THE APPLICATION OF THE AIRSHIP TO REGIONS LACKING IN TRANSPORT INFRASTRUCTURE

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ABSTRACT: This paper considers the requirements for two areas of airship application. The first of these are those countries where there is a need to move consignments that are too large for the existing transport systems, and secondly those regions where ground characteristics have resulted in an area totally devoid of transport. The needs of the second group are considered in detail since they also require transport to provide social as well as economic growth. With this problem in mind, a philosophy is put forward for using airships in conjunction with LASH vessels. A specimen design is outlined and the initial costs estimated.

Introduction

In order to justify the future development of the airship, it is necessary to first identify those areas of application where it can provide transport facilities far superior to any other transport option. In an attempt to identify these areas, a number of operational situations have been considered. The most promising result of this study was the unique advantage displayed by the airship in its ability to provide transport facilities in those regions presently lacking in transport infrastructure, the results of which are summarised in this paper.

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Identifying Areas of Need

In studying the present distribution of surface transport facilities it becomes apparent that although existing transport technology provides an effective coverage for most of the worlds land masses there are two major areas where present transport technology is seen to be inadequate:

1) those countries where increased industrial development is demanding the ability to transport units so large that existing transport infrastructure is unable to cope.

and 2) certain discrete land areas almost totally devoid of any form of inland transport.

The first of these is a simple limitation of existing transport systems, and its implications are covered far more adequately by Stephen Keating in a later paper of this session. The second area of need is seen however as a complete inadequacy in our present technology, and it is with this area that this paper is primarily concerned, although in producing an airship design the needs of both markets will be considered.

The Implications of Inadequate Technology

The reason for the total lack of inland transport facilities in the regions outlined above is easily identified as the adverse terrain that exists within them. The legacy of this problem is a situation that has extensive ramifications upon the economic and social health of the regions involved. The lack of transport infrastructure makes it impossible for both the commercial agricultural and the industrial activity of the hinterland (mainly agrarian) to expand and develop. This prevents these regions improving their production from the land, and therefore constrains one of their major assets. Furthermore the lack of communication retards the growth of other industries into the hinterland, added to which the lack of transport infrastructure itself removes a major source of industry. For developing countries, that is, the provision of the facilities themselves.

This situation leaves those responsible for these regions in a frustrated position; the ability to transport goods is a primary requirement of any economy and many of the regions involved are rich in natural resources, presently in high demand in the world market an attribute they are eager to exploit.

The exploitation of these resources in the past has been hindered by the expense of actually providing the transport facilities necessary to extract them from within their adverse terrain. This situation is however changing rapidly; the increased demand for these resources has led to a major price escalation, which may justify the economic development of the hinterland. This has encouraged a radical reappraisal of available transport technologies, the results of which have included the use of helicopters for logging in Canada and proposals for many strange conventional aircraft for carrying oil out of Alaska. These extremes of technological application serve as perfect examples of the inadequacy of our existing transport technology, both conventional air and ground modes being unable to meet the full demands of the market.

Market Requirements

The transport needs of the regions discussed appear to be ideally met by the airship. It has been shown to provide a high capacity, low cost operation, totally independent of the surface conditions, although the topography of the region can give rise to economic constraints. Before it is proposed as the complete solution, however, the total implication of its application must be considered.

The Transport Needs of these Regions

The introduction of transport infrastructure is more than a simple ability to transfer goods. A developing country must not only consider the industry that is being served but also the industry generated by the operation and implementation of the system. With a ground based system there is probably as much economic advantage from the employment of those actually building the road or laying the track, as there is from the growth introduced by the ability of existing industries to transport their goods over a wider area.

With an airborne system this advantage is lost and it may be further aggravated where the country in question has to depend upon technical back-up from other countries due to the technological complexity of the vehicle. A situation like this could lead to a balance of payments situation that stifles rather than stimulates economic growth.

A developing country must therefore adopt a system that has a low foreign participation and foreign exchange component, thus dictating a system based upon conventional technology with very little need for specialist servicing or repair back-up. As it also has to operate is sparsely populated areas well away from centralised technical facilities, its construction should be such that it can sustain minor damage and still operate, or be easily repairable by the flight crew. What is in fact required is a standard "work horse" which can be simply flown and operated.

This is also likely to be the requirement for the first group outlined, (i.e. those requiring to transfer large unit loads), and the ideal "work horse" should cater for both of these markets.

For different reasons, both "user" groups outlined require a system that is based upon a minimum investment in ground facilities. This is consistent with a further requirement, that the system should be flexible in operation, and should not therefore depend upon specialised ground equipment, but use facilities readily available at present.

All of these points help to reduce the investment risk and make it possible to transfer the operation if it becomes justifiable to introduce alternative systems once the market is developed.

Design Philosophy

In terms of size, the requirements of the unit load sector of the market is an airship with a payload capacity at least in excess of several hundred tons. Those areas developing a transport infrastructure, however, will require a range of airship designs, with payloads from 20 tons upto several hundred tons.

Bearing the requirements of both groups in mind and attempting to produce a design that would interest both of the user groups, a large payload airship has been considered. The specimen design chosen has a useful lift capacity of 1000 tons. This provides a unit lift capacity for superior to any other option available for transport across difficult terrain whilst, for the general goods market for the areas discussed, it provides an acceptable commodity flow. The major attribute of this size of vehicle however is that, for the general commodity market, it is capable of carrying one of the large LASH barges. This allows the development of a total transport system with attributes well beyond any system yet available, a facility that will be discussed later.

Vehicle Design - The design of the hull is a key area in any airship project, but more so when considering operation in adverse terrain many miles from the nearest technical back-up. Past studies have normally proposed rigid shells which, if damaged, would require a highly competent technical back-up and extensive engineering facilities.

In an attempt to avoid this problem, Cranfield have been studying designs based on a fabric outer shell with a concentrated load bearing structure within it (ref 1). With this type of design, the shell is more easily replaced and repaired than with conventional rigid structures, and the central structure is far more substantial in proportion to its size and is therefore more easily constructed and handled. Both of these attributes provide a structure that can be easily handled by personnel with very little specialist training. A similar philosophy has been adopted in selecting the other systems (i.e. low technology engines and control systems).

Cargo Handling - Because of the difficult terrain in the regions being considered, the loading of the cargo must be undertaken as quickly as possible. For this reason it is far more efficient if the payload can be loaded as a single unit, with the airship hovering above the area. This does present design problems, but these can be easily catered for at the design stage, and would simplify all future operation.

Although it has been suggested that the loading of the airship is undertaken with a single unit, it is assumed that the container will be loaded with smaller units, the size of which will be matched to the market requirements. This provides a great deal of flexibility to the operation, as it means that the larger unit can be loaded with anything from trucks to plastic bags, a facility that should prove useful to this type of operation.

The development of the primary container could be undertaken very simply, if necessary. There is however, a standard container available that has a capacity of 850 tons. This has been developed by a shipping company as a barge for use on "lighter aboard ship" (LASH) operations. The further flexibility introduced by using a barge adds an extra dimension to the operation, by reducing the trip end facilities required. The reduced specialised equipment required for filling the container has already been mentioned, the container being able to accept any form of payload from the origin. At the outer end of the trip however, the barge can be placed in any piece of sheltered water and left for collection by tugs or a LASH vessel.

Terminal Facilities

Facilities at Origin - As the origins are expected to be located in rugged terrain, and the airship is at its highest risk when operating close to the ground, the loading manouvre must be undertaken as quickly as possible. For this reason the operation at the origin will be restricted to the loading of the payload and the discharge of any return load or ballast. The loading of fuel and replacement parts for the airship being undertaken at the outer end of the trip, where the terrain will be more amenable to long stays.

Because of its susceptibility to terrain it may be necessary to position the loading area away from the origin. It is estimated that the loading area should be chosen such that within the area of 2 miles by 1 mile a central area of a ½ mile radius does not have any variations greater than 10' in the centre rising to 1,000' at the outer boundary, and for the area between the ½ mile boundary and the outer limits the terrain should not vary much more than 2,000' in general, although odd peaks greater than this could be acceptable. The layout of the area will also depend upon the direction of the prevailing wind. An assessment of the total implications of this can only be undertaken in a complete feasibility analysis, but a preliminary study has shown that this is possible, although not always adjacent to the true origin of the goods.

The general philosophy will be to keep the equipment required at the inland end of the flight to a minimum, and hence reduce the "off vehicle" capital costs. This can only be introduced to a certain extent as the problems are difficult, and although the use of hovering and single load units will simplify this, special equipment will be necessary. The major problem is the quick loading of the containers and the removal of the returned unit. Fine manoeuvering of the airship to place and pick up a container from a specific point is very unlikely. This gives two options.

a) Design the large container to be moved quickly to and from the airship

b) Leave the container on the airship and unload and reload quickly

Both of these are technically feasible and would rely most probably on using an air cushion under either the whole container or cargo pallets. This keeps the equipment down to a minimum and will require very little specialised handling equipment, the facility requiring no more than standard agricultural vehicles. In addition to this a tank for holding standby ballast will also be required, with a capacity of approximately 250,000 gallons.

Facilities at Destination - The use of a barge as the container means that the airship can unload in sheltered water. This provides an ideal modal interchange; the payload either being taken ashore from the barge or being transferred directly to a ship for export. In addition to the interchange advantages the use of a sea-based terminal has many further advantages, i.e.

i) Sea water ballast

ii) Level terrain

iii) Space to allow a certain amount of drift

iv) Ample space for storage of barges close to shore, whilst waiting for shipping out

v) No specialised equipment required

vi) No investment for storage or terminal area.

The ballasting will be discussed later in the report but the ready available ability of water must not be ignored. By far the greatest attribute of the sea terminal is the unobstructed space and the flexibility of the location. The unobstructed space can allow more time to be spent at the terminal for repairs, refuelling and crew replacement, without a high risk. At the destination the only equipment needed will be a tug boat together with the exchange barge. This implies a very low capital investment, a facility that is only available with this type of system.

Ballasting System

For this type of operation the use of sea water ballast would seem logical. Fresh water may have advantages in certain areas but it does not provide the control advantage offered by a sea water system unless available in large quantities (i.e. lakes, etc). The ballasting system developed for this study plays a dual role of both stabilising the airship whilst moored and supplying the necessary ballast for flight.

The technique consists of suspending water carriers under the airship, which in a balanced situation would be half immersed in the sea. Any deviation from a balanced situation would either decrease the load on the airship by lowering the carrier into the water or vice versa. This means that the force which caused the airship to move is balanced by the automatic removal or addition of ballast, returning the airship to a balanced position. When ready for flight, ballast is discharged until the carriers leave the water and the airship is in equilibrium.

At the inland end of the trip a storage tank of standby ballast would be required to hold the airship during loading and unloading.

Discussion of Cargo Handling System

The cargo handling system that has been outlined is based on a low "off vehicle" capital investment and a high flexibility in types of application. This then makes it ideal for supplementing existing systems on an ad hoc basis, as special requirements occur; and also as an exploratory vehicle for serving new mines, oilfields etc until output justifies the investment in ground based systems. Apart from the specialised handling equipment no special equipment is required at the loading site, and the destination demands no more than standard port equipment. A further attribute is their implications on the project cash flow, as the whole system can be written off over a large network of operations. The characteristics of the cargo handling system also make it generally applicable to many types of market giving the airship resale and charter value, an attribute not available from many transport modes.

Implication of Cargo Handling System on Airship Design

The major penalty imposed by the cargo handling system outlined is the effect of the concentrated load applied to the structure. To cope with this, it would require extra structure within the hull to distribute the forces. The weight penalty would be small, but has been catered for in the design.

To prevent further weight penalties the ballasting system will be distributed in small units along the structure, and therefore reduce further load concentration problems.

Design of the Airship

To produce the design, a computer technique was adopted. This consisted of a parametric model, based on the latest design information, and a simple cash flow optimisation technique. The results of the study is given in Table 1.

LIFT AT 100% INFLATION	2,300 TONS
NORMAL LIFT	1,920 TONS
PAYLOAD	850 TONS + 150 TON CONTAINER
RANGE	1,000 MILES
FLIGHT ALTITUDE	6,000 FEET
VOLUME	83,000,000 FT^3
LENGTH	1,700 FEET
L/D	6
CRUISE SPEED	109 KNOTS
MAXIMUM SPEED	120 KNOTS
INSTALLED POWER	75,000 HP
PAYLOAD/NORMAL LIFT	46%

TABLE 1 TECHNICAL DETAILS

Cost Analysis

The estimated cost breakdown of the projects are given in Table 2. In producing these figures, the following assumptions were made:

Write off period	10 years
Interest on capital invested	20% per annum
Return load	75% possible payload

Maintenance	4% of first cost/annum
Insurance	1% of first cost/annum
Crew Costs	£140,000 per annum

The first cost can be further broken down into:

15% R & D wages and salaries

16% production wages and salaries

10% other wages and salaries

24% other overhead costs

35% purchased materials and components (inc. gas and engines)

These costs are structured to include a portion of an initial R & D investment of £100 million, assumed to be written off over forty large airships. This is assumed to be based on a consortium agreement and will be used for all initial R & D and the production of two test vehicles.

First Cost	£M 21
Annual Cost	£M 6.4
Fuel Cost/Year	£M 6.0
Total Cost/Year	£M 12.4
Cost/Ton.Mile Available	£ .038*
Break even Cost/Ton.Mile	£ .044**

TABLE 2 COST DETAILS

* Assumes 100% return load

** Assumes 75% return load

These costs represent a 1000 mile range airship. An operating cost of £.042/TON MILE AVAILABLE is extremely competative in a normal situation; in regions that are biased against ground modes it is likely to be far cheaper than any other option available. A more generalised cost curve showing the variation of operating cost with range is given in figure 1. It can be clearly seen that even on the short ranges the economics of the airship are attractive.

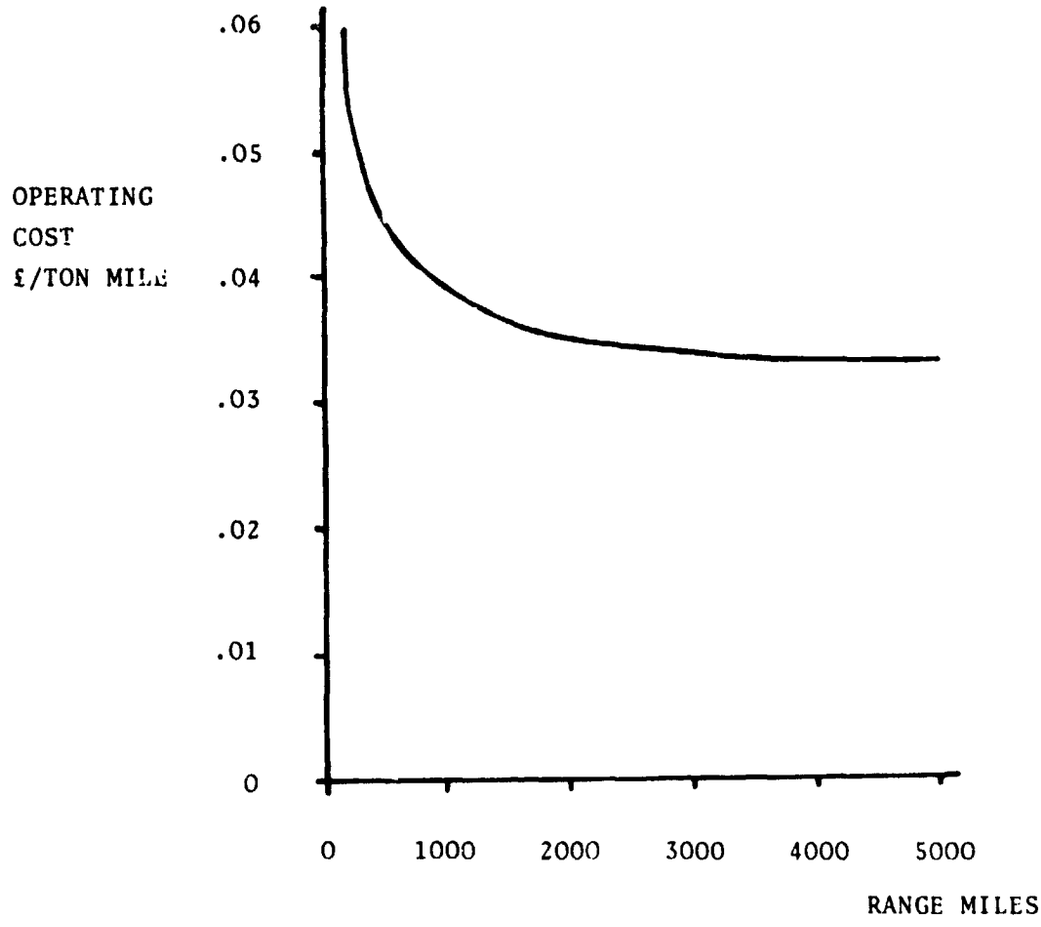

FIGURE 1 - VARIATION OF OPERATING COST WITH RANGE

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MILITARY APPLICATIONS OF RIGID AIRSHIPS

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ABSTRACT: The objective of this paper is to examine military roles and missions for which the rigid airship appears to be suited, and to suggest specific applications that the airship could potentially perform in an effective manner. Principal missions examined are the movement of military cargo and the surveillance aspects of the sea control mission.

MOVEMENT OF MILITARY CARGO

Probably the most general application of large rigid airships in military employment lies in its capabilities as a cargo carrier or troop transport. The unique capabilities of a rigid airship to haul commercial cargo and passengers is presented in some detail in other sessions. The use of an airship as a military transport requires only a few additional considerations. These include the ability to operate from relatively unprepared sites, the requirement for some structural alterations to the airship hull to permit hauling of military cargo, and provision for some degree of self-defense capability.

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The ability to deliver large quantities of cargo and troops into remote areas with little or no ground support equipment is an extremely important military asset. Such a capability would permit a rapid response to emergency military needs of a brush-fire nature. It would also provide a new dimension in the flexibility with which military forces could be redeployed as the operational or political situation warranted. In areas in which no ground support equipment was available, advantage would be taken of the airship's capability to hover at low altitude, perhaps 100 to 300 feet. Cargo or troops would then be lowered to the ground on pallets or specially designed containers by winches contained in the airship's cargo holds. No runway or prepared area would be required for this operation.

If it appears likely that continued re-supply operations into the same area would be carried on, it might be desirable to erect an expeditionary mast to which the airship could be moored for loading and unloading and for servicing. Such a mooring mast could be carried aboard the airship itself and lowered to the ground as part of the initial cargo. It would be necessary that the site selected for the mast be cleared of obstructions in all directions to a distance at least equal to the length of the airship in order to permit the ship to weather-vane when moored to the mast. Thus, additional equipment might be required for site preparation and for mechanical handling of the airship. The U.S. Navy developed such an expeditionary mast for use with its blimp fleet. It was air transportable and could be erected for use within 8 hours.

Another means of accomplishing moored logistic operations in forward areas would be to use a ship equipped with a suitable mooring mast. The U.S. Navy successfully developed this technique for use with its large rigid airships. This type of operation would, of course, require an adequately protected anchorage area in the vicinity of the beach and lighterage or small craft to form the link between airship and beach.

Another mode in which the rigid airship could be used in military logistics would be to employ V/STOL aircraft capable of launching from and being recovered by the airship. This would permit the airship to maintain a stand-off distance from hotly contested battle areas. In this case site preparation would be a function of the landing and take-off characteristics of the V/STOL aircraft being employed as the cargo hauler.

VULNERABILITY CONSIDERATIONS

The use of rigid airships in the proximity of battle areas brings up the question of vulnerability of these large vehicles. This has always been a foremost argument against the military use of airships, both rigid and non-rigid. It should be remembered, however, that the military rigid airship evolved during World War I as a bombing platform designed to operate against formidable opposition—and at that time the lifting gas used was highly flammable hydrogen! The airship eventually lost the battle to become a first-line bomber or dreadnought of the skies, and has never since been considered seriously as a combat vehicle. Current technology has not reversed this decision but has contributed to the improvement in expected survivability when the airship is used in military support roles such as cargo transport or in other possible missions to be suggested.

From a technical aspect the large rigid airship could probably sustain hits from a number of air-to-air missiles or surface-to-air missiles without serious consequences. In this respect it is much more survivable than a C-5A, for example, where a single missile hit would normally be catastrophic. Damage control is feasible in a rigid airship since all of the structure and the gas cells are accessible to repair parties during flight. Even more important is the fact that the airship can be equipped with a very credible self-defense capability. This could consist of early warning and fire control radar, anti-air and anti-missile missiles, ESM equipment and a variety of electronic countermeasures suitable to the threat. In spite of this capability to sustain damage, to conduct in-flight repair and to provide for its own self-defense, prudent military operation would not permit the airship to be used in situations that were beyond its limited combat capabilities. In short, the answer to achieving acceptable levels of survivability lies in employing the airship in missions for which it is particularly suited, and in tactical environments for which it has been designed. In this regard the vulnerability aspects of a rigid airship are no different than a C-5A, a B-52 bomber, a CVA aircraft carrier or a large surface troop transport. Each of these vehicles must be operated in a tactical environment for which it has been designed if an acceptable level of survivability is to be attained.

NAVAL APPLICATIONS

Aside from its role as a cargo carrier and troop transport, the military applications of the large rigid airship seem most appropriate to the missions of the Navy. The over-water (and over-ice) environment has traditionally been most suitable for airship operations. It should also be noted that the airship is basically a low altitude vehicle. It can be operated most efficiently at altitudes below 10,000 feet. These inherent characteristics cause the military roles of the rigid airship to gravitate toward the recognized Navy missions. However, before examining potential specific military applications of the rigid airship, it is useful to note the change that is presently occurring in the major missions of the U.S. Navy.

Since World War II a primary mission of the Navy was perceived as the capability to project power ashore. To accomplish this mission required the ability to conduct a number of sub-missions: sortie and protect forces in transit to a forward objective area; establish air superiority and submarine defense in the forward area; provide air defense and strike support to amphibious forces as required; and conduct strikes against designated enemy sea and land targets. The essential combatant in this power projection mission was the large attack aircraft carrier.

In the last few years the Navy has gradually backed away from the power projection mission as its primary task. This has been evidenced by a significant reduction in its inventory of active aircraft carriers; development of the CV concept, a new operational technique that permits a single carrier to be equipped with a mixed complement of both attack and anti-submarine aircraft; and evolution of the sea control ship, a small ship that would initially be outfitted with ASW helicopters and V STOL attack aircraft of the Harrier-type, but would eventually provide the optimum merger of high speed advanced ship concepts with high performance V STOL ASW and attack aircraft. This evolving new mission has in fact been termed the sea control mission. It is perceived as the capability to gain control of the sea in any designated area of the world, including the surface, air and sub-surface domains, and to deny the use

of such an area to enemy forces. The sea control mission would be concerned primarily with protection of sea lines of communication but residual capability would exist to perform all of the traditional Navy missions including power projection ashore. The strategic missions of the Navy, involving employment of the Polaris/Poseidon fleet ballistic missile force (and the follow-on TRIDENT) would remain essentially unchanged.

The evolving emphasis on the mission of sea control requires, as a prime necessity, the capability to conduct surveillance of wide areas of the open ocean. This capability must include surveillance of the ocean surface, the air (and perhaps space), and the sub-surface if the entire threat spectrum is to be covered. It is in this role of ocean surveillance that the large rigid airship is best suited and in which its military effectiveness might be best applied. Let us look at the possible roles in which the rigid airship might be employed in each of the surveillance domains.

SURFACE SURVEILLANCE MISSION

Surface surveillance is a relatively straightforward task requiring that detection of all surface targets entering a specified ocean area. It has become increasingly important, however, as the size and military effectiveness of Soviet surface forces continues to grow at a geometric rate. The large rigid airship is ideally suited to conduct surface surveillance because of its size and shape. Using the immense sides of the airship, a phased array radar could be designed of unprecedented power and performance capability. This would permit the airship to maintain surface surveillance over extremely large ocean areas. The airship might also be used as a platform for surface surveillance sensors other than conventional radar as the tactical situation might warrant. Such sensors include IR, ESM, HF/DF and over-the-horizon radar.

The effectiveness of the airship's surface surveillance capability might be further enhanced if suitable classification or intelligence of detected targets is available. This would permit the airship to assume an offensive role by firing air-to-surface missiles at targets identified as unfriendly. Alternatively, the airship might launch its own aircraft to classify and attack detected targets. The use of aircraft might also be considered when the tactical situation indicates that the use of the airship's high powered surveillance radar would not be prudent due to the high threat level. In this case the airship would assume a condition of electromagnetic emission control (EMCON), and aircraft would be launched to conduct surveillance of the assigned area. In this situation the airship would still function as an airborne command and control post to receive and assess the surveillance information as it is transmitted from its aircraft. The parallel to surface aircraft carrier operations is obvious.

AIR SURVEILLANCE MISSION

The air surveillance task is similar in many respects to surface surveillance. Again it is the capability of the airship to act as a platform for very high performance radar (and other sensors) that makes it so well suited for the job. Against manned enemy aircraft the rigid airship might also be used as an offensive weapon system in addition to its surveillance role. Air-to-air missiles could be launched against detected targets at stand-off ranges approaching the detection range of the radar. Or interceptor aircraft might be launched and vectored to conduct the kill with their own air-to-air missiles.

If friendly surface forces are operating in the ocean area of interest, it is extremely important that the enemy be thwarted in any attempt to conduct air reconnaissance in the area. This denial of targeting intelligence can result in significant improvement in survival probability of the friendly surface forces. It stems from the fact that the effectiveness of stand-off surface-to-surface missiles is degraded when uncertainty exists about the location, composition and disposition of potential targets. This situation is emphasized also by the operational mode required of the Soviet cruise missile submarines of the JULIETTE and ECHO-II class. They would normally receive their targeting information from specially configured reconnaissance aircraft. If this information is denied, then they must close to acoustic detection range and their classification and targeting problem is much more difficult.

In this regard, the airship can provide a multiple capability against the cruise missile submarine threat. This threat is probably the most formidable one facing our surface naval forces (as well as our non-military convoys). The airship offers a capability to accomplish underwater detection of the submarine, and this is discussed further in regard to sub-surface surveillance. It also can contribute to the denial of targeting intelligence to enemy reconnaissance efforts. Additionally, the air surveillance capability of the rigid airship permits it to detect the cruise missile after it has been launched. This allows early warning of an attack to be given to the threatened forces and alerting of their area and point defense units. The airship might also take an active part in defense against the cruise missile by launching appropriate intercepting missiles, or vectoring CAP aircraft to an intercept position. Electronic warfare measures could also be directed against the cruise missile from the airship platform.

The air surveillance capabilities of the rigid airship could also play a vital strategic role. In this mission the airship would provide early warning of manned bomber attack in the same manner that Navy and Air Force radar pickets were used for many years. In fact, the last squadron of Navy non-rigid airships (ZPG-3W) were designed to perform this mission. The rigid airship would be vastly superior to both the blimps and the fixed wing aircraft due to its much longer endurance and improved radar performance.

The rigid airship would also provide a means for detection and early warning of ballistic missiles fired from submarines. This threat has become increasingly more important as the Soviets continue to construct and deploy their second-generation YANKEE class submarines. The YANKEE has 16 ballistic missiles with an estimated range of about 1500 nmi.[1] Employment of a depressed flight trajectory provides very little early warning time to CONUS defensive forces. The air surveillance capability of the rigid airship would provide for a significant improvement in available early warning time. Further, if the airship can also conduct suitable sub-surface surveillance, it provides a platform for launching counter-weapons against both the firing submarine and the missiles during their boost phase. The ballistic missile is most vulnerable to attack during the boost phase where its speed is low, exo-atmospheric conditions do not apply, and a large IR signature is available to an intercepting weapon.

It would also be feasible to design a rigid airship todetect submarine launched ballistic missiles in their mid-course trajectory, and to launch suitable interceptor missiles. This would be similar to the Navy's SABMIS ship concept, now dormant, but with significantly improved operational flexibility and survivability.

UNDERWATER SURVEILLANCE MISSION

Underwater surveillance is the third domain in which the rigid airship could contribute to accomplishment of the sea control mission. In this role the airship could be employed in several ways. It could be used to emplace and monitor large fields of moored sonar buoys in specific ocean areas where it is desired to establish a high level of underwater surveillance. Such sonar buoys would be similar to the Navy's Moored Surveillance System (MSS) currently in the developmental stage. The airship would monitor the buoy fields, classify and correlate detections and vector ASW forces to accomplish localization and attack against threat submarines. These ASW support forces might take the form of ASW aircraft operated from the airship itself. The airship would be capable of recovering and replacing surveillance buoys that fail, are damaged or drift from their desired position. Maintenance facilities could be carried aboard the airship. An entire surveillance buoy field might be recovered and redeployed as the situation warranted.

The rigid airship might be operated entirely as an ASW aircraft carrier (CVS) in order to accomplish the underwater surveillance role. In this mode the ASW aircraft would employ their own surveillance sensors in open ocean search. The airship would launch and recover the aircraft, provide facilities for maintenance and stores, and function as the command and control center for the search, localization and attack operations. As previously noted, the dedicated ASW aircraft carrier has been replaced in the Navy by the CV concept in which a mixed complement of ASW and attack aircraft must be carried. The rigid airship ASW aircraft carrier could provide a means of returning to a single mission ASW carrier, and without the need for accompanying destroyers or underway replenishment groups. It would again provide the Navy with a capability to conduct offensive ASW operations in the open ocean as opposed to the basically defensive posture associated with the CV concept. This hunter-killer type of operation proved to be very effective in the attrition of German submarines during World War II.

Another mode in which the rigid airship could be employed for underwater surveillance would be as a platform to tow horizontal linear passive sonar arrays. Such arrays could be designed with an extremely large aperture, essentially to the limits of the environment. Improved performance would result further from the fact that the interfering radiated noise of the towing ship would be eliminated. The resulting performance characteristics in terms of sweep rate should greatly exceed any other type of available platform-passive sonar system. The airship, once again, could carry its own ASW aircraft to localize and attack detections that are made, or it could vector other ASW forces to the scene.

The use of towed array systems with rigid airships seems especially suited to the task of maintaining surveillance on Soviet ballistic missile submarines. Coupling this capability with a boost phase intercept system, as indicated above in the discussion of air surveillance applications, would result in a particularly effective employment of the rigid airship's attributes.

COMMAND AND CONTROL MISSION

A final possible employment of rigid airships seems worthy of note. In all of the possible roles mentioned above to support the sea control mission, a single task always seems to emerge: the necessity for an adequate command and control system. The airship appears to be eminently suited to perform command and control tasks, either in conjunction with a specific surveillance role, or as an airborne mobile command and control post. In this latter task the airship would serve as the central command post and the operational control center for a designated sector of open ocean. The airship is large enough to house the most sophisticated communication equipment, computers and ancillary software, analysis and display equipment suitable for a major fleet command. The mobility of the airship would permit the area commander to remain literally "on top" of the situation in his assigned sector.

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POTENTIAL ASW MISSIONS FOR LIGHTER THAN AIR SHIPS

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ABSTRACT: This paper deals with the LTA as a potential counter to the ballistic and cruise missile launching submarine. The LTA ship can deploy a wide variety of submarine detection equipments effectively. Its long endurance, high speed, and large weapons inventory capability, coupled with the facts that it need not alert a potential submarine target as to its presence, and that it is essentially immune to attack by submarines indicate that it would prove to be a highly effective ASW unit.

A number of characteristics of the Lighter Than Air Ship indicate that it can be an ideal platform for mounting an effective counter to the threat posed by Ballistic Missile Launching and Attack Submarines. This paper investigates the requirements for such a counterforce and briefly illustrates why it is felt that the LTA ship can play a significant role.

Land-based ballistic missiles are presently being deployed on the basis of a counterforce strategy--that is missiles attacking missile bases rather than population centers, thereby providing additional scope for both negotiation and, if need arises, for controlled escalation. At this time, in the case of the Submarine Launched Ballistic Missile, there is no parallel to the land-based missile strategy. The SLBM represents a last option in a strategic missile war. At present, the SLBM remains as an uncountered threat.

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If it were possible to bring into being even a modestly effective counter to the SLBM, it would provide additional incentive for negotiation and, again if need be, additional options for escalation. However, at this time, it does not appear to be either technically or economically feasible to construct and deploy an effective counterforce to the SLBM.

In order to understand the nature of the problem, it is instructive to review the process by which the SLBM threat might be countered. The process consists of the following functional elements: (1) Initial detection, classification and localization of the submarine as it transits from its base to its patrol area; (2) Track and trail of the submarine on a "steady state" basis (a continuous stalking operation) to assure that the large majority of deplo ed submarines are continuously under surveillance and the threat of attack; (3) Attack, if and when necessary. The counterforce capability must be in position to deliver an attack with high lethality against the submarine under surveillance with minimal time delays.

INITIAL DETECTION

A number of technical alternatives have been employed to fulfill these functions in the past.

Initial detection, classification, and tracking is accomplished by means of wide area acoustic surveillance systems. However, if submarine radiated noise is reduced by quieting and the choice of operating areas is expanded by increasing the range of submarine launched missiles, the probability of detecting, localizing and tracking a large fraction of the deployed submarines will decrease. Present fixed passive acoustic area surveillance systems allow one to detect submarines transiting at higher speeds in selected areas. Since areas in which these systems are effective are limited by geo-oceanographic conditions, systems of this type will be of limited usefulness in the future. Initial detection, classification and localization can be provided by systems of this type, if augmented and deployed to cover the routes employed by submarines in transiting to their patrol areas. However, they may not provide a method of tracking and trailing these submarines on a continuous basis.

TRACK, TRAIL AND ATTACK

In the future, following detection in transit, it will be necessary to provide one or more platforms or vehicles to carry out the "steady state" tracking and trailing missions, as well as the attack mission, if and when required. The functional specifications for a platform that will fulfill these mission requirements is unique in the following respects: (1) The platform must have sufficient endurance and/or be supplied in sufficient number to provide long-term track and trail of all detected targets; (2) It must have sufficient speed capability to allow rapid deployment to a given holding position and vectoring on to a detected target. It must also have speed sufficient to allow it to out-maneuver a fast target attempting to escape continued tracking and attack; (3) It must be capable of utilizing a wide spectrum of sensors including sonobuoys, the more advanced towed acoustic arrays and active/passive reliable acoustic path sonars and MAD equipment; (4) It must be capable at all times of effective long-range communication and integration into a fast reaction command and control system; (5) It should not be subject to pre-emptive attack by the submarine

that is under surveillance. Preferably, the presence of the tracking and trailing platform should not alert the submarine; (6) The platform must be capable of carrying a sufficient weapons payload to provide a high probability of kill against the submarine if attack is ordered; (7) The costs associated with the construction, operation and maintenance of a fleet of these platforms to provide an effective counter to the limited number of submarines deployed must be such that the cost of mounting an effective submarine launched attack becomes prohibitively high, that is the platform must provide a low cost-to-benefit ratio.

A series of studies have been carried out to assess the potential of a number of different alternatives for satisfying these functional specifications including attack submarines, conventional displacement type ships; high speed ships such as the surface effects ship and hydrofoils; and aircraft including fixed wing, helicopters and VSTOL units. Each of these alternatives do, to a greater or lesser degree, fail to satisfy one or more of the specifications outlined above. A comparison of the alternatives, including LTA ships, for satisfying these requirements follows.

SUBMARINE DETECTION

In spite of the highly complicated and individual nature of any anti-submarine operation as it actually occurs, the effectiveness of the instrumentalities for detection can be characterized by a few simple parameters, that combine the effects of sensor and platform.

One of these is the search rate S: the number of square miles per hour that an idealized searcher would "sweep clean" (if it detects with certainty every target in the area it sweeps). For less idealized searches, S is defined statistically as the expected fraction of targets detected per hour out of a population of targets distributed uniformly and at random. Not only the sensor's detection range, but the relative speed of the platform, or the mean speed made good in a stop-and-start detection cycle, contribute vitally to the search rate S.

A second general parameter of search performance is the localization area A: to understand its importance we must realize that even after the detection of a target, only the probability distribution of its possible positions is known; this narrows down its probable positions, but in most cases leaves much uncertainty. Assuming that after detection the target's position is bivariate normal, the localization area A is defined as the area of the ellipse, centered at the center of the normal law, within which there is a probability 1-1/e of the target's being located. Obviously the smaller the A the better the information given by detection.

A third parameter of effectiveness measures the degree of confidence with which detection signals can be used to classify the target: "false alarm rate" is used for certain types of automatized detection devices; some equivalent quantity is needed in the present class of ASW systems; the subject will not be considered here in further detail.

In the light of these factors, the very special contribution of the Ligher Than Air ship can be explained as follows:

The possible methods of acoustic search include: (1) fixed listening arrays that provide bearing only data on noisy targets at long ranges; (2) ship or LTA towed listening arrays that provide data similar to fixed arrays at towing speeds at approximately 10 knots; (3) ship mounted echo ranging equipment which may provide bearing and range information to the order of 30 miles at ship speeds of 15 knots; (4) magnetic airborne detection to ranges of approximately 0.5 miles from aircraft making speeds of approximately 200 knots; and (5) reliable acoustic path sonars cable deployed from an LTA providing range and bearing data to ranges of 20-25 miles.

Both fixed and towed listening arrays provide bearings only data with uncertainty as to which of a number of narrow near surface zones the submarine may be in. These zones typically occur at 30-mile intervals. It is therefore necessary to follow up a detection made with a listening array by a second type of detector on a moving platform. Under these conditions, only the last three of the alternatives listed above are available. If we look in detail at these alternatives, one can consider the detection ranges and speeds listed in Table 1 for the three follow up alternatives.

DEPLOYMENT METHOD	DETECTION METHOD	DETECTION RANGE (MILES)	SPEED (KNOTS)	SEARCH RATE SQ. MI./HR.
Aircraft	MAD	0.5	200	200
Ship	Hull Mounted Sonar	30-35	15	900-1050
LTA	Reliable Acoustic Path Sonar (RAP)	20-25	100	1250-2000

Table 1
Relative Area Search Rates for
Alternative Submarine Detection Methods

The way that the search rate is developed in these three cases is illustrated in Figure 1. The aircraft sweeps out a long, narrow strip approximately one mile wide. Thus, it approximately is flying down a line in bearing, and there is a high probability that it can miss detecting target. The surface ship sweeps out a 60 mile wide swath at a speed of 15 knots. In doing so, it alerts the submarine as to its progress so that the submarine can maneuver to avoid detection.

The echo ranging equipment to be deployed from an LTA ship will most likely be a sonar that can be operated either passively or actively, cable deployed to deep depths to provide reliable acoustic path propagation conditions. In following up a prior "bearings only contact," the LTA ship can proceed down a line of bearing, deploy its sonar and listen. The submarine target at this time has no way of knowing that it is under surveillance. If no listening contact is made, the sonar can then be used in its active echo ranging mode to assure that the target is not attempting to hide by being quiet.

In order to illustrate the reasons for attempting to maximize search rate, it is illustrative to consider searching an area as large as the North Atlantic ($\sim 10^7$ square miles) and ask how long one might have to

search in order to attain a 50% probability of detection of these submarines under the assumption that the probability of finding a submarine at a particular location is uniform throughout the region. The results for fixed wing aircraft, conventional ships and for LTA ships under the above search rate assumptions is shown in Figure 2. The results indicate that ~35,000 fixed wing aircraft hours, ~8000 conventional ship hours and ~3500-6000 LTA ship hours would be required to obtain the indicated result. The first number for fixed wing aircraft even under the most optimistic assumption as to the number of aircraft that we could deploy is unreasonably high. The same is true of conventional ships; however, one could attain the indicated level of performance with 20 LTA ship units searching for a period of one to two weeks. Thus, it appears that, for the first time, one can attain reasonable wide area search capability with a limited number of searching units deployed.

SUBMARINE DETECTION EQUIPMENT OPTIONS

At this point, it is useful to consider the options for deploying the various types of submarine detection devices from alternative types of ships or aircraft. These possibilities are outlined in Table 2. Large listening arrays can either be fixed geographically or towed from any platform that is capable of making the slow speeds necessary for good listening. This rules out fixed wing aircraft, and it is perhaps not the most useful way of employing high speed ships such as hydrofoils or surface effect ships. Hull mounted echo ranging equipment may be deployed from any of the ship types and potentially it may be possible to design a towed body deployed from a LTA ship that could provide this type of performance. Deep cable deployed listening/echo ranging equipment can be usefully deployed from platforms that are capable of high speeds required for effective search rates. Thus, they may be used with high speed ships, helicopters or LTA ship platforms. Other means of detection include sonobuoys which can be deployed from any platform but which require reasonably high altitudes for effective monitoring. For this reason, only aircraft are considered as useful platforms in this case. Magnetic detection requires high speed to obtain useful search rates due to limited range. Therefore, only aircraft are considered as useful platforms for deploying this type of equipment. A review of the various equipments and deployment options show the LTA ship to be a generally useful deployment platform when compared with the other possible alternatives.

TARGET LOCALIZATION

In addition to the concern over search rate S, there is the additional concern over localization area A. In the three cases considered, this area is estimated to be of the order of 0.25 square miles. It is extremely important that this area be small as possible, since it directly affects the probability that one can place a weapon in the water within effective weapon range. The value quoted here is within acceptable limits. In the case of passive magnetic airborne detection, since the detection is made only after the aircraft is flown by the target, several aircraft passes are necessary to localize the target magnetically and in fact, final localization is usually made with the aid of air dropped sonobuoys. Magnetic airborne detection equipment and sonobuoys can be used as well by LTA ships as they can be from other types of aircraft.

TARGET CLASSIFICATION

If one considers the various data separately: (1) propeller noises on a given bearing; (2) an echo at a given range and bearing; and (3) a magnetic anomaly of the type generated by a submarine, one can possibly classify a distant ship, a whale or a natural magnetic phenomenon as a submarine. However, if these individual indicators coincide, then one can have high confidence in their correct classification of submarine and non-submarine targets.

ATTACK

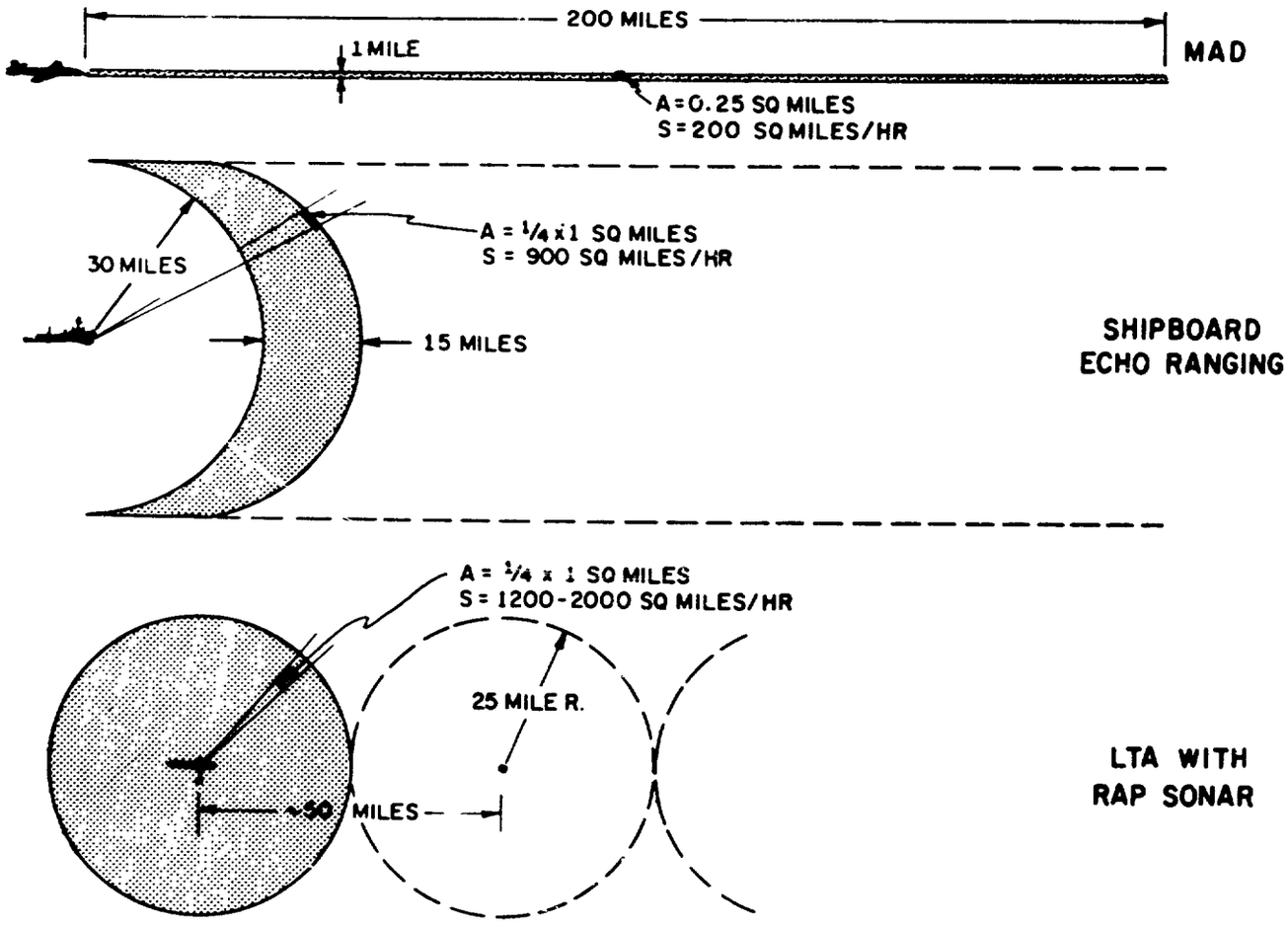
All too often the analysis of ASW systems stop at detection, localization and classification of submarine targets. In addition to these functions, it is necessary to have the capability of launching an effective attack on detected targets. Largely because of weight limitations, air ASW weapons utilizing conventional explosives have a limited effectiveness against submarine targets. Even in the case of nuclear ASW weapons, there are severe limitations on the number of weapons that can be carried aboard a single aircraft or helicopter. As a result, first attack capability for air units is limited and, because of inventory limitations, multiple attack capability is almost non-existent. In general, it is necessary for air units to re-arm prior to mounting a second attack. Similar attack restrictions apply to our present smaller, conventional ship ASW units and smaller potential high speed ship ASW units.

An LTA ship, particularly larger air ships, should be capable of carrying a significant weapons payload coupled with the on-station endurance to provide a highly effective multiple attack capability. If this combination can be provided, one of the major limitations to the ASW effectiveness of single air or surface craft will have been overcome.

An additional concern in the attack situation is the vulnerability of the attacking platform to attack by the submarine. In the case of surface ships, this is extremely critical since it is almost impossible for our present or projected surface ASW units to close within weapons range of a submarine without alerting the submarine as to its presence and location. Thus, against surface ships, the submarine has the option of attacking as soon as it feels threatened. In the case of aircraft and LTA ship units, this first attack option is not available to the submarine. In fact, in the large majority of cases, the submarine will not know that it is under attack until after an ASW weapon has been launched.

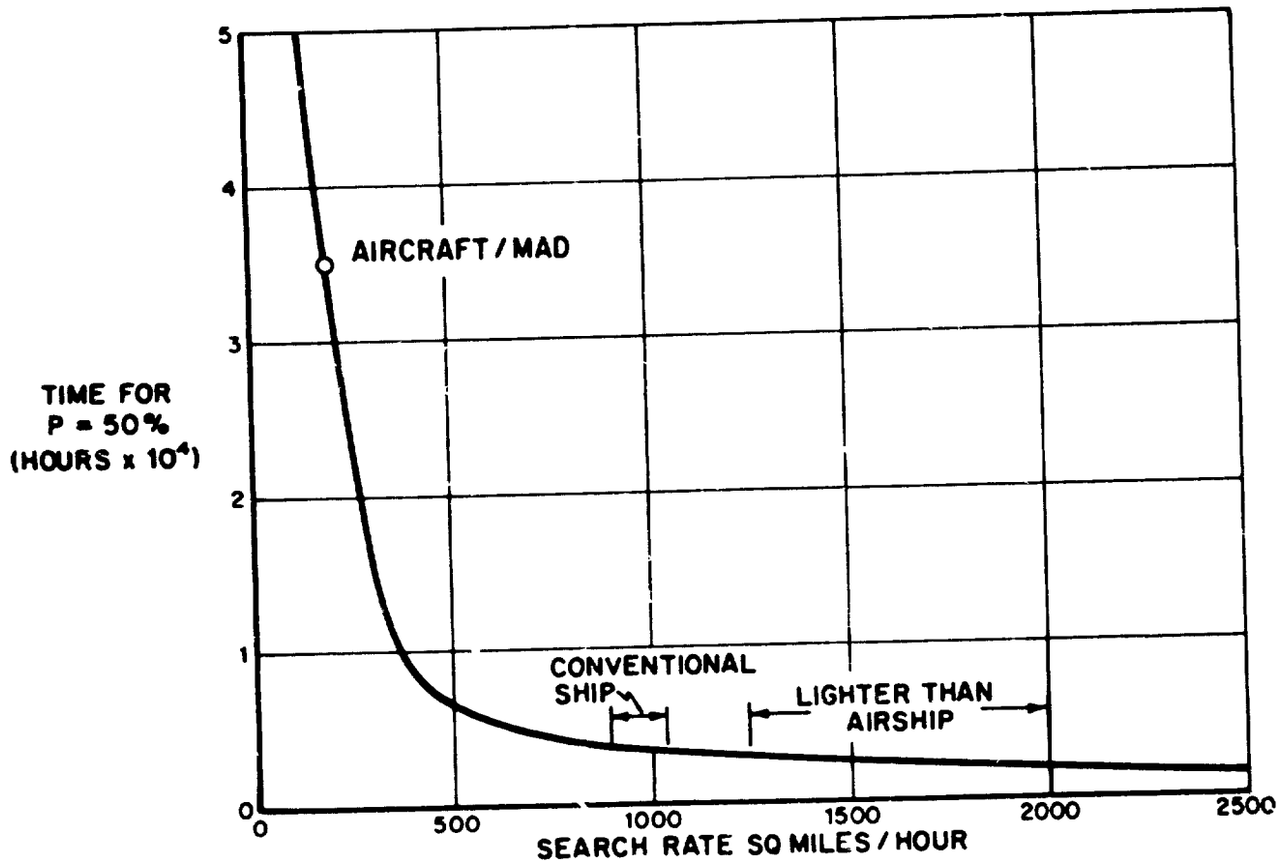
CONCLUSIONS

In this paper, we have not analyzed the ASW capability of an LTA ship in detail. In terms of on-station endurance, search rate, target localization, and classification capability, ASW detection equipment deployment flexibility, attack capability in terms of on-board weapons inventory and nonvulnerability to direct attack by the submarine, it appears that a LTA ship would provide a unique and highly effective ASW unit. The ability to deploy a limited number of LTA ship units capable of long on-station endurance over wide ocean areas would provide the possibility of a highly effective counter to both Ballistic Missile Launching and Attack Submarines.



ALTERNATIVE SONAR SEARCH METHODS

Figure 1



TIME REQUIRED TO OBTAIN A 50% PROBABILITY OF DETECTION IN 10^7 SQ MILES VS SEARCH RATE

Figure 2

DEPLOYMENT METHOD

DETECTION EQUIPMENT	STATIONARY SURVEILLANCE	CONVENTIONAL SHIPS	HIGHSPEED SHIPS	FIXED WING AIRCRAFT	HELICOPTERS	LIGHTER THAN AIRSHIP
LARGE LISTENING ARRAYS	●	●	○		●	●
HULL MOUNTED LISTENING/ECHO RANGING		●	●			○
DEEP CABLE DEPLOYED LISTENING/ECHO RANGING			●		○	●
SONOBUOYS				●	●	●
MAGNETIC DETECTION				●	●	●

SUBMARINE DETECTION EQUIPMENT
DEPLOYMENT ALTERNATIVES

Table 2

ANTISUBMARINE WARFARE (ASW) - A SPECIFIC NAVAL MISSION FOR THE AIRSHIP

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ABSTRACT:** In discussions of conceptual platforms there is a general tendency to consider a platform with the potential to perform a wide range of tasks. This is done for the simple reason that the new platform advocate must convince a variety of sponsors that his nonexistent, or perhaps rudimentary, platform is worthy of further development. However, universal platforms usually perform no one task well enough to survive competition with other specialized platforms. Thus this paper will attempt to narrow the discussion of the airship platform to a reasonably specific issue - the potential usefulness of airships in performing the naval antisubmarine warfare (ASW) mission.

This discussion of the airship as an ASW platform is divided into four parts :

I. A discussion of the kinds of tasks associated with the naval ASW mission,
II. A definition of the platform characteristics which are critical to performing these tasks,
III. A comparison of the airship to other competitive and complementary ASW platforms, and
IV. A short discussion of the obvious research and development required to make the airship a successful ASW platform.

Part I discusses why the Navy discontinued its use of the airship as an ASW platform in the 1950's, the changes which have occurred since then to make it worth while reconsidering the airship as a naval platform and finally, examines the ASW tasks it could best perform. Part II discusses the more apparent constraints that the ASW mission imposes on airship characteristics while Part III discusses how the potential capabilities of the airship compare with the capabilities of other ASW platforms. Finally in Part IV a cursory look is taken at what appears to be the most important R & D for both the sensors which could be borne by an ASW airship and the airship platform itself.

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This paper concludes that

- The ASW airship appears to be a potentially cost effective alternative to those systems which are being designed to replace present ASW platforms,
- The airship's greatest ASW potential lies in the convoy escort role, and
- The airship will appear in Navy inventory only if the other armed reserves, government agencies, and industry are willing to share the costs of development.

THE SURVEILLANCE AIRSHIP

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ABSTRACT:** Airships have a variety of attractive characteristics among which are their long endurance and ability to operate at low altitudes and low speeds. Because many of the evolving Naval surveillance systems require a platform with these characteristics, the airship warrants consideration for these military missions. In addition, these same characteristics make airships viable platforms for civilian uses such as search and rescue, coastal and open ocean monitoring for pollution control, natural resources surveying and other non-military surveillance missions.

The Navy employed airships in a valuable anti-submarine warfare (ASW) and airborne early warning role for many decades. Their usefulness in World War II as convoy escorts is unquestioned. Because airships could conduct close surface surveillance, they were a major ASW asset in the era when submarines were closely tied to the surface for charging batteries and gaining intelligence.

With the advent of nuclear and deep-diving submarines and the development of improved submarine sonars for search and fire control use, the submarines' tie to the surface diminished. Hence the value of close surface surveillance was downgraded, perhaps overly so. By the late 50's, the sonobuoys deployed in widely dispersed buoy fields became the primary airborne search sensor. The airship, due to its slow speed, was clearly unsuited for planting and monitoring such buoy fields and responding to surveillance contacts. These were among the reasons that LTA was no longer considered competitive with fixed wing or rotary wing aircraft for ASW missions.

However, subsequent sensor development may now be tilting the balance back towards the airship. Just as the sonobuoy systems clearly required platforms with the capabilities of fixed wing aircraft, the development of towed systems for search and surveillance clearly rules out

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fixed wing aircraft and makes the rotary wing aircraft a doubtful candidate because of its short endurance. Their use to monitor long endurance moored surveillance systems is also questionable. However, the special ability of the airship to operate for long periods and at low altitudes and low ground speeds makes it well suited as a towing or monitoring surveillance platform for surveillance systems.

The study presented in this paper investigated the endurance of a variety of airships to evaluate their use for surveillance. The airships considered were a three million cubic foot non-rigid, and three, four, and six million cubic foot rigids. Airships of these sizes would involve minimal technical risks for design, construction, equipping, and manning because of past experience and thus a realistic evaluation can be made of their mission capabilities.

Winds have considerable effect on an airship's endurance even at low speeds due to the airship's large surface area. The wind conditions considered were a) no winds, b) 100% head winds, c) 50% head winds - 50% no winds, and d) 50% head winds - 50% tail winds. In order to simplify these preliminary endurance calculations, it was assumed that when winds occurred, the airship was flying either directly into or with the winds and the wind conditions for each case prevailed for the full duration of the patrol and the transits to and from the patrol areas.

From a survey of the wind speeds existing in a plausible patrol area, wind speeds of 10, 20, 25, and 30 knots were used to cover the range of the more probable winds the airship would encounter. Gusts of higher speeds would be encountered, but were not considered because they would be of relatively short duration.

The results of the study indicate that non-rigid airships of three million cubic feet and larger, and rigid airships of four million cubic feet and larger will provide adequate on-station endurance for possible low speed, low altitude surveillance missions.