# Flutter Margins for Multimode Unstable Couplings

bending and torsion modes with analysis by a Routh criterion for stability. The method was formulated for a two-mode flutter mechanism but has since been extended to consider one- [14] or three-mode [15] instability or generalized multimode couplings [16,17]; however, these methods are essentially using more terms from the Routh criterion and, thus, may have difficulties in implementation.

The essence of the method is to consider the characteristic polynomial, $; \bar{q}$ , that describes the poles, , of the continuous-time aeroelastic system whose dynamics vary with dynamic pressure, $\bar{q}$

$F_{ij}$ 

### B. Flutter Margins

A set of flutter margins are computed using the original and extended formulations of the Zimmerman-Weissenburger approach. These margins, as shown in Fig. 2, have large variations in accuracy. Each set of margins shows questionable accuracy at low-speed test points, but each set of margins improves significantly as the test point approaches the flutter speed.

The original formulation based on modal pairs has 10 sets of such pairings. Of these, only the modal pair of f4–5g is consistently accurate at all test points, as shown in Fig. 2a. The modal pair of f3–4g never correctly predicts the flutter speed; however, the resulting predictions are reasonably close and well behaved throughout the flight envelope. The modal pairs of f2–

couplings have dramatic increases in confidence as the test point increases beyond 425 KEAS.

These results clearly show a strong correlation between the confidence metric and the accuracy of the associated predictions for flutter margins. The predictions with the highest confidence are not always the most accurate; however, a prediction with a consistently high level of confi