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GOODYEAR AEROSPACE CONCEPTUAL DESIGN MARITIME PATROL AIRSHIP - ZP3G

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A Conceptual design of a modern technology airship with precision hover capability for use in maritime patrol is described. The size and major characteristics are established by a series of United States Coast Guard missions set forth by the contracting agency.

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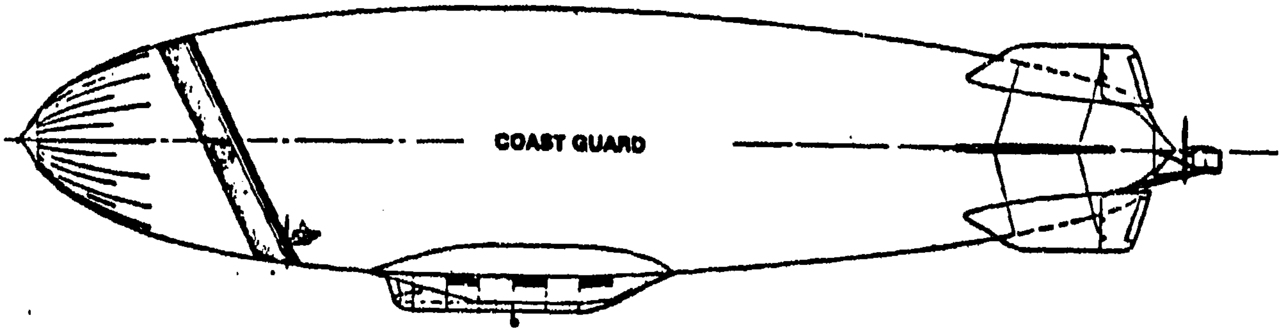

MARITIME PATROL AIRSHIP

ZP3G

Prepared For

NAVAL AIR DEVELOPMENT CENTER

Warminster, Pennsylvania

By

GOODYEAR AEROSPACE CORPORATION

AKRON, OHIO

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PREFACE

Goodyear Aerospace Corporation [GAC] has completed the design study for the ZP3G Maritime Patrol Airship. This effort was performed by the Advanced Airship Application Group at GAC. N. D. Brown was the project engineer and principal participant. The effort was guided by consultation with D. B. Bailey who directed the effort for NADC, and with Summit Research Incorporation [Gaithersburg, Md] who performed the missions analysis for this study under separate contract to NADC.

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1. INTRODUCTION

This report documents the results of a contract funded by Naval Air Development Center to perform a conceptual airship design study for the Maritime Patrol Airship Study. The study examines the characteristics of a modernized airship and incorporates these features to satisfy and comply with the Coast Guard missions set forth in the work statement. The scope of the contract effort was approximately $10,000; however previous work on a ZP5K and ZPG-X type airships by GAC provided additional inputs for the study.

2. AIRSHIP MISSIONS

Because the airship appears to be very effective and economical in Maritime Patrol Service, it may be employed by the Coast Guard in a variety of programs, missions and tasks which are presently being conducted with ships, airplanes, and helicopters. In the work statement eight representative missions have been presented which show the airship in the maritime patrol role. They are:

a. The airship will be operated in patrol, station keeping and boarding tasks of the Enforcement of Laws and Treaties Program [ELT] to regulate commercial fishing offshore, apprehend smugglers and enforce other maritime laws and agreements.

b. The airship will be operated in the Search and Rescue [SAR] Program, to save lives and property at sea. The airship crew may take rescued persons directly aboard, fight fire or flooding aboard an endangered ship, tow a disabled boat, and serve as an on-scene command center and search platform in multiunit operations.

c. A maritime airship is used to detect, identify, obtain samples, deliver and deploy containment booms for oil and other pollution sources in United States coastal waters for the Marine Environmental Protection Program, [MEP]. The airship also serves as an aerial command post supporting extensive pollution clean-up operations.

d. In the Aids to Navigation [AN] Program, a Coast Guard airship unit performs buoy tending tasks - the on-scene servicing of buoys, and other aids to navigation [i.e., placing and replacing small buoys].

e. In the Military Operations [MO] Program, Coast Guard airships are operated jointly in patrols of offshore oil production areas to deter sabotage of oil production platforms, and oil exploration drill rigs. While the airship crews may board threatened platforms and ships to assist in defense, their greater effectiveness may develop from early detection of approaching saboteurs [or early detection of sabotage attempts] and their transmitting requests, by radio, for Coast Guard unit augmentation, or for military support. In time of war these vehicles could be employed in coastal ASW [Antisubmarine Warfare] using sonobuoys or towed arrays.

f. In Port Safety and Security [PSS] Programs, Coast Guard crews aboard airships may patrol port waterways to escort and clear traffic ahead of hazardous cargo vessels or ships in distress. In such patrols the units aboard airships may regulate traffic generally; they may observe and report potentially hazardous conditions in the waterways of the port area.

g. In the Marine Science Activities [MSA] Program, the Coast Guard airship units contribute to improving environmental-related predictions to oceanography, to tracking sea life migrations, and to scientific support of other programs. Their activities include support of environmental buoys, weather surveys, ocean surveys, and ice patrol.

h. For ice operation [IO] on the Great Lakes, the airship may be used to map both ice flows, leads and open channels. It can also serve as an aerial command post in directing ice breakers or aid in navigating ships through open waters.

2.1 Mission Profiles

To arrive at a vehicle size and its major characteristics, a representative profile of each type mission mentioned above and established by the work statement is listed in the following tables, I thru VIII. Included in these tables is a weight breakdown of each mission payload.

For convenience, the fixed payload has been listed in Table XIII which shows the vehicle empty weight breakdown. It may be deducted from the essential empty weight basis if costing is to be considered.

In the tables it should be noted that altitude changes between sea level and 5000 ft [or vice versa] are accomplished in a matter of minutes at a normal rate of climb; therefore, the lapsed time in hover is rounded to zero.

TABLE I - ELT MISSION PROFILE

ELT: Search and Board		[27.5 Hrs] Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	0.25
2.	Climb to Alt = 5000 Ft	0
3.	Cruise 250 nm @ 50 kn	5.0
4.	Sweep @ 50 kn for 5 hrs	5.0
5.	Dash @ 90 kn for 0.5 hrs	.5
6.	Descend to Alt = 50 ft	0
7.	Hover for 0.25 hrs	.25
8.	Loiter @ 30 kn for 1 hr	1.0
9.	Hover for 0.25 hrs	.25
10.	Climb to Alt = 5000 ft	0
11.	Sweep @ 50 kn for 4 hrs	4.0
12.	Repeat Steps #4-11 once	6.0
13.	Cruise 250 nm @ 50 kn	5.0
14.	Descend and land @ S.L. with 10% fuel remaining	.25

ELT: Mission Payload		Lbs
1.	Crew of 11 [@ 200 lb/man]	2200
2.	Provisions, General Stores and Potable water [@ 25 lb/man-day]	315
3.	Inflatable boat w/motor fuel and boat winch	500
4.	Rescue Equipment	81
5.	Dewatering Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 6 lbs each]	42
	TOTAL	3338

TABLE II - MEP MISSION PROFILE

MEP: Initial Clean-Up, C		[12.5 Hrs] Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2.	Climb to Alt = 1000 Ft	0
3.	Cruise 50 nm @ 50 kn	1.0
4.	Descend to Alt = 100 Ft	0
5.	Hover [pick-up mission payload]	.5
6.	Climb to Alt = 1000 Ft	0
7.	Cruise 25 nm @ 50 kn	.5
8.	Off-load payload - Hover .5 hr	.5
9.	Cruise back 25 nm @ 50 kn	.5
10.	Repeat Steps #4 - 9 two times	4.0
11.	Climb to Alt - 5000 Ft	0
12.	Loiter @ 30 kn for 3.5 hrs	3.5
13.	Cruise 75 nm @ 50 kn	1.5
14.	Descend and land @ S.L. with 10% fuel remaining	.25

MEP: Mission Payload		Lbs
1.	Crew of 6 [@ 200 lbs/man]	1200
2.	Provisions, General Stores and Potable water [@ 25 lbs/man-day]	78
3.	Inflatable boat w/motor fuel and winch	500
4.	Rescue Equipment	81
5.	Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 6 lbs each]	42
8.	Chemicals for Spill	500
9.	Harbor Oil Boom [one @ 2 lbs/ft]	440
10.	Oil Recovery Devices	15,000
	TOTAL	18,041

TABLE III - MO MISSION PROFILE

MO/MP: Towed Array ASW, Attack			[27.5 Hrs] Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]		.25
2.	Climb to Alt = 5000 Ft		0
3.	Cruise 300 nm @ 40 kn		7.5
4.	Descend to Alt = 500 Ft		0
5.	Tow array @ 10 kn	2300 Lbs Drag	.5
6.	Cruise 15 nm @ 30 kn	1200 Lbs Drag	.5
7.	Repeat Steps #5 - 7 fourteen times		14.0
8.	Dash @ 90 kn for 1 Hr		1.0
9.	Attack [deploy weapons]		0
10.	Cruise 100 nm @ 40 kn		2.5
11.	Descend and land @ S.L. with 10% fuel remaining		.25

MO/MP: Mission Payload		Lbs
1.	Crew of 11 [@ 200 lbs/man]	2200
2.	Provisions, General Stores and Potable water [@ 25 lbs/man-day]	315
3.	Rescue Equipment	81
4.	Towed Array System [including processor]	1500
5.	MK-46 NT [3]	1524
6.	VLA/DIFAR [Dwarf] [20]	200
7.	Marker, BT; AN	300
8.	MAD Gear	400
	TOTAL	6520

TABLE IV - PSS MISSION PROFILE

PSS: Hazardous Vessel Escort	[8.35 Hrs]
	Hrs
1. Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2. Climb to Alt = 5000 Ft	0
3. Cruise 50 nm @ 40 kn	1.25
4. Loiter @ 30 kn for 6 hrs	6.0
5. Descend to Alt = 1000 Ft	0
6. Cruise 25 nm @ 40 kn	.6
7. Descend and land @ S.L. with 10% fuel remaining	.25

PSS: Mission Payload	Lbs
1. Crew of 6 [200 lbs/man]	1200
2. Provisions, General Stores and Potable water [@ 25 lbs/man-day]	52
3. Rescue Equipment	81
4. Dewatering Pump [2]	220
5. Firefighting Equipment Set [2]	180
6. Smoke and Light Floats [@ 12 lbs each]	84
TOTAL	1817

TABLE V - SAR MISSION PROFILE

SAR: Search, Board, Tow		[15.6 Hrs] Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2.	Climb to Alt = 5000 Ft	0
3.	Cruise 25 nm @ 90 kn	.3
4.	Search for 1.5 hrs @ 60 kn	1.5
5.	Descend to Alt = 100 Ft	0
6.	Hover for .5 hrs	.5
7.	Loiter @ 35 kn for 2 hr	2.0
8.	Hover for .5 hrs	.5
9.	Tow @ 6 kn for 50 nm - 3500 lbs Drag	8.3
10.	Cruise 100 nm @ 50 kn	2.0
11.	Descend and land @ S.L. with 10% Fuel remaining	.25

SAR: Mission Payload		Lbs
1.	Crew of 8 [@ 200 lbs/man]	1600
2.	Provisions, General Stores and Potable water [@ 25 lbs/man - day]	114
3.	Inflatable boat w/motor, fuel and winch	500
4.	Rescue Equipment	81
5.	Dewatering Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 12 lbs each]	84
	TOTAL	2579

TABLE VI - A/N MISSION PROFILE

A/N: Buoy Maintenance		[17.0 Hrs] Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2.	Climb to Alt = 1000 Ft	0
3.	Cruise 150 nm @ 50 kn	3.0
4.	Descend to Alt = 100 Ft	0
5.	Hover for 0.5 hrs	0.5
6.	Climb to Alt = 500 Ft	0
7.	Cruise 80 nm @ 50 kn	1.6
8.	Repeat Steps #4 - 7 four times	8.4
9.	Climb to Alt = 1000 Ft	0
10.	Cruise 150 nm @ 50 kn	3.0
11.	Descend and land @ S.L. with 10% Fuel remaining	.25

A/N: Mission Payload		Lbs
1.	Crew of 8 [@ 200 lbs/man]	1600
2.	Provisions, General Stores and Potable water [@ 25 lbs/man-day]	110
3.	Inflatable boat w/motor fuel and winch	500
4.	Rescue Equipment	81
5.	Dewatering Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 6 lbs each]	42
8.	Buoy Maintenance Kit	500
	TOTAL	3033

TABLE VII - MSA MISSION PROFILE

MSA: Ice Patrol [St. Johns]		[35.5 Hrs]
		Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2.	Climb to Alt = 5000 Ft	0
3.	Cruise 100 nm @ 40 kn	2.5
4.	Sweep @ 60 kn for 30 hrs	30.0
5.	Cruise 100 nm @ 40 kn	2.5
6.	Descend and land @ S.L. with 10% Fuel remaining	.25

MSA: Mission Payload		Lbs
1.	Crew of 11 [@ 200 lbs/man]	2200
2.	Provisions, General Stores and Potable water [@ 25 lbs/man - day]	407
3.	Inflatable boat w/motor fuel and winch	500
4.	Rescue Equipment	81
5.	Dewatering Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 6 lbs each]	42
	TOTAL	3430

TABLE VIII - IO MISSION PROFILE

IO: Ice Mapping [Great Lakes]		[20.5 Hrs]
		Hrs
1.	Warm-up, take-off @ S.L. TOGW Standard day [T = 59° F]	.25
2.	Climb to Alt = 5000 Ft	0
3.	Map @ 60 kn for 20 hrs	20.0
4.	Descend and land @ S.L. with 10% Fuel remaining	.25

IO: Mission Payload		Lbs
1.	Crew of 6 [@ 200 Lbs/man]	1200
2.	Provisions, General Stores, and Potable water [@ 25 lbs/man - day]	66
3.	Inflatable boat w/motor fuel and winch	500
4.	Rescue Equipment	81
5.	Dewatering Pump	110
6.	Firefighting Equipment Set	90
7.	Smoke and Light Floats [@ 6 lbs each]	42
8.	Scientific Instruments	1000
	TOTAL	3089

2.2 Mission Analysis

To bring these mission scenarios into perspective and realize the capability of the airship, a study was made using the helicopter and airplane for two of these missions. Figure 1 represents the maritime environmental protection profile. From the schematic the airship takes off, cruises 50 nautical miles, hovers for a half hour to on-load the 16,000 lb pallet of oil spill clean up equipment. The airship cruises 25 nautical miles to the oil spill and hovers a half hour in off-loading the payload. It then returns to the pick-up point to lift a 17,000 lb pallet and transfer it to the oil spill. This operation is repeated for the third time then the airship climbs to altitude and serves as an aerial command post for 2.5 hours in the clean-up operation.

Substituting the airship with a CH-54B helicopter fully loaded with fuel and the mission is discontinued at lift-off after the first pallet has been delivered to the oil spill because the fuel supply has been depleted.

For the second case, using the Marine Science Activity [MSA] mission, the profile cruise speed is 60 knots and the mission time is approximately 36 hours. The mission time is nominal for an airship because station keeping for several days is not uncommon. However, missions of this duration that are associated with 60 knot speeds become unconventional. In the mid 1950's the ZPG-2 airship had an endurance record of 11 days and flew over 9400 nautical miles. Since this was a publicity flight no mention was made that most of the mission was in favorable trade winds and the indicated air speed was approximately 15 knots with an average ground speed approaching 35 knots. The endurance flight was also void of mission equipment and carried extra fuel on board. In this study the cruise speed of 60 knots for the MSA mission associated with the 36 hrs becomes the design criteria for the maximum fuel to be carried on the Maritime Patrol Airship. It should be mentioned that the fuel consumption per hour for the 60 knot speed is nine times greater then that used for the ZPG-2 record flight.

When time on station is important, replacing an airship with an airplane requires a vehicle with a low fuel consumption and a large fuel payload. A literature search

(1) Take-off from base, climb to 1000 Ft.

(2) Cruise 50 nautical miles at 50 knots

(3) Descend to 100 Ft.

(4) Hover for 0.5 hour and pick up mission payload

(5) Climb to 1000 Ft.

(6) Cruise 25 nautical miles at 50 knots

(7) Descend to 100 Ft.

(8) Hover for 0.5 hour and off-load payload

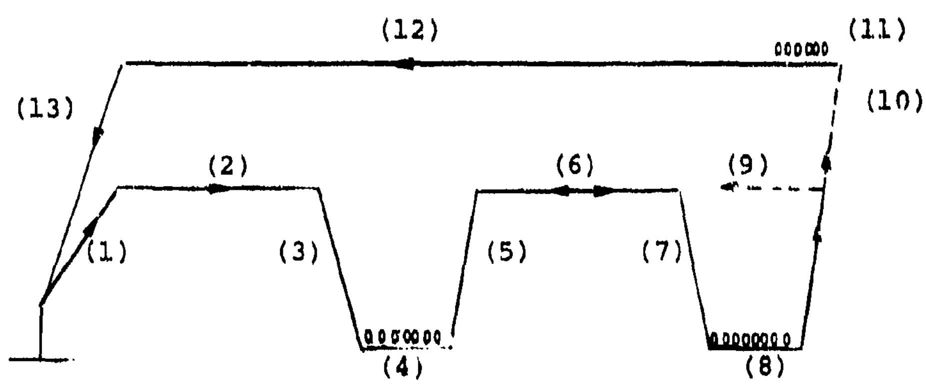
(9) Climb to 1000 Ft, cruise 25 nautical miles at 50 knots, and repeat Steps #3-8 two times

(10) Climb to 2000 Ft.

(11) Loiter at 30 knots for 2.5 hours

(12) Cruise 75 nautical miles at 50 knots

(13) Descend and land at sea level with 10% fuel remaining



Fixed Payload:	4,420 Lbs
Mission Payload: [Crew of 6]	18,041 Lbs
Total Payload	22,461 Lbs

Figure 1 - Marine Environmental Protection Flight Profile

indicates that the PBY Catalina flying boat exceeded other airplanes for endurance and with minimum crew, a radar and maximum fuel the aircraft flew 24 hour missions during World War II. It was not a stable platform and the environment for long missions was not beneficial due to engine noise, vibration and confined quarters. With today's technology these areas can be improved, however, achieving a 36-hour flight time with an airplane is still a challenge.

Of the six remaining missions only the Military operations [MO] program with the towed array and the towing scenario of the [SAR] required an unconventional airship with a large thrust capability and low-speed control. Other than the hover mode of operation, a conventional airship of the ZP5K size could perform the other four missions.

3. VEHICLE ANALYSIS

Through preliminary estimates relative to airship size and propulsion requirements each of the eight missions for maritime patrol were analyzed. An iterative process established an envelope size of 875,000 cubic feet, which appeared capable of performing all tasks. From this base point along with characteristics of the mission, the propulsion system was defined using three 800 HP engines. Table IX shows the results of this effort and underlines the controlling factors that dictate the design features of the ZP3G concept. The enforcement of Laws and Treaties [ELT] set up the design criteria for the propulsion system because of the 90-knot dash at the 5000 ft altitude. The available static thrust from the ELT propulsion system deducting the thrust required for acceleration and attitude control, as discussed in Section 3.3 and 6.0; established the hover capability of the vehicle. This minus the gross weight required for the Marine environmental protection program [MEP] determined the envelope size and confirmed the 875,000 cubic feet. The [MEP] mission also sized the ballast system and assumed that helium be valved if the aerial command post scenario must be performed at the 5000 ft altitude. The maximum ballast column depicts the amount of ballast required to assure a heaviness condition of several hundred pounds for the airship when it lands at termination of the mission. Ballast could be reduced by 3900 lb; however, there is an appreciable loss in attitude control during landing.

As mentioned previously in the mission analysis, the [MSA] profile dictated the on-board fuel requirements. If this marine science activity mission could be performed at a 2000 ft altitude, take-off could either be conventional or VTOL. However, the operational altitude of 5000 ft, as dictated by the profile requires a vectored thrust lift-off [STOL]. Lift-off would occur at 30 knots with a take-off distance of 450 ft.

3.1 Propulsion System

Choice of an Air Propulsor depends on the mission characteristics of the vehicle. It is shown in Table IX that 90 knots is the maximum velocity. Figure 2, which summarizes propulsor thrust efficiencies, indicates that in

TABLE IX - CONCEPTUAL VEHICLE CHARACTERISTICS FOR VARIOUS MISSION PROGRAMS

MISSION	TOTAL MISSION PAYLOAD	MAX WT LESS BALLAST [LB]	FUEL USED + RESERVE [LB]	TAKE OFF HEAVINESS (LB)	MAX BALLAST [LB]	MAX VELOCITY [KTS]	MAX ALTITUDE [FT]	MISSION ENDURANCE [HR]	MAX ENDURANCE @ MAX T.O.G.W
ELT	7758	53759	12261	8500	5837	90	5000	27.5	32.5
MEP	22461	60664	4427	8500	12609	50	2000*	12.5	12.5
MOP	10940	55111	10431	8500	3054	90	5000	27.5	30.4
PSS	6237	42046	2068	3000	8636	40	5000	8.4	53.4
SAR	6999	49373	8634	8500	6809	90	5000	13.6	26.6
A/N	7453	47823	6575	7000	6859	50	1000	17.0	34.0
MSA	7850	58915 59379	17325 17789	8500 11700	8293 5500	60	2000 5000	35.5	39.5
IO	7509	51357	10108	8500	6825	60	5000	20.5	30.5

*Valve helium (73000 Ft^3) for 5000 ft the 90 knot range a propeller exceeds the prop-fan and fan-jet in thrust/shaft horsepower. Table IX recording endurance missions lasting up to 35.5 hours also demands a propulsion system that has low fuel consumption. For fuel efficiency it can be seen in Figure 3 that the conventional turboshaft engine is not a suitable power plant. In the low power setting range, the reciprocating engine appears superior. However, in all mission profiles of the study, a major portion of the cruise flight is operating at speeds which require power settings for single engine operation in the 60 to 80 percent range. The estimated fuel consumption of the new GMA-500 Allison engine in this range becomes competitive with the piston engine and thus reduces power plant installation weight by a factor of three and a half. This comparison is based on the installation of the Wright R-1300 engine in the ZPN airship.

Placement or location of the propeller also affects propulsion and fuel efficiency. In Figure 4 the thrust of the stern propeller is indicated in both free stream and in the wake of the airship. It can be seen that at higher speeds, the available thrust in the wake is greater. By comparison, thrust for the stern propeller is approximately equal to the free stream condition at 75 percent of the vehicle speed. In addition to a more effective thruster, the location of the stern propeller and the inverted vee tail also serves to control the airship at low speeds. [Reference 4 and 5.]

The stern propulsion concept which was proposed in Reference 4 on the ZPG-X design, consisted of two small Allison engines. It provided a one-engine-out condition in the stern and permitted a better SFC at very low speeds. The ZP3-G concept flys at 40 knots in normal operation with any two of the three engines out. Mission requirements also cover a propulsion range which exceeds that of the small engine capability. In this concept a primary reason for selection of the one stern engine is the low SFC in the 60 to 75 percent power range of the new Allison 500 engine, now under development. See Figure 3 for the comparison.

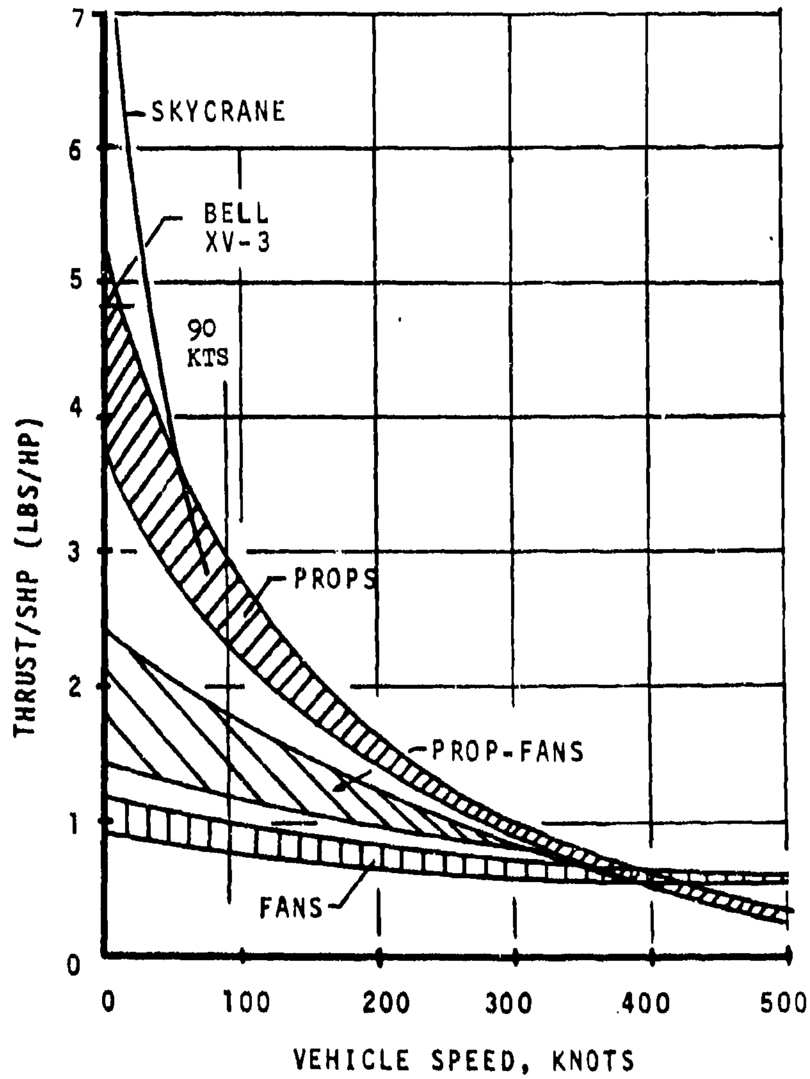


Figure 2 - Thrust Characteristics of Air Propulsors
(Reference 3)

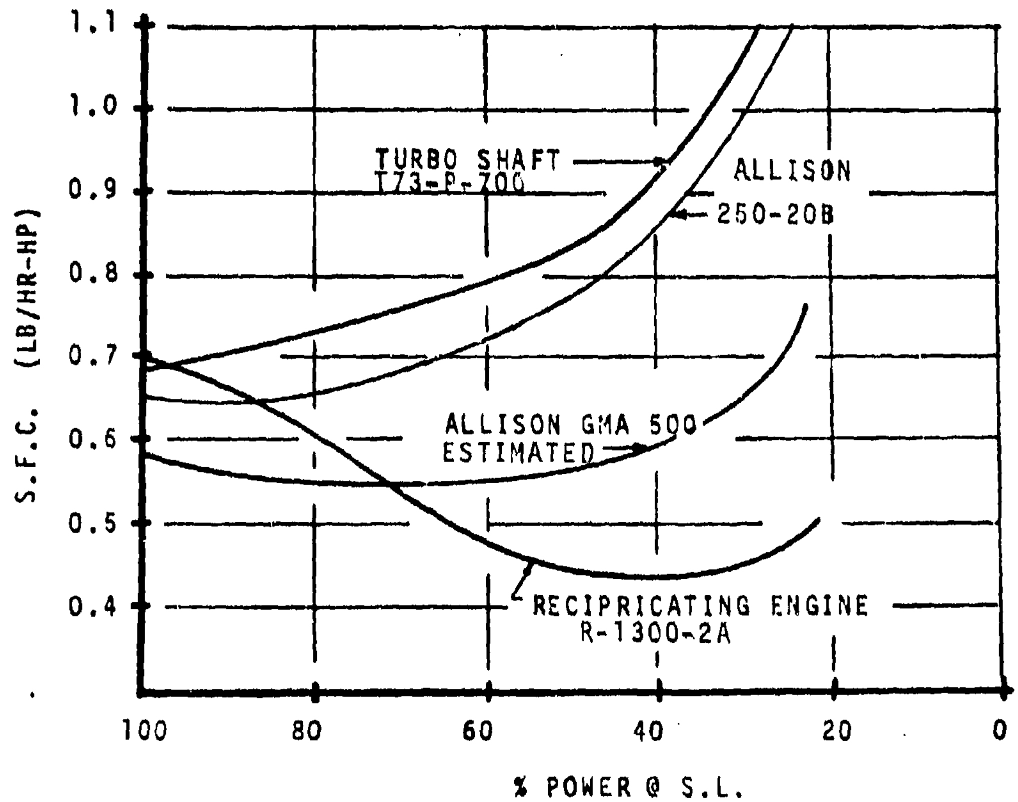


Figure 3 Fuel Consumption Comparison
Reference 2, 4 and 6

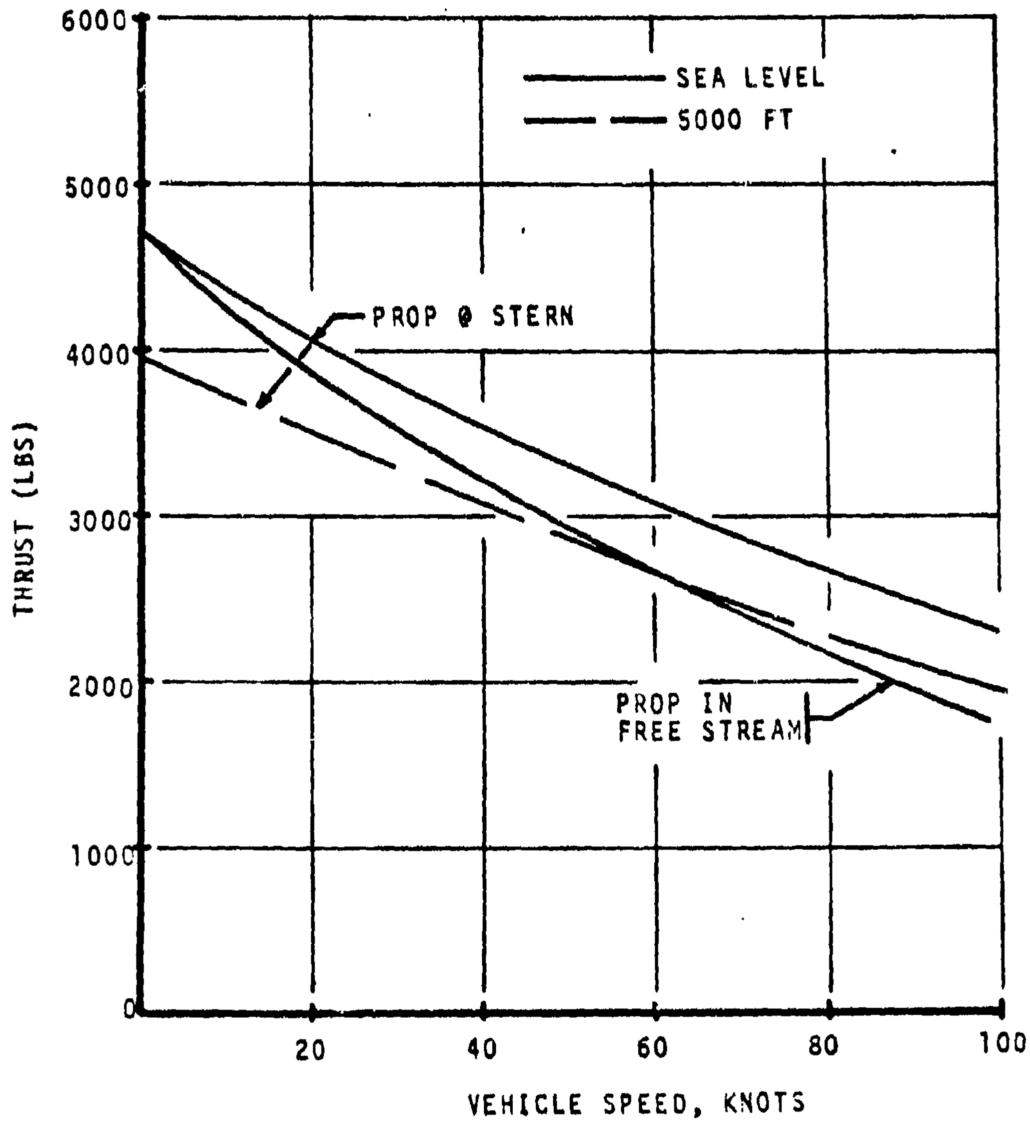


Figure 4 - Stern Propellar Effectiveness

3.2 Drag

To size the propulsion system, the vehicle drag, acceleration and control forces must be analyzed. Total drag of the vehicle is the summation of the profile and induced drag. Figure 5 shows the drag - area [$C_{D_O}A$] of the vehicle and its variation with the velocity due to the Reynolds number. Table X associated with the profile drag area is a breakdown of the drag units which comprise the total. Most of these drag areas have been taken from the ZPN flight test vehicle which is the ZP3G envelope size. Therefore profile drag-areas for the conceptual design should be quite reliable.

An airship flying heavy requires an aerodynamic lift to compensate for the difference between static lift and gross weight. From Figure 6 the induced drag-area [$C_{D_i}A$] may be estimated. The airship heaviness divided by the dynamic pressure establishes the lift-area [C_LA] and projected from this, the induced drag-area is determined. Reference area "A" in Figures 5 and 6 represents the envelope volume to the 2/3 power.

A dynamic pressure curve has been incorporated in the report to serve later in a sample case of selecting power setting and fuel requirement. Figure 7 shows the dynamic pressure at standard atmosphere for sea level and 5000 ft altitude.

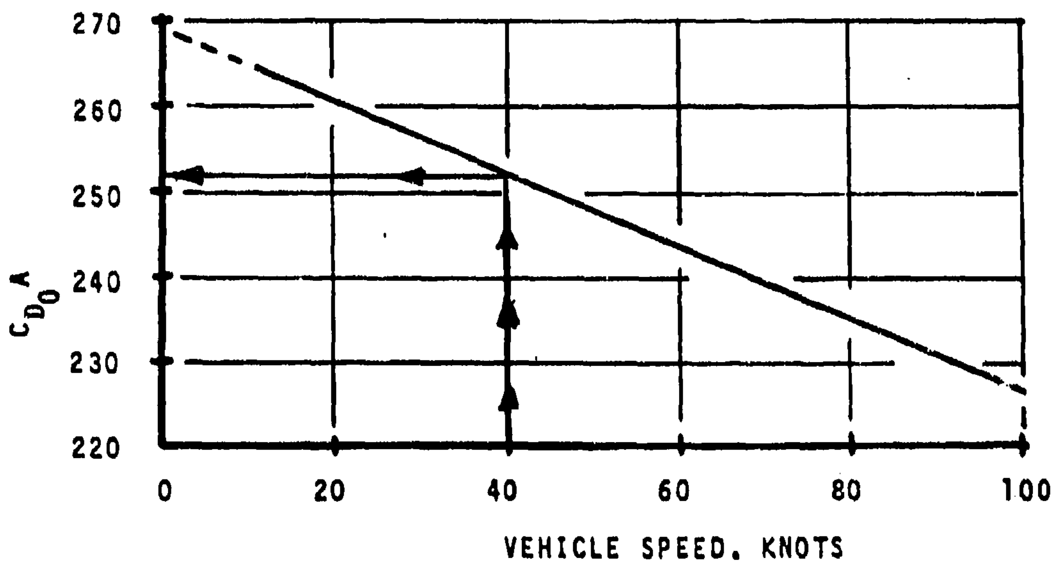


Figure 5 Vehicle Profile Drag

TABLE X ZP3G DRAG AREA @ 70 KTS

ENVELOPE	136.5
ENVELOPE ACCESSORIES	3.5
TAIL & ACCESSORIES	54.3
CONTROL CAR	20.0
OUTRIGGER	4.5
NACELLE	0.5
CAR ENGINE ACCESSORIES	2.5
HANDLING LINES	1.7
MISC. & INTERFERENCE	4.2
	227.7
5% CONTINGENCY	239.0

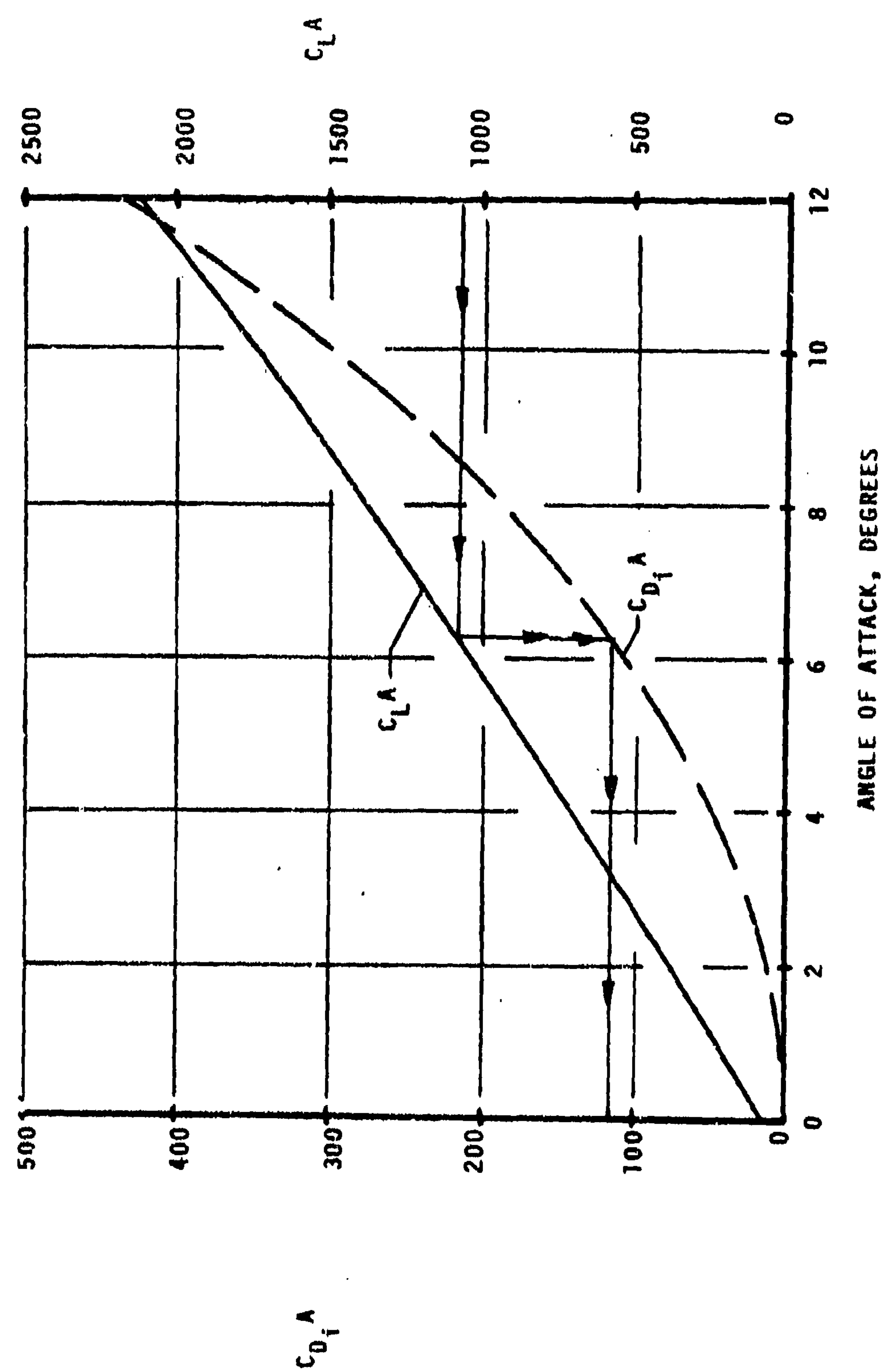


Figure 6 Vehicle Lift and Induced Drag

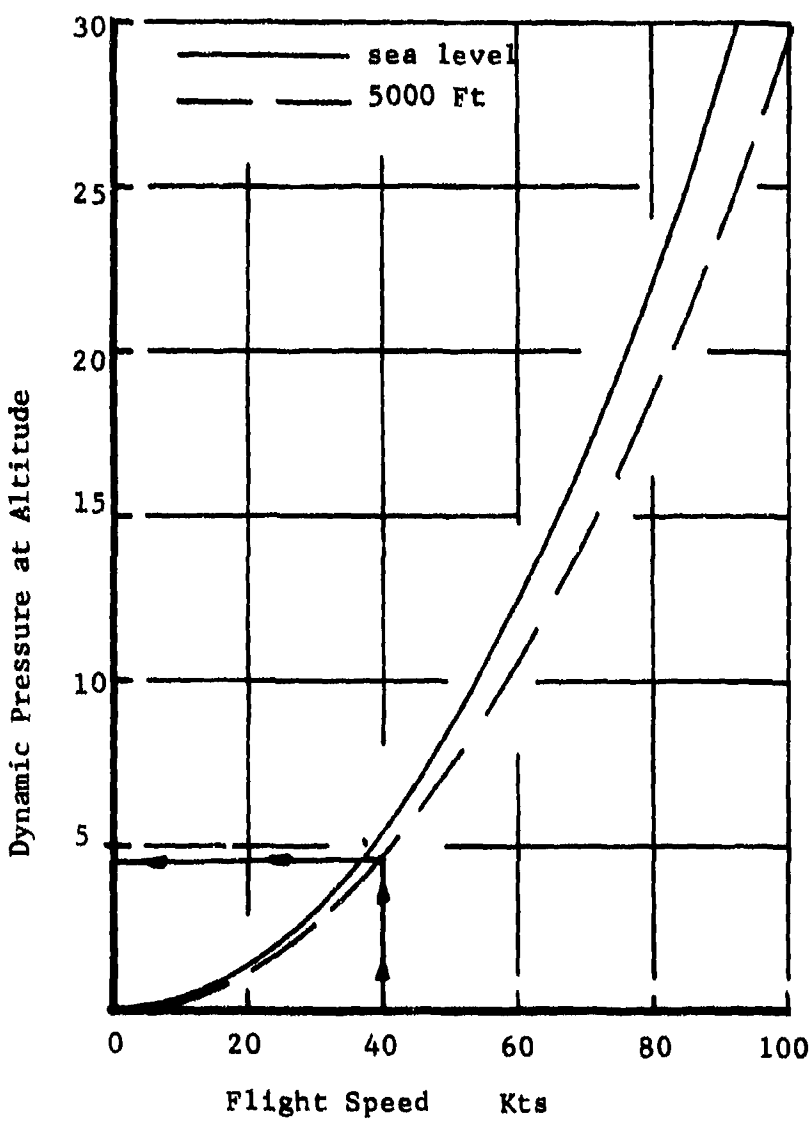


Figure 7 Dynamic Pressure at Standard Atmosphere

3.3 Low Speed Control and Acceleration

At speeds below 15 knots, in zero wind conditions, operational experience at Goodyear has shown that empennage effectiveness becomes inadequate for positive control of the larger airship. For this reason the stern propeller in the hover and transitional attitude should supply the force vector to compensate for this deficiency. Figure 8 indicates the added thrust required from the stern propeller to maintain attitude control for the airship in hover and tow.

For lift-off in the VTOL attitude, the vehicle must be able to accelerate at a reasonable rate. In the study using a virtual mass of 0.7 it appears that an additional 2500 lb of thrust is required at lift-off to achieve an altitude of 100 ft in 17½ seconds and 975 ft in one minute. The rate of climb in conventional flight is 2400 ft/minute, limited by the discharge rate of the ballonet air valves.

3.4 Propeller Performance

In this study the propellers have not been optimized. Diameters are established by the configuration geometry and characteristics assume standard activity factors and integrated design lift coefficients.

The thrust per propeller for the main [forward] propulsors is presented in Figure 9. The curve represents both positive and negative thrust in hover because the propellers rotate plus or minus 90° from the horizontal. In the 40 to 70 knot speed range, cross coupling requires one engine to operate at a higher[more efficient]power setting. In addition, the propeller thrust/horsepower ratio is increased and the net results are savings of up to 35% in fuel consumption. Figure 10 represents the available thrust with one engine cross coupled to the two forward propellers. Available thrust for the stern propeller is shown in Figure 11. Power settings for the stern engine assumes that 75 horsepower is driving accessories and that the reduction gear box is 96% efficient. The figures present the available thrust at sea level and at an altitude of 5000 ft. The airship in the lighter-than-air mode loses attitude control effectiveness due to the inefficiency of the propeller in negative thrust and reverse flow across the control surfaces. Figure 12 shows the available reverse thrust for

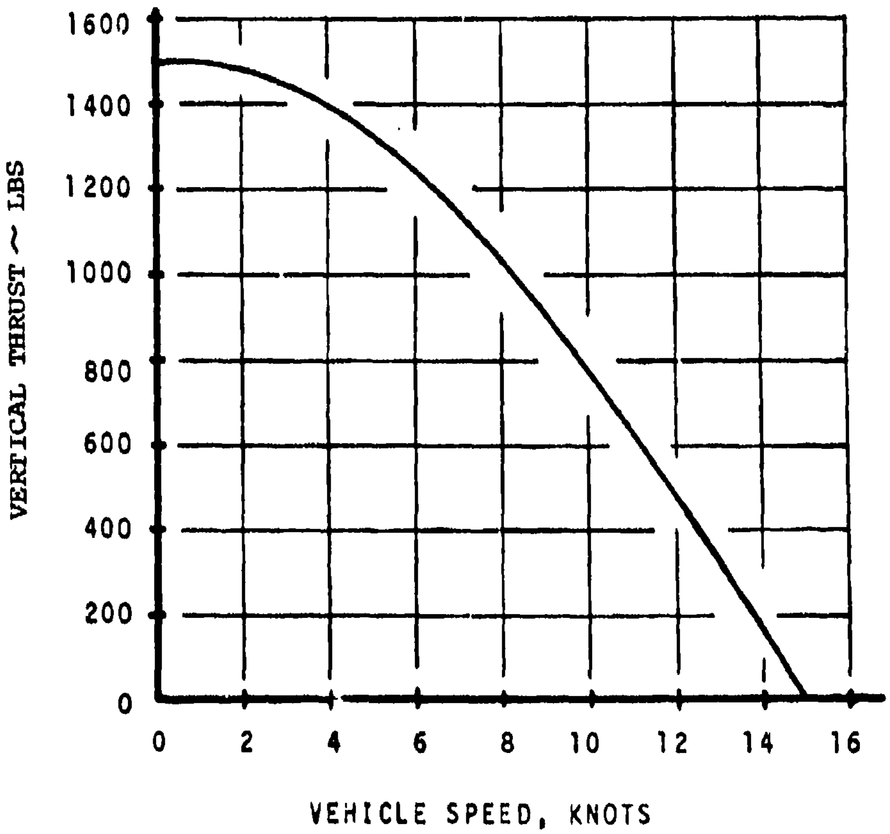


FIGURE 8 - CONTROL THRUST REQUIRED BY STERN PROPELLER FOR HOVER AND TOW

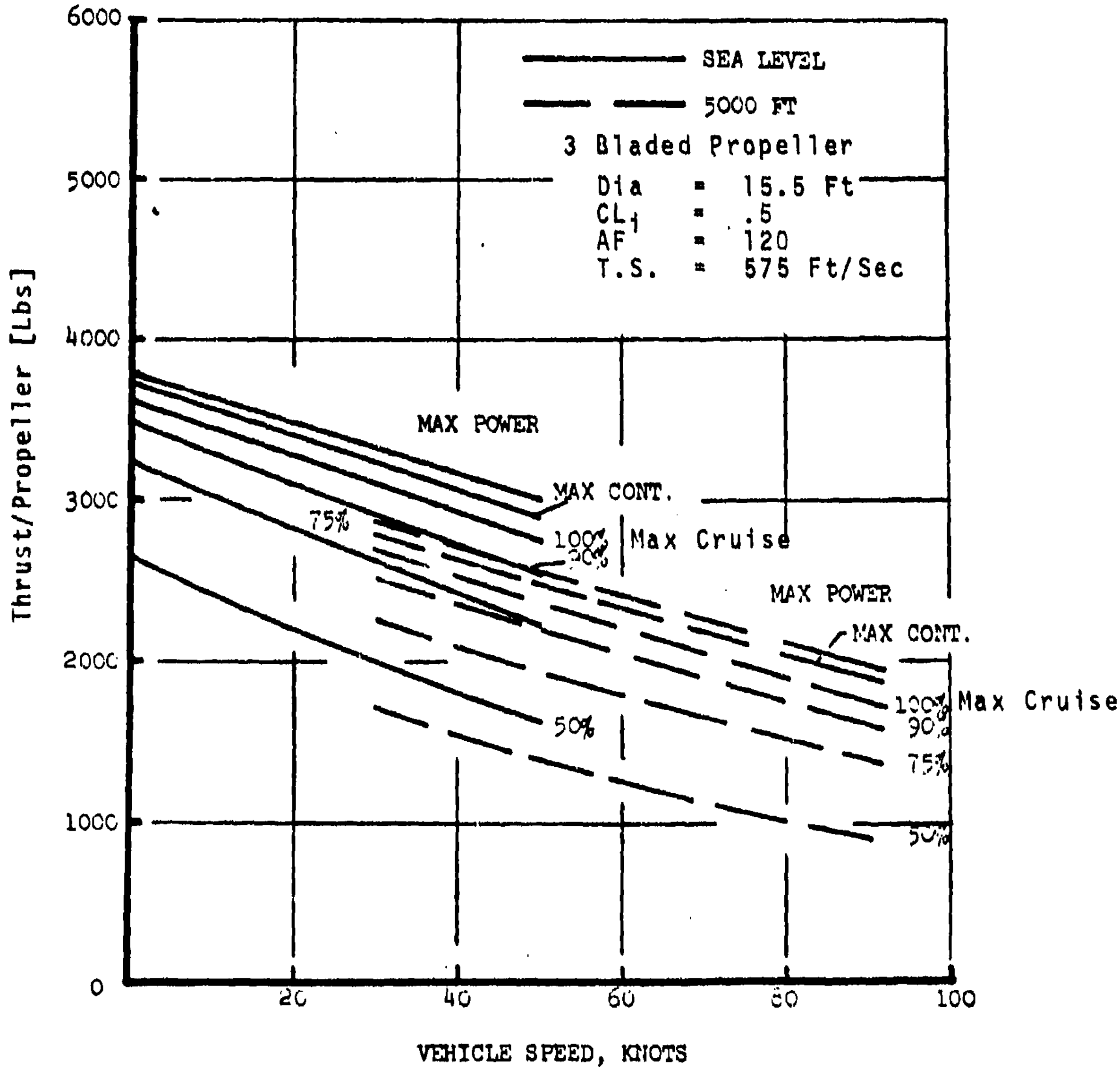


Figure 9 Forward Propeller Performance
(Both Engines Operating)

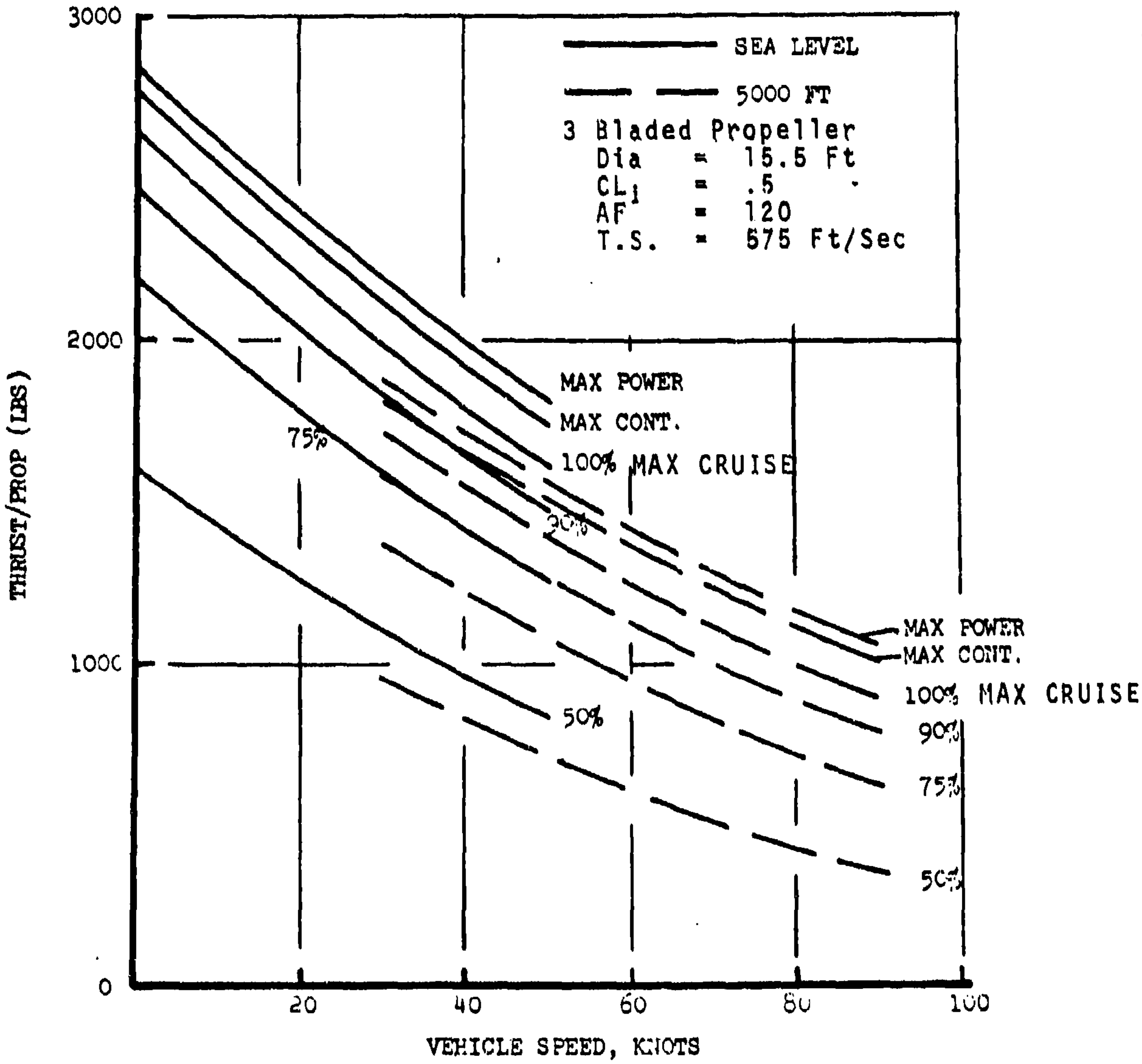


Figure 10 Forward Propeller Performance (One Engine Operating)

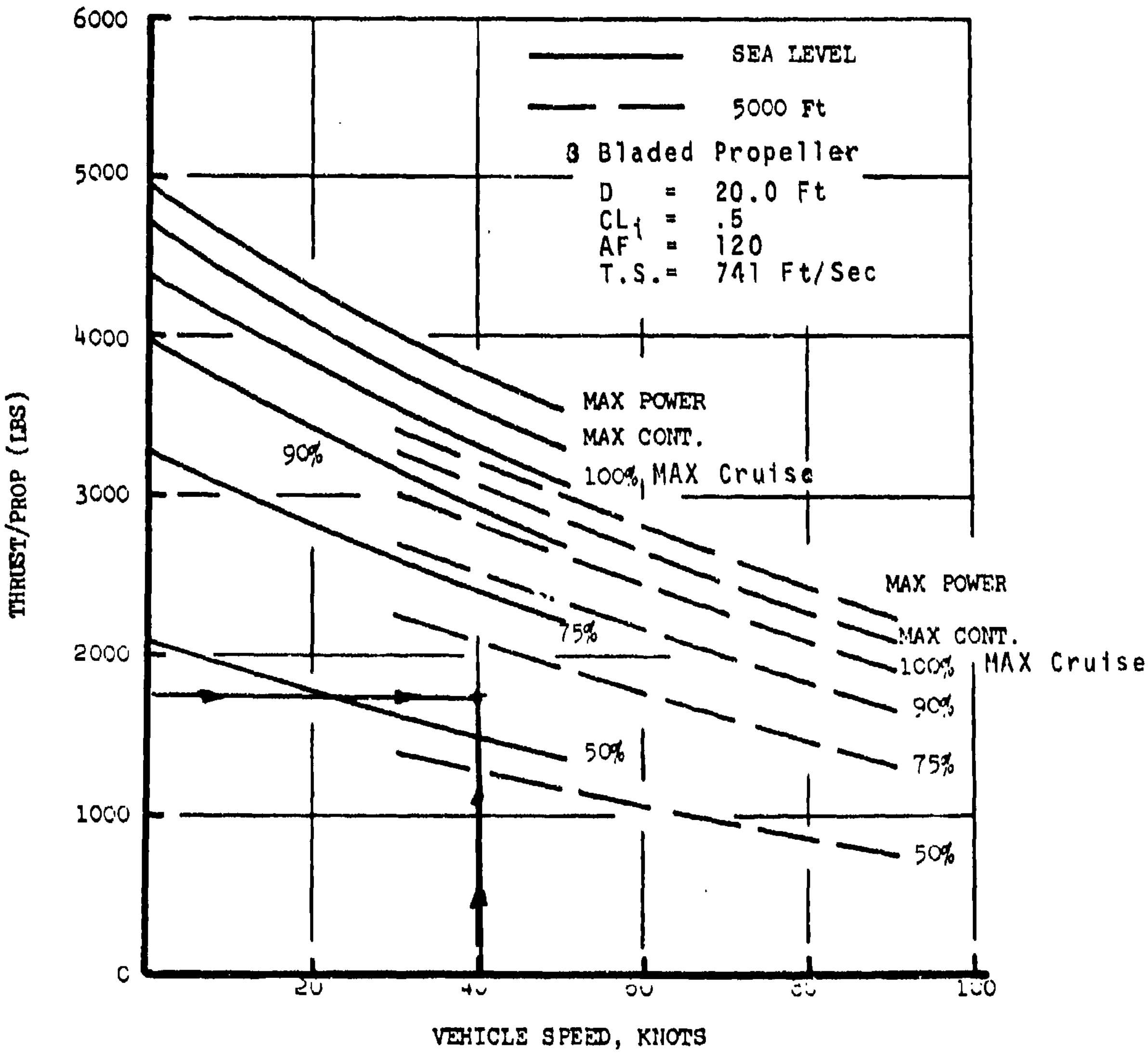


Figure 11 Stern Propeller Performance In Wake

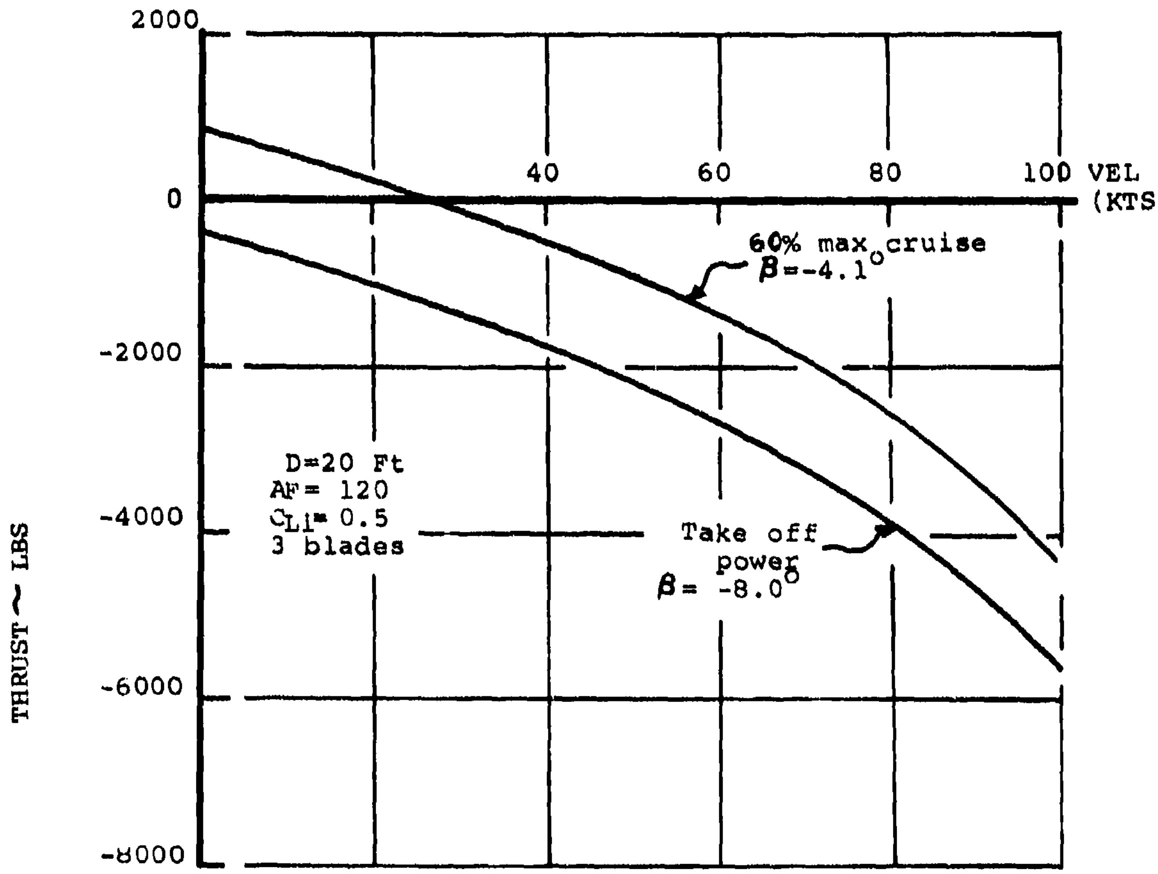


Figure 12 - Stern Propeller Reverse Thrust @ S.L., Corrected for Boundary Layer

the stern propeller at speeds from 0 to 100 knots. It should be noted that in the hover mode, at a 60% power setting the thrust is still positive.

The outrigger configuration of the forward propulsors imposes a 10° lateral tilt on the propellers in the hover attitude. The prime purpose of the tilt minimized interference of the envelope with the propeller free stream. The feature also provides a modest 930 lb side force capability when the airship heaviness varies from 1100 to 5400 lbs. Although this thrust vector is minimal, it is capable of maintaining the lateral position of the airship in gusts up to 24 ft per second at a 15° angle of attack off the bow.

3.5 Fuel Consumption

Figure 13 shows the estimated fuel rate in lb/hr and the specific fuel consumption for the Allison GMA-500 engine at the two altitudes. Basically the GMA-500 engine is a spin-off of the old Allison Model 250 engine. The Army has sponsored the development of the engine and at this time most of the information is proprietary. Fundamentally the 800 horsepower engine is a two stage compressor with a three stage turbine. The overall dimensions are 18 inches in diameter and 30 inches long. Engine weight is 220 lbs, however, the planetary gear box weight reducing the turbine speed [33,000 RPM] to approximately 1800 RPM adds 80 lbs to the base weight bringing the total to 300 lbs. To date all individual components have been built and functionally tested. It is anticipated that the preliminary flight rating test will be initiated in October of 1979. On the SFC curve, the one definitive point is .55 at 60 percent power with a very flat rise in power reduction.

3.6 Power Setting

Power requirements and fuel rates for each mission profile were established by a step-by-step process computing drag, lift, thrust required and fuel used for that time interval. As an example: assume the ZP3G airship is 5000 lbs heavy and flying 40 knots at 5000 ft altitude.

From Figure 5 profile drag-area [$C_{D_O}A$] at 40 knots is 252. The dynamic pressure for 40 knots at 5000 ft altitude is 4.67 lb/ft^2 [see Figure 7]. The 5000 lb heaviness

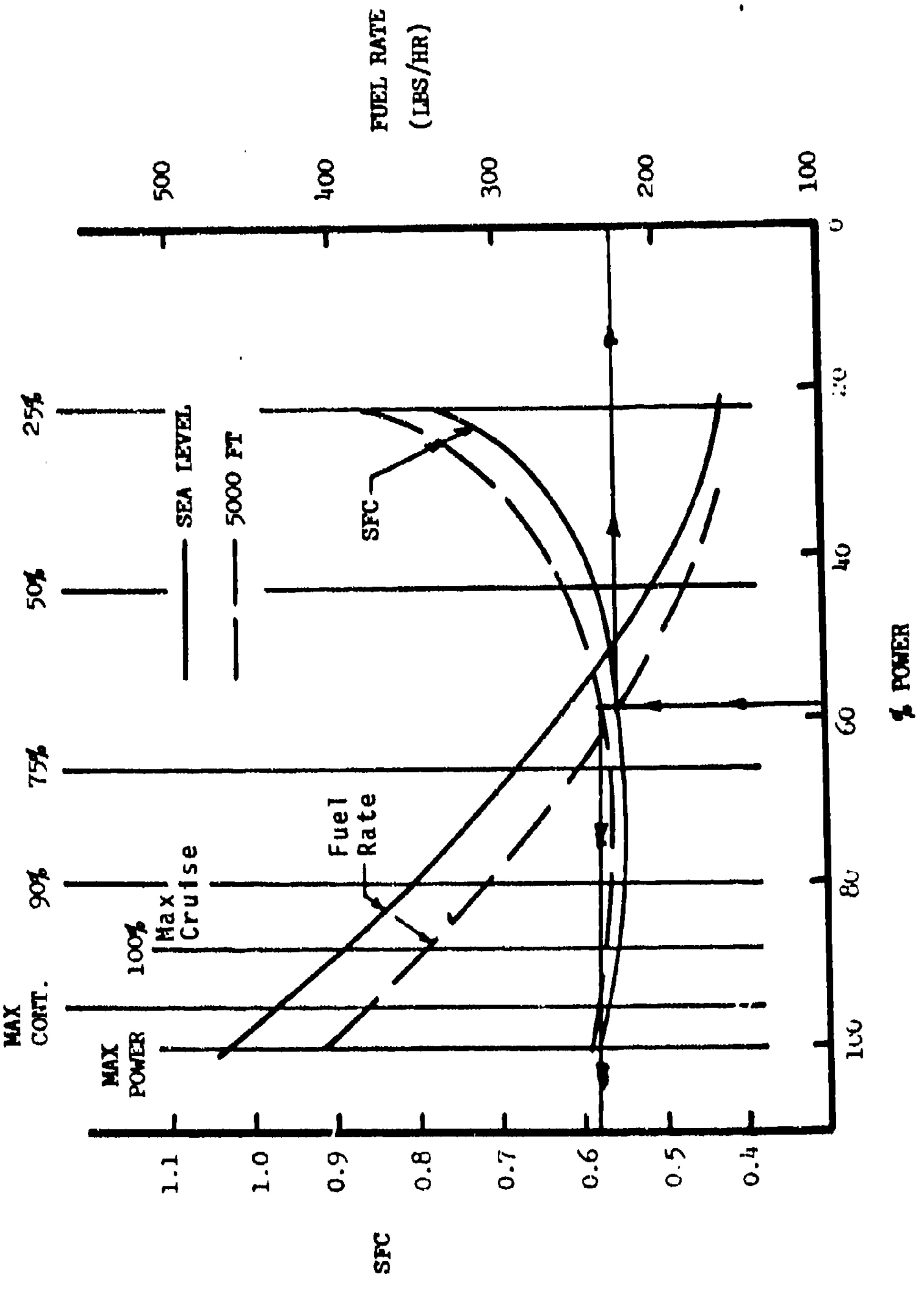


Figure 13 - Fuel Consumption

divided by the dynamic pressure gives us a lift-area of 1070 [5000/4.67]. A lift area of 1070 in Figure 6 establishes an induced drag-area [$C_{Di}A$] of 115. Summation of the two drags [252 + 115] is 367. The total drag-area [$C_{DT}A$] multiplied by the dynamic pressure 4.67 lb/ft^2 gives us 1713 lb of drag. Therefore a power setting which produces 1713 lb of thrust is required. From Figure 11 the stern engine at 65 percent maximum cruise [57 percent power setting] provides the necessary thrust which permits a one engine operation. From Figure 12, the SFC for a 57 percent power setting at 5000 ft is .57 and the fuel flow rate/hour is 235 lbs. This process is repeated at time intervals in each phase of the mission showing a reduction in fuel rate as the heaviness of the airship decreases.

To approximate power requirements and fuel flows for the ZP3G airship, Figures 14 and 15 with Table XI and XII are presented for both sea level and 5000 ft altitude operations. The figures represent the airship flying at various speeds in three heaviness conditions with engine combinations operating in different modes and power settings.

Knowing the airship heaviness and the speed, the engine combination and power setting can be derived from the figures. Referring then to the tables, the fuel consumption per hour can be estimated.

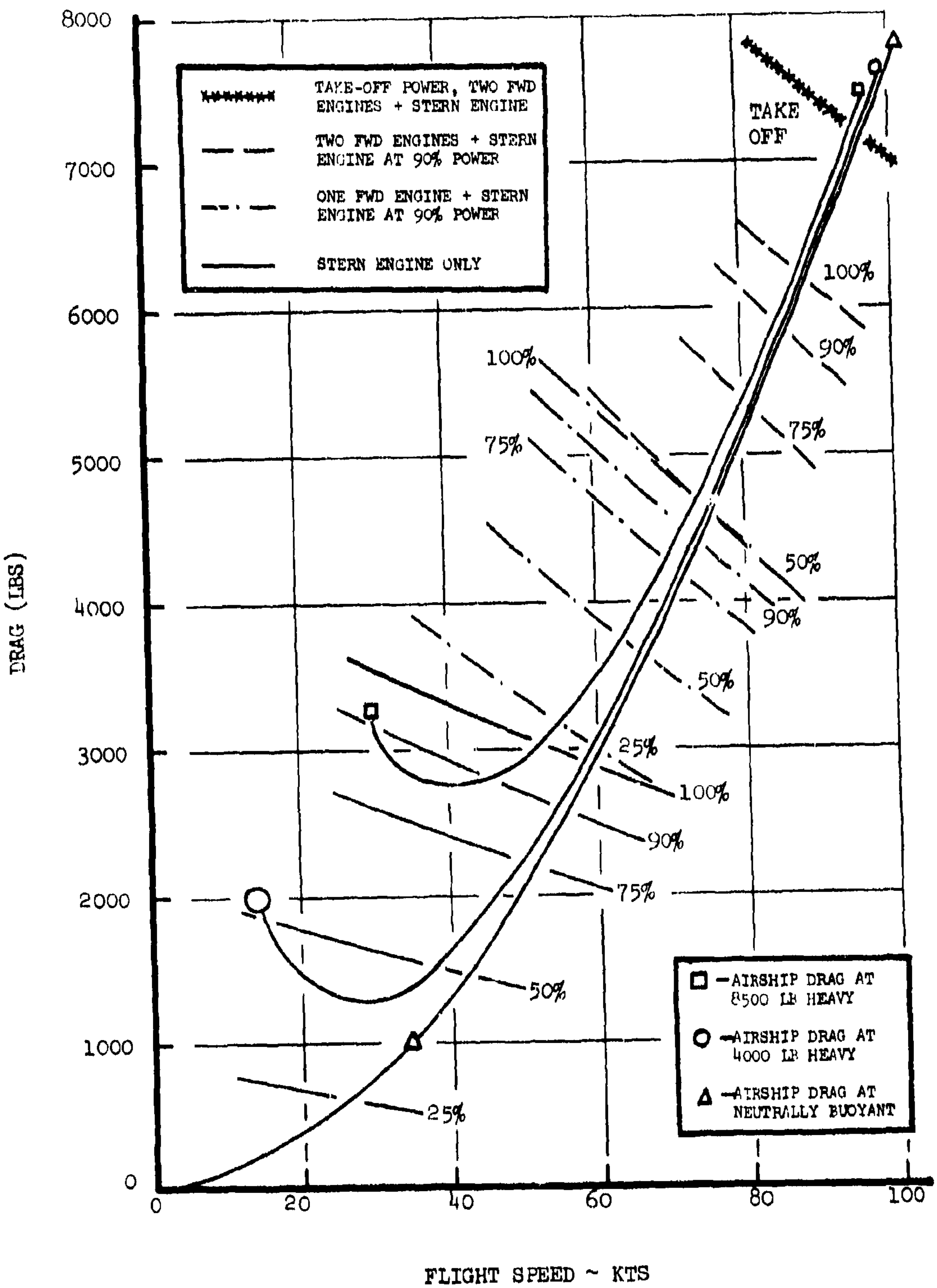


FIGURE 14 - POWER REQUIREMENTS @ SEA LEVEL

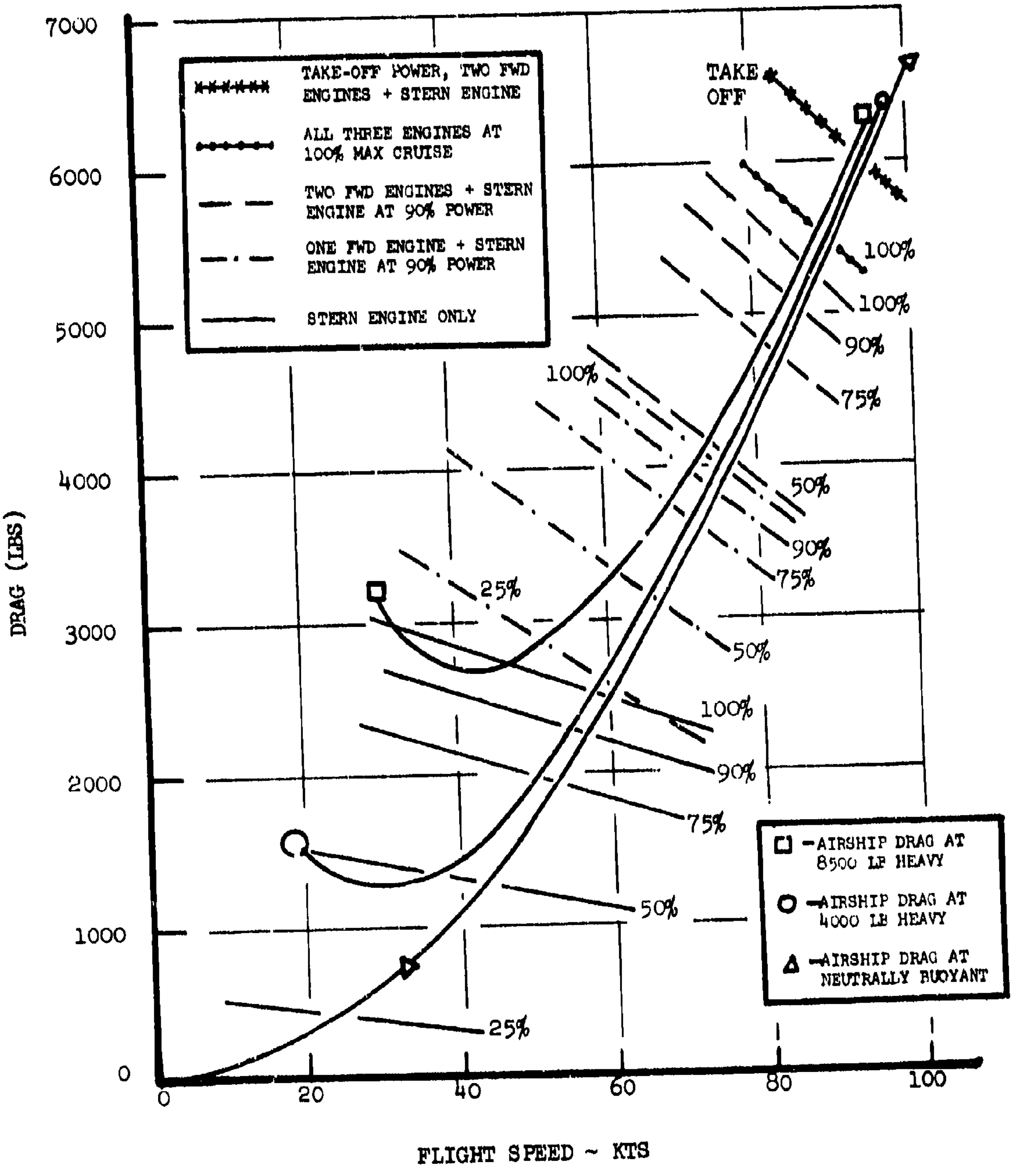


Figure 15 - Power Requirements @ 5000 Ft. Alt.

TABLE XI - POWER SETTINGS AND FUEL RATES AT SEA LEVEL

		Stern Eng. Only	1 Fwd Eng. +1 Stern at 90%	2 Fwd Eng. +1 Stern at 90%; Take-Off at Max
Power Setting [HP]	Take Off	-	-	2400
	100%	704	1344	2048
	90%	640	1280	1920
	75%	525	1165	1690
	50%	350	990	1340
	25%	176	816	-
Fuel Rate at Power Setting [Lb/Hr]	Take Off	-	-	1404
	100%	394	749	1143
	90%	355	690	1065
	75%	290	645	935
	50%	205	560	765
	25%	165	515	-

TABLE XII - POWER SETTINGS AND FUEL RATES AT 5000 FT

		STERN ENG. ONLY	1 FWD ENG. + 1 STERN AT 90%	2 FWD ENG. + 1 STERN AT 90%	2 FWD ENG. + 1 STERN ENG.
POWER SETTING (HP)	TAKE OFF	-	-	-	2070
	100%	605	1147	1752	1815
	90%	542	1084	1626	-
	75%	454	996	1450	-
	50%	302	844	1146	-
	25%	151	693	-	-
FUEL RATE at POWER SETTING (LB/HR)	TAKE OFF	-	-	-	1214
	100%	355	663	1000	1065
	90%	308	616	924	-
	75%	257	565	822	-
	50%	187	495	682	-
	25%	160	468	-	-

4. ENVELOPE SIZING

The volume of the airship envelope is a function of the altitude the vehicle is to fly and the weight to be carried by the lifting gas.

4.1 Ballonet

The ZP3G Conceptual design has a static lift capability of 55,335 lb at sea level. This assumes that the ballonet is 97 percent empty, that the helium has a 97 percent purity and the envelope stretch has increased the design volume of 875,000 cu ft by 2 percent. An airship flying at 5000 ft altitude as required in some of the study missions necessitates an envelope with a 16 percent increase in volume to maintain the same static lift. Figure 16 illustrates the loss of static lift with pressure height when an envelope volume of 875,000 cu ft, used in this study is fixed. For example, the figure shows that the ZP3G airship loses approximately 4500 lb of lift between an altitude of 2000 and 5000 ft.

4.2 Weight Breakdown

The major factors in sizing the envelope is the gross weight to be carried by the lifting gas. Table XIII is a weight breakdown of the vehicle less fuel and mission payload. Except for the propulsion systems and car, component and installation weights are the same or comparable to those used on previous airships. The basic car standard weight was estimated in an R and D program when an effort was made to reduce manufacturing costs.

The 4293 lb for the car in this study includes the secondary structure, provisions for all the mission equipment and maximum crew facilities. The fixed payload weighing 4420 lb is standard in the eight missions, therefore it is included in the empty vehicle weight of 38,160 lb. Referring back to Table IX it can be seen that the marine environmental protection mission has a maximum lift-off weight of 60,664 lb. 8500 lb of this weight is carried by the hover capability of the propulsion system or the aerodynamic lift of the envelope. The remaining weight must be lifted by the helium. At an altitude of 2000 ft Figure 16 shows that the required 52,164 lbs of static lift is possible with the 875,000 cu ft envelope.

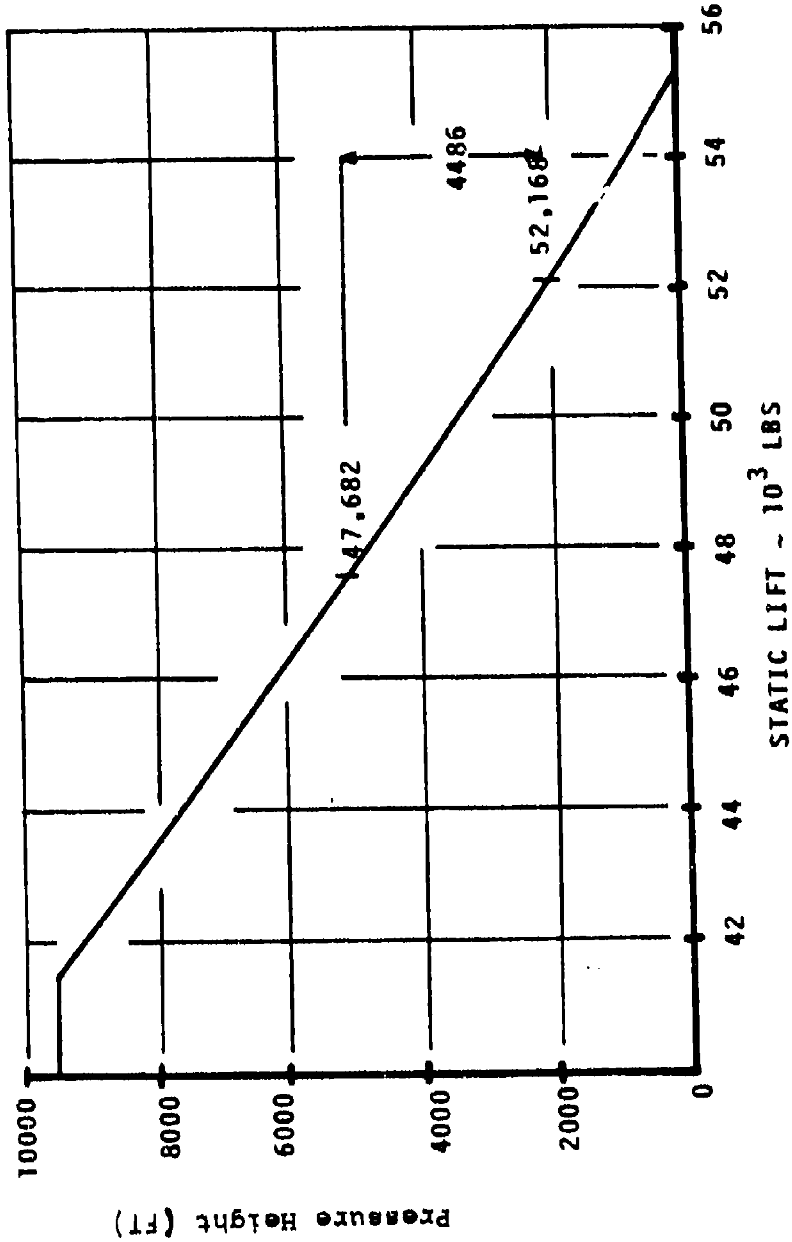


Figure 16 - Static Lift Decrease with Altitude

TABLE XIII - ZP3G WEIGHT BREAKDOWN

	LBS
Envelope	11,605
Empennage	3,030
Car	4,293
Landing Gear	818
Pressure System	1,188
Surface Controls	1,062
Ballast System	510
Outrigger + Carry Through	2,711
Fwd Propulsion	1,726
Aft Propulsion	2,146
Fuel System	1,586
Furnishings and Equipment	3,065
Fixed Payload	4,420
TOTAL	38,160

*See Appendix A for more detailed weight breakdown

5. INBOARD PROFILE

Figure 17 presents a possible configuration for the ZP3G car. The basic car is over 70 ft long and 7.5 ft wide. It provides for maximum crew facilities, the large radar and a winch for towing or hoisting. This particular configuration shows provisions for carrying an inflatable 15 ft boat with a 70 horsepower outboard motor. The boat is raised and lowered with two hydraulic utility winches with access to the boat made through trap doors in the car floor. Due to the design of the ZP3G airship a portion of the fixed equipment such as isolated electronic components, ballast and fuel tanks are carried on the exterior of the car, within the external catenary fairing. This feature permits a reduction in car size and increases the available space in the interior. Car drag remains the same because the reduction in car size results in an increased frontal area of the fairing associated with the concept.

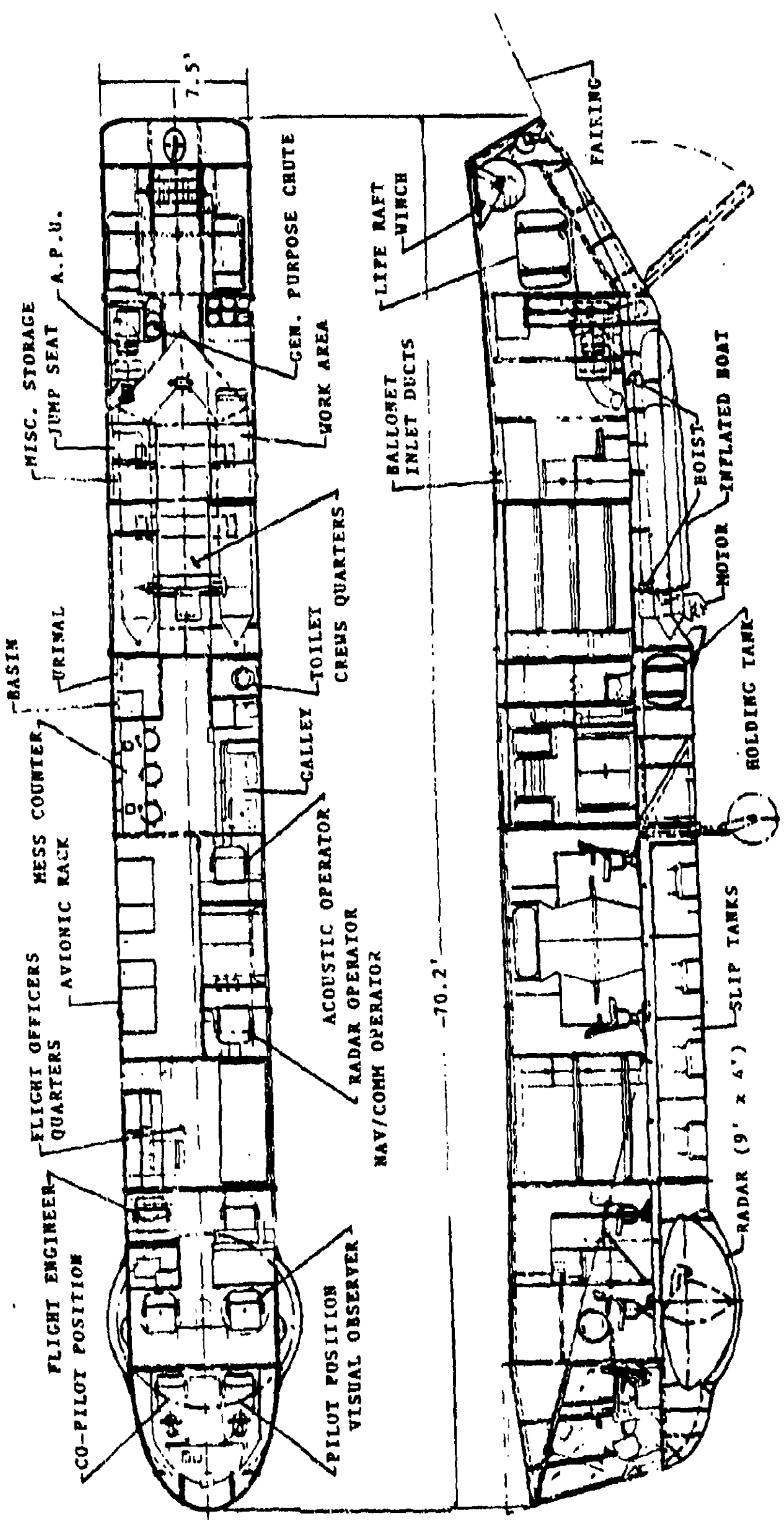


Figure 17 Inboard Profile

6. ZP3G CONFIGURATION

The conceptual design of the ZP3G is shown in Figure 18. Its overall length of 324 ft exceeds that of the original ZP5K design study by 35 ft. Also the maximum diameter of the envelope is approximately six feet larger. In this configuration the propulsion systems are shown in the cruise or conventional take-off position. The forward propellers, however, do rotate plus or minus 90° and the stern propulsion system rotates a plus 90° for VTOL operation.

The conceptional design uses four ballonets. The forward and aft ballonets serve to trim the airship in addition to compensating for large altitude changes. The center ballonets permit nominal changes in altitude, that are repeatedly required in some of the missions, without effecting the airship trim condition. Ballonet configuration is governed by geometric restrictions and size. To maintain trim fore and aft, ballonets are nearly equal in volume and location relative to the center of buoyancy. The catenary system on the ZP3G restricts the size of the forward ballonet therefore the geometry of the aft ballonet is controlled. The remaining ballonet air volume is made up in the center section of the envelope, outboard of the car suspension system. Although the ballonets are less efficient weight wise, the huge surging air mass plus the flapping and flexing of the ballonet fabric, during partial inflation, is minimized when the ballonet consists of several compartments.

Bow stiffening and the X-type tail for the ZP3G concept are of conventional design, because flight dynamics and performance characteristics of an airship with this volume and configuration have been substantiated. Furthermore, the "X" type empennage provides the necessary ground clearance for short take-offs with a reasonable angle of attack. A base structure for the fin suspension cables is an added feature since it eliminates the fin catenary and reduces the number of brace cables. In the concept the car is supported at the floor level by the internal and external catenaries. A separate catenary system for the forward propulsion system divorces the power plant from the car to permit a more stable platform and reduce the noise level for the crew. Location of the forward propellers in this position is also necessary to balance the thrust forces during the hover mode of operation. The stern propulsion system is mounted on an inverted "Vee"

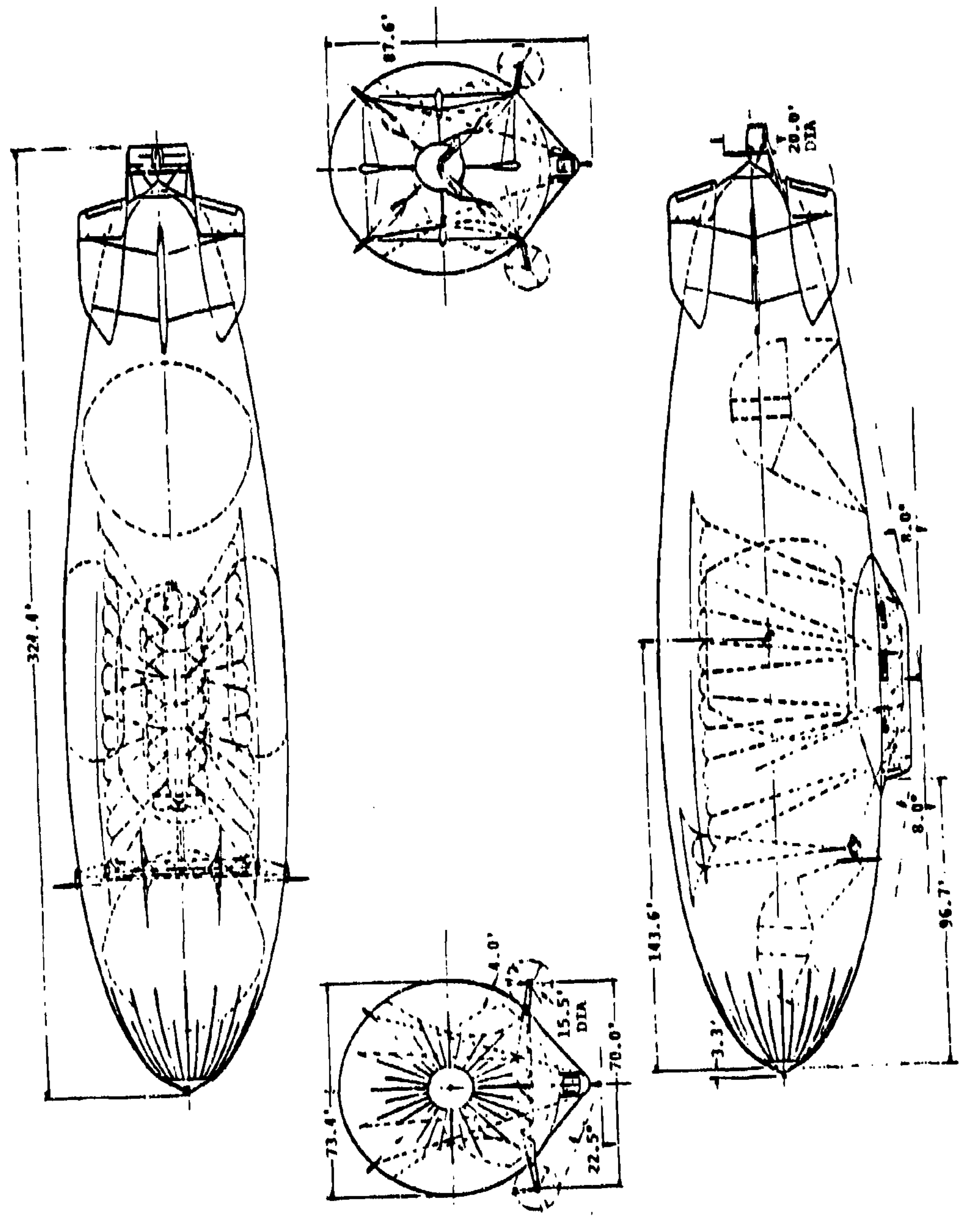


FIGURE 18 ZP3G AIRSHIP

tail which provides the tilt capability for the propeller. The "Vee" tail also supports the deflectable ruddevator which greatly improves control effectiveness in both hover and low speed cruise via ruddevator deflection in the propeller slip stream. Further information on the "Vee" tail control effectiveness is discussed in Reference 4.

6.1 Major Characteristics

Principle characteristics of the ZP3G conceptual design are listed in Table XIV. The envelope volume of 875,000 cu ft is the design volume. With Dacron fabric the increase in volume due to stretch is assumed to be two percent. A ballonet volume of 216,250 cu ft permits the airship to fly missions at 5000 ft altitude. Under standard atmospheric conditions it limits the ballonet ceiling to 9700 ft. The dynamic lift of 8500 lb in hover is established as follows. The total propeller thrust at maximum power setting is 12,500 lb. On the stern propeller, 1500 lb of thrust is reserved for low speed attitude control; 2500 lb of excess thrust is required for acceleration from hover to climb, leaving a total of 8500 lb for dynamic lift. A 3900 lb negative lift is also available with the propulsion system to counteract excess static lift during landing. This capability is provided by rotating the forward propellers down 90°. The 3900 lbs is limited by an assumed maximum acceptable negative pitch attitude of 10° for the vehicle and not by the available propeller thrust. The pitching moment resulting from this force is counteracted only by the metecentric center of the airship since the negative thrust of the stern engine in minimal in this mode of operation. Again this negative lift feature should be used only when necessary because the loss of thrust on the stern propeller greatly reduces the attitude control capability. The gross weight of 60,664 lb could be increased 3200 lb when a vectored thrust STOL operation is incorporated. This in turn would increase the useful payload to 25,704 lb.

The performance summary is listed in Table XV. Maximum speeds are taken at sea level using the take-off thrust of all engines. Range is listed at 40 and 50 knots minimum speed. Although the 40 knot velocity obtains an additional 100 nautical miles; the 50 knot speed reduces flight time by 25 percent. The maximum available horsepower for climb occurs at 55 knots. However, catenary limitations restrict the pitch angle of the airship to 30° and with this

TABLE XIV - MAJOR CHARACTERISTICS

Envelope Volume	875,000 Cu Ft
Ballonet Volume	216,250 Cu Ft
Fineness Ratio	4.40
Beta Factor	.86
Static Lift @ 2000 Ft Altitude	52,164 Lb
Dynamic Lift	8,500 Lb
Maximum Gross Weight	60,664 Lb
Weight Empty including Fixed Mission Payload	38,160 Lb
Useful Load	22,504 Lb
Power Plant	
[3] Allison GMA-500	800 Shp Ea.

TABLE XV - ZP3G PERFORMANCE SUMMARY

MAXIMUM SPEED (8500 LB HEAVY)	94 KNOTS
MAXIMUM SPEED (8500 LB HEAVY, REAR ENGINE ONLY) (MAXIMUM CONTINUOUS POWER)	52 KNOTS
MAXIMUM SPEED (NEUTRALLY BUOYANT)	97 KNOTS
RANGE @ 40 KNOTS ≥	3407 N.M.
RANGE @ 50 KNOTS ≥	3290 N.M.
BEST CLIMB VELOCITY	71 KNOTS
RATE OF CLIMB AT MAXIMUM POWER	3375 FT/MIN.
RATE OF CLIMB LIMITED BY AIR SYSTEM	2400 FT/MIN.
CONVENTIONAL TAKE-OFF DISTANCE (8500 LB HEAVY)	1025 FT.
VELOCITY @ LIFT-OFF	50 KN
DISTANCE TO CLEAR 50 FT OBJECT	2400 FT.
VELOCITY @ CLEARANCE HEIGHT	65 KN
TIME TO ACCELERATE TO 40 KNOTS (NEUTRALLY BUOYANT)	15 SEC.
TIME TO ACCELERATE TO 92 KN (95% MAXIMUM SPEED, NEUTRALLY BUOYANT)	64 SEC
TIME TO DECELERATE FROM 97 KNOTS TO 0 (NEUTRALLY BUOYANT)	55 SECs
ALTITUDE LIMIT	5000 FT.
BALLONET CEILING	9700 FT.
ENDURANCE ≥ 25 KNOTS	101 HRS.

limitation the velocity for maximum climb is 71 knots. The air system, proposed in the concept, limits the maximum rate of climb to 2400 ft per minute; therefore climb at the normal rated power, is restricted unless the air valve system discharge rate is increased.

For conventional take-off the vehicle attitude assumes a maximum pitch angle of 6° to assure a margin of safety for tail clearance. The performance for acceleration and deceleration uses maximum power at sea level. To accelerate from zero velocity the airship is considered to be neutrally buoyant. For the time to decelerate, from the 97 knot maximum speed, a six second transition phase is assumed to change the propeller from zero to full reverse thrust. In the table, range and endurance assumes that the vehicle is operating at the 2000 ft altitude with a useful payload of 6370 lbs. Lift-off is STOL with vectored thrust and the performance is based on 90 percent of the maximum fuel load of 23,750 lbs.

7. EXTENDED MISSION CAPABILITIES

Since the ZP3G design concept was sized by four of the missions, the remaining maritime patrol missions could have extended capabilities. Port safety and security could carry four times the mission equipment or loiter and stay on station seven times longer. In search, board and tow [SAR] missions, a 180 ton vessel could be towed two and a half times the mission profile distance. Although it may not be favored by the crew the [A/N] mission could service over twice as many buoys and double the maintenance service time. Ice mapping on the Great Lakes [IO] could be extended to 30 hours. Table XVI summaries the extended capabilities of these missions, showing the additional features that could be employed.

TABLE XVI - EXTENDED MISSION CAPABILITY

	Mission Requirement		Mission Capability
P.S.S.	Payload	7758 Lb.	16,358 Lb.
	Loiter	6 Hr.	51 Hrs.
	Cruise	1.85 Hrs.	30 Hrs.
S.A.R.	Payload	6999 Lb.	13,808 Lb.
	Tow	8.3 Hrs.	21.3 Hrs.
	Distance	50 NM	125. NM
A/N	Payload	7453 Lb.	14,312 Lb.
	No. Buoys Serviced	5	13
	Mission Time	17 Hrs.	34 Hrs.
I.O.	Payload	7509 Lb.	11895 Lb.
	Map @ 60 KN	20 Hr.	30 Hrs.

8. GENERAL COMMENTS

Goodyear's inventory of airships, designed and produced, covers a volumetric range varying from 100,000 to 1.5 million cu ft. For study and conceptual designs within this range the experience gained in the construction and performance of the vehicle, is used to establish size and characteristics of the airship under consideration.

The ZP3G airship could be considered a modernized ZPN-1, and since most weights and performances characteristics of the vehicle are lifted from detail weight and flight test report, [Reference 1 and 2] general sizing equations are minimal. Major differences in the two airships are the envelope material, car configuration and propulsion system. The ZPN envelopes were made of cotton and the ZP3G substitutes a polyester fabric. The car, similar to that used on the GZ-16, replaces the ZPN structure to simplify design and reduce production costs. The forward propulsion system employs cross-shafting, similar to the ZPN airship, to maintain efficient fuel consumption in the intermediate speed ranges and provide a one-engine-out capability. Engines are horizontally mounted externally on struts adjacent to the envelope. The propeller gear box and the rotating thrust axis mechanisms are located outboard of the engines.

Except for the one-engine installation, details of the stern propulsion system are identical to the configuration on the ZPG-X point design. Characteristics and improved control capabilities of this arrangement are discussed in Reference 4.

On the mast, maintenance of the propulsion system is limited to minor overhaul. Access to the forward engines is gained from the car, to the air duct, through the cross-beam tunnel to the engine cowl. For access to the stern engine, the nose pendant cable is payed out of the mooring cap to permit mechanical mules, with constant tension winches, to pull and hold the stern of the airship down to ground level. With the engine in the vertical attitude, a work platform is latched to the support structure for maintenance. This permits the airship to weathervane to some degree when tensions in the winch cables are relaxed. In the hanger, major overhaul should be no problem. The vehicle may be tied down to minimize movement and positioned such that the maximum engine height above ground level is 25 ft. On a comparable basis the DC-10 fin engine exceeds a ground height of 35 ft.

The marine environmental protection program [MEP] relies heavily on ballast management to perform the mission of transporting oil clean-up and recovery devices. Pallet weights for the oil containment equipment on this program vary between 16,000 and 17,000 lb and since the maximum dynamic lift of the ZP3G propulsion system is 8500 lb, the remaining payload weight must be carried by static lift. In flight, when the airship is without payload, water ballast is carried to establish a near neutrally buoyant condition. In the process of installing the MEP payload for transport, the water ballast on board the airship is released after hook-up of the pallet is made with the payload attachment cables. At termination of flight when the pallet has been deposited, a pump and hose are lowered into the water to take on ballast prior to release of the payload from the cables. Water is pumped on board until the payload cables go slack, indicating a near neutral condition. With an eight horsepower pump the operation of taking on ballast requires approximately two minutes.

9. CONCLUSIONS

The results of the study indicate that an airship with hover capability can perform all missions established in the contract.

Many characteristics of the subject airship are based on a previous vehicle and as a result much of the system weights and performance data was taken from documented flight reports, [Reference 1, 2].

The conceptual design airship, referred to as the ZP3G, is a near-term low-risk concept. The envelope is of modern Dacron fabric; most of the rigid structure is state-of-the-art aluminum or steel alloys, and the engines for the propulsion system start PFRT [preliminary flight rating tests] in October 1979. The design provides improvements in slow speed control and incorporates a vertical take-off and landing capability. The vehicle is designed to take-off and land conventionally. It can operate [VTOL] by using vertical thrust and buoyant lift as necessary or it can also operate [STOL] in an overload configuration with vectored thrust and a short running take-off. At sea level, in the neutrally buoyant condition, the top speed is 97 knots. The maximum ferry range is 3407 nautical miles with a 4420 lb fixed onboard payload, a crew of six, provisions for five days, a 10 percent fuel reserve and flying at a minimum speed of 40 knots. Lift-off weight of the vehicle less fuel is 40,110 lb. Maximum endurance with the same payload, at a 25-knot minimum speed is 101 hours. The low-speed control of the ZP3G provides the capability to tow an acoustic array for passive ASW screening operations. It also permits towing a disabled ship with up to 400-ton displacement at 6 knots. This displacement would approximate a ship 120 ft long with a 26 ft beam. The technical risk associated with the ZP3G concept is low and an operational prototype could be flying in three years.

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AN-9103-D
SUPERSEDING
AN-9103-C
FOR AIRSHIPS

NAME ____________
DATE ____________

PAGE 1
MODEL ZP3G
REPORT ____________

APPENDIX "A"

GER - 16607

GROUP WEIGHT STATEMENT

ESTIMATED - CALCULATED - ACTUAL

(Cross out those not applicable)

CONTRACT NO. N62269-78-M-4580

AIRSHIP, **GOVERNMENT NO.** ____________

AIRSHIP, **CONTRACTOR NO.** ____________

MANUFACTURED BY Goodyear Aerospace Corporation

		MAIN	STERN
ENGINE	MANUFACTURED BY	Allison	Allison
	MODEL	GMA 500	GMA 500
	NO.	2	1
PROPELLER	MANUFACTURED BY	Hamilton Std.	Hamilton Std.
	DESIGN NO.		
	NO.	2	1

NAME ______________________

DATE ______________________

MODEL ZP3G

REPORT ______________________

GROUP WEIGHT STATEMENT
WEIGHT EMPTY

No.	Item			
1	ENVELOPE GROUP			11605
2	ENVELOPE		6884	
3	BALLONETS		1290	
4	FORWARD	300		
5	CENTER	649		
6	AFT	341		
7	AIR LINES		232	
8	CAR SUSPENSION		973	
9	INSIDE	471		
10	OUTSIDE	502		
11	BOW STIFFENING AND MOORING		1258	
12	MOORING CONE, SPINDLE, NOSE CONE, TAPES	329		
13	BATTENS	651		
14	BATTEN ATTACHMENT	81		
15	NOSE STIFFENING COVER	197		
16	FIN CATENARIES OR SUSPENSION PROVISIONS		296	
17	CAR FAIRING		200	
18	MISCELLANEOUS		443	
19	Bonding & Lighting		29	
20				
21	TAIL GROUP			3030
22	FINS - UPPER		982	
23	FINS - LOWER		994	
24	Ruddevator-Upper		411	
25	Ruddevators-Lower		414	
26	ELEVATORS			
27	FIN SUSPENSION		229	
28				
29	CAR GROUP			4293
30	BASIC STRUCTURE		3200	
31	SECONDARY STRUCTURE - CAR		528	
32	Provision for equipment		565	
33				
34	ALIGHTING GEAR GROUP (TYPE: Single wheel)			818

No.		LOCATION	WHEELS, BRAKES, TIRES, TUBES, AIR	STRUCTURE	CONTROLS		
35–36							
37	Main	car				818	
38							
39							
40							

No.	Item			
41	PRESSURE GROUP			1188
42	PRESSURE SYSTEM (LESS CONTROLS)		870	
43	CONTROLS		318	
44				
45	BALLAST GROUP			510
46	TANKS AND SUPPORTS		310	
47	PIPING, VALVES, PUMPS, ETC.		146	
48	WATER pick-up pump & hose		64	
49				
50	SURFACE CONTROL GROUP			1062
51	COCKPIT CONTROLS		920	
52	AUTOMATIC PILOT		142	
53	SYSTEM CONTROLS (INCL. POWER AND FUEL CONTROLS)			
54				
55	OUTRIGGER GROUP Main			2581
56	Stern			805
57	TOTAL TO BE BROUGHT FORWARD			25892

NAME ______________________

DATE ______________________

GROUP WEIGHT STATEMENT
WEIGHT EMPTY

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MODEL ZP3G

REPORT ______________________

No.	Item		Stern		Main	Total
1	ENGINE SECTION AND NACELLE GROUP					370
2	ENGINE SECTION				175	
3	NACELLES				195	
4	DOORS, PANELS, MISCELLANEOUS					
5						
6	PROPULSION GROUP		Stern		MAIN	4413
7	ENGINE INSTALLATION		320		640	
8	ACCESSORY DRIVES		122			
9	AIR INDUCTION SYSTEM					
10	EXHAUST SYSTEM		8			
11	COOLING SYSTEM					
12	LUBRICATING SYSTEM		12			
13	TANKS	5		10		
14	COOLING INSTALLATION	4		8		
15	PLUMBING, ETC.	3		6		
16	FUEL SYSTEM		25		1561	
17	TANKS	10		1066		
18	PLUMBING, ETC.	15		495		
19	TRANSMISSION SYSTEM		125		250	
20	ENGINE CONTROLS		275		67	
21	STARTING SYSTEM		20		40	
22	PROPELLER INSTALLATION		359		554	
23						
24	AUXILIARY POWER PLANT GROUP					100
25						
26	INSTRUMENTS AND NAVIGATIONAL EQUIPMENT GROUP					334
27						
28	HYDRAULIC AND PNEUMATIC GROUP					150
29						
30	ELECTRICAL GROUP					
31						
32	ELECTRONICS GROUP					4420
33	GOVERNMENT FURNISHED EQUIPMENT				4420	
34	CONTRACTOR INSTALLATIONS					
35						
36	ARMAMENT GROUP					
37						
38	FURNISHINGS AND EQUIPMENT GROUP					1261
39	ACCOMMODATIONS FOR PERSONNEL				805	
40	MISCELLANEOUS EQUIPMENT				304	
41	FURNISHINGS					
42	EMERGENCY EQUIPMENT				152	
43						
44	AIR CONDITIONING AND ANTI-ICING EQUIPMENT GROUP					240
45	AIR CONDITIONING					
46	ANTI-ICING					
47						
48	AUXILIARY GEAR GROUP					
49	WINCH AND CONTROLS					730
50	HANDLING LINES				600	
51					130	
52						
53						
54						
55						
56	TOTAL FROM PAGE					25892
57	WEIGHT EMPTY					38160

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MODEL	ZP3G
REPORT	

NAME ____________

DATE ____________

GROUP WEIGHT STATEMENT
DIMENSIONAL AND STRUCTURAL DATA

1	LENGTH - OVERALL (FT)	324.4	HEIGHT OVERALL STATIC (FT)		87.6
2		ENVELOPE	CAR	OUTRIGGERS	NACELLES
3	VOLUME - DESIGN (CU. FT.)	875,000			
4	VOLUME - STRETCHED (CU. FT.)	892,500			
5	LENGTH - MAXIMUM (FT)	305.3	70.3		
6	DEPTH - MAXIMUM (FT)	73.4	10.0		
7	WIDTH - MAXIMUM (FT)	73.4	7.5		
8	WETTED AREA (SQ. FT.)	58230	1519		
9					

10	THEORETICAL ENVELOPE DATA		
11	SURFACE AREA	6470	SQ.YDS.
12	FINENESS RATIO (theoretical)	4.37	
13	DISTANCE OF MAXIMUM SECTION FROM BOW	128.4	FEET
14	DISTANCE OF CENTER OF BUOYANCY FROM BOW	143.6	FEET
15	DISTANCE OF CENTER OF VOLUME OF BALLONETS FROM BOW	143.6	FEET
16			
17			
18	BALLONET VOLUMES		
19	FWD BALLONET	48600	CU.FT.
20	CTR BALLONET	107750	CU.FT.
21	AFT BALLONET	59900	CU.FT.
22	TOTAL VOLUME	216250	CU.FT.
23	% ENVELOPE - STRETCHED	24.3	%
24			
25			
26	EMPENNAGE SURFACE AREA		
27	FINS (4)	2080	SQ.FT.
28	RUDDEVATORS (4)	952	SQ.FT.
29	ELEVATORS		SQ.FT.
30	TOTAL AREA	3032	SQ.FT.
31			
32			

33	ALIGHTING GEAR	MAIN	AUXILIARY
34	LENGTH - OLEO EXTENDED ℄ AXLE TO ℄ TRUNNION (INCHES)	70	
35	OLEO TRAVEL - FULL EXTENDED TO FULL COLLAPSED (INCHES)	20	
36			
37			

38	FUEL AND LUBE SYSTEM	LOCATION	NO. TANKS	GALLONS
39	FUEL - INTERNAL (slip)	car	4	1400
40		stern	1	20
41	- EXTERNAL	car	6	1350
42	OIL			
43				
44				

45	HYDRAULIC SYSTEM CAPACITY (GALS.)		
46			
47	GENERAL DATA		
48	STATIC LIFT @ 2,000 Ft. Alt.	52164	LBS.
49	DYNAMIC LIFT	8500	LBS.
50	GROSS LIFT	60664	LBS.
51	USEFUL LOAD -		LBS.
52	USEFUL LOAD -	22504	LBS.
53			
54			
55			
56			
57			