# Technical Comments

AIAA 82-4166

## Comment on "Estimation of Flutter Boundary from Random Responses Due to Turbulence at Subcritical Speeds"

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THERE are two comments which need to be made with regard to a statement made by Drs. Matsuzaki and Ando.[1] They stated that, "It is evident that this estimation technique of the flutter boundary is quite effective even for the signals which contain more than two degrees of freedom, as is seen [in their plot of stability parameter, frequency, and coefficients vs dynamic pressure for the three mode analysis] where the data at the lowest third and fourth pressure should be neglected." It is only evident when all of the data have been collected and the critical speed is known before the analysis is done. For the three-mode case presented, the first three points indicated flutter would occur just above 0.6 kg/cm². If the first three points were the only information that the engineer had, and this would be a normal sequence of events, then the test would have to be halted. What is not indicated in the paper is a procedure for determining when data can safely be omitted when all the data has not been obtained.

Second, subcritical analysis of flight test data is not only carried out to allow for extrapolation of test data to determine the critical speed, but also to allow for analytical/experimental data comparison throughout the flight envelope instead of just at the critical speed. It would have been of interest to see a comparison of the method applied to a numerical model of wind tunnel model/test and the experimental model/test data for both the two- and three-mode cases.

Because there are differences between the results obtained for the two-mode analysis and the three-mode analysis of the same experimental data, a numerical example of a three-mode case would seem to be in order.

### Reference

[1]Matsuzaki, Y. and Ando, Y., "Estimation of Flutter Boundary from Random Response Due to Turbulence at Subcritical Speeds," *Journal of Aircraft*, Vol. 18, Oct. 1981, pp. 862-868.

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## Reply by Authors to C.D. Turner

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THE authors would like to thank Professor C.D. Turner for his comments on our paper (Ref. 1). The experiment described in the paper was done by the authors in 1977. The present estimation method has been proposed after several different theories and data processings were used in analyzing the measured signals.[2-4] Improvements in data analysis and others are still being made while the method is applied to the signals obtained from the flight records and responses measured in different wind tunnels.

Let us describe a procedure for estimation of the boundary which is now recommended:

1) Measure the response at a subcritical speed.

2) Evaluate a set of the AR coefficients from the signal measured.

3) Compare this set with those already calculated at lower speeds.

4a) Return to step 1 to measure the response again at the same speed, providing the set of newly calculated values deviates greatly from that obtained at the last speed.

4b) Otherwise, make a new estimation using all the sets evaluated up to this point.

5) Determine the next speed at which the response is to be measured.

The above procedure is repeated until the speed range is covered so that a satisfactory estimation may be obtained. In Ref. 1, the reliability of the data was examined comparing the sets of frequencies and dampings. However, the examination which is based on the sets of all AR coefficients is more straightforward and reliable. See Table 1 for the AR coefficients of the three mode analysis. Many of the values on the third and fourth rows diverge significantly from those of the other rows. This would become much more evident if the coefficients were plotted on a graph. Even though all of the data have not been collected and no critical speed is known, one would naturally want to repeat the measurement at the third or fourth dynamic pressure if the information on the coefficients at the first to fourth pressures are available during the test.

It has also been of interest to see the comparison between the results obtained by the present method and numerical model. However, since the flutter or divergence speed is the most important quantity to be estimated, we have concentrated our efforts on establishing the estimation method of the instability boundary.

**Table 1 Estimated values of the AR coefficients [$\hat{b}(m)$; m = 0,1,...,7]**

| Q, kg/cm² | $\hat{b}(7)$ | $\hat{b}(6)$ | $\hat{b}(5)$ | $\hat{b}(4)$ | $\hat{b}(3)$ | $\hat{b}(2)$ | $\hat{b}(1)$ | $\hat{b}(0)$ |
|---|---|---|---|---|---|---|---|---|
| 0.53 | −2.72 | 3.84 | −4.07 | 3.98 | −3.72 | 2.91 | −1.49 | 0.391 |
| 0.59 | −2.68 | 3.64 | −3.66 | 3.51 | −3.36 | 2.76 | −1.50 | 0.411 |
| 0.64 | −3.19 | 5.19 | −5.79 | 5.42 | −4.76 | 3.71 | −2.00 | 0.548 |
| 0.67 | −2.58 | 3.35 | −3.25 | 3.11 | −2.92 | 2.33 | −1.22 | 0.323 |
| 0.75 | −2.90 | 4.13 | −4.08 | 3.79 | −3.66 | 3.15 | −1.80 | 0.504 |
| 0.76 | −3.12 | 4.89 | −5.17 | 4.66 | −4.12 | 3.34 | −1.86 | 0.510 |
| 0.80 | −3.06 | 4.62 | −4.68 | 4.21 | −3.93 | 3.43 | −2.01 | 0.576 |
| 0.83 | −3.18 | 5.05 | −5.26 | 4.53 | −3.82 | 3.11 | −1.80 | 0.526 |
| 0.84 | −3.21 | 5.17 | −5.45 | 4.66 | −3.83 | 3.04 | −1.73 | 0.499 |
| 0.86 | −3.26 | 5.34 | −5.78 | 5.08 | −4.16 | 3.20 | −1.77 | 0.499 |
| 0.90 | −3.19 | 5.10 | −5.28 | 4.47 | −3.71 | 3.03 | −1.76 | 0.517 |

### References

[1]Matsuzaki, Y. and Ando, Y. "Estimation of Flutter Boundary from Random Response Due to Turbulence at Subcritical Speeds," *Journal of Aircraft*, Vol. 18, Oct. 1981, pp. 862-868.

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