NASA STTR 2018 Phase I Solicitation

T12.01 Thin-Ply Composite Technology and Applications

Lead Center: LaRC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

The use of thin-ply composites is one area of composites technology that has not yet been fully explored or exploited.Â Thin-ply composites are those with cured ply thicknesses below 0.0025 in. and commercially available prepregs are now available with ply thicknesses as thin as 0.00075 in.Â By comparison, a standard-ply-thickness composite would have a cured ply thickness of approximately 0.0055 in. or greater.Â Thin-ply composites hold the potential for reducing structural mass and increasing performance due to their unique structural characteristics, which include (when compared to standard-ply-thickness composites):Â

- Improved damage tolerance.
- Resistance to microcracking (including cryogenic-effects).
- Improved aging and fatigue resistance.
- Reduced minimum-gage thickness.
- Thinner sections capable of sustaining large deformations without damage.
- Increased scalability.Â

These characteristics can make thin-ply composites attractive for a number of applications in both aeronautics and space.Â For example, preliminary analyses show that the notched strength of a hybrid of thin and standard ply layers can increase the notched tensile strength of composite laminates by 30%. Thus, selective incorporation of thin plies into composite aircraft structures may significantly reduce their mass. There are numerous possibilities for space applications.Â The resistance to microcracking and fatigue makes thin-ply composites an excellent candidate for a deep-space habitation structure where hermeticity is critical.Â Since the designs of these types of pressurized structures are typically constrained by minimum gage considerations, the ability to reduce that minimum gage thickness also offers the potential for significant mass reductions. For other space applications, the reduction in thickness enables: thin-walled, deployable structural concepts only a few plies thick that can be folded/rolled under high strains for launch (and thus have high packaging efficiencies) and deployed in orbit; and greater freedom in designing lightweight structures for satellite buses, landers, rovers, solar arrays, and antennas.Â For these reasons, NASA is interested in exploring the use of thin-ply composites for aeronautics applications requiring very high structural efficiency, for pressurized structures (such as habitation systems and tanks), for lightweight deep-space exploration systems, and for low-mass high stiffness deployable space structures (such as rollable booms or foldable panels, hinges or reflectors). There are many needs in development, qualification and deployment of composite structures incorporating thin-ply materials â€“ either alone or as a hybrid system with standard ply composite materials.Â

The particular capabilities requested for in a Phase I proposal in this subtopic are:Â

- New processing methods for making repeatable, consistent, high quality thin-ply carbon-fiber prepreg materials, (i.e., greater than 55% fiber density with low degree of fiber twisting, misalignment and damage, low thickness non-uniformity and minimal gaps in the material across the width). Prepreg product forms of interest have areal weights below 60 g/m^2 for unidirectional tape with tape widths between 6 and 100 mm wide, and below 130 g/m^2 for woven/braided prepreg materials.Â Matrices of interest include both toughened epoxy resins for aeronautics applications, and resins qualified for use in space.
- Initial process development in using thin-ply prepregs for component fabrication using automated tape layup or other robotic technologies.
- Contributing to the development of the design and qualification database though testing and interrogation of the structural response and damage initiation/progression at multiple scales including evaluation of environmental durability and ageing.
- Analysis and design tool validation and calibration to ensure that the technology to appropriately design, identify any application-specific shortcomings with suggested improvements,Â and certify thin-ply composite components is matured sufficiently to be used for NASA applications.
- Micromechanics models for spread-tow woven/braided laminates, including viscoelastic response.
- Development of testing methods adapted for thin-ply high-strain composite materials and structures, with particular interest to dedicated large deformation bending and creep tests.
- Engineering viscoelastic behavior of thin-ply laminates for controlled deployment of space structures.Â

The intention of a Phase II follow-on effort would be to develop or to further mature the necessary design/analysis codes, and to validate the approach though design, build, and test of an article representative of the component/application of interest to NASA.