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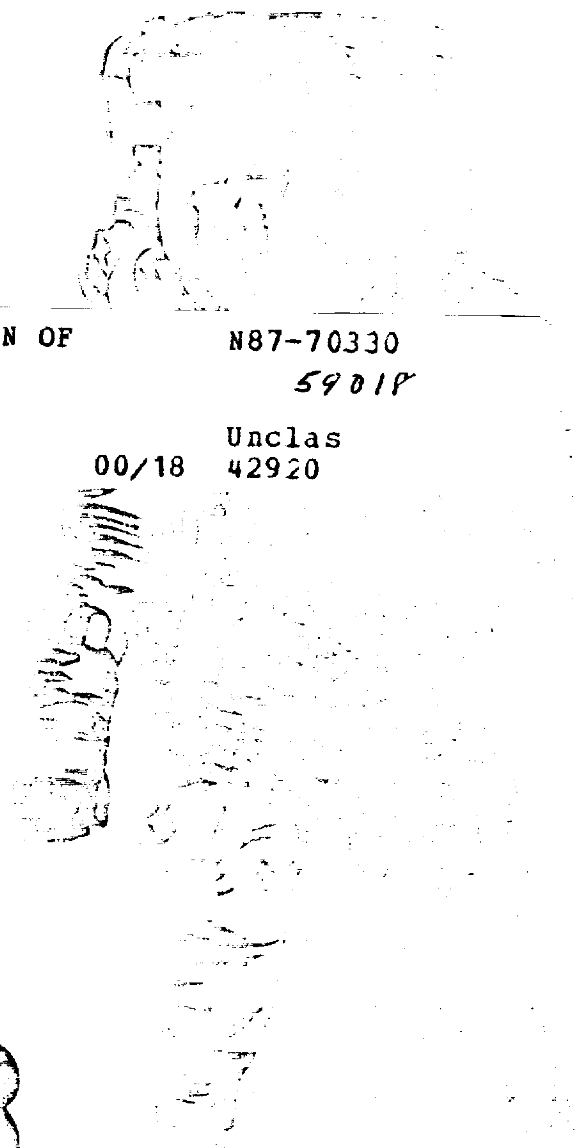
FINAL REPORT

DESIGN DEFINITION OF A LIGHTER-THAN-AIR (LTA) HIGH ALTITUDE POWERED PLATFORM (HAPP)

NASA CONTRACT NO. NAS 6-3131



(NASA-CR-168350-Vol-1) DESIGN DEFINITION OF A LIGHTER-THAN-AIR (LTA) HIGH ALTITUDE POWERED PLATFORM (HAPP). VOLUME 1 Final Report (ILC Dover) 11 p

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of a

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High Altitude Powered Platform (HAPP)

NASA Contract No. NAS 6-3131

Prepared for

Wallops Flight Center

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1.0 INTRODUCTION

This report presents results of a feasibility study for a lighter-than-air High Altitude Powered Platform (HAPP) performed under Contract No. NAS6-3131 with the National Aeronautics and Space Administration, Wallops Flight Center, Wallops Island, VA.

The work was accomplished in two phases. Phase I developed an integrated set of system characteristics including operational criteria for a lighter-than-air HAPP vehicle powered via microwave link. Phase II developed the design definition for a proof-of-concept model of the HAPP airship as conceived in Phase I.

The reports for Phase I and Phase II are attached as Attachment I and Attachment II, respectively.

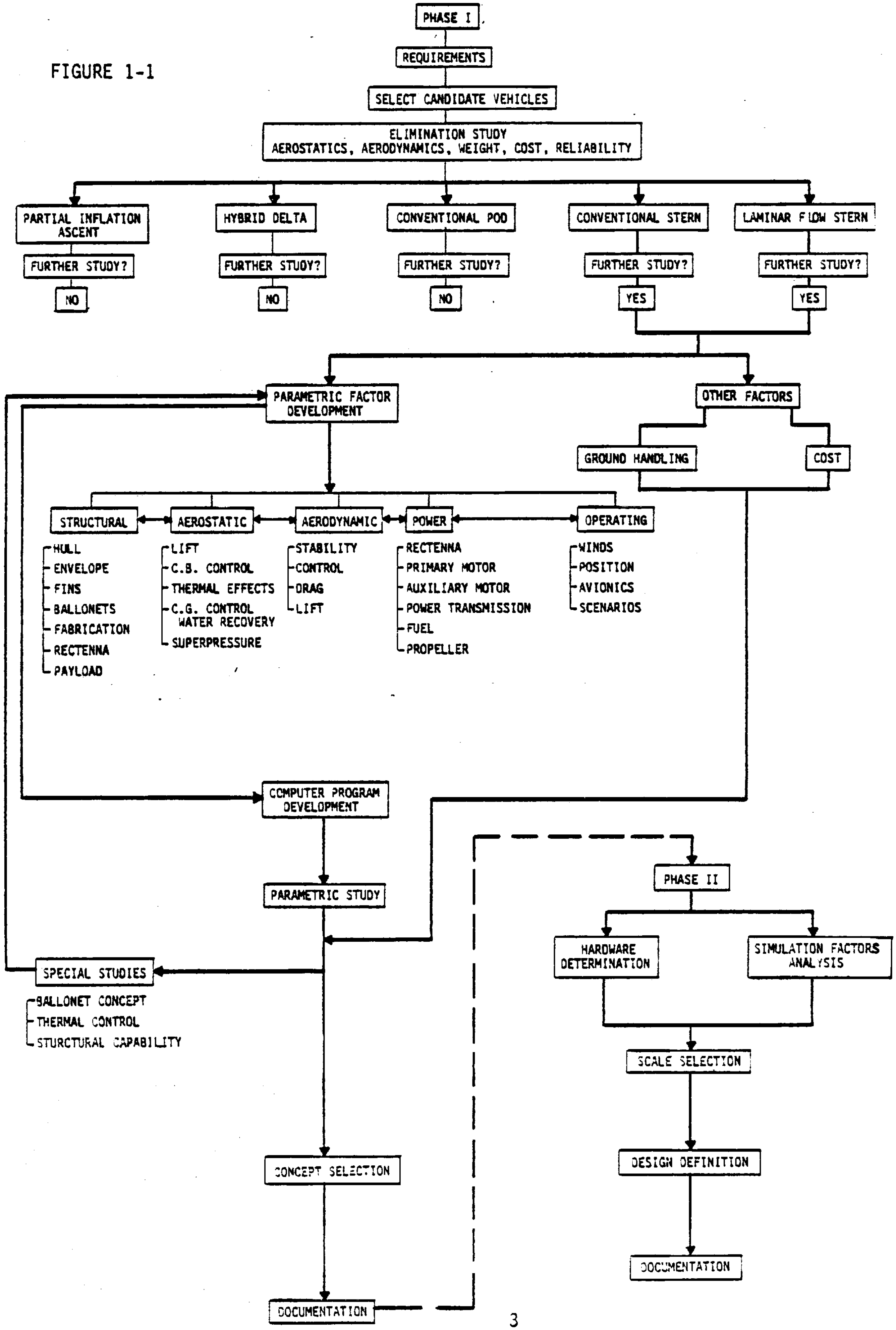
In general concept, the HAPP vehicle was to ascend into the stratosphere to an altitude of prevailing low wind speeds (nominally 21 km), position itself in a microwave power transmission beam from a source on the ground, and thereafter fly on microwave power for three months or more. It would return to a ground station for refurbishment and then repeat the flying cycle.

Concurrent with this study, ILC also worked on a subcontract for Lockheed Missile and Space Corporation to develop an airship concept for the Navy HI-SPOT Study. The objectives of HI-SPOT were similar in many respects to its counterpart the HAPP Program.

The HI-SPOT ship was to ascend to an altitude of minimum winds as intended for HAPP, it was to fly 6,000 miles to and from an operating station and to remain on station for as long as possible. The principle difference from HAPP is that the HI-SPOT must carry all of its propulsion energy on board while HAPP is to be supplied on station energy by microwave beam from the ground. It turned out that the same general configuration was applicable to both ships and the studies were mutually supportive in many respects. With the permission of both sponsors, ILC freely exchanged information between the programs to avoid duplication or replication of the efforts.

This study program had many facets which were coordinated and reiterated extensively in order to converge upon a satisfactory HAPP airship design concept. The flow of work during the program is diagrammed in Figure 1-1.

FIGURE 1-1


PHASE I
REQUIREMENTS
SELECT CANDIDATE VEHICLES
ELIMINATION STUDY
AEROSTATICS, AERODYNAMICS, WEIGHT, COST, RELIABILITY
PARTIAL INFLATION ASCENT
HYBRID DELTA
CONVENTIONAL POD
CONVENTIONAL STERN
LAMINAR FLOW STERN
FURTHER STUDY?
NO
YES
PARAMETRIC FACTOR DEVELOPMENT
OTHER FACTORS
GROUND HANDLING
COST
STRUCTURAL
HULL
ENVELOPE
FINS
BALLONETS
FABRICATION
RECTENNA
PAYLOAD
AEROSTATIC
LIFT
C.B. CONTROL
THERMAL EFFECTS
C.G. CONTROL WATER RECOVERY
SUPERPRESSURE
AERODYNAMIC
STABILITY
CONTROL
DRAG
LIFT
POWER
RECTENNA
PRIMARY MOTOR
AUXILIARY MOTOR
POWER TRANSMISSION
FUEL
PROPELLER
OPERATING
WINDS
POSITION
AVIONICS
SCENARIOS
COMPUTER PROGRAM DEVELOPMENT
PARAMETRIC STUDY
SPECIAL STUDIES
BALLONET CONCEPT
THERMAL CONTROL
STURCTURAL CAPABILITY
CONCEPT SELECTION
DOCUMENTATION
PHASE II
HARDWARE DETERMINATION
SIMULATION FACTORS ANALYSIS
SCALE SELECTION
DESIGN DEFINITION
DOCUMENTATION

2.0 CHRONOLOGY FOR THE HAPP STUDY PROGRAM

Prior to the start of the contract, NASA had conducted statistical wind studies which established the basic requirements for vehicle flight characteristics. The contract was then let for development of the HAPP design concept. A milestone chronology and brief description of work accomplished between milestone dates is given below.

OCTOBER 1980 - Contract Start.

A technology review and analysis was conducted and data collated to establish conceptual possibilities for the vehicle and its components.

FEBRUARY 1981 - Technology Assessment Report.

The design possibilities were established and parametric relationships were prepared and a parametric computation program developed. Parametric studies were conducted towards optimization of the airship design for mission performance.

Open issues which required additional study in order to provide confidence in the design were recognized as follows: gust response, thermal effects and ballonet concepts.

JULY 1981 - Parametric Review, Open Issues Presented.

At this point, work was held in abeyance pending resolution of the open issues.

AUGUST 1981 - Additional Study Proposed.

A proposal was submitted for investigation of open issues in more detail.

JANUARY 1982 - Proposal Accepted, Work Recommenced.

The investigation proposal was approved. The open issues were studied and resolved, the parametric comparisons were finished and the HAPP conceptual design was selected.

JULY 1982 - Phase I Report Submitted.

The Phase I draft report was submitted presenting the HAPP conceptual design. Phase II, the design definition for a proof-of-concept model, was commenced. Performance requirements for a proof-of-concept model were determined and component definition developed.

OCTOBER 1982 - Phase II Work Completed.

The Phase II study was completed and an executive presentation given at NASA Wallops.

NOVEMBER 1982 - Program Final Report Submitted.

3.0 SUMMARY

The basic technical objective for the program was development of the conceptual design for a cost effective airship to fly for prolonged periods in the stratosphere over a fixed position on the ground and powered by a microwave beam from the ground. The primary driver for such a design is the windspeed that the ship must counter with an equivalent airspeed capability. The statistical distribution of wind velocities in the United States was available from NASA, References A and B, and were used to prepare possible flight patterns or scenarios for the on station operation of the vehicle. A dual power plant was hypothesized: an all electrical system for microwave power use, and an auxiliary combustion power plant with on-board fuel for off station operation. On-station flight scenarios, which were studied, included various combinations of microwave power and auxiliary power use. It was determined that the optimum configuration was to size the microwave power system to handle the total spectrum of winds on station and to size the auxiliary power plant to handle only the ascent, descent, and landing operations. From the statistical studies, a maximum windspeed of 93 knots was selected as the design point.

The parametric factor development was the most significant part of the study and established the factors which determined the final design configuration. The critical configurations for component selection were reliability and weight, and to this end the following features were adopted.

1. A passive laminar flow hull shape constructed with a composite Kevlar based fabric.

2. Electrical machinery utilizing Samarium/Cobolt technology for light weight.

3. Hardware components such as the propeller using ultra light composites structure.

4. The auxiliary engine is a turbocharged reciprocating engine, which is the lightest weight reliable engine that can be started at altitude.

One of the most significant design features is the use of a passive laminar flow control hull shape. The required flight speeds and altitude of the HAPP airship produce a Reynolds number which is compatible with laminar flow. However, other severe constraints for retention of laminar flow must be observed, such as close tolerance smoothness for the hull surface, and avoidance of skin surface heating which may trip the ship into turbulent flow. This is a new technology area but has significant beneficial aspects toward the HAPP mission performance.

Stern propulsion was adopted to provide high propulsion efficiency. It does require special attention to weight distribution to avoid a tail heavy condition. Because of this, the auxiliary engine is placed forward in the ship with an electrical generator and fuel, thus, auxiliary power is generated by the reciprocating engine and delivered to the propeller through an electrical interface. In order to maintain balance when fuel is burned, a water recovery system is provided to compensate for loss of fuel weight by recovering water from the exhaust gases.

The airship selected with the above features and capable at flying at 93 knots on rectenna power has a volume of 77,900 cubic meters, it is 123.3

meters long, and 37.8 meters in diameter. It will fly at 20 km for a 3 month duration with an estimated overall reliability for the 3 months of 90%. Reliability estimates are based on use of standard military components and could be improved by use of space craft reliability criteria.

Following selection of the HAPP airship conceptual design, the study continued with the design definition of a proof-of-concept model called the "Demonstrator". A design was prepared for a ship to fly at 15 km altitude, volume 10,500 M^3, simulating hull shape, propulsion, and ballonets, and able to duplicate the maximum Reynolds number of the full scale ship.