Comment on "Canard-Wing Interaction in Unsteady Supersonic Flow"

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An application of various supersonic oscillatory aerodynamic computer programs was made in Ref. 1 to an idealization of the SAAB 37 Viggen canard airplane. It was suggested that the harmonic gradient method (HGM) of Chen and Liu[2] only had accuracy comparable to the PG version of Hounjet's potential gradient method.[3] However, the HGM has been extended from a velocity potential formulation to an acceleration potential formulation since the publication of Ref. 2. The formulation of this HGM/acceleration-potential method has been published in Ref. 4, and the associated computer program, known as the ZONA51C code, now has comparable accuracy to Hounjet's CP method.[5] It seems appropriate to compare the newer harmonic gradient results to the NLR SPNLRI-CP results on the Viggen configuration.

The calculations were carried out in the Flutter Solution Sequence of MSC/NASTRAN for the Viggen idealization of Ref. 1 shown in Fig. 1. (ZONA51D, an improved version of ZONA51C, has been incorporated into Version 67 of MSC/NASTRAN in a new option as a variation on the subsonic Doublet Lattice Method since the aerodynamic modeling is identical for the two methods; the branching within MSC/NASTRAN is simply determined by the Mach number.) The canard is slightly above the wing plane by a distance of 0.1 length units. The generalized force $Q_{1,2}$ shown is the lift coefficient of the wing due to a unit rotation of the canard about its midchord. The lift coefficient is obtained by dividing the generalized force by the dynamic pressure and the square of the wing span (1.20 units). As in Ref. 1, the wing lift is calculated by considering two rigid-body modes of motion, the first being the wing alone undergoing unit plunging, and the second being unit canard rotation. (Example HA75H of Ref. 6 illustrates the application of MSC/NASTRAN to this task, including the necessary DMAP Alters.) The reduced frequency is based on a reference semichord of 1.00 unit.

The results are shown in Fig. 1 and almost coincide with the NLR SPNLRI-CP results up to the high reduced frequency of $k = 5.0$. To verify convergence, two aerodynamic element ("box") idealizations were considered. In the first, the canard was divided into 8 equal width strips with 8 equal chordwise divisions, and the wing was divided into 12 equal width strips and 12 equal chordwise divisions, giving a total of 208 boxes. In the second idealization, the equal divisions were 10 × 10 on the canard and 20 × 20 on the wing for a total of 500 boxes. The two sets of results agreed within plotting accuracy and are not distinguished in Fig. 1.

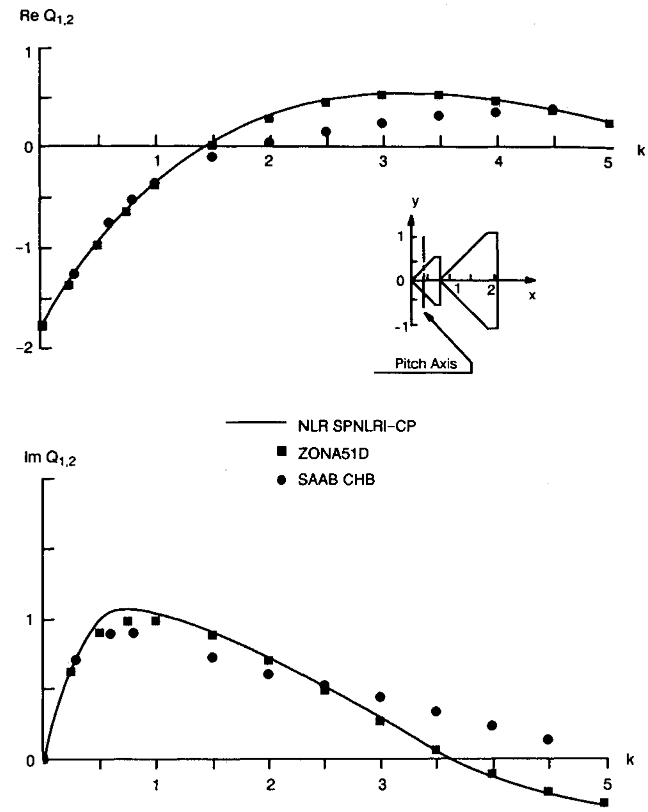

Fig. 1 Real and imaginary part of the lift on the main wing due to pitch of the canard, $M = 1.054$.

Stark's Characteristic Box Method[7] (CHB) results are also shown in Fig. 1. Although there are differences from the other results, these differences are not substantial. This suggests that the supersonic calculations based on Stark's method are reasonably accurate in the AGARD comparative study of interfering lifting surface oscillatory aerodynamic loads.[8]

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