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OPERATIONAL CONSIDERATIONS FOR THE AIRSHIP IN SHORT-HAUL TRANSPORTATION

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ABSTRACT: This paper surveys the airship's problems and the possibilities for their solution in a short-haul transportation environment. The problems are derived from both past experience and envisioned operation. Problems relative to both fully buoyant and semi-buoyant configurations are considered and their origins in principle discussed. Also addressed in this paper are the state-of-the-art technologies with the potential of providing answers to the airship's operational difficulties.

The airship as a mode of short-haul transportation appears among the long list of potential applications for the modern operational vehicle. But there is, at present, no operational transport airship. The anticipated problems of operation, a necessary element of the concept evaluation for any new system, must then be based upon any pertinent past operation. This operational experience is, however, limited in its direct correlation to modern demands. It is limited not only in the scope of applications but also in time base (as compared to span of operations for Heavier Than Air) and level of technology. Virtually all inputs keyed to large rigid airships originated prior to 1939. Military and limited commercial (mainly advertising) experience continued to the early 1960's in the form of non-rigids. Only limited commercial application is on going. Current research and development is almost nonexistent.

So the present day planner, wishing to determine the applicability of a modern airship to the short-haul air transport market, must either ignore the labors of his technological forebearers and start from scratch or he can build on the past. He has the ability to survey, filter and assimilate the facts and figures of the airship's operational history. Determining the operations and the problems that are now relevant to a short-haul role, he can make swifter, less costly and less risky system design decisions. This paper will make a beginning in this direction.

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REQUIREMENTS OF THE MODERN AIRSHIP IN SHORT-HAUL TRANSPORTATION

Eventually, a set of criteria will be required to evaluate the engineering solutions of the airship's operational shortcomings. These criteria can be extrapolated from the general requirements of a short-haul system.[1, 2]

Requirements of Short-Haul Transportation

The general requirements of the short-haul system are no different than those of any large transport system: safety, convenience and comfort, comparable cost, and community benefit. From these general requirements, the technical requirements of a short-haul mode aircraft may be drawn. These are shown in Table 1.

Table 1
Technical Requirements of an Aircraft Short-Haul Mode

- Reliability at Least Equal to Fixed-Wing Aircraft
- Navigational and Flight Path Control Aids to Provide All Weather Operation
- Internal Noise Vibration, Sensitivity to Atmospheric Conditions at Levels Attractive to the Traveler/Shipper
- Competitive Payload Capacity
- Competitive Block Speed
- Accessible to the Traveler/Shipper
- Compatible with the Traveler/Shipper
- External Noise at Acceptable Levels
- Low Air Pollution
- Low Energy Consumption
- Minimize Utilization of Land and New Facilities

The short-haul aircraft will be operating over travel distances of up to 500 miles and in low, medium and high density markets.

OPERATIONAL PROBLEMS OF THE MODERN AIRSHIP

It can be assumed that in this operational environment the modern airship will encounter many of the same difficulties as its ancestors during the first third of this century. There will also be new problems spawned by market demand, institutions, and modern technology. The list of problems that follows contains those difficulties that appear to be most nearly associated with the short-haul operating mode.

Slow Speed Aerodynamic Control

This problem is not one peculiar to the airship. It is common to all aerodynamically controlled bodies. Basically it is the control surfaces' inability to provide an adequate resultant force due to lack of sufficient flow velocity. The upper threshold for loss of aerodynamic control is generally 15 mph. It was found that a kind of control reversal also occurs at these low speeds. This has been investigated and procedural remedies can be instituted.[3] This problem is particularly hazardous during landing maneuvers when positive control is required for mooring operations, as well as for the welfare of the ship itself.

Trim Control

The balance adjustment of an airship in flight has two inputs - aerodynamic and static.

Aerodynamic trimming is done by deflection of the elevators. Again, this is a common point for controlled aerodynamic bodies. But static trimming is more obvious in a buoyant vehicle. Static trim is accomplished by adjusting the center-of-gravity longitudinally. The medium of static trim adjustment has usually been ballast movement, ballonet inflation control, valving of lifting gas, or even shifting on-board personnel. Obviously, the principle is positional control of mass. Adequate control of static trim can effectively minimize the demand for aerodynamic trim.[4]

Buoyancy Control

This problem area can be basically described as the requirement to maintain a level of static lift. Control is a function of vehicle altitude and lifting medium temperature.

Gas Valving

The valving of lifting gas is intimately tied to buoyancy control. In fact, it is a means of control. Gas will be valved if the airship exceeds its pressure altitude and the gas cell or envelope is at maximum volume condition. There is the potential of a catastrophic failure of the envelope, so gas is released to reduce the pressure differential. Gas may be valved to control ascent and descent, although it is the most expensive and risky means.

Ballast Management

Again, this is a means of buoyancy control and also potentially a trim control technique. Ballast is mass and has consisted of such innocuous items as sand, lead, and water. The inefficient use of ballast (and gas valving) in flight can lead to a condition called "exhaustion" by the Germans. It is the condition of an airship that has lost its means of buoyancy (and possibly trim) control.

Manpower (Ground Crew)

The bulk of the airship required many personnel actively engaged in holding her down when the ship was not flying. Being a buoyant body, the airship was generally at the mercy of some of the elements and people were the most easy means of active control. Today, this kind of labor intensive activity is a problem.

Weathervaning

Another ground problem, weathervaning is actually a result of the vehicle being a buoyant body and subject to any sufficiently large disturbing motion of the surrounding medium - wind. With a streamlined configuration and airfoils aft, the airship continually tries to point into the wind. Mooring and ground handling equipment and operations must be adaptable accordingly.

Weather

Perhaps potentially the greatest problem, weather has many facets. Gusting near the ground may cause a vehicle/ground collision. Turbulence at altitude can produce structurally damaging shear forces. Thermals can produce an undesirably rocky ride-trim control problems. Precipitation and condensation provide buoyancy problems through mass accumulation on the vehicle's surface and possible cooling of the lifting gas, reducing displacement. Temperature variations result in changes of lifting gas and thus affect buoyancy. The control surfaces can easily be jammed if ice is allowed to accumulate. This problem is common to all aircraft. Loss of visibility is not as great a problem for an airship as it is for a heavier than aircraft because an airship can reduce its velocity to zero in obstacle avoidance without loosing lift. It will be more of a danger in congested airspaces. Lightning strikes are not a great problem because even a large puncture of the gas container doesn't mean a catastrophic loss of lift. And the use of helium, rather than hydrogen as the lifting gas, means that combustion is negated.

Human Error

This problem is all pervasive and, as long as man remains in the operational system, this problem area will, to some degree, be present.

Air Traffic Control

This heading refers to a catagory of problems derived from the interaction of air vehicles within a limited volume of airspace. An air transport system brings these problems of congestion upon the airship.

Useful-Load Transfer

The transfer of payload to or from the airship, both on the ground and hovering, is seen as presenting some tough engineering and procedural problems. Problems of positive load positioning, vehicle control, and buoyancy control are foremost in this new area.

Landing Impact Control

Because airships were originally constructed of girder and wire frames overlayed with fabric skins, any impacting contact with the earth could cause structural damage. Impact loading would still be a problem with rigid structures of this type.

Interface With Ground Handling/Support Equipment

Problems of equipment/systems interfacing will become a larger concern when the design complexity of the airship escalates to meet the problems touched on previously. Both active and passive ground support will be important to a moored or docked airship.

POSSIBLE TECHNOLOGICAL APPROACHES

All of the previously descussed problem areas must be evaluated to determine their basic nature. Only then can effective, detailed approaches to solving the problem be programmed. In the paragraphs to follow, however, a start is made at isolating state-of-the-art concepts and techniques that may be able to evolve solutions.

Vectored/Lift Thrust

Producing vectored thrust by swiveling propulsors and by reversing propellors is possible. Both methods are either in operation today or in the prototype stage.[5] Another approach that is in operation is the use of the directed thrust jet of a turbine engine; an application of blown flap technology.

Improved Control Surface Response

Several current control systems appear to be applicable. Control Augmentation System, fly-by-wire, and Active Control Technology would provide an attractive coupling of digital/electrical/hydraulic/mechanical systems for the increasingly complex control requirements of the modern airship.[6, 7] Boundary Layer Control would go far toward solving the principle cause of surface control loss.

Improved Static Trim

The approach to improving static trimming may be the positional control of mass in the form of a liquid. Aircraft are currently utilizing on-board fuel for this purpose by controlling its location in the fuel tanks. Additionally, the concept of a semi-buoyant airship would provide mass for an inertial keel that is inherently trim stabilizing.

Thermodynamic Lifting Gas Management

Suggestions for artificial means of super heating the lifting gas to increase lift on one hand and cool, compress or liquify the gas to decrease lift on the other, have obvious merit. The means of compression and liquification may prove too massive, however.

Mechanical/Thermal Icing Prevention

Proven means of applying thermal energy to aerodynamic surfaces to prevent icing are available. The heat produced by a thermodynamic gas management system would also prove helpful. Hydraulic and mechanical means of releasing the ice are practical.

Increased Speed Capability

This improvement has many benefits including economic competitiveness and weather avoidance. It may be accomplished by use of laminar flow control to reduce drag, better aerodynamic design, and turboprop/turbofan propulsors.

Avionics

The wide range of systems available and programmed can provide aids to solve the weather and air traffic control problems. Instrument Landing System and Area Navigation are two systems in existance. Micro-wave landing and discrete-address beacon systems are projected aids of importance. Weather forecasting provided to the systems user will go far to assist the operational airship.

Improved Flight Crew Training

Simulators, currently an indispensible part of flight crew training should improve the airships' efficiency and safety.

Ground Handling/Material Handling Equipment

In a competitive transport market, the airship cannot ignore the existing containerized/bulk cargo handling systems. In addition, consideration to adapting conventional general purpose equipment such as vans and flat-bed trucks should be given. This could assist in opening new markets.

Improved Mooring Methods

The problems of mooring and handling airships will not soon be gone. But innovative devices such as turntables for mooring and direct mooring to the airship's undercarriage structure could ease them.

Further study and clarification of the semi-buoyant lift concept may in itself prove the most important solution to the modern airship's problems. The successful adaptation of the safest form of air travel with the best understood and utilized form could mean a more efficient complete transportation system.

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