

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 Faiss¹ 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 gimbaled 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 DeLaurier³ 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 Sumantran⁴ is a particularly informative example of other work being done in this field.

References

- ¹Nagabhushan, B. L. and Faiss, G. D., "Thrust Vector Control of a V/STOL Airship," *Journal of Aircraft*, Vol. 21, June 1984, pp. 408-413.
- ²Evans, J. R. and DeLaurier, J. D., "The Shenandoah Flies Again: A Computer Simulation," AIAA Paper 81-1325, July 1981.
- ³Jones, S. P. and DeLaurier, J. D., "Aerodynamic Estimation Techniques for Aerostats and Airships," *Journal of Aircraft*, Vol. 20, Feb. 1983, pp. 120-126.
- ⁴Curtiss, 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 thrust 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. Copyright © American Institute of Aeronautics and Astronautics, Inc., 1984. All rights reserved.

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

†Development Engineer, Defense Systems Division.

Received July 1, 1984. Copyright © American Institute of Aeronautics and Astronautics, Inc., 1984. All rights reserved.

*Research Associate, Subsonic Aerodynamics Group.