Experimental Characterization of Flutter in a Straight Spar Using Modal Analysis and Wind Tunnel Testing

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Source JOURNAL OF AERONAUTICS ASTRONAUTICS AND AVIATION

View Journal Impact

Volume: 58 Issue: 3 Page: 355-363

DOI: 10.6125/JoAAA.202603_58(3).06

Published MAR 2026

Indexed 2026-04-28

Document Type Article

Abstract This study presents the experimental design and validation of a Straight Spar structure intended for aeroelastic flutter testing, particularly for fixedwing UAV applications. The main objective is to develop a spar that exhibits flutter onset within a target velocity range of 20-25 m/s. The research employs fully experimental methods, including vibration testing for modal analysis and wind tunnel testing to observe flutter behavior. Comparative analysis with simulation results was conducted for validation. The designed spar successfully demonstrated flutter at 20 m/s, with only a 0.32 m/s deviation from simulation predictions. Furthermore, both experimental and simulation methods identified the bending and torsion mode shapes at nearly identical frequencies, confirming strong agreement and model validity. These findings affirm the suitability of the proposed spar design for UAVs operating within the specified flight speed range and lay the foundation for future studies on aeroelastic energy harvesting.

Keywords **Author Keywords:** Wing Spar; Flutter; Aeroelastic; Modal Analysis; Wind Tunnel

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Categories/ Classification

Research Areas: Engineering

Citation Topics: 7 Engineering & Materials Science › 7.63 Mechanics › 7.63.1328 Topology Optimization