Technical Comments

Comment on "Thrust Vector Control of a V/STOL Airship"

James D. Lowe*
Institute for Aerospace Studies, University of Toronto Toronto, Canada

THE conclusions made by Nagabhushan and Faiss[1] concerning the use of thrust vectoring as a means of controlling a hovering V/STOL airship do not follow from the test results that they present. A lack of detailed information about the vehicle prevents the results from being independently tested.

Figure 10 shows the results of an attempt made by the lateral autopilot to minimize the sideways motion of the vehicle while it encounters a 20 ft/s side gust. The airship responds by drifting nearly 275 ft at a constant velocity of 2.75 ft/s while rolled an average −22 deg. The velocity and the roll angle show no sign of leveling off at the end of the simulation. The only conclusion made from Fig. 10 was that "the error in lateral ground position of the airship obtained here is surely less than the corresponding response of a conventional airship having no lateral control at all." An example of an uncontrolled response was not presented for comparison and, more importantly, the details of the operational requirements that the vehicle were to fulfill were not presented so that an assessment of the control system effectiveness could be made. The question still remains as to whether a vehicle that has drifted 275 ft without any decrease in speed has been sufficiently controlled.

Consider next the results presented in Fig. 11. It was shown that the roll experienced by the vehicle while encountering a similar 20 ft/s side gust could be counteracted by a control system that utilized large gains. It was stated that "the corresponding tilt rate required for favorable roll response is perhaps beyond that of a gimballed ducted fan," but the associated 1000 ft drift of the airship was ignored. It would have been interesting to see an example showing whether both roll angle and lateral position could be controlled using thrust vectoring.

Many of the assumptions and much of the information inherent in the results presented in Figs. 10 and 11 were ignored. Readers are not given any detail about the mission the vehicle is expected to perform, and under what sort of environmental conditions it is to be accomplished. This information would suggest which aspects of the vehicle's state are important to control and, therefore, set limits on state variables such as roll attitude and lateral location.

It is not possible to test the validity of the results because the description of the vehicle is incomplete. The data could be used by other flight simulations, such as the one described by Evans and DeLaurier,[2] to test the effectiveness of the control schemes. It should also be possible to explicitly define the thrust vectoring control systems and their reasons for use. Lastly, the aerodynamic estimation techniques that were used should have been fully described because the references that were cited are not detailed enough to completely estimate the aerodynamics of an airship. Jones and DeLaurier[3] present a thorough means for estimating the aerodynamic properties of typical lighter-than-air vehicles.

In the relatively new field concerned with the powered hovering control of buoyant and semibuoyant vehicles, one needs to take care in presenting how results are arrived at. All fundamental assumptions, analysis techniques, and mission objectives should be clearly stated. The paper by Curtiss and Sumantran[4] is a particularly informative example of other work being done in this field.

Received July 1, 1984.

*Research Associate, Subsonic Aerodynamics Group.

References

[1] Nagabhushan, B. L. and Faisse, G. D., "Thrust Vector Control of a V/STOL Airship," *Journal of Aircraft*, Vol. 21, June 1984, pp. 408-413.

[2] Evans, J. R. and DeLaurier, J. D., "The Shenandoah Flies Again: A Computer Simulation," AIAA Paper 81-1325, July 1981.

[3] Jones, S. P. and DeLaurier, J. D., "Aerodynamic Estimation Techniques for Aerostats and Airships," *Journal of Aircraft*, Vol. 20, Feb. 1983, pp. 120-126.

[4] Curtiss, H. C. and Sumantran, V., "Stability and Control of VTOL Capable Airships in Hovering Flight," AIAA Paper 83-1987, July 1983.

Reply by Authors to J. D. Lowe

B. L. Nagabhushan* and G. D. Faiss†
Goodyear Aerospace Corporation, Akron, Ohio

WE would like to thank Mr. Lowe for his critique of our paper.[1] Before responding to his specific comments, we wish to point out that the results presented here were based on an exploratory study, conducted to identify potential benefits of thrust vector controls. No specific design or operational requirements were addressed. Instead, an existing design of a conventional airship was modified to include various thrust vector controls. For such a configuration the marginal improvements in vehicle control and maneuverability were assessed.

Figure 10 illustrates the inherent lateral/roll coupling effect on the airship response to a crosswind. It is shown that using a lateral thrust control can "minimize" the lateral excursion of the vehicle, but at the cost of sustained rolling oscillation.

Figure 11 demonstrates the potential for roll control although at the expense of sustained lateral drift. Indeed, the same thrust vector cannot be simultaneously used to obtain both lateral and roll control since that requires directing the components of the same thrust vector in opposition. Consequently, one has to use separate thrust vectors for roll and lateral control. As discussed in the paper, greater potential exists for thurst vectored roll control than for lateral control. In fact, the approach is quite clear after one examines Fig. 12; that is, in the event of a lateral disturbance, the vehicle ground plane excursions could be minimized by using the thrust vectored directional control to head into the wind. Simultaneously, the lateral thrust could be used to generate roll control moment for maintaining vehicle roll attitude. As noted in the paper, pilot-in-the-control-loop simulation would give better insight into these novel control techniques.

Received Sept. 4, 1984.

*Specialist Engineer, Defense Systems Division. Associate Fellow AIAA.

†Development Engineer, Defense Systems Division.

We believe adequate description of the airship configuration and its physical and aerodynamic properties have been provided in this paper and in its cited references. The aerodynamic estimation techniques used here are based on both analytical and test data of past airship designs which are proprietary. We regret any inconvenience this may cause Mr. Lowe in his independent checking. It is felt that the estimation techniques available in the open literature augmented with good engineering judgement would help in such an endeavor.

Finally, it is observed that one should be familiar with airship flight dynamics and operational practice in airship ground handling in order to readily appreciate the results presented here. For the novice, we suggest a careful review of this paper and its references as a first step in this regard. Although we welcome our peers to check our results independently, one has much more to accomplish by pursuing further studies, indicated in the concluding remarks section of the paper.

References

[1] Nagabhushan, B. L. and Faiss, G. D., "Thrust Vector Control of a V/STOL Airship," *Journal of Aircraft*, Vol. 21, June 1984, pp. 408-413.

Comment on "Apparent-Mass Coefficients for Isosceles Triangles and Cross Sections Formed by Two Circles"

Peter R. Payne*
Ketron, Inc., Annapolis, Maryland

IT was a pleasure to read Huang and Chow's[1] elegant paper and learn that such fundamental work is still being funded by the Air Force. But I have a problem with their Fig. 13, the curve from which is replicated in my Fig. 1, together with Taylor's[2] result for a rhomboid. One would expect the two curves to be very similar, and yet they are not.

There is little doubt that Taylor's relationship is correct. Without knowing he had published (we may admit to regarding the British *Philosophical Magazine* as being obscure in Berlin, Moscow, or Boston), the analysis was repeated by Wagner,[3] Sedov,[4] Monaghan,[5] and Bisplinghoff and Doherty,[6] all getting the correct result. (Ferdinande[7] was less fortunate.) And as implied by Fig. 2, abstracted from Payne,[8] all comparisons with experiment made so far have given excellent agreement.

An example of two different wedge shapes, abstracted from Yim,[9] is given in Fig. 3. This is the sort of fairly close agreement that would be expected in the Fig. 1 presentation, but is not found. Indeed, increasing the deadrise from $\theta = 0$ to 20 deg gives a 15% *increase* in added mass, according to Huang and Chow, rather than the roughly 11% reduction with which most naval architects are familiar. Perhaps the authors will find an error if they check their analysis for this case. I hasten to add that the other cases I checked, at known limits, were correct, and that the authors have made a valuable contribution to our knowledge.

I would also like to correct the record on the origins of slender-body theory, which, the authors say, "was suggested by Jones,[10] generalized by Bryson,[11] and later summarized by Nielsen.[12]" As an airplane designer[13] turned naval architect,[14]

Received Sept. 20, 1983.

*Group Manager.

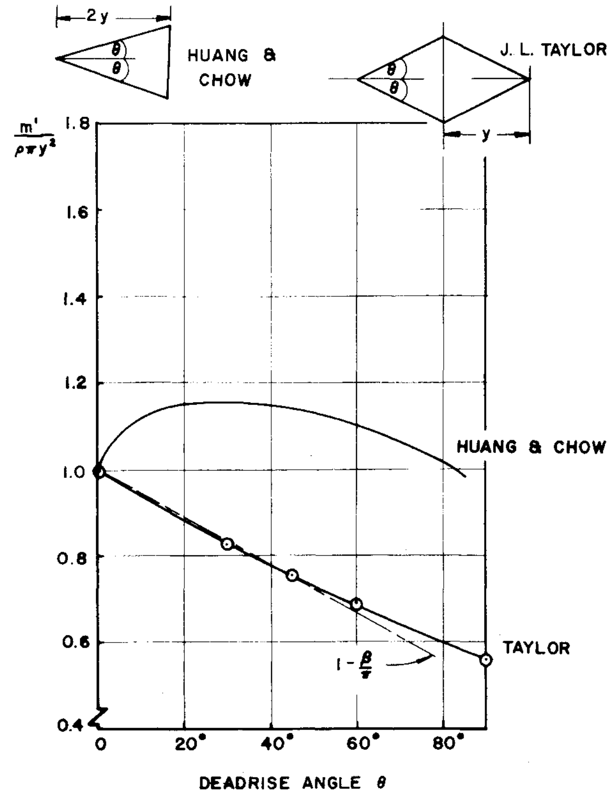

Fig. 1 Huang and Chow's isosceles triangle added mass compared with that of Taylor's rhomboid.

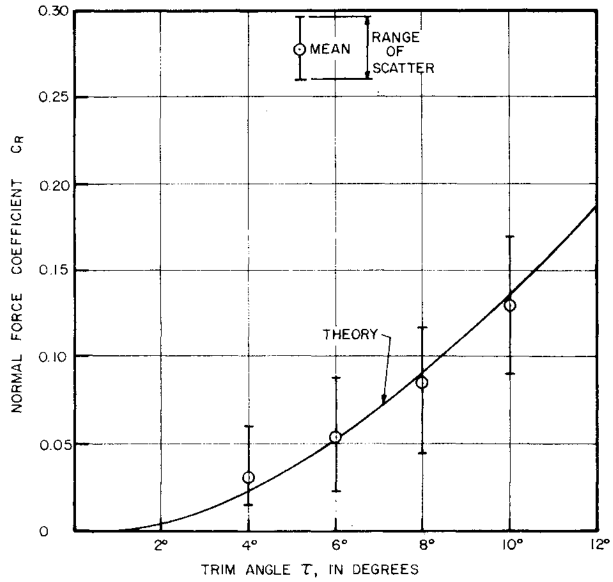

Fig. 2 Shoemaker's[37] dry chine data for a deadrise angle of $\beta = 30$ deg compared with virtual mass theory.

I will admit that aerodynamics is generally ahead of hydrodynamics, but not always. Jones pays tribute to Munk's much earlier paper[15] as being the first publication of what we call today "slender-body theory" in aeronautics and "virtual mass theory" in hydrodynamics, even though it ought to be "added mass." Then, perhaps unknown to Jones, von Kármán[16] proposed its use in connection with calculating the landing impact of seaplanes. Subsequent contributions to the virtual mass theory of planing were made by Pabst,[17] Wagner,[3] and Kreps[18] before the war, and of course many others afterward. Payne[19] has reviewed those which apply to the vertical impact of a wedge. And, in a series of subsequent