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ESTIMATING THE POTENTIAL DEMAND FOR AIRSHIP SERVICES: A METHODOLOGY

By

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Whenever we attempt to develop a formal model of a real situation, we are attempting to express a conviction as to which factors of the real situation are central and which are peripheral. These convictions may be contradicted by comparing their implications with actual observations or data, but can never be finally verified. It is worth noting, however, that even a contradiction or rejection must rest on some interpretation of our observations so that there must always be uncertainty in both directions.

- John P. Mayberry

What is true today may not necessarily be true tomorrow.

- Taoist saying

ABSTRACT

Although commercial airship operations ceased over 40 years ago, interest in resurrecting lighter-than-air vehicles has surfaced during the last decade on many fronts. One of the major problems confronting airship enthusiasts is the difficulty involved in evaluating the economic viability of this "new" transport mode. It was the objective of this study to formulate a methodology for determining the airship's potential in the commercial freight market.

In meeting the stated objective, two separate and distinct parts were involved. First, after briefly reviewing the literature pertinent to estimating the demand for transportation as well as the determinants of modal split, an abstract mode model was formulated which could be used to estimate the demand for airship services in a particular market. In addition, an extensive discussion of the theory upon which the abstract mode model is based was also presented.

The second part of formulating the methodology was initiated with an examination of some of the more substantial studies which have recently been carried out to ascertain plausible airship cost and service characteristics. Following this, a model for determining airship cost structure was presented. Finally, various crude estimates of airship rates were calculated employing differing assumptions regarding initial airship cost and performance characteristics.

Due to data limitations, no formal estimation of the demand for airship services was undertaken. However, a brief appraisal of airship costs and capabilities compared with rail, truck and airplane revealed that even at the lowest estimated rate, airships were currently still more expensive on a ton-mile basis than either rail or truck, but were less expensive than airplane. However, it was also found that while airships are somewhat slower than airplanes, they offer a faster delivery time than either road or rail freight movement by a fairly significant margin. Thus, while it is impossible to draw any definite conclusions regarding the "cost versus time" decisions which shippers will make, it does not seem unreasonable to say that the airship seems to offer a reasonable alternative to existing modes, especially in the movement of commodities where speed is an important factor.

It remains for a future study to combine the two parts of the methodology when the necessary data becomes available to formally determine the potential demand for airship services in the commercial freight market.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

While the crash of the German dirigible Hindenburg, in 1937, effectively put an end to commercial airship operation over forty years ago, it failed to extinguish the enthusiasm for airships which was felt by many. Apparently, this interest has managed to survive four decades of near inactivity and has surfaced during the last decade on many fronts.

In the forefront of the current attempt to resurrect lighter-than-air vehicles (LTA's) are engineers, economists, and businessmen whose various and varied studies started to appear with increasing regularity in both professional and popular publications. Although the reasons given to justify an airship resurgence have been many, they have tended to focus upon three factors. The first is the fact that the airship is an ecologically sound vehicle, both in terms of pollution and resource use.[1] The second factor is the more ready availability of helium at a reasonable price,[2] while the third involves the advances which have been made in structural engineering since the 1930's.[3] The latter reasons are important

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[1] R.D. Neuman and L.R. Hackney, "Airship Economics," Proceedings of the Interagency Workshop on Lighter Than Air Vehicles, ed. J.F. Vittek, Jr. (Cambridge, Mass.: M.I.T. Flight Transportation Laboratory, 1975), p. 42.

[2] D. Howe, The Feasibility of the Large Freight Airship, Cranfield Report Aero No. 5 (Cranfield, U.K.: Cranfield Institute of Technology, 1971), p. 2.

[3] R.G. O'Lone, "Lighter-Than-Air Technology Broadens," Aviation Week and Space Technology, (Sept. 1974):42.

in dispelling the still commonly held belief that all airships are in imminent danger of either structural failure or bursting into flames, or both.

In addition to the variety of reasons given for a serious reappraisal of the airship's transport potential, enthusiastic proponents have also put forward a plethora of commercial and non-commercial applications for airships. The proposals, which are based primarily on LTA's unique ability to hover and float in the air, range from the movement of indivisible heavy loads[4] to the leisurely transportation of people to exotic places in what would in effect be a floating luxury hotel.[5]

However, no matter how good the uses of and reasons for a widespread reintroduction of airships may seem, the fundamental criterion for determining whether or not such a move is warranted at this time must be its economic feasibility. That is, is there sufficient demand to sustain the operation of a commercial airship service? It is this question which the present study was originally intended to address. Unfortunately, insurmountable problems in obtaining the necessary data have led to a shift in the focus, such that the fundamental objective of this study is to

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[4]P.O. Roberts, H.S. Marcus, and J.H. Pollock, "An Approach to Market Analysis for Lighter Than Air Transportation of Freight," Proceedings of the Interagency Workshop on Lighter Than Air Vehicles, ed. J.F. Vittek, Jr. (Cambridge, Mass.: M.I.T. Flight Transportation Laboratory, 1975), p. 88.

[5]Jack R. Hunt, et al., "The Many Uses of the Dirigible," Astronautics and Aeronautics, (October 1973):60.

provide a methodology for assessing the potential economic viability of introducing airships into the commercial freight market.

Now, it seems reasonable to assume that the potential for successful market penetration by airships will be greater in some sectors of the transport market than in others. Unfortunately, no ready comparison of airship rates and service attributes with those of other transport modes is possible due to the fact that current airship information simply does not exist. While this is not surprising considering that there have been no commercial airship operations for forty years, it does present a problem. However, it is believed that reasonable rate estimates can be obtained by estimating airship operating and cost characteristics, given specific performance requirements. Once this has been done, the area of the transport market in which the airship would be best suited to compete can be selected.

In addition to the difficulty involved in intermodal comparisons, there are obvious problems associated with attempting to determine the specific level of demand for a non-existent transport mode. In order to make this determination, it is first necessary to identify those factors which strongly influence the modal choice decisions of shippers. Once these factors have been ascertained, they may be incorporated into an abstract mode model and an estimate of the demand for any transport mode can be obtained provided that the necessary data is available. As this latter requirement was not met, an explanation of the abstract mode approach to the demand for transport will be followed by the formulation of an

abstract mode model; but no estimate of the demand for airship services will be attempted.

In essence, then, fulfilling the objective of this study, to provide a method of determining the economic feasibility of employing airships in freight transport, will entail two distinct steps. The first step will involve the explanation and formulation of an abstract mode model, while the second step will entail developing a costing methodology for airships in order to facilitate reasonable estimates of airship freight rates.

Now, before going on to formulate either the abstract mode or airship costing model, the second chapter will contain a review of the studies which have been done in the area of airship development and economics. Following this, the third chapter will include a review of the literature pertaining to demand and modal-split modelling for transportation.

The theory upon which abstract mode models rest as well as an actual model of this type will be presented in the fourth chapter, while the airship costing model, in theory and practice, will be the subject of chapter five. A discussion of the results which were obtained, the limitations of the study and any conclusions which can be drawn comprise the sixth and final chapter.

CHAPTER 2

AIRSHIPS DEMYTHOLOGIZED

2.1 Background to the Resurgence

Due to a series of spectacular disasters, one of which was alluded to earlier, the airship has been in a general state of disrepute for over four decades. However, in recent years, a number of individuals and organizations have attempted to revive interest in lighter than air vehicles (LTA's) and have to some extent succeeded. The question which arises, then, is why, after such a long period of obscurity, has interest in airships been renewed at this time? As was mentioned in the introduction, the answers given by most LTA enthusiasts most often pertain to improved aeronautical technology,[6] the increased availability of helium,[7] and a host of environmental considerations, such as waste and noise pollution, as well as the increasingly critical shortage of fossil fuels.[8]

The first two reasons cited, namely improved technology and ready helium availability, are critical to any LTA resurgence. This is because the disasters which led to the virtual disappearance of airships were due, for the most part, to either structural break-up under stress[9] or to the

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[6] O'Lone, "Transportation Broadens," p. 42.

[7] Howe, Feasibility, p. 2.

[8] Neuman and Hackney, "Airship Economics," p. 42.

[9] Howe, Feasibility, p. 1.

fact that hydrogen, an extremely flammable gas, was employed as the agent of buoyancy.[10]

There is, however, some concern about the validity of the claims which have been made. While helium may be more readily available, the critical matter of price remains unsettled, and even when considering the purchase of large quantities, the price may still prove to be prohibitive.[11] With regard to the improvement in aeronautical technology over the past forty years, very little disclaimer can be made. However, too often "...[t]he massive problems of the past are eliminated with the stroke of a pen and the all encompassing words 'New Technology'."[12] This is not to say that technological advance has not rendered the airship practicable, but rather, merely serves to point out that many of the claims made by airship proponents are thus far largely unsubstantiated.[13]

In meeting the concerns of environmentalists, however, LTA's are almost matchless in the transportation field. They are almost noiseless[14] and are far more efficient in their use of fuel and other resources than most other modes of transport.[15] In this latter regard, the fact that LTA's

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[10] M. Rynish, "Cargo Airships - A Plan for the Future," ICHCA. (Oct. 1971):15.

[11] Howe, Feasibility, p. 3.

[12] Neuman and Hackney, "Airship Economics," p. 42.

[13] O'Lone, "Technology Broadens," p. 42.

[14] F. Morse, "Cargo Airships: A Renaissance?" Handling and Shipping. (June 1972):45.

[15] J.G. Vaeth, "The Airship Can Meet the Energy Challenge," Astronautics and Aeronautics, (Feb. 1974):25.

are airborne eliminates the need for roadway facilities. In addition, since they are VTOL craft they do not require the expensive airport facilities which are needed by heavier-than-air craft.[16]

2.2 The Economics of Airship Viability

Even if the claims about the technical improvements in and environmental desirability of the airship are accepted as being true, they do not of themselves provide sufficient justification to undertake development of the airship at this time. The question which must be answered is whether or not there is a substantial market for the services which the airship can offer.[17]

In order to become an economically viable transport mode, airships must either generate an increased demand for transportation or else they must draw some users away from the modes which are presently in use. In order to achieve the former, LTA's would either have to offer services which were previously unavailable or they could extend the market areas for currently available products by means of absolute improvements in one or more service levels.[18]

To "steal" business away from already existing modes would require, perhaps, only relative improvements in some service characteristics.[19] In

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[16] Howe, Feasibility, p. 18.

[17] K.R. Stehling, "Vers Une Renaissance du Dirigible?" Interavia. (Sept. 1975):989.

[18] J.F. Vittek, Jr., "The Economic Realities of Air Transport," (M.I.T. Flight Transportation Laboratory, 1975), p. 1, (unpublished paper).

[19] Ibid.

effect, the first option would require an increase in the total amount of transportation consumed, while the second would involve a redistribution of the modal split. A third possibility might entail both an increase in total transport consumption as well as a change in the relative share of the transportation market captured by each mode.

Airship enthusiasts envisage many new roles for airships which will tend to increase the total consumption of transportation. Already mentioned in this list of innovative uses for LTA's is the conveyance of very heavy and/or indivisible loads, such as nuclear reactor parts, to presently inaccessible areas.[20] On the lighter side, it has been suggested that airships be used to transport natural gas from the arctic to more southern locations.[21] It has also been put forward that LTA's would make excellent floating hotels or luxury liners where people could relax and enjoy the passing scenery or travel in comfort to exotic places such as the south pole.[22] Other possible uses have included the fitting of airships as portable hospitals for use in emergencies arising from natural or man-made disasters,[23] as well as their employment as orbiting laboratories to carry out extensive biological and meteorological research.[24]

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[20] Roberts, Marcus and Pollock, "An Approach to Market Analysis," p. 88.

[21] N.P. Biederman, "Natural Gas by Airfreight," Pipeline and Gas Journal. (Oct. 1970):62-69.

[22] Hunt, et al., "Many Uses," p. 60.

[23] Stehling, "Vers," p. 989.

[24] Hunt, et al., "Many Uses," p. 61.

If we ignore its potential for carrying passengers, then it seems apparent that, with the exception of transporting heavy and/or indivisible loads and perhaps natural gas, the other uses put forward for LTA's are at best questionable insofar as their commercial viability in the private sector are concerned. Even the heavy-lift capability of the airship incurs problems in that the demand for this service would generally be limited to "one shot" moves.[25] Thus, a stable demand for its services, which is essential to the continuation of any transport mode, appears to be lacking in this case. Also, while it is apparently promising, further study will be required to determine the feasibility of moving natural gas by airship.

It has been suggested that airships can induce more transportation demand by extending the market areas of presently available products by offering faster or cheaper service than any other mode. Closer examination of this suggestion reveals that the former possibility can be eliminated (except for relatively short hauls, perhaps) due to the fact that the anticipated average block speed of the airship will be substantially lower than that of the airplane.[26] With regard to price, it seems unlikely that LTA's will be able to undercut the rates of all their competitors, even if the regulatory bodies allowed them to do so.[27]

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[25]Roberts, Marcus and Pollock, "An Approach to Market Analysis," p. 88.

[26]Most estimates of airship block speed are in the neighborhood of 100 MPH, well below present airplane speeds.

[27]Roberts, Marcus and Pollock, "An Approach to Market Analysis," p. 94.

It seems most plausible that while not totally dismissing other potential income sources, the major portion of airship revenues will have to derive from business drawn away from other transport modes by the particular rate and service characteristics which the airship offers. The question which still remains is whether or not LTA's will be able to wrest enough traffic away from existing transport modes to make them economically viable in the highly competitive transport market. Perhaps an even more fitting question would be whether or not it is possible at this time to make the necessary determination. In this regard, a rather apt statement by Dr. R. Ausrotas may be of assistance:

> In the field of Lighter Than Air, there is a wealth of performance data and a dearth of economic data. Thus, it is not surprising that most discussions about the potential of LTA end in agreement that an airship of a given size could carry out a specific mission, but in disagreement as to how much it would cost. Since commercial airship operations have not been undertaken for almost forty years, this paucity of data is not surprising, and any new proposal for LTA--as far as its economic viability--runs into immediate suspicion...[28]

2.3 Recent Airship Cost Studies

While the lengthy quotation above sums up the general problem faced by those wishing to determine the economic feasibility of commercial airship operations, this is not to say that attempts have not been made to deal with the problem. A number of serious studies have been undertaken to examine the economic prospects for LTA's, and a discussion of some of these attempts follows.

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[28] Raymond A. Ausrotas, "Basic Relationships for LTA Economic Analysis," Proceedings of the Interagency Workshop on Lighter Than Air Vehicles, ed. J.F. Vittek, Jr. (Cambridge, Mass.: M.I.T. Flight Transportation Laboratory, 1975), p. 1.

Now, if it is assumed that the airship's rate structure will be such as to provide a sufficient rate of return to make the supply of airship services economically viable, then it is first necessary to determine the cost structure upon which such rates will be based. As such, the development of a costing methodology for airships is a prerequisite to a detailed cost analysis. To this end, Hill devised a costing framework which made use of historical airship cost data updated to include "...the effects of new materials, propulsion techniques, and logistics concepts on costs and [the] adjustment of the dollar data to current price levels."[29] He suggests further, that the data base could be augmented by information derived from non-rigid airship operations which were just recently discontinued.[30]

The simplified flow chart presented in Table 1 below indicates the procedures which were followed in Hill's study. From the chart, it is evident that any cost analysis must be based on a comprehensive knowledge of vehicle characteristics and system requirements as developed by the designers, as well as any assumptions which may be involved. This is not to say that airship costs are necessarily highly sensitive to all design assumptions, but merely points out the need to test for such sensitivity.[31]

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[29]L.S. Hill, "An Integrated Approach to the Structuring of a Cost Model," paper presented at the 1st International Meeting of the Operations Research Society of America, Honolulu, Hawaii, Sept. 1964, p. 5.

[30]Ibid., p. 4.

[31]Ibid., p. 8.

Proceeding from the conceptual framework, Hill puts forward an aggregated general cost model for airships (Eq. 1).[32] That is, the model includes all elements of cost which should be considered during the entire life cycle of any airship project. This model

$$C = R + I + nU \quad (1)$$

where:

C = total program cost

R = research, development, test, and evaluation cost

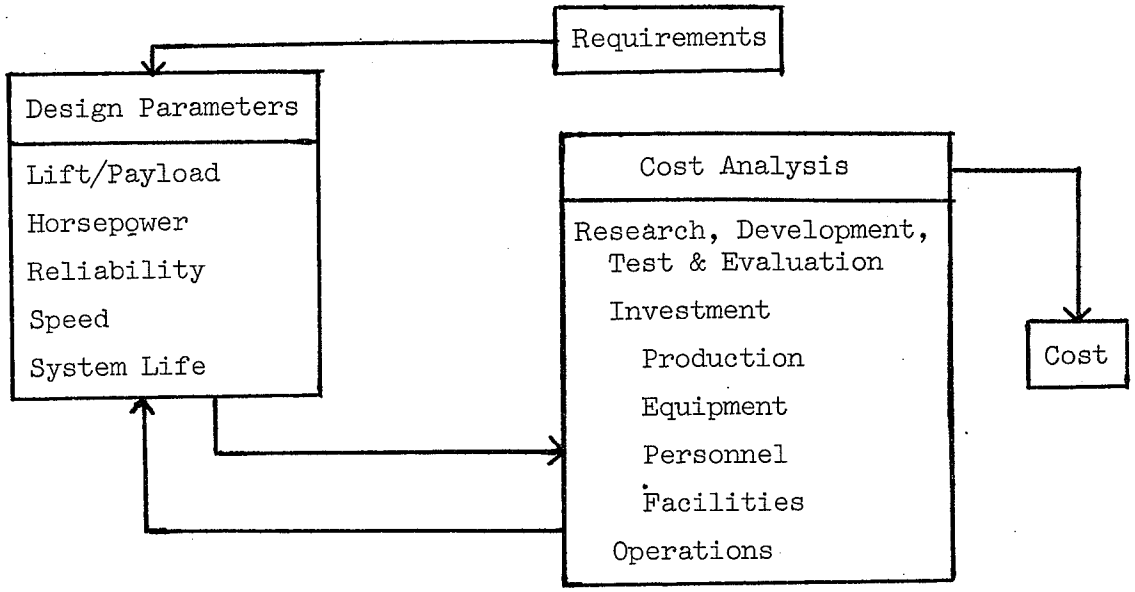
I = initial investment cost

n = number of operational years

U = annual operating costs

Table 1

Simplified Operation Flow Chart for Structuring an Airship Cost Model



[32] Ibid., p. 10.

can be disaggregated into three separate but interrelated cost sub-models which are presented in equations (2), (3) and (4).[33] Of the three costs, research and development costs, (R) which are described in equation (2) are the most difficult to estimate due to the lack of a detailed data base.

$$R = D+T+T_s+\varepsilon_1 \tag{2}$$

where:

D = cost of design and development

T = cost of test vehicles and testing operations

T_s = cost of test support equipment

ε_1 = miscellaneous costs not included in the above

$$I = A+E+F+V+T+\varepsilon_2 \tag{3}$$

where:

A = cost of airships

E = cost of specialized equipment (mooring masts, ground handling equipment, helium purifiers, etc.)

F = cost of facilities

V = cost of personnel travel

T = cost of personnel training

ε_2 = other costs not included above.

$$U = A_2+E_2+F_2+V_2P+T_2+L+M_A+M_E+M_F+\varepsilon_3 \tag{4}$$

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[33] Ibid., pp. 10-11.