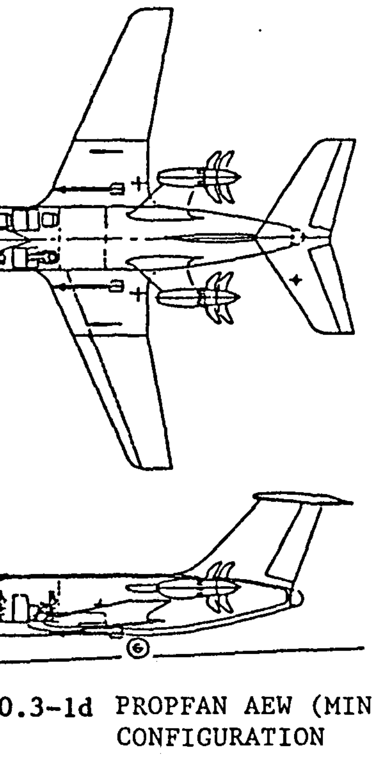


FIGURE 4.10.3-1d PROPFAN AEW (MINIMUM) CONFIGURATION

MK-60 torpedoes. The wing stores are shown for an alternate surface strike mission with two Harpoons and two air-to-air missiles. The wing box has been moved above the bottom of the vehicle to accommodate the bomb bay.

Figure 4.10.3-1d shows the AEW minimum configuration with propfans. AEW antenna accommodations are two 2 ft. x 8 ft. S-band side looking, a 4 ft. diameter nose, and 2 ft. diameter tail antennas. Wing hard points may accommodate air-to-air missiles or external fuel tanks.

4.11 CONCEPTUAL WEIGHTS BREAKDOWN

Estimated base weight breakdowns for each mission and propulsion type are presented in the following sections.

4.11.1 PROPFAN

The estimated base weight breakdown for the propfan full multimission configuration is shown in Table 4.11.1-Ia and the partial multimission is shown in Table 4.11.1-Ib. The propulsion weights are taken as the composite average of the STS-679 and the GE-36 (UDF). The final trades (Task III) break out each propulsion system. The structures weights were also a composite average of the UDF and propfan configurations. The final trades (Task III) break out each structures weight separately. Maximum ranges are presented in nautical miles.

4.11.2 TURBOFAN

The estimated base weight breakdown for the turbofan full multimission configuration is shown in Table 4.11.2-Ia. The partial multimission is displayed in Table 4.11.2-Ib.

4.12 FIGURES OF MERIT

A key figure of merit influencing the design activity for Task II was the takeoff gross weight, which was minimized. The results are presented in Table 4.12-I. It should be noted that fuel burn per aircraft, acquisition cost per aircraft, and life cycle cost per aircraft are first order functions of TOGW and propulsion system selection.

The second key figure of merit was the deck spot size of the aircraft. The deck spot values, which are presented in Figure 4.12-II, were calculated by Boeing parametric methods, which are consistent with current Navy practice.

		AEW	ASW	TANKER	COD
WING	5850				
EMPENNAGE	1600				
BODY	9500				
GEAR	2550				
TOTAL STRUCTURE	19500				
PROPULSION(1)	8700				
STRUCTURES & PROPULSION	28200	28200	28200	28200	28200
EQUIPMENT & PAYLOAD		18700	24000	36800	26200
EXPENDABLE PAYLOAD (REF ONLY)		(776)	(8580)	(25000)	(15000)
GROSS WEIGHT LESS MISSION FUEL		46900	52200	65100	54400
FUEL		23900	18600	6500	16400
GROSS WEIGHT		70800	70800	71600	70800
MAX RANGE - NM		(5000)	(3800)	(1200)	(3300)

NOTES:

(1) PROPULSION*

PROPULSION*	
ENGINE & NAC	6748
EBU	1900
TOTAL	8648 (USED 8700)

BODY GROUP	
FUSELAGE	7950
NUCLEAR HARDENING	660
ENGINE STRUTS	490
ARRESTING HOOK	770
SOUND PROOFING	125
	9495 (USED 9500)

*COMPOSITE AV OF STS 679 AND GE-36 (UDF), FINAL TRADES WILL BREAK OUT AS SEPARATE PROPULSION SYSTEMS

TABLE 4.11.1-Ia EXAMPLE-FULL MULTI-MISSION ESTIMATED WEIGHTS (PROPFANS)

		AEW	ASW	TANKER	COD
WING	4500				
EMPENNAGE	1600				
BODY	6900				
GEAR	1800				
TOTAL STRUCTURE	14800				
PROPULSION(1)	7300				
STRUCTURES & PROPULSION	22100	22100	22100	22100	22100
EQUIPMENT & PAYLOAD		18700	20100	23300	20800
EXPENDABLE PAYLOAD (REF ONLY)		(776)	(4715)	(11500)	(9600)
GROSS WEIGHT LESS MISSION FUEL		40800	42200	45400	42900
FUEL		9300	9500	4700	7200
GROSS WEIGHT		50100	51700	50100	50100
MAX RANGE - NM		(2700)	(2700)	(1200)	(2100)

NOTES:

(1) PROPULSION

PROPULSION	
ENGINE	5377
EBU	1900
TOTAL	7277 (USED 7300)

*COMPOSITE AV FOR STS 679 AND UDF, FINAL TRADES WILL BREAK OUT AS SEPARATE PROPULSION SYSTEMS

TABLE 4.11.1-Ib EXAMPLE-PARTIAL MULTI-MISSION ESTIMATED BASELINE WEIGHTS (PROPFANS)

		AEW	ASW	TANKER	COD
WING	6300				
EMPENNAGE	1700				
BODY	9500				
GEAR	2800				
TOTAL STRUCTURE	20400				
PROPULSION(1)	10900				
STRUCTURES & PROPULSION		31300	31300	31300	31300
EQUIPMENT & PAYLOAD		18700	24000	36800	26200
EXPENDABLE PAYLOAD (REF ONLY)		(776)	(8570)	(25000)	(15000)
GROSS WEIGHT LESS MISSION FUEL		50000	55300	68100	57500
FUEL		28100	21700	8900	19000
GROSS WEIGHT		77000	77000	77000	77000
	MAX RANGE NM	(4500)	(3300)	(1200)	(2900)

NOTES:

(1) PROPULSION

ENGINE & NAC	8986
EBU	1900
TOTAL	10886 (USED 10900)

TABLE 4.11.2-Ia EXAMPLE-FULL MULTI-MISSION ESTIMATED BASELINE WEIGHTS (TURBOFANS)

		AEW	ASW	TANKER	COD
WING	4900				
EMPENNAGE	1800				
BODY	6900				
GEAR	2000				
TOTAL STRUCTURE	15600				
PROPULSION(1)	9200				
STRUCTURES & PROPULSION	24800	24800	24800	24800	24800
EQUIPMENT & PAYLOAD		18700	20100	26300	23200
EXPENDABLE PAYLOAD (REF ONLY)		(776)	(4715)	(14500)	(12000)
GROSS WEIGHT LESS MISSION FUEL		43500	44900	51100	4800
FUEL		13500	14000	6000	10500
GROSS WEIGHT		57000	58900	57100	58500
	MAX RANGE - NM	(2700)	(2700)	(1200)	(2100)

NOTES:

(1) PROPULSION

ENGINE	7296
EBU	1900
TOTAL	9196 (USED 9200)

TABLE 4.11.2-Ib EXAMPLE-PARTIAL MULTI-MISSION ESTIMATED BASELINE WEIGHTS (TURBOFANS)

MISSION	PROPULSION TYPE UNDUCTED FAN	 TURBO PROP	 TURBO FAN
MULTI-MISSION (AEW, ASW, COD, ECM, TANKER)	71,000 LBS. FUEL BURN = 23.900 LBS (AEW ONLY)	71,000 LBS. FUEL BURN = 23.900 LBS (AEW ONLY)	77,000 LBS. FUEL BURN = 28.100 LBS (AEW ONLY)
LIMITED (ASW/AEW)	50,000 LBS. FUEL BURN = 9300 LBS (AEW ONLY)	50,000 LBS FUEL BURN = 9300 LBS (AEW ONLY)	57,000 LBS. FUEL BURN = 13,500 LBS (AEW ONLY)

TABLE 4.12-I PRELIMINARY ESTIMATED MAXIMUM GROSS WEIGHT

MISSION	HORIZONTAL TAIL	PROPULSION TYPE TURBO FAN	 PROP FAN	 UNDUCTED FAN
MULTI-MISSION	UNFOLDED FOLDED	2.40 1.85	2.40 2.00	2.00 1.70
LIMITED (ASW/AEW)	UNFOLDED FOLDED	1.80 1.40	1.75 1.40	1.75 1.40

TABLE 4.12-II PRELIMINARY ESTIMATED SPOT FACTOR

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5.0 TASK III: DETAILED CALCULATIONS AND AIRCRAFT OPTIMIZATION

The six CTOL configurations are sized and the resulting point design mission performance and design sensitivities are presented. Details on each point design such as drag breakdowns, weight breakdowns, and spot factors are also presented in the following sections.

5.1 THREE VIEW DRAWINGS

Three views of the configurations selected for detailed analysis in Task II are presented in their final form in Figures 5.1-1 through 5.1-12. Geometric parameters and three view drawings for the three multimission aircraft (UDF, propfan, and turbofan) and the three minimum AEW/ASW aircraft (UDF, propfan, and turbofan) are presented in two variants, AEW and ASW. The shaded areas in the front views show the estimated deck clearance with one gear strut collapsed and the tire flat.

The multimission UDF configuration presented in Task II had structural interference problems between the wing box and the bomb bay. It was suggested to reconfigure the aircraft from the low wing shown in Task II to the high wing shown here. Since this study was primarily done to assess the effects of powerplant on aircraft size and performance, weight and TSFC penalties resulting from the engine and inlet being in the wake of the wing were not included because this would unfairly penalize the UDF for a unique configuration dependent effect.

5.2 FIXED EQUIPMENT AND PAYLOAD WEIGHTS BREAKDOWN

The weights presented in Task II were rough order of magnitude accessments of overall system weights. The weights presented in Task III represent a detailed assessment of weights to the component level. The equipment weights were further divided into those present on all mission variants, common core; and those present on specific mission variants, mission unique equipment. Weight reductions for optical data busses and new avionics weights are the major items causing the weight changes between Task II and Task III.

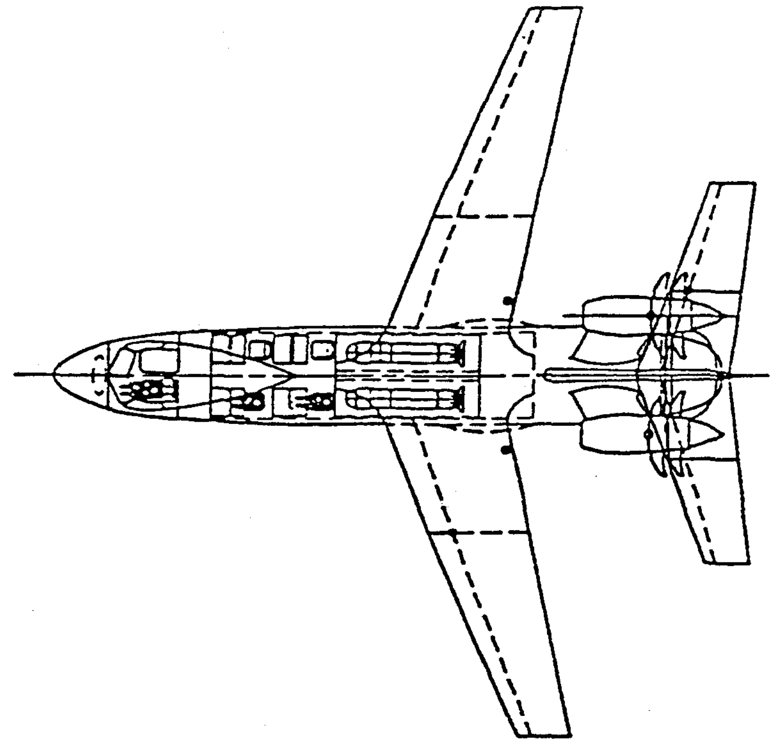
Common core avionics equipment weights are presented in Table 5.2-I. These systems are carried by all configurations regardless of design mission. Mission unique equipment and payload weights presented in Table 5.2-II and 5.2-III are broken down by design mission. The mission dependent miscellaneous equipment is presented in Table 5.5-II.

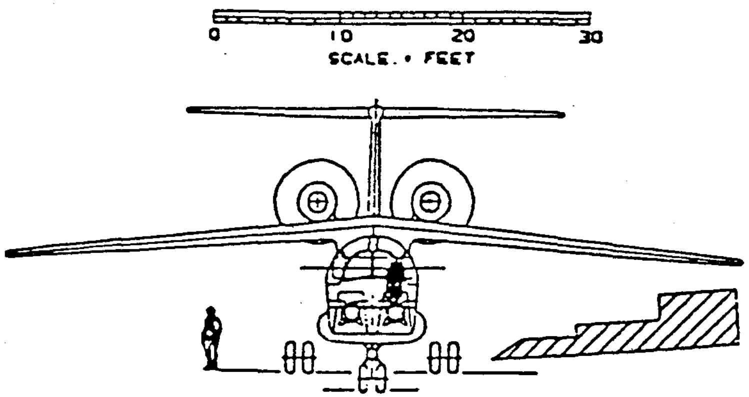
Final weights breakdowns for each of the configurations on their respective design mission are presented in Section 5.5.

5.3 CTOL SIZING MATRICES

Two sizing matrices are presented for each configuration. The gross weight sizing matrix shows the behavior of gross weight with changes in wing loading and aspect ratio. Constraints such as the 80 ft. wing span limit, the locus of minimum fuel burns, the transition locus of engine

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	71,156 LBS
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	71.9 FT
AREA	646.9 FT2
ASPECT RATIO	8.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.50 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	37.3 FT
AREA	250 FT2
ASPECT RATIO	5.6
TAPER RATIO	.500
SWEEP @ C/4	16.9 DEG
DIHEDRAL	0.0
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.7 FT
AREA	220 FT2
ASPECT RATIO	.98
TAPER RATIO	.500
SWEEP @ C/4	27.1 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) G.E. UDF (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	14,232 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	8.5 FT





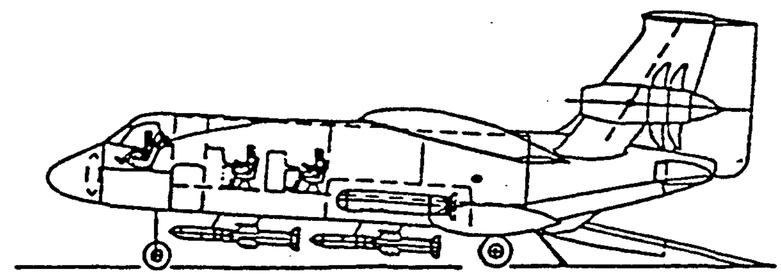
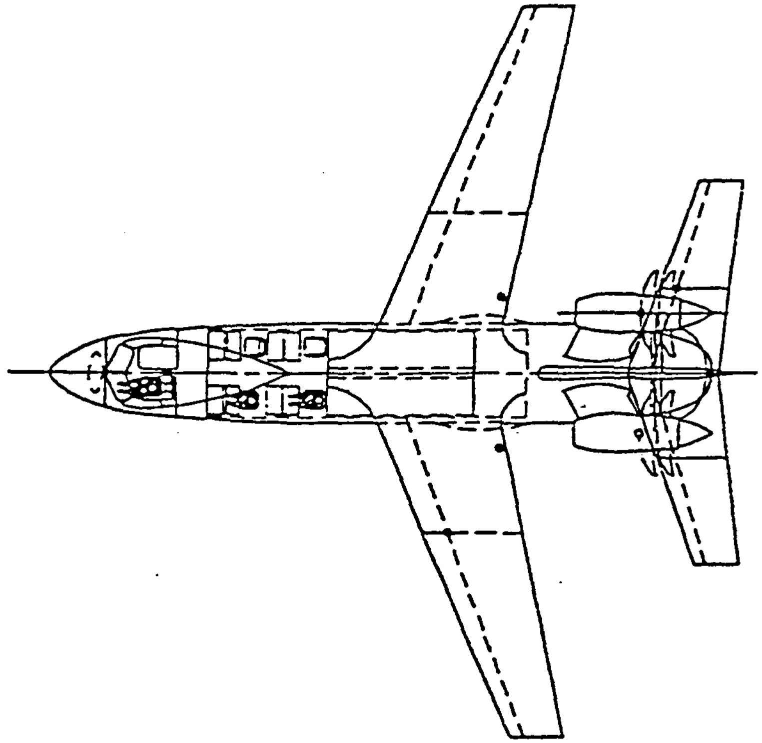
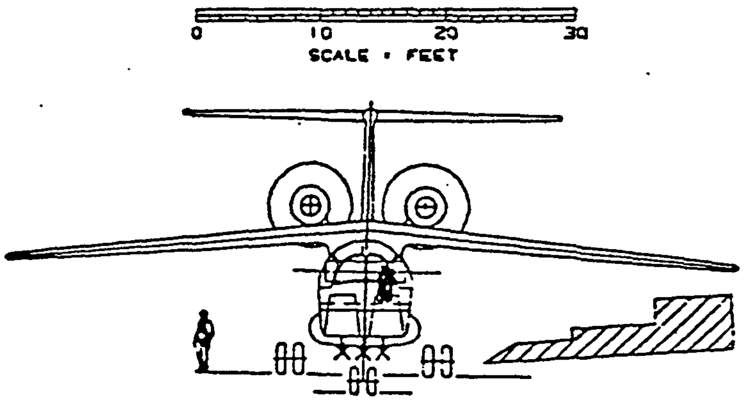


FIGURE 5.1-1 MULTIMISSION UDF ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	71,156 LBS
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	71.9 FT
AREA	646.9 FT2
ASPECT RATIO	8.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.50 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	37.3 FT
AREA	250 FT2
ASPECT RATIO	5.6
TAPER RATIO	.500
SWEEP @ C/4	16.9 DEG
DIHEDRAL	0.0
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.7 FT
AREA	220 FT2
ASPECT RATIO	.98
TAPER RATIO	.500
SWEEP @ C/4	27.1 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) G.E. UDF (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	14,232 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	8.5 FT





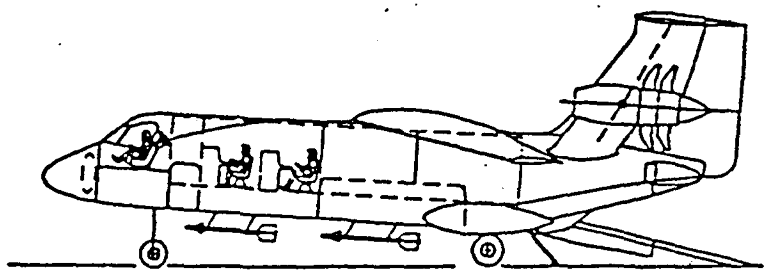
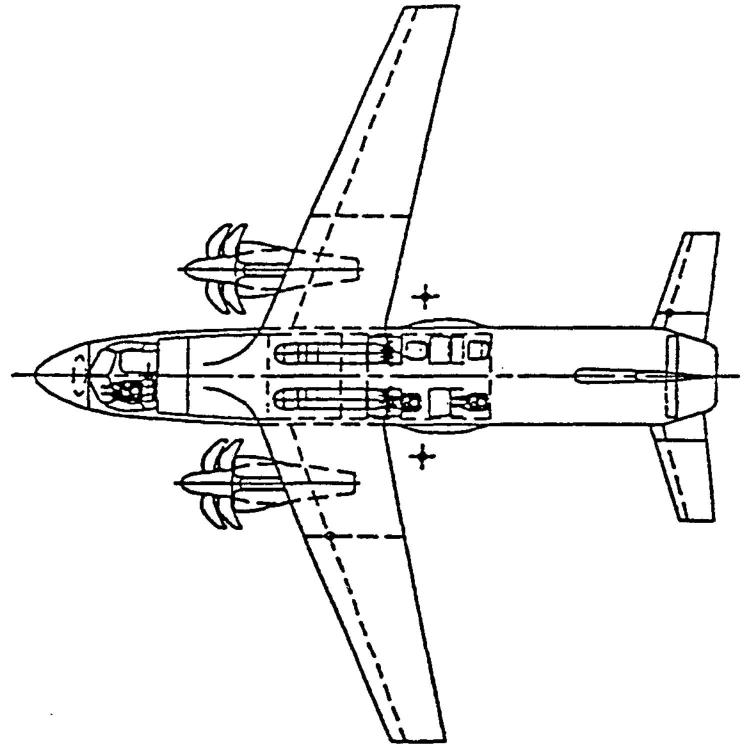
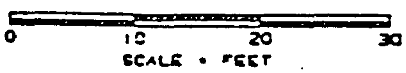
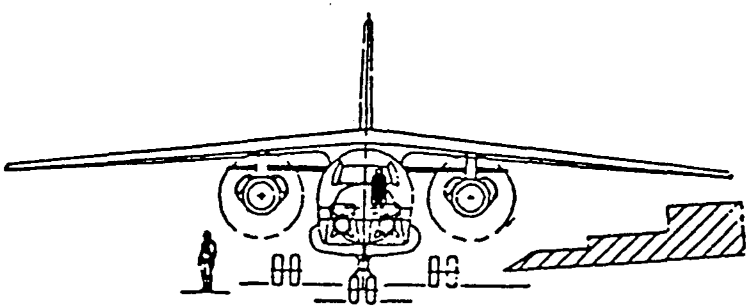


FIGURE 5.1-2 MULTIMISSION UDF AEW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	72,607 LB
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	72.7 FT
AREA	660.1 FT2
ASPECT RATIO	8.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.6 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	28.08 FT
AREA	141 FT2
ASPECT RATIO	5.59
TAPER RATIO	.500
SWEEP @ C/4	16.9 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.75 FT
AREA	158.56 FT2
ASPECT RATIO	1.37
TAPER RATIO	.500
SWEEP @ C/4	21.8 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN
SEA LEVEL STATIC THRUST (SLST) EA.	14,522 LBS
OR THRUST HORSEPOWER (THP) EA.	----- HP
PROPELLER DIAMETER	8.50 FT







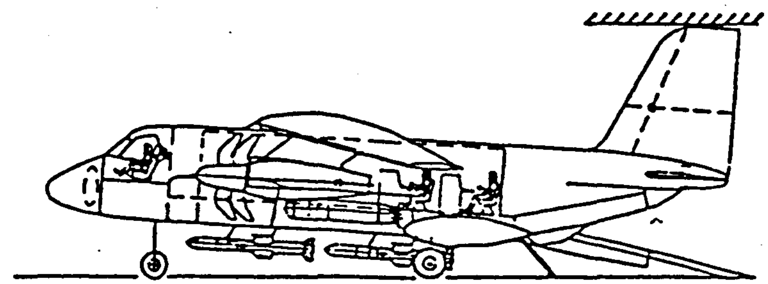
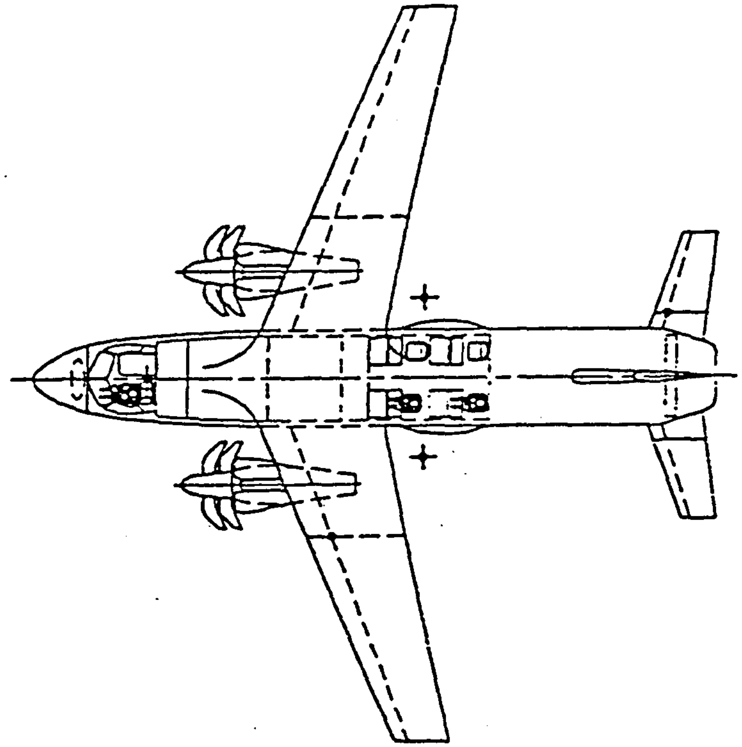
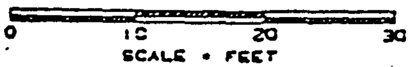
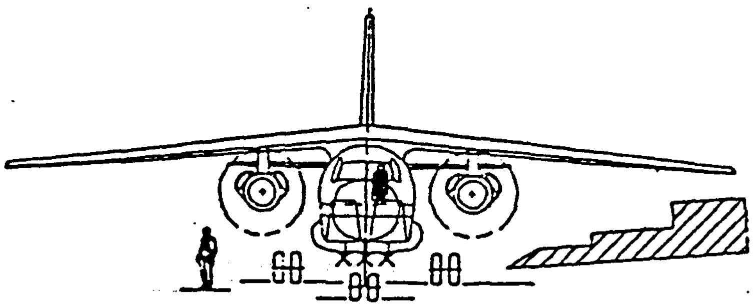


FIGURE 5.1-3 MULTIMISSION PROPFAN ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	72,607 LB
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	72.7 FT
AREA	660.1 FT2
ASPECT RATIO	8.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.6 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	28.08 FT
AREA	141 FT2
ASPECT RATIO	5.59
TAPER RATIO	.500
SWEEP @ C/4	16.9 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.75 FT
AREA	158.56 FT2
ASPECT RATIO	1.37
TAPER RATIO	.500
SWEEP @ C/4	21.8 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN
SEA LEVEL STATIC THRUST (SLST) EA.	14,522 LBS
OR THRUST HORSEPOWER (THP) EA.	----- HP
PROPELLER DIAMETER	8.50 FT







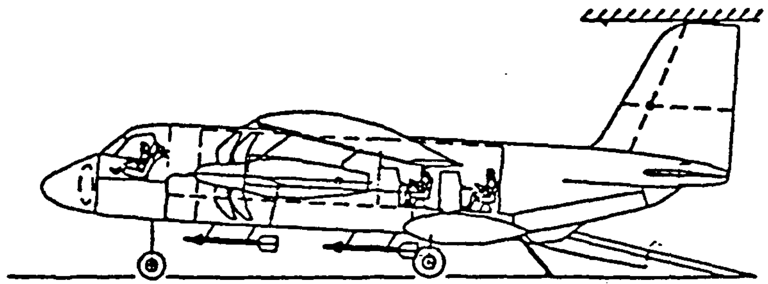
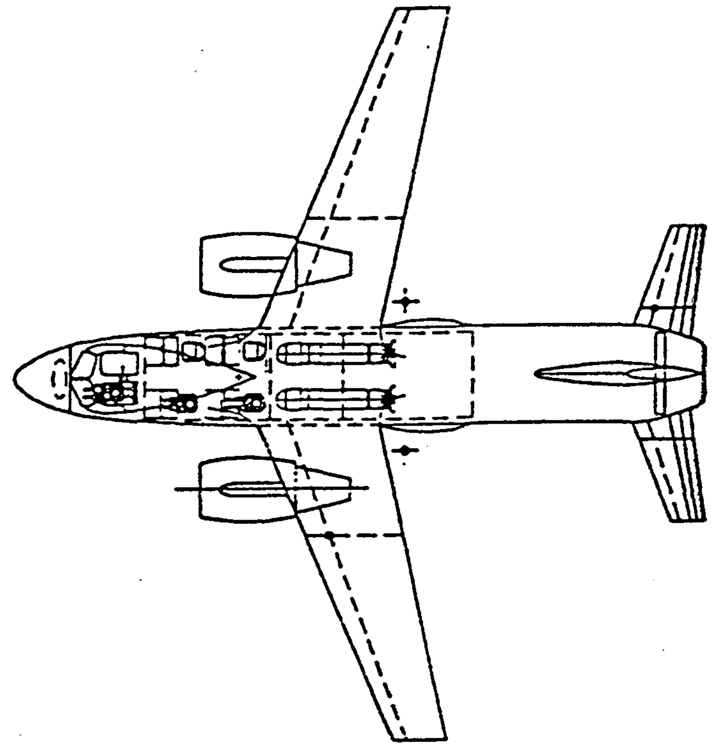
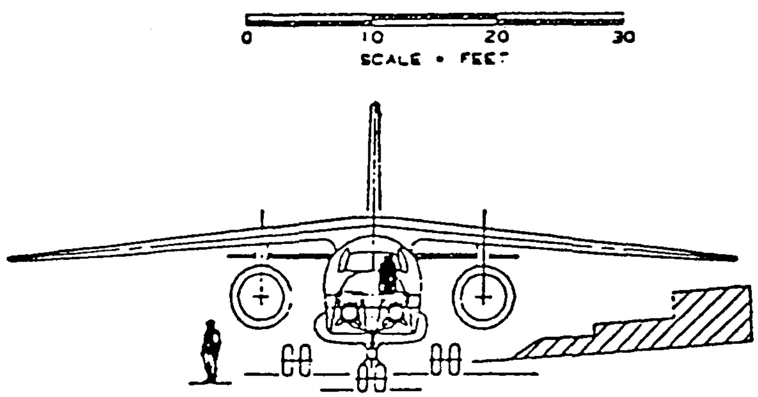


FIGURE 5.1-4 MULTIMISSION PROPFAN AEW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	78,337 LBS
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	80.1 FT
AREA	721.2 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.4 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	28.87 FT
AREA	150 FT2
ASPECT RATIO	5.6
TAPER RATIO	.500
SWEEP @ C/4	16.91 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.8 FT
AREA	169.6 FT2
ASPECT RATIO	1.28
TAPER RATIO	.500
SWEEP @ C/4	21.3 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN
SEA LEVEL STATIC THRUST (SLST) EA.	15,668 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	---- FT





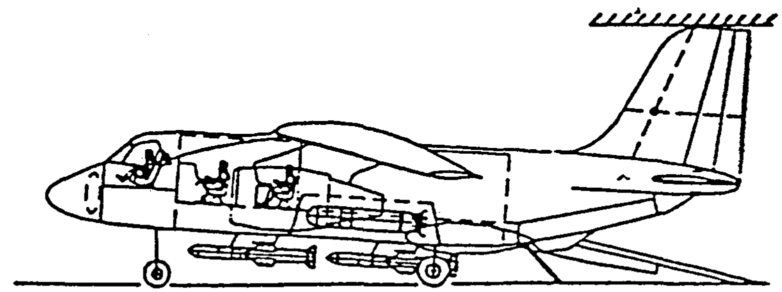
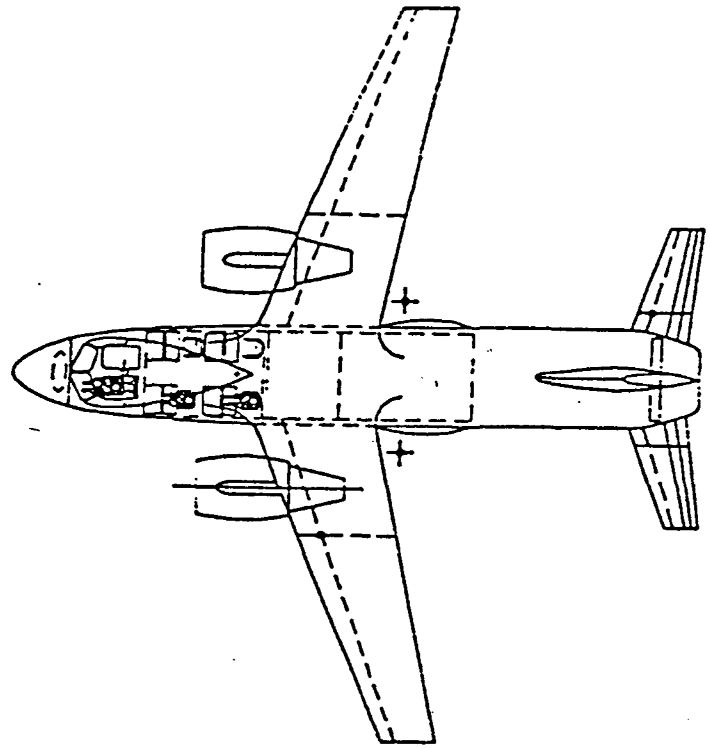
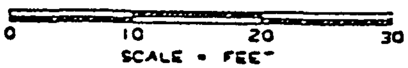
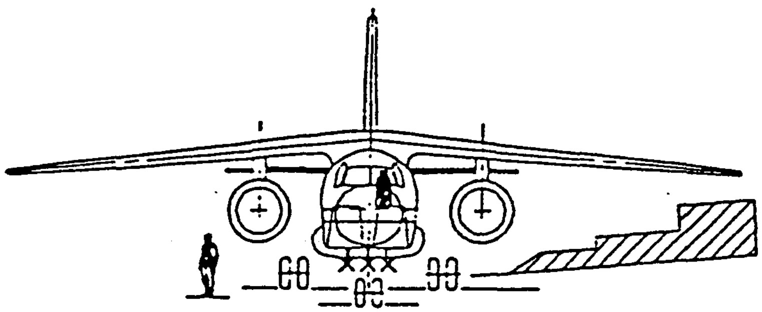


FIGURE 5.1-5 MULTIMISSION TURBOFAN ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	78,337 LBS
FUSELAGE LENGTH	67.4 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	80.1 FT
AREA	721.2 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	-5.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	9.4 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	28.87 FT
AREA	150 FT2
ASPECT RATIO	5.6
TAPER RATIO	.500
SWEEP @ C/4	16.91 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	14.8 FT
AREA	169.6 FT2
ASPECT RATIO	1.28
TAPER RATIO	.500
SWEEP @ C/4	21.3 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN
SEA LEVEL STATIC THRUST (SLST) EA.	15,668 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	---- FT







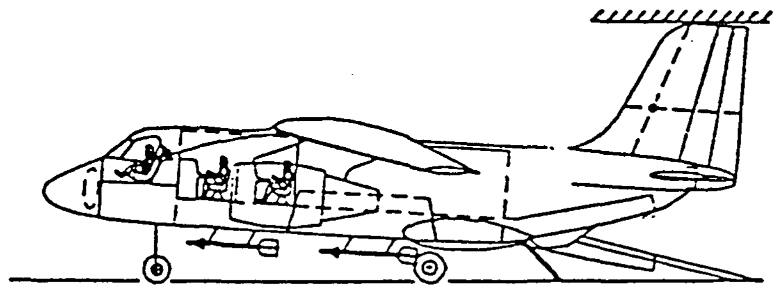
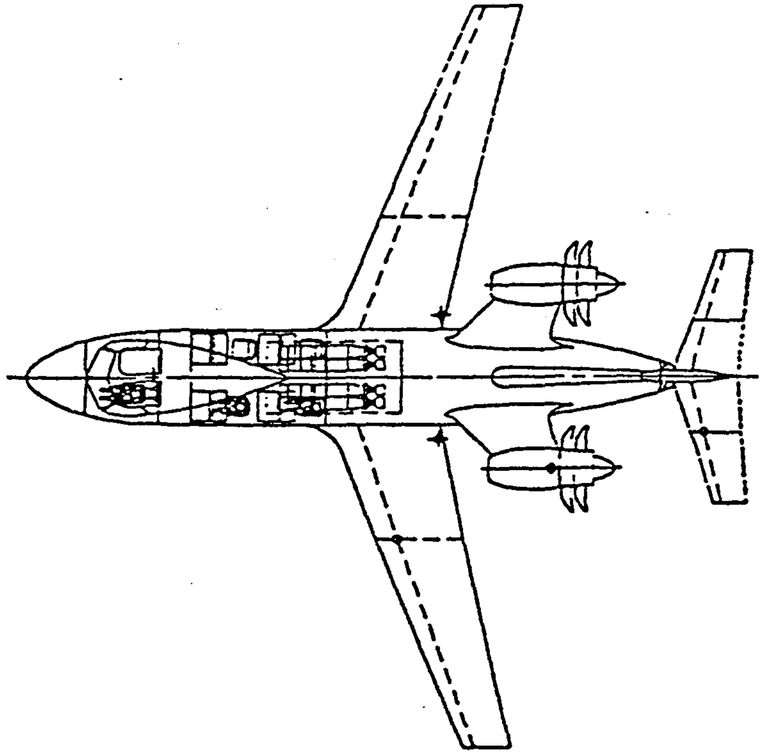
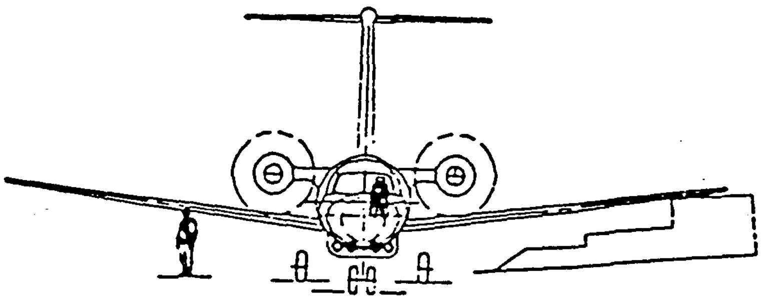


FIGURE 5.1-6 MULTIMISSION TURBOFAN AEW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	53,740 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	66.30 FT
AREA	488.5 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	7.80 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	22.40 FT
AREA	120.00 FT2
ASPECT RATIO	4.18
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	15.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) G.E. UDF (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	10,757 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	7.4 FT





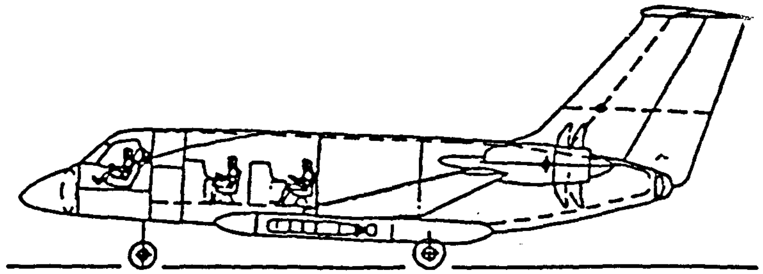
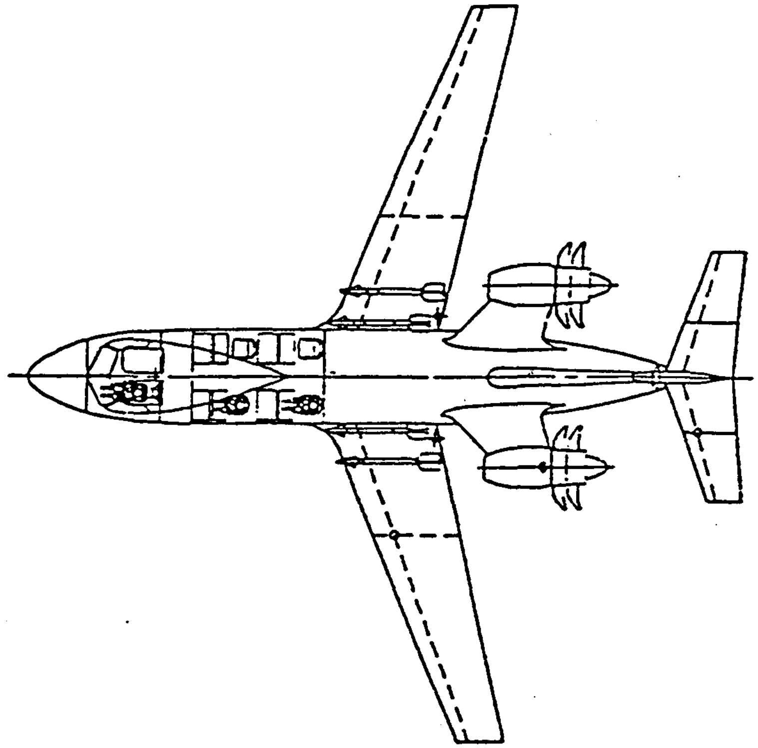
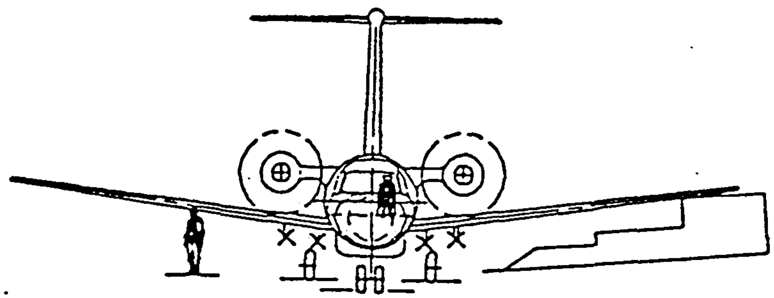


FIGURE 5.1-7 MINIMUM UDF ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	53,740 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	66.30 FT
AREA	488.5 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	7.80 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	22.40 FT
AREA	120.00 FT2
ASPECT RATIO	4.18
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	15.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) G.E. UDF (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	10,757 LBS
OR THRUST HORSEPOWER (THP) EA.	---- HP
PROPELLER DIAMETER	7.4 FT





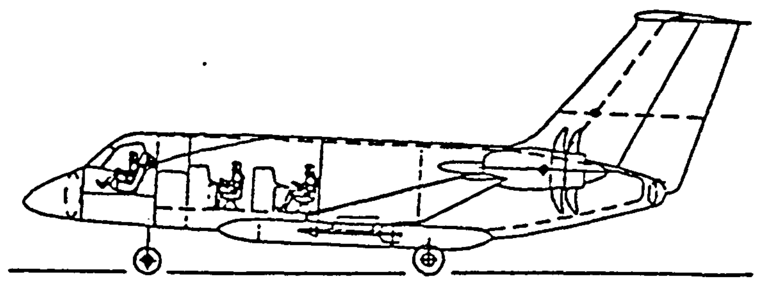
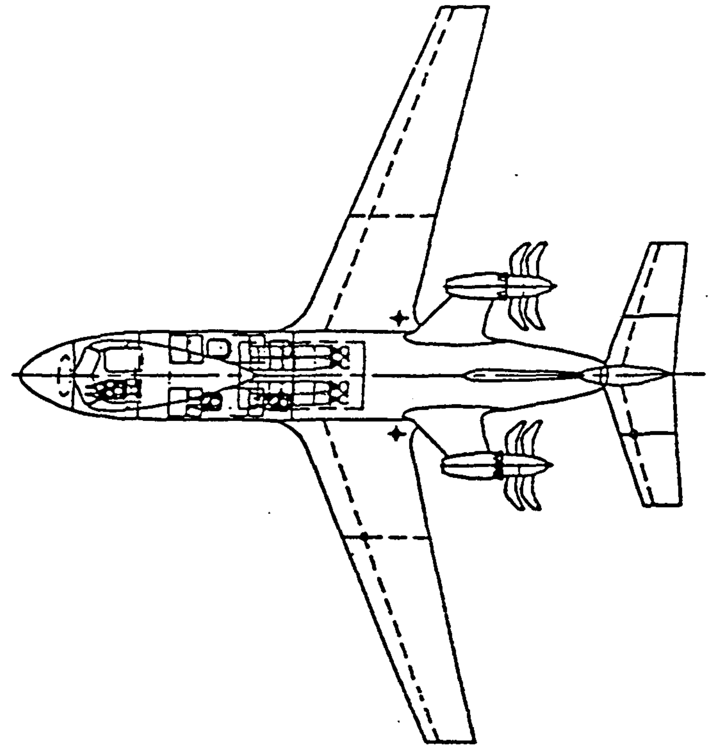
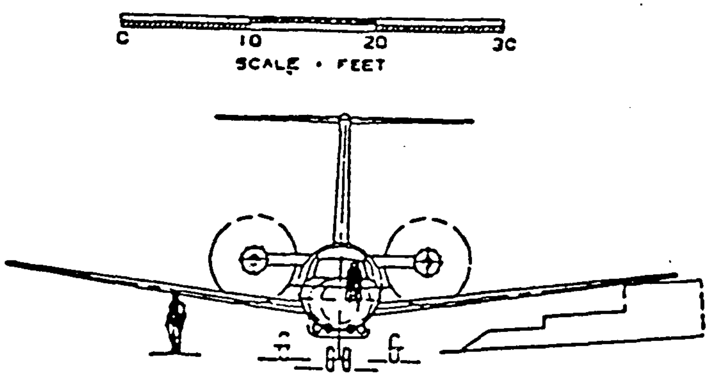


FIGURE 5.1-8 MINIMUM UDF AEW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	54,876 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	72.1 FT
AREA	577.0 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	8.50 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	25.4 FT
AREA	100.0 FT2
ASPECT RATIO	4.03
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	15.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	11,583 LBS
OR THRUST HORSEPOWER (THP) EA.	----- LBS
PROPELLER DIAMETER	8.5 FT





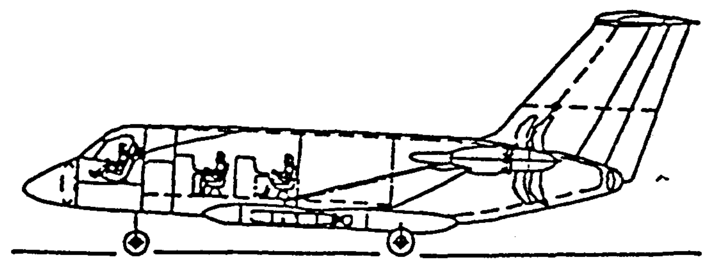
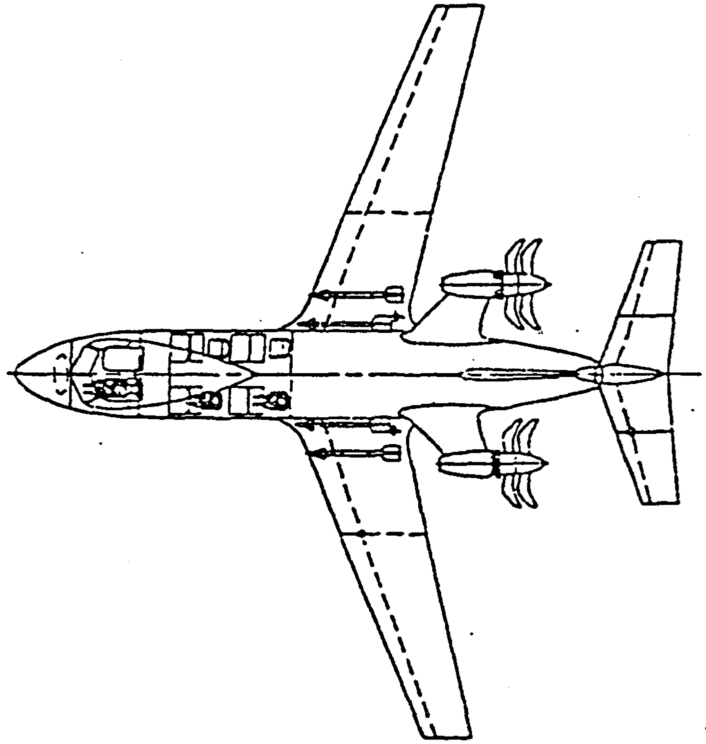
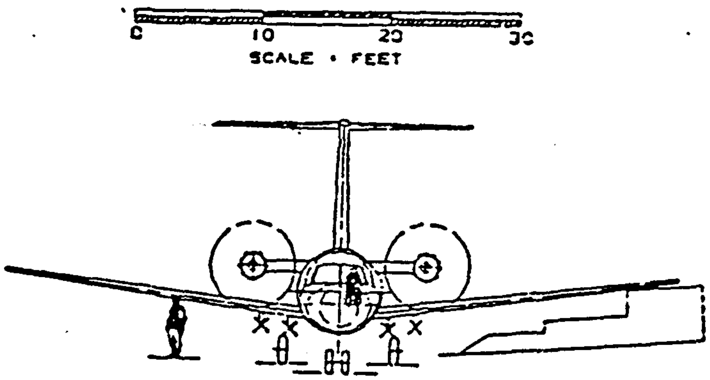


FIGURE 5.1-9 MINIMUM PROPFAN ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	54,876 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	72.1 FT
AREA	577.0 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	8.50 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	25.4 FT
AREA	100.0 FT2
ASPECT RATIO	4.03
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	15.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	11,583 LBS
OR THRUST HORSEPOWER (THP) EA.	----- LBS
PROPELLER DIAMETER	8.5 FT





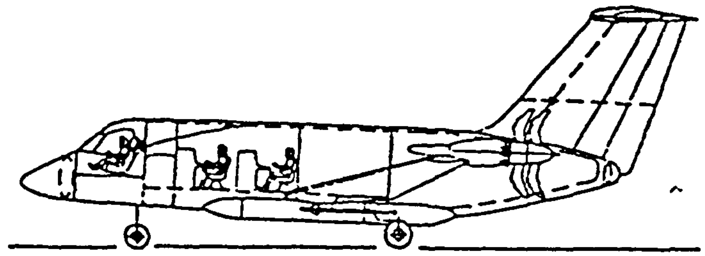
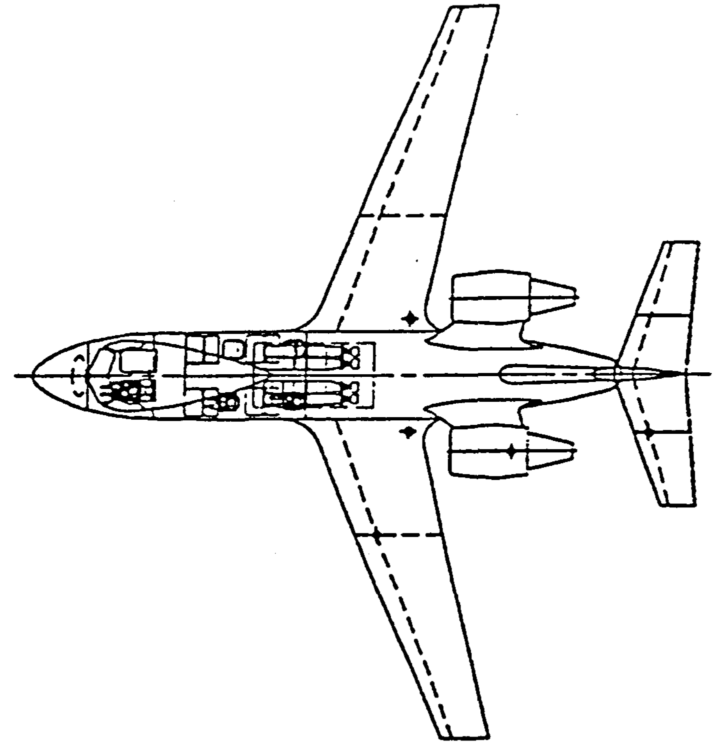
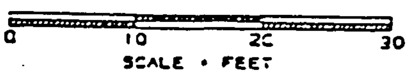
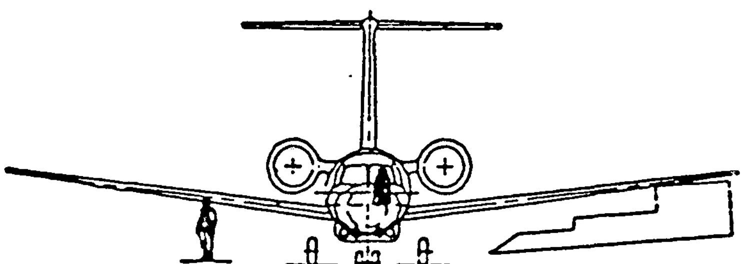


FIGURE 5.1-10 MINIMUM PROPFAN AEW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	59,348 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	72.5 FT
AREA	584.7 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	8.60 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	25.7 FT
AREA	160.0 FT2
ASPECT RATIO	4.13
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	5.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) TURBOFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	12,015 LBS
OR THRUST HORSEPOWER (THP) EA.	----- HP
PROPELLER DIAMETER	----- FT







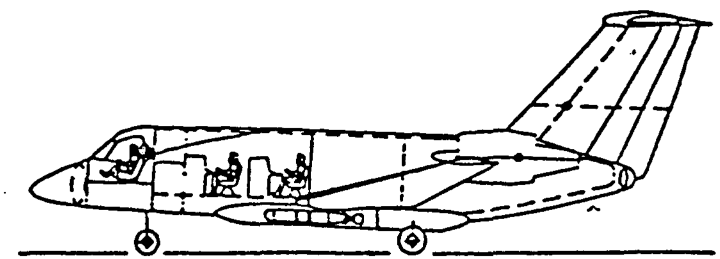
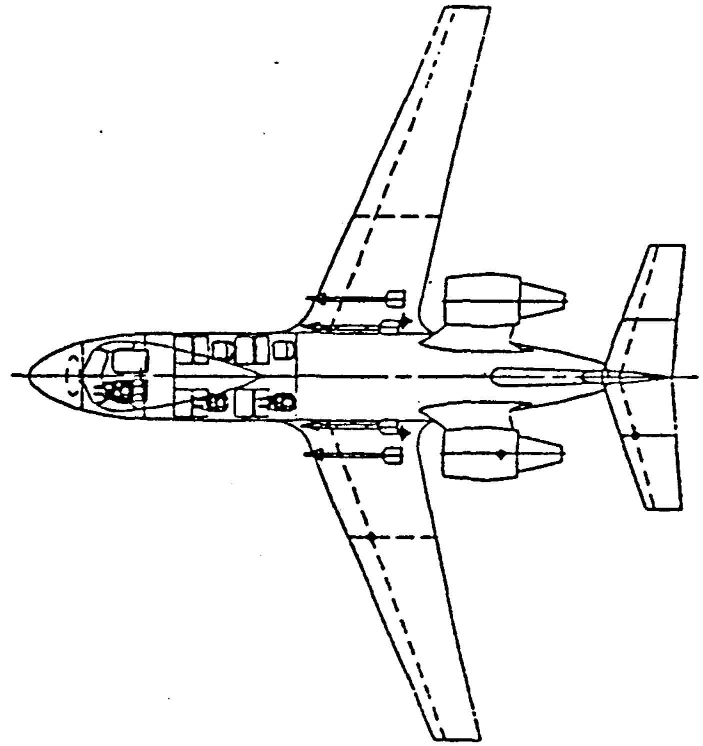
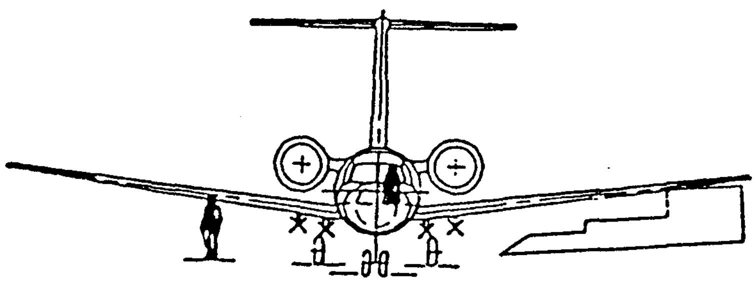


FIGURE 5.1-11 MINIMUM TURBOFAN ASW CONFIGURATION

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	59,348 LBS
OVERALL LENGTH	65.0 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	72.5 FT
AREA	584.7 FT2
ASPECT RATIO	9.0
TAPER RATIO	.400
SWEEP @ C/4	20.0 DEG
DIHEDRAL	7.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	.150
TIP THICKNESS RATIO	.120
MEAN AERODYNAMIC CHORD	8.60 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	25.7 FT
AREA	160.0 FT2
ASPECT RATIO	4.13
TAPER RATIO	.500
SWEEP @ C/4	16.34 DEG
DIHEDRAL	0.0 DEG
THICKNESS RATIO	.100
VERTICAL SURFACE	
SPAN	5.17 FT
AREA	197.2 FT2
ASPECT RATIO	1.17
TAPER RATIO	.530
SWEEP @ C/4	35.4 DEG
THICKNESS RATIO	.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) TURBOFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA.	12,015 LBS
OR THRUST HORSEPOWER (THP) EA.	----- HP
PROPELLER DIAMETER	----- FT





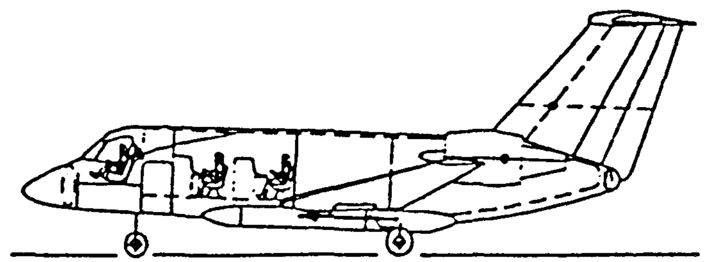


FIGURE 5.1-12 MINIMUM TURBOFAN AEW CONFIGURATION

	ALL MISSIONS
FIXED EQUIPMENT WEIGHT INCREMENT	
COMMON CORE AVIONICS EQUIPMENT	
COMMUNICATIONS	
UHF/VHF RADIOS (2)	30
HF RADIO	188.7
CRYPTO DEVICES (3)	106.2
INTERCOM SET (1) W/REMOTES (2)	19.3
FLEET SATELLITE COMMUNICATIONS	39.9
NAVIGATION	
RADAR ALTIMETER	8.5
TACAN	42.5
AUTO. CARRIER LANDING SYSTEM	20
ATTITUDE HEADING REFERENCE SYS.	18
INERTIAL NAVIGATION SYSTEM (2)	96
AIR DATA COMPUTER	16
AUTOMATIC DIRECTION FINDER	7.5
GLOBAL POSITIONING SYSTEM	24.6
IDENTIFICATION	
IFF TRANSPONDER	30.1
PROCESSING	
COMPUTER PROCESSORS	100
OTHER EQUIPMENT	
FLIGHT DATA RECORDER	20
TOTAL	767.3 LBS

TABLE 5.2-I COMMON CORE AVIONICS EQUIPMENT

	ASW	AEW	TANKER	COD
MISSION UNIQUE EQUIPMENT				
COMMUNICATIONS				
UHF / VHF RADIOS		45		
INTERCOM REMOTE SETS	4.8	9.6		
JTIDS	95	95		
HF RADIO			188.7	
NAVIGATION				
LOW FREQ. AUTO. DIRECTION FINDER	15			15
WEATHER RADAR			113.7	113.7
RADAR ALTIMETER, HIGH ALT.			10	
TACAN			42.5	
OMEGA			39.2	39.2
VHF NAVIGATION SET (VOR)			36.6	
THREAT ASSOCIATED				
ARMAMENT MONITOR AND CONTROL	200			
WEAPONS DELIVERY SYSTEM		40		
SONOBUOY REFERENCE SYSTEM	56			
ADVANCED SONOBUOY COMM. LINK	115			
SONOBUOY ACOUSTIC REC / REP	76			
MAGNETIC ANOMALY SYSTEM	100			
ISAR RADAR	472			
INFRARED RADAR	264.6			
SEARCH AND TRACK RADAR		2200		
IR / OPTICAL / K-BAND RADAR		550		
ELECTRONIC SURVEILLANCE MEASURES	115	579.9		
DECEPTIVE COUNTERMEASURE		70.5		
THREAT COUNTERMEASURE	40	40		
IFF INTERROGATOR	19.8	19.8	19.8	
PROCESSING				
COMPUTER PROCESSORS	500	500		
OTHER EQUIPMENT				
AIRBORNE MICROWAVE REFRAC.		30		
TOTAL	2073.2 LBS	4179.8 LBS	450.5 LBS	167.9 LBS

TABLE 5.2-II MISSION UNIQUE EQUIPMENT

PAYLOADS	ASW FULL MULTIMISSION	ASW MINIMUM AEW/ASW	AEW	TANKER	COD
SIDEWINDERS (4)			776		
HARPOONS (2)	2336				
MK-60 MINES (2)	4732				
MK-50 TORPEDOES (4)		3200			
SONOBUOYS (60)	1515	1515			
CARGO					15000
FUEL OFFLOAD				25000	
TOTAL PAYLOAD	8583 LBS	4715 LBS	776 LBS	25000 LBS	15000 LBS.

TABLE 5.2-III PAYLOADS

sizing for takeoff to engine sizing for cruise, and the wind over deck limits are shown when applicable. The mission fuel sizing matrices show the variation of mission fuel with wing loading and aspect ratio.

Carrier based aircraft require more rigid wings than their land based counterparts because of takeoff/landing loads and sink rates. Therefore, none of the configurations were allowed to exceed an arbitrary aspect ratio limit of nine.

5.3.1 MULTIMISSION CTOL SIZING MATRICES

The critical mission for sizing the UDF multimission configuration was tanker. The data shown in Figure 5.3.1-1 reflects both the gross weight and fuel requirements as a function of wing loading and aspect ratio. Also shown on the gross weight matrix is the locus of minimum fuel required and the 80 ft. span limit. The design point chosen is a wing loading of 110 psf and an aspect ratio of eight. Higher wing loadings would provide a lighter aircraft at the expense of high altitude capability on the AEW mission. Aspect ratio eight was selected because it yields the minimum gross weight at the chosen wing loading of 110 psf. The entire matrix is sized to a takeoff thrust/weight ratio of 0.4.

The multimission propfan critical sizing mission is the same as the multimission UDF, tanker. The wind over deck limits for zero wind over deck, with and without engine acceleration, are shown for the propfan and not the UDF because the propfan is heavier than the UDF at the same wing loading. See Section 3.1 for more details on the catapult limits. Figure 5.3.1-2 shows that the design point was chosen at a wing loading of 110 psf and an aspect ratio of eight to remain within the zero wind over deck constraint and to achieve minimum gross weight at the smallest span.

Turbofan engines have poorer fuel consumption than propfans, especially for low altitude endurance. This fact drives the multimission turbofan to the ASW critical sizing mission. Task II seems to indicate that tanker should have been the driving mission but Task II assumed similar AEW/ASW payloads/missions and the ASW mission was not specifically addressed. Figure 5.3.1-3 shows the constraints of 80,000 lb. maximum gross weight, 80 ft. span, and zero wind over deck launch. These constraints all intersect at a point and thus do not allow any design flexibility. Therefore, the wind over deck criteria was relaxed from zero to five knots, with engine thrust acceleration, yielding an aspect ratio of nine at a wing loading of 110 psf. This keeps the gross weight approximately 1,600 lb. below the 80,000 lb. limit.

5.3.2 MINIMUM AEW/ASW SIZING MATRICES

Task II conceptual sizing indicated a probable configuration match between AEW and ASW missions with a reduced ASW payload. Therefore, the minimum AEW/ASW configurations were all sized to the AEW mission and the ASW loiter time is allowed to vary depending on fuel available. The

SIZING MISSION:TANKER

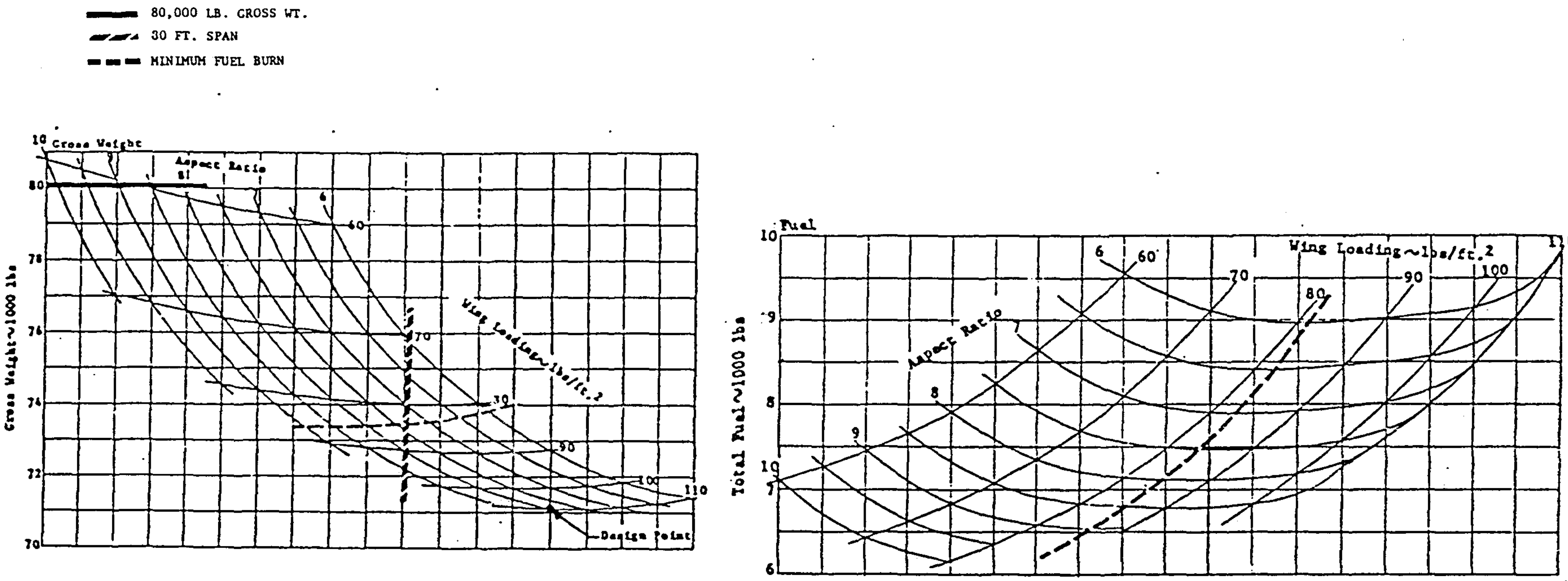


FIGURE 5.3.1-1 MULTIMISSION UDF SIZING MATRIX

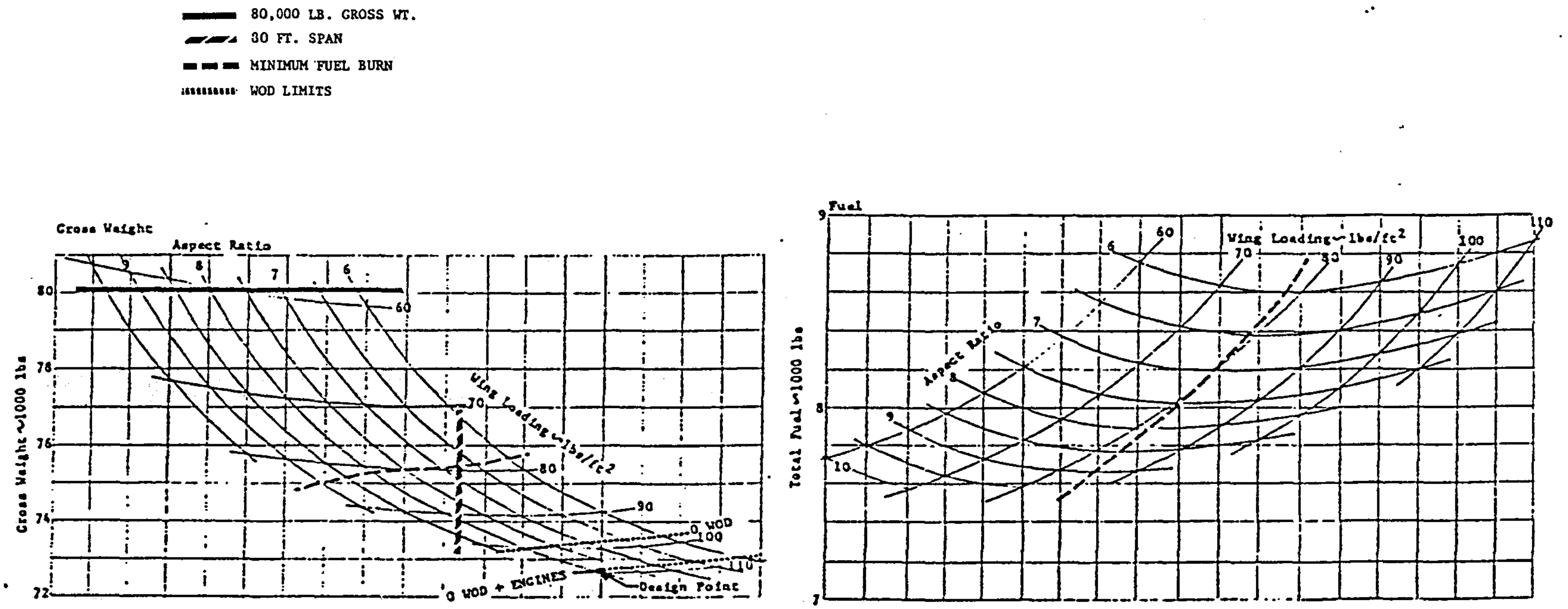


FIGURE 5.3.1-2 MULTIMISSION PROPFAN SIZING MATRIX

SIZING MISSION:ASW

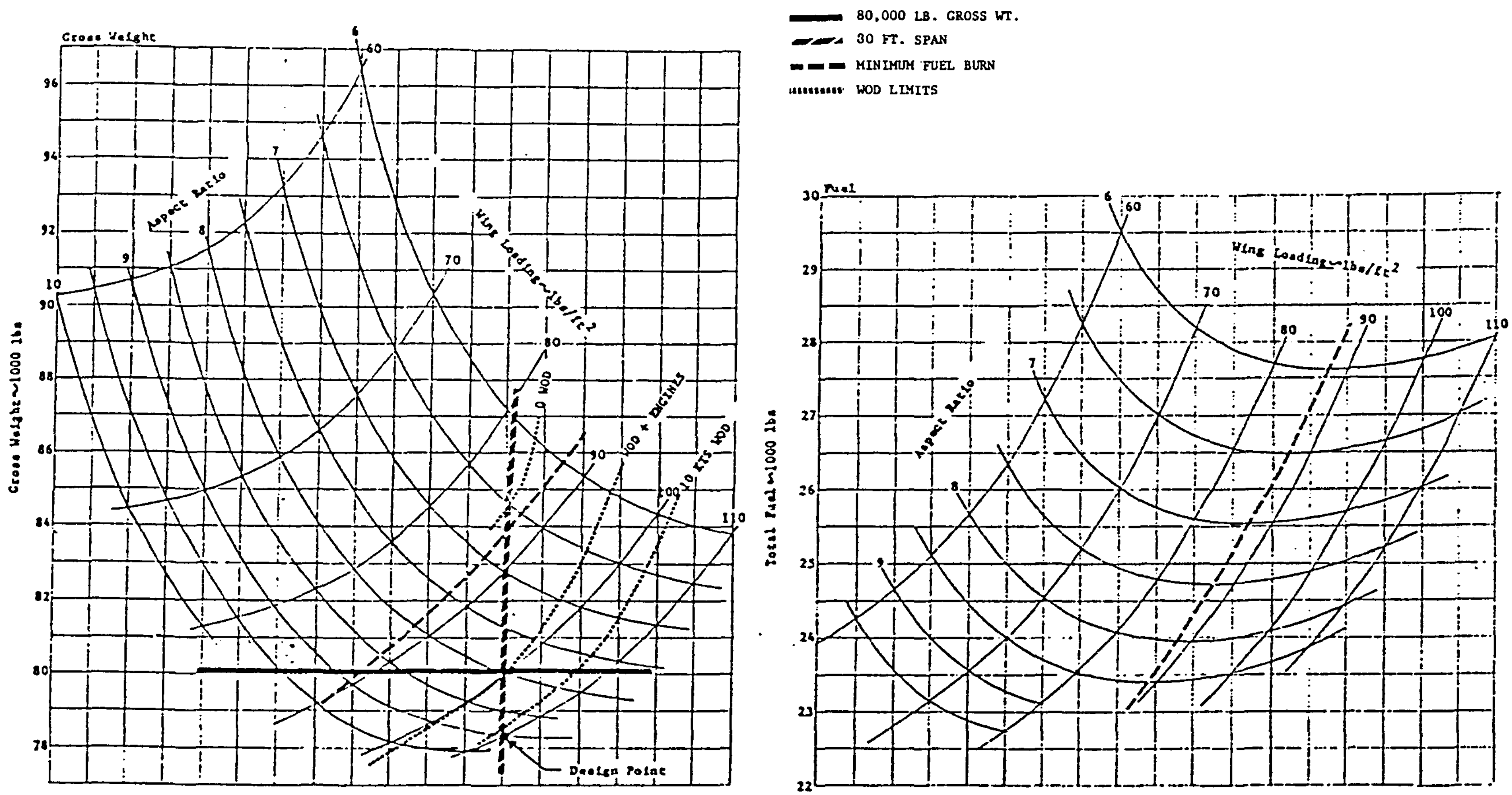


FIGURE 5.3.1-3 MULTIMISSION TURBOFAN SIZING MATRIX

small configurations size on both takeoff thrust/weight and cruise engine sizing criteria. The locus of points showing where the engine sizing transitions from being sized for cruise to being sized for takeoff is shown on all the minimum AEW/ASW configurations. This locus of points shows where the engines are matched for both sizing conditions.

The locus of points depicting the engine sizing transition is shown in Figure 5.3.2-1 for the UDF configuration. All the points to the right of the T/W=.4 line sized for cruise. The design point for the UDF is at a wing loading of 95 psf and an aspect ratio of nine. This yields a good engine match between takeoff and cruise requirements and falls on the locus of gross weight buckets with wing loading.

The propfan sizing matrix in Figure 5.3.2-2 shows similar trends as the UDF. However, in this case, an aspect ratio of 11 would be required to size to a thrust/weight ratio of .4 and achieve minimum gross weight. The design point selected is at an aspect ratio nine which yields a more rigid wing for approximately a 1,000 lb. weight penalty. The wing loading of the propfan was optimized at 110 psf instead of the 95 psf of the UDF.

The turbofan design point is also selected at aspect ratio nine as shown in Figure 5.3.2-3. Here the design is near minimum thrust to weight ratio and falls on the locus of gross weight buckets with wing loading.

5.4 MISSION PERFORMANCE AND BREAKDOWN BY MISSION LEG

Multimission and Minimum AEW/ASW aircraft mission performance on AEW, ASW, Tanker, and COD missions is presented. Additionally, a breakdown of mission performance at the end of each mission leg is shown for each point design.

5.4.1 MULTIMISSION CTOL

Multimission aircraft performance data for AEW, ASW, tanker, and COD missions is presented in Figures 5.4.1-1 through 5.4.1-3. There is a large amount of excess capability on those missions not used for sizing. Therefore, it is not necessary to load the aircraft to the maximum gross weight when performing the alternate missions. Conversely, it would be possible in some cases to carry additional payload or equipment and perform a mission mix. It is important to note that although the multimission turbofan is sized for the ASW mission, it is only 300 lb. over being a perfect match with the tanker mission. A summary of the gross weight and fuel burns for the multimission CTOL aircraft is presented in Table 5.4-1-I.

Design mission breakdowns by leg are shown in Tables 5.4.1-II through 5.4.1-IV. Data for range, time, weight, altitude, and Mach number are presented at the end of each segment.

SIZING MISSION: AEW

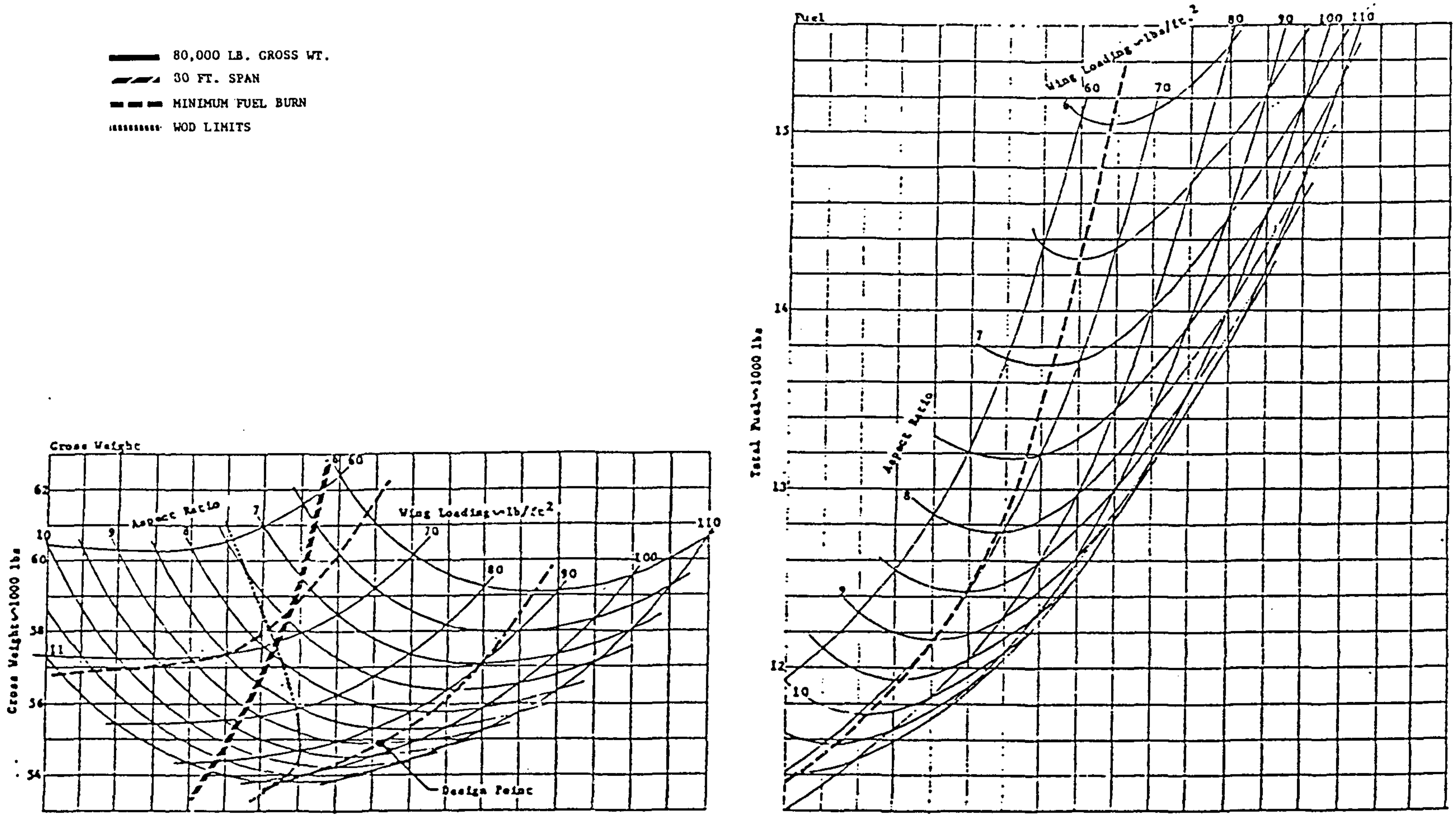


FIGURE 5.3.2-1 MINIMUM AEW/ASW UDF SIZING MATRIX

SIZING MISSION:AEW

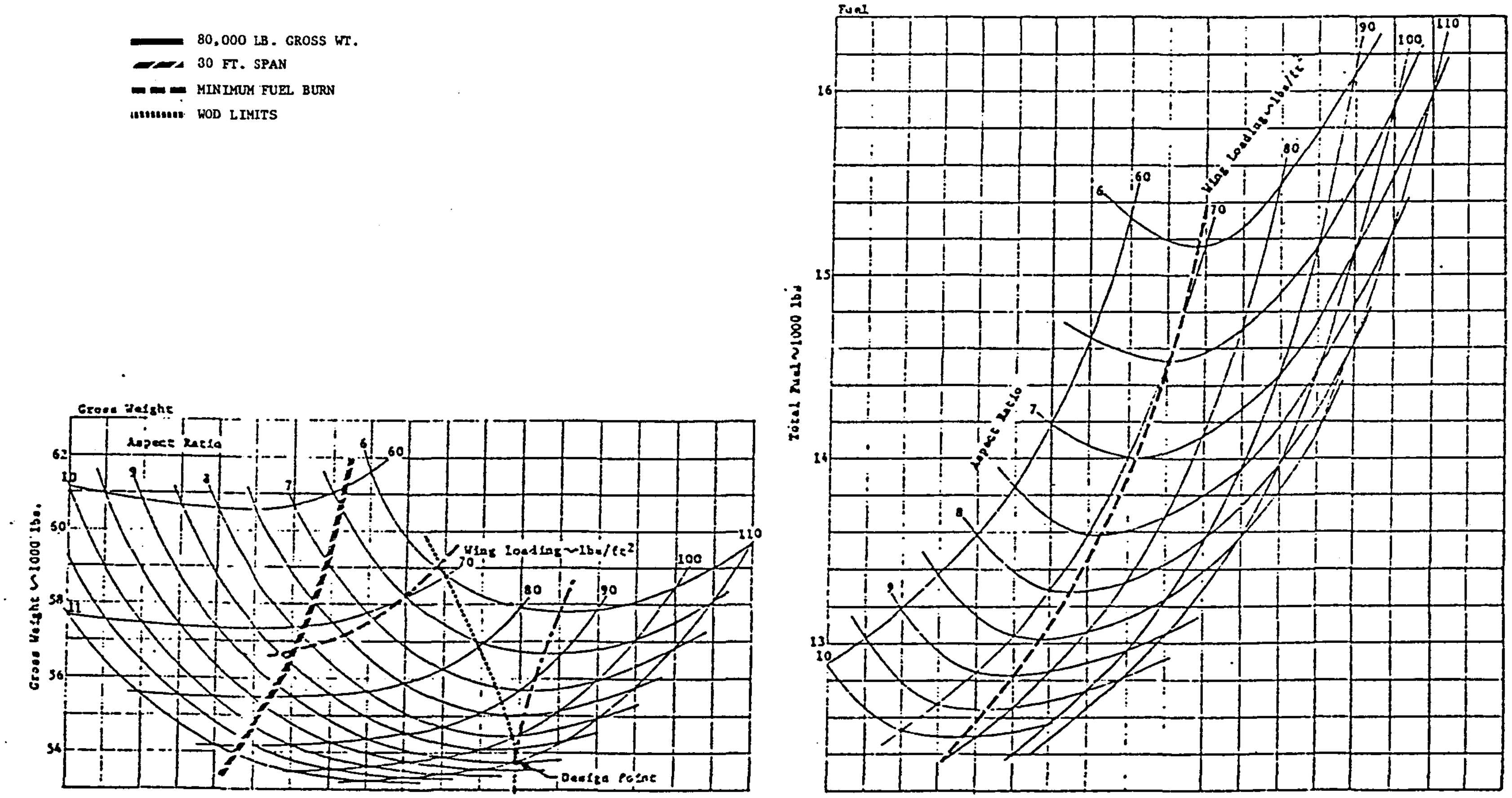


FIGURE 5.3.2-2 MINIMUM AEW/ASW PROPFAN SIZING MATRIX

SIZING MISSION: AEW

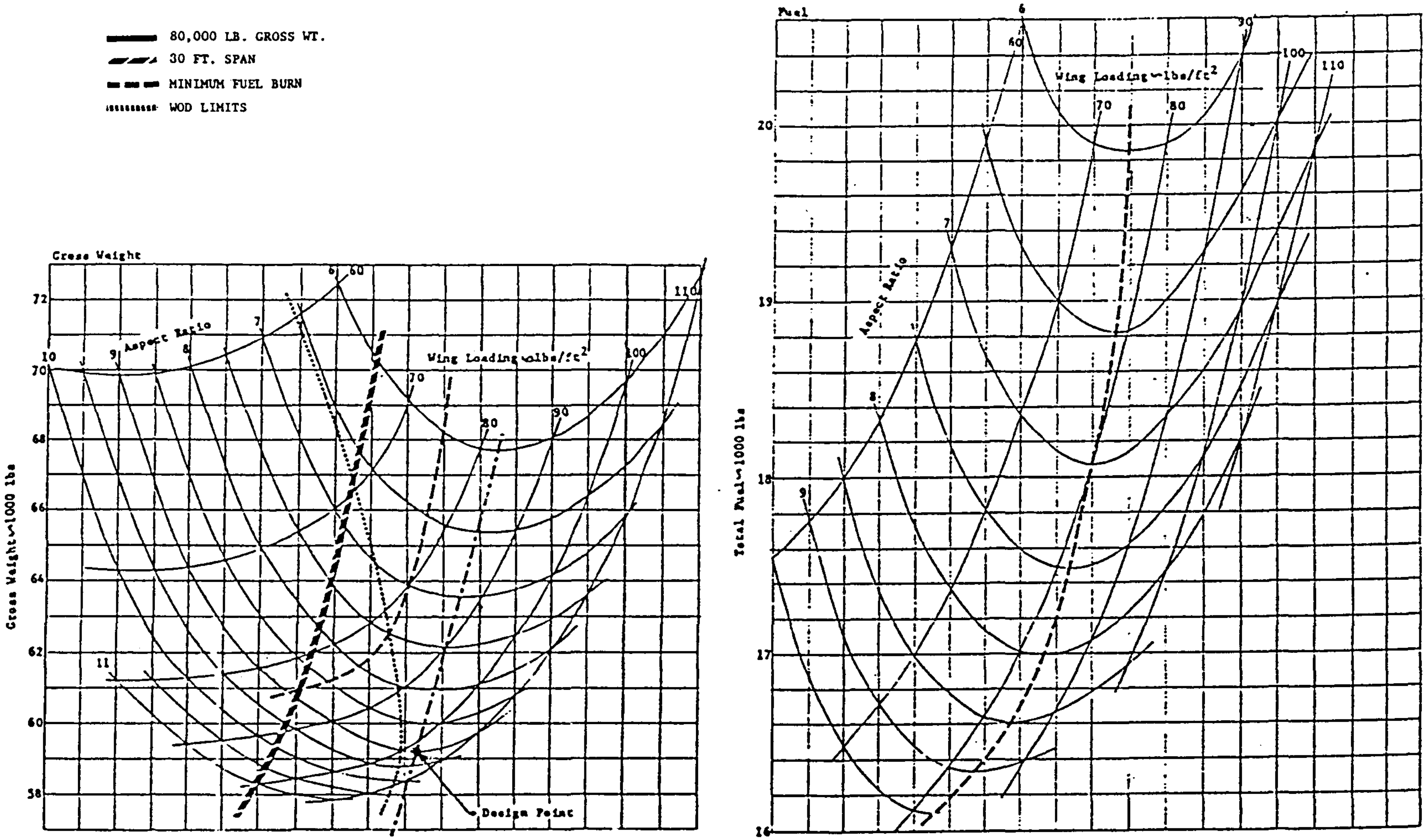


FIGURE 5.3.2-3 MINIMUM AEW/ASW TURBOFAN SIZING MATRIX

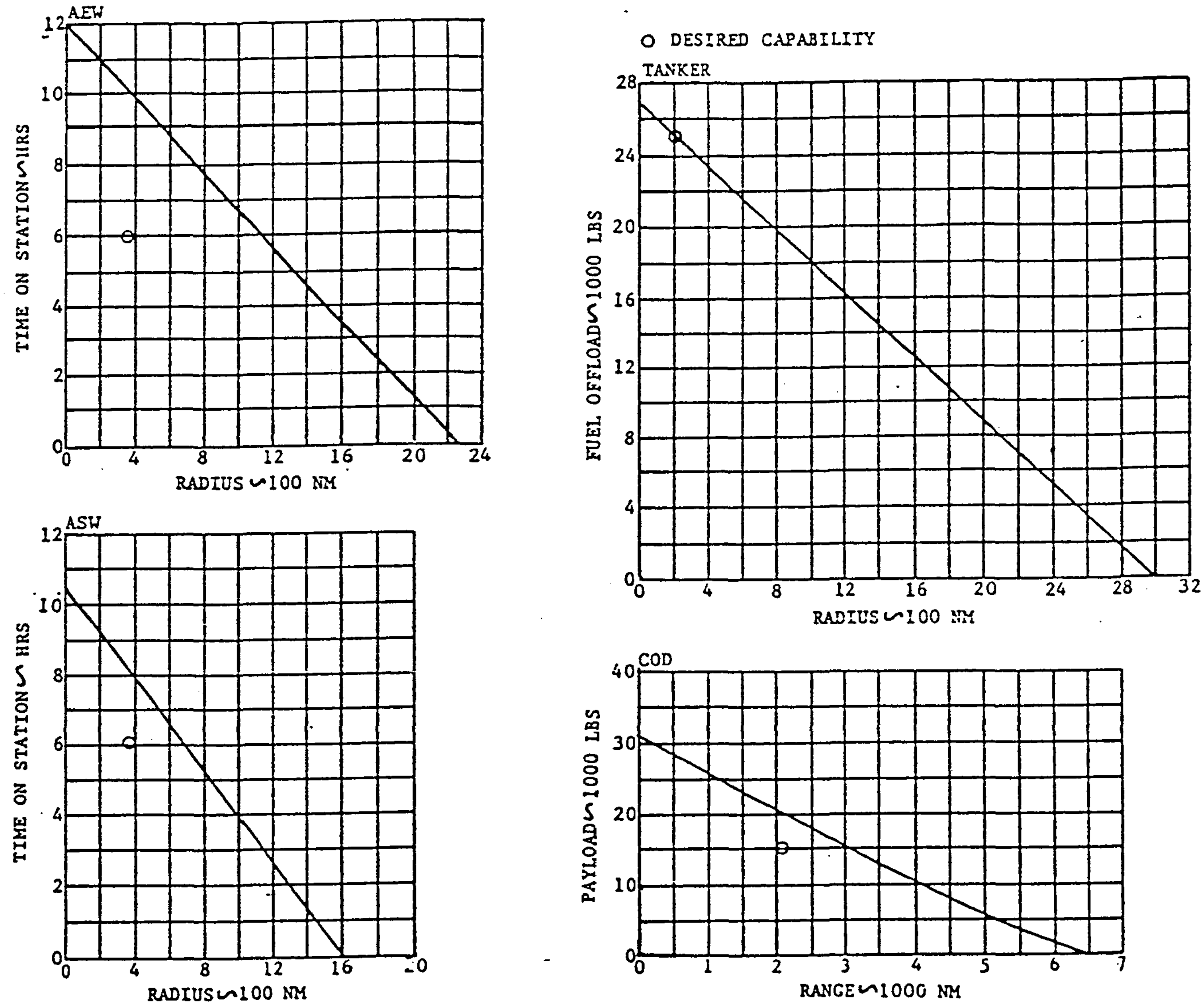


FIGURE 5.4.1-1 MULTIMISSION UDF MISSION PERFORMANCE

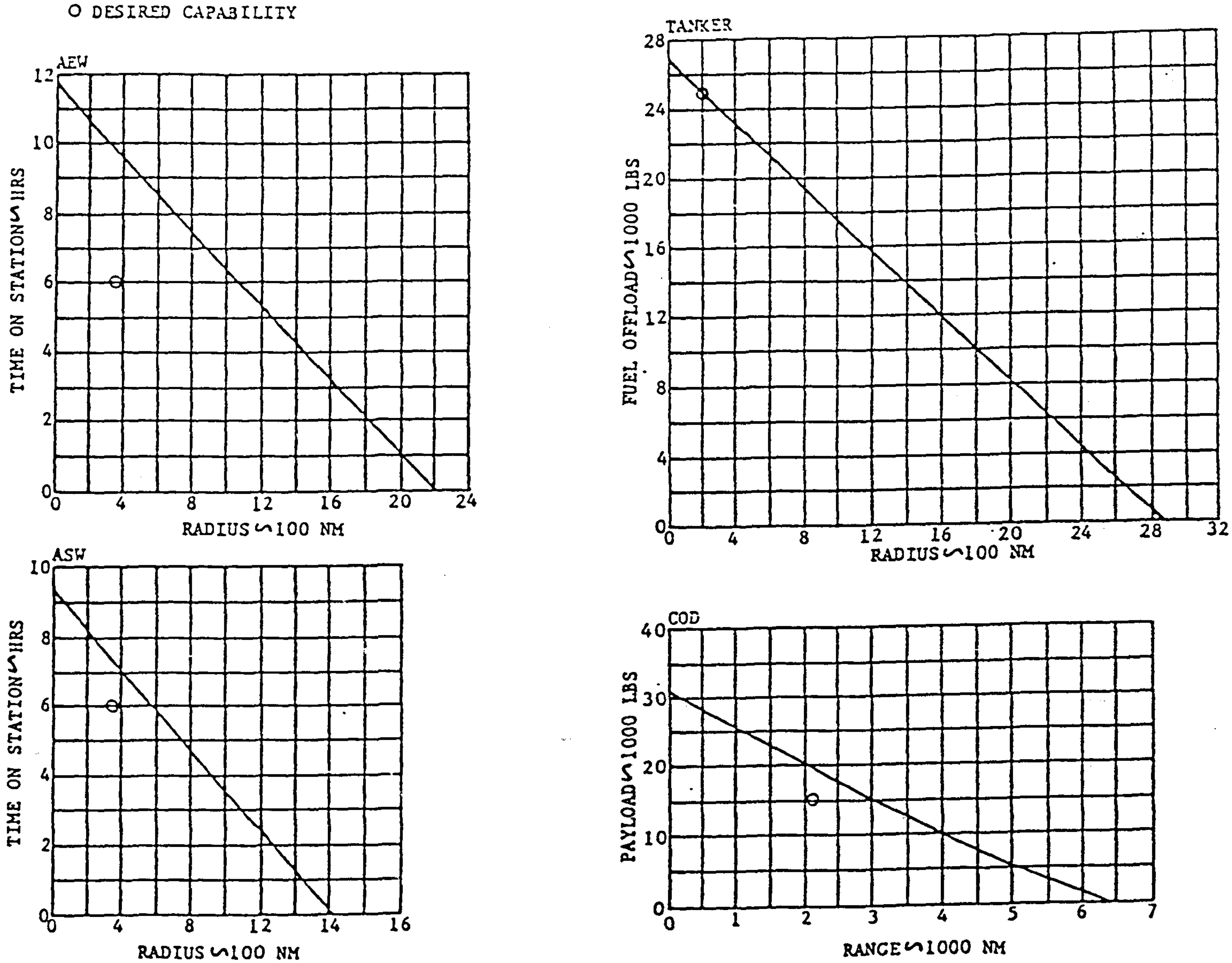


FIGURE 5.4.1-2 MULTIMISSION PROPFAN MISSION PERFORMANCE

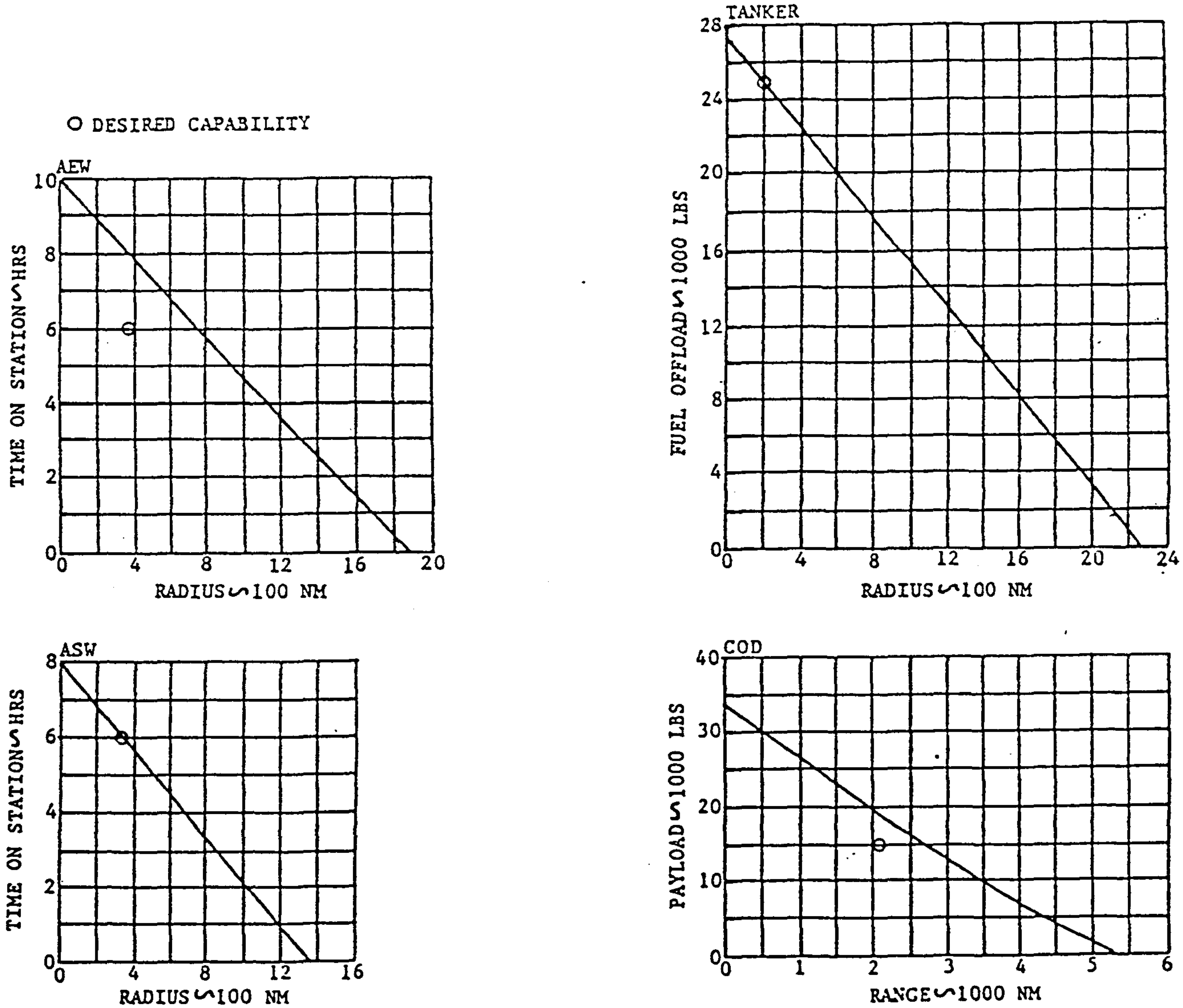


FIGURE 5.4.1-3 MULTIMISSION TURBOFAN MISSION PERFORMANCE

	W_{GROSS} (LBS)	MISSION FUEL WEIGHTS - LBS			
		AEW	ASW	TANKER*	COD†
MULTIMISSION TF	78337	27911	23399	11471	21425
MULTIMISSION PF	72607	24938	20036	7998	17346
MULTIMISSION UDF	71156	24614	19756	7674	17044
MULTIMISSION STOVL	96810	28572	23670	11639	20980
MIN AEW/ASW TF	59348	16988	16085	7648	9462
MIN AEW/ASW PF	54876	12882	11981	5942	5356
MIN AEW/ASW UDF	53740	13712	12815	6172	6188
MIN AEW/ASW STOVL	71660	16640	15735	8996	9110

TABLE 5.4.1.-I GROSS WEIGHT AND MISSION FUEL BURN SUMMARY

* DOES NOT INCLUDE FUEL OFFLOAD AT 200 NM RADIUS
† FUEL LOADS WITH 15000 LBS PAYLOAD

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.063	70633.72	0.00		0.00	0.083
CLIMB	66.35	0.200	69706.00	34088.73	0.694	66.38	0.283
CRUISE	133.65	0.354	68933.29	34088.73	0.690	200.00	0.637
LOITER		1.250	66648.15	25000.00	0.488	200.00	1.887
REFUEL		0.083	41157.95	25000.00	0.663	200.00	1.971
LOITER		1.250	39846.43	25000.00	0.377	200.00	3.231
CLIMB	49.36	0.126	39504.53	46019.39	0.694	249.36	3.347
CRUISE	150.64	0.400	38981.06	46019.39	0.690	400.00	3.747
LOITER		0.333	38606.50	0.00	0.261	400.00	4.080

DISTANCE CUT AT END REFUEL = 200.00 NAM

TOTAL MISSION RANGE = 400.00 NAM

TOTAL MISSION FUEL = 7165.64 LBS

TOTAL FUEL RESERVES = 308.36 LBS

TOTAL MISSION TIME = 4.08 HRS

PAYLOAD = 0.00 LBS

TOTAL FUEL OFFLOAD = 25000.00 LBS

TABLE 5.4.1-II MISSION LEG BREAKDOWN-MULTIMISSION UDF ON TANKER MISSION

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.093	72079.36	0.00		0.00	0.083
CLIMB	70.49	0.218	21088.77	33092.27	0.683	70.49	0.301
CRUISE	129.51	0.338	70337.94	33092.27	0.678	200.00	0.639
LOITER		1.250	68017.22	25000.00	0.488	200.00	1.889
REFUEL		0.083	42508.21	25000.00	0.665	200.00	10.973
LOITER		1.250	41102.47	25000.00	0.374	200.00	3.223
CLIMB	44.89	0.117	40767.51	44820.91	0.683	244.89	3.340
CRUISE	155.11	0.403	40222.36	44820.91	0.687	400.00	3.743
LOITER		0.333	39744.90	0.00	0.262	400.00	4.076

DISTANCE CUT AT END REFUEL = 200.00 NAM

TOTAL MISSION RANGE = 400.00 NAM

TOTAL MISSION FUEL = 7375.58 LBS

TOTAL FUEL RESERVES = 622.42 LBS

TOTAL MISSION TIME = 4.08 HRS

PAYLOAD = 0.00 LBS

TOTAL FUEL OFFLOAD = 25000.00 LBS

TABLE 5.4.1-III MISSION LEG BREAKDOWN-MULTIMISSION PROPFAN ON TANKER MISSION

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	77572.50	0.00		0.00	0.083
CLIMB	71.85	0.218	76183.88	33121.29	0.674	71.85	0.301
CRUISE	278.15	0.717	74092.66	33121.29	0.666	350.00	1.018
LOITER		4.000	64717.46	5000.00	0.308	350.00	5.018
LOITER		1.800	60783.06	0.00	0.270	350.00	6.818
LOITER		0.200	59044.25	0.00	0.696	350.00	7.018
CLIMB	18.06	0.047	58817.01	38718.02	0.674	368.06	7.064
CRUISE	331.94	0.860	56828.16	38718.02	0.671	700.00	7.924
LOITER		0.333	56114.16	0.00	0.286	700.00	8.257

TOTAL MISSION RANGE = 700.00 NAM

TOTAL MISSION FUEL = 21508.84 LBS

TOTAL FUEL RESERVES = 1890.16 LBS

TOTAL MISSION TIME = 8.26 HRS

PAYLOAD = 8583.00 LBS

TABLE 5.4.1-IV MISSION LEG BREAKDOWN-MULTIMISSION TURBOFAN ON ASW MISSION

5.4.2 MINIMUM AEW/ASW CTOL

The minimum AEW/ASW mission performance is presented in Figures 5.4.2-1 through 5.4.2-3. All configurations perform the full AEW mission and fall less than 30 minutes short of the desired six hours on-station for the ASW mission with the reduced payload. AEW design mission breakdowns by leg are presented in Tables 5.4.2-I through 5.4.2-III. They show the same type of data as was presented for the multimission configurations.

5.5 AIRCRAFT WEIGHT BREAKDOWNS

A detailed weight breakdown for each configuration on its design mission is presented in Tables 5.5-I through 5.5-III. Table 5.5-I is a breakdown of the propulsion and structure, Table 5.5-II is a breakdown of fixed equipment, and Table 5.5-III is a summary of the complete weight breakdown of each configuration.

5.6 DRAG BREAKDOWNS

Drag coefficient breakdowns, based on wing planform area for each configuration, are presented in Table 5.6-I through 5.6-VI. These breakdowns show by aircraft component the levels of friction drag, pressure drag, and the total parasite drag. Additionally, the drag rise due to compressibility, induced drag, and trim drag are also shown. The breakdown is presented at the engine cruise sizing condition and maximum gross weight on the design mission. The drag breakdowns, and the drag polars shown in Appendix A, include the store drag of the design configurations. A breakdown of store weights and drag levels is shown in Table 5.6-VII.

5.7 CTOL DESIGN SENSITIVITY TRADES

The sensitivity of the CTOL point designs sizing to changes in weight, TSFC, and drag are presented in the following sections. The sensitivity on the design mission radius for a fixed aircraft size is also presented.

5.7.1 AIRCRAFT SIZING SENSITIVITY

Aircraft gross weight sensitivity to changes in drag, specific fuel consumption, and incremental weight are shown in Table 5.7-I and Table 5.7-II for each configuration design mission. These data can be used as trade factors to assess the penalty in aircraft size resulting from subsequent changes in propulsion efficiency, equipment weights, and external configuration changes affecting drag. Note that only comparisons between configurations having the same design mission are valid.

5.7.2 DESIGN MISSION PERFORMANCE SENSITIVITY

With aircraft geometry and gross weight held constant, mission sensitivity to changes in drag, specific fuel consumption, and

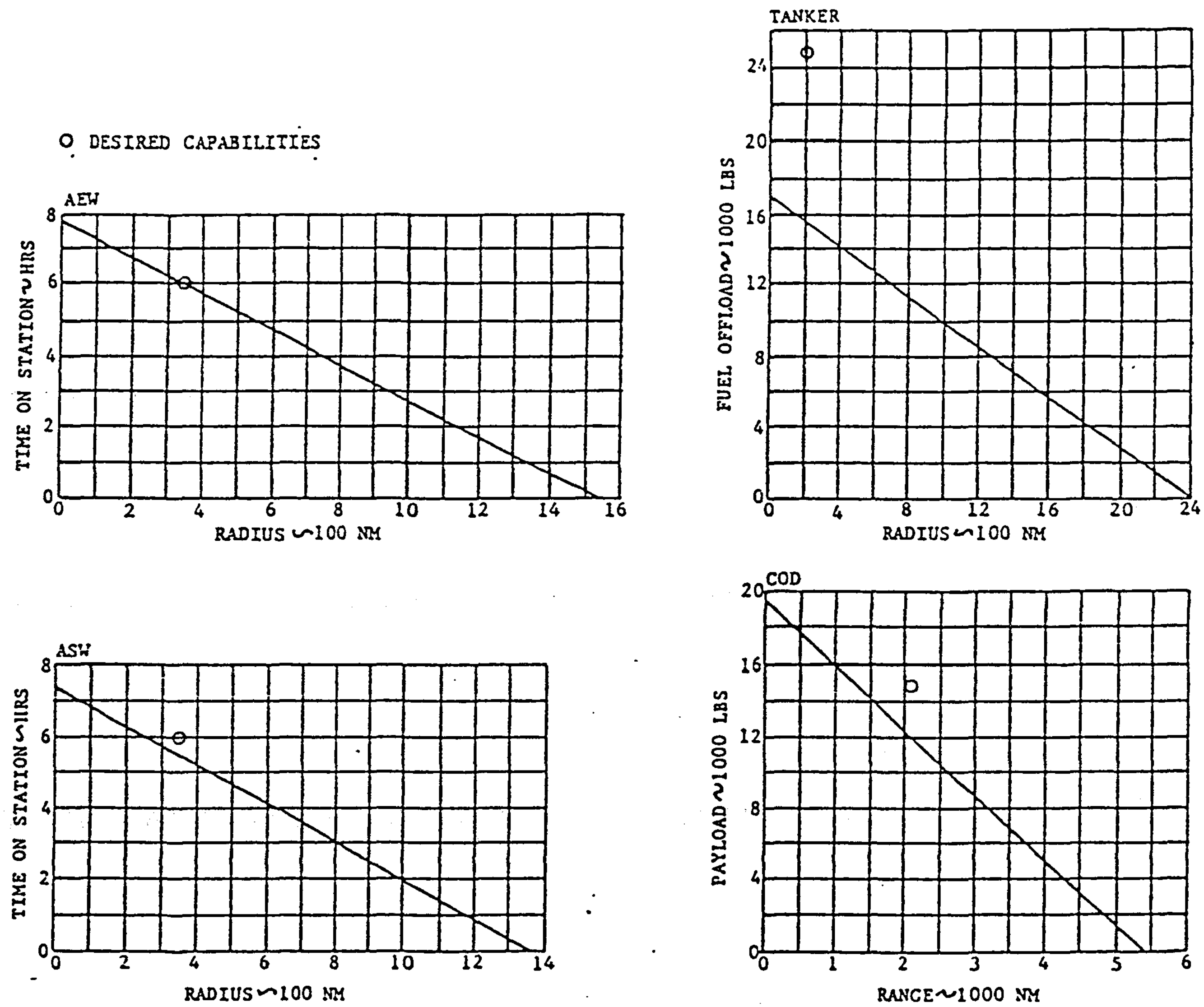


FIGURE 5.4.2-1 MINIMUM AEW/ASW UDF MISSION PERFORMANCE

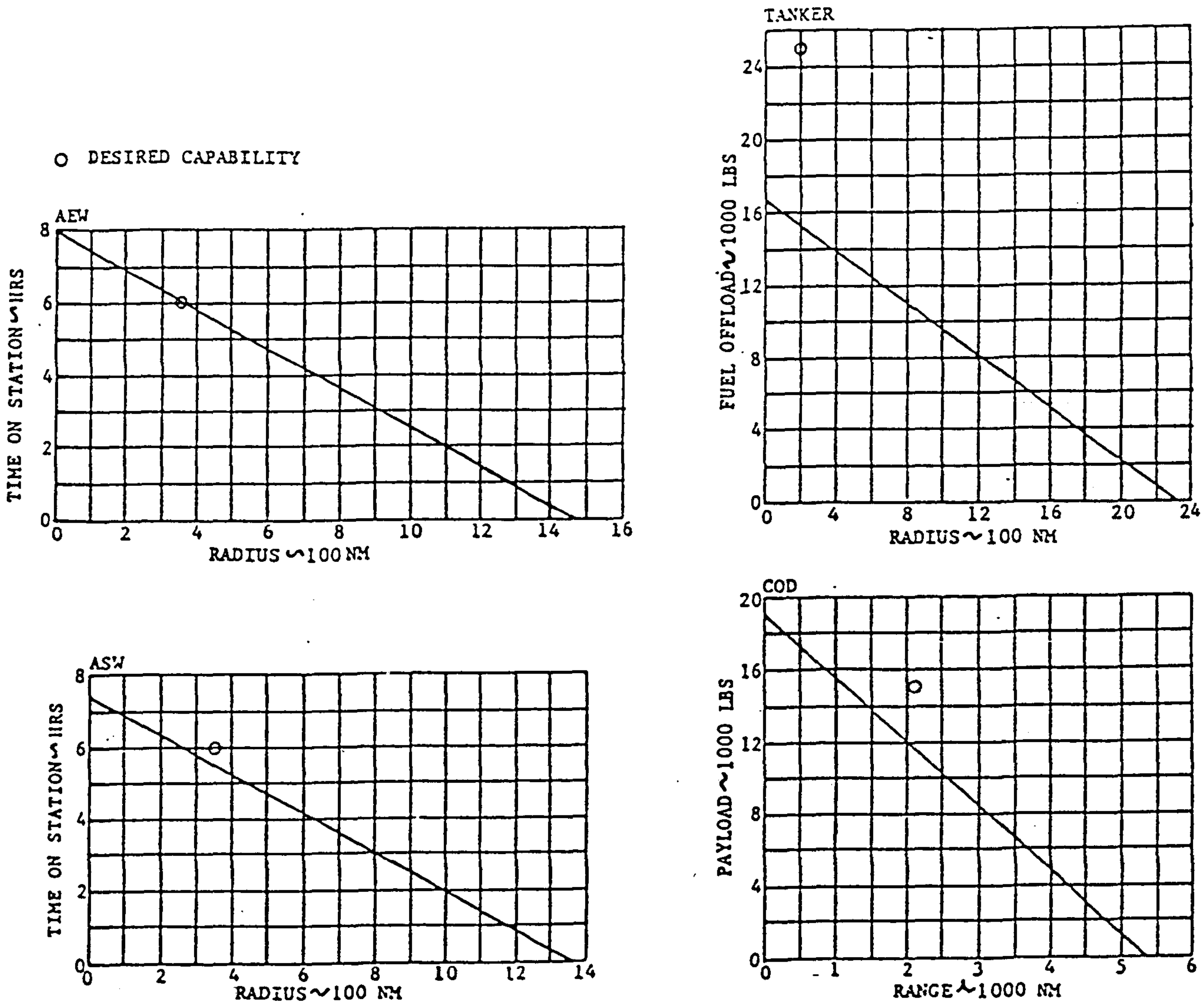


FIGURE 5.4.2-2 MINIMUM AEW/ASW PROPFAN MISSION PERFORMANCE

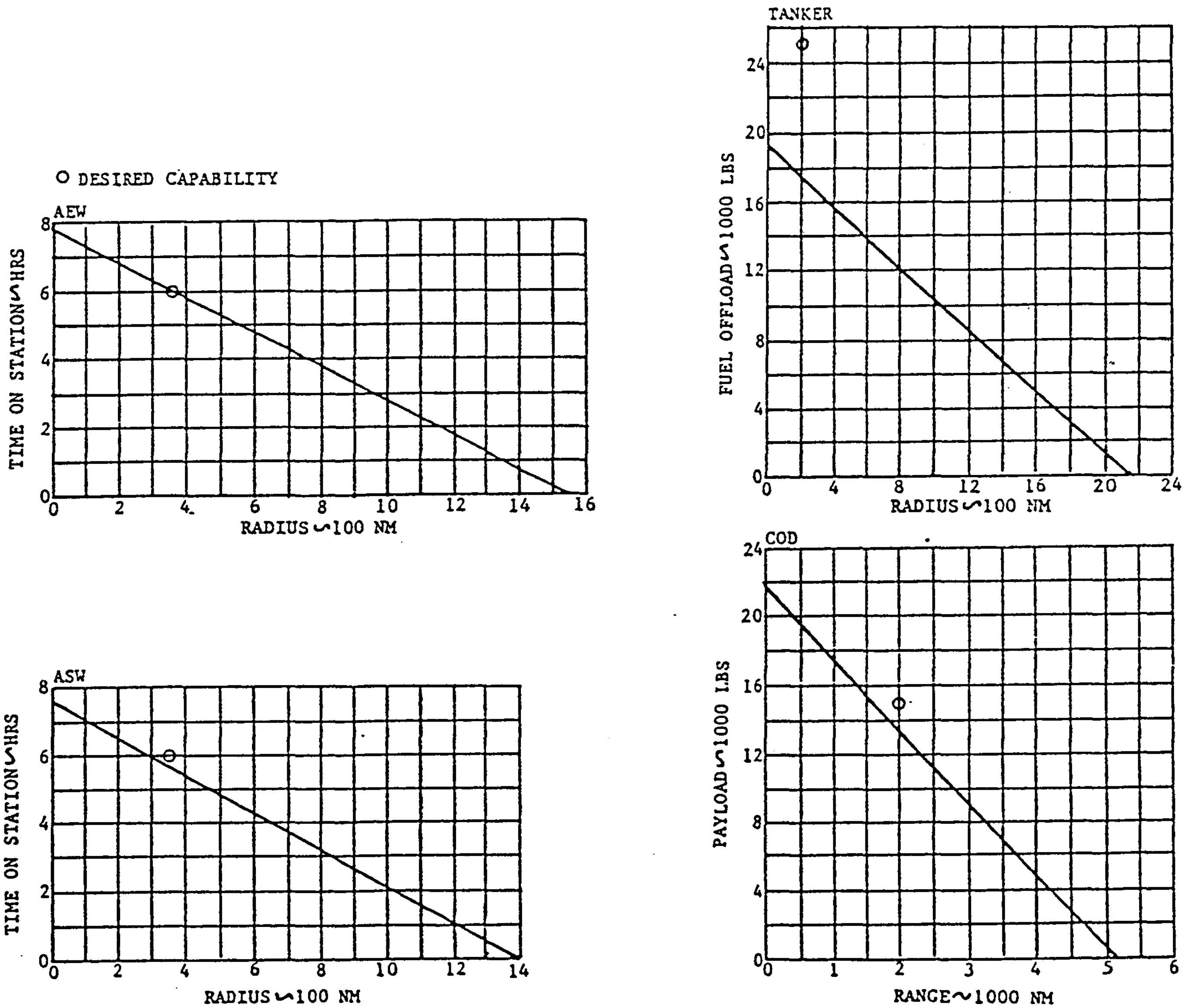


FIGURE 5.4.2-3 MINIMUM AEW/ASW TURBOFAN MISSION PERFORMANCE

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	53323.65	0.00		0.00	0.083
CLIMB	75.37	0.222	52529.64	35848.56	0.701	75.37	0.306
CRUISE	236.62	0.630	51466.50	35848.56	0.700	311.99	0.936
CLIMB	37.23	0.093	51269.54	40000.00	0.701	349.22	1.028
CRUISE	0.77	0.002	51266.26	40000.00	0.695	350.00	1.030
LOITER		6.000	42398.87	40000.00	0.589	350.00	7.030
CLIMB	4.00	0.010	42379.87	40620.60	0.701	354.00	7.040
CRUISE	345.99	0.902	41120.57	40620.60	0.701	700.00	7.942
LOITER		0.333	40704.23	0.00	0.272	700.00	8.275

TOTAL MISSION RANGE	=	700.00 NAM
TOTAL MISSION FUEL	=	12610.06 LBS
TOTAL FUEL RESERVES	=	1101.94 LBS
TOTAL MISSION TIME	=	8.28 HRS
PAYLOAD	=	776.00 LBS

TABLE 5.4.2-I : MISSION LEG BREAKDOWN-AEW/ASW UDF ON AEW MISSION

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	54510.21	0.00		0.00	0.083
CLIMB	122.59	0.378	53480.79	39575.60	0.695	122.59	0.461
CRUISE	202.41	0.508	52655.11	39575.60	0.706	325.00	0.969
CLIMB	8.31	0.021	52617.53	40000.00	0.695	333.31	0.990
CRUISE	16.69	0.041	52550.95	40000.00	0.709	350.00	1.031
LOITER		6.000	44300.04	40000.00	0.568	350.00	7.031
CLIMB	52.34	0.131	44087.45	43890.79	0.695	402.34	7.162
CRUISE	297.66	0.749	43065.25	43890.79	0.700	700.00	7.911
LOITER		0.333	42628.44	0.00	0.280	700.00	8.244

TOTAL MISSION RANGE = 700.00 NAM

TOTAL MISSION FUEL = 11801.09 LBS

TOTAL FUEL RESERVES = 1080.91 LBS

TOTAL MISSION TIME = 8.24 HRS

PAYLOAD = 776.00 LBS

TABLE 5.4.2-II MISSION LEG BREAKDOWN-AEW/ASW PROPFAN ON AEW MISSION

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	58774.41	0.00		0.00	0.083
CLIMB	87.96	0.256	57616.63	36513.65	0.717	87.96	0.339
CRUISE	233.05	0.581	56379.02	36513.65	0.714	321.01	0.920
CLIMB	28.41	0.069	56188.67	40000.00	0.717	349.42	0.990
CRUISE	0.59	0.001	56185.65	40000.00	0.713	350.01	0.991
LOITER		6.000	45263.52	40000.00	0.609	350.01	6.991
CLIMB	11.96	0.029	45192.76	41948.25	0.717	361.97	7.020
CRUISE	338.03	0.839	43753.85	41948.25	0.714	700.00	7.829
LOITER		0.333	43199.62	0.00	0.282	700.00	8.192

TOTAL MISSION RANGE = 700.00 NAM
TOTAL MISSION FUEL = 15584.37 LBS
TOTAL FUEL RESERVES = 1403.63 LBS
TOTAL MISSION TIME = 8.19 HRS
PAYLOAD = 776.00 LBS

TABLE 5.4.2-III MISSION LEG BREAKDOWN-AEW/ASW TURBOFAN ON ADW MISSION

	MINIMUM AEW / ASW			MULTIMISSION		
ENGINE TYPE	UDF	PROPFAN	TURBOFAN	UDF	PROPFAN	TURBOFAN
DESIGN MISSION	AEW	AEW	AEW	TANKER	TANKER	ASW
PROPULSION GROUP						
PRIMARY ENGINES	5210	6290	5338	6005	6777	6648
EBU	1200	1200	1200	1200	1200	1200
FUEL SYSTEM	433	408	528	940	948	705
ENGINE / PILOT CONTROL LINK	60	60	60	60	60	60
TOTAL	6903 LBS	7958 LBS	7126 LBS	8205 LBS	8985 LBS	8613 LBS
STRUCTURES GROUP						
WING	3389	4081	4125	4795	4493	5335
HORIZONTAL TAIL	429	552	562	554	571	604
VERTICAL TAIL	672	863	879	600	618	735
FUSELAGE	5217	5288	5313	6767	7488	8129
LANDING / ARRESTING GEAR	2472	2524	2730	3273	3340	3604
ENGINE STRUTS	484	465	554	867	824	1081
ENGINE NACELLES	618	432	1368	811	656	1580
NUCLEAR HARDENING	751	751	751	751	751	751
WING FOLD PENALTY	1000	1000	1000	1000	1000	1000
WING HARD POINTS (4)	100	100	100	100	100	100
DOUBLE HINGED RUDDER	50	50	50	50	50	50
SOUND PROOFING	250	250	---	250	250	---
AIR REFUELING PROBE	60	60	60	60	60	60
AIR REFUELING FUEL SYS.	60	60	60	60	60	60
BOMB BAY DOGHOUSE	---	---	---	---	---	400
SONOBAY	---	---	---	---	---	420
TOTAL	15552 LBS	16476 LBS	17552 LBS	19938 LBS	20261 LBS	23909 LBS

TABLE 5.5-I PROPULSION AND STRUCTURE WEIGHTS

	MULTIMISSION			MINIMUM AEW / ASW		
ENGINE TYPE	UDF	PROPFAN	TURBOFAN	UDF	PROPFAN	TURBOFAN
DESIGN MISSION	TANKER	TANKER	ASW	AEW	AEW	AEW
FIXED EQUIPMENT GROUP						
FLIGHT CONTROLS	1236	1254	1433	1100	1071	1154
HYDRAULICS	163	164	167	154	154	157
PNEUMATICS	147	148	149	143	143	144
ELECTRICALS	2480	2480	2885	2600	2600	2600
CREW ACCOMMODATIONS	404	404	668	848	848	848
CARGO ACCOMMODATION	25	25	25	16	16	16
EMERGENCY EQUIPMENT	364	365	368	355	355	358
AIR CONDITIONING	1119	1119	1119	993	993	993
ANTI-ICING	337	338	350	322	331	333
APU	330	330	330	330	330	330
COMMON CORE AVIONICS	767	767	767	767	767	767
MISSION UNIQUE AVIONICS	451	451	2073	4180	4180	4180
AVIONICS INSTALLATION (21%)	256	256	597	1039	1039	1039
LAUNCHERS AND RACKS	---	---	282	344	344	344
MISSION CREW CONSOLES	---	---	600	1200	1200	1200
EXTERNAL REFUELING POD	700	700	---	---	---	---
FLIGHT / ENGINE / FUEL INSTRUMENTS	600	600	600	600	600	600
	9379 LBS	9401 LBS	12413 LBS	14991 LBS	14971 LBS	15063 LBS

TABLE 5.5-II FIXED EQUIPMENT WEIGHTS

	MULTIMISSION			MINIMUM AEW / ASW		
ENGINE TYPE	UDF	PROPFAN	TURBOFAN	UDF	PROPFAN	TURBOFAN
DESIGN MISSION	TANKER	TANKER	ASW	AEW	AEW	AEW
PROPULSION GROUP	8205	8985	8613	6903	7958	7126
STRUCTURES GROUP	19938	20261	23909	15552	16476	17552
FIXED EQUIPMENT GROUP	9379	9401	12413	14991	14971	15063
STANDARD AND OPERATIONAL ITEMS						
CREW AND EQUIPMENT	500	500	1000	1500	1500	1500
TRAPPED OIL AND FUEL	478	479	425	362	357	385
OPERATIONAL EMPTY WEIGHT	38500	39626	46360	39308	41262	41626
PAYLOAD						
SIDEWINDERS (4)	---	---	---	776	776	776
HARPOONS (2)	---	---	2336	---	---	---
MK-60 MINES (2)	---	---	4732	---	---	---
SONOBUOYS (60)	---	---	1515	---	---	---
FUEL OFFLOAD	25000	25000	---	---	---	---
MISSION FUEL AND RESERVES	7674	7998	23399	13712	12882	16988
TAKEOFF MAXIMUM GROSS WEIGHT	71174 lbs	72624 lbs	78342 lbs	53796 lbs	54920 lbs	59390 lbs

TABLE 5.5-III AIRCRAFT WEIGHTS BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

$S_{ref} = 647\ ft^2$

MACH NO. = 0.66 CL = 0.45 RE / FT = 0.22328E + 07 ALT = 0.25000E + 05

GEOMETRY TOTAL DRAG 0.033889	PARASITE DRAG 0.023486	FLAT PLATE FRICTION DRAG 0.013412	PRESSURE DRAG 0.010074	DRAG RISE 0.000187	VORTEX DRAG 0.010216
COMPONENT DRAG					INDUCED DRAG 0.009277
WING	0.005158	0.003336	0.001821	0.0	TRIM DRAG 0.000939
BODY	0.008162	0.005626	0.002537	0.0	
HORZ TAIL	0.001074	0.000786	0.000287	0.0	
VERT TAIL	0.001885	0.001357	0.000528	0.0	
NACELLE	0.002592	0.000835	0.001757	0.000187	
STRUT	0.000474	0.000298	0.000177	0.0	
STORES	0.001174	0.001174	0.0	0.0	
EXCRESCENCE	0.002966				

TABLE 5.6-I MULTIMISSION UDF DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

S_{ref} = 660 ft^2

MACH NO. = 0.66 CL = 0.45 RE / FT = 0.22328E + 07 ALT = 0.25000E + 05

GEOMETRY TOTAL DRAG 0.033775	PARASITE DRAG 0.023354	FLAT PLATE FRICTION DRAG 0.013277	PRESSURE DRAG 0.010077	DRAG RISE 0.000201	VORTEX DRAG 0.010221
COMPONENT DRAG					INDUCED DRAG 0.009274
WING	0.005161	0.003338	0.001823	0.0	TRIM DRAG 0.000946
BODY	0.007999	0.005513	0.002486	0.0	
HORZ TAIL	0.001082	0.000793	0.000289	0.0	
VERT TAIL	0.001900	0.001368	0.000533	0.0	
NACELLE	0.002873	0.000965	0.001908	0.000201	
STRUT	0.000248	0.000150	0.000098	0.0	
STORES	0.001151	0.001151	0.0	0.0	
EXCRESCENCE	0.002940				

TABLE 5.6-II MULTIMISSION PROPFAN DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

$S_{ref} = 712\ ft^2$

MACH NO. = 0.66 CL = 0.45 RE/FT = 0.22328E+07 ALT = 0.25000E+05

GEOMETRY TOTAL DRAG	PARASITE DRAG	FLAT PLATE FRICTION DRAG	PRESSURE DRAG	DRAG RISE	VORTEX DRAG
0.034022	0.024635	0.013599	0.011036	0.000313	0.009074
COMPONENT DRAG					INDUCED DRAG 0.008222
WING	0.005262	0.003414	0.001848	0.0	TRIM DRAG 0.000852
BODY	0.007375	0.005110	0.002265	0.0	
HORZ TAIL	0.001055	0.000773	0.000282	0.0	
VERT TAIL	0.002066	0.001487	0.000579	0.0	
NACELLE	0.004045	0.001197	0.002848	0.000313	
STRUT	0.000417	0.000285	0.000132	0.0	
STORES	0.001333	0.001333	0.0	0.0	
EXCRESCENCE	0.003082				

TABLE 5.6-III MULTIMISSION TURBOFAN DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

S_{ref} = 489 ft^2

MACH NO. = 0.63 CL = 1.02 RE / FT = 0.11953E + 07 ALT = 0.40000E + 05

GEOMETRY TOTAL DRAG <u>0.077780</u>	PARASITE DRAG <u>0.033824</u>	FLAT PLATE FRICTION DRAG <u>0.017496</u>	PRESSURE DRAG <u>0.016328</u>	DRAG RISE <u>0.000343</u>	VORTEX DRAG <u>0.043614</u>
COMPONENT DRAG					INDUCED DRAG 0.040878
WING	0.012072	0.003827	0.008245	0.0	TRIM DRAG 0.002736
BODY	0.006635	0.005475	0.001160	0.0	
HORZ TAIL	0.001245	0.000912	0.000333	0.000343	
VERT TAIL	0.003053	0.002198	0.000856	0.0	
NACELLE	0.001684	0.000946	0.000737	0.0	
STRUT	0.001361	0.000865	0.000496	0.0	
STORES	0.003273	0.003273	0.0	0.0	
EXCRESCENCE	0.004500				

TABLE 5.6-IV AEW/ASW UDF DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

$S_{ref} = 578 \text{ ft}^2$

MACH NO. = 0.63 CL = 0.88 RE / FT = 0.11953E + 07 ALT = 0.40000E + 05

GEOMETRY TOTAL DRAG 0.061152	PARASITE DRAG 0.028399	FLAT PLATE FRICTION DRAG 0.015798	PRESSURE DRAG 0.012600	DRAG RISE 0.0	VORTEX DRAG 0.032753
COMPONENT DRAG					INDUCED DRAG 0.030408
WING	0.009482	0.003838	0.005645	0.0	TRIM DRAG 0.002345
BODY	0.005665	0.004630	0.001034	0.0	
HORZ TAIL	0.001326	0.000971	0.000355	0.0	
VERT TAIL	0.003255	0.002343	0.000912	0.0	
NACELLE	0.001357	0.000762	0.000594	0.0	
STRUT	0.000823	0.000485	0.000338	0.0	
STORES	0.002768	0.002768	0.0	0.0	
EXCRESCENCE	0.003722				

TABLE 5.6-V AEW/ASW PROPFAN DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

S_{ref} = 585 ft^2

MACH NO. = 0.63 CL = 0.94 RE / FT = 0.11953E + 07 ALT = 0.40000E + 05

GEOMETRY TOTAL DRAG 0.066908	PARASITE DRAG 0.029556	FLAT PLATE FRICTION DRAG 0.016080	PRESSURE DRAG 0.013476	DRAG RISE 0.00048	VORTEX DRAG 0.037304
COMPONENT DRAG					INDUCED DRAG 0.034711
WING	0.010621	0.003839	0.006782	0.0	TRIM DRAG 0.002593
BODY	0.005571	0.004574	0.000997	0.0	
HORZ TAIL	0.001332	0.000976	0.000356	0.000048	
VERT TAIL	0.003270	0.002354	0.000917	0.0	
NACELLE	0.001826	0.001371	0.000455	0.0	
STRUT	0.000352	0.000232	0.000120	0.0	
STORES	0.002735	0.002735	0.0	0.0	
EXCRESCENCE	0.003849				

TABLE 5.6-VI AEW/ASW TURBOFAN DRAG BREAKDOWN

	QTY	WEIGHT-LBS	DRAG-FT^2
SIDEWINDERS AND RACKS	4	1120	1.6
HARPOONS AND RACKS	2	2618	.95
REFUELING POD	1	700	.8
300 GALLON EXTERNAL TANK	2	414	1.04
400 GALLON EXTERNAL TANK	2	528	1.19
600 GALLON TXTERNAL TANK	2	536	1.34

TABLE 5.6-VII STORE WEIGHT AND DRAG INCREMENTS

MULTIMISSION AIRCRAFT	TANKER		ASW
	UDF	PF	TF
SIZING SENSITIVITY			
Δ GW / Δ W ~ LB / LB	1.72	1.59	2.44
Δ GW / % Δ TSFC ~ LB / %	71.74	122.25	573.5
Δ GW / Δ DRAG/$_q$ ~ LB / FT^2	308.4	281.48	1200.5
Δ FUEL / Δ W ~ LB / LB	.1896	.1764	1.557
Δ FUEL / % Δ TSFC ~ LB / %	49.46	89.79	373.8
Δ FUEL / Δ DRAG/$_q$ ~ LB / FT^2	212.71	207.21	779.0
FIXED GEOMETRY MISSION SENSITIVITY			
Δ RADIUS / Δ W ~ NM / LB	.1226	.1178	.0596
Δ RADIUS / % Δ TSFC ~ NM / %	7.94	9.21	15.287
Δ RADIUS / Δ DRAG/$_q$ ~ NM / FT^2	10.92	17.72	14.271

TABLE 5.7-I MULTIMISSION AIRCRAFT DESIGN SENSITIVITY

AEW / ASW AIRCRAFT	AEW		
	UDF	PF	TF
SIZING SENSITIVITY			
Δ GW / Δ W ~ LB / LB	1.90	1.84	2.28
Δ GW / % Δ TSFC ~ LB / %	238.3	216.6	321.1
Δ GW / Δ DRAG/$_q$ ~ LB / FT^2	1083.93	917.50	1565.43
Δ FUEL / Δ W ~ LB / LB	.4124	.3675	.5601
Δ FUEL / % Δ TSFC ~ LB / %	175.9	160.10	224.40
Δ FUEL / Δ DRAG/$_q$ ~ LB / FT^2	710.88	599.93	925.14
FIXED GEOMETRY MISSION SENSITIVITY			
Δ RADIUS / Δ W ~ NM / LB	.1494	.1538	.1240
Δ RADIUS / % Δ TSFC ~ NM / %	15.77	15.16	15.87
Δ RADIUS / Δ DRAG/$_q$ ~ NM / FT^2	31.38	27.86	37.14

TABLE 5.7-II AEW/ASW AIRCRAFT DESIGN SENSITIVITY

incremental weight are presented in Tables 5.7-I and 5.7-II as they affect design mission radius.

5.8 STABILITY AND CONTROL ANALYSIS

CTOL longitudinal and lateral directional control analysis used to size the horizontal and vertical tails for all six point designs is presented below.

5.8.1 CTOL LONGITUDINAL STABILITY

The results of a limited stability and control analysis to size the horizontal tail for each multimission aircraft is presented in Figure 5.8.1-1. Shown are lines representing neutral point loci, maneuver point loci, and takeoff rotation power as a function of center of gravity and horizontal tail area. Also shown are the worst case center of gravity limits for each aircraft based on the missions and requirements of the MPSNA-MAPS study. The sensitivity of takeoff rotation power to variable horizontal tail incidence and to single/double hinged elevators is also shown. The design areas selected are presented above each configurations X-plot.

Tail sizing data is presented in Figure 5.8.1-2 for the minimum AEW/ASW configurations. The worst case is the turbofan which is neutrally stable at the most aft center of gravity.

5.8.2 CTOL LATERAL-DIRECTIONAL STABILITY

The results of the two degree of freedom stability and control static sizing analysis are shown in Figures 5.8.2-1 through 5.8.2-6 for the multimission configurations. The vertical tail and rudder geometries are sized for either the critical engine out maneuver or low speed approach. The multimission UDF configuration has a maximum aft C.G. limit of 47% and is a short coupled configuration. These constraints do not allow adequate static directional stability for aft C.G. locations.

For this study, the criteria used to determine the level of C_{N_β} recommended by Perkins & Hage is:

$$C_{N_\beta} \text{ DESIRABLE} = .005\left(\frac{W}{b^2}\right)$$

The multimission UDF configuration with the vertical tail sized at

$$S_V = 220 \text{ Ft}^2$$

has acceptable engine out directional control and positive but <u>weak</u> directional stability (C_{N_β} = .0008).

In order to assess the impact of this weak open loop static directional stability. The lateral/directional dynamic response characteristics must be identified.

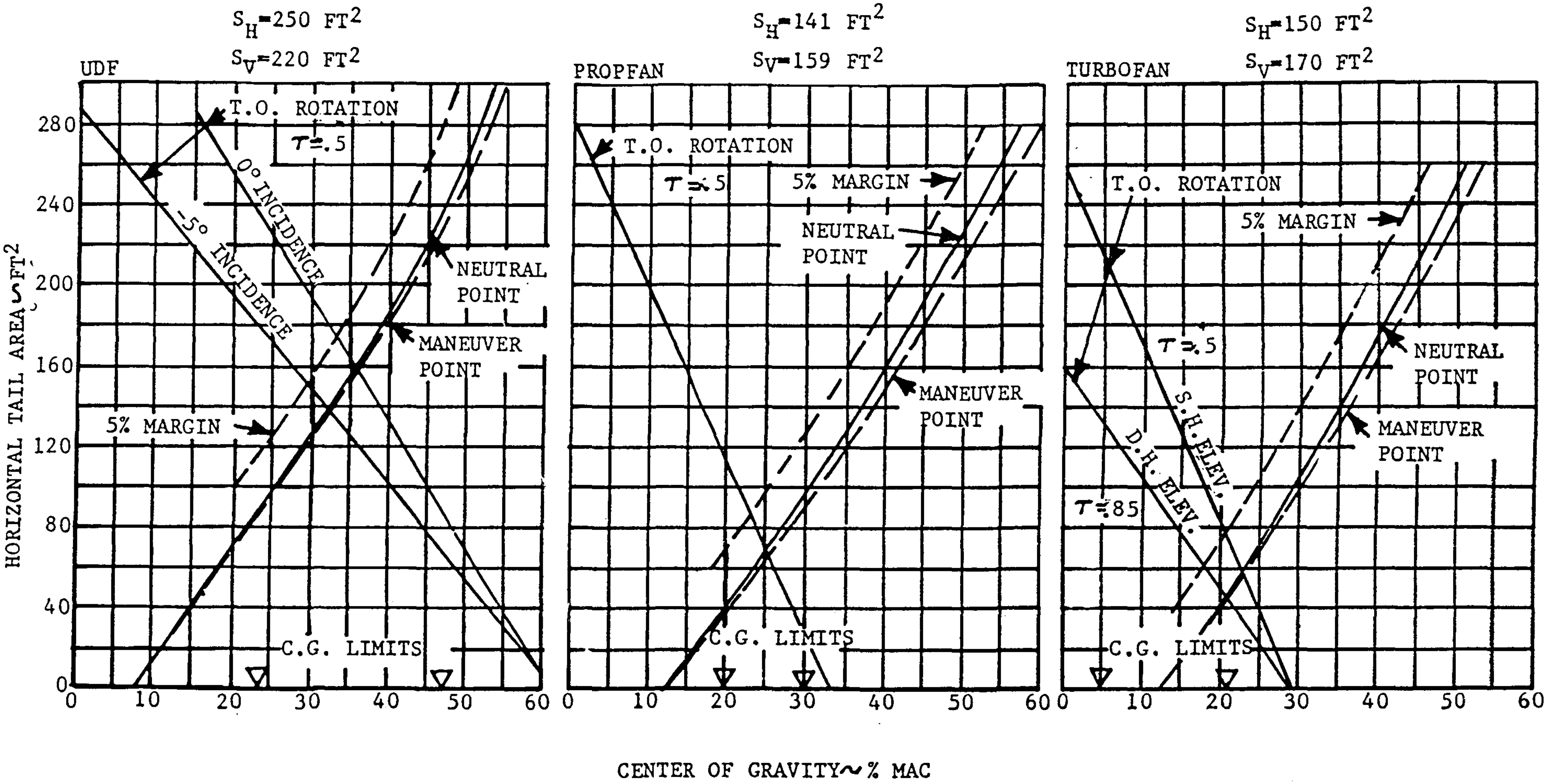


FIGURE 5.8.1-1 MULTIMISSION HORIZONTAL TAIL SIZING

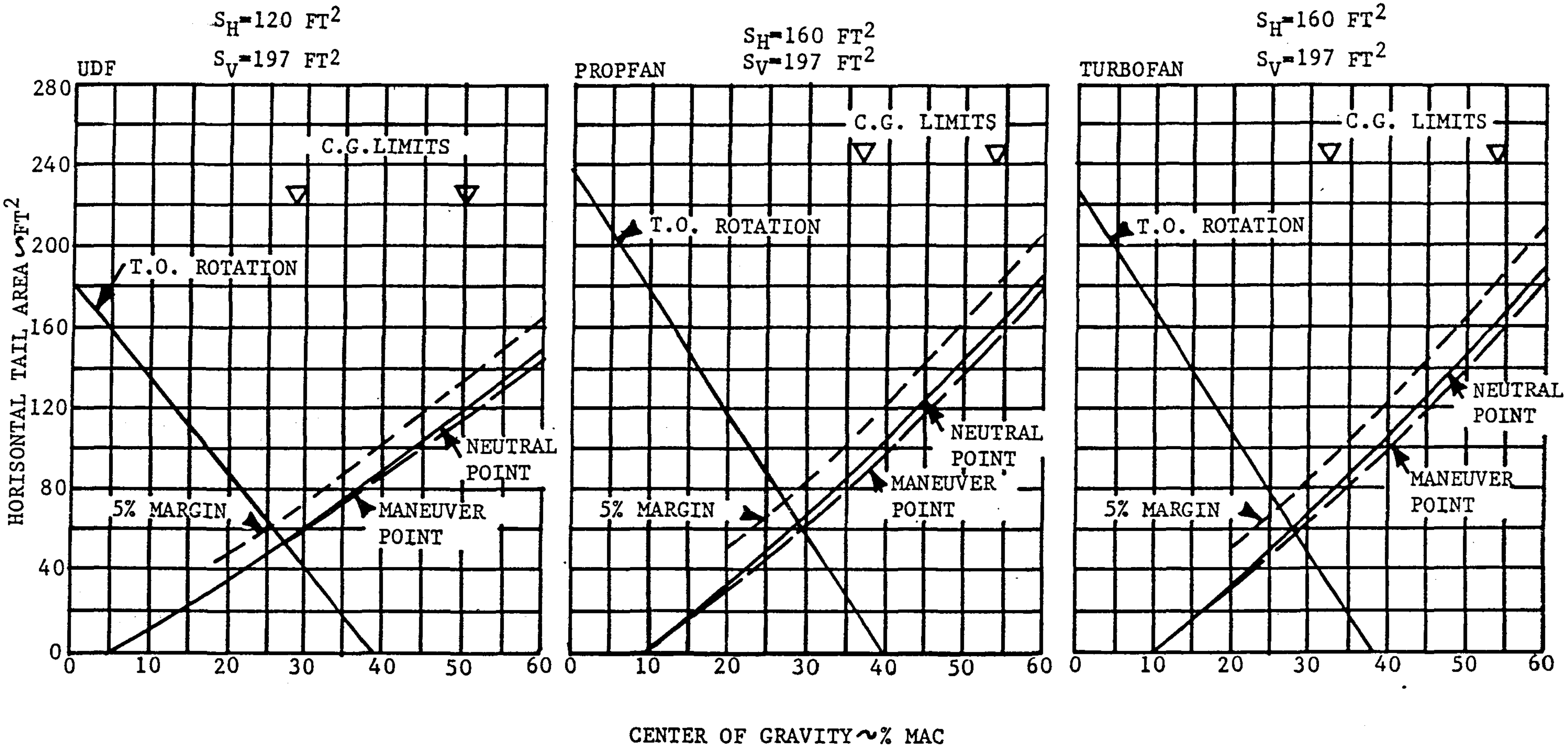


FIGURE 5.8.1-2 MINIMUM AEW/ASW HORIZONTAL TAIL SIZING

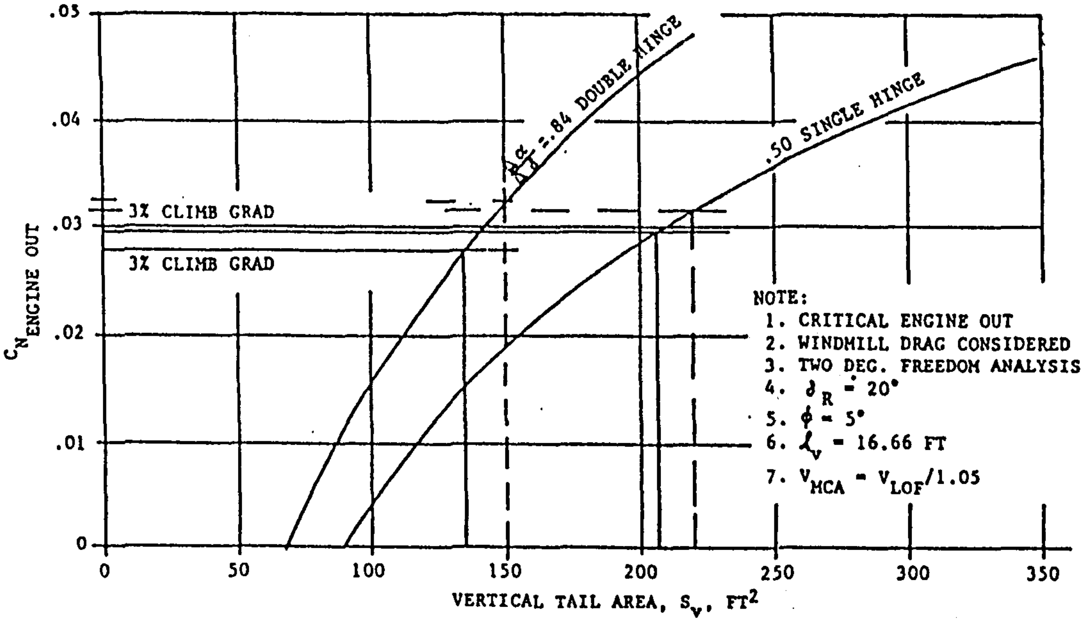


FIGURE 5.8.2-1 ENGINE OUT YAWING MOMENT COEFFICIENT VS VERTICAL TAIL AREA

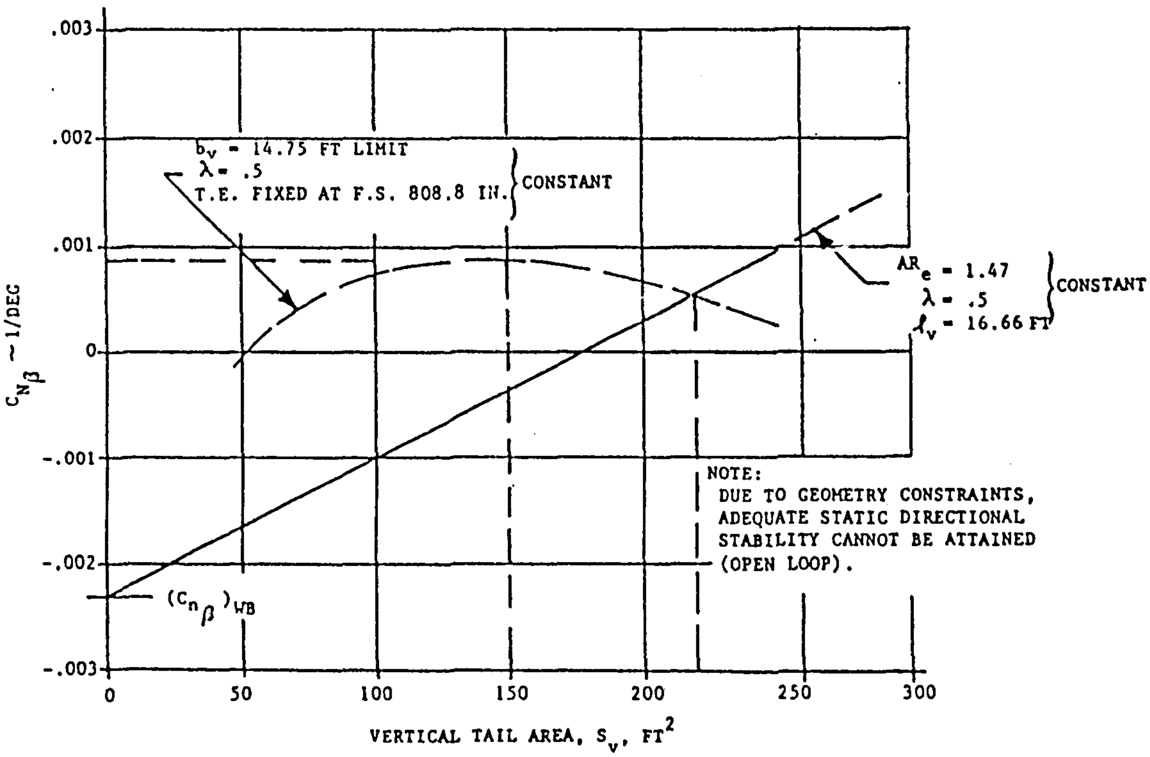


FIGURE 5.8.2-2 STATIC DIRECTIONAL STABILITY COEFFICIENT VS VERTICAL TAIL AREA

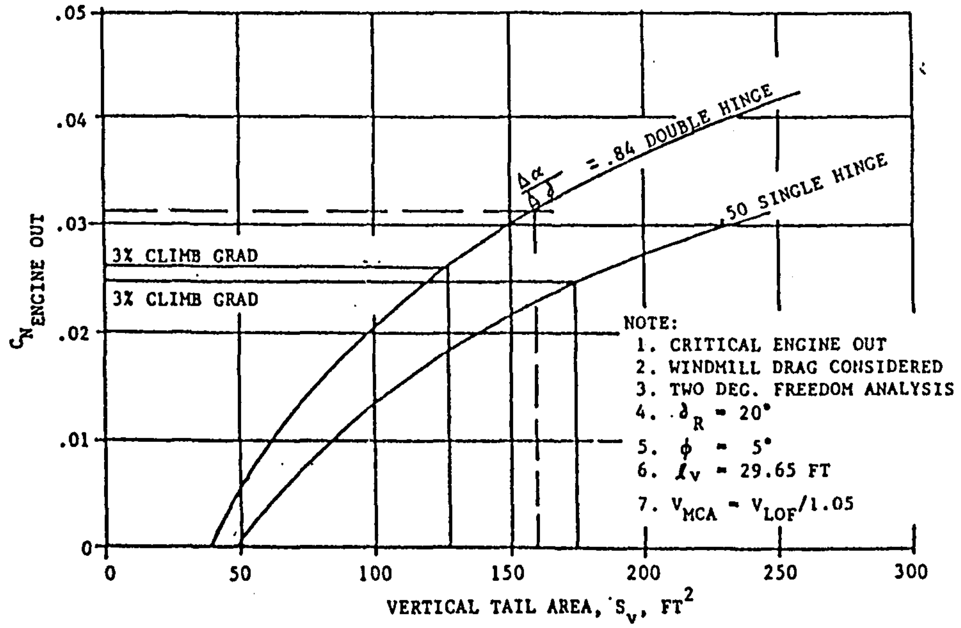


FIGURE 5.8.2-3 ENGINE OUT YAWING MOMENT COEFFICIENT VS VERTICAL TAIL AREA

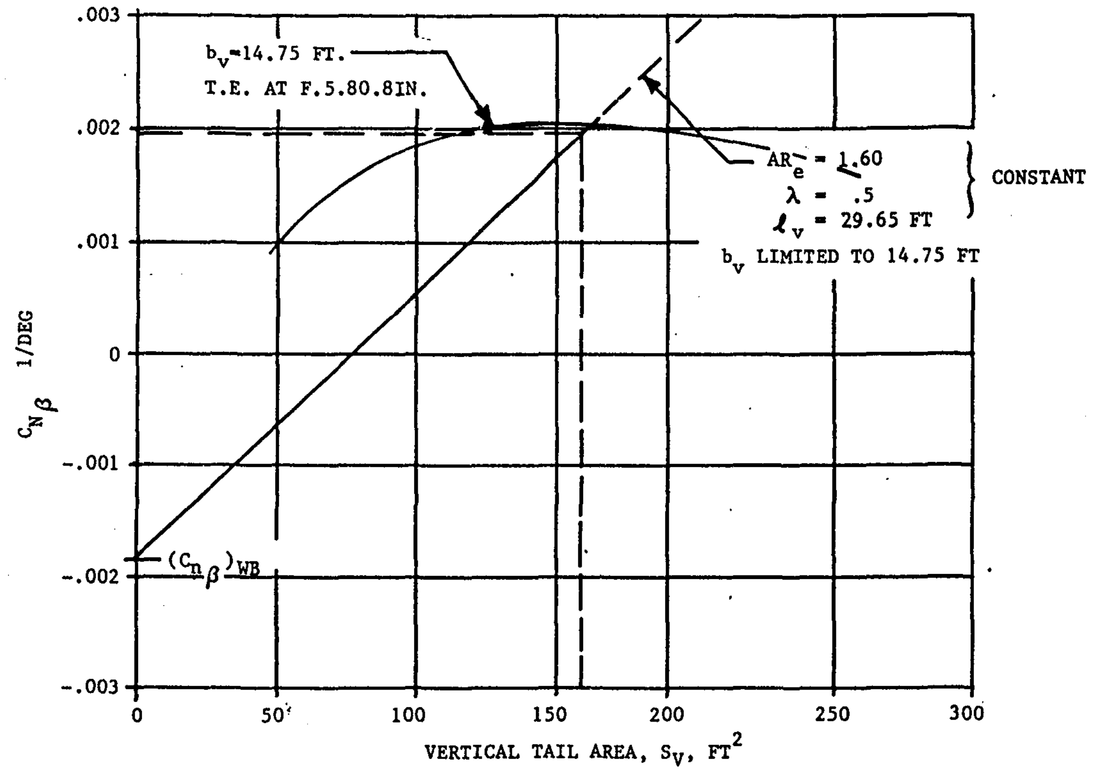


FIGURE 5.8.2-4 STATIC DIRECTIONAL STABILITY COEFFICIENT VS VERTICAL TAIL AREA

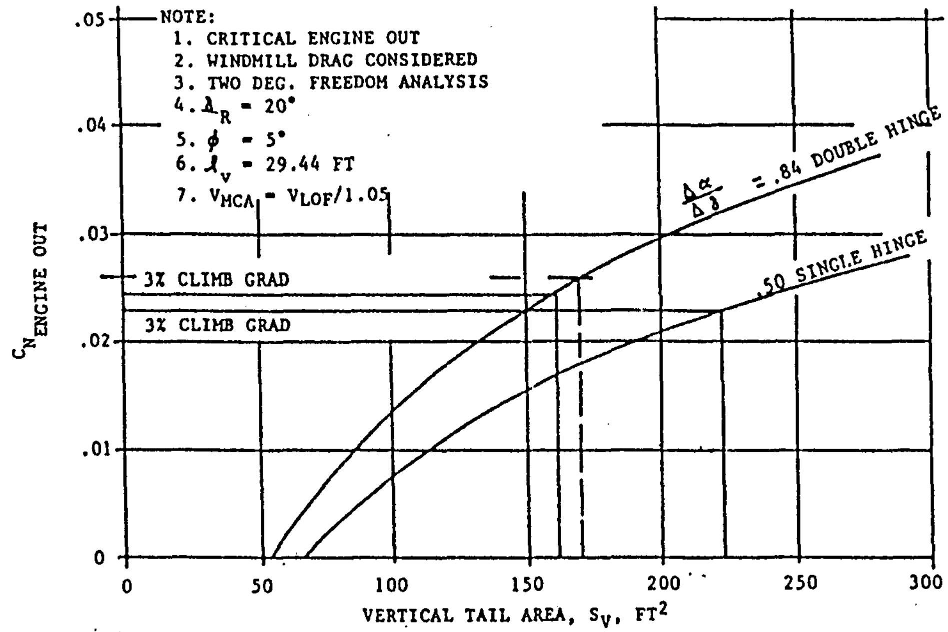


FIGURE 5.8.2-5 ENGINE OUT YAWING MOMENT COEFFICIENTS VS VERTICAL TAIL AREA

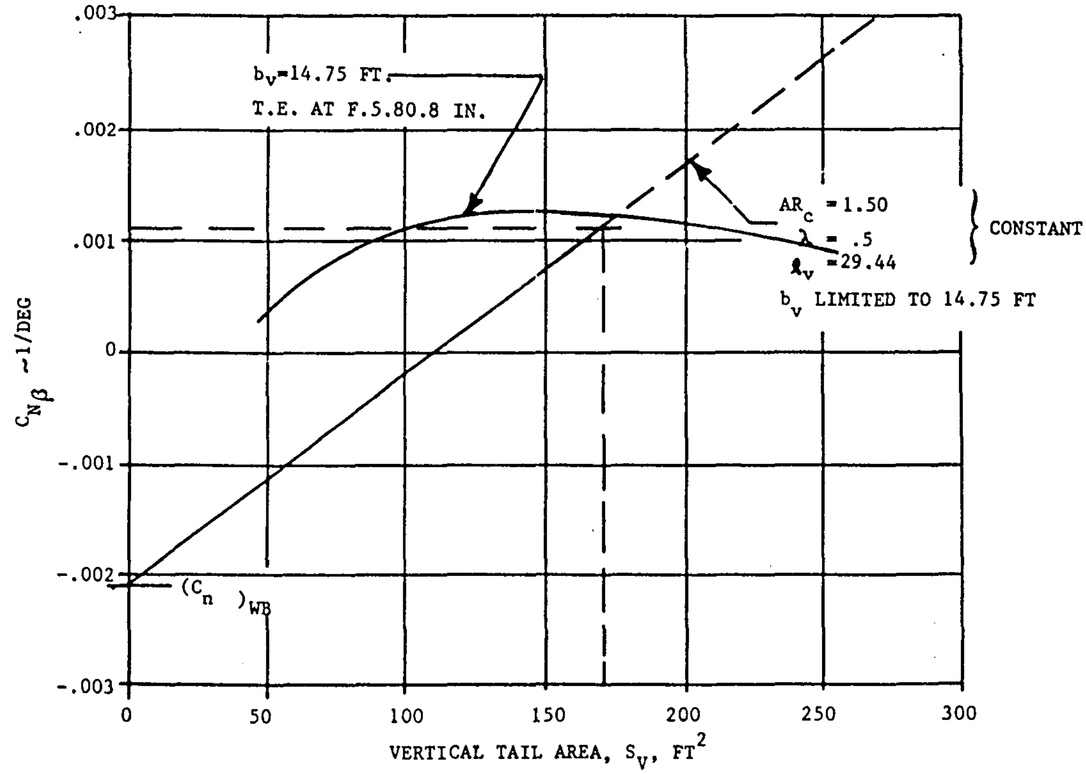


FIGURE 5.8.2-6 STATIC DIRECTIONAL STABILITY VS VERTICAL TAIL AREA

The same methodology is used to size the vertical tail and rudder geometry of the minimum AEW/ASW configurations in Figures 5.8.2-7 through 5.8.2-12.

The vertical tail areas selected appear with the horizontal tail areas selected in Figures 5.8.1-1 and 5.8.1-2.

5.9 WING FOLD AND SPOT FACTOR DRAWINGS

The wing fold arrangements and resulting spot factors for the optimized configurations are presented in Figure 5.9-1 for the multimission configurations and Figure 5.9-2 for the minimum AEW/ASW configurations. Each configuration has a 9 in. minimum clearance line drawn around the aircraft. They were manually spotted using scale model cutouts at the BMAC Aircraft Carrier Spotting Facility (similar to the USN spotting facility at Lakehurst, N.J.) in accordance with current Navy practice. Spotting studies used the USS Nimitz (CVN-68) with the A-7 type as baseline (SF = 1.0).

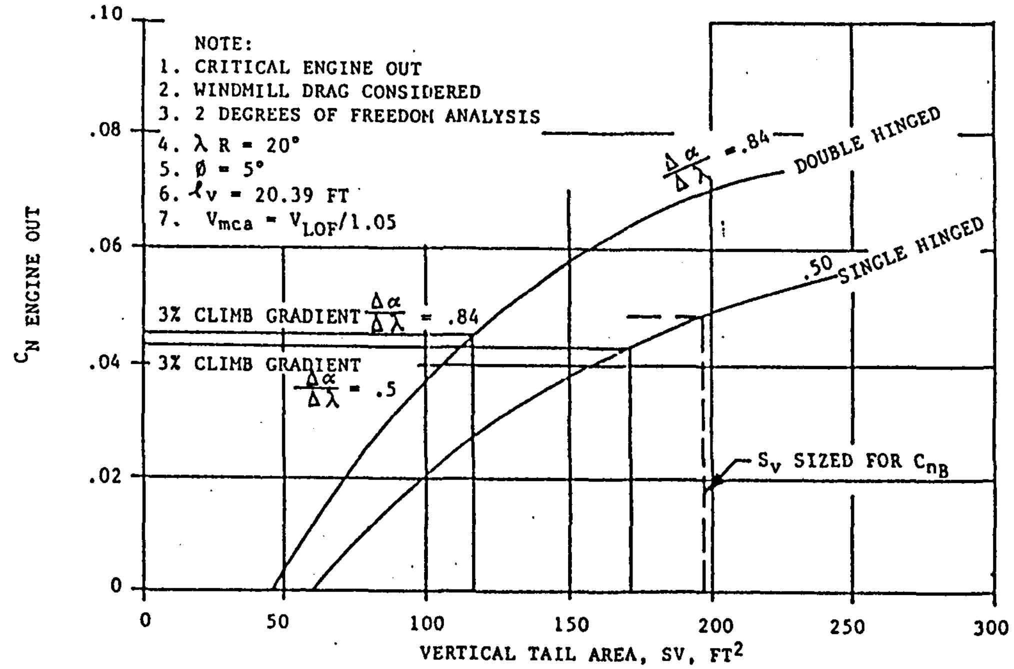


FIGURE 5.8.2-7 ENGINE OUT YAWING MOMENT COEFFICIENT VS VERTICAL TAIL AREA

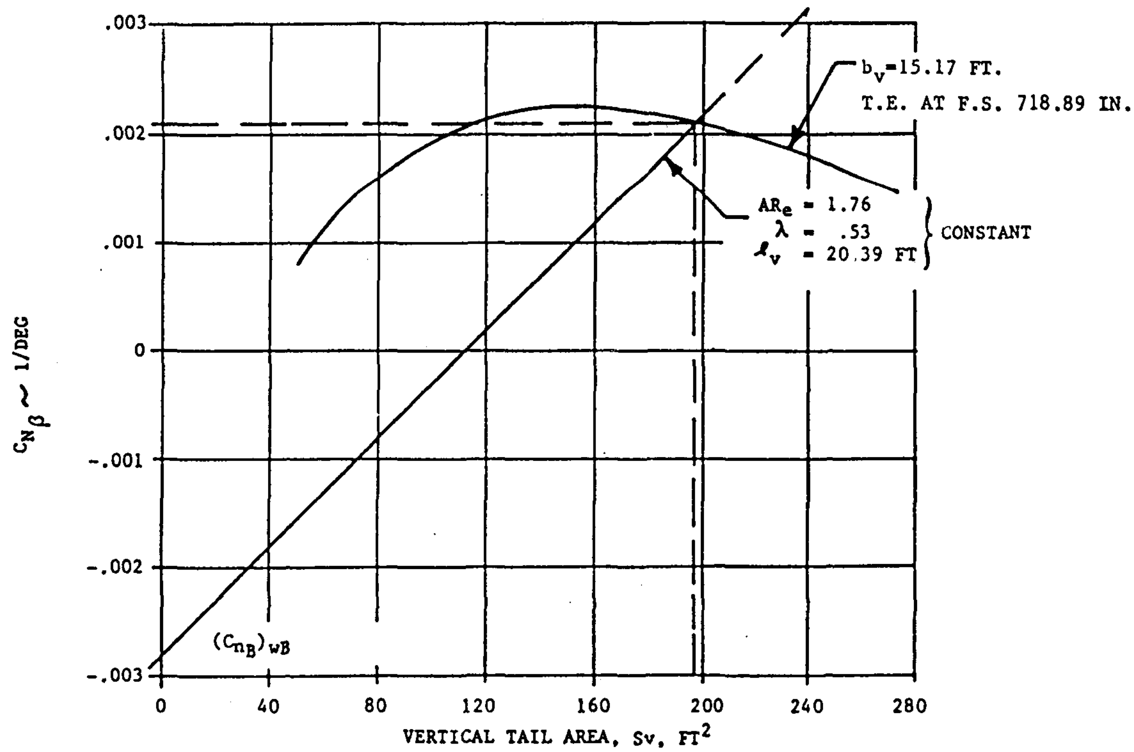


FIGURE 5.8.2-8 STATIC DIRECTIONAL STABILITY VS VERTICAL TAIL AREA

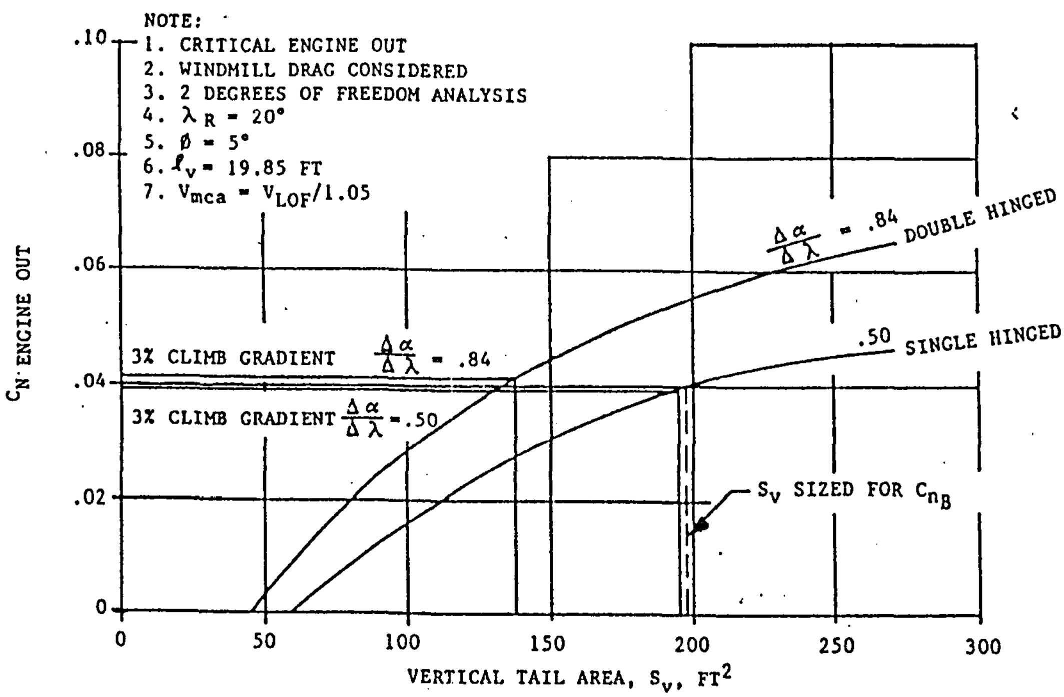


FIGURE 5.8.2-9 ENGINE OUT YAWING MOMENT COEFFICIENT VS VERTICAL TAIL AREA

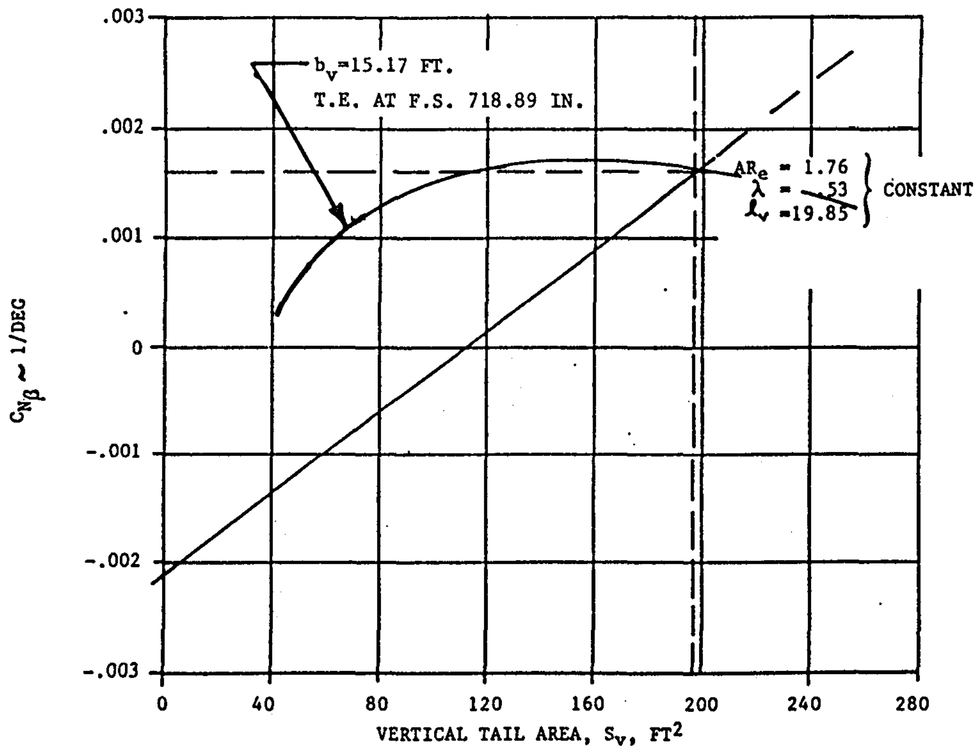


FIGURE 5.8.2-10 STATIC DIRECTIONAL VS VERTICAL TAIL AREA

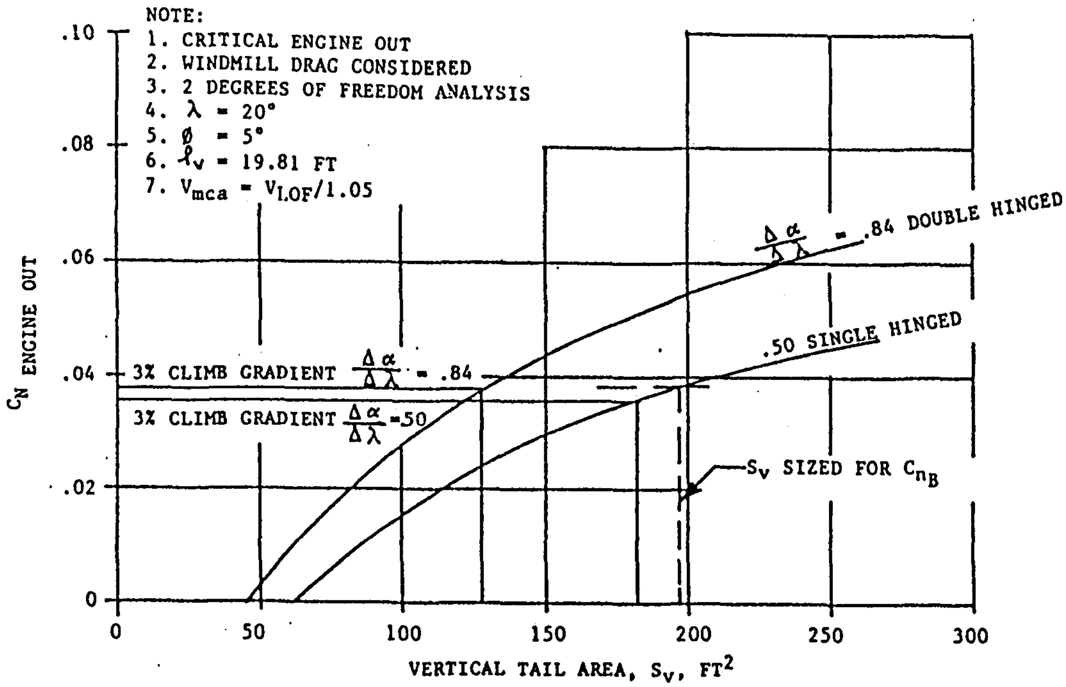


FIGURE 5.8.2-11 ENGINE OUT YAWING MOMENT COEFFICIENT VS VERTICAL TAIL AREA

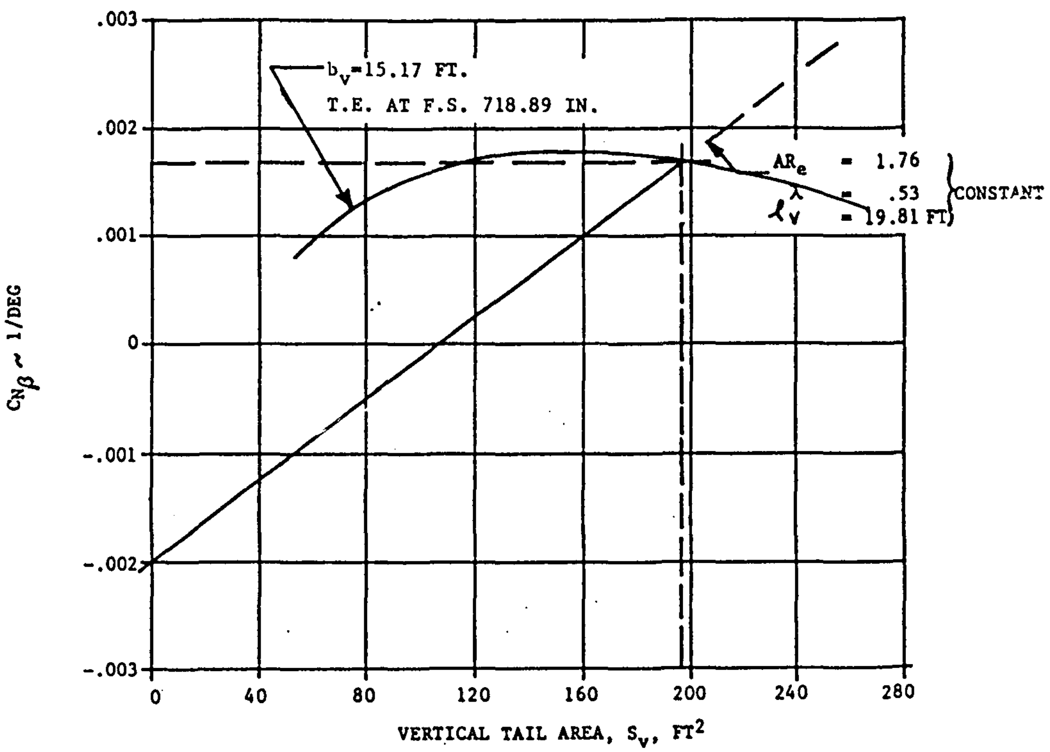


FIGURE 5.8.2-12 STATIC DIRECTIONAL STABILITY VS VERTICAL TAIL AREA

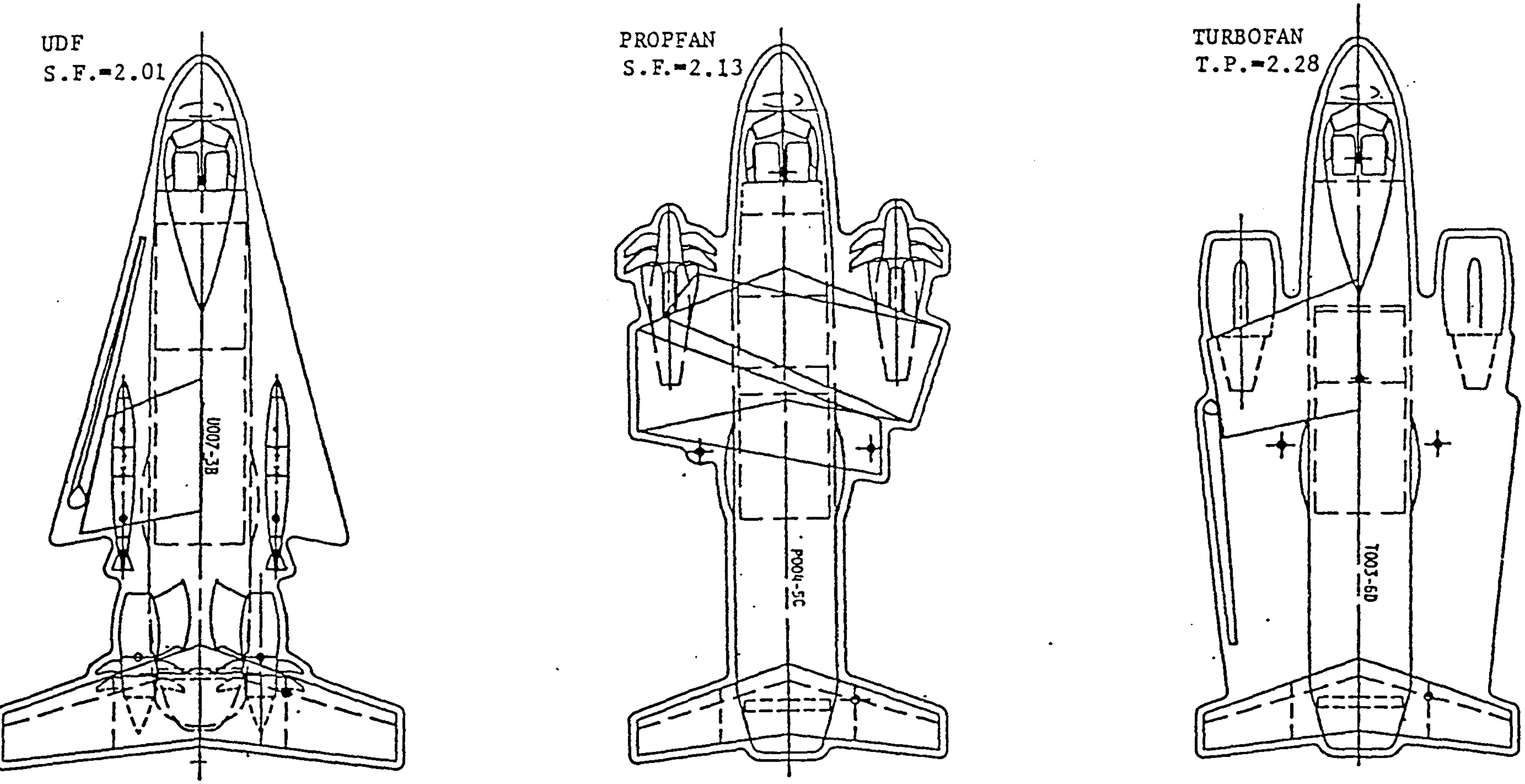


FIGURE 5.9-1 MULTIMISSION SPOTTING FACTORS

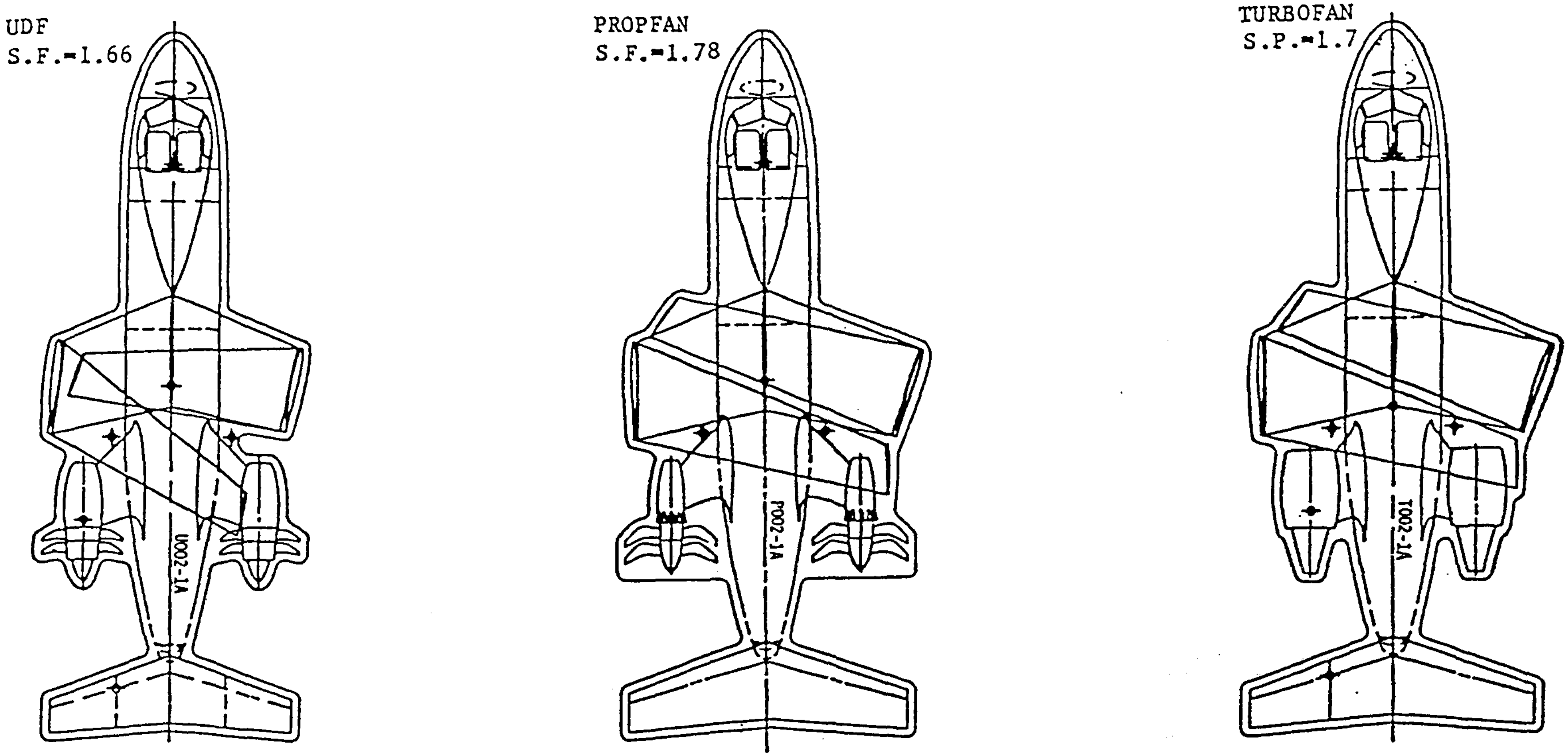


FIGURE 5.9-2 MINIMUM AEW/ASW SPOTTING FACTORS

6.0 TASK IV: STOVL ALTERNATE DESIGNS

The intent of this task was to identify the effects/penalties of V/STOL or STOVL on the basic MPSNA concepts. A general assumption made to facilitate this limited examination was that STOVL would be a lesser penalty to the basic MPSNA concepts than V/STOL. It was also deemed expedient to change the basic aircraft concept to one which would allow rotation of the propfan propulsion systems from cruise position to vertical landing position near the aircraft center of gravity.

6.1 PROPULSION SYSTEM ASSUMPTIONS

Consistent with the limited nature of this task, certain propulsion system assumptions were also made. The following paragraphs identify the major assumptions and address the rationale leading to them.

6.1.1 REACTION CONTROL SYSTEM SIZING

Task I defined the maximum weight for any MPSNA aircraft as 80,000 lb. Therefore, stability and control (S&C) analysis was performed to establish the nominal reaction control forces required for an 80,000 lb. STOVL configuration in the vertical landing segment of its mission. Table 6.1.1-I presents the results of the S&C analysis for two conditions, a step input of control force (instantaneous) and a ramp input of control force (one second delay). The roll and pitch step input levels were chosen based on use of the bleed and burn reaction control system to be discussed in Paragraph 6.1.3. The yaw ramp input was chosen based on the differential tilt nacelle concept discussed in Paragraph 6.1.4.

6.1.2 ALL ENGINES OPERATING

The advantages of assuming all engines operating during the vertical landing phase are:

- o Simplified system by eliminating the requirements for cross shafting and/or cross ducting (no engine out capability during vertical operations).
- o Reduces the required installed thrust to a level which is more compatible with the cruise thrust requirements of the aircraft.
- o These assumptions were first promulgated by Cmdr. M.P. LaReau, USN during discussions/presentations with BMAC in 1984.

A disadvantage of this assumption is reduced safety in the event of an engine failure.

The rationale for accepting this assumption is of course based on Cmdr. LaReau's remarks and further justified on a cursory basis by taking into account the continued improvement of turbomachinery reliability and the

- MAX GROSS WT = 80000 LBS.

	CONTROL STEP INPUT	CONTROL RAMP INPUT
ROLL	± 17,082 FT.-LBS.	± 34,164 FT.-LBS.
PITCH	± 27,513 FT.-LBS.	± 55,026 FT.-LBS.
YAW	± 77,770 FT.-LBS.	± 155,540 FT.-LBS.

TABLE 6.1.1-I SIZING OF REACTION CONTROL SYSTEM

- AUGMENTATION DUE TO BURN = 2.0
- QUASI INSTANTANEOUS RESPONSE
- CONTINUOUS BY-PASS BLEED TO SUSTAIN COMBUSTION

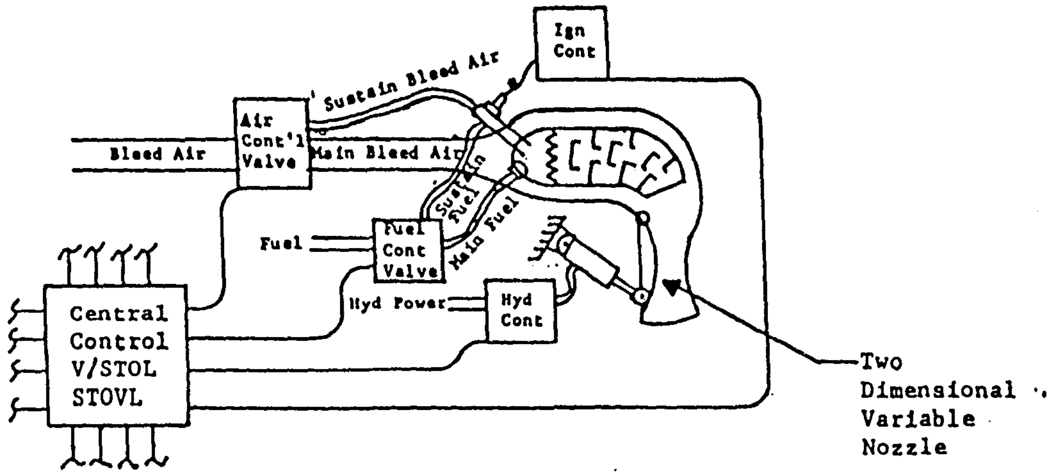


FIGURE 6.1.3-1 BLEED AND BURN REACTION CONTROL-PITCH AND ROLL

- ± 12° DIFFERENTIAL TILT FOR YAW AT 12°/SEC MIN.
- TRANSITION TILT RATE MODULATED AS REQUIRED
  - FORE AND AFT THRUST COMPONENTS = 21% AXIAL
  - VERTICAL COMPONENTS = 98% AXIAL

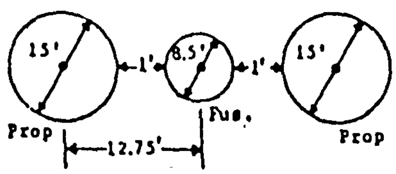


FIGURE 6.1.4-1 TILT NACELLE FOR TRANSITION AND YAW CONTROL

achieved and projected advance in engine monitoring to warn the pilot of deteriorating/unreliable conditions.

In the event of one engine out or indications that a vertical landing would be unacceptably risky (engine monitoring indications) the pilot would have to execute a one engine out arrested landing during peacetime operations. In the case of these aircraft conditions during hostile conditions, there is the possibility of having to ditch the aircraft.

6.1.3 PITCH AND ROLL BLEED AND BURN REACTION CONTROL

The relatively cold interstage bleed air offers the potential for relatively high augmentation due to burning. Since plenum chamber burning used by Rolls Royce in the advanced Pegasus produces an augmentation over 2.0, that level was assumed for this study. Figure 6.1.3-1 presents the notional bleed and burn system assumed. Its features include:

- Sustained combustion during vertical operations
- Variable nozzle for maximum thrust
- Central control system for quasi instantaneous response
- Static stability and control system weight of 175 lb.
- Burner exit temperature of 2540°F

6.1.4 TILT NACELLE FOR TRANSITION AND YAW CONTROL

Figure 6.1.4-1 presents the assumed geometry to assess yaw control authority. Resulting analysis showed that differential tilting of the nacelle $\pm 12^{\circ}$ while in hover provided the required control authority specified in Paragraph 6.1.1. Therefore, the rate of tilt required to be consistent with the assumed "ramp input" was 12°/sec. minimum. The fore and aft components at 12° differential tilt yield 21% of the axial engine thrust while the vertical thrust component is degraded only 2%.

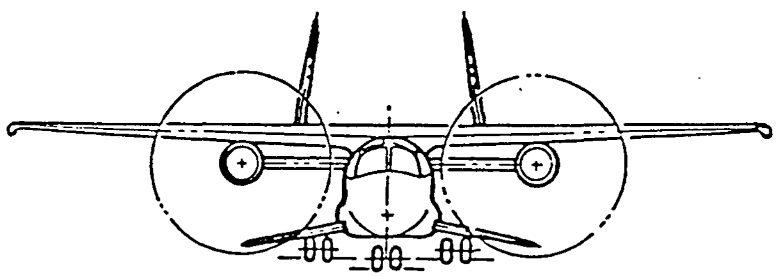
6.1.5 PROPELLER OVERSPEED FOR TAKEOFF AND VERTICAL OPERATIONS

In circumstances where maximum propfan performance is required for takeoff or vertical operations, the use of propfan overspeed yields significant increases in static and low speed thrust. A reasonable tip speed was assumed to be 900 ft./sec., which allows for low speed transition without excessive losses due to exceeding sonic tip velocity. The resulting thrust increase is approximately 30% with an increase of propeller weight proportional to the ratio of the design tip speeds raised to the 0.3 power, i.e., $(900/750)^{0.3} = 1.0662$ or 6.62% weight increase.

6.2 THREE VIEW DRAWINGS

Three views of the STOVL configurations selected in Task IV are shown in Figure 6.2-1 for the multimission STOVL and Figure 6.2-2 for the minimum AEW/ASW STOVL. These aircraft are only configured and analyzed for the propfan engine.

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	96,810 LBS
OVERALL LENGTH	70 FT
FUSELAGE DIAMETER	9.5 FT
WING	
SPAN	83.9 FT
AREA	880.10 FT2
ASPECT RATIO	8.0
TAPER RATIO	.40
SWEEP @ C/4	-20.0 DEG
DIHEDRAL	1.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	0.150
TIP THICKNESS RATIO	0.120
MEAN AERODYNAMIC CHORD	11.1 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	32.1 FT
AREA	218.40 FT2
ASPECT RATIO	4.73
TAPER RATIO	.50
SWEEP @ C/4	16.36 DEG
DIHEDRAL	-10.0 DEG
THICKNESS RATIO	0.100
VERTICAL SURFACE	
SPAN	14.0 FT
AREA	154.0 FT2
ASPECT RATIO	1.27
TAPER RATIO	.375
SWEEP @ C/4	35.8 DEG
THICKNESS RATIO	0.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA. OR THRUST HORSEPOWER (THP) EA.	41,144 LBS
PROPELLER DIAMETER	19.1 FT



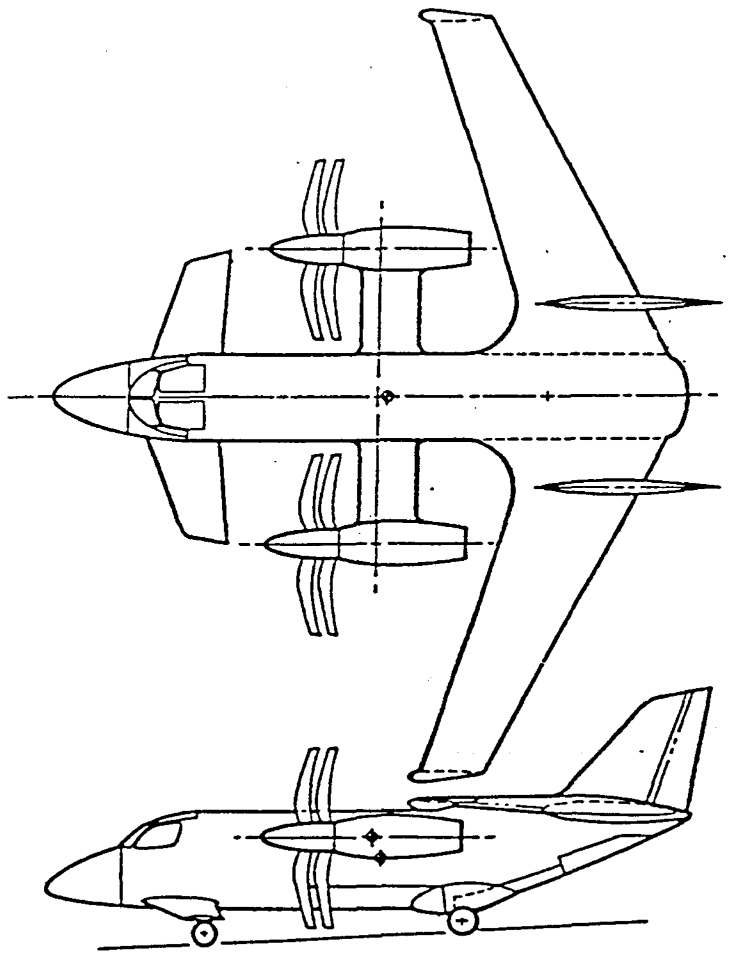
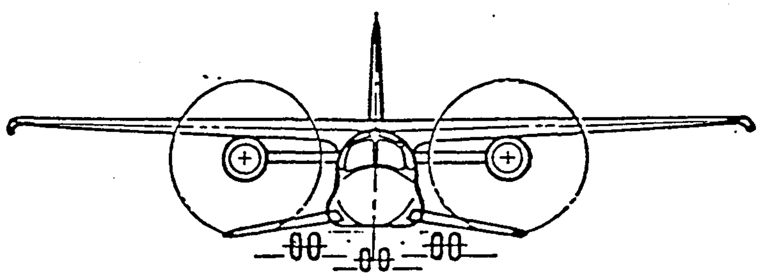


FIGURE 6.2-1 MULTIMISSION STOVL PROPFAN CONFIGURATION (U)

GENERAL SPECIFICATIONS	
MAX DESIGN GROSS WEIGHT	71,660 LBS
OVERALL LENGTH	65 FT
FUSELAGE DIAMETER	8.5 FT
WING	
SPAN	79.9 FT
AREA	754 FT2
ASPECT RATIO	8.5
TAPER RATIO	.40
SWEEP @ C/4	-20.0 DEG
DIHEDRAL	1.0 DEG
INCIDENCE	3.0 DEG
ROOT THICKNESS RATIO	0.150
TIP THICKNESS RATIO	0.120
MEAN AERODYNAMIC CHORD	10.0 FT
HORIZONTAL (CANARD) SURFACE	
SPAN	31.1 FT
AREA	204.30 FT2
ASPECT RATIO	4.73
TAPER RATIO	.50
SWEEP @ C/4	16.4 DEG
DIHEDRAL	-10.0 DEG
THICKNESS RATIO	0.100
VERTICAL SURFACE	
SPAN	14.9 FT
AREA	200.0 FT2
ASPECT RATIO	1.11
TAPER RATIO	.33
SWEEP @ C/4	37.8 DEG
THICKNESS RATIO	0.100
POWERPLANT DATA	
NUMBER (NO) AND TYPE OF ENGINES	(2) PROPFAN (SCALED)
SEA LEVEL STATIC THRUST (SLST) EA. OR THRUST HORSEPOWER (THP) EA.	30,993 LBS
PROPELLER DIAMETER	- 16.5 FT



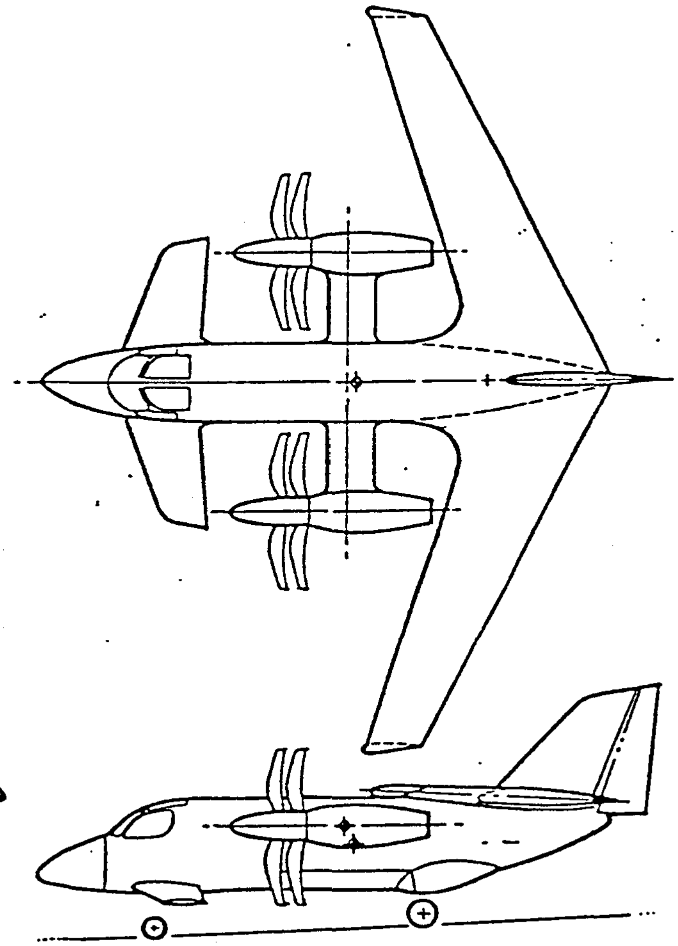


FIGURE 6.2-2 MINIMUM AEW/ASW PROPFAN CONFIGURATION (U)

6.3 STOVL SIZING

The effect of disk loading on aircraft gross weight as thrust/weight ratio increases is shown in Figure 6.3-1. The sizing missions used to size the STOVL configurations were selected to be the same as their CTOL counterparts; tanker for the multimission and AEW for the minimum AEW/ASW. The dashed line representing the CTOL configuration lies above the .4 thrust/weight line because the aircraft requires higher thrust/weight ratios to meet the cruise altitude and speed requirements. The weight trend in this figure does not include thrust losses resulting from the additional bleed required for the hover control or the extra thrust produced by overspeeding the propfan at low speeds. At this point the possibility of a VSTOL aircraft to do the AEW mission is eliminated because it would exceed the 80,000 lb. gross weight limit.

The effect of engine bleed for hover control and overspeeding the propfan is shown in Figure 6.3-2.

Sizing trends for CTOL and VSTOL/STOVL as a function of thrust/weight are presented in Figure 6.3-3. The overlap in the data is due to using overspeed for the VSTOL/STOVL aircraft and not for the CTOL aircraft. Figure 6.3-4 shows that as aircraft thrust/weight increases, engine thrust to weight ratio is decreasing. The CTOL exhibits this same behavior until the physical size of the engine and accessories become constrained to a physical size limit. The effect of aircraft thrust/weight ratio on propeller diameter is shown in Figure 6.3-5.

Final sizing for the multimission and minimum AEW/ASW STOVL aircraft was accomplished by varying takeoff thrust/weight until landing thrust to weight ratio reached 1.1. Figure 6.3-6 and 6.3-7 shows the behavior of takeoff gross weight (solid lines) and landing gross weight (dashed lines) as a function of landing thrust to weight ratio. The carrier design maximum landing weights of the multimission AEW and ASW variants were also examined in Figure 6.3-7. The heaviest variant at the 1.1 landing thrust to weight ratio was ASW. It sized the engines because all the variants have to be capable of vertically landing on the carrier. Note that the engines have to be sized to handle the ASW variant landing weight on an aircraft sized to the tanker mission.

6.4 MISSION PERFORMANCE AND BREAKDOWN BY MISSION LEG

A design mission performance breakdown by mission leg is presented for the STOVL point designs. Alternate mission performance on the AEW, ASW, Tanker, and COD missions is also shown.

6.4.1 MULTIMISSION STOVL

Mission performance data for AEW, ASW, tanker, and COD missions for the multimission STOVL is presented in Figure 6.4.1-1. This aircraft does not meet the time on-station requirements of the ASW mission. Since sizing was accomplished using the same sizing missions as the CTOL configurations, this can be considered as an additional penalty for

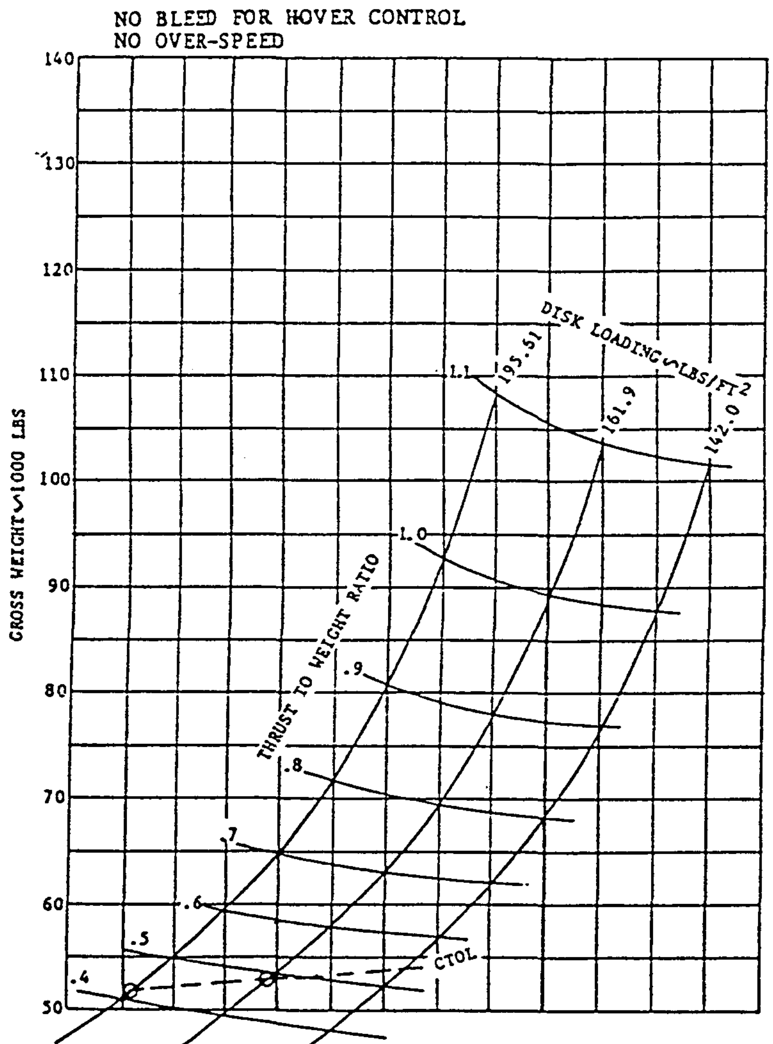


FIGURE 6.3-1 EFFECT OF DISK LOADING & THRUST TO WEIGHT RATIO ON AIRCRAFT GROSS WEIGHT

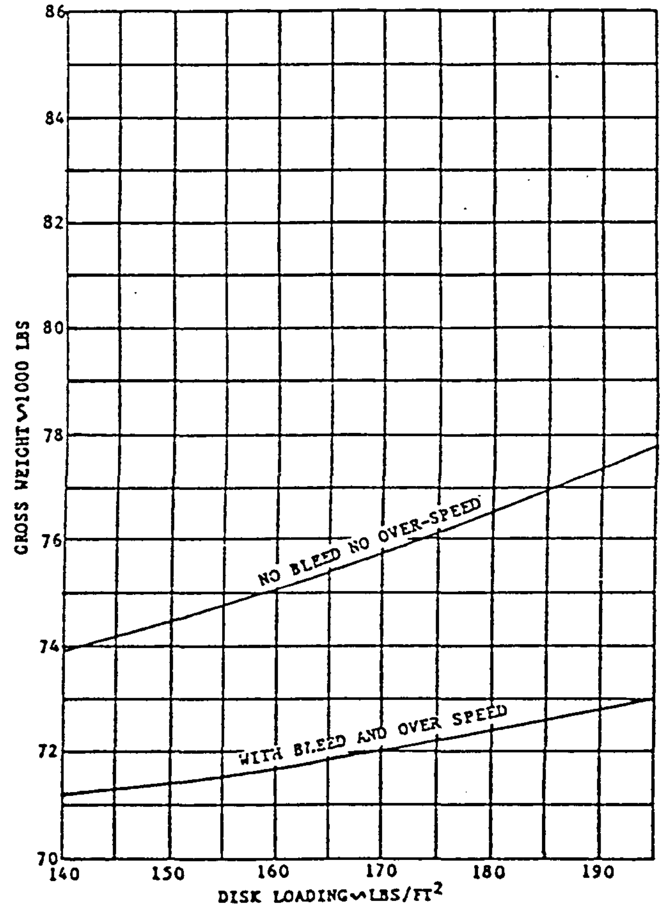


FIGURE 6.3-2 EFFECT OF BLEED & OVERSPEED ON AIRCRAFT GROSS WEIGHT

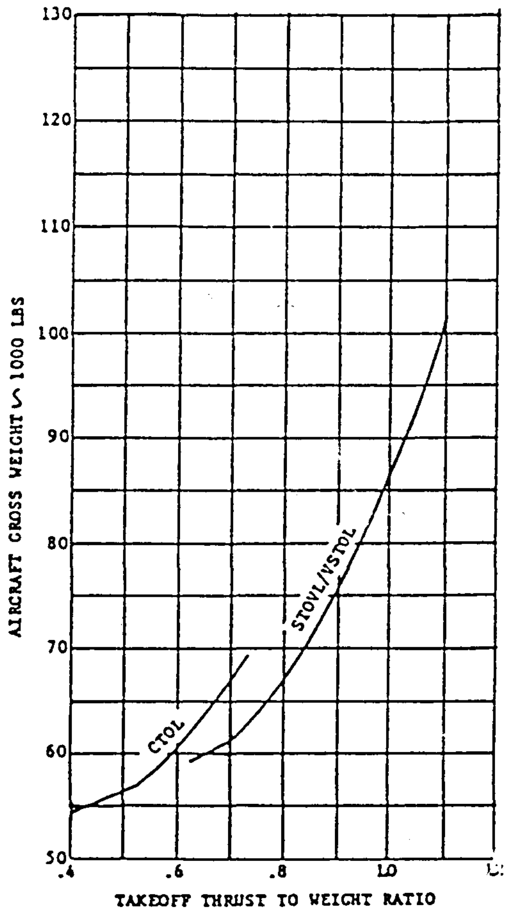


FIGURE 6.3-3 GROSS WEIGHT GROWTH DUE TO TAKEOFF THRUST TO WEIGHT RATIO

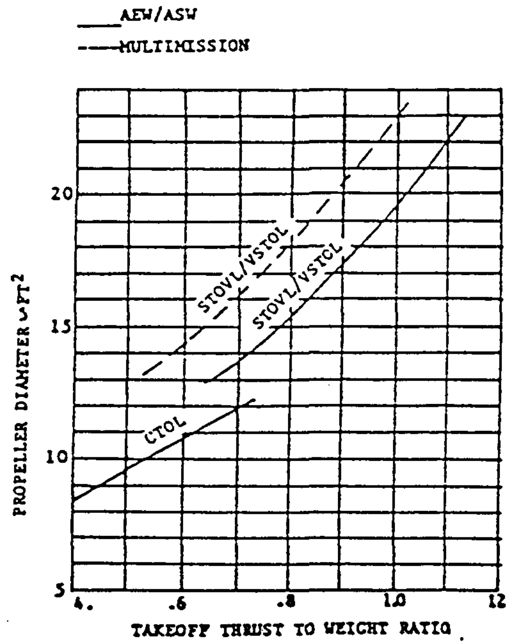


FIGURE 6.3-4 ENGINE THRUST TO WEIGHT BEHAVIOR WITH AIRCRAFT TAKEOFF THRUST TO WEIGHT RATIO

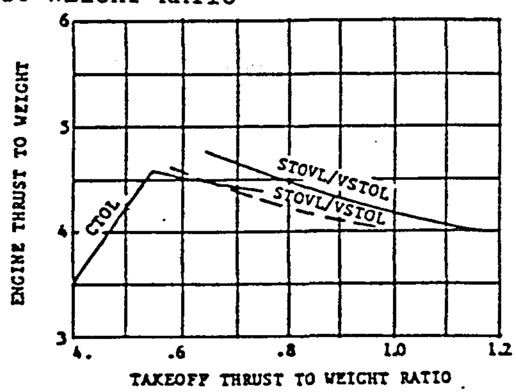


FIGURE 6.3-5 PROPELLER DIAMETER AS A FUNCTION OF AIRCRAFT TAKEOFF THRUST TO WEIGHT RATIO

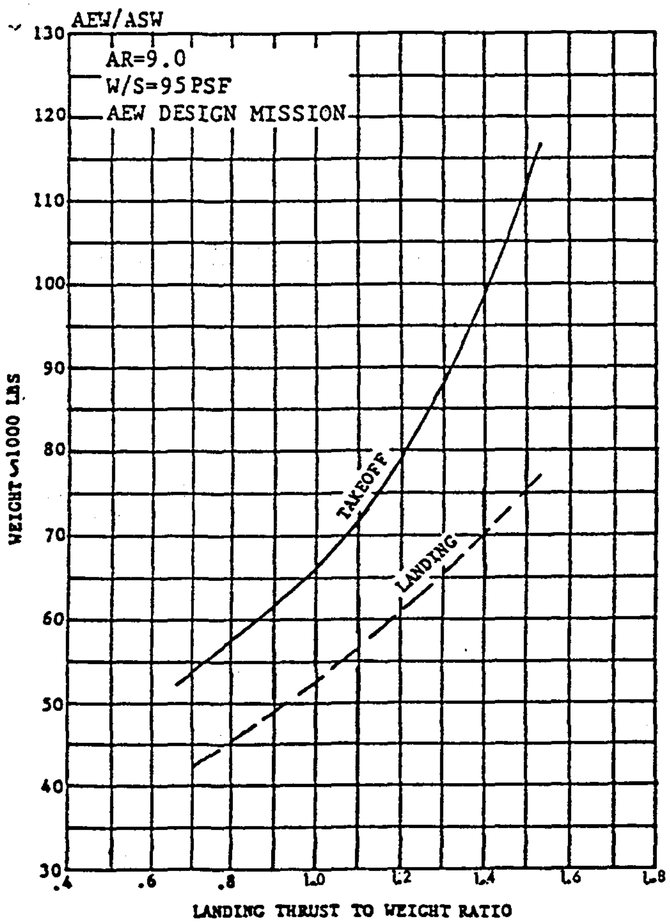


FIGURE 6.3-6 MINIMUM AEW/ASW STOVL SIZING

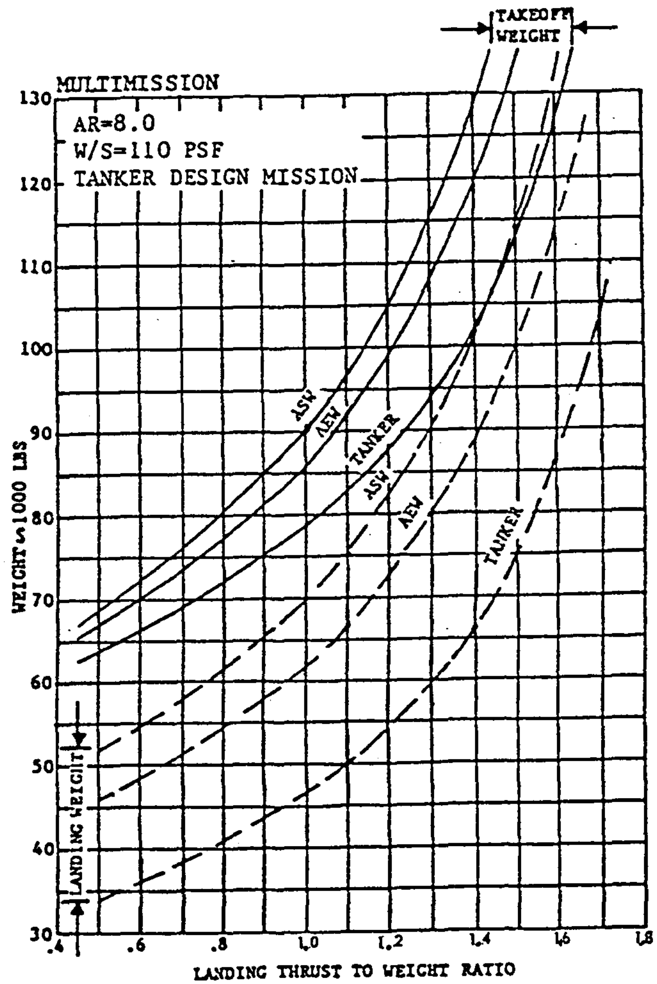


FIGURE 6.3-7 MULTIMISSION STOVL SIZING

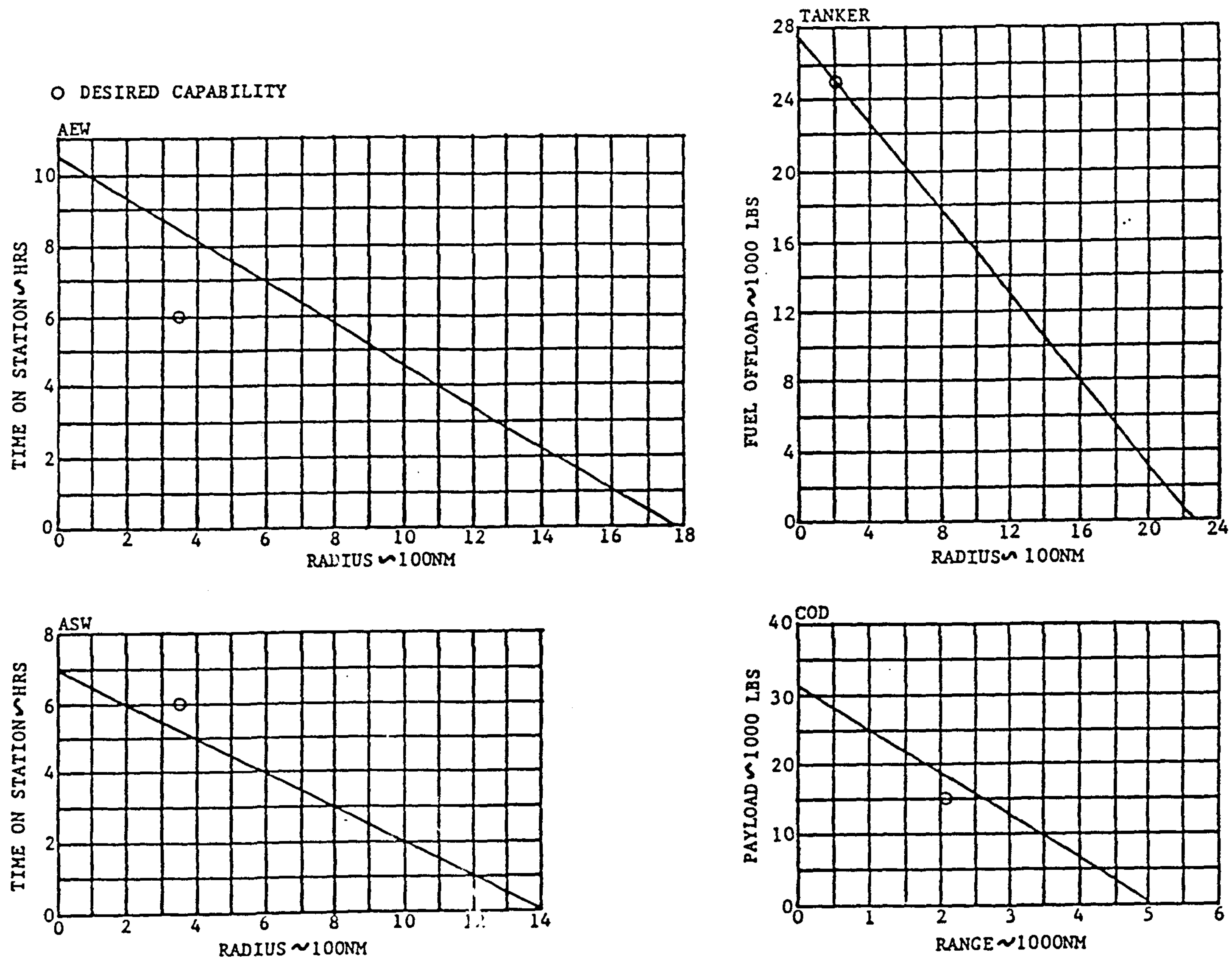


FIGURE 6.4.1-1 MULTIMISSION STOVL PROPFAN MISSION PERFORMANCE

STOVL capability. If the sizing mission were changed to ASW, the additional weight penalty would be approximately 3,700 lb. A mission breakdown by leg is presented in Table 6.4.1-I for the tanker design mission.

6.4.2 MINIMUM AEW/ASW STOVL

Minimum AEW/ASW STOVL mission performance data is presented in Figure 6.4.2-1. Again, the STOVL capability is exacting a more severe penalty on the ASW mission than was found in the CTOL designs of Task III. A breakdown of the AEW design mission by leg is presented in Table 6.4.2-I.

6.5 AIRCRAFT WEIGHT BREAKDOWNS

Detailed weights breakdowns for the multimission STOVL and minimum AEW/ASW are presented in Tables 6.5-I through 6.5-III. A breakdown of the propulsion and structure groups is shown in Table 6.5-I, and the fixed equipment group is shown in Table 6.5-II. The weights breakdowns for common core avionics, mission unique equipment, and payloads are the same as presented in Section 5.2. A summary of aircraft weight breakdown is presented in Table 6.5-III.

6.6 STOVL DRAG BREAKDOWNS

Drag breakdowns of the STOVL configurations on their design missions are presented in Table 6.6-I for the multimission STOVL and Table 6.6-II for the minimum AEW/ASW STOVL. The same information is provided on the STOVL drag breakdowns as was presented on the CTOL configurations. High speed cruise drag polars for the STOVL configurations are presented in Appendix A. These drag data include drag of the stores carried on the design mission.

6.7 WING FOLD AND SPOT FACTOR DRAWINGS

The spot factors presented with the drawings in Figure 6.7-1 were determined using the same ground rules as the CTOL configurations presented in Section 4.9.

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	95929.30	0.00		0.00	0.083
CLIMB	41.42	0.126	94945.03	38278.12	0.675	41.42	0.209
CRUISE	158.58	0.474	93612.11	38278.12	0.685	200.00	0.683
LOITER		1.250	90527.36	25000.00	0.433	200.00	1.933
REFUEL		0.083	64757.84	25000.00	0.665	200.00	2.017
LOITER		1.250	62524.62	25000.00	0.373	200.00	3.267
CLIMB	28.76	0.076	62155.98	47184.09	0.675	228.76	3.343
CRUISE	171.24	0.508	61187.98	47184.09	0.680	400.00	3.851
LOITER		0.333	60398.13	0.00	0.283	400.00	4.184

DISTANCE OUT AT END REFUEL = 200.00 NAM
TOTAL MISSION RANGE = 400.00 NAM
TOTAL MISSION FUEL = 10613.16 LBS
TOTAL FUEL RESERVES = 1018.84 LBS
TOTAL MISSION TIME = 4.18 HRS
PAYLOAD = 0.00 LBS
TOTAL FUEL OFFLOAD = 25000.00 LBS

TABLE 6.4.1-I MISSION LEG BREAKDOWN - MULTIMISSION STOVL ON TANKER MISSION

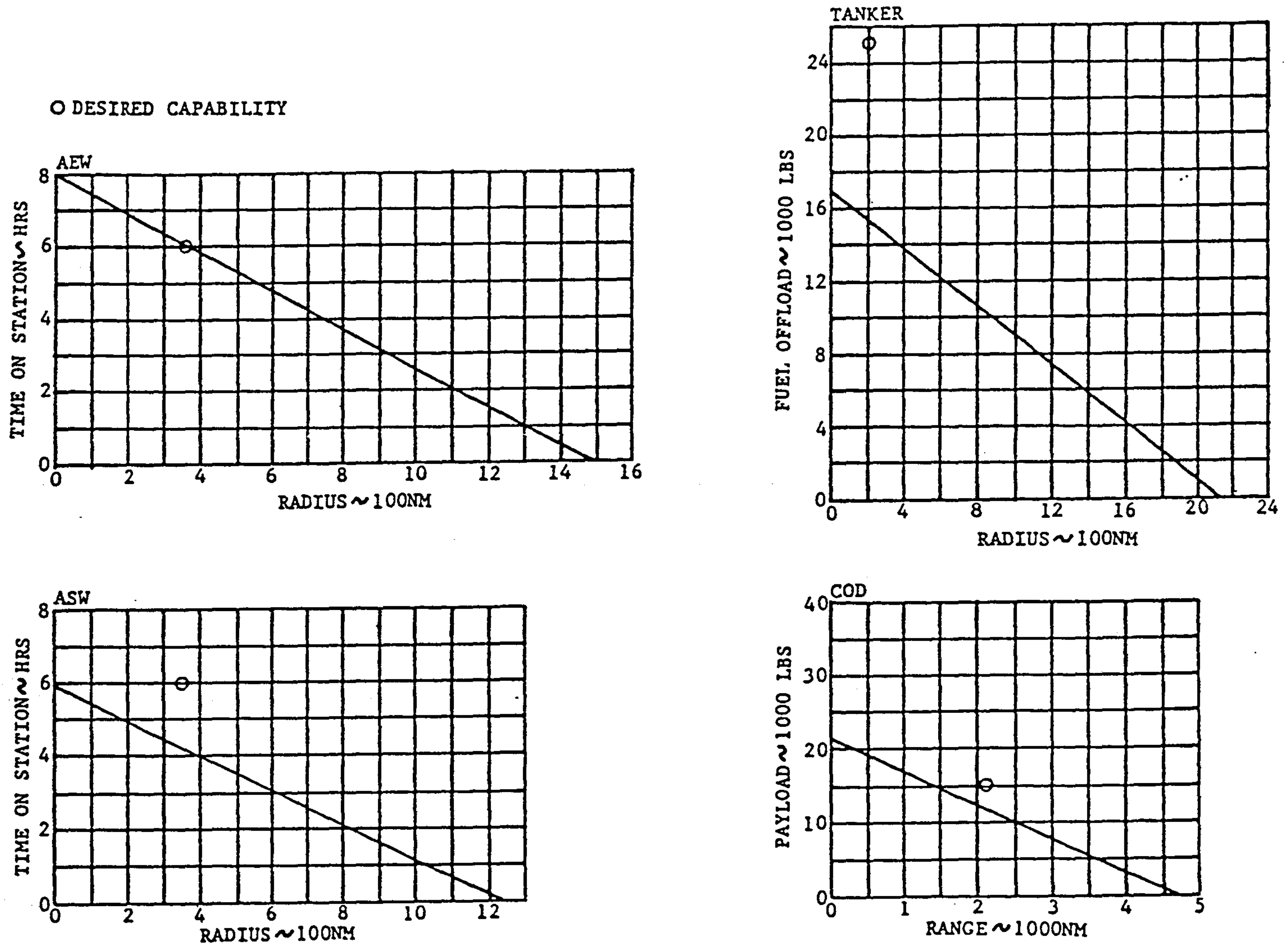


FIGURE 6.4.2-1 MINIMUM AEW/ASW STOVL PROPFAN MISSION PERFORMANCE

PARAMETERS AT END OF SEGMENT

SEGMENT	SEGMENT RANGE NAM	SEGMENT TIME HRS	GROSS WEIGHT LBS	ALTITUDE FT	MACH	TOTAL RANGE NAM	TOTAL TIME HRS
TAKEOFF		0.083	70813.95	0.00		0.00	0.083
CLIMB	39.82	0.118	70057.78	39835.70	0.696	39.82	0.202
CRUISE	285.29	0.754	68530.70	39835.70	0.708	325.11	0.956
CLIMB	0.38	0.001	68527.16	40000.00	0.696	325.49	0.957
CRUISE	24.51	0.061	68405.52	40000.00	0.709	350.00	1.017
LOITER		6.000	58125.53	40000.00	0.530	350.00	7.017
CLIMB	7.97	0.020	58057.46	43943.84	0.696	357.97	7.037
CRUISE	342.14	0.901	56528.22	43943.84	0.702	700.00	7.938
LOITER		0.333	55846.22	0.00	0.286	700.00	0.272

TOTAL MISSION RANGE = 700.00 NAM
TOTAL MISSION FUEL = 15122.20 LBS
TOTAL FUEL RESERVES = 1513.80 LBS
TOTAL MISSION TIME = 8.27 HRS
PAYLOAD = 776.00 LBS

TABLE 6.4.2-I MISSION LEG BREAKDOWN - AEW/ASW STOVL ON AEW MISSION

	STOVL AEW/ASW	STOVL MULTIMISSION
ENGINE TYPE	PROPFAN	PROPFAN
DESIGN MISSION	AEW	TANKER
PROPULSION GROUP		
PRIMARY ENGINES	13989	19682
EBU	1352	1396
FUEL SYSTEM	518	1033
ENGINE/PILOT CONTROL LINK	60	60
TOTAL	15919 LBS	22171 LBS
STRUCTURES GROUP		
WING	5636	6148
HORIZONTAL TAIL	823	880
VERTICAL TAIL	648	952
FUSELAGE	5490	8237
LANDING/ARRESTING GEAR	4203	5678
ENGINE STRUTS	1232	1597
ENGINE NACELLES	730	1295
NUCLEAR HARDENING	751	751
WING FOLD PENALTY	1000	1000
WING HARD POINTS (4)	100	100
DOUBLE HINGED RUDDER	50	50
SOUND PROOFING	250	250
AIR REFUELING PROBE	60	60
AIR REFUELING FUEL SYS.	60	60
TOTAL	21033 LBS	27058 LBS

TABLE 6.5-I STOVL WEIGHTS - PROPULSION AND STRUCTURE

	STOVL AEW / ASW	STOVL MULTIMISSION
ENGINE TYPE	PROPFAN	PROPFAN
DESIGN MISSION	AEW	TANKER
FIXED EQUIPMENT GROUP		
FLIGHT CONTROLS	1286	1526
HYDRAULICS	163	177
PNEUMATICS	148	154
ELECTRICALS	2600	2480
CREW ACCOMMODATIONS	848	404
CARGO ACCOMMODATIONS	16	25
EMERGENCY EQUIPMENT	364	378
AIR CONDITIONING	993	1119
ANTI-ICING	386	410
APU	330	330
COMMON CORE AVIONICS	767	767
MISSION UNIQUE AVIONICS	4180	451
AVIONICS INSTALLATION (21%)	1039	256
LAUNCHERS AND RACKS	344	---
MISSION CREW CONSOLES	1200	---
EXTERNAL REFUELING POD	---	700
FLIGHT / ENGINE / FUEL INSTRUMENTS	600	600
TOTAL	15264 LBS	9777 LBS

TABLE 6.5-II STOVL WEIGHTS - FIXED EQUIPMENT

	STOVL AEW/ASW	STOVL MULTIMISSION
ENGINE TYPE	PROPFAN	PROPFAN
DESIGN MISSION	AEW	TANKER
PROPULSION GROUP	15919	22171
STRUCTURES GROUP	21033	27058
FIXED EQUIPMENT GROUP	15264	9777
STANDARD AND OPERATIONAL ITEMS		
CREW AND EQUIPMENT	1500	500
TRAPPED OIL AND FUEL	528	665
OPERATIONAL EMPTY WEIGHT	54244 LBS	60171 LBS
PAYLOAD		
SIDEWINDERS (4)	776	---
HARPOONS (2)	---	---
MK-60 MINES (2)	---	---
SONOBUOYS (60)	---	---
FUEL OFFLOAD	---	25000
MISSION FUEL AND RESERVES	16640	11639
TAKEOFF MAXIMUM GROSS WEIGHT	71660 LBS	96810 LBS

TABLE 6.5-III STOVL WEIGHTS - AIRCRAFT WEIGHT BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

S_{REF} = 880.1

MACH NO. = 0.66 CL = 0.45 RE/FT = 0.22328E+07 ALT = 0.25000E+05

GEOMETRY TOTAL DRAG	PARASITE DRAG	FLAT PLATE FRICTION DRAG	PRESSURE DRAG	DRAG RISE	VORTEX DRAG
0.031406	0.020930	0.011957	0.008973	0.000178	0.010298
COMPONENT DRAG					INDUCED DRAG 0.009239
WING	0.005190	0.003357	0.001833	0.0	TRIM DRAG 0.001059
BODY	0.005999	0.004135	0.001865	0.0	
HORZ TAIL	0.001207	0.000884	0.000323	0.0	
VERT TAIL	0.002124	0.001528	0.000595	0.0	
NACELLE	0.002844	0.001075	0.001769	0.000178	
STRUT	0.000189	0.000114	0.000075	0.0	
STORES	0.000863	0.000863	0.0	0.0	
EXCRESCENCE	0.002514				

TABLE 6.6-I MULTIMISSION STOVL PROPFAN DRAG BREAKDOWN

DRAG BREAKDOWN AT ENGINE CRUISE SIZING CONDITION

S_{REF} = 754.3

MACH NO. = 0.63 CL = 0.88 RE/FT = 0.11953E+07 ALT = 0.40000E+05

GEOMETRY TOTAL DRAG	PARASITE DRAG	FLAT PLATE FRICTION DRAG	PRESSURE DRAG	DRAG RISE	VORTEX DRAG
0.059029	0.026120	0.013961	0.012159	0.0	0.032909
COMPONENT DRAG					INDUCED DRAG 0.030319
WING	0.009498	0.003844	0.005654	0.0	TRIM DRAG 0.002590
BODY	0.004338	0.003546	0.000792	0.0	
HORZ TAIL	0.001466	0.001074	0.000392	0.0	
VERT TAIL	0.001914	0.001377	0.000536	0.0	
NACELLE	0.001814	0.001020	0.000795	0.0	
STRUT	0.001663	0.000980	0.000683	0.0	
STORES	0.002120	0.002120	0.0	0.0	
EXCRESCENCE	0.003307				

TABLE 6.6-II AEW/ASW STOVL PROPFAN DRAG BREAKDOWN

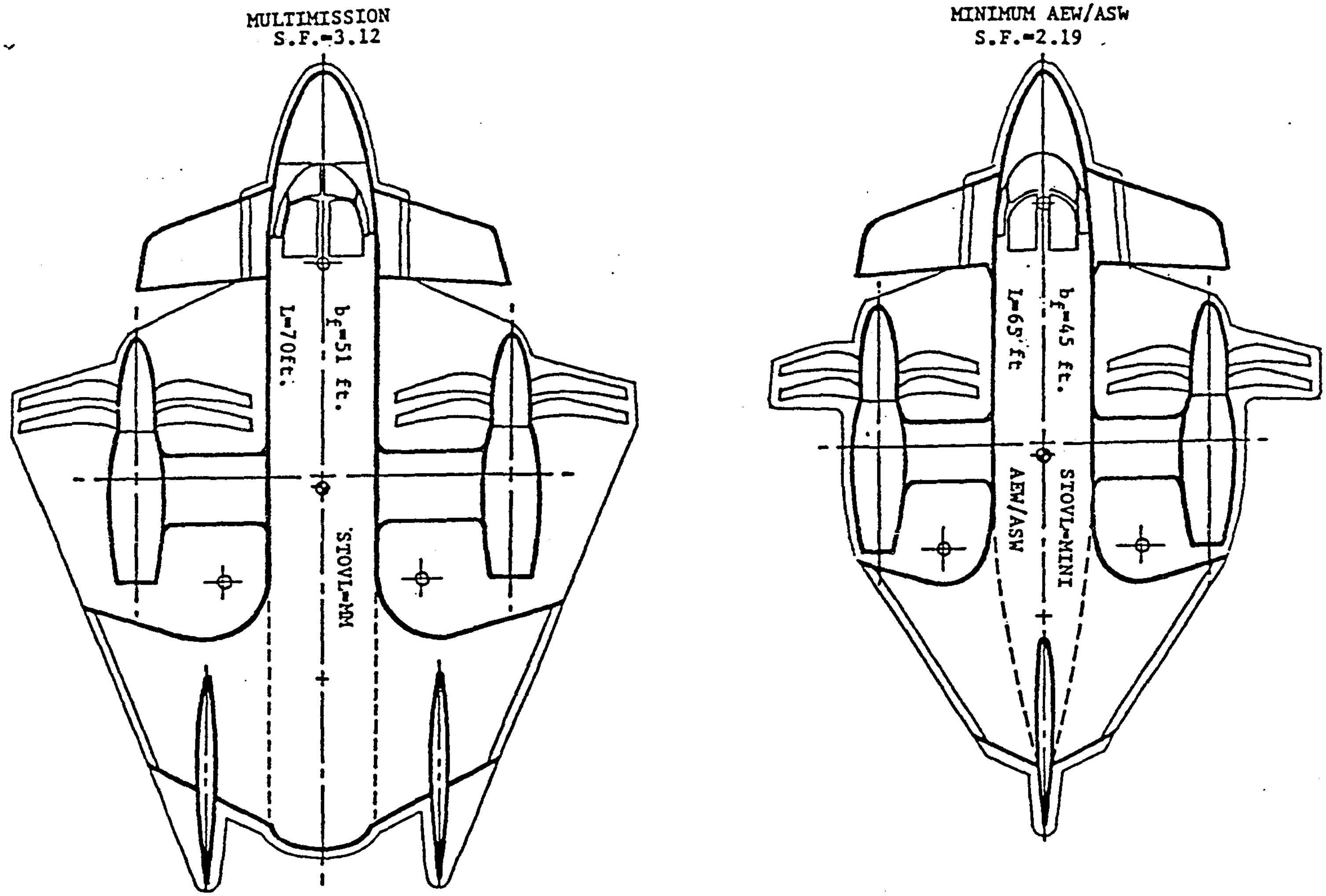


FIGURE 6.7-1 STOVL SPOTTING FACTORS

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7.0 TASK V - ADVANCED TECHNOLOGY RESEARCH PLAN

The following paragraphs outline the areas of research which can logically be conducted by BMAC or other airframe companies. Items which are generally in the engine companies sphere of interest are not addressed since they would tend to be a repeat of recommendations put forth in the APET series of studies.

7.1 ADVANCED TECHNOLOGY RESEARCH RECOMMENDATIONS

Two specific recommendations are made relating to the propfan/airframe installation effects. One recommendation is related to investigating "state-of-the-art" engine cycle effects on the MPSNA-MAPS life cycle cost. The other recommendation is for investigation of V/STOL/STOVL propfan reaction control systems.

7.1.1 PROPFAN/AIRFRAME INSTALLATION GUIDELINES

The purpose of this effort is to collect data on propfan engine integration with respect to the fuselage or any aerodynamic surface. More specifically for fuselage mounted configurations, this effort would formulate guidelines relating propfan engine placement with respect to upstream or downstream aerodynamic surfaces, coincident aerodynamic surfaces, and the fuselage surface. Also for wing mounted configurations, guidelines would be developed relating propfan efflux over and under the wing as well as position of a canard wake into the inlet and propeller planes.

To accomplish this effort, it is suggested that it be approached from four ways:

1) sponsor national meeting sessions devoted to propfan installation.
2) make a survey of airframe companies.
3) make a survey of engine/propfan companies.
4) make a search of national and international literature/data.

The schedule, shown in Figure 7.1-1, indicates this activity being completed in three years. In actuality, the activity could continue indefinitely on a sustaining basis but with the first publication within the indicated three year period. Cost for that initial effort should be based on 1/3 man year level for first two years and one man level for the third year for final documentation which equates to approximately $210,000 in 1986 dollars.

7.1.2 PROPFAN ANALYSIS CODES FOR AIRFRAME INSTALLATION

The purpose of this effort is to develop analytical tools to predict non-uniform flow effects on the engine/propfan performance. The scope of this effort should include the effects of maneuvering flight, low speed flight (high angles of attack), thrust effects due to asymmetric and/or angular wake flow ingestion, and inlet pressure/temperature rise/decrement for tractor installations.

The plan includes conducting a survey of existing propfan analysis codes, selecting one and enhancing it as required to meet all of the objectives. Figure 7.1-1 shows that approximately two people working for two years will be required to accomplish this activity. The cost is based on two men for two years which equates to approximately $500,000 in 1986 dollars.

7.1.3 PROPFAN ENGINE CYCLE OPTIMIZATION FOR MPSNA-MAPS

As implied by the title, it may be advantageous to examine lower gas generator technology levels for a Navy application that has approximately 400 to 450 hrs. per year flight time vs. the 2000+ hrs. per year flight time of the commercial aircraft for which the higher technology gas generators were designed. The basis will be the aircraft life cycle cost (LCC) as a function of technology level with approximately three levels being examined. The primary variables will be overall pressure ratio and turbine inlet temperature.

The plan is to use the Navy/NASA Engine Program (NNEP) with its weight and cost codes to generate approximately three levels of technology with attendant cost. This data applied to the vehicle and mission in the Airplane Synthesis and Mission Program (ASAMP) will yield information necessary to determine initial aircraft cost and operating and support costs. With this data input to an existing LCC model code, the LCC effects of engine technology can be quantified.

Two people for approximately 10 months will be required to accomplish this activity (Figure 7.1-1). The approximate cost will be $210,000 in 1986 dollars.

7.1.4 PROPFAN HOVER CONTROL SYSTEMS FOR V/STOL OR STOVL

The increasing interest in propfan V/STOL and STOVL makes this investigation important. Since the gas generators driving the propfan are relatively small in comparison to turbofan or turbojet configurations, the means to accomplish reaction hover control becomes more critical.

The plan to accomplish this study includes several means of control, all of which impose some thrust/drag penalty on the aircraft configuration. Among the possibilities to be examined are gas generator bleed with no form of augmentation; gas generator bleed with ejector augmentation; gas generator bleed and burn (afterburning augmentation); the placing of aerodynamic control surfaces in the propfan efflux; and the implementation of cyclic pitch of the propfan blades.

This activity, as noted in Figure 7.1-1, will require two people for approximately one year and yields an approximate cost of $250,000 in 1986 dollars.

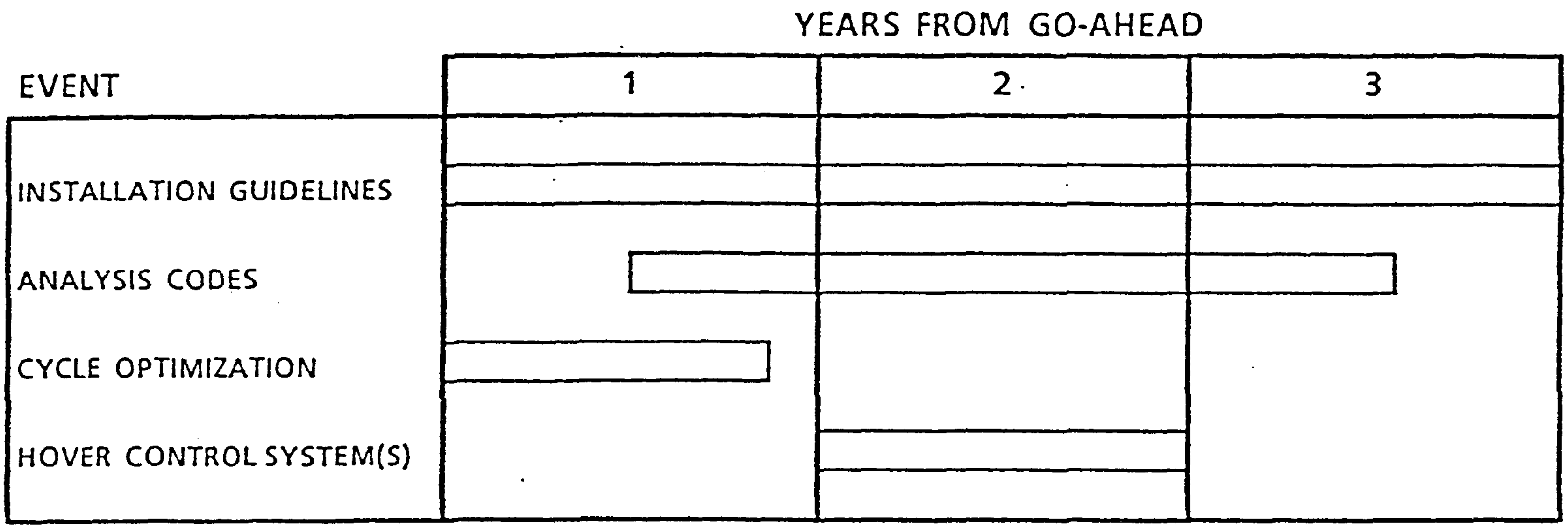

FIGURE 7.1-1 ADVANCED TECHNOLOGY RESEARCH SCHEDULE

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8.0 LIFE CYCLE COST, FIGURE OF MERIT, AND SUMMARY

The life cycle cost (LCC) of the CTOL and STOVL point designs and figures of merit are addressed in the sections below. The results of this study are then summarized.

8.1 LIFE CYCLE COST

The methodology used to develop the operating and support costs is presented in the following sections.

8.1.1 MARKET POTENTIAL

The baseline market potential and the adjustment for each mission variant is used to compute the adjusted market potential in the manner discussed below.

8.1.1.1 BASELINE MARKET POTENTIAL

The baseline market projection for a 1993 fleet utilizing current fleet aircraft is shown in Table 8.1.1.1-I. It assumes one-for-one replacement of the current support aircraft fleet. This table was submitted with the groundrules and assumptions letter which was approved.

The mission performance parameters used to adjust the baseline market potential are shown in Table 8.1.1.1-II.

8.1.1.2 AEW MARKET POTENTIAL ADJUSTMENT

Tables 8.1.1.2-I through 8.1.1.2-III show the market adjustment buildup of the AEW mission aircraft. The method used is based on the Boeing multiple element station keeping model. The baseline mission provides a 550 NM detection range for a 120° threat sector. This requires a 350 NM station range and three orbits. The utilization rate used for both new and old aircraft is 16 hours per day. The number of mission capable aircraft required is calculated in Table 8.1.1.2-I as:

$$\frac{\text{(NUMBER OF ORBITS REQUIRED)*(MISSION TIME)}}{\text{(UTILIZATION RATE)* (TIME ON-STATION)}} * \text{(24HOURS/DAY)}$$

This number represents ideal aircraft with 100% reliability. The adjusted operational deployment, Table 8.1.1.2-II, is calculated by first calculating the number of real aircraft with 85% reliability required to supply this number of ideal aircraft with a 95% confidence level. Appendix B presents the derivation of this calculation. A 10% reserve is added to the calculated number of real aircraft.

Finally, adjusted operational deployment is calculated as:

$$\frac{\text{(NUMBER OF NEW AIRCRAFT REQUIRED)}}{\text{(NUMBER OF OLD AIRCRAFT REQUIRED)}} * \text{BASELINE OPERATIONAL DEPLOYMENT}$$

MISSION	OPERATIONAL DEPLOYMENT	REPLACEMENT AIR GROUP (RAG)	PIPELINE	ATTRITION	TOTAL LIFE CYCLE PROCUREMENT
AEW	75	19	11	34	139
TANKER	82	21	12	37	152
ASW	128	32	19	58	237
EW	60	15	9	27	111
COD	15	4	2	7	28

OPERATIONAL DEPLOYMENT FOR 15 CARRIER FLEET

RAG CALCULATED AS 25% OF OPERATIONAL DEPLOYMENT

PIPELINE CALCULATED AS 15% OF OPERATIONAL DEPLOYMENT

ATTRITION CALCULATED AS 45% OF OPERATIONAL DEPLOYMENT (BASED ON 3% PER YEAR FOR 15 YEARS)

THE ASUW, MIW, ESM, C^3I, AND AAW MISSIONS ARE CONSIDERED DERIVATIVES OF THE PRIMARY SUPPORT MISSIONS

INCLUDES ONLY U.S. NAVY PROCUREMENT

AIRCRAFT REPLACED ON A ONE-FOR-ONE BASIS

TABLE 8.1.1.1-I BASELINE MARKET POTENTIAL - 1993 FLEET PROJECTION OF CURRENT FLEET AIRCRAFT

AIRCRAFT	AEW MISSION (350 nmi)		ASW MISSION (350 nmi)		TANKER MISSION OFFLOAD (200 nmi)	COD MISSION (1397 nmi)	
	BLOCK SPEED	TOS	BLOCK SPEED	TOS		PAYLOAD	BLOCK SPEED
MULTIMISSION - TF	367	8.1	363	6.70	25,300	23,000	369
MULTIMISSION - PF	370	10.0	367	7.65	25,000	23,200	380
MULTIMISSION - UDF	374	10.3	373	8.20	25,000	23,400	378
MIN AEW/ASW - TF	383	6.0	382	4.95	17,400	15,800	398
MIN AEW/ASW - PF	370	6.0	369	4.95	15,000	14,000	382
MIN AEW/ASW - UDF	376	6.0	374	5.00	15,600	14,400	391
MULTIMISSION - PF STOVL	394	8.7	391	6.00	25,000	22,500	396
MIN AEW/ASW - PF STOVL	402	6.0	401	4.25	15,700	14,750	404
BASELINE (REF.)	220	2.0	344	4.25	17,000	10,000	250

TABLE 8.1.1.1-II SIGNIFICANT MISSION PERFORMANCE PARAMETERS

AIRCRAFT	BLOCK SPEED	TOS	MISSION TIME	MISSION CAPABLE AIRCRAFT	
				CALCULATED	ROUNDED UP
MULTIMISSION - TF	367	8.1	10.0	5.56	6
MULTIMISSION - PF	370	10.0	11.9	5.36	6
MULTIMISSION - UDF	374	10.3	12.2	5.33	6
MIN AEW/ASW - TF	383	6.0	7.8	5.85	6
MIN AEW/ASW - PF	370	6.0	7.9	5.93	6
MIN AEW/ASW - UDF	376	6.0	7.9	5.93	6
MULTIMISSION - PF STOVL	394	8.7	10.5	5.43	6
MIN AEW/ASW - PF STOVL	402	6.0	7.7	5.78	6
BASELINE (REF.)	220	2.0	5.2	11.70	12

TABLE 8.1.1.2-I AEW MISSION CAPABLE AIRCRAFT REQUIRED

AIRCRAFT	IDEAL AIRCRAFT REQUIRED	POOL AIRCRAFT REQUIRED	+ 10% RESERVE	RATIO	ADJUSTED OPERATIONAL DEPLOYMENT	
					CALCULATED	ROUNDED
MULTIMISSION - TF MULTIMISSION - PF MULTIMISSION - UDF MIN AEW/ASW - TF MIN AEW/ASW - PF MIN AEW/ASW - UDF MULTIMISSION - PF STOVL MIN AEW/ASW - PF STOVL	6	9	10	0.526	39.5	40
BASELINE (REF.)	12	17	19	1.000	75.0	75

TABLE 8.1.1.2-II AEW ADJUSTED OPERATIONAL DEPLOYMENT

AIRCRAFT	OPERATIONAL DEPLOYMENT	REPLACEMENT AIR GROUP (RAG)	PIPELINE	ATTRITION	TOTAL LIFE CYCLE PROCUREMENT
MULTIMISSION - TF MULTIMISSION - PF MULTIMISSION - UDF MIN AEW/ASW - TF MIN AEW/ASW - PF MIN AEW/ASW - UDF MULTIMISSION - PF STOVL MIN AEW/ASW - PF STOVL	40	10	6	18	74
BASELINE (REF.)	75	19	11	34	139

TABLE 8.1.1.2-III AEW ADJUSTED MARKET POTENTIAL

The adjusted market potential, Figure 8.1.1.2-3, is calculated using the same ratios as the baseline market potential.

8.1.1.3 ASW MARKET POTENTIAL ADJUSTMENT

The new ASW aircraft time on-station is chosen so the (weapons payload)/(time on-station) ratio matches that of the S-3A baseline mission. The baseline mission has a 350 NM station radius.

The adjusted operational deployment, Table 8.1.1.3-I, is calculated as:

$$\frac{\frac{\text{(MISSION TIME)}}{\text{(TIME ON-STATION)}}\text{ NEW AIRCRAFT}}{\frac{\text{(MISSION TIME)}}{\text{(TIME ON-STATION)}}\text{ OLD AIRCRAFT}} \text{ *BASELINE OPERATIONAL DEPLOYMENT}$$

The adjusted market potential, Table 8.1.1.3-I, is calculated using the same ratios as the baseline market potential.

8.1.1.4 TANKER MARKET POTENTIAL ADJUSTMENT

The tanker fuel offload available during a 2-1/2 hour hold at a 200 NM radius is used to determine the market potential adjustment.

The adjusted operational deployment, Table 8.1.1.4-I, is calculated as:

$$\frac{\text{OFFLOAD OF OLD AIRCRAFT}}{\text{OFFLOAD OF NEW AIRCRAFT}} * \text{ BASELINE OPERATIONAL DEPLOYMENT}$$

The adjusted market potential, shown in Table 8.1.1.4-II, is calculated using the same ratios as the baseline market potential.

8.1.1.5 COD MARKET POTENTIAL ADJUSTMENT

The COD payload and block speed capabilities for a 1397 NM range mission is used to determine the market potential adjustment. This is the maximum range at which the C-2 aircraft can deliver its payload.

The adjusted operational deployment, Table 8.1.1.5-I, is calculated as:

$$\frac{\text{PAYLOAD*BLOCK SPEED OF OLD AIRCRAFT}}{\text{PAYLOAD*BLOCK SPEED OF NEW AIRCRAFT}} * \text{ BASELINE OPERATIONAL DEPLOYMENT}$$

The adjusted market potential, shown in Table 8.1.1.5-II, is calculated using the same ratios as the baseline market potential.

8.1.1.6 ADJUSTED MARKET POTENTIAL

Table 8.1.1.6-I summarizes the adjusted market potential. It shows the total life cycle procurement from the preceding adjusted market

AIRCRAFT	BLOCK SPEED	TOS	MISSION TIME	RATIO	ADJUSTED OPERATIONAL DEPLOYMENT	
					CALCULATED	ROUNDED UP
MULTIMISSION - TF	363	6.70	8.63	0.872	111.62	112
MULTIMISSION - PF	367	7.65	9.56	0.846	108.29	109
MULTIMISSION - UDF	373	8.20	10.08	0.832	106.50	107
MIN AEW/ASW - TF	382	4.95	6.78	0.927	118.66	119
MIN AEW/ASW - PF	369	4.95	6.85	0.937	119.94	120
MIN AEW/ASW - UDF	374	5.00	6.87	0.930	119.04	120
MULTIMISSION - PF STOVL	391	6.00	7.79	0.879	112.51	113
MIN AEW/ASW - PF STOVL	401	4.25	6.00	0.955	122.24	123
BASELINE (REF.)	344	4.25	6.28	1.000	128.00	128

TABLE 8.1.1.3-I ASW ADJUSTED OPERATIONAL DEPLOYMENT

AIRCRAFT	OPERATIONAL DEPLOYMENT	REPLACEMENT AIR GROUP (RAG)	PIPELINE	ATTRITION	TOTAL LIFE CYCLE PROCUREMENT
MULTIMISSION - TF	112	28	17	50	207
MULTIMISSION - PF	109	27	16	49	201
MULTIMISSION - UDF	107	27	16	48	198
MIN AEW/ASW - TF	119	30	18	54	221
MIN AEW/ASW - PF	120	30	18	54	222
MIN AEW/ASW - UDF	120	30	18	54	222
MULTIMISSION - PF STOVL	113	28	17	51	209
MIN AEW/ASW - PF STOVL	123	31	18	55	227
BASELINE (REF.)	128	32	19	58	237

TABLE 8.1.1.3-II ASW ADJUSTED MARKET POTENTIAL

AIRCRAFT	OFFLOAD	RATIO	ADJUSTED OPERATIONAL DEPLOYMENT	
			CALCULATED	ROUNDED UP
MULTIMISSION - TF	25,300	0.672	55.10	56
MULTIMISSION - PF	25,000	0.680	55.76	56
MULTIMISSION - UDF	25,000	0.680	55.76	56
MIN AEW/ASW - TF	17,400	0.977	80.11	81
MIN AEW/ASW - PF	15,000	1.133	92.91	93
MIN AEW/ASW - UDF	15,600	1.090	89.38	90
MULTIMISSION - PF STOVL	25,000	0.680	55.76	56
MIN AEW/ASW - PF STOVL	15,700	1.083	88.81	89
BASELINE (REF.)	17,000	1.000	82.00	82

TABLE 8.1.1.4-I TANKER ADJUSTED OPERATIONAL DEPLOYMENT

AIRCRAFT	OPERATIONAL DEPLOYMENT	REPLACEMENT AIR GROUP (RAG)	PIPELINE	ATTRITION	TOTAL LIFE CYCLE PROCUREMENT
MULTIMISSION - TF	56	14	8	25	103
MULTIMISSION - PF	56	14	8	25	103
MULTIMISSION - UDF	56	14	8	25	103
MIN AEW/ASW - TF	81	20	12	36	149
MIN AEW/ASW - PF	93	23	14	42	172
MIN AEW/ASW - UDF	90	23	14	41	168
MULTIMISSION - PF STOVL	56	14	8	25	103
MIN AEW/ASW - PF STOVL	89	22	13	40	164
BASELINE (REF.)	82	21	12	37	152

TABLE 8.1.1.4-II TANKER ADJUSTED MARKET POTENTIAL

AIRCRAFT	PAYLOAD	BLOCK SPEED	BLOCK SPEED X PAYLOAD	RATIO	ADJUSTED OPERATIONAL DEPLOYMENT	
					CALCULATED	ROUNDED UP
MULTIMISSION - TF	23,000	369	8487000	0.295	4.43	5
MULTIMISSION - PF	23,200	380	8816000	0.284	4.26	5
MULTIMISSION - UDF	23,400	378	8845200	0.283	4.25	5
MIN AEW/ASW - TF	15,800	398	6288400	0.398	5.97	6
MIN AEW/ASW - PF	14,000	382	5348000	0.467	7.01	8
MIN AEW/ASW - UDF	14,400	391	5630400	0.444	6.66	7
MULTIMISSION - PF STOVL	22,500	396	8910000	0.281	4.22	5
MIN AEW/ASW - PF STOVL	14,750	404	5959000	0.420	6.30	7
BASELINE (REF.)	10,000	250	2500000	1.000	15.00	15

TABLE 8.1.1.5-I COD ADJUSTED OPERATIONAL DEPLOYMENT (RANGE=1397 NM)

AIRCRAFT	OPERATIONAL DEPLOYMENT	REPLACEMENT AIR GROUP (RAG)	PIPELINE	ATTRITION	TOTAL LIFE CYCLE PROCUREMENT
MULTIMISSION - TF	5	1	1	2	9
MULTIMISSION - PF	5	1	1	2	9
MULTIMISSION - UDF	5	1	1	2	9
MIN AEW/ASW - TF	6	2	1	3	12
MIN AEW/ASW - PF	8	2	1	4	15
MIN AEW/ASW - UDF	7	2	1	3	13
MULTIMISSION - PF STOVL	5	1	1	2	9
MIN AEW/ASW - PF STOVL	7	2	1	3	13
BASELINE (REF.)	15	4	2	7	28

TABLE 8.1.1.5-II COD ADJUSTED MARKET POTENTIAL

potential figures for each mission type. The EW mission aircraft are replaced on a one-for-one basis. The current fleet aircraft have sufficient capability to minimize the number of aircraft required for the examined missions. The baseline aircraft is included for reference. The numbers include U.S. Navy procurement only.

8.1.2 AVERAGE TOTAL SPOTS PER CARRIER

The average spots per carrier is presented in Table 8.1.2-I. Spot factor was determined per U.S. Navy practices at the Boeing spotting facility. The deployed aircraft numbers are taken from the preceding adjusted operational deployment figures. COD aircraft are considered to be land-based. The average calculated is for a 15 carrier deployment.

8.1.3 OPERATING AND SUPPORT COSTS

The estimated operating and support costs are summarized in Table 8.1.3-I. These values were calculated using a modified version of the operating and support portion of the Modular Life Cycle Cost Model. The major modification was to replace the parametric engine cost calculations in the model with estimates provided by the engine and propeller manufacturers. Costs for the EW aircraft were assumed identical to the AEW aircraft. The average was calculated using the adjusted market potential quantities as weighting factors.

8.2 FIGURES OF MERIT

Table 8.2-I summarizes size parameters presented in Section 4.0. Table 8.2-II presents cost values. Total aircraft required and O&S costs were explained in the previous sections. Acquisition costs were developed from three sources. The airframe costs were estimated parametrically using the Boeing developed Advanced Technology Airframe Cost Model (ATACM). Avionics costs were estimated by applying relative complexity factors to data from the Offensive Avionics System/Cruise Missile Integration historical data base. Engine cost estimates were supplied by the manufacturers. Learning curve factors were applied to all data. A 20% foreign market potential was applied to the STOVL aircraft. The cost data includes a 15% increment for Class II changes and warranty, and a 16% profit. *System life cycle cost assumes 25 years of operating a per year average number of aircraft equal to the operational deployment plus the replacement air group.

*These cost figures have been revised since the final oral briefing to reflect recent refinement in the ATACM.

AIRCRAFT	AEW	ASW	EW	TANKER	COD	TOTAL
MULTIMISSION - TF	74	207	111	103	9	504
MULTIMISSION - PF	74	201	111	103	9	498
MULTIMISSION - UDF	74	198	111	103	9	495
MIN AEW/ASW - TF	74	221	111	149	12	567
MIN AEW/ASW - PF	74	222	111	172	15	594
MIN AEW/ASW - UDF	74	222	111	168	13	588
MULTIMISSION - PF STOVL	74	209	111	103	9	506
MIN AEW/ASW - PF STOVL	74	227	111	164	13	589
BASELINE (REF.)	139	237	111	152	28	667

TABLE 8.1.1.6-I ADJUSTED MARKET POTENTIAL - TOTAL PROCUREMENT

AIRCRAFT	DEPLOYED AIRCRAFT					SPOT FACTOR	TOTAL SPOTS	AVERAGE PER CARRIER
	AEW	ASW	EW	TANKER	TOTAL			
MULTIMISSION - TF	40	112	60	56	268	2.28	611.04	40.74
MULTIMISSION - PF	40	109	60	56	265	2.13	564.45	37.63
MULTIMISSION - UDF	40	107	60	56	263	2.01	528.63	35.24
MIN AEW/ASW - TF	40	119	60	81	300	1.70	510.00	34.00
MIN AEW/ASW - PF	40	120	60	93	313	1.78	557.14	37.14
MIN AEW/ASW - UDF	40	120	60	90	310	1.66	514.60	34.31
MULTIMISSION - PF STOVL	40	113	60	56	269	3.12	839.28	55.95
MIN AEW/ASW - PF STOVL	40	123	60	89	312	2.19	683.28	45.55

TABLE 8.1.2-I AVERAGE TOTAL SPOTS PER CARRIER

AIRCRAFT	OPERATING AND SUPPORT COST PER AIRCRAFT PER YEAR					
	AEW	ASW	EW	TANKER	COD	AVERAGE
MULTIMISSION - TF	2,566,594	2,378,261	2,566,594	1,513,022	2,281,859	2,267,987
MULTIMISSION - PF	2,514,435	2,311,455	2,514,435	1,473,049	2,218,296	2,210,936
MULTIMISSION - UDF	2,507,902	2,296,050	2,507,902	1,469,218	2,213,700	2,200,853
MIN AEW/ASW - TF	2,515,042	2,313,014	2,515,042	1,445,070	2,161,478	2,196,901
MIN AEW/ASW - PF	2,472,336	2,266,052	2,472,336	1,407,904	2,081,619	2,077,224
MIN AEW/ASW - UDF	2,474,418	2,259,373	2,474,418	1,408,946	2,103,369	2,081,485
MULTIMISSION - PF STOVL	2,617,694	2,470,893	2,617,694	1,527,842	2,308,612	2,328,679
MIN AEW/ASW - PF STOVL	2,559,823	2,391,068	2,559,823	1,464,567	2,179,827	2,181,423

TABLE 8.1.3-I OPERATING AND SUPPORT COSTS

AIRCRAFT	GROSS WEIGHT	LENGTH	SPAN	FOLDED SPAN	SPOT FACTOR	TOTAL SPOTS PER CARRIER
MULTIMISSION - TF	78,337	67.3	80.1	29.1	2.28	40.74
MULTIMISSION - PF	72,607	67.3	72.7	28.4	2.13	37.63
MULTIMISSION - UDF	71,156	67.3	71.9	27.2	2.01	35.24
MIN AEW/ASW - TF	59,348	65.0	72.5	26.8	1.70	34.00
MIN AEW/ASW - PF	54,876	65.0	72.1	26.8	1.78	37.14
MIN AEW/ASW - UDF	53,740	65.0	66.3	25.0	1.66	34.31
MULTIMISSION - PF STOVL	96,810	70.0	80.0	51.0	3.12	55.95
MIN AEW/ASW - PF STOVL	71,660	65.0	80.0	45.0	2.19	45.55

TABLE 8.2-I FIGURES OF MERIT - SIZE PARAMETERS

AIRCRAFT	TOTAL AIRCRAFT REQUIRED	AVERAGE ACQUISITION COST PER AIRCRAFT (MILLIONS)	AVERAGE O & S COST PER AIRCRAFT PER YEAR (MILLIONS)	TOTAL ACQUISITION COST (MILLIONS)	SYSTEM LIFE CYCLE COST (MILLIONS)
MULTIMISSION - TF	504	75.3	2.27	37,954	57,289
MULTIMISSION - PF	498	71.6	2.21	35,655	54,282
MULTIMISSION - UDF	495	77.1	2.20	38,151	56,583
MIN AEW/ASW - TF	567	66.3	2.15	37,601	58,158
MIN AEW/ASW - PF	594	65.6	2.08	38,987	59,811
MIN AEW/ASW - UDF	588	68.9	2.08	40,525	61,184
MULTIMISSION - PF STOVL	506	81.5	2.33	41,295	61,205
MIN AEW/ASW - PF STOVL	589	70.3	2.18	41,380	63,140

TABLE 8.2-II FIGURES OF MERIT - COST PARAMETERS

9.0 CONCLUSIONS

The upper portion of Table 9.0-I summarizes geometry and performance characteristics of all the configurations on their respective design missions. The lower portion of the figure summarizes the alternate mission performance of each point design at the conditions noted.

Propfan configurations weigh 7.5% less and consume 24% less fuel than turbofan configurations on the same design mission. This is due to the propfan having better fuel consumption characteristics than the turbofan and the gross weight spiral on the turbofan required to carry the additional fuel to do the mission. The resulting effect on LCC is a 5% savings for the propfan over the turbofan.

Fewer, more capable aircraft (multimission) have lower LCC than more numerous, less capable aircraft (minimum AEW/ASW).

The STOVL propfan weighs 31% more and consumes 30% more fuel than the CTOL propfan on the same design mission. The STOVL aircraft require 23% to 49% more total spots per carrier than their CTOL counterparts. The LCC of the STOVL aircraft are 8% and 16% more than their CTOL counterparts without the foreign market advantage. The foreign market sales reduce the STOVL LCC approximately 3%.

		MINIMUM AEW / ASW				MULTIMISSION			
		CTOL UDF	CTOL PF	CTOL TF	STOVL PF	CTOL UDF	CTOL PF	CTOL TF	STOVL PF
DESIGN MISSION		AEW	AEW	AEW	AEW	TANKER	TANKER	ASW	TANKER
DESIGN GROSS WEIGHT	- LBS	53740	54876	59348	71660	71156	72607	78337	96810
ENGINE THRUST	- LBS	10757	11583	12015	30993	14232	14522	15668	41144
PROPELLER DIAMETER	- FT	7.4	8.5	N/A	16.5	8.5	8.5	N/A	19.1
WING SPAN	- FT	66.3	72.1	72.5	80.0	71.9	72.7	80.1	80.0
SPOT FACTOR		1.66	1.78	1.70	2.19	2.01	2.13	2.28	3.12
TOTAL MISSION FUEL	- LBS	13732	12899	16988	16640	7643	8001	23430	11639
INITIAL CRUISE ALTITUDE	- FT	35848	39532	36517	39836	34188	33093	33434	38278
CRUISE CEILING AT MAX. GROSS	- FT	39431	39532	40334	50000*	38567	38353	38624	50000*
SERVICE CEILING AT MAX. GROSS	- FT	40109	40706	41120	50000*	39409	39234	39539	50000*
CRUISE SPEED (OUTBOUND / INBOUND)	KTAS	402/402	405/401	409/409	406/402	390/388	388/386	383/383	393/390
MAXIMUM RADIUS (NO LOITER)	- NM	1520	1470	1515	1480	2255	2201	1852	2250
TOTAL MISSION TIME	- HRS	8.12	8.25	8.16	8.18	4.21	4.22	8.27	4.21
ALTERNATE MISSION PERFORMANCE									
AEW - LOITER TIME @ 350 NM	- HRS	6.0	6.0	6.0	6.0	10.3	10.0	8.1	8.6
TANKER - OFFLOAD @ 200 NM	- LBS	15600	15000	17400	15700	25000	25000	25300	25000
ASW - LOITER TIME @ 350 NM	- HRS	5.7	5.4	5.1	4.2	8.2	7.6	6.0	5.1
COD - PAYLOAD @ 2100 NM	- LBS	11800	11500	12750	12000	19800	19500	18250	18200
- RANGE @ 15000 LBS P/L	- NM	1250	1130	1800	1350	3050	3000	2600	2600

* PRESSURE SUIT LIMIT

TABLE 9.0-I SUMMARY

APPENDIX A

MPSNA-MAPS HIGH SPEED DRAG POLARS

PAGE

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

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CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02441	0.02430	0.02421	0.02411	0.02402	0.02393	0.02390	0.02394
0.15000	0.02471	0.02461	0.02451	0.02442	0.02433	0.02424	0.02421	0.02424
0.20000	0.02527	0.02517	0.02507	0.02498	0.02489	0.02480	0.02477	0.02481
0.25000	0.02610	0.02600	0.02590	0.02581	0.02572	0.02563	0.02560	0.02564
0.30000	0.02716	0.02706	0.02696	0.02687	0.02678	0.02669	0.02666	0.02670
0.35000	0.02845	0.02835	0.02825	0.02815	0.02806	0.02798	0.02795	0.02798
0.40000	0.02997	0.02987	0.02977	0.02967	0.02958	0.02949	0.02946	0.02950
0.45000	0.03171	0.03161	0.03151	0.03141	0.03132	0.03123	0.03120	0.03124
0.50000	0.03368	0.03358	0.03348	0.03339	0.03329	0.03320	0.03317	0.03325
0.55000	0.03591	0.03581	0.03571	0.03561	0.03552	0.03543	0.03540	0.03555
0.60000	0.03841	0.03830	0.03820	0.03810	0.03801	0.03792	0.03795	0.03841
0.65000	0.04122	0.04111	0.04101	0.04091	0.04082	0.04074	0.04090	0.04229
0.70000	0.04431	0.04420	0.04409	0.04400	0.04390	0.04394	0.04472	0.04778
0.75000	0.04773	0.04762	0.04751	0.04741	0.04738	0.04767	0.04959	0.06221
0.80000	0.05142	0.05131	0.05120	0.05111	0.05122	0.05245	0.06316	0.10831
0.85000	0.05571	0.05559	0.05548	0.05551	0.05621	0.05984	0.10474	0.22466
0.90000	0.06021	0.06009	0.06004	0.06027	0.06213	0.09472	0.23394	0.48302
0.95000	0.06492	0.06479	0.06491	0.06609	0.09188	0.22743	0.53552	1.00499
1.00000	0.06984	0.06985	0.07051	0.07426	0.20132	0.56253	1.15622	1.98240

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

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0.15000	0.02439	0.02476	0.02682	0.03167	0.04644	0.07460
0.20000	0.02496	0.02533	0.02741	0.03236	0.04734	0.07580
0.25000	0.02579	0.02621	0.02839	0.03372	0.04961	0.07931
0.30000	0.02686	0.02736	0.02961	0.03543	0.05250	0.08388
0.35000	0.02816	0.02884	0.03129	0.03822	0.05734	0.09137
0.40000	0.02971	0.03060	0.03335	0.04216	0.06399	0.10130
0.45000	0.03150	0.03277	0.03661	0.04845	0.07417	0.11591
0.50000	0.03359	0.03558	0.04101	0.05837	0.08949	0.13721
0.55000	0.03651	0.03953	0.05012	0.07442	0.11334	0.16972
0.60000	0.04048	0.04767	0.06905	0.10519	0.15759	0.22908
0.65000	0.04801	0.06619	0.10297	0.15769	0.23185	0.32828
0.70000	0.06430	0.10452	0.16783	0.25490	0.36724	0.50769
0.75000	0.10734	0.18535	0.29642	0.44124	0.62131	0.83946
0.80000	0.20608	0.35281	0.54870	0.79442	1.09148	1.44271
0.85000	0.41818	0.68534	1.02632	1.44179	1.93328	2.50360
0.90000	0.84196	1.31082	1.88976	2.57948	3.38147	4.29857
0.95000	1.63587	2.42818	3.38210	4.49832	5.77835	7.22501
1.00000	3.04109	4.33234	5.85630	7.61368	9.60597	11.83600

MINIMUM AEW/ASW UDF HIGH SPEED DRAG POLAR, SEALEVEL

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02635	0.02623	0.02612	0.02601	0.02591	0.02581	0.02577	0.02580
0.15000	0.02664	0.02653	0.02642	0.02631	0.02621	0.02611	0.02607	0.02610
0.20000	0.02721	0.02709	0.02698	0.02688	0.02677	0.02667	0.02663	0.02666
0.25000	0.02804	0.02792	0.02781	0.02771	0.02760	0.02750	0.02746	0.02749
0.30000	0.02910	0.02899	0.02888	0.02877	0.02867	0.02857	0.02853	0.02855
0.35000	0.03039	0.03028	0.03017	0.03006	0.02996	0.02986	0.02982	0.02984
0.40000	0.03192	0.03180	0.03169	0.03159	0.03148	0.03138	0.03134	0.03137
0.45000	0.03367	0.03355	0.03344	0.03333	0.03323	0.03313	0.03309	0.03311
0.50000	0.03565	0.03553	0.03542	0.03531	0.03521	0.03511	0.03507	0.03513
0.55000	0.03789	0.03777	0.03766	0.03755	0.03744	0.03734	0.03730	0.03745
0.60000	0.04040	0.04028	0.04017	0.04006	0.03995	0.03985	0.03987	0.04032
0.65000	0.04324	0.04312	0.04300	0.04289	0.04279	0.04270	0.04284	0.04423
0.70000	0.04636	0.04624	0.04612	0.04601	0.04590	0.04593	0.04670	0.04975
0.75000	0.04982	0.04970	0.04958	0.04946	0.04942	0.04970	0.05160	0.06421
0.80000	0.05357	0.05344	0.05332	0.05321	0.05331	0.05453	0.06522	0.11037
0.85000	0.05794	0.05781	0.05768	0.05770	0.05838	0.06200	0.10688	0.22679
0.90000	0.06252	0.06238	0.06232	0.06253	0.06438	0.09696	0.23617	0.48523
0.95000	0.06731	0.06717	0.06727	0.06844	0.09421	0.22975	0.53783	1.00729
1.00000	0.07232	0.07231	0.07296	0.07669	0.20373	0.56493	1.15860	1.98477

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02593	0.02628	0.02831	0.03311	0.04785	0.07607
0.15000	0.02624	0.02659	0.02864	0.03349	0.04824	0.07640
0.20000	0.02680	0.02717	0.02923	0.03417	0.04914	0.07760
0.25000	0.02764	0.02804	0.03022	0.03554	0.05142	0.08111
0.30000	0.02871	0.02920	0.03144	0.03725	0.05431	0.08568
0.35000	0.03002	0.03068	0.03312	0.04004	0.05916	0.09318
0.40000	0.03157	0.03244	0.03519	0.04399	0.06581	0.10311
0.45000	0.03337	0.03462	0.03845	0.05028	0.07600	0.11773
0.50000	0.03546	0.03745	0.04286	0.06021	0.09133	0.13904
0.55000	0.03839	0.04141	0.05199	0.07627	0.11519	0.17155
0.60000	0.04238	0.04956	0.07093	0.10706	0.15945	0.23094
0.65000	0.04993	0.06810	0.10487	0.15958	0.23373	0.33016
0.70000	0.06625	0.10647	0.16976	0.25683	0.36916	0.50959
0.75000	0.10933	0.18733	0.29840	0.44320	0.62326	0.84141
0.80000	0.20812	0.35484	0.55072	0.79643	1.09348	1.44470
0.85000	0.42030	0.68745	1.02841	1.44388	1.93535	2.50567
0.90000	0.84417	1.31301	1.89194	2.58164	3.38362	4.30071
0.95000	1.63815	2.43044	3.38436	4.50057	5.78058	7.22724
1.00000	3.04345	4.33468	5.85864	7.61600	9.60829	11.83830

MINIMUM AEW/ASW UDF HIGH SPEED DRAG POLAR, 20000 FT

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02911	0.02898	0.02885	0.02873	0.02861	0.02849	0.02843	0.02844
0.15000	0.02941	0.02927	0.02914	0.02902	0.02890	0.02878	0.02873	0.02874
0.20000	0.02996	0.02983	0.02970	0.02958	0.02946	0.02934	0.02929	0.02930
0.25000	0.03080	0.03066	0.03054	0.03041	0.03029	0.03018	0.03012	0.03013
0.30000	0.03187	0.03174	0.03161	0.03148	0.03136	0.03125	0.03119	0.03120
0.35000	0.03317	0.03303	0.03291	0.03278	0.03266	0.03254	0.03249	0.03250
0.40000	0.03470	0.03457	0.03444	0.03431	0.03419	0.03408	0.03402	0.03403
0.45000	0.03646	0.03633	0.03620	0.03607	0.03595	0.03583	0.03578	0.03578
0.50000	0.03846	0.03832	0.03819	0.03806	0.03794	0.03782	0.03777	0.03782
0.55000	0.04071	0.04057	0.04044	0.04031	0.04019	0.04007	0.04002	0.04015
0.60000	0.04325	0.04311	0.04298	0.04285	0.04272	0.04261	0.04261	0.04304
0.65000	0.04612	0.04598	0.04585	0.04572	0.04560	0.04549	0.04562	0.04698
0.70000	0.04929	0.04915	0.04901	0.04888	0.04875	0.04876	0.04951	0.05255
0.75000	0.05281	0.05267	0.05253	0.05239	0.05233	0.05259	0.05448	0.06707
0.80000	0.05663	0.05648	0.05633	0.05620	0.05629	0.05749	0.06817	0.11329
0.85000	0.06112	0.06096	0.06082	0.06081	0.06147	0.06507	0.10994	0.22983
0.90000	0.06582	0.06566	0.06557	0.06577	0.06760	0.10015	0.23934	0.48838
0.95000	0.07073	0.07057	0.07065	0.07179	0.09754	0.23306	0.54112	1.01056
1.00000	0.07586	0.07583	0.07645	0.08016	0.20718	0.56836	1.16201	1.98816

LIST Minimum AEW/ASW UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02857	0.02890	0.03091	0.03570	0.05043	0.07863
0.15000	0.02886	0.02920	0.03124	0.03607	0.05081	0.07895
0.20000	0.02942	0.02977	0.03183	0.03675	0.05171	0.08015
0.25000	0.03026	0.03065	0.03281	0.03812	0.05399	0.08367
0.30000	0.03134	0.03181	0.03404	0.03984	0.05689	0.08825
0.35000	0.03265	0.03330	0.03573	0.04264	0.06174	0.09575
0.40000	0.03421	0.03508	0.03781	0.04660	0.06840	0.10569
0.45000	0.03602	0.03727	0.04108	0.05290	0.07860	0.12032
0.50000	0.03813	0.04010	0.04550	0.06284	0.09394	0.14163
0.55000	0.04108	0.04408	0.05464	0.07891	0.11781	0.17417
0.60000	0.04509	0.05225	0.07361	0.10972	0.16210	0.23357
0.65000	0.05267	0.07083	0.10759	0.16228	0.23642	0.33283
0.70000	0.06903	0.10924	0.17252	0.25957	0.37189	0.51231
0.75000	0.11218	0.19016	0.30121	0.44600	0.62605	0.84417
0.80000	0.21103	0.35774	0.55360	0.79929	1.09632	1.44753
0.85000	0.42332	0.69046	1.03141	1.44685	1.93831	2.50861
0.90000	0.84730	1.31613	1.89504	2.58473	3.38669	4.30377
0.95000	1.64140	2.43368	3.38758	4.50377	5.78377	7.23041
1.00000	3.04682	4.33803	5.86197	7.61932	9.61158	11.84160

MINIMUM AEW/ASW UDF HIGH SPEED DRAG POLAR, 40000 FT

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02219	0.02210	0.02201	0.02192	0.02184	0.02176	0.02173	0.02178
0.15000	0.02252	0.02242	0.02234	0.02225	0.02217	0.02209	0.02206	0.02211
0.20000	0.02310	0.02301	0.02292	0.02283	0.02275	0.02267	0.02265	0.02269
0.25000	0.02395	0.02385	0.02377	0.02368	0.02360	0.02352	0.02349	0.02354
0.30000	0.02503	0.02493	0.02485	0.02476	0.02468	0.02460	0.02457	0.02462
0.35000	0.02633	0.02624	0.02615	0.02606	0.02598	0.02590	0.02587	0.02592
0.40000	0.02787	0.02777	0.02768	0.02760	0.02751	0.02743	0.02741	0.02745
0.45000	0.02962	0.02953	0.02944	0.02935	0.02927	0.02919	0.02916	0.02921
0.50000	0.03161	0.03152	0.03143	0.03134	0.03126	0.03117	0.03115	0.03124
0.55000	0.03385	0.03375	0.03366	0.03358	0.03349	0.03341	0.03338	0.03356
0.60000	0.03636	0.03626	0.03617	0.03608	0.03600	0.03592	0.03596	0.03645
0.65000	0.03918	0.03909	0.03899	0.03890	0.03882	0.03875	0.03893	0.04038
0.70000	0.04228	0.04218	0.04209	0.04200	0.04191	0.04197	0.04279	0.04594
0.75000	0.04571	0.04561	0.04551	0.04542	0.04541	0.04573	0.04771	0.06054
0.80000	0.04942	0.04932	0.04922	0.04913	0.04927	0.05056	0.06140	0.10687
0.85000	0.05372	0.05361	0.05350	0.05356	0.05430	0.05803	0.10321	0.22345
0.90000	0.05822	0.05811	0.05808	0.05835	0.06028	0.09310	0.23266	0.48208
0.95000	0.06294	0.06282	0.06297	0.06422	0.09015	0.22606	0.53451	1.00434
1.00000	0.06787	0.06791	0.06862	0.07247	0.19985	0.56143	1.15549	1.98205

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02195	0.02234	0.02444	0.02943	0.04462	0.07373
0.15000	0.02228	0.02268	0.02480	0.02985	0.04506	0.07412
0.20000	0.02286	0.02327	0.02542	0.03056	0.04600	0.07538
0.25000	0.02372	0.02417	0.02642	0.03197	0.04833	0.07895
0.30000	0.02480	0.02534	0.02767	0.03371	0.05127	0.08358
0.35000	0.02612	0.02684	0.02937	0.03655	0.05617	0.09115
0.40000	0.02769	0.02862	0.03147	0.04056	0.06290	0.10116
0.45000	0.02950	0.03082	0.03478	0.04693	0.07318	0.11589
0.50000	0.03161	0.03367	0.03928	0.05697	0.08863	0.13733
0.55000	0.03457	0.03768	0.04853	0.07317	0.11264	0.17002
0.60000	0.03859	0.04598	0.06765	0.10414	0.15711	0.22962
0.65000	0.04623	0.06469	0.10178	0.15687	0.23161	0.32907
0.70000	0.06272	0.10324	0.16687	0.25433	0.36726	0.50875
0.75000	0.10598	0.18430	0.29571	0.44093	0.62161	0.84081
0.80000	0.20496	0.35202	0.54825	0.79439	1.09207	1.44438
0.85000	0.41732	0.68482	1.02616	1.44207	1.93419	2.50560
0.90000	0.84138	1.31060	1.88992	2.58008	3.38273	4.30093
0.95000	1.63558	2.42827	3.38259	4.49927	5.77997	7.22776
1.00000	3.04113	4.33277	5.85715	7.61500	9.60799	11.83920

MINIMUM AEW/ASW TURBOPROP HIGH SPEED DRAG POLAR, SEALEVEL

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02395	0. 02385	0. 02375	0. 02365	0. 02356	0. 02347	0. 02343	0. 02347
0. 15000	0. 02427	0. 02417	0. 02407	0. 02397	0. 02388	0. 02379	0. 02375	0. 02379
0. 20000	0. 02485	0. 02475	0. 02465	0. 02455	0. 02446	0. 02437	0. 02434	0. 02437
0. 25000	0. 02570	0. 02560	0. 02550	0. 02540	0. 02531	0. 02522	0. 02518	0. 02522
0. 30000	0. 02679	0. 02668	0. 02658	0. 02649	0. 02639	0. 02630	0. 02627	0. 02630
0. 35000	0. 02810	0. 02799	0. 02789	0. 02779	0. 02770	0. 02761	0. 02757	0. 02761
0. 40000	0. 02964	0. 02953	0. 02943	0. 02934	0. 02924	0. 02915	0. 02911	0. 02915
0. 45000	0. 03140	0. 03130	0. 03120	0. 03110	0. 03100	0. 03091	0. 03088	0. 03091
0. 50000	0. 03340	0. 03329	0. 03319	0. 03309	0. 03300	0. 03291	0. 03287	0. 03295
0. 55000	0. 03565	0. 03554	0. 03544	0. 03534	0. 03525	0. 03515	0. 03512	0. 03528
0. 60000	0. 03817	0. 03807	0. 03796	0. 03786	0. 03777	0. 03767	0. 03771	0. 03818
0. 65000	0. 04103	0. 04092	0. 04081	0. 04071	0. 04061	0. 04053	0. 04070	0. 04214
0. 70000	0. 04415	0. 04404	0. 04394	0. 04383	0. 04374	0. 04379	0. 04459	0. 04773
0. 75000	0. 04763	0. 04751	0. 04740	0. 04730	0. 04727	0. 04759	0. 04956	0. 06238
0. 80000	0. 05138	0. 05127	0. 05115	0. 05105	0. 05119	0. 05246	0. 06329	0. 10875
0. 85000	0. 05576	0. 05564	0. 05553	0. 05557	0. 05630	0. 06001	0. 10518	0. 22542
0. 90000	0. 06035	0. 06023	0. 06018	0. 06044	0. 06236	0. 09516	0. 23471	0. 48412
0. 95000	0. 06515	0. 06502	0. 06516	0. 06639	0. 09231	0. 22821	0. 53664	1. 00646
1. 00000	0. 07017	0. 07019	0. 07089	0. 07472	0. 20209	0. 56366	1. 15771	1. 98425

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02362	0. 02401	0. 02610	0. 03108	0. 04627	0. 07537
0. 15000	0. 02395	0. 02434	0. 02646	0. 03150	0. 04670	0. 07575
0. 20000	0. 02453	0. 02494	0. 02707	0. 03221	0. 04764	0. 07701
0. 25000	0. 02539	0. 02583	0. 02808	0. 03361	0. 04997	0. 08058
0. 30000	0. 02648	0. 02701	0. 02933	0. 03537	0. 05291	0. 08521
0. 35000	0. 02781	0. 02851	0. 03104	0. 03821	0. 05782	0. 09279
0. 40000	0. 02938	0. 03030	0. 03314	0. 04222	0. 06455	0. 10281
0. 45000	0. 03120	0. 03251	0. 03645	0. 04860	0. 07484	0. 11754
0. 50000	0. 03331	0. 03537	0. 04096	0. 05865	0. 09030	0. 13899
0. 55000	0. 03628	0. 03939	0. 05023	0. 07486	0. 11432	0. 17169
0. 60000	0. 04032	0. 04770	0. 06936	0. 10584	0. 15880	0. 23130
0. 65000	0. 04798	0. 06644	0. 10351	0. 15859	0. 23333	0. 33078
0. 70000	0. 06450	0. 10502	0. 16863	0. 25608	0. 36901	0. 51049
0. 75000	0. 10780	0. 18612	0. 29752	0. 44272	0. 62340	0. 84259
0. 80000	0. 20683	0. 35388	0. 55010	0. 79623	1. 09391	1. 44620
0. 85000	0. 41927	0. 68676	1. 02809	1. 44399	1. 93610	2. 50750
0. 90000	0. 84341	1. 31261	1. 89192	2. 58208	3. 38472	4. 30291
0. 95000	1. 63769	2. 43037	3. 38468	4. 50135	5. 78204	7. 22981
1. 00000	3. 04332	4. 33495	5. 85931	7. 61716	9. 61013	11. 84130

MINIMUM AEW/ASW TURBOPROP HIGH SPEED DRAG POLAR, 20000 FT

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02647	0.02635	0.02623	0.02612	0.02601	0.02590	0.02585	0.02587
0.15000	0.02678	0.02666	0.02654	0.02643	0.02632	0.02622	0.02616	0.02619
0.20000	0.02736	0.02724	0.02712	0.02701	0.02690	0.02680	0.02674	0.02677
0.25000	0.02821	0.02809	0.02797	0.02786	0.02775	0.02765	0.02760	0.02762
0.30000	0.02930	0.02918	0.02906	0.02895	0.02884	0.02874	0.02869	0.02871
0.35000	0.03062	0.03050	0.03038	0.03026	0.03016	0.03005	0.03000	0.03002
0.40000	0.03217	0.03205	0.03193	0.03182	0.03171	0.03160	0.03155	0.03157
0.45000	0.03394	0.03382	0.03370	0.03359	0.03348	0.03337	0.03332	0.03334
0.50000	0.03595	0.03583	0.03571	0.03559	0.03548	0.03537	0.03532	0.03539
0.55000	0.03822	0.03809	0.03797	0.03786	0.03775	0.03764	0.03759	0.03774
0.60000	0.04077	0.04064	0.04052	0.04040	0.04029	0.04018	0.04020	0.04066
0.65000	0.04365	0.04353	0.04340	0.04329	0.04317	0.04308	0.04323	0.04465
0.70000	0.04683	0.04670	0.04657	0.04645	0.04634	0.04637	0.04717	0.05029
0.75000	0.05036	0.05023	0.05010	0.04998	0.04994	0.05023	0.05219	0.06499
0.80000	0.05419	0.05405	0.05392	0.05380	0.05392	0.05518	0.06599	0.11143
0.85000	0.05869	0.05855	0.05841	0.05843	0.05914	0.06284	0.10799	0.22821
0.90000	0.06340	0.06325	0.06318	0.06342	0.06532	0.09811	0.23764	0.48703
0.95000	0.06832	0.06817	0.06828	0.06949	0.09539	0.23127	0.53969	1.00949
1.00000	0.07345	0.07345	0.07412	0.07794	0.20528	0.56684	1.16086	1.98739

LIST Minimum AEW/ASW Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02602	0.02638	0.02846	0.03344	0.04861	0.07770
0.15000	0.02633	0.02671	0.02881	0.03384	0.04904	0.07807
0.20000	0.02691	0.02730	0.02943	0.03455	0.04997	0.07933
0.25000	0.02777	0.02820	0.03044	0.03596	0.05231	0.08290
0.30000	0.02887	0.02939	0.03169	0.03772	0.05525	0.08754
0.35000	0.03020	0.03090	0.03341	0.04056	0.06017	0.09512
0.40000	0.03178	0.03269	0.03552	0.04459	0.06691	0.10515
0.45000	0.03361	0.03491	0.03884	0.05097	0.07720	0.11990
0.50000	0.03574	0.03778	0.04336	0.06103	0.09268	0.14135
0.55000	0.03872	0.04182	0.05264	0.07726	0.11671	0.17407
0.60000	0.04278	0.05015	0.07180	0.10827	0.16122	0.23370
0.65000	0.05048	0.06893	0.10599	0.16105	0.23578	0.33322
0.70000	0.06704	0.10755	0.17115	0.25859	0.37150	0.51297
0.75000	0.11040	0.18871	0.30009	0.44528	0.62594	0.84513
0.80000	0.20949	0.35653	0.55274	0.79886	1.09652	1.44880
0.85000	0.42205	0.68953	1.03084	1.44672	1.93883	2.51021
0.90000	0.84631	1.31549	1.89479	2.58492	3.38755	4.30573
0.95000	1.64070	2.43336	3.38765	4.50431	5.78499	7.23274
1.00000	3.04644	4.33805	5.86240	7.62023	9.61319	11.84430

MINIMUM AEW/ASW TURBOPROP HIGH SPEED DRAG POLAR, 40000 FT

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02209	0.02199	0.02191	0.02182	0.02174	0.02166	0.02163	0.02168
0.15000	0.02241	0.02232	0.02223	0.02215	0.02207	0.02199	0.02196	0.02201
0.20000	0.02300	0.02291	0.02282	0.02273	0.02265	0.02257	0.02255	0.02259
0.25000	0.02385	0.02376	0.02367	0.02358	0.02350	0.02342	0.02339	0.02344
0.30000	0.02493	0.02484	0.02475	0.02466	0.02458	0.02450	0.02447	0.02452
0.35000	0.02623	0.02614	0.02605	0.02597	0.02588	0.02581	0.02578	0.02582
0.40000	0.02777	0.02768	0.02759	0.02750	0.02742	0.02734	0.02731	0.02736
0.45000	0.02953	0.02943	0.02935	0.02926	0.02918	0.02910	0.02907	0.02911
0.50000	0.03152	0.03142	0.03133	0.03125	0.03116	0.03108	0.03105	0.03115
0.55000	0.03376	0.03366	0.03357	0.03348	0.03340	0.03332	0.03329	0.03347
0.60000	0.03627	0.03617	0.03608	0.03599	0.03591	0.03583	0.03587	0.03636
0.65000	0.03909	0.03900	0.03890	0.03881	0.03873	0.03866	0.03884	0.04029
0.70000	0.04219	0.04209	0.04200	0.04191	0.04182	0.04188	0.04270	0.04586
0.75000	0.04562	0.04552	0.04542	0.04533	0.04532	0.04565	0.04763	0.06048
0.80000	0.04933	0.04923	0.04913	0.04904	0.04919	0.05048	0.06133	0.10682
0.85000	0.05362	0.05352	0.05341	0.05347	0.05422	0.05795	0.10315	0.22342
0.90000	0.05813	0.05802	0.05799	0.05826	0.06020	0.09303	0.23262	0.48207
0.95000	0.06285	0.06273	0.06289	0.06413	0.09008	0.22602	0.53449	1.00435
1.00000	0.06778	0.06782	0.06853	0.07239	0.19979	0.56141	1.15550	1.98208

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02165	0.02224	0.02434	0.02935	0.04458	0.07375
0.15000	0.02218	0.02258	0.02471	0.02977	0.04502	0.07415
0.20000	0.02277	0.02318	0.02533	0.03049	0.04597	0.07541
0.25000	0.02362	0.02407	0.02634	0.03189	0.04830	0.07898
0.30000	0.02471	0.02525	0.02758	0.03365	0.05124	0.08362
0.35000	0.02603	0.02675	0.02929	0.03648	0.05615	0.09119
0.40000	0.02760	0.02853	0.03139	0.04050	0.06288	0.10121
0.45000	0.02941	0.03074	0.03470	0.04688	0.07317	0.11595
0.50000	0.03152	0.03359	0.03921	0.05693	0.08863	0.13740
0.55000	0.03448	0.03761	0.04847	0.07314	0.11265	0.17010
0.60000	0.03851	0.04591	0.06760	0.10412	0.15714	0.22972
0.65000	0.04616	0.06464	0.10175	0.15687	0.23165	0.32919
0.70000	0.06266	0.10321	0.16686	0.25434	0.36733	0.50889
0.75000	0.10594	0.18429	0.29572	0.44097	0.62169	0.84098
0.80000	0.20493	0.35202	0.54828	0.79445	1.09218	1.44457
0.85000	0.41731	0.68484	1.02621	1.44215	1.93433	2.50582
0.90000	0.84140	1.31064	1.88999	2.58018	3.38288	4.30117
0.95000	1.63562	2.42834	3.38269	4.49941	5.78016	7.22803
1.00000	3.04120	4.33286	5.85727	7.61516	9.60820	11.83950

MINIMUM AEW/ASW TURBOFAN HIGH SPEED DRAG POLAR, SEALEVEL

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02384	0.02374	0.02364	0.02354	0.02345	0.02336	0.02332	0.02336
0.15000	0.02416	0.02406	0.02396	0.02386	0.02377	0.02368	0.02364	0.02368
0.20000	0.02474	0.02464	0.02454	0.02445	0.02435	0.02427	0.02423	0.02426
0.25000	0.02560	0.02549	0.02539	0.02530	0.02520	0.02512	0.02508	0.02511
0.30000	0.02668	0.02658	0.02648	0.02638	0.02629	0.02620	0.02616	0.02620
0.35000	0.02799	0.02789	0.02779	0.02769	0.02760	0.02751	0.02747	0.02751
0.40000	0.02953	0.02943	0.02933	0.02923	0.02914	0.02905	0.02901	0.02905
0.45000	0.03130	0.03119	0.03109	0.03100	0.03090	0.03081	0.03077	0.03081
0.50000	0.03329	0.03319	0.03309	0.03299	0.03290	0.03281	0.03277	0.03285
0.55000	0.03555	0.03544	0.03534	0.03524	0.03515	0.03505	0.03502	0.03519
0.60000	0.03807	0.03797	0.03786	0.03776	0.03767	0.03758	0.03761	0.03809
0.65000	0.04092	0.04082	0.04071	0.04061	0.04051	0.04044	0.04061	0.04205
0.70000	0.04405	0.04394	0.04384	0.04374	0.04364	0.04369	0.04450	0.04764
0.75000	0.04753	0.04741	0.04731	0.04720	0.04718	0.04749	0.04947	0.06230
0.80000	0.05128	0.05117	0.05106	0.05096	0.05109	0.05237	0.06321	0.10870
0.85000	0.05566	0.05554	0.05543	0.05547	0.05620	0.05992	0.10511	0.22538
0.90000	0.06025	0.06013	0.06008	0.06034	0.06227	0.09509	0.23467	0.48410
0.95000	0.06506	0.06492	0.06506	0.06630	0.09223	0.22815	0.53662	1.00646
1.00000	0.07007	0.07009	0.07079	0.07464	0.20202	0.56363	1.15770	1.98428

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02352	0.02390	0.02600	0.03100	0.04621	0.07538
0.15000	0.02384	0.02424	0.02636	0.03141	0.04665	0.07577
0.20000	0.02443	0.02483	0.02698	0.03212	0.04760	0.07703
0.25000	0.02529	0.02573	0.02798	0.03353	0.04993	0.08061
0.30000	0.02638	0.02691	0.02924	0.03529	0.05287	0.08525
0.35000	0.02771	0.02842	0.03094	0.03813	0.05779	0.09282
0.40000	0.02928	0.03021	0.03305	0.04215	0.06452	0.10285
0.45000	0.03110	0.03242	0.03637	0.04854	0.07482	0.11760
0.50000	0.03322	0.03528	0.04089	0.05859	0.09029	0.13905
0.55000	0.03619	0.03930	0.05016	0.07482	0.11432	0.17177
0.60000	0.04023	0.04763	0.06931	0.10582	0.15882	0.23140
0.65000	0.04790	0.06638	0.10348	0.15859	0.23336	0.33090
0.70000	0.06443	0.10498	0.16861	0.25609	0.36907	0.51062
0.75000	0.10775	0.18609	0.29751	0.44275	0.62347	0.84275
0.80000	0.20680	0.35388	0.55012	0.79628	1.09401	1.44638
0.85000	0.41925	0.68678	1.02813	1.44406	1.93623	2.50771
0.90000	0.84342	1.31265	1.89199	2.58218	3.38487	4.30314
0.95000	1.63772	2.43043	3.38477	4.50148	5.78222	7.23007
1.00000	3.04338	4.33503	5.85943	7.61731	9.61034	11.84160

MINIMUM AEW/ASW TURBOFAN HIGH SPEED DRAG POLAR, 20000 FT

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02634	0. 02622	0. 02610	0. 02599	0. 02588	0. 02578	0. 02573	0. 02575
0. 15000	0. 02666	0. 02653	0. 02642	0. 02631	0. 02620	0. 02609	0. 02604	0. 02607
0. 20000	0. 02724	0. 02712	0. 02700	0. 02689	0. 02678	0. 02668	0. 02663	0. 02665
0. 25000	0. 02809	0. 02797	0. 02785	0. 02774	0. 02763	0. 02753	0. 02748	0. 02750
0. 30000	0. 02918	0. 02906	0. 02895	0. 02883	0. 02872	0. 02862	0. 02857	0. 02859
0. 35000	0. 03050	0. 03038	0. 03026	0. 03015	0. 03004	0. 02994	0. 02988	0. 02991
0. 40000	0. 03205	0. 03193	0. 03181	0. 03170	0. 03159	0. 03149	0. 03143	0. 03146
0. 45000	0. 03383	0. 03370	0. 03359	0. 03347	0. 03336	0. 03326	0. 03321	0. 03323
0. 50000	0. 03583	0. 03571	0. 03559	0. 03548	0. 03537	0. 03526	0. 03521	0. 03528
0. 55000	0. 03810	0. 03798	0. 03786	0. 03774	0. 03763	0. 03753	0. 03747	0. 03763
0. 60000	0. 04065	0. 04053	0. 04041	0. 04029	0. 04018	0. 04007	0. 04009	0. 04056
0. 65000	0. 04354	0. 04341	0. 04329	0. 04318	0. 04306	0. 04297	0. 04312	0. 04455
0. 70000	0. 04672	0. 04659	0. 04646	0. 04634	0. 04623	0. 04626	0. 04706	0. 05019
0. 75000	0. 05025	0. 05012	0. 04999	0. 04987	0. 04983	0. 05013	0. 05209	0. 06490
0. 80000	0. 05407	0. 05394	0. 05381	0. 05369	0. 05381	0. 05507	0. 06590	0. 11136
0. 85000	0. 05858	0. 05843	0. 05830	0. 05832	0. 05904	0. 06274	0. 10791	0. 22816
0. 90000	0. 06329	0. 06314	0. 06307	0. 06331	0. 06522	0. 09802	0. 23758	0. 48700
0. 95000	0. 06821	0. 06805	0. 06817	0. 06938	0. 09530	0. 23120	0. 53965	1. 00948
1. 00000	0. 07334	0. 07334	0. 07402	0. 07784	0. 20521	0. 56679	1. 16085	1. 98740

LIST Minimum AEW/ASW Turbofan Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02590	0. 02627	0. 02835	0. 03334	0. 04854	0. 07770
0. 15000	0. 02621	0. 02660	0. 02870	0. 03375	0. 04898	0. 07808
0. 20000	0. 02680	0. 02719	0. 02932	0. 03446	0. 04991	0. 07934
0. 25000	0. 02766	0. 02809	0. 03033	0. 03587	0. 05225	0. 08292
0. 30000	0. 02876	0. 02928	0. 03159	0. 03763	0. 05520	0. 08756
0. 35000	0. 03009	0. 03079	0. 03330	0. 04048	0. 06012	0. 09515
0. 40000	0. 03167	0. 03259	0. 03542	0. 04451	0. 06687	0. 10519
0. 45000	0. 03350	0. 03481	0. 03875	0. 05090	0. 07717	0. 11994
0. 50000	0. 03563	0. 03768	0. 04327	0. 06097	0. 09265	0. 14141
0. 55000	0. 03862	0. 04172	0. 05256	0. 07721	0. 11670	0. 17413
0. 60000	0. 04268	0. 05006	0. 07173	0. 10823	0. 16122	0. 23379
0. 65000	0. 05039	0. 06885	0. 10594	0. 16103	0. 23580	0. 33332
0. 70000	0. 06697	0. 10749	0. 17112	0. 25858	0. 37155	0. 51309
0. 75000	0. 11034	0. 18867	0. 30007	0. 44530	0. 62601	0. 84527
0. 80000	0. 20945	0. 35651	0. 55275	0. 79889	1. 09660	1. 44897
0. 85000	0. 42202	0. 68953	1. 03087	1. 44678	1. 93894	2. 51041
0. 90000	0. 84630	1. 31552	1. 89484	2. 58501	3. 38769	4. 30595
0. 95000	1. 64072	2. 43341	3. 38773	4. 50442	5. 78515	7. 23299
1. 00000	3. 04648	4. 33812	5. 86250	7. 62037	9. 61338	11. 84460

MINIMUM AEW/ASW TURBOFAN HIGH SPEED DRAG POLAR, 40000 FT

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02002	0.01993	0.01985	0.01977	0.01970	0.01963	0.01959	0.01961
0.15000	0.02037	0.02029	0.02021	0.02013	0.02006	0.01998	0.01995	0.01997
0.20000	0.02098	0.02090	0.02082	0.02074	0.02067	0.02060	0.02056	0.02058
0.25000	0.02186	0.02177	0.02169	0.02162	0.02154	0.02147	0.02144	0.02146
0.30000	0.02296	0.02288	0.02280	0.02272	0.02265	0.02257	0.02254	0.02256
0.35000	0.02429	0.02421	0.02413	0.02405	0.02397	0.02390	0.02387	0.02389
0.40000	0.02585	0.02577	0.02569	0.02561	0.02553	0.02546	0.02542	0.02545
0.45000	0.02763	0.02754	0.02746	0.02739	0.02731	0.02724	0.02720	0.02722
0.50000	0.02964	0.02955	0.02947	0.02939	0.02932	0.02924	0.02921	0.02928
0.55000	0.03190	0.03181	0.03173	0.03165	0.03157	0.03150	0.03146	0.03164
0.60000	0.03442	0.03434	0.03426	0.03418	0.03410	0.03402	0.03407	0.03458
0.65000	0.03727	0.03718	0.03710	0.03701	0.03694	0.03688	0.03709	0.03859
0.70000	0.04038	0.04029	0.04021	0.04013	0.04005	0.04014	0.04101	0.04428
0.75000	0.04383	0.04374	0.04365	0.04357	0.04357	0.04395	0.04604	0.05921
0.80000	0.04755	0.04746	0.04737	0.04729	0.04749	0.04887	0.05994	0.10595
0.85000	0.05186	0.05176	0.05167	0.05176	0.05258	0.05647	0.10216	0.22298
0.90000	0.05638	0.05628	0.05627	0.05660	0.05867	0.09189	0.23207	0.48208
0.95000	0.06111	0.06101	0.06121	0.06256	0.08877	0.22532	0.53441	1.00487
1.00000	0.06605	0.06613	0.06693	0.07096	0.19892	0.56120	1.15593	1.98315

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.01974	0.02007	0.02204	0.02670	0.04093	0.06758
0.15000	0.02010	0.02044	0.02244	0.02717	0.04144	0.06806
0.20000	0.02071	0.02107	0.02309	0.02793	0.04245	0.06941
0.25000	0.02159	0.02199	0.02413	0.02939	0.04486	0.07308
0.30000	0.02271	0.02319	0.02542	0.03120	0.04788	0.07782
0.35000	0.02406	0.02473	0.02716	0.03413	0.05290	0.08552
0.40000	0.02565	0.02655	0.02932	0.03825	0.05976	0.09570
0.45000	0.02749	0.02879	0.03271	0.04478	0.07022	0.11063
0.50000	0.02964	0.03171	0.03739	0.05503	0.08591	0.13233
0.55000	0.03266	0.03582	0.04689	0.07150	0.11022	0.16534
0.60000	0.03677	0.04441	0.06636	0.10284	0.15509	0.22537
0.65000	0.04462	0.06348	0.10087	0.15598	0.23002	0.32529
0.70000	0.06147	0.10242	0.16638	0.25389	0.36615	0.50547
0.75000	0.10513	0.18391	0.29568	0.44097	0.62101	0.83807
0.80000	0.20455	0.35209	0.54872	0.79496	1.09203	1.44222
0.85000	0.41738	0.68540	1.02716	1.44320	1.93474	2.50406
0.90000	0.84196	1.31172	1.89149	2.58181	3.38391	4.30005
0.95000	1.63672	2.42997	3.38478	4.50165	5.78183	7.22759
1.00000	3.04286	4.33510	5.85999	7.61807	9.61056	11.83970

MINIMUM AEW/ASW STOVL HIGH SPEED DRAG POLAR, SEALEVEL

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02161	0. 02151	0. 02142	0. 02134	0. 02125	0. 02117	0. 02113	0. 02114
0. 15000	0. 02196	0. 02186	0. 02177	0. 02169	0. 02160	0. 02152	0. 02148	0. 02149
0. 20000	0. 02257	0. 02248	0. 02238	0. 02230	0. 02221	0. 02213	0. 02209	0. 02210
0. 25000	0. 02345	0. 02335	0. 02326	0. 02317	0. 02309	0. 02301	0. 02297	0. 02298
0. 30000	0. 02456	0. 02446	0. 02437	0. 02428	0. 02420	0. 02412	0. 02407	0. 02409
0. 35000	0. 02589	0. 02579	0. 02570	0. 02562	0. 02553	0. 02545	0. 02541	0. 02542
0. 40000	0. 02745	0. 02736	0. 02727	0. 02718	0. 02710	0. 02701	0. 02697	0. 02698
0. 45000	0. 02924	0. 02915	0. 02905	0. 02896	0. 02888	0. 02880	0. 02875	0. 02877
0. 50000	0. 03126	0. 03116	0. 03107	0. 03098	0. 03089	0. 03081	0. 03077	0. 03083
0. 55000	0. 03353	0. 03343	0. 03334	0. 03325	0. 03316	0. 03308	0. 03303	0. 03320
0. 60000	0. 03607	0. 03597	0. 03588	0. 03579	0. 03570	0. 03562	0. 03566	0. 03616
0. 65000	0. 03894	0. 03884	0. 03875	0. 03866	0. 03857	0. 03850	0. 03870	0. 04019
0. 70000	0. 04209	0. 04199	0. 04189	0. 04180	0. 04171	0. 04179	0. 04266	0. 04591
0. 75000	0. 04558	0. 04547	0. 04537	0. 04528	0. 04527	0. 04565	0. 04772	0. 06088
0. 80000	0. 04935	0. 04924	0. 04914	0. 04905	0. 04923	0. 05061	0. 06167	0. 10767
0. 85000	0. 05374	0. 05363	0. 05352	0. 05360	0. 05441	0. 05829	0. 10397	0. 22477
0. 90000	0. 05834	0. 05823	0. 05820	0. 05852	0. 06058	0. 09379	0. 23396	0. 48396
0. 95000	0. 06316	0. 06303	0. 06323	0. 06456	0. 09076	0. 22730	0. 53638	1. 00683
1. 00000	0. 06818	0. 06824	0. 06903	0. 07305	0. 20099	0. 56326	1. 15798	1. 98518

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02125	0. 02158	0. 02354	0. 02820	0. 04242	0. 06906
0. 15000	0. 02161	0. 02194	0. 02393	0. 02866	0. 04292	0. 06954
0. 20000	0. 02222	0. 02257	0. 02459	0. 02942	0. 04393	0. 07088
0. 25000	0. 02311	0. 02349	0. 02563	0. 03088	0. 04634	0. 07456
0. 30000	0. 02423	0. 02470	0. 02692	0. 03270	0. 04937	0. 07930
0. 35000	0. 02558	0. 02624	0. 02867	0. 03563	0. 05439	0. 08701
0. 40000	0. 02718	0. 02807	0. 03083	0. 03975	0. 06126	0. 09719
0. 45000	0. 02903	0. 03032	0. 03423	0. 04629	0. 07173	0. 11213
0. 50000	0. 03119	0. 03324	0. 03892	0. 05655	0. 08742	0. 13384
0. 55000	0. 03421	0. 03737	0. 04843	0. 07303	0. 11174	0. 16686
0. 60000	0. 03834	0. 04597	0. 06791	0. 10439	0. 15662	0. 22690
0. 65000	0. 04621	0. 06506	0. 10245	0. 15755	0. 23158	0. 32684
0. 70000	0. 06309	0. 10403	0. 16799	0. 25548	0. 36774	0. 50705
0. 75000	0. 10679	0. 18556	0. 29732	0. 44261	0. 62264	0. 83969
0. 80000	0. 20626	0. 35379	0. 55041	0. 79664	1. 09370	1. 44388
0. 85000	0. 41917	0. 68717	1. 02893	1. 44496	1. 93649	2. 50581
0. 90000	0. 84383	1. 31357	1. 89334	2. 58365	3. 38573	4. 30187
0. 95000	1. 63866	2. 43191	3. 38670	4. 50357	5. 78374	7. 22948
1. 00000	3. 04489	4. 33711	5. 86199	7. 62007	9. 61255	11. 84170

MINIMUM AEW/ASW STOVL HIGH SPEED DRAG POLAR, 20000 FT

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02388	0.02377	0.02367	0.02357	0.02347	0.02337	0.02331	0.02332
0.15000	0.02423	0.02412	0.02401	0.02391	0.02381	0.02372	0.02366	0.02366
0.20000	0.02483	0.02472	0.02462	0.02452	0.02442	0.02432	0.02427	0.02427
0.25000	0.02571	0.02560	0.02550	0.02540	0.02530	0.02520	0.02515	0.02515
0.30000	0.02683	0.02672	0.02661	0.02651	0.02641	0.02632	0.02626	0.02626
0.35000	0.02817	0.02806	0.02795	0.02785	0.02775	0.02766	0.02760	0.02760
0.40000	0.02974	0.02963	0.02953	0.02942	0.02933	0.02923	0.02917	0.02917
0.45000	0.03154	0.03143	0.03132	0.03122	0.03112	0.03102	0.03096	0.03096
0.50000	0.03357	0.03346	0.03335	0.03324	0.03314	0.03305	0.03299	0.03304
0.55000	0.03586	0.03574	0.03563	0.03553	0.03543	0.03533	0.03527	0.03543
0.60000	0.03842	0.03831	0.03820	0.03809	0.03799	0.03789	0.03792	0.03841
0.65000	0.04133	0.04121	0.04110	0.04100	0.04089	0.04081	0.04100	0.04248
0.70000	0.04452	0.04440	0.04429	0.04418	0.04407	0.04414	0.04499	0.04824
0.75000	0.04807	0.04795	0.04783	0.04772	0.04770	0.04806	0.05012	0.06326
0.80000	0.05191	0.05178	0.05166	0.05156	0.05173	0.05309	0.06413	0.11011
0.85000	0.05642	0.05629	0.05616	0.05623	0.05702	0.06088	0.10655	0.22734
0.90000	0.06114	0.06101	0.06096	0.06127	0.06330	0.09650	0.23665	0.48664
0.95000	0.06607	0.06593	0.06611	0.06742	0.09360	0.23012	0.53918	1.00962
1.00000	0.07121	0.07125	0.07202	0.07602	0.20395	0.56619	1.16090	1.98809

LIST Minimum AEW/ASW STOVL DRAG Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH. 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02342	0.02373	0.02568	0.03033	0.04453	0.07117
0.15000	0.02376	0.02409	0.02607	0.03078	0.04503	0.07163
0.20000	0.02438	0.02471	0.02672	0.03153	0.04604	0.07298
0.25000	0.02526	0.02564	0.02776	0.03301	0.04845	0.07666
0.30000	0.02639	0.02685	0.02906	0.03483	0.05149	0.08141
0.35000	0.02775	0.02840	0.03082	0.03776	0.05652	0.08912
0.40000	0.02936	0.03023	0.03298	0.04189	0.06339	0.09931
0.45000	0.03122	0.03249	0.03640	0.04844	0.07387	0.11426
0.50000	0.03338	0.03543	0.04109	0.05871	0.08957	0.13598
0.55000	0.03642	0.03957	0.05062	0.07520	0.11391	0.16902
0.60000	0.04058	0.04819	0.07012	0.10659	0.15881	0.22908
0.65000	0.04848	0.06732	0.10469	0.15978	0.23381	0.32905
0.70000	0.06540	0.10633	0.17028	0.25776	0.37001	0.50930
0.75000	0.10916	0.18792	0.29967	0.44494	0.62496	0.84200
0.80000	0.20869	0.35621	0.55282	0.79904	1.09609	1.44626
0.85000	0.42171	0.68971	1.03145	1.44746	1.93898	2.50829
0.90000	0.84649	1.31622	1.89597	2.58627	3.38834	4.30447
0.95000	1.64143	2.43467	3.38944	4.50630	5.78645	7.23219
1.00000	3.04777	4.33998	5.86485	7.62291	9.61537	11.84450

MINIMUM AEW/ASW STOVL HIGH SPEED DRAG POLAR, 40000 FT

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0 00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02432	0.02424	0.02416	0.02415	0.02421	0.02433	0.02459	0.02503
0.15000	0.02457	0.02448	0.02440	0.02439	0.02446	0.02458	0.02484	0.02527
0.20000	0.02510	0.02502	0.02494	0.02493	0.02499	0.02511	0.02538	0.02581
0.25000	0.02593	0.02584	0.02577	0.02576	0.02582	0.02595	0.02622	0.02666
0.30000	0.02702	0.02693	0.02686	0.02686	0.02692	0.02705	0.02732	0.02777
0.35000	0.02836	0.02828	0.02820	0.02821	0.02828	0.02842	0.02871	0.02917
0.40000	0.02997	0.02989	0.02981	0.02984	0.02992	0.03007	0.03038	0.03086
0.45000	0.03183	0.03174	0.03170	0.03174	0.03184	0.03202	0.03235	0.03287
0.50000	0.03395	0.03386	0.03385	0.03391	0.03404	0.03425	0.03464	0.03524
0.55000	0.03635	0.03628	0.03631	0.03640	0.03656	0.03683	0.03727	0.03802
0.60000	0.03905	0.03905	0.03911	0.03923	0.03946	0.03981	0.04040	0.04153
0.65000	0.04214	0.04218	0.04228	0.04246	0.04276	0.04321	0.04401	0.04618
0.70000	0.04555	0.04562	0.04577	0.04602	0.04641	0.04705	0.04856	0.05251
0.75000	0.04935	0.04946	0.04967	0.05001	0.05053	0.05152	0.05427	0.06788
0.80000	0.05348	0.05365	0.05393	0.05435	0.05511	0.05713	0.06878	0.11505
0.85000	0.05824	0.05847	0.05883	0.05946	0.06089	0.06541	0.11135	0.23254
0.90000	0.06329	0.06360	0.06410	0.06502	0.06772	0.10130	0.24171	0.49222
0.95000	0.06863	0.06902	0.06977	0.07173	0.09847	0.23513	0.54457	1.01553
1.00000	0.07425	0.07485	0.07624	0.08087	0.20896	0.57144	1.16663	1.99430

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02567	0.02663	0.02937	0.03482	0.04985	0.07735
0.15000	0.02592	0.02689	0.02965	0.03515	0.05018	0.07762
0.20000	0.02646	0.02744	0.03021	0.03580	0.05104	0.07878
0.25000	0.02732	0.02834	0.03123	0.03721	0.05338	0.08236
0.30000	0.02844	0.02956	0.03252	0.03900	0.05635	0.08702
0.35000	0.02987	0.03118	0.03436	0.04197	0.06141	0.09475
0.40000	0.03162	0.03317	0.03668	0.04620	0.06838	0.10503
0.45000	0.03372	0.03570	0.04034	0.05294	0.07909	0.12017
0.50000	0.03622	0.03898	0.04527	0.06349	0.09512	0.14217
0.55000	0.03968	0.04355	0.05510	0.08036	0.11986	0.17557
0.60000	0.04441	0.05256	0.07505	0.11231	0.16529	0.23611
0.65000	0.05282	0.07208	0.11013	0.16602	0.24075	0.33651
0.70000	0.07005	0.11153	0.17623	0.26446	0.37737	0.51713
0.75000	0.11419	0.19361	0.30607	0.45205	0.63268	0.85014
0.80000	0.21416	0.36235	0.55962	0.80649	1.10411	1.45465
0.85000	0.42754	0.69616	1.03851	1.45514	1.94718	2.51681
0.90000	0.85264	1.32294	1.90326	2.59412	3.39667	4.31307
0.95000	1.64787	2.44163	3.39693	4.51429	5.79486	7.24083
1.00000	3.05446	4.34714	5.87248	7.63099	9.62383	11.85320

MULTIMISSION UDF HIGH SPEED DRAG POLAR, SEALEVEL

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02590	0. 02581	0. 02572	0. 02570	0. 02575	0. 02586	0. 02612	0. 02654
0. 15000	0. 02614	0. 02605	0. 02596	0. 02594	0. 02599	0. 02610	0. 02636	0. 02678
0. 20000	0. 02667	0. 02658	0. 02649	0. 02647	0. 02652	0. 02664	0. 02689	0. 02731
0. 25000	0. 02750	0. 02741	0. 02732	0. 02730	0. 02736	0. 02748	0. 02774	0. 02817
0. 30000	0. 02860	0. 02850	0. 02841	0. 02840	0. 02846	0. 02858	0. 02884	0. 02928
0. 35000	0. 02994	0. 02985	0. 02976	0. 02976	0. 02983	0. 02996	0. 03023	0. 03068
0. 40000	0. 03156	0. 03146	0. 03138	0. 03140	0. 03147	0. 03161	0. 03191	0. 03238
0. 45000	0. 03342	0. 03333	0. 03327	0. 03330	0. 03339	0. 03356	0. 03389	0. 03440
0. 50000	0. 03555	0. 03546	0. 03544	0. 03548	0. 03560	0. 03581	0. 03618	0. 03678
0. 55000	0. 03796	0. 03789	0. 03790	0. 03798	0. 03813	0. 03839	0. 03883	0. 03956
0. 60000	0. 04068	0. 04066	0. 04071	0. 04083	0. 04105	0. 04139	0. 04197	0. 04309
0. 65000	0. 04379	0. 04382	0. 04391	0. 04408	0. 04438	0. 04481	0. 04560	0. 04776
0. 70000	0. 04724	0. 04730	0. 04743	0. 04768	0. 04805	0. 04868	0. 05019	0. 05412
0. 75000	0. 05107	0. 05117	0. 05137	0. 05170	0. 05221	0. 05319	0. 05593	0. 06953
0. 80000	0. 05525	0. 05541	0. 05568	0. 05609	0. 05684	0. 05885	0. 07049	0. 11675
0. 85000	0. 06009	0. 06031	0. 06066	0. 06127	0. 06269	0. 06720	0. 11314	0. 23432
0. 90000	0. 06522	0. 06552	0. 06601	0. 06691	0. 06960	0. 10317	0. 24357	0. 49407
0. 95000	0. 07064	0. 07101	0. 07176	0. 07370	0. 10042	0. 23707	0. 54651	1. 01746
1. 00000	0. 07634	0. 07693	0. 07830	0. 08292	0. 21100	0. 57346	1. 16864	1. 99630

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02718	0. 02813	0. 03086	0. 03631	0. 05132	0. 07882
0. 15000	0. 02742	0. 02839	0. 03113	0. 03662	0. 05165	0. 07908
0. 20000	0. 02796	0. 02893	0. 03169	0. 03727	0. 05251	0. 08024
0. 25000	0. 02882	0. 02984	0. 03272	0. 03869	0. 05485	0. 08382
0. 30000	0. 02995	0. 03106	0. 03401	0. 04048	0. 05783	0. 08849
0. 35000	0. 03138	0. 03269	0. 03585	0. 04345	0. 06289	0. 09622
0. 40000	0. 03313	0. 03467	0. 03818	0. 04769	0. 06986	0. 10650
0. 45000	0. 03524	0. 03721	0. 04185	0. 05444	0. 08058	0. 12165
0. 50000	0. 03775	0. 04050	0. 04679	0. 06500	0. 09662	0. 14366
0. 55000	0. 04122	0. 04508	0. 05662	0. 08188	0. 12137	0. 17707
0. 60000	0. 04597	0. 05410	0. 07658	0. 11384	0. 16681	0. 23763
0. 65000	0. 05439	0. 07365	0. 11170	0. 16757	0. 24230	0. 33805
0. 70000	0. 07166	0. 11312	0. 17782	0. 26604	0. 37894	0. 51870
0. 75000	0. 11583	0. 19524	0. 30770	0. 45366	0. 63429	0. 85175
0. 80000	0. 21584	0. 36402	0. 56129	0. 80815	1. 10576	1. 45630
0. 85000	0. 42931	0. 69791	1. 04026	1. 45688	1. 94891	2. 51853
0. 90000	0. 85448	1. 32477	1. 90508	2. 59593	3. 39847	4. 31486
0. 95000	1. 64979	2. 44353	3. 39882	4. 51618	5. 79674	7. 24269
1. 00000	3. 05645	4. 34912	5. 87445	7. 63295	9. 62578	11. 85510

MULTIMISSION UDF HIGH SPEED DRAG POLAR, 20000 FT

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02815	0.02804	0.02793	0.02790	0.02794	0.02804	0.02828	0.02869
0.15000	0.02838	0.02827	0.02817	0.02813	0.02817	0.02827	0.02851	0.02893
0.20000	0.02891	0.02880	0.02870	0.02866	0.02870	0.02880	0.02905	0.02946
0.25000	0.02974	0.02964	0.02953	0.02950	0.02954	0.02965	0.02989	0.03031
0.30000	0.03084	0.03073	0.03063	0.03061	0.03065	0.03076	0.03101	0.03143
0.35000	0.03220	0.03209	0.03199	0.03197	0.03202	0.03214	0.03240	0.03284
0.40000	0.03382	0.03371	0.03361	0.03362	0.03367	0.03380	0.03409	0.03455
0.45000	0.03570	0.03559	0.03551	0.03553	0.03561	0.03576	0.03608	0.03657
0.50000	0.03783	0.03772	0.03769	0.03772	0.03782	0.03802	0.03838	0.03896
0.55000	0.04026	0.04017	0.04017	0.04023	0.04037	0.04062	0.04104	0.04176
0.60000	0.04300	0.04297	0.04300	0.04311	0.04331	0.04364	0.04420	0.04531
0.65000	0.04615	0.04616	0.04623	0.04639	0.04667	0.04709	0.04787	0.05002
0.70000	0.04964	0.04968	0.04980	0.05003	0.05039	0.05100	0.05250	0.05642
0.75000	0.05353	0.05361	0.05380	0.05411	0.05461	0.05557	0.05830	0.07188
0.80000	0.05777	0.05791	0.05817	0.05856	0.05929	0.06129	0.07292	0.11916
0.85000	0.06272	0.06292	0.06326	0.06386	0.06526	0.06976	0.11567	0.23684
0.90000	0.06797	0.06825	0.06872	0.06961	0.07228	0.10583	0.24622	0.49670
0.95000	0.07350	0.07386	0.07458	0.07651	0.10321	0.23984	0.54926	1.02020
1.00000	0.07931	0.07989	0.08124	0.08584	0.21390	0.57635	1.17151	1.99915

LIST Multimission UDF Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02932	0.03026	0.03297	0.03841	0.05342	0.08090
0.15000	0.02955	0.03051	0.03324	0.03872	0.05374	0.08116
0.20000	0.03009	0.03105	0.03380	0.03937	0.05460	0.08232
0.25000	0.03095	0.03196	0.03483	0.04079	0.05694	0.08590
0.30000	0.03209	0.03319	0.03613	0.04259	0.05992	0.09057
0.35000	0.03353	0.03482	0.03798	0.04557	0.06499	0.09832
0.40000	0.03528	0.03681	0.04031	0.04981	0.07197	0.10860
0.45000	0.03740	0.03936	0.04398	0.05657	0.08270	0.12376
0.50000	0.03992	0.04266	0.04894	0.06713	0.09875	0.14578
0.55000	0.04341	0.04726	0.05878	0.08403	0.12351	0.17920
0.60000	0.04818	0.05630	0.07877	0.11602	0.16897	0.23978
0.65000	0.05664	0.07588	0.11391	0.16978	0.24449	0.34023
0.70000	0.07394	0.11539	0.18008	0.26829	0.38118	0.52092
0.75000	0.11817	0.19757	0.31001	0.45597	0.63658	0.85403
0.80000	0.21824	0.36641	0.56366	0.81052	1.10811	1.45864
0.85000	0.43181	0.70040	1.04274	1.45934	1.95136	2.52097
0.90000	0.85710	1.32737	1.90767	2.59851	3.40103	4.31741
0.95000	1.65251	2.44624	3.40152	4.51886	5.79941	7.24535
1.00000	3.05928	4.35194	5.87725	7.63574	9.62855	11.85790

MULTIMISSION UDF HIGH SPEED DRAG POLAR, 40000 FT

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02425	0.02417	0.02409	0.02409	0.02416	0.02429	0.02454	0.02495
0.15000	0.02450	0.02442	0.02434	0.02434	0.02441	0.02454	0.02479	0.02520
0.20000	0.02504	0.02496	0.02488	0.02488	0.02495	0.02508	0.02533	0.02574
0.25000	0.02587	0.02579	0.02571	0.02571	0.02579	0.02592	0.02618	0.02659
0.30000	0.02697	0.02688	0.02681	0.02681	0.02689	0.02702	0.02729	0.02770
0.35000	0.02832	0.02823	0.02815	0.02817	0.02826	0.02840	0.02867	0.02910
0.40000	0.02993	0.02984	0.02977	0.02981	0.02990	0.03005	0.03034	0.03079
0.45000	0.03179	0.03170	0.03166	0.03171	0.03182	0.03199	0.03231	0.03281
0.50000	0.03391	0.03383	0.03382	0.03390	0.03402	0.03423	0.03459	0.03518
0.55000	0.03631	0.03625	0.03629	0.03639	0.03654	0.03680	0.03721	0.03796
0.60000	0.03902	0.03902	0.03910	0.03922	0.03944	0.03976	0.04034	0.04149
0.65000	0.04211	0.04216	0.04227	0.04245	0.04273	0.04315	0.04396	0.04617
0.70000	0.04554	0.04562	0.04576	0.04600	0.04636	0.04699	0.04854	0.05253
0.75000	0.04934	0.04946	0.04966	0.04997	0.05048	0.05148	0.05428	0.06796
0.80000	0.05348	0.05364	0.05391	0.05430	0.05507	0.05712	0.06884	0.11518
0.85000	0.05823	0.05845	0.05879	0.05941	0.06087	0.06544	0.11147	0.23272
0.90000	0.06328	0.06357	0.06406	0.06499	0.06773	0.10138	0.24187	0.49244
0.95000	0.06861	0.06897	0.06973	0.07173	0.09852	0.23527	0.54478	1.01582
1.00000	0.07421	0.07481	0.07622	0.08090	0.20908	0.57163	1.16689	1.99464

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02558	0.02655	0.02932	0.03485	0.04995	0.07756
0.15000	0.02583	0.02682	0.02961	0.03518	0.05029	0.07783
0.20000	0.02637	0.02737	0.03018	0.03583	0.05116	0.07901
0.25000	0.02724	0.02828	0.03121	0.03726	0.05350	0.08259
0.30000	0.02836	0.02950	0.03251	0.03906	0.05648	0.08727
0.35000	0.02980	0.03113	0.03435	0.04204	0.06155	0.09501
0.40000	0.03154	0.03312	0.03668	0.04628	0.06853	0.10531
0.45000	0.03366	0.03567	0.04037	0.05305	0.07927	0.12047
0.50000	0.03617	0.03897	0.04534	0.06362	0.09534	0.14251
0.55000	0.03965	0.04357	0.05519	0.08052	0.12011	0.17594
0.60000	0.04442	0.05263	0.07518	0.11252	0.16559	0.23654
0.65000	0.05287	0.07220	0.11032	0.16628	0.24110	0.33699
0.70000	0.07016	0.11169	0.17646	0.26477	0.37778	0.51767
0.75000	0.11433	0.19382	0.30636	0.45241	0.63314	0.85074
0.80000	0.21435	0.36261	0.55996	0.80691	1.10463	1.45531
0.85000	0.42779	0.69648	1.03891	1.45562	1.94776	2.51752
0.90000	0.85294	1.32332	1.90372	2.59466	3.39731	4.31385
0.95000	1.64824	2.44207	3.39745	4.51490	5.79557	7.24167
1.00000	3.05488	4.34764	5.87306	7.63166	9.62460	11.85410

MULTIMISSION TURBOPROP HIGH SPEED DRAG POLAR, SEALEVEL

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02582	0.02573	0.02564	0.02562	0.02569	0.02580	0.02605	0.02645
0.15000	0.02606	0.02597	0.02588	0.02587	0.02593	0.02605	0.02630	0.02670
0.20000	0.02660	0.02651	0.02642	0.02641	0.02647	0.02659	0.02683	0.02723
0.25000	0.02744	0.02734	0.02725	0.02725	0.02731	0.02743	0.02768	0.02809
0.30000	0.02853	0.02844	0.02835	0.02835	0.02842	0.02854	0.02880	0.02921
0.35000	0.02989	0.02979	0.02970	0.02972	0.02979	0.02992	0.03019	0.03061
0.40000	0.03150	0.03141	0.03133	0.03135	0.03144	0.03158	0.03186	0.03230
0.45000	0.03337	0.03328	0.03323	0.03327	0.03336	0.03353	0.03384	0.03432
0.50000	0.03550	0.03541	0.03540	0.03546	0.03557	0.03577	0.03612	0.03670
0.55000	0.03792	0.03784	0.03787	0.03796	0.03810	0.03835	0.03876	0.03949
0.60000	0.04063	0.04063	0.04069	0.04081	0.04102	0.04133	0.04190	0.04304
0.65000	0.04376	0.04379	0.04389	0.04406	0.04433	0.04475	0.04554	0.04774
0.70000	0.04721	0.04728	0.04741	0.04764	0.04799	0.04862	0.05015	0.05414
0.75000	0.05106	0.05116	0.05135	0.05165	0.05215	0.05314	0.05593	0.06960
0.80000	0.05524	0.05539	0.05564	0.05603	0.05678	0.05883	0.07053	0.11687
0.85000	0.06007	0.06028	0.06060	0.06121	0.06266	0.06722	0.11324	0.23448
0.90000	0.06520	0.06547	0.06595	0.06687	0.06960	0.10324	0.24372	0.49428
0.95000	0.07061	0.07096	0.07170	0.07369	0.10047	0.23720	0.54670	1.01773
1.00000	0.07629	0.07687	0.07827	0.08294	0.21111	0.57364	1.16889	1.99663

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02707	0.02804	0.03080	0.03632	0.05141	0.07902
0.15000	0.02732	0.02830	0.03108	0.03664	0.05175	0.07929
0.20000	0.02786	0.02885	0.03165	0.03730	0.05262	0.08046
0.25000	0.02873	0.02976	0.03268	0.03873	0.05496	0.08405
0.30000	0.02986	0.03099	0.03398	0.04053	0.05795	0.08873
0.35000	0.03130	0.03262	0.03584	0.04351	0.06302	0.09648
0.40000	0.03305	0.03462	0.03817	0.04776	0.07001	0.10677
0.45000	0.03517	0.03717	0.04186	0.05454	0.08075	0.12195
0.50000	0.03769	0.04048	0.04684	0.06511	0.09682	0.14399
0.55000	0.04118	0.04509	0.05671	0.08202	0.12161	0.17743
0.60000	0.04596	0.05417	0.07671	0.11404	0.16710	0.23804
0.65000	0.05443	0.07376	0.11187	0.16782	0.24264	0.33852
0.70000	0.07175	0.11327	0.17804	0.26634	0.37934	0.51923
0.75000	0.11597	0.19545	0.30797	0.45402	0.63474	0.85233
0.80000	0.21603	0.36428	0.56162	0.80856	1.10627	1.45694
0.85000	0.42954	0.69822	1.04065	1.45735	1.94947	2.51923
0.90000	0.85477	1.32514	1.90553	2.59646	3.39910	4.31563
0.95000	1.65014	2.44396	3.39933	4.51677	5.79743	7.24353
1.00000	3.05686	4.34961	5.87502	7.63361	9.62654	11.85600

MULTIMISSION TURBOPROP HIGH SPEED DRAG POLAR, 20000 FT

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02805	0. 02794	0. 02784	0. 02781	0. 02786	0. 02796	0. 02820	0. 02858
0. 15000	0. 02829	0. 02818	0. 02808	0. 02805	0. 02810	0. 02820	0. 02844	0. 02882
0. 20000	0. 02882	0. 02872	0. 02861	0. 02859	0. 02864	0. 02874	0. 02897	0. 02936
0. 25000	0. 02966	0. 02955	0. 02945	0. 02943	0. 02948	0. 02959	0. 02982	0. 03022
0. 30000	0. 03076	0. 03066	0. 03055	0. 03054	0. 03059	0. 03070	0. 03094	0. 03134
0. 35000	0. 03212	0. 03202	0. 03191	0. 03191	0. 03197	0. 03209	0. 03234	0. 03275
0. 40000	0. 03375	0. 03364	0. 03354	0. 03356	0. 03363	0. 03375	0. 03402	0. 03445
0. 45000	0. 03563	0. 03552	0. 03545	0. 03548	0. 03556	0. 03571	0. 03601	0. 03648
0. 50000	0. 03777	0. 03766	0. 03763	0. 03768	0. 03778	0. 03797	0. 03830	0. 03887
0. 55000	0. 04020	0. 04011	0. 04012	0. 04019	0. 04033	0. 04056	0. 04095	0. 04167
0. 60000	0. 04294	0. 04292	0. 04297	0. 04307	0. 04326	0. 04356	0. 04412	0. 04525
0. 65000	0. 04610	0. 04612	0. 04620	0. 04635	0. 04661	0. 04701	0. 04780	0. 04998
0. 70000	0. 04959	0. 04965	0. 04976	0. 04998	0. 05031	0. 05092	0. 05245	0. 05642
0. 75000	0. 05350	0. 05358	0. 05376	0. 05404	0. 05453	0. 05550	0. 05828	0. 07194
0. 80000	0. 05774	0. 05788	0. 05811	0. 05849	0. 05922	0. 06126	0. 07295	0. 11926
0. 85000	0. 06269	0. 06288	0. 06319	0. 06378	0. 06521	0. 06976	0. 11576	0. 23698
0. 90000	0. 06793	0. 06819	0. 06864	0. 06955	0. 07226	0. 10589	0. 24635	0. 49690
0. 95000	0. 07345	0. 07378	0. 07451	0. 07648	0. 10324	0. 23996	0. 54944	1. 02046
1. 00000	0. 07925	0. 07981	0. 08119	0. 08584	0. 21399	0. 57650	1. 17174	1. 99946

LIST Multimission Turboprop Drag TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02919	0. 03015	0. 03290	0. 03841	0. 05349	0. 08109
0. 15000	0. 02944	0. 03040	0. 03318	0. 03873	0. 05382	0. 08135
0. 20000	0. 02997	0. 03095	0. 03374	0. 03938	0. 05469	0. 08252
0. 25000	0. 03084	0. 03187	0. 03478	0. 04081	0. 05703	0. 08611
0. 30000	0. 03198	0. 03310	0. 03608	0. 04262	0. 06003	0. 09079
0. 35000	0. 03343	0. 03474	0. 03794	0. 04561	0. 06510	0. 09855
0. 40000	0. 03519	0. 03674	0. 04029	0. 04987	0. 07210	0. 10886
0. 45000	0. 03731	0. 03930	0. 04399	0. 05665	0. 08285	0. 12404
0. 50000	0. 03984	0. 04263	0. 04897	0. 06723	0. 09893	0. 14609
0. 55000	0. 04335	0. 04725	0. 05885	0. 08416	0. 12373	0. 17955
0. 60000	0. 04815	0. 05635	0. 07888	0. 11620	0. 16925	0. 24018
0. 65000	0. 05666	0. 07598	0. 11407	0. 17001	0. 24482	0. 34069
0. 70000	0. 07402	0. 11553	0. 18028	0. 26857	0. 38156	0. 52143
0. 75000	0. 11829	0. 19775	0. 31027	0. 45630	0. 63701	0. 85459
0. 80000	0. 21841	0. 36665	0. 56398	0. 81091	1. 10861	1. 45926
0. 85000	0. 43204	0. 70070	1. 04311	1. 45980	1. 95191	2. 52166
0. 90000	0. 85737	1. 32772	1. 90810	2. 59902	3. 40164	4. 31816
0. 95000	1. 65285	2. 44665	3. 40201	4. 51943	5. 80009	7. 24617
1. 00000	3. 05967	4. 35241	5. 87780	7. 63638	9. 62930	11. 85880

MULTIMISSION TURBOPROP HIGH SPEED DRAG POLAR, 40000 FT

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02531	0.02522	0.02514	0.02518	0.02533	0.02559	0.02603	0.02671
0.15000	0.02551	0.02542	0.02534	0.02538	0.02553	0.02579	0.02623	0.02691
0.20000	0.02597	0.02588	0.02580	0.02584	0.02600	0.02625	0.02669	0.02737
0.25000	0.02670	0.02661	0.02653	0.02658	0.02674	0.02700	0.02745	0.02814
0.30000	0.02766	0.02757	0.02749	0.02755	0.02771	0.02798	0.02844	0.02914
0.35000	0.02885	0.02877	0.02868	0.02876	0.02893	0.02921	0.02969	0.03041
0.40000	0.03028	0.03019	0.03012	0.03022	0.03041	0.03071	0.03122	0.03198
0.45000	0.03193	0.03184	0.03182	0.03194	0.03216	0.03250	0.03307	0.03389
0.50000	0.03381	0.03373	0.03377	0.03392	0.03418	0.03458	0.03522	0.03616
0.55000	0.03595	0.03590	0.03601	0.03620	0.03652	0.03700	0.03774	0.03887
0.60000	0.03836	0.03842	0.03858	0.03885	0.03927	0.03988	0.04082	0.04241
0.65000	0.04118	0.04130	0.04153	0.04189	0.04242	0.04319	0.04441	0.04713
0.70000	0.04430	0.04449	0.04478	0.04525	0.04592	0.04694	0.04896	0.05353
0.75000	0.04781	0.04805	0.04845	0.04904	0.04992	0.05136	0.05470	0.06901
0.80000	0.05163	0.05197	0.05249	0.05322	0.05440	0.05696	0.06927	0.11633
0.85000	0.05608	0.05652	0.05716	0.05817	0.06009	0.06523	0.11192	0.23399
0.90000	0.06083	0.06139	0.06224	0.06361	0.06688	0.10116	0.24240	0.49389
0.95000	0.06587	0.06656	0.06773	0.07022	0.09761	0.23505	0.54542	1.01741
1.00000	0.07118	0.07215	0.07403	0.07927	0.20809	0.57143	1.16765	1.99635

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02770	0.02912	0.03244	0.03867	0.05473	0.08368
0.15000	0.02790	0.02933	0.03267	0.03895	0.05501	0.08390
0.20000	0.02837	0.02981	0.03317	0.03952	0.05580	0.08499
0.25000	0.02915	0.03064	0.03412	0.04087	0.05808	0.08851
0.30000	0.03016	0.03175	0.03531	0.04257	0.06097	0.09310
0.35000	0.03149	0.03328	0.03707	0.04548	0.06598	0.10080
0.40000	0.03312	0.03518	0.03932	0.04966	0.07293	0.11108
0.45000	0.03515	0.03766	0.04299	0.05644	0.08372	0.12630
0.50000	0.03760	0.04094	0.04796	0.06708	0.09991	0.14845
0.55000	0.04105	0.04557	0.05790	0.08414	0.12488	0.18208
0.60000	0.04589	0.05476	0.07813	0.11648	0.17069	0.24300
0.65000	0.05444	0.07452	0.11355	0.17055	0.24651	0.34376
0.70000	0.07183	0.11421	0.17998	0.26932	0.38346	0.52472
0.75000	0.11617	0.19660	0.31013	0.45721	0.63907	0.85803
0.80000	0.21638	0.36562	0.56395	0.81193	1.11078	1.46281
0.85000	0.43003	0.69969	1.04311	1.46083	1.95410	2.52521
0.90000	0.85536	1.32670	1.90808	2.60004	3.40381	4.32169
0.95000	1.65079	2.44559	3.40194	4.52041	5.80220	7.24965
1.00000	3.05755	4.35127	5.87766	7.63727	9.63133	11.86210

MULTIMISSION TURBOFAN HIGH SPEED DRAG POLAR, SEALEVEL

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0. 10000	0. 02692	0. 02683	0. 02674	0. 02676	0. 02691	0. 02716	0. 02759	0. 02826
0. 15000	0. 02712	0. 02702	0. 02693	0. 02696	0. 02711	0. 02735	0. 02779	0. 02846
0. 20000	0. 02758	0. 02748	0. 02739	0. 02742	0. 02757	0. 02781	0. 02825	0. 02892
0. 25000	0. 02831	0. 02821	0. 02812	0. 02816	0. 02831	0. 02856	0. 02900	0. 02968
0. 30000	0. 02928	0. 02918	0. 02909	0. 02913	0. 02929	0. 02954	0. 02999	0. 03069
0. 35000	0. 03047	0. 03038	0. 03028	0. 03035	0. 03052	0. 03078	0. 03125	0. 03197
0. 40000	0. 03191	0. 03181	0. 03173	0. 03182	0. 03200	0. 03229	0. 03279	0. 03354
0. 45000	0. 03356	0. 03347	0. 03343	0. 03355	0. 03376	0. 03409	0. 03464	0. 03545
0. 50000	0. 03546	0. 03536	0. 03539	0. 03554	0. 03578	0. 03617	0. 03680	0. 03774
0. 55000	0. 03761	0. 03754	0. 03764	0. 03783	0. 03813	0. 03861	0. 03933	0. 04046
0. 60000	0. 04003	0. 04008	0. 04023	0. 04049	0. 04089	0. 04149	0. 04243	0. 04402
0. 65000	0. 04287	0. 04299	0. 04320	0. 04355	0. 04408	0. 04483	0. 04604	0. 04875
0. 70000	0. 04603	0. 04620	0. 04649	0. 04694	0. 04760	0. 04862	0. 05062	0. 05518
0. 75000	0. 04957	0. 04981	0. 05020	0. 05078	0. 05164	0. 05308	0. 05640	0. 07071
0. 80000	0. 05345	0. 05377	0. 05428	0. 05500	0. 05617	0. 05871	0. 07102	0. 11807
0. 85000	0. 05798	0. 05840	0. 05903	0. 06003	0. 06194	0. 06707	0. 11374	0. 23580
0. 90000	0. 06281	0. 06335	0. 06419	0. 06555	0. 06881	0. 10307	0. 24430	0. 49579
0. 95000	0. 06792	0. 06861	0. 06976	0. 07224	0. 09961	0. 23704	0. 54740	1. 01939
1. 00000	0. 07331	0. 07428	0. 07614	0. 08136	0. 21017	0. 57351	1. 16971	1. 99840

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02924	0. 03065	0. 03397	0. 04019	0. 05624	0. 08519
0. 15000	0. 02944	0. 03086	0. 03420	0. 04046	0. 05652	0. 08540
0. 20000	0. 02990	0. 03133	0. 03469	0. 04104	0. 05731	0. 08648
0. 25000	0. 03068	0. 03217	0. 03564	0. 04239	0. 05959	0. 09001
0. 30000	0. 03170	0. 03329	0. 03684	0. 04409	0. 06248	0. 09460
0. 35000	0. 03303	0. 03482	0. 03860	0. 04700	0. 06749	0. 10231
0. 40000	0. 03467	0. 03672	0. 04086	0. 05119	0. 07445	0. 11259
0. 45000	0. 03671	0. 03921	0. 04453	0. 05798	0. 08524	0. 12781
0. 50000	0. 03916	0. 04250	0. 04951	0. 06863	0. 10144	0. 14998
0. 55000	0. 04263	0. 04713	0. 05946	0. 08569	0. 12642	0. 18362
0. 60000	0. 04748	0. 05635	0. 07970	0. 11805	0. 17225	0. 24456
0. 65000	0. 05606	0. 07613	0. 11515	0. 17214	0. 24810	0. 34534
0. 70000	0. 07348	0. 11585	0. 18161	0. 27094	0. 38507	0. 52632
0. 75000	0. 11785	0. 19828	0. 31180	0. 45887	0. 64072	0. 85967
0. 80000	0. 21811	0. 36734	0. 56567	0. 81363	1. 11247	1. 46449
0. 85000	0. 43184	0. 70149	1. 04490	1. 46261	1. 95587	2. 52698
0. 90000	0. 85724	1. 32858	1. 90995	2. 60190	3. 40566	4. 32353
0. 95000	1. 65275	2. 44754	3. 40388	4. 52234	5. 80412	7. 25156
1. 00000	3. 05959	4. 35330	5. 87968	7. 63928	9. 63333	11. 86410

MULTIMISSION TURBOFAN HIGH SPEED DRAG POLAR, 20000 FT

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000 00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02923	0.02912	0.02901	0.02902	0.02916	0.02939	0.02981	0.03047
0.15000	0.02942	0.02931	0.02920	0.02921	0.02934	0.02958	0.03000	0.03066
0.20000	0.02987	0.02976	0.02966	0.02967	0.02980	0.03003	0.03045	0.03111
0.25000	0.03061	0.03050	0.03039	0.03041	0.03055	0.03078	0.03121	0.03188
0.30000	0.03158	0.03147	0.03136	0.03139	0.03153	0.03178	0.03221	0.03289
0.35000	0.03278	0.03267	0.03256	0.03262	0.03277	0.03302	0.03348	0.03418
0.40000	0.03423	0.03411	0.03402	0.03409	0.03426	0.03453	0.03502	0.03576
0.45000	0.03589	0.03578	0.03573	0.03583	0.03602	0.03634	0.03688	0.03768
0.50000	0.03780	0.03768	0.03770	0.03783	0.03806	0.03844	0.03905	0.03998
0.55000	0.03996	0.03988	0.03996	0.04014	0.04043	0.04089	0.04160	0.04271
0.60000	0.04241	0.04244	0.04258	0.04282	0.04321	0.04380	0.04472	0.04629
0.65000	0.04529	0.04539	0.04558	0.04592	0.04643	0.04717	0.04837	0.05106
0.70000	0.04849	0.04865	0.04891	0.04935	0.05000	0.05100	0.05299	0.05754
0.75000	0.05209	0.05231	0.05268	0.05325	0.05410	0.05551	0.05882	0.07312
0.80000	0.05603	0.05634	0.05683	0.05754	0.05869	0.06122	0.07351	0.12054
0.85000	0.06068	0.06109	0.06170	0.06268	0.06457	0.06968	0.11634	0.23839
0.90000	0.06562	0.06615	0.06697	0.06831	0.07155	0.10580	0.24702	0.49849
0.95000	0.07086	0.07152	0.07266	0.07512	0.10247	0.23988	0.55023	1.02219
1.00000	0.07637	0.07731	0.07915	0.08435	0.21314	0.57646	1.17265	2.00132

LIST Multimission Turbofan Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.03143	0.03284	0.03614	0.04235	0.05839	0.08732
0.15000	0.03163	0.03304	0.03636	0.04261	0.05866	0.08753
0.20000	0.03209	0.03351	0.03685	0.04318	0.05944	0.08861
0.25000	0.03287	0.03434	0.03780	0.04454	0.06173	0.09214
0.30000	0.03390	0.03547	0.03901	0.04625	0.06463	0.09674
0.35000	0.03523	0.03701	0.04078	0.04917	0.06965	0.10446
0.40000	0.03688	0.03892	0.04304	0.05336	0.07661	0.11474
0.45000	0.03892	0.04142	0.04672	0.06016	0.08741	0.12998
0.50000	0.04139	0.04471	0.05172	0.07082	0.10362	0.15215
0.55000	0.04487	0.04937	0.06168	0.08790	0.12862	0.18580
0.60000	0.04975	0.05860	0.08194	0.12028	0.17447	0.24677
0.65000	0.05836	0.07842	0.11743	0.17440	0.25035	0.34758
0.70000	0.07582	0.11818	0.18392	0.27325	0.38737	0.52860
0.75000	0.12025	0.20066	0.31417	0.46123	0.64307	0.86200
0.80000	0.22057	0.36979	0.56810	0.81606	1.11488	1.46689
0.85000	0.43441	0.70404	1.04744	1.46514	1.95839	2.52948
0.90000	0.85992	1.33124	1.91260	2.60454	3.40828	4.32614
0.95000	1.65555	2.45032	3.40664	4.52508	5.80686	7.25428
1.00000	3.06249	4.35618	5.88255	7.64214	9.63617	11.86700

MULTIMISSION TURBOFAN HIGH SPEED DRAG POLAR, 40000 FT

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 1

ALT = 0.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02158	0.02150	0.02143	0.02143	0.02149	0.02159	0.02181	0.02217
0.15000	0.02189	0.02182	0.02175	0.02174	0.02180	0.02191	0.02212	0.02249
0.20000	0.02249	0.02242	0.02235	0.02234	0.02240	0.02251	0.02272	0.02309
0.25000	0.02338	0.02331	0.02323	0.02323	0.02330	0.02340	0.02362	0.02400
0.30000	0.02453	0.02445	0.02438	0.02439	0.02445	0.02456	0.02479	0.02516
0.35000	0.02593	0.02585	0.02578	0.02580	0.02587	0.02598	0.02622	0.02660
0.40000	0.02759	0.02751	0.02745	0.02747	0.02755	0.02768	0.02793	0.02833
0.45000	0.02950	0.02942	0.02938	0.02942	0.02951	0.02966	0.02993	0.03037
0.50000	0.03166	0.03159	0.03158	0.03164	0.03174	0.03192	0.03223	0.03276
0.55000	0.03411	0.03405	0.03408	0.03416	0.03429	0.03451	0.03487	0.03556
0.60000	0.03685	0.03685	0.03691	0.03701	0.03720	0.03748	0.03799	0.03910
0.65000	0.03997	0.04001	0.04010	0.04025	0.04049	0.04086	0.04162	0.04380
0.70000	0.04342	0.04349	0.04360	0.04381	0.04411	0.04471	0.04621	0.05022
0.75000	0.04724	0.04734	0.04751	0.04777	0.04823	0.04920	0.05198	0.06587
0.80000	0.05139	0.05152	0.05175	0.05209	0.05282	0.05486	0.06667	0.11339
0.85000	0.05615	0.05634	0.05662	0.05720	0.05864	0.06324	0.10960	0.23124
0.90000	0.06120	0.06144	0.06188	0.06278	0.06553	0.09943	0.24034	0.49130
0.95000	0.06652	0.06683	0.06756	0.06955	0.09646	0.23366	0.54360	1.01505
1.00000	0.07210	0.07266	0.07406	0.07879	0.20737	0.57039	1.16609	1.99427

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 2

ALT = 0.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02276	0.02369	0.02644	0.03209	0.04766	0.07631
0.15000	0.02308	0.02402	0.02680	0.03251	0.04810	0.07670
0.20000	0.02368	0.02464	0.02743	0.03324	0.04907	0.07800
0.25000	0.02460	0.02560	0.02852	0.03474	0.05151	0.08170
0.30000	0.02578	0.02688	0.02988	0.03662	0.05460	0.08650
0.35000	0.02726	0.02856	0.03178	0.03970	0.05978	0.09438
0.40000	0.02904	0.03059	0.03417	0.04405	0.06688	0.10481
0.45000	0.03118	0.03317	0.03792	0.05094	0.07776	0.12014
0.50000	0.03372	0.03651	0.04302	0.06166	0.09399	0.14236
0.55000	0.03723	0.04117	0.05306	0.07876	0.11897	0.17602
0.60000	0.04202	0.05043	0.07329	0.11099	0.16471	0.23690
0.65000	0.05059	0.07025	0.10867	0.16502	0.24052	0.33768
0.70000	0.06814	0.11000	0.17509	0.26382	0.37752	0.51871
0.75000	0.11260	0.19242	0.30530	0.45179	0.63324	0.85217
0.80000	0.21292	0.36153	0.55925	0.80667	1.10513	1.45716
0.85000	0.42668	0.69575	1.03858	1.45578	1.94870	2.51984
0.90000	0.85220	1.32298	1.90381	2.59527	3.39872	4.31667
0.95000	1.64789	2.44215	3.39799	4.51598	5.79749	7.24303
1.00000	3.05497	4.34819	5.87409	7.63327	9.62708	11.85800

MULTIMISSION STOVL HIGH SPEED DRAG POLAR, SEALEVEL

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 3

ALT = 20000. 00000

CL/M	0. 60000	0. 62000	0. 64000	0. 66000	0. 68000	0. 70000	0. 72000	0. 74000
0 10000	0. 02301	0. 02292	0. 02284	0. 02283	0. 02288	0. 02298	0. 02318	0. 02354
0. 15000	0. 02332	0. 02323	0. 02315	0. 02314	0. 02319	0. 02329	0. 02349	0. 02385
0. 20000	0. 02391	0. 02383	0. 02375	0. 02373	0. 02378	0. 02388	0. 02409	0. 02445
0. 25000	0. 02480	0. 02472	0. 02464	0. 02463	0. 02468	0. 02478	0. 02500	0. 02536
0. 30000	0. 02596	0. 02587	0. 02579	0. 02578	0. 02584	0. 02594	0. 02616	0. 02653
0. 35000	0. 02736	0. 02727	0. 02719	0. 02720	0. 02726	0. 02737	0. 02760	0. 02797
0. 40000	0. 02903	0. 02894	0. 02886	0. 02888	0. 02895	0. 02907	0. 02931	0. 02971
0. 45000	0. 03094	0. 03085	0. 03080	0. 03084	0. 03092	0. 03106	0. 03132	0. 03175
0. 50000	0. 03311	0. 03303	0. 03301	0. 03306	0. 03316	0. 03333	0. 03363	0. 03415
0. 55000	0. 03557	0. 03550	0. 03552	0. 03559	0. 03571	0. 03592	0. 03627	0. 03696
0. 60000	0. 03832	0. 03832	0. 03837	0. 03846	0. 03864	0. 03891	0. 03942	0. 04052
0. 65000	0. 04147	0. 04150	0. 04158	0. 04172	0. 04196	0. 04232	0. 04306	0. 04524
0. 70000	0. 04495	0. 04501	0. 04512	0. 04531	0. 04561	0. 04619	0. 04769	0. 05169
0. 75000	0. 04881	0. 04890	0. 04906	0. 04931	0. 04976	0. 05072	0. 05350	0. 06738
0. 80000	0. 05300	0. 05313	0. 05335	0. 05368	0. 05440	0. 05643	0. 06823	0. 11494
0. 85000	0. 05785	0. 05802	0. 05829	0. 05886	0. 06029	0. 06488	0. 11124	0. 23287
0. 90000	0. 06297	0. 06320	0. 06363	0. 06452	0. 06726	0. 10115	0. 24205	0. 49300
0. 95000	0. 06837	0. 06867	0. 06938	0. 07136	0. 09827	0. 23545	0. 54538	1. 01682
1. 00000	0. 07403	0. 07458	0. 07597	0. 08069	0. 20925	0. 57226	1. 16795	1. 99613

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 4

ALT = 20000. 00000

CL/M	0. 76000	0. 78000	0. 80000	0. 82000	0. 84000	0. 86000
0. 10000	0. 02412	0. 02505	0. 02779	0. 03343	0. 04899	0. 07763
0. 15000	0. 02443	0. 02537	0. 02814	0. 03384	0. 04943	0. 07803
0. 20000	0. 02503	0. 02598	0. 02877	0. 03457	0. 05040	0. 07932
0. 25000	0. 02595	0. 02695	0. 02986	0. 03608	0. 05284	0. 08302
0. 30000	0. 02714	0. 02823	0. 03122	0. 03796	0. 05593	0. 08783
0. 35000	0. 02862	0. 02991	0. 03313	0. 04104	0. 06111	0. 09571
0. 40000	0. 03041	0. 03195	0. 03552	0. 04540	0. 06822	0. 10614
0. 45000	0. 03256	0. 03454	0. 03928	0. 05229	0. 07910	0. 12148
0. 50000	0. 03510	0. 03789	0. 04439	0. 06303	0. 09534	0. 14371
0. 55000	0. 03862	0. 04256	0. 05444	0. 08013	0. 12033	0. 17738
0. 60000	0. 04343	0. 05183	0. 07468	0. 11238	0. 16609	0. 23828
0. 65000	0. 05202	0. 07167	0. 11009	0. 16643	0. 24192	0. 33907
0. 70000	0. 06960	0. 11146	0. 17654	0. 26526	0. 37895	0. 52014
0. 75000	0. 11410	0. 19391	0. 30678	0. 45327	0. 63471	0. 85363
0. 80000	0. 21446	0. 36306	0. 56077	0. 80818	1. 10664	1. 45867
0. 85000	0. 42830	0. 69735	1. 04018	1. 45737	1. 95028	2. 52142
0. 90000	0. 85389	1. 32466	1. 90548	2. 59693	3. 40038	4. 31832
0. 95000	1. 64965	2. 44391	3. 39973	4. 51772	5. 79922	7. 24676
1. 00000	3. 05681	4. 35002	5. 87591	7. 63509	9. 62888	11. 85980

MULTIMISSION STOVL HIGH SPEED DRAG POLAR, 20000 FT

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 5

ALT = 40000.00000

CL/M	0.60000	0.62000	0.64000	0.66000	0.68000	0.70000	0.72000	0.74000
0.10000	0.02504	0.02494	0.02484	0.02482	0.02486	0.02494	0.02514	0.02549
0.15000	0.02534	0.02524	0.02515	0.02512	0.02516	0.02524	0.02544	0.02579
0.20000	0.02593	0.02584	0.02574	0.02571	0.02575	0.02584	0.02604	0.02638
0.25000	0.02683	0.02673	0.02664	0.02661	0.02665	0.02674	0.02694	0.02730
0.30000	0.02799	0.02789	0.02779	0.02777	0.02782	0.02791	0.02811	0.02847
0.35000	0.02940	0.02930	0.02920	0.02920	0.02925	0.02934	0.02956	0.02992
0.40000	0.03107	0.03097	0.03088	0.03089	0.03095	0.03105	0.03128	0.03167
0.45000	0.03299	0.03289	0.03283	0.03285	0.03292	0.03305	0.03330	0.03372
0.50000	0.03518	0.03508	0.03505	0.03509	0.03517	0.03533	0.03562	0.03613
0.55000	0.03765	0.03757	0.03757	0.03763	0.03774	0.03794	0.03828	0.03895
0.60000	0.04043	0.04040	0.04044	0.04053	0.04069	0.04094	0.04144	0.04253
0.65000	0.04361	0.04363	0.04369	0.04382	0.04404	0.04439	0.04512	0.04728
0.70000	0.04713	0.04717	0.04727	0.04745	0.04773	0.04830	0.04978	0.05378
0.75000	0.05105	0.05112	0.05127	0.05150	0.05194	0.05289	0.05565	0.06952
0.80000	0.05531	0.05542	0.05562	0.05594	0.05664	0.05866	0.07044	0.11714
0.85000	0.06026	0.06042	0.06068	0.06123	0.06264	0.06722	0.11356	0.23518
0.90000	0.06550	0.06571	0.06612	0.06700	0.06972	0.10360	0.24448	0.49542
0.95000	0.07101	0.07129	0.07199	0.07395	0.10084	0.23801	0.54792	1.01935
1.00000	0.07679	0.07731	0.07868	0.08338	0.21193	0.57493	1.17060	1.99876

LIST Multimission STOVL Drag Polar TABLE NO. 1 3-DIMENSIONAL (19X 14X 3) TABLE LENGTH 925 PAGE 6

ALT = 40000.00000

CL/M	0.76000	0.78000	0.80000	0.82000	0.84000	0.86000
0.10000	0.02605	0.02697	0.02970	0.03534	0.05088	0.07952
0.15000	0.02636	0.02729	0.03004	0.03573	0.05132	0.07990
0.20000	0.02696	0.02790	0.03067	0.03647	0.05228	0.08119
0.25000	0.02788	0.02887	0.03177	0.03798	0.05473	0.08490
0.30000	0.02907	0.03015	0.03314	0.03986	0.05782	0.08971
0.35000	0.03056	0.03184	0.03505	0.04295	0.06301	0.09760
0.40000	0.03236	0.03389	0.03745	0.04731	0.07013	0.10804
0.45000	0.03452	0.03648	0.04122	0.05422	0.08102	0.12338
0.50000	0.03707	0.03984	0.04634	0.06496	0.09727	0.14563
0.55000	0.04060	0.04453	0.05640	0.08208	0.12227	0.17931
0.60000	0.04543	0.05382	0.07666	0.11435	0.16805	0.24023
0.65000	0.05406	0.07370	0.11210	0.16843	0.24391	0.34106
0.70000	0.07168	0.11352	0.17859	0.26730	0.38098	0.52216
0.75000	0.11623	0.19603	0.30889	0.45537	0.63680	0.85571
0.80000	0.21665	0.36524	0.56294	0.81034	1.10879	1.46080
0.85000	0.43060	0.69964	1.04245	1.45963	1.95253	2.52366
0.90000	0.85629	1.32705	1.90786	2.59930	3.40273	4.32066
0.95000	1.65217	2.44641	3.40222	4.52020	5.80169	7.24920
1.00000	3.05943	4.35262	5.87850	7.63766	9.63144	11.86240

MULTIMISSION STOVL HIGH SPEED DRAG POLAR, 40000 FT

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APPENDIX B

CALCULATION OF RELIABILITY EFFECTS ON AIRCRAFT DEPLOYED

Section 8.1.1.2 calculates the number of aircraft required to support the mission neglecting the reliability of the aircraft. When the aircraft reliability is not equal to one, more aircraft must be available than the number of required mission capable aircraft. The average number of aircraft required is equal to the number of mission capable aircraft divided by the aircraft reliability; however, this satisfies the mission requirements only 50% of the time. In order to estimate the number required for other levels of confidence, a more sophisticated approach is required. The Binomial probability distribution is appropriate for this estimation.

The Binomial probability distribution is expressed as:

$$P(n,i) = \binom{n}{i} * p^{i} * q^{(n-i)}$$

where:

$P(n,i)$ is the probability of i successes out of n trials.

$\binom{n}{i}$ is the number of combinations of n things taken i at a time.

This is calculated as $\dfrac{(n)!}{(i)!(n-i)!}$

where $(\cdot)!$ represents the factorial function.

p is the probability of a success on each trial.

q is the probability of a failure on each trial and is equal to $(1-p)$.

In our calculations we will assign:

p as the reliability of an aircraft, the probability that it is mission capable.

i as the number of mission capable aircraft assumed.

n as the number of aircraft available to provide i number of aircraft.

This leads to:

$P(n,i)$ is the probability that i aircraft selected from the n available will be mission capable.

For our purpose, we wish to calculate $P_2(n,m)$; the probability that <u>at least</u> m aircraft selected from the n available will be mission capable. This can be calculated as:

$$P_2\,(n,m) = \sum_{i=m}^{n} P(n,i)$$

Fully expanding the expression, we get:

$$P_2(n,m) = \sum_{i=m}^{n} \frac{(n)!}{(i)!(n-i)!} * p^i * (1-p)^{(n-i)}$$

As an example, let us assume an aircraft reliability of 85%, that five aircraft are required, and that seven aircraft are available. This gives:

$$P_2(7,5) = P(7,5) + P(7,6) + P(7,7)$$

$$= \frac{(7)!}{(5)!(2)!}(.85)^5(.15)^2 + \frac{(7)!}{(6)!(1)!}(.85)^6(.15)^1 + \frac{(7)!}{(7)!(0)!}(.85)^7(.15)^0$$

$$= .2097 + .3960 + .3206$$

$$= .9262$$

This can be interpreted as meaning that seven aircraft will be able to provide five mission capable aircraft with a 93% confidence level.

By repeating the above calculations for many combinations of aircraft required (m) and aircraft available (n), Table B-I was created. This Table was then used in Section 8.1.1.2 to determine that nine aircraft with 85% reliability will provide the six mission capable aircraft required with at least a 90% confidence level. This entry is shown on Table B-I as the example.

TABLE B-1 NUMBER OF AVAILABLE AIRCRAFT REQUIRED

UNIT RELIABILITY = 0.850

MISSION CAPABLE AIRCRAFT REQUIRED	MISSION CONFIDENCE LEVEL 0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
1	1	1	1	1	1	1	1	2	2	2
2	2	2	2	2	2	3	3	3	3	4
3	3	3	4	4	4	4	4	4	5	5
4	4	5	5	5	5	5	5	6	6	6
5	6	6	6	6	6	6	7	7	7	8
6	7	7	7	7	7	8	8	8	9	9
7	8	8	8	8	9	9	9	10	10	11
8	9	9	10	10	10	10	10	11	11	12
9	10	11	11	11	11	11	12	12	12	13
10	12	12	12	12	12	13	13	13	14	15
11	13	13	13	13	14	14	14	14	15	16
12	14	14	14	14	15	15	15	16	16	17
13	15	15	15	16	16	16	17	17	18	18
14	16	16	17	17	17	17	18	18	19	20
15	17	18	18	18	18	19	19	19	20	21
16	19	19	19	19	20	20	20	21	21	22
17	20	20	20	21	21	21	22	22	23	24
18	21	21	21	22	22	22	23	23	24	25
19	22	22	23	23	23	24	24	24	25	26
20	23	24	24	24	24	25	25	26	26	27
21	24	25	25	25	26	26	26	27	28	29
22	26	26	26	26	27	27	28	28	29	30
23	27	27	27	28	28	28	29	29	30	31
24	28	28	29	29	29	30	30	31	31	32
25	29	30	30	30	31	31	31	32	33	34

Example: Six mission capable aircraft are required. A 90% confidence level is desired. Looking in the "6" row and "0.90" column gives "9" aircraft with 0.85 reliability required.

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16. Abstract
Study requirements, assumptions and guidelines were identified regarding carrier suitability, aircraft missions, technology availability, and propulsion considerations. Conceptual designs were executed for two missions, a full multimission aircraft and a minimum mission aircraft using three different propulsion systems, the UnDucted Fan (UDF), the Propfan and an advanced Turbofan. Detailed aircraft optimization was completed on those configurations yielding gross weight performance and carrier spot factors. Propfan STOVL conceptual designs were exercised also to show the effects of STOVL on gross wt, spot factor and cost. An advanced technology research plan was generated to identify additional investigation opportunities from an airframe contractors standpoint. Life cycle cost analysis was accomplished yielding a comparison of the UDF and propfan configurations against each other as well as against a turbofan with equivalent state of the art turbo-machinery.

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