AAE FALL COLLOQUIUM SERIES

Load Alleviation for Very Flexible Aircraft

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Abstract:
Transport aircraft designs are evolving towards having wings with higher aspect ratio to improve aerodynamic performance and meet demanding flight mission specifications for reduced fuel consumption, lower emissions, and more efficient flight. With the resulting increased wing structural flexibility, flight loads also increase. Airworthiness certification mandated by regulatory agencies requires demonstrating that critical loads in these aircraft do not exceed specified limits that ensure safety and structural integrity. Active load alleviation schemes can enable reduced structural mass while satisfying certification requirements. Conventional approaches to maneuver load alleviation call for automatically deflecting control surfaces, such as elevons, to concentrate lift inboard and reduce the wing bending moment at critical stations. These control surfaces are deflected proportionally to some monitored parameters (e.g., load factor or wing curvature), which are obtained from sensor measurements.
This presentation will address the challenges encountered on load alleviation for very flexible aircraft (VFA). It will start by reviewing the unique aeroservoelastic challenges that arise from large deformations of the wings and coupled aeroelastics–flight mechanics behavior, and the importance of having a framework able to capture geometrically nonlinearities to allow the study of how the loads (and vibration) characteristics changes when compared with a more traditional, less flexible aircraft. This will be followed by a proposed control technique to enable maneuver load alleviation (MLA) based on reference governor and model predictive control. Based on these numerical studies, a half-aircraft model of a VFA is studied in the wind tunnel. The experimental results confirmed the ability of the control technique to reduce loads but also indicated remaining challenges to be address for such solution. The presentation will end with a short outlook on how we intend to extend the MLA to also address gust load alleviation (GLA) and how to bring those load alleviation concepts into the multidisciplinary aircraft design.

Biography
Carlos E. S. Cesnik is the Richard A. Auhll Aerospace Engineering Department Chair and Clarence L. (Kelly) Johnson Collegiate Professor and Professor of Aerospace Engineering at the University of Michigan. He is also the founding Director of the Active Aeroelasticity and Structures Research Laboratory. His research interests have focused on computational and experimental structural mechanics and aeroelasticity; aerothermoelastic modeling, analysis, and simulation of hypersonic vehicles; coupled nonlinear aeroelasticity and flight dynamic response of very flexible aircraft; active vibration and noise reductions in helicopters; structural health monitoring for metallic and composite structures. He has over three decades of experience in the multi-fidelity, multi-physics modeling, design, simulation, and experimentation of various aircraft concepts, spanning fundamental and applied research.
Professor Cesnik is Fellow of the American Institute of Aeronautics and Astronautics, the Vertical Flight Society, and the Royal Aeronautical Society. He has over 350 publications as archival journal and conference papers, a recent book in dynamics of flexible aircraft, and several invited lectures in the areas of aeroelasticity, smart structures, structural mechanics, and structural health monitoring. Professor Cesnik has been an active private pilot since 1981.

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