Formulating an advanced severe gust load spectrum for transport aircraft, grounded in analyzed measured load data

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Abstract

Developing a severe load spectrum for transport aircraft structures is essential to enhance the correlation between full-scale fatigue testing results and operational service conditions. This study addresses the lack of standardized methods for severe spectrum development by proposing an innovative approach to constructing a severe gust load spectrum based on the acceleration cumulative exceedance surface.

Measured load data were analyzed using a novel model that employs the cumulative exceedance surface to characterize exceedance number variations. An improved multivariate Markov Chain Monte Carlo sampling method was utilized to estimate fleet fatigue damage distribution, enabling the precise determination of severe spectrum severity and its corresponding cumulative exceedance surface. A severe gust load spectrum was then constructed based on this surface.

The proposed methodology minimizes the randomness of peak-trough pairs by incorporating the correlation between spectrum peaks and troughs, thus reducing variation in fleet fatigue damage. This reduction decreases the required severity of fatigue damage in severe spectra, improving the efficiency of fatigue analysis. Extending the conventional one-dimensional curve representation to a two-dimensional surface, this approach provides a more accurate depiction of acceleration cumulative exceedance number variations, offering a significant advancement in fatigue damage calculations. The findings serve as a valuable reference for developing severe load spectra for transport aircraft, promoting improved reliability and structural performance.

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