

Technical Comments

Comment on "Aerodynamic Estimation Techniques for Aerostats and Airships"

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JONES and DeLaurier¹ have undertaken a difficult task in developing methods for estimating the aerodynamic forces on aerostats and airships. We trust that their results will be of practical utility to workers in this field. However, the portion of their paper that deals with the modeling of forces in unsteady flow has errors in the theory that users should be aware of. In particular, Eq. (45) of the paper is wrong. It reads

$$\dot{w} = \dot{W} + \dot{P}y - \dot{Q}x - Pv + Qu \quad (1)$$

In fact, w is defined correctly in Eq. (14) of Ref. 1, and its time rate of change \dot{w} (for a quasirigid vehicle with $\dot{y} = \dot{x} \approx 0$) is

$$\dot{w} = \dot{W} + \dot{P}y - \dot{Q}x \quad (2)$$

This follows clearly and simply from the definitions of the quantities in Eq. (14); w is nothing other than the component, along the z -body axis, of the inertial velocity of the center of the panel (slice). The authors arrive at their incorrect equation (45) by a convoluted and erroneous argument following Eq. (40). The source of the error appears to be an invalid statement in Eq. (41). The vector r cannot be both as in Eq. (14) and in Eq. (41); according to the definition of r preceding Eq. (14), r is constant in the body-fixed frame, so that $\dot{r} = 0$, whereas in Eq. (41) $\dot{r} \neq 0$. The incorrect value of \dot{w} is then substituted into Eq. (38), which is the strip-theory application of an exact theoretical result. An erroneous expression for the dZ_I force component is then obtained in Eq. (46). It should read

$$dZ_I = -\rho[k_3(\dot{W} + \dot{P}y - \dot{Q}x) - k_1'Qu + k_2'Pv]Ad\xi \quad (3)$$

This error carries through into Eq. (47) and, of course, in a similar way, into expressions for the X_I and Y_I forces. One consequence is that the aerodynamic derivatives Z_q , M_q , Y_r , and N_r will all have extra erroneous terms related to terms such as Qu in Eq. (1).

When applied to the steady rotating arm experiment, to which the paper refers, the force Z_I for an axisymmetric body would correctly read [noting that only the Q and u components in Eq. (3) are different from zero in that case]:

$$dZ_I = [\rho k_1'Qu]Ad\xi \quad (4)$$

If the authors have found that additional terms in this equation are needed to produce agreement with experiment then that is an empirical consequence of the real fluid properties, and cannot be justified by recourse to an ideal-fluid theory.

We have not calculated any examples to see what effect the errors in the paper have on numerical results.

References

- ¹Jones, S. P. and DeLaurier, J. D., "Aerodynamic Estimation Techniques for Aerostats and Airships," *Journal of Aircraft*, Vol. 20, Feb. 1983, pp. 120-126.

Reply by Authors to B. Etkin and G. D'Eleuterio

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CRITICISM by Professor Etkin is not taken lightly, especially when it is so unequivocal. In this case we maintain that our analysis is correct. The question raised is fundamental, of importance not only to the dynamics of airships, but of missiles, submarines, and wide-body aircraft. It is appropriate, therefore, that it should be aired in a public forum.

The terms to which objection is taken represent the convective acceleration, $-(V \cdot \nabla)V = -\omega \times V$ in our coordinate system. Omitting these terms assumes apparent mass behaves as a rigid body for which $\dot{r} = 0$. While this appears to be the case in the solutions given by Lamb¹ for a rotating and translating body, it is true only at closure, to which his solutions apply. Lamb's solutions cannot be obtained from strip theory without including the convective acceleration, which vanishes at closure. For nonclosure, to which our analysis applies, these terms must be included. Confirmation of this is found in Brown,² Schlichting and Truckenbrodt,³ and Multhopp,⁴ whose formulations agree with ours, including the term due to convective acceleration.

To illustrate, consider a body of revolution rotating and translating in its vertical plane. For simplicity, assume a slender body for which

$$K = k_3 = 1; \quad k_1 = 0$$

and a reference point at the nose about which the body rotates. In the nomenclature of our paper,

$$w(\xi) = W + \xi Q, \quad u = U \quad (a)$$

Neglecting cross-flow friction drag, the vertical force is

$$Z = Z_a + Z_I \quad (b)$$

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