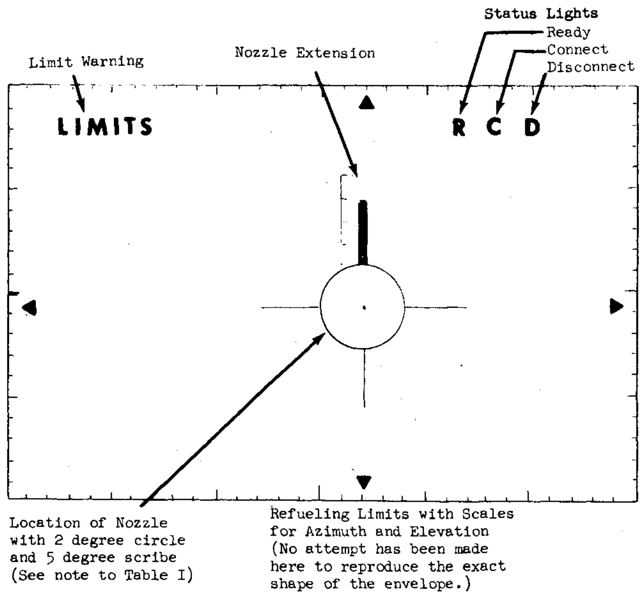

Fig. 4 Boom operator's HUD format.

Summary

Based on conversations with air-to-air refueling boom operators, observations of refueling operations, and general familiarity with head-up displays, it is felt that a BO HUD would improve mission effectiveness and flight safety. These goals are achieved by providing the BO's with the minimum data they need in their field of view. A HUD would minimize the need to look at their instruments. As a result, hook-ups would be faster with fewer disconnects, and flight safety would improve. The BO HUD would be of most benefit when refueling unusual sized airplanes, such as the very large C-5 or E-4 or the very small fighters, or at night.

Since the student BO would have quantitative data in his field of view, training requirements may be reduced when using a HUD. A HUD would also minimize the time needed for an experienced BO to become proficient in refueling a new receiver aircraft. This results from the reinforcement of accurate augmented cues and the lessening of the use of vague size-related cues.

References

[1] *Basic Flight Crew Air Refueling Procedures*, USAF T.O. 1-1C-1, July 1972, revised through April 1974.

Technical Comments

Comments on "Feasibility Study of a Hybrid Airship Operating in Ground Effect"

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IN Ref. 1, an assessment is made of the economic feasibility of a hybrid airship concept in the long-haul cargo market. The concept consists of a helium-filled rectangular cross-sectioned body with a fixed wing, operating in ground effect. (Since only 5½% of the total lift is due to static lift, one wonders why static lift was employed at all.) The conclusion of the paper is that for a range of payload sizes the concept offers economic advantages over both conventional airships and airplanes. This conclusion, however, is rendered invalid by the many errors and overly optimistic assumptions which apparently were made in the paper. It is the purpose of this Technical Comment to discuss the most serious of these.

First, the structural weight of the hybrid concept has been underestimated by a significant amount due to the following four factors: 1) the problems and weight penalties associated with attaching the heavily loaded wing structure to the relatively very lightly loaded body structure were ignored; 2) bodies with noncircular cross sections were assumed to weigh the same as bodies with circular cross sections on an equal volume basis; 3) the influence of speed (i.e., dynamic pressure) on hull weight was neglected; and 4) the effects of the severe near-sea environment were neglected. These assumptions imply that the body of a noncircular cross-sectioned hybrid airship with a heavy wing operating at 150 knots near the surface of the water would have the same weight as a conventional, circular cross-sectioned, wingless airship operating at 75 knots out of ground effect for the same enclosed volume. The unrealistically low empty weight which results is evidenced by the data in Table 5 of Ref. 1. A more realistic empty weight would be 50% higher than that shown, resulting in a halving of the payload for the same mission. In fact, a preliminary study of winged hybrid airships (Ref. 2) which took account of the above factors concluded that such vehicles were uncompetitive with other airship concepts due mainly to their high structural weights.

Second, and more seriously, major errors apparently were made in the estimation of crew costs. These are as follows: 1) there are many items in the crew cost element of D.O.C. other than crew salary such as the cost of fringe benefits and proficiency training; 2) flight crew salaries for the large-size vehicles being considered likely would be closer to $60,000/year than the $30,000/year which was assumed; 3) flight crew typically work 1000 hours/years – since the vehicles are assumed to have a utilization of about 6000 hours/year, six crews will be needed per vehicle, not the one which apparently was assumed; 4) because of the long flight durations (in excess of 20 hours) relief personnel must be onboard, giving a flight crew of six and not the three which was assumed. The combined effect is to underestimate the annual crew costs by as much as a factor of 25; this alone is enough to invalidate the conclusion of the study. It should be noted that many other recent airship economic studies have made these same mistakes, as discussed in Ref. 3.

Third, there are some accounting problems with the operating cost calculation as follows: 1) To compute indirect costs as a percentage of direct costs defeats the purpose of breaking down costs into D.O.C and I.O.C. since it has the effect of making the latter an element of the former. This can lead to serious errors in comparing significantly different systems. By definition, D.O.C. is the cost directly associated with actual operation of the vehicle while I.O.C. is the rest of the cost of operating the transportation system. 2) Ground crew is normally an I.O.C. and not a D.O.C. element. 3)It is not clear why ten onboard technicians are needed for the conventional airship but not for the hybrid.

Received Sept. 30, 1977.
Index categories: Ground Effect Machines; Lighter-than-Airships.
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Fourth, in addition to the crew costs, estimates of many other D.O.C. elements seem low when compared with airplane experience, particularly maintenance. The operating costs of potential civil long-haul airships are critically discussed in Refs. 3 and 4.

Finally, there are some discrepancies in the paper. Table 2 states that the net lift of the helium was assumed to be .063 lb/ft^3 while the discussion indicates that .072 lb/ft^3 was actually used in the computation. Figure 11 shows that costs per ton-mile increase as size increases for the hybrid, in contradiction to past experience, one's intuition, and the discussion in the text.

Figure 11 of Ref. 1 shows that even with the apparent errors and optimistic assumptions just discussed, the hybrid airship has an operating cost per available ton of payload per mile roughly equivalent to the 747F. It therefore seems clear that a correct analysis would show the hybrid concept to be uncompetitive. Further, in the vehicle size class being considered (1000 tons gross weight) there are airplane concepts which promise to have significantly lower operating costs per ton-mile than does the 747F (Ref. 5).

References

[1] Calkins, D. E., "Feasibility Study of a Hybrid Airship Operating in Ground Effect," *Journal of Aircraft*, Vol. 14, Aug. 1977, pp. 809-815.

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[3] Ardema, M. D., "Economics of Modern Long-Haul Cargo Airships," AIAA Paper 77-1192, presented at the AIAA Lighter Than Air Systems Technology Conference, Melbourne, Fla., Aug. 11-12, 1977.

[4] Vittek, J. F., "The Economic Realities of Air Transport," presented at the Symposium on the Future of the Airship – A Technical Appraisal, London, England, Nov. 20, 1975.

[5] Whitehead, A. H., "The Promise of Air Cargo-System Aspects and Vehicle Design," *Acta Astronautica*, Vol. 4, Jan.-Feb. 1977, pp. 77.

Reply by Author to M.D. Ardema

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I WOULD like to thank Dr. Ardema for his careful critique of my paper. However I would like to take exception to some of the comments which were made, and to his basic definition of the phrase "many errors." He claims that the conclusion concerning the discussed type of hybrid airship is rendered invalid by "many errors." The type of paper that is presented, i.e. a concept presentation, may be regarded as one which is based, to a large extent, on opinion. In other words, since there is not a large technical data base upon which to draw to verify the concept's validity, the author must rely on his judgment and opinion. It is possible, therefore, to have a difference of opinion, among technical people, on the assumptions that are made in the paper. However, for one person, whose opinions differ from those of another, to state that his are correct, while those of the other are "errors," is incorrect. Therefore, I cannot agree that my paper contains "many errors," because Dr. Ardema's opinions differ.

Received Nov. 23, 1977.

Index categories: Ground Effect Machines; Lighter-than-Airships.

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Further, the study was done as an unfunded project during 1975, making use of the limited amount of research material that was available to the author at the time. This data base should be compared to Dr. Ardema's airship program at NASA Ames which involves two large aerospace corporations, The Boeing Company and Goodyear Aircraft. I believe that Dr. Ardema's comments are based on the voluminous studies which have been the result of this program. I would like to point out that at the time that I did the study, I did not have the resources that were available to both Boeing and Goodyear, including the computer time. It should also be pointed out that, as a basic part of both of the Goodyear and Boeing studies, comprehensive computer-aided design programs were developed which were used to do vehicle parametric studies. These computer programs are discussed in Ref. 1. It is interesting to note in this reference, which discusses the hybrid type of airship, that agreement between the results of the contractors was not reached as to whether or not the hybrid airship was a good concept, nor were they able to define an optimum design. Are these differences in results, which obviously arise because of different design assumptions, to be regarded as "errors" on the part of either contractor?

Dr. Ardema's first comment concerns the structural weight of the hybrid. The particular expressions for the structural weight were developed based on data available to me at that time, Ref. 2. While it is true that the technically correct way to do it would be a detailed structural design, such as the approach that was used by both Boeing and Goodyear, it was beyond the scope of my paper.

Dr. Ardema indicates that the problems and weight penalties associated with attaching a heavily loaded wing structure to a lightly loaded body structure, were ignored. They were not ignored; I had an insufficient data base upon which to rationally include the effect. In addition, he states that bodies with noncircular cross sections were assumed to weight the same as bodies with circular cross sections, implying that this is incorrect. Does he have a detailed structural analysis to prove this?

He states that "the effects of the severe near-sea environment were neglected." It is discussed on page 810 of my original paper. While he may argue the validity of flight in ground effect, as done in Ref. 3, this is again a difference in opinion as may be seen by comparing it to the noted reference.

Dr. Ardema states that a more realistic empty weight would be 50% higher than that shown in my paper. Why 50%? Why not 45% or even 60%? I would be interested in knowing how Dr. Ardema arrived at this figure.

Dr. Ardema then discusses the "major errors" made in the accounting procedures used in the paper. If Dr. Ardema is at all familiar with accounting practices, he is aware that there are many different types which are used in business. I would appreciate the particular reference that he uses as the basis for his economic analysis. The economic analysis used in the paper was based on Ref. 4. It is also interesting to note that he points out that other economic studies have made the same mistakes as have I. Again, I think he means that other people have different opinions as to how to conduct economic analyses, which just happen to be different from his. Dr. Ardema states that the estimates of other D.O.C. elements seem low when compared with airplane experience. I am sure that this comment is based on data which is available to him. Again, I would appreciate his reference.

Dr. Ardema talks about discrepancies in the paper. Table 2 states that the net lift of the helium was assumed to be .063 lb/ft^3 and the discussion indicates a value of .072. The figure that was used in my calculations is .063. I am unable to locate in the discussion the implication of the value .072.

He states that Fig. 11 shows that the cost per ton-mile increases for the hybrid, which is in contradiction to his experience. I assure Dr. Ardema that I have rechecked my calculations, and the figure is correct as drawn.