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Multiscale Modeling in the Development of Light Weight, High Strength Carbon Nanotube Composites for Space Applications[1]

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The implacable arithmetic of the rocket equation tells us that the initial mass of a rocket increases exponentially with the change in velocity (delta-v) required to reach a target destination. As NASA contemplates manned missions to Mars and potential visits to other high delta-v deep space locations, reducing non-propellant mass will be critical in making these missions achievable, affordable, and scientifically productive. Because of the constant demand to increase the mass allocated to scientific payloads and life support equipment, vehicle designers are looking for ways to reduce the mass of both structural and non-structural components. While carbon fiber composites will certainly play an important role, their specific strength and stiffness are not sufficient to meet the mass reduction requirements for the mission designs mentioned above. To address this gap, a multi-institution collaborative team has been working for the past few years to advance the properties of carbon nanotube yarn-based composites, and recently demonstrated CNT composites with uniaxial specific strengths and moduli nearly equivalent to those of state-of-the-art aerospace-grade carbon fiber composites, despite a far from optimal microstructure. A modeling program, closely coupled with the experimental work, is also being established to provide insight into the structure and properties of this hierarchically structured material and to guide experimental efforts focused on improving the mechanical properties by a factor of three relative to current aerospace carbon fiber composites. This presentation will describe the current status of the modeling program, which spans the scales from atomistic molecular dynamics to systems analysis.

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