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AIRSHIP LOGISTICS--  
THE LTA VEHICLE A TOTAL CARGO SYSTEM

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**ABSTRACT:** This paper deals with the design considerations for logistics, as they pertain to the large rigid LTA vehicle as either a commercial or military cargo carrier. Pertinent factors discussed are: (1) the basic mission; (2) types of payload; (3) the payload space in regards to configuration and sizing, its capacity, and its loadability. A logistic capability comparison of selected cargo airships versus jumbo jets is also made.

INTRODUCTION

As a member of the "fixed-wing" aircraft fraternity for many years, like all too many of us in aviation--the airship has been considered obsolete--a vehicle of the past. In brief, "elderly windbags" to quote from the title of a technical magazine article<sup>1</sup> which summarized the results of the AIAA meeting on LTA in Washington last winter, as "a heavy dose of cold water."

The mere thought that the airship might be modernized to perform certain of today's commercial and military logistic missions more efficiently than a modern jet, helicopter, or VTOL vehicle, seemed inconceivable. However, after being exposed to the in-depth work and logic of the LTA Technical Task Force of the Southern California Aviation Council, Inc. (SCACI) and then joining same--sufficient valid

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evidence has been seen, to become convinced that a "fresh and unbiased look" at airship transportation is warranted.

The purpose, therefore, during this workshop session is to discuss the LTA vehicle as a total cargo system. Using as the basis the family of seven rigid airship preliminary designs (ranging in size from 7.4 million cubic foot volume up to 55 million) developed by the LTA Technical Task Force of SCACI.<sup>2</sup> To describe for consideration, an airlift system which is unrestricted as to the size or weight of shipments or geographic destination.

While today's wide-body jet aircraft represents the sixth or seventh generation of progressive product improvement cycles, since the 1920-1930 time period--the same is far from the case for the lighter than air vehicle. These often maligned craft, for all ostensible purposes, are still in the state-of-the-art time-frames of the Fokker and Ford tri-motor transports.<sup>3</sup> Granted there has been some LTA development in the ensuing period by Goodyear. Unfortunately, however, lack of funds and Government support for such vehicles precluded much in the way of modernization as compared to fixed wing aircraft.

#### DESIGN CONSIDERATIONS FOR LOGISTICS

Obviously in the time allocated, it is not possible to adequately cover the entire spectrum of LTA logistics. It was elected, therefore, to concentrate on the airship, as an airfreight carrier. A role for which it is uniquely suited--for airlifting both civil and military cargoes. This is not to say that there are not a number of other missions for which the LTA vehicle, when appropriately modified, is not equally well qualified to perform. Fortunately, these are being covered by others on this workshop agenda who are more intimately qualified to discuss same.

In the development of any future viable LTA configuration it is imperative that "design considerations for logistics" be taken into account concurrently along with all other major design factors. This allows for timely analysis to determine the most effective tradeoffs--before the fact rather than as a compromise after.

#### Basic Mission

As previously mentioned, for purposes of this discussion, the "basic mission" is examined only as: (1) a long range commercial cargo carrier, for either transcontinental operation; and/or (2) a very long range heavy lift logistic carrier for the Military Airlift Command (MAC), capable of operating non-stop from any U. S. aerial port of embarkation to any location overseas. For either type mission the basic configuration of the airship could well be much the same.

#### Types of Payload

As to types of payload, the large rigid LTA vehicle provides a true intermodal cargo system capability. It offers an airlift system which for all ostensible purposes is unrestricted as to a shipment's weight or size. As to the upper end of the spectrum, it is foreseeable that single shipments of over 300 tons or more will be moving by air.

This is evidenced by the presence of Combustion Engineering, Inc., transportation experts on the LTA Workshop program. C-E's Industrial Boiler Operations Division with its Schnabel car (maximum capacity 600,000 lbs.) developed for boiler transport has been moving its 220,000 lb. Type A units over the U.S. rail network for several years<sup>4</sup>. Manufacturers of large steam turbines and condensers, electric generators, forging presses, nuclear powerplant components, etc., have similar heavy lift transportation requirements.

A viable LTA vehicle offers the opportunity for greatly expanding the dimensional envelope restrictions now imposed by rail movement. No longer would it be necessary for builders of massive industrial equipment, as their respective product line grows in weight and size--to consider relocation of their expensive facilities adjacent to inland waterways or seacoasts. They can continue to factory assemble and pretest their huge units--thus avoiding the expensive process of assembly in the field. Further they can put their units into service more quickly after delivery to the site.

In addition to the massive or so-called extra heavy and outsize payloads just discussed, the large rigid airship should likewise be ideally suited for carrying all types and sizes of commercial and military vehicles. These can range up to the biggest truck mounted industrial crane, or to the Army's largest mobile combat equipment.

Regarding the more conventional types of commercial payloads presently moving by air on wide body cargo jets--the airship can readily accommodate these, including all types of ISO containers up to 40'. However, as to a very few types of commodities which might be carried therein (or separately)--there is question of the need for pressurization. For instance, certain pharmaceutical shipments may require a pressurized cargo compartment or its own pressurized container. Such specialized cargo traffic, however, is well below one percent of the total moving by air today.

As to air traffic of fresh fruits and vegetables as well as fresh flowers and nursery stock, both groups of which move in sizeable volume--it was at one time believed these were sensitive to altitude. Regarding fruits and vegetables, controlled laboratory tests have shown no adverse effects of altitude up to 30,000 feet and rates of climb or descent up to 3,000 feet per minute<sup>5</sup>, while altitudes as high as 20,000 feet had no effect on the flowers tested.

#### The Payload Space

During the recent resurgence of interest in LTA transportation systems, considerable material has been written and attention given to the airship as a whole--its hull design, powerplants, performance, economics, etc. Unfortunately however, little work or attention appears to have been given to the airship's payload space (or in the case of the military--useful load) requirements, and the design considerations relating thereto. It is trusted that the contents of other workshop papers will indicate this is no longer the case. In the event this is not so, it cannot be emphasized too strongly that this is an area which warrants much in-depth study by the LTA payloads design engineer.

Configuration and Sizing--First, a decision must be made as to the types and sizes of commercial and/or military cargoes, the payload compartment (or compartments) will be designed to accommodate. To mention a few, such questions which must be answered:

1. Will outsize and heavy shipments be airlifted, such as boilers, turbines, generators, etc? If so, will they be carried within the airship hull or suspended beneath? If carried internally, what are the cargo deck area requirements for spreading such concentrated bearing loads?
2. Assuming that ISO type intermode containers are carried, what will the cell arrangement be for storing same--single, double, or tiers? Will the containers be aligned fore and aft or thwartship in the payload compartment?
3. What are the number, size, and location of all cargo compartment access hatches (doors)? Will these be side entrance or bottom entrance hatches, or both?

Capacity--It is the practice of the U. S. Maritime Commission to use the 20' ISO container, as the common denominator, when rating the capacity of container ships<sup>7</sup>. As the LTA vehicle is for all purposes a ship, rather than an aircraft--it seems logical to follow suit--at least as one means of measuring cargo capacity.

Take for example the large rigid airship preliminary design MC-55 (55 million cu. ft. volume)--the largest of the seven classes developed as part of SCACI's Technical Task Force Report<sup>8</sup>. This LTA vehicle was estimated to have a cargo payload of some 1,026 tons at 6,000 statute miles. Based on past experience however, it has been observed that sufficient weight is seldom allocated for today's sophisticated onboard cargo handling and restraint systems and the supporting structure required for same. Therefore, an additional 26 tons (52,000 lbs.) is arbitrarily transferred, thus reducing the payload to 1,000 tons.

The common 20' ISO dry container's useful volume averages 1,100 cu. ft. per van. Thus:

20' Van Payload Cap. @ 15 lbs./cu/ft & 85% cube utilization =	14,025 lbs.
20' Van Tare Weight @	3,375 lbs.
Total	17,400 lbs. or 8.7 tons

$$\frac{1,000 \text{ tons}}{8.7 \text{ tons}} = 115 \text{ 20' Container Capacity for the MC-55}$$

As to the cargo space requirements to accommodate 115 20' containers. Allowing (8.5' x 20.5') 175.25 sq. ft. per unit, plus allocating some (174.25 sq. ft. x 5) 871.25 sq. ft. for cargo entrance hatches. The 115 units if stowed as a single tier--would require a cargo compartment of 51' in width by 410' in length. This is predicated on the containers being aligned fore and aft six abreast, with four rows of 20 each, one of 18 and one of 17 units.

Loadability--Obviously there are a number of container storage patterns which are feasible--two or three tiers high, etc.<sup>9</sup> All of these justify a so-called "loadability study" using a systems engineering approach, before final selection. For loadability per se, involves the entire cargo loading and handling operations cycle--both into or out of the airship as well as the interfacing cargo procedures on the ground. One example of loadability would be--should a roll-on, roll-off capability be provided for the large LTA vehicle? Ro/Ro ships are growing in popularity in the maritime trade, as it permits all types of wheel vehicles to be readily driven on and off the vessel under their own power.

#### The On-Board Cargo Handling System

This is an area which is wide open to new ideas and innovations. It would be a most serious mistake for LTA payload designers to attempt to adopt or modify cargo jet aircraft loading systems for the airship without first taking into consideration all factors.

While these systems are satisfactory for aircraft--commerce of the type which the airship will be transporting, make it a somewhat different ball game. To name a few:

1. The aircraft cargo handling is aircraft movement oriented--not surface movement oriented. It is the outgrowth as well as the victim of the old 463 L Universal Cargo Pallet System which was initiated in the days of the Douglas C-124 transport. It started with the introduction of the 88"x 105" military cargo pallet--so sized that it could pass through this aircraft's bottom loading cargo hatch.
2. This system from its inception has espoused handling all aircraft type pallets, unit load devices, and containers--up to and including ISO size, from the bottom, on various types of roller conveyor systems. In consequence, most all intermodal ISO containers offered for air movement must first be placed on a special slave pallet before entering any wide body cargo jet.
3. On the other hand surface cargo, and ISO size containers in particular, are designed for hoisting from above, using the standardized corner fittings incorporated therein. As world commerce, with few exceptions, moves in these sea-land type containers rather than SAE AS 832 air-land demountable containers--any LTA logistics should take this fact into account.
4. The LTA cargo hoisting system will undoubtedly be patterned to a degree after the large quay side gantry crane systems used by containership terminals.

#### LOGISTIC CAPABILITY COMPARISON

If trade press coverage is any indication--it appears that 1974 will be known as "the year of the jumbo jet freighter." For this year is seeing a number of U.S. and foreign carriers following Lufthansa's footsteps, by introducing their own 747 F equipment--and thus offer van size container service.

### Cargo Compartment Access

Recognition of shipper demand to extend the outsize cargo capability of the 747 F, is evidenced by the 10'x11' side cargo door being installed aft of the wing by a number of operators.<sup>11</sup> This feature overcomes the 8' height limit on containers loaded through the standard nose door. In fact, Boeing is considering elevating the 747 flight deck 38"--thus increasing the nose door from 8'2" to 11'4" in height and from 11'8" to 12'9" in width at the floor.<sup>12</sup> One objective being to increase the aircraft's ability to load and carry outsize military equipment.

The purpose of discussing the continuing efforts of the airframe constructor to provide improved access to the cargo compartment of its aircraft--is to draw a comparison with the ease of doing such work to a metal airship hull. Further, it is possible to incorporate much larger access provisions, as well as a greater number, for far less cost and weight. This is due to the relative simplicity of the LTA hull structure and its ability to accommodate sizeable cut-outs, with only minor beef-up to the surrounding structure.

### Van Container Capacity

It was interesting to note that one jumbo jet operator has recently elected to describe its new 15 slot 20' container capacity cargo aircraft as "containerships."<sup>13</sup> Yet this is a mere David in comparison with Sea-Land's new Goliath SL-7 supercontainerships. These 946', 51,000 ton vessels have a slot capacity for the equivalent of over 2,000 20' units.

To give a picture of 20' container capacities for the existing or proposed family of U.S. jumbo cargo jets--versus lighter than air containerships, the following figures are presented based on the listed assumptions.

#### Assumptions:

1. For jumbo jet freighters: 20' van capacity @ 1,100 cu. ft x 15 lbs. cu. ft. cargo density x 85(%) percent cube utilization = 14,025 lbs. plus van tare weight (for SAE AS 832 Air-Land demountable cargo container) of 2,200 lbs. A total weight of 16,225 lbs. or 8.1 tons per container.
2. For LTA freighters: tare weight of 20' container increased from 2,200 lbs. to 3,375 lbs. to allow for heavier surface type units. Thus, 14,025 lbs. + 3,375 lbs. = 17,400 lbs. or 8.7 tons per container.
3. Payload of all MC-series LTA freighters arbitrarily reduced 2.5 (2 1/2) percent to allow for onboard cargo loading and handling systems.

## 20' Intermode Container Capacity

### Jumbo Jet Freighters<sup>14</sup>

### LTA Freighters

<u>Manufacturer and Model</u>	<u>Container Capacity</u>	<u>SCACI Series (Model No.)</u>	<u>Container Capacity</u>
Douglas C-2	6	MC-7.4	10
Douglas DC-10	6	MC-15	26
Lockheed 1011	6	MC-22	41
Douglas C-4	12	MC-35	67
Lockheed L-500 (C-5A)	14	MC-42	84
Boeing 747F	15	MC-52	98
Douglas C-6	28	MC-55	115

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