STATISTICAL DISCRETE GUST METHOD FOR ATMOSPHERIC TURBULENCE LOADS IN AEROELASTIC RESPONSE MODELS

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ABSTRACT

The Statistical Discrete Gust (SDG) method proposed by Jones [1] represents an approach to assessing severe gust and continuous turbulence loads on aircraft. The standard methods, Power Spectral Density (PSD) and Discrete Gust (DG), capture the nature of atmospheric disturbances in different concepts, while SDG method unify both representations using a discrete element build-up and statistical modeling the non-Gaussian stochastic characteristics of extreme gusts for evaluate the aircraft's critical response and loads based on a worst-case approach.

The objective is the assessment of aeroelastic response and dynamic loads due to gust and turbulence encounters by implementing the SGD method in two different didactic aeroelastic response models: typical-section (TS) and assumed flexible modes (AFM) aircraft. The SDG method represents the gust profile as an aggregate of discrete smooth ramps with first half of the one-minus-cosine function, ramp-hold elements. This input in aeroelastic system results in a set of responses. Then, it uses a tuning process for build a critical gust pattern and implement statistical model to establish the patterns in a equiprobable basis.

In the present work, the set of ramp-hold responses are obtained with a proposed methodology base on [2] that uses FRF (frequency response functions), Inverse Fourier Transform (with the IFFT algorithm) and signal processing techniques to calculate responses and integrate loads. The linear system SDG formulation and the restricted tuning process implementation are used for simplification. Comparing the tuned responses for TS and AFM models, the first one, being a stiffness supported system, have a single ramp element composing the critical pattern in contrast to multiple elements for the second model.

In the final result was possible to obtain the aircraft critical pattern for generalized coordinates responses and dynamic loads. Also, validate the numerical results with comparison to PSD in Design Envelope and Mission Analysis approaches for continuous turbulence. The comparison indicates that a meaningful overlap between PSD and SDG indeed exists for the didactic aeroelastic models adopted, as meeting the conditions for the overlap, the ratio of SDG-PSD dynamic responses analyzed in this work is in agreement with the reference values from [3] and [4].

References

[1] J.G. Jones, Statistical-discrete-gust method for predicting aircraft loads and dynamic response. Journal of Aircraft, v. 26, n. 4, p. 382–392, 1989.

[2] P. F. Taylor, R. K. Narisetti, A. Stewart, HILDEBRAND, S. Advances in aeroelasticity and structural dynamics in the gulfstream dynamics group. In: AIAA SCITECH 2023 Forum. p. 1887. Proceedings 2023.

[3] B. Perry III, A. S. Pototzky, J. A. Woods, Nasa investigation of a claimed 'overlap' between two gust response analysis methods. Journal of Aircraft, v. 27, n. 7, p. 605–611, 1990.

[4] J. G. Jones, Documentation of the linear statistical discrete gust method. [S.l.]: Office of Aviation Research, Federal Aviation Administration, 2004.