AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE

2. AMENDMENT/MODIFICATION NUMBER: 0001

3. EFFECTIVE DATE: 02/12/2019

4. REQUISITION/PURCHASE REQUISITION NUMBER

5. PROJECT NUMBER *(If applicable)*

6. ISSUED BY / CODE

NASA Shared Services Center (NSSC)
Building 1111, Jerry Hlass Road
Stennis Space Center, MS 39529-6000

7. ADMINISTERED BY *(If other than Item 6)* / CODE

8. NAME AND ADDRESS OF CONTRACTOR *(Number, street, county, State and ZIP Code)*

CODE / FACILITY CODE

(X)

☐ 9A. AMENDMENT OF SOLICITATION NUMBER: NNX19SBIRSTTR

9B. DATED *(SEE ITEM 11)*: 02/05/2019

☐ 10A. MODIFICATION OF CONTRACT/ORDER NUMBER

10B. DATED *(SEE ITEM 13)*

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended. ☒ is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
(a) By completing items 8 and 15, and returning ____________ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or electronic communication which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by letter or electronic communication, provided each letter or electronic communication makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA *(If required)*

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NUMBER AS DESCRIBED IN ITEM 14.

CHECK ONE	
☐	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: *(Specify authority)* THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NUMBER IN ITEM 10A.
☐	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES *(such as changes in paying office, appropriation data, etc.)* SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
☐	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
☐	D. OTHER *(Specify type of modification and authority)*

E. IMPORTANT: Contractor ☐ is not ☐ is required to sign this document and return __________ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (*Organized by UCF section headings, including solicitation/contract subject matter where feasible.)*

This Amendment is hereby issued to:

1. Revise by adding language to Subtopic T12.01 Thin-Ply Composite Technology and Applications (STTR)

See Summary of Changes on SF30 Continuation Page

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER *(Type or print)*

16A. NAME AND TITLE OF CONTRACTING OFFICER *(Type or print)*

15B. CONTRACTOR/OFFEROR

(Signature of person authorized to sign)

15C. DATE SIGNED

16B. UNITED STATES OF AMERICA

BENJAMIN BENVENUTTI

Digitally signed by BENJAMIN BENVENUTTI
Date: 2019.02.12 15:02:20 -06'00'

(Signature of Contracting Officer)

16C. DATE SIGNED

Previous edition unusable

STANDARD FORM 30 (REV. 11/2016)
Prescribed by GSA FAR (48 CFR) 53.243

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

SUMMARY OF CHANGES

1. Revise **Subtopic T12.01 Thin-Ply Composite Technology and Applications (STTR)** by incorporating additional language.

FROM:

T12.01 Thin-Ply Composite Technology and Applications (STTR)
Lead Center: LaRC
Participating Center(s): LaRC
Related Subtopic Pointer(s): Z4.03

The use of thin-ply composites is one area of composites technology that has not yet been fully explored or exploited. 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. By comparison, a standard-ply-thickness composite would have a cured ply thickness of approximately 0.0055 in. or greater. 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):

- 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 of structures.

Thin-ply composites are attractive for a number of applications in both aeronautics and space as they have the potential for significant weight savings over the current state-or-the-art standard-ply materials due to improved performance. 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. The resistance to microcracking and fatigue makes thin-ply composites an excellent candidate for a deep-space habitation structure where hermeticity is critical. 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. 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 – either alone or as a hybrid system with standard ply composite materials. In particular, there is substantial interest in proposals that address manufacturability and production of composite structures utilizing thin-ply composites that at minimum develop the process and plan for the production of one prototype in Phase I and demonstrate reproducibility of prototype manufacturing and key parameter validation of repeated samples in Phase II. Another area requiring development is in new testing methods adapted for thin-ply, high strain composites for folded and rolled structures. The Phase II deliverables will depend on the aspect addressed, but in general will be documentation of the analytical foundation and process, maturing 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.

Relevance to NASA

The most applicable ARMD program is AAVP, and within that is Advanced Air Transport Tech. (AATT). Additional projects within AAVP that could leverage this technology Commercial Supersonic Tech. (CST), Hypersonic Technology (HT), and Revolutionary Vertical Lift Tech. (RVLT). Projects within TACP could also benefit. That is, any project in need of lightweight structures can benefit from the thin-ply technology development. Within STMD, projects with deployable composite booms, landing struts, and other very lightweight structures can benefit from the thin-ply technology.

References:

- https://www.nasa.gov/aeroresearch/programs/aavp
- https://www.nasa.gov/aeroresearch/programs/tacp
- https://www.nasa.gov/directorates/spacetech/home/index.html
- https://gameon.nasa.gov/projects/deployable-composite-booms-dcb/

TO:

T12.01 Thin-Ply Composite Technology and Applications (STTR)
Lead Center: LaRC
Participating Center(s): LaRC
Related Subtopic Pointer(s): Z4.03

The use of thin-ply composites is one area of composites technology that has not yet been fully explored or exploited. 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. By comparison, a standard-ply-thickness composite would have a cured ply thickness of approximately 0.0055 in. or greater. 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):

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Thin-ply composites are attractive for a number of applications in both aeronautics and space as they have the potential for significant weight savings over the current state-or-the-art standard-ply materials due to improved performance. 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. The resistance to microcracking and fatigue makes thin-ply composites an excellent candidate for a deep-space habitation structure where hermeticity is critical. 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. For these reasons, NASA is interested in exploring the use of thin-ply composites for aeronautics and space 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 – either alone or as a hybrid system with standard ply composite materials. In particular, there is substantial interest in proposals that address manufacturability and production of composite structures utilizing thin-ply composites that at minimum develop the process and plan for the production of one prototype in Phase I and demonstrate reproducibility of prototype manufacturing and key parameter validation of repeated samples in Phase II. Another area requiring development is in new analysis and testing methods adapted for thin-ply flexible composites for folded and rolled structures. The Phase II deliverables will depend on the aspect addressed, but in general will be documentation of the analytical foundation and process, maturing 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.

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

- 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) using currently used and commercially available fiber/matrix combinations. Prepreg product forms of interest have fiber areal weights below 70 g/m^2 for unidirectional tape with tape widths between 6 and 100 mm, and below 130 g/m^2 for woven/braided prepreg materials. Dry woven/braided fabrics below 80 g/m^2 are also of interest. Matrices of interest include both toughened epoxy resins for aeronautics applications, and toughened epoxy and cyanate ester resins with a Tg higher than 300 °F qualified for use in space. The intent of this requirement is to provide thin-ply prepreg material with the same quality as the standard-ply material of the same material system in order to facilitate substitution of thin-ply into structural concepts.
- 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, from which design recommendations can be formulated.
- Analysis and design tool validation and calibration to ensure appropriate behavior of thin-ply composites is captured, to identify any application-specific shortcomings with suggested improvements, and to certify thin-ply composite components are matured sufficiently to be used for NASA applications.
- Fabrication of very long slender composite structures, such as helicopter blades or deployable booms/beams, are not readily made in autoclaves due to length constraints. Innovative out-of-autoclave processing methods of the thin-ply composite is sought for the fabrication of very long parts to facilitate the use of thin-ply lamina in such structures. Additionally, the method should guarantee the curing process variables (temperature, pressure, etc) are uniform over the long parts to achieve better final products with less process-related defects and part-to-part variability.
- Cured-induced deformation of thin composite structures such as the spring-in effect is a known phenomenon that affects part accuracy during fabrication. Simulation software with general purpose finite element environments such as ABAQUS or ANSYS for the manufacturing process-induced deformations and residual stresses adapted to thin-ply composite structures with a final thickness under 1.5 mm are sought after. The goal is to develop recommendations for geometric tool compensation, as well as cure cycles and tooling that meets cure cycle specifications. In addition, simulation capability of complex hybrid, multi-step processes (co-cure, co-bond and secondary bonding) is of interest.
- Micromechanical models for spread-tow woven/braided lamina, as well as laminates that combine these with spread-tow unidirectional plies, including viscoelastic/viscoplastic and thermo-mechanical response. Such models shall be readily integrated into commercial finite element software packages like ABAQUS for the efficient thermo-mechanical analysis of large structural systems.
- Fracture mechanics models for thin-ply high strain composite shell structures for better prediction or remedy of damage initiation and progression in foldable/rollable structural members. The study of

influential parameters such as creep/stress relaxation, fiber sizing, thermal fatigue, radiation dosage, atomic oxygen and ultra-high vacuum exposure, and low-strain resin microcracking as related to environmental ageing and dimensional stability is of special interest as part of a larger goal to qualify these structures for space flight.

- Development of new testing methods adapted for thin-ply flexible composite materials that allow folding/rolling of structures, with particular interest to dedicated large deformation bending relaxation and creep tests. Innovative non-contact techniques for accurately measuring the structure's high surface bending strains, curvatures and overall shape change over the large deformation process are of interest.
- Engineering viscoelastic behavior of thin-ply laminates for controlled deployment of space structures. For bistable thin-shell structures, the study of the viscoelastic/viscoplastic response and how that affects bistability and the ability of the structure to self-deploy after long-term stowage is of special interest.
- Development of novel low creep and low stress relaxation polymer thin-ply composites for inflatable and rollable/foldable space structures. Amongst others, approaches of interest are: designing new molecular structures showing high restriction of distortion of atomic bond angle under stress; controlling cross-linking density by reactive functional groups of molecular chains to keep a good balance between restriction of molecular rearrangement and material brittleness; restricting large scale rearrangements of polymer molecules by second phase of components; and securing strong interfaces between reinforcing fibers and polymer matrix by chemical bonding to prevent fibers and polymer molecules slippage under load. The temperature dependent viscoelastic/viscoplastic properties of the developed thin-ply material shall be characterized to predict the long-term behavior of the system under continuous loading.

Relevance to NASA

The most applicable ARMD program is AAVP, and within that is Advanced Air Transport Tech. (AATT). Additional projects within AAVP that could leverage this technology Commercial Supersonic Tech. (CST), Hypersonic Technology (HT), and Revolutionary Vertical Lift Tech. (RVLT). Projects within TACP could also benefit. That is, any project in need of lightweight structures can benefit from the thin-ply technology development. Within STMD, projects with deployable composite booms, landing struts, space habitats, tanks, and other very lightweight structures can benefit from the thin-ply technology.

References:

- https://www.nasa.gov/aeroresearch/programs/aavp
- https://www.nasa.gov/aeroresearch/programs/tacp
- https://www.nasa.gov/directorates/spacetech/home/index.html
- https://gameon.nasa.gov/projects/deployable-composite-booms-dcb/

End of Summary of Changes