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Aeroelastic Uncertainty and Reliability of Undamaged and Damaged Composite Airframes

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ABSTRACT

Aircraft structures, due to material and manufacturing variability and possible material and structural degradation over time, exhibit variability of their aeroelastic characteristics. Damage, with its own probabilistic characteristics regarding type, size, and location, as well as maintenance procedures with the uncertainty of their damage detection and repair quality, all add uncertainty to the aeroelastic stability and dynamic response problems. Linear and nonlinear aeroelastic behavior mechanisms can be affected by such uncertainties which can lead to variability of flutter speeds, limit cycle oscillation behavior, and dynamic stresses due to gust excitation in a fleet of aircraft at any given time and over the time of service. With flight conditions during operation also subject to certain uncertainties, the question of the probability that a damaged airplane with compromised aeroelastic safety margins will find itself flown into flight conditions that would lead to failure becomes an important question for designers, government agencies, and flight operators.

Over the last few years research at the University of Washington addressed these issues by pursuing three directions; (a) the development of aeroelastic and aeroservoelastic probabilistic reliability methodology for uncertain composite aircraft; (b) the development of a practical nonlinear aeroelastic modeling approach capable of capturing global and local nonlinear structural behavior in composites; and (c) an experimental wind tunnel aeroelastic research program supported by numerical simulation to study the behavior of damaged composite tail / rudder systems as prototype composite airframe systems.

The talk will present an overview of the University of Washington's work in this area and present future challenges.