Multiscale Modeling of Advanced Composite Materials and Structures: Choosing the Right Tool for the Job

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Composite materials and structures contain numerous inherent length scales at which various non-linear phenomena occur. Traditional analysis methods consider the composite to be a homogenous material with anisotropic properties, and do not account for any of the microstructural details. Using micromechanics and multiscale analysis techniques, it is demonstrated that incorporating the appropriate length scale into the numerical analysis of composite materials is necessary to capture the physics that results in the non-linear response of the material. Multiscale modeling at and across length scales ranging from molecular to structural (vehicle) is presented. A variety of computational tools are linked together to achieve the necessary modeling across the disparate length scales. The breadth of tools used to solve numerous, relevant structural aerospace engineering problems, at the appropriate scales, demonstrates the importance of flexibility in the skills of a structural aerospace engineer and the need for his or her toolbox to contain a variety of computational tools ranging in fidelity and efficiency. The research presented is part of work done for NASA's Space Launch Systems (SLS), Advanced Composites Project (ACP), Transformational Tools and Technologies (TTT), Composites for Exploration (CoEx), and Constellation programs.