MUREP Small Business Technology Transfer (M-STTR) Planning Grants

Title: Scalable and Tailorable Thermoforming and Reforming of Large Composite Spacecraft Structures
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SUMMARY: Functional structures in space such as solar arrays, reflector antennas, and solar sails rely on large and shape-accurate mechanical structures for their performance, but today's launch fairings limit the structural size and mass that can be brought onto orbit. Composite deployable structures that can be elastically folded for launch and automatically deploy in space are the state-of-the-art approach to overcome the volume and mass constraints of launching large spacecraft components. However, composite deployable structures based purely on elastic deformation offer only incremental advances in volume efficiency, suffer from poor shape accuracy after deployment, and requires high capital investment for manufacturing.

This project proposes a novel composite material concept that provides tighter packaging efficiency, on-orbit shape adjustment, and is suitable for size-scalable manufacturing of composite structures, thereby solving all the current critical challenges. The proposed concept is a flexible conductive composite feedstock material based on high-temperature thermoplastic composite laminate with integrated carbon nanotube (CNT) films. The highly conductive CNT films act as in-situ heaters for energy-efficient thermoforming of the composite, removing the need for large, custom-built, and energy-intensive ovens. Combined with a high-temperature thermoplastic composite, the CNT films can reform the structure into a different shape and anneal the structure on demand. This capability allows the composite structure to have a tightly folded, compliant configuration for packaging, and an expanded, stiff configuration for operation, which leads to a dramatic improvement of volume efficiency without sacrificing structural performance and shape accuracy.

The ultimate goal is to demonstrate scalability, packaging efficiency, and shape accuracy of composite structures based on the conductive composite material. The technical objectives are: (1) production of CNT/thermoplastic films and CNT/thermoplastic/carbon-fabric prepregs with tailorable conductivity via an additive manufacturing method, (2) fabrication of deployable booms via in-situ thermoforming and reforming, (3) characterization of the packaging efficiency, structural stiffness, and shape accuracy, and (4) modeling of the electro-thermo-mechanical characteristics of the composite during manufacturing.

In this planning grant, we seek to establish a strong collaborative partnership between University of Central Florida (UCF) and Opterus Research & Development (Opterus) in the pursuit of the proposed innovation. The UCF team has years of experience and technical publications on composite manufacturing, structural mechanics, and spacecraft design. The core technologies for the proposed concept will come from UCF. Opterus is a fast-growing small business provider of spacecraft components and deployable spacecraft structures. The Opterus team comprises of industry veterans with decades of flight project experience and patents related to space systems, and will be responsible for transitioning the technology into viable products and identifying commercialization opportunities. Initial research on the technical and commercial aspects will be conducted in this project. The expected outcome is a competitive joint university-industry proposal for the upcoming NASA STTR award competition.