Technical Comments

Comment on "Effect of Stabilizer Dihedral and Static Lift on T-Tail Flutter"

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IT is reassuring in an engineering sense to see in Ref. 1 that the archaic methods of strip theory and lifting-line theory can still be made to arrive at reasonable solutions to modern problems. However, the strip theory employed in Ref. 1 lacks many of the refinements of the modified strip theory of Yates[2] and, more significantly, it does not possess the growth potential to treat the general problem of the T-tail with partial span elevators and rudders. Hence, the experimental correlation achieved (*a posteriori?*) in Ref. 1 is a necessary but *insufficient* condition for validation of the authors' method. It would have been more informative if the authors had utilized their experimental data to evaluate modern methods for calculating the aerodynamic interference loads on the T-tail. However, before surveying these modern methods we might add four historical references[3-6] on early T-tail investigations to the authors' list.

The earliest applications of lifting-surface theory to the T-tail configuration were made by Stark[7] and Davies.[8] General discussions of interference problems have been given by Ferrari,[9] Ashley and Landahl,[10] Landahl and Stark,[11] Laschka,[12] and Ashley and Rodden.[13] A symposium on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces was sponsored by AGARD in 1970 and eight of the fifteen papers contained in the conference proceedings[14] were related to the T-tail problem. A comparison of results computed by different methods for wing-tail-fin combinations, taken two a time, is the subject of a recent AGARD report[15] by this commentator. Interfering lifting-surface methods contain none of the limitations on aspect ratio, taper ratio, sweep, and compressibility effects that are implicit in strip theory and lifting-line theory.†

The importance of static deformation of the stabilizer should not have come as such a surprise to the authors since the change in dihedral of a wing under load factor has been recognized for many years (although not in the stability and control textbooks) as an important aspect of lateral-directional motion at limit load factor. This was first considered by Lovell[19] in 1948, and an analysis of the problem by lifting-surface methods was outlined by this commentator in 1965[20]; Ref. 20 also contains some experimental correlation but only with an earlier simplified method[21] and not with a lifting-surface method. The fact that the dihedral effect of a flexible wing typically doubles at limit load factor suggests that the stabilizer trim load is an essential parameter in T-tail flutter analysis, as the authors of Ref. 1 eventually observed.

A final criticism of Ref. 1 is the authors' inconsistency in treating the rotary effects of the stabilizer. The rolling moment due to yawing was included, but the yawing moment due to rolling was neglected even though the Japanese work in this connection was cited. The authors could have used the quasistatic approximation of stability and control (see, e.g., Seckel[22]) or they could have used the oscillatory strip theory of Garrick.[23] The rolling moment due to yawing C_{l_r} in terms of the lift coefficient C_L for a wing is frequently approximated as $C_{l_r} = C_L/4$, and the yawing moment due to rolling C_{n_p} is taken as $C_{n_p} = -C_L/8$; we cannot therefore conclude that the latter effect is negligible relative to the former. Estimation of C_{n_p} by the Vortex-Lattice Method was discussed in Ref. 24. The current state-of-the-art in lifting surface theory for calculating distributions of induced drag (i.e., C_{n_p}) is typified by Lan's Quasi-Vortex-Lattice Method,[25] and his extension to the oscillatory case[26] permits the estimation of higher order derivatives, e.g.,

$$C_{n_{\dot{p}}} = \frac{\partial C_n}{\partial(\dot{p}b^2/4V^2)}$$

Lan's application of his Quasi-Vortex-Lattice Method for estimation of lateral-directional stability derivatives in general has just appeared in Ref. 27.

We conclude by noting that the state-of-the-art of T-tail flutter analysis still needs advancements, particularly in the estimation of the moments caused by yawing motion of the horizontal stabilizer in a compressible flow. However, the state-of-the-art is considerably more advanced than Ref. 1 leads us to believe.

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†It may also be of historical interest that the development of the subsonic Doublet-Lattice Method[16-18] was primarily motivated by concern for the T-tail/elevator/rudder interference problem.

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Editor's Comments Concerning "Remarks on Thin Airfoil Theory"

IN June 1977, Abraham Miller identified the error in Rajendra Bera's Engineering Note (*J. Aircraft*, Vol. 14, 1977, pp. 508-509). Dr. Bera published an Errata (*J. Aircraft*, Vol. 14, Nov. 1977, p. 1248). In January 1978, Mr. Miller corresponded with the *Journal of Aircraft* stating that the equation in the Errata was correct only for $n=1$ and $n=2$. Subsequently, a second Errata by Dr. Bera was published (*J. Aircraft*, Vol. 15, May 1978, p. 320). Equation (5) of the second Errata corresponds to an equation stated in Mr. Miller's letter of June 1977. Hence, Mr. Miller should have first claim to the results.

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