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ADVANCED TECHNOLOGIES AIRSHIPS

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ABSTRACT

The abundance of new materials, processes, components and systems incorporating advanced technologies offer the airship designer many choices to improve mission capabilities, with resulting economic benefits.

This paper highlights many of these available advanced technologies. In turn, a specific application for these technologies is presented.

It must be mentioned that utilization of advanced technologies is a never-ending process. Thus, the airship designer is permitted to continue to incorporate improvements and upgrade air vehicles in a sequential manner.

I. INTRODUCTION

Airships have always been an acceptable means of air transportation, with its own niche, along with airplanes and helicopters. With the historical use of helium as the lifting medium, a non-inflammable gas, safe operations do result.

Advanced technologies can be applied to lighter-than-air vehicles to produce enhanced operational capabilities. It has now been sixty years since the zenith of non-rigid and rigid airships were developed and operated in the mid-1930's. Now new materials, systems, and equipment permit the development of advanced airships, both in the non-rigid and rigid design categories.

II. AIRSHIP DESIGN PHILOSOPHY

In order to efficiently adopt, consider and use advanced technologies, it is firmly believed that a design philosophy be established. Figure 1 shows eight areas where this principle of having a design philosophy for airships can be carried out. Of course, a major advantage is use of advanced technologies.

1. Efficient Operation/Aerodynamic Cleanliness
   - -High Ratio: Useful Load to Weight Empty
2. Advanced Technologies
   - -Materials/Structures
   - -Processes/Minimum parts count
   - -Equipment
   - -Power Plants
   - -Systems
3. Low Observables
   - -Types of Materials
   - -Configuration
   - -Color
4. Configurations
   - -Adoption of Applicable Technologies
5. Safety/Operations
   - -Adverse weather/ Visibility
   - -Lightning/Bonding
   - -Weather/Surveillance Radar
   - -Helium/Air ballonets
   - -Envelope/Visibility Dome
6. Operations/Maintenance
   - -Ground level refueling; no ladders
   - -On-board Maintenance Monitoring
   - -Crash Worthiness
   - -Air Drops/Clear exit
   - -Fuselage end loading & unloading
   - -Mooring options
   - -Repair considerations
7. Computer Aided Management
   - -Design
   - -Manufacturing
   - -Testing
   - -Operations
8. Variable Payloads
   - -Passengers
   - -Animals
   - -Small vehicles
   - -Small boats
   - -Surveying
   - -Para Drops
   - -Etc.

FIGURE 1. AIRSHIP DESIGN PHILOSOPHY

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III. ADVANCED TECHNOLOGIES

The benefits of advanced technologies applications to airships are considered in the following categories:

Configuration and Design Integration
Materials and Structures
Key Technologies
USAF - PROJECT Forecast: Technologies
USAF - Project Forecast: Systems
Advanced Technologies Applications
Propulsion
Performance, Stability & Control
Systems & Sub-systems
Manufacturing
Operations
Human Factors

Configuration and Design Integration

The analytical tools such as CFD and CAD/CAM is available for designers as computer tools to develop advanced configurations. New configurations permit extreme aerodynamic cleanliness as well as unique structural arrangements to permit unique payload to weight empty ratios.

Materials and Structures

Recent development in advanced composites can be applied to airship envelopes as well as to the airship airframe. Figure 2 "Airship Technologies Applications" shows the historical development over time for application of new technologies. In Figure 2, the comparison relates to airframe materials.

Key Technologies

Figure 3 is a tabulation of key technologies from four U.S. sources. In addition to materials, propulsion and system technologies are included. Obviously, each design project will select from such a list to meet their requirements. Figure 4 further illustrates the application of advanced technology sources.

ENVELOPE TECHNOLOGIES				
TIME PERIOD	RIGID		NON-RIGID	
	MATERIAL	MODEL	MATERIAL	MODEL
1900-1919	CLOTH COVER, ALUMINUM FRAME	ZEPPELIN LZ SERIES	CLOTH (NATURAL MATERIALS)	VARIOUS
	CLOTH COVER, WOOD FRAME	SHUTTE-LANZ SERIES		
1920-1937	CLOTH COVER, ALUMINUM FRAME	ZR-1, ETC.		
1929-1939	ALUM. COVER, ALUM. FRAME	ZMC-2		
1920-1980	-----	-----	CLOTH (NATURAL & SYNTHETIC)	VARIOUS
1980-2000	ADVANCED COMPOSITES	MODEL 622	ADVANCED COMPOSITES	MODEL 633

FIGURE 2. AIRSHIP TECHNOLOGIES APPLICATIONS

NCAT/AIA KEY TECHNOLOGIES Compared with DoD, Commerce, and White House Assessments			
NCAT/AIA KEY TECHNOLOGIES	**DOD CRITICAL TECHNOLOGIES**	**DOC EMERGING TECHNOLOGIES**	**NATIONAL CRITICAL TECHNOLOGIES**
Advanced Composites	Composite Materials	Advanced Materals	Ceramics Composites Synthesis & Processing
Advanced Metallic Structures			High Performance Metals & Alloys
Advanced Sensors	Sensitive Radars Passive Sensors Data Fusion	Sensor Technology Digital Imaging Technology	Sensors & Signal Processing
Airbreathing Propulsion	Airbreathing Propulsion		Aeronautics
Artificial Intelligence	Machine Intelligence & Robotics	Artificial Intelligence	Intelligent Processing Equipment
Computational Science	Parallel Computer Architecture Signal Processing Computational Fluid Dynamics	High Performance Computing High Density Data Storage	High Performance Computing & Networking Computer Simulation & Modeling
Optical Information Processing	Photonics	Optoelectronics	Electronic & Photonic Materials
Rocket Propulsion Software Development	High Energy Density Materials Software Producibility		Software
Ultrareliable Electronic Systems	Semiconductors & Electronic Circuits	Advanced Semiconductor Devices	Microelectronics & Optoelectronics
Superconductivity	Biotechnology Materials & Processes Flexible Manufacturing Simulation & Modeling Signature Control Weapon System Environment Pulsed Power Hypervelocity Projectiles Superconductivity	Biotechnology Medical Devices & Diagnostics Flexible Computer-Aided Manufacturing Superconductivity	Applied Molecular Biology Medical Technology Flexible Computer-Integrated Manufacturing Micro- & Nanofabrication High Definition Imaging & Displays Data Storage & Peripherals Systems & Management Technologies Energy Technologies Pollution Minimization, Remediation & Waste Management Surface Transportation Technologies

FIGURE 3 - NCAT/AIA KEY TECHNOLOGIES

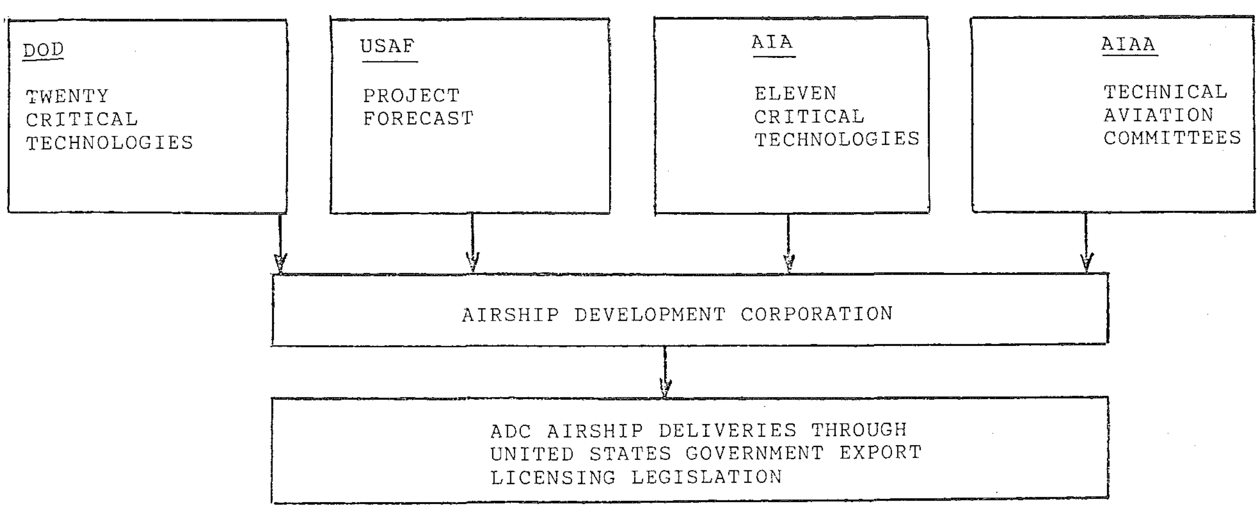

FIGURE 4. ADVANCED TECHNOLOGIES OF THE UNITED STATES

USAF: PROJECT FORECAST II

About every twenty years, the U. S. Air Force convenes a conference to look ahead for technology and systems that should be developed to enhance the mission of the Air Force. Their most recent efforts are summarized in Figures 5 and 6. Only those technologies and systems that will perhaps have application to airships are included in these figures.

PROPULSION & POWER	VEHICLES & STRUCTURES
High Performance Turbine Engine	Ultralight Airframes
Combined Cycle Engine	STOL/STOVL/VTOL Technology
High Temperature Materials	
WEAPONS TECHNOLOGY & COUNTERMEASURES	**SYSTEMS ACQUISITION AND SUPPORT**
Anti-Terrorism Technology	Advanced Manufacturing Technology
	Unified Life-Cycle Engineering
	Smart Built-In Test (V/STOL)
INFORMATION/ COMPUTATION C^3	**ELECTRONICS/ELECTRO-OPTICS**
Rapidly Reconfigurable Crew Sta.	Photonics
Knowledge-Based Systems	Non-Linear Optics
Virtual Man-Machine Interaction	Broad Spectrum Signature Control
Distributed Information Processing	Fail-Soft, Fault-Tolerant Electronics
Ultra-High Software Quality & Productivity	Ultra-Structured Materials
Low Cost-High Speed Military Computer	Advanced Deception
Aircrew Mission Enhancement	Survivable Communications Network
	Smart Skins

FIGURE 5. USAF PROJECT FORECAST II: TECHNOLOGIES

RECONNAISSANCE & SURVEILLANCE	WEAPONS
Multi-Static Surveillance System	Long-Range Air-to-Air Missile
Airborne Surveillance System	Multi-Role Conventional Weapons
AEROSPACE PLATFORMS	**COMMAND CONTROL & COMMUNICATIONS**
Intra-Theatre V/STOL Transport Aircraft	Theatre Air Warfare Command, Control, Communications & Intelligence
Multi-Role Global Range Aircraft	Super Cockpit
High-Altitude, Long Endurance, Unmanned Aircraft	Imaging System
Special Operations Aircraft	Battle Management Processing & Display System
Tactical Low Cost Drones	
Multimission Remotely Piloted Vehicles	

FIGURE 6. USAF PROJECT FORECAST II: SYSTEMS

ADVANCED TECHNOLOGY APPLICATIONS

In the case of ADC's Model 533B, Figures 7 and 8 tabulate specific applications of technologies to result in an advanced technology airship. Categories included in Figures 7 and 8 are:

Aerodynamics
Low Observables
Airframe
Flight Station
Control Systems

Power Plant
Avionics
Operations
Safety

CATEGORY	EXAMPLES
AERODYNAMICS	LOW DRAG ENVELOPE PROFILE RETRACTABLE MOORING ELEMENT RETRACTABLE LANDING GEAR INTERNAL FLIGHT CONTROLS TRI-ELEMENT EMPENNAGE FLUSH CONTOURS RETRACTABLE REAR RAMP RETRACTABLE INTEGRAL STEP DOOR SHROUDED PROPELLERS IN-FLIGHT COMPUTER SUPPORT
LOW OBSERVABLES	CRITICAL SELECTION OF: -ADVANCED MATERIALS -EQUIPMENT -CONFIGURATION -DESIGNED COMPONENTS -COLORS RESULTS IN MINIMIZED DETECTION BY: -VISUAL -INFRA-RED -NOISE LEVELS -ELECTRONICS (RADAR)

CATEGORY	EXAMPLES
AIRFRAME	ENVELOPE: MULTI-LAYER ADV. TECH. FABRIC/FILM EMPENNAGE: NOMEX HONEYCOMB ENVELOPE : KEVLAR CLOTH & ROPES CURTAINS FUSELAGE: ADVANCED COMPOSITES (1) ACRYLIC WINDOWS OUTRIGGERS: ADVANCED COMPOSITES (1) (1) SELECTIVE THERMOPLASTIC & THERMOSETTING RESINS.
FLIGHT STATION	EFIS FLIGHT STATION (1) TWO PLACE; BUT SINGLE PILOT OPTIONAL OPERATION EXCELLENT FIELD OF VIEW (1) THREE DISPLAY SYSTEM

ADC PROPRIETARY INFORMATION

FIGURE 7. ADVANCED TECHNOLOGIES APPLICATIONS - MODEL 533B

CATEGORY	EXAMPLES
CONTROL SYSTEMS	REDUNDANT FLY-BY-LIGHT INTERNAL SYSTEMS INTEGRATED COMPUTER-BASED CONTROL SYSTEM INTEGRATED CONTROLS OF: -FLIGHT CONTROL SURFACES -PROPELLER PITCH SETTINGS -POWER PLANT ATTITUDE ANGLE -FUEL FLOW DUAL SIDE STICK CONTROL
POWER PLANT	SELECTIVE POSITIVE & NEGATIVE ATTITUDE POSITIONS ADVANCED COMPOSITES PROPELLER SHROUDS ADVANCED COMPOSITES NACELLE TURBO-PROP ENGINES
AVIONICS	LIGHT WEIGHT VLSIC UNITS MULTIPURPOSE UNITS WEATHER RARAR (MULTI-COLOR)

CATEGORY	EXAMPLES
OPERATIONS	LONG ENDURANCE HOVERING CTOL, STOL, VTOL, STOVL MINIMIZED DETECTION ALL-WEATHER DAY & NIGHT UNIQUE TAKEOFF & LANDING FEATURES MULTI-MISSIONS OPTIONS SEA & LAND BASING OPTIONS IN-FLIGHT PAYLOAD DROPS MULTI-POSITION OUTRIGGER PYLONS
SAFETY	FUEL & POWER PLANTS @ OUTRIGGER AVIATION KEROSENE FUEL INERT PUIFIED HELIUM GAS ALL-ENGINES OUT LANDINGS ONE-ENGINE OUT OPERATIONS SINGLE PILOT OPERATION SHROUDED PROPELLERS

ADC PROPRIETARY INFORMATION

FIGURE 8. ADVANCED TECHNOLOGIES APPLICATIONS - MODEL 533B

Propulsion

Turbine power plants are preferred for application to airships for the following reasons:

- Major users of aircraft and helicopters operate their vehicles with gas turbine fuels.
- Gas turbines permit relatively light weight installations.
- Vibration and fatigue of structure is reduced.
- Kerosene-based fuels have safety attributes.

Assuming that there will be a long-term growth in developing a variety of non-rigid and rigid airships, it will be incumbent upon the power plant manufacturer to develop gas turbines applicable to the operating performance of airships. Figure 9 indicates some of the criteria for gas turbine engines to be developed by the manufacturer.

TYPES

- CONVENTIONAL TURBO PROP
- DUCTED PROP FAN
- UNDUCTED PROP FAN
- ADVANCED CONCEPTS

DESIGN AIMS

- RELIABILITY/MTBF
- LOW WEIGHT
- LOW SFC
- MINIMIZE FOREIGN OBJECT DAMAGE

POWER CLASSES

- 500 ESHP
- 1000 ESHP
- 5000 ESHP
- 10000 ESHP

ALTITUDES

- SEA LEVEL - 12,000 FT. (Unpressurezed)
- SEA LEVEL - 25,000 FT. (Pressurezed)

UNIQUE FEATURES

- MULTIPLE ATTITUDE CAPABILITIES
- WATER RECOVERY SYSTEMS
- INTEGRATED CONTROLS

FIGURE 9. POWER PLANTS FOR ADVANCED TECHNOLOGIES AIRSHIPS

Performance, Stability & Control

Advanced materials, structures, and power plants permit enhanced performance, such as retractable landing gear and the elimination of the need for rope handling landing systems. Stability and control are integrated through advanced computer aided control systems. This integration relates to aerodynamic control settings, propeller settings, fuel flow settings, and power plant attitude. This integration will permit safe and rapid responses to inputs from the pilot and co-pilot.

Systems and Sub-systems

The use of EFIS in the flight station, coupled with integrated on-board computers, as well as weather radar, permit weight savings, as well as minimizes the work duties of the flight crew.

Manufacturing

The trend toward advanced composite structures can lead to efficiencies in manufacturing by the usage of automatic layup of structural materials as well as processing these materials during the curing cycle. Commonality of components without penalty of aerodynamic requirements will further reduce manufacturing costs.

Operations

As an example of increased efficiency in the operating of airships, it is possible by the use of on-board winching systems that landing operations can be performed by one ground crew personnel rather than the historic use of many ground crew members to facilitate the landing and mooring of airships. This approach is unique and serves operations, whether at an airport or at an unprepared landing area in a remote location.

Operational tradeoffs, even though advanced technologies enhance the operation of airships, go beyond advanced technologies. Figure 10 shows the tradeoffs necessary to perform missions but still take into account meteorology and the field of operation.

Human Factors

Great effort has been made to simplify the duties and efforts on the on-board flight crew, as well as the ground support personnel. Reductions in on-board weight and operating efficiencies result.

MISSIONS	METEOROLOGY	AIRFIELD
MAX. OPERATING WEIGHT	TEMPERATURES	RUNWAY SURFACE
CRUISE SPEED	HUMIDITY	RUNWAY LENGTH
DISTANCE VS ENDURANCE	VISIBILITY	LANDING OPTIONS
ENGINE OUT PERFORMANCE	PREVAILING WINDS	PIVOTING ENGINES
OPERATING ALTITUDES	WIND VELOCITY	FIELD ALTITUDE

FIGURE 10. OPERATIONAL TRADE-OFFS

IV. ADJUNCT TO AIRLINES

Studies indicate that the unique flight characteristics of airships permits jet transport routes enhancement. Figure 11 illustrates the routes augmentations provided by airships.

V. SAFETY CONSIDERATIONS

The use of inert non-inflammable helium lifting gas provides a new level of flight safety in comparison to the hydrogen gas used sixty years ago. The inherent reliability of gas turbine engines provides an additional level of safety. The utilization of weather radar and advanced navigational equipment further enhances the safety of operation.

VI. ECONOMIC BENEFITS

Studies are available that inter-relate enhanced national economic development benefits when airships are utilized; see Figure 12.

The elements of cost, procurement, and utilization of airships is pictorially shown in Figure 13. The appropriate application of specific advanced technologies directly effect most of the cost items shown on the chart.

Figure 14 clearly shows the numerous benefits stimulating employment and economic growth. That is, ADC activities can measurably enhance national development.

VII. SUMMARY

By the application of advanced technologies, the design and operations of airships will provide enhanced benefits to uses/missions by military, government and commercial operators; see Figure 15.

A specific example of the advanced technologies applied to airships is shown in Figure 16.

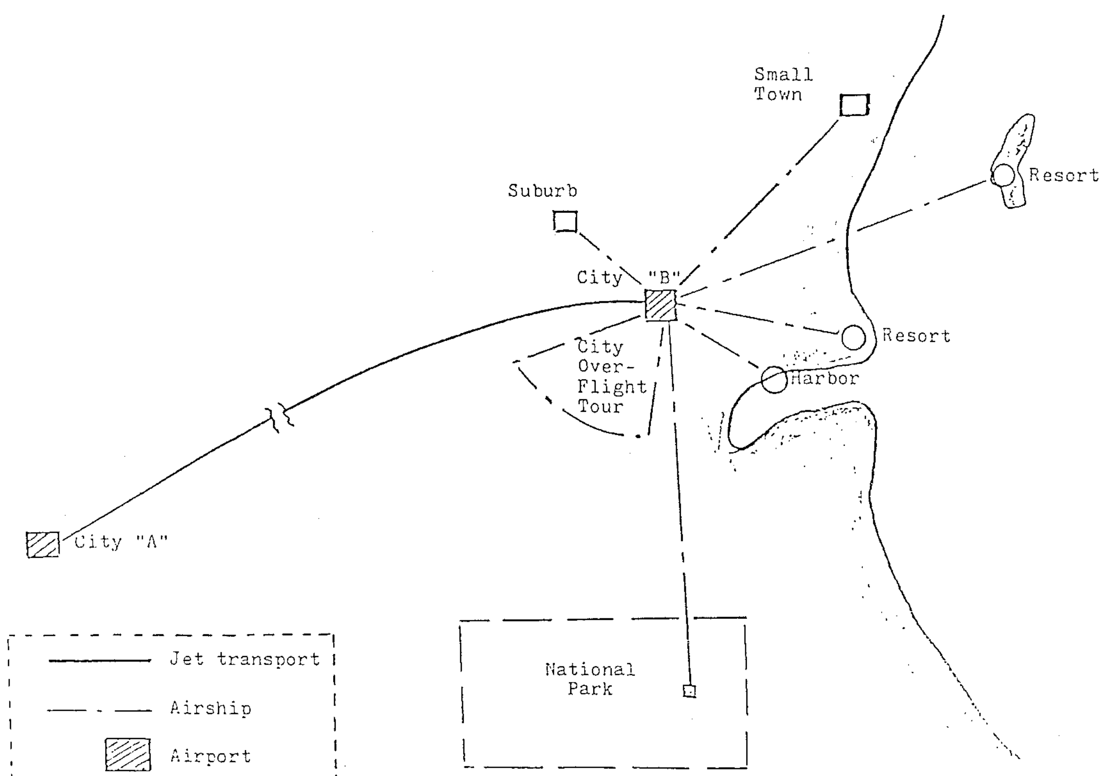

FIGURE 11. AIRLINES ROUTES AUGMENTATION BY AIRSHIPS

-INCREASED EMPLOYMENT: INDUSTRIAL SECTORS

-INCREASED EMPLOYMENT: SERVICES SECTORS

-EDUCATION ENHANCEMENT WITH ADVANCED TECHNOLOGY AIRSHIPS

-INCREASED NATIONAL GNP

-INCREASED TAX REVENUES TO GOVERNMENT

FIGURE 12. NATIONAL DEVELOPMENT WITH AIRSHIPS - ECONOMIC BENEFITS

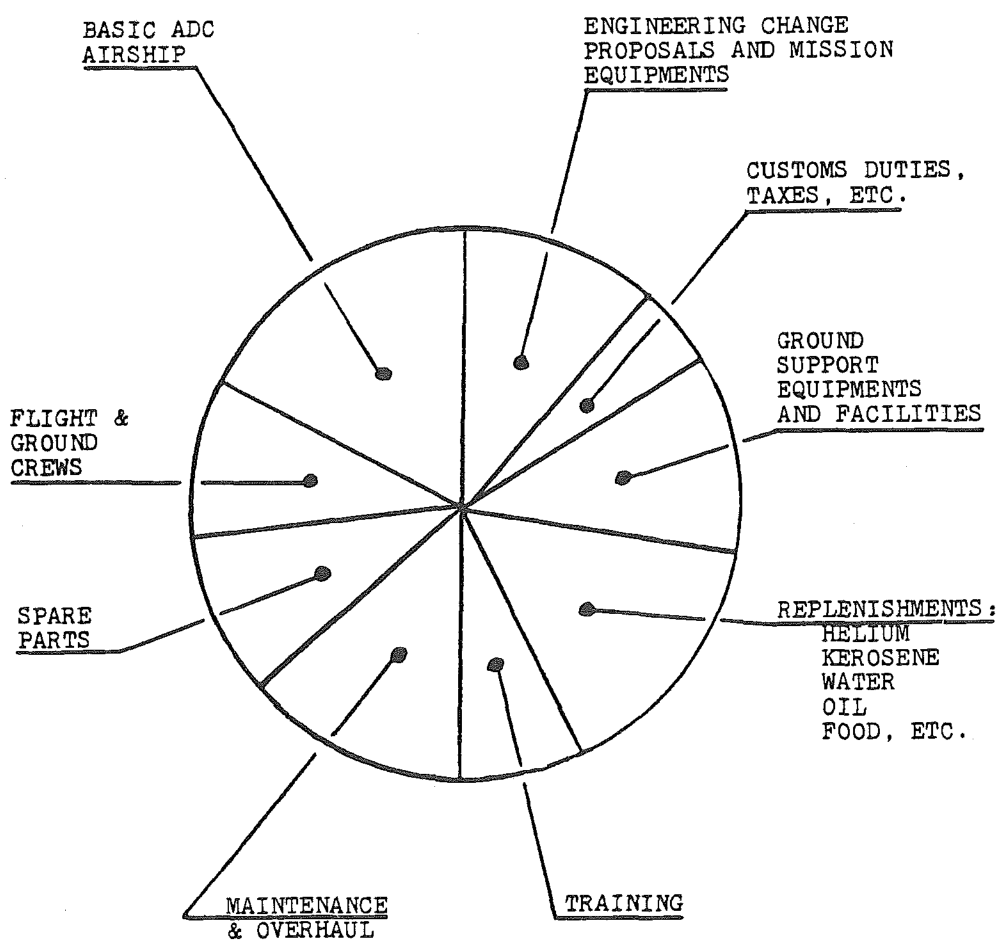

FIGURE 13. TOTAL OPERATING COSTS

NATIONAL INTER-RELATIONSHIPS

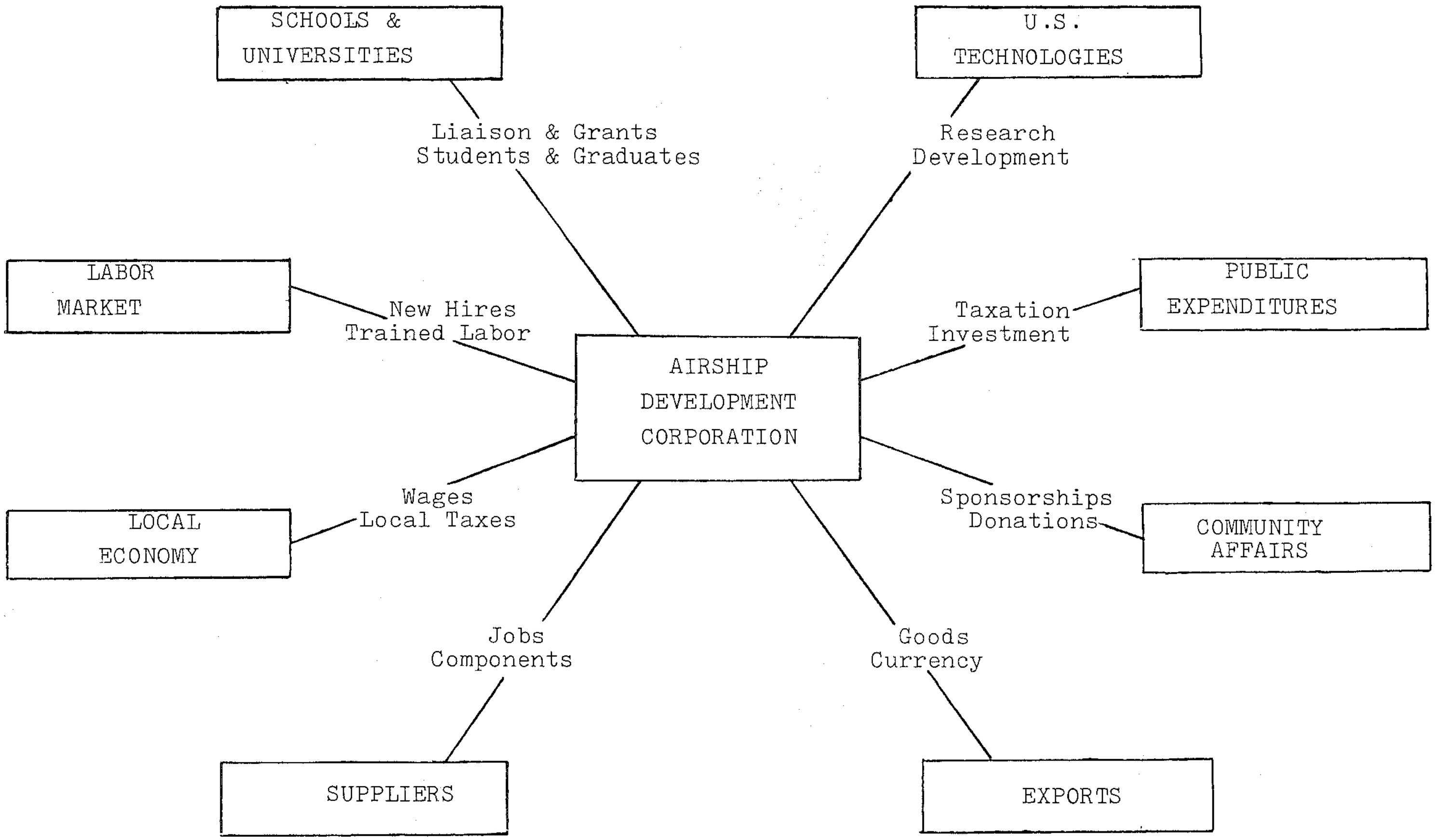

FIGURE 14. NATIONAL INTER-RELATIONSHIPS

DESIGN	OPERATIONS
Gas Turbine Engines	Non-inflammable Lifting Gas
Advanced Composites	Minimum Crew (Flight and Ground)
Aerodynamic Refinements	Low Operating Costs
Computer Aided Design & Structural Analysis.	Low Observables
Advanced Integrated Control Systems	Basing Alternatives: - Airfields - Open Land - Shipboard
Advanced Avionics	Take-off & Landing Options: - CTOL - VTOL - STOL - STOVL
Simplified Take-off & Landing System	Mooring Options
Retractable Landing Gear	Hovering/Loitering
FAA Airworthiness Certification	Long Endurance
Concurrent Engineering	Niche Missions
	Real Time Meteorological Data
	Low Noise Levels

FIGURE 15. AIRSHIP ATTRIBUTES

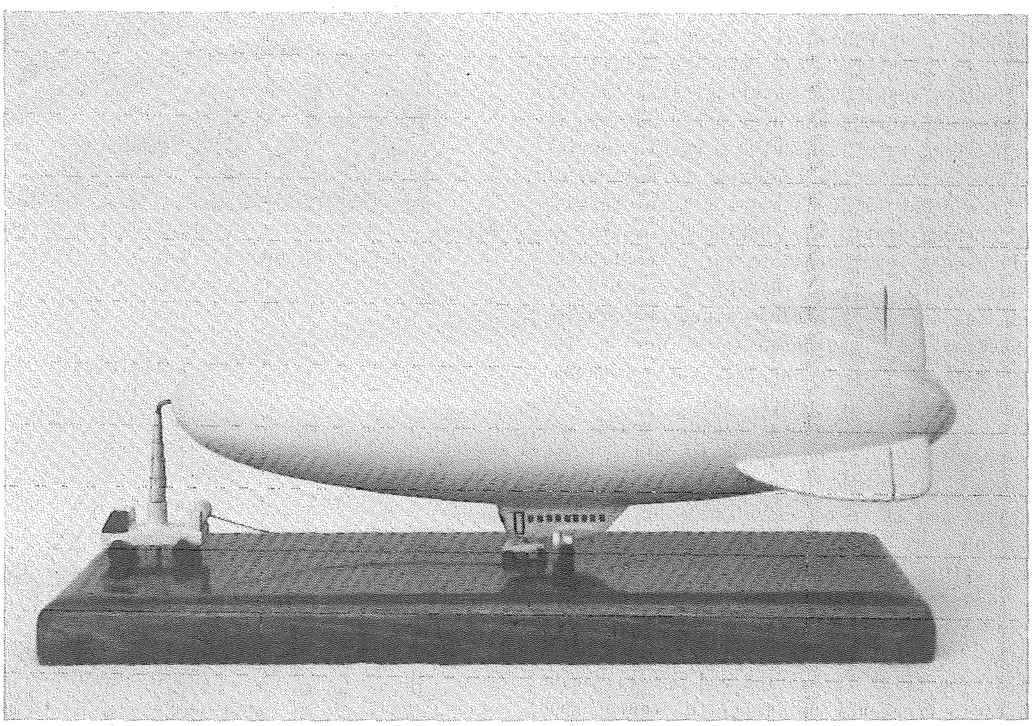

FIGURE 16. - ADC MODEL 533B