Computational Modeling for Manufacturing and Certification of Future Aerostructures

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The current practice of designing composite airframe structures relies on extensive testing, coupled to a bottom-up, pyramidal building block approach, to ensure structural integrity and damage tolerance. Reducing the number of tests can lead to a substantial decrease in total design cost of many vehicles. Cost reduction is enabled by developing high fidelity computational models which can provide valuable information regarding the performance of a structure up to and including failure. This activity, which is now a major area of research falls under the broad umbrella of "virtual" testing, and includes parallel activities such as ICME (integrated computational materials science and engineering), and "digital twin" (the process of creating a high fidelity computational model of individual aircraft, to integrate computation of structural deflections and temperatures in response to flight conditions, with a depository of local damage evolution so that the "state" of the vehicle is updated and current at any given time). With a view towards addressing future, robotically manufactured aerospace structures, this talk will address elements of ICME, to analyze the effect of the curing process on the in-service performance of fiber reinforced composite structures. A polymer curing model based on the notion of polymer networks that are continuously formed in a body of changing shape due to changes in temperature, chemistry and external loads is used in conjunction with multiple fiber representative volume elements (RVE) to assess the strength of the RVE when subjected to mechanical loads after virtual curing. Nonlinear material response, including damage and failure, is incorporated in conjunction with the mesh-objective crack band model. It is shown that significant stresses can develop during cure, and depending on the cure cycle, the matrix material can be subjected to damage prior to insertion in service. The notions of composite strength are re-examined in light of the results obtained. Examples from continuous fiber reinforced polymer matrix composites and textile composites will be presented.

Short Biography of Anthony M. Waas

Professor Anthony M. Waas is the Boeing Egtvedt Endowed Chair Professor in the William E. Boeing Department of Aeronautics and Astronautics at the University of Washington, Seattle. Professor Waas's research interests are: computational modeling of lightweight composite structures, Automated manufacturability, 3D printing in aerospace, damage tolerance of composites & mechanics of textile composites. Professor Waas was the Felix Pawlowski Collegiate Chair Professor of Aerospace Engineering and Director, Composite Structures Laboratory at the University of Michigan, from 1988 to 2014. Professor Waas is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineering (ASME), and the American Academy of Mechanics (AAM). He is a recipient of several best paper awards, the 2016 AIAA SDM award, the AAM Jr. Research Award, the ASC Outstanding Researcher Award, and several distinguished awards from the University of Michigan. He received the AIAA-ASC James H. Starnes, jr. Award, 2017, for seminal contributions to composite structures and materials and for mentoring students and other young professionals. Professor Waas obtained his B.Sc in Aeronautics with First Class Honors from Imperial College, London, 1982, the MS and Ph.D in Aeronautics and Applied Mathematics (minor) from Caltech, 1983 and 1988, respectively.