NASA Ames Research Center
Request for Information # NNA13STITCH2-L

Woven TPS Seam Joining Techniques including but not limited to Stitching, Tufting, Pinning, Z-Pinning, and other Mechanical Attachment Techniques

NASA/ARC is hereby soliciting information about potential sources to provide the services described below.

NASA is developing a new ablative Thermal Protection System (TPS) that takes advantage of state of the art 3D weaving technologies to place various fibers in an optimized 3D configuration. A traditional manufacturing approach would then infuse woven preforms with a resin, machine it to shape, and assemble it as a tiled solution on the entry vehicle substructure. Figure 1 presents an exploded view of the woven TPS tiles (Yellow) and the underlying substructure (Grey). The woven TPS tiles would then be joined together with an adhesive, which would fill any gaps between the tiles. Such an adhesively bonded seam approach has significant challenges, not the least of which is the reduction in thermal-mechanical performance compared to that of the acreage woven material.

A mechanically enhanced seam inserted into the assembly process either before or after resin infusion would offer many advantages compared to the traditional adhesively bonded approach. The purpose of this Request for Information (RFI) is to gather and assess industry availability and capability for the development and manufacturing of a mechanically enhanced WTPS joint/seam. All forms of joint enhancement, such as stitching, tufting, z-pinning, or some alternative mechanical solution to name a few, are within scope of this RFI. It is essential that the joint be able to withstand harsh dynamic loading at launch, and temperature extremes while in the vacuum of space and during re-entry, and most importantly not adversely impact the recession and thermal performance of the system.

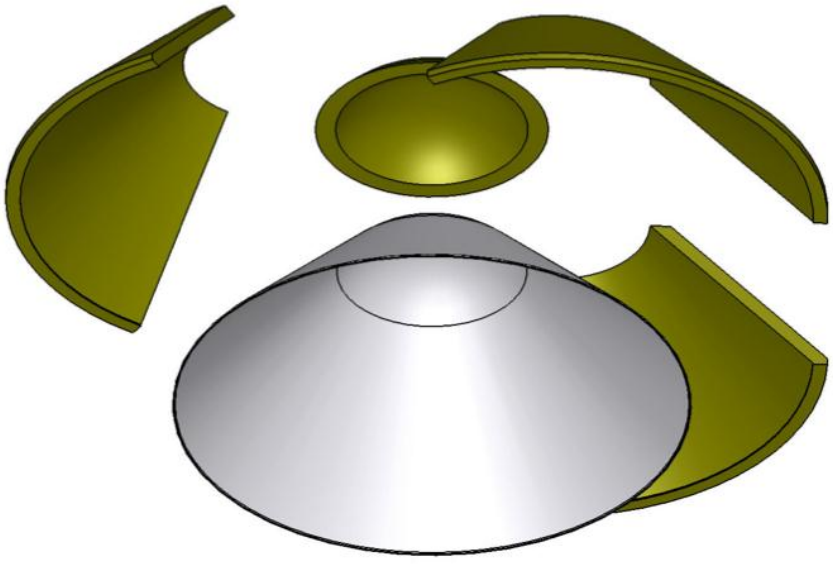

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Figure 1: *Exploded view of TPS gores and nosecap (Brown), and underlying substructure (Silver).*

Developing reliable joint enhancement using one of the aforementioned methods would be a major contribution for the successful development of woven TPS materials. The woven TPS material will range in thickness from 1-4 inches depending on the mission and the location of the vehicles heatshield. A single technique that is applicable over the full range of thicknesses is preferable, but if due to the nature of the joint approach, or limitations on existing equipment, a joint approach that addresses a thickness of 1.5-2 inches is acceptable as not every mission will require the full thickness. There are numerous parameters to investigate stitching solutions including, but not limited to thread/yarn type, thread/yarn denier, seam type, stitch pattern/density, and sewing process variables. Similarly for alternative joint options (tufting, z-pinning, etc…) there are numerous parameters to investigate. Evaluating the various vendor-proposed joint designs through load testing (performed by NASA), combined

structural and aero-thermal loading, and component interface tests should identify candidate designs to carry further along in the development process.

Mechanically Enhanced (including stitching) information sought includes, but is not limited to:

1. Ability to stitch or tuft large area substrates. Provide current maximum dimensions for substrate (including thickness) that you have worked with.
2. Ability to stitch or tuft high density weaves. A high fiber volume fraction material that is up to 4" thick may be needed for this application. Is the stitching (or equivalent) process amenable to such thicknesses?
    a. The Woven TPS system may consist of a high density (50+ volume percent) carbon outer layer with a lower density weave beneath. The outer layer may comprise between ¼ and ½ the total thickness of the part.
3. Ability to stitch at a non-surface normal angle. Provide maximum off-nominal angle stitched to date and any additional capability information.
4. Provide information on yarns (provide chemical composition, denier etc if available) that you have stitched with.
5. Provide information on previous efforts to join or stitch representative (woven) substrates. Provide details of approach, seam design, properties of joint if applicable
6. Provide information on evaluation of woven substrate stitched area for damage as a result of the stitching process (NDE or other)
7. Other proposed joining approaches (other than stitching) that you believe suitable for this application
8. Provide any available properties on representative substrate materials that has been stitched including, physical, thermal, mechanical
9. Ability to stitch material draped over a gentle radius of curvature.
    a. Stitching at a non-normal angle with respect to the material surface, up to 60 degrees off-normal.
    b. Stitching along compound curvature shapes
10. If draping is not possible for stitching is there an alternative approach proposed to allow such stitching
11. Provide some indication of costs and schedules for modifications of current facilities to accommodate the following tasks (A – C). Responses should address plans, approaches and estimated cost for completing each task element as appropriate.

Task A. Stitching and Alternate Joining Technique Design Feasibility Study

This task will investigate the feasibility of joining samples of woven carbon fabric using carbon fiber based threads. Initially batches of small-scale carbon fabric samples (~6x6 inches by 1 inch thickness) possessing the required design features will be evaluated. If particular joining techniques are more amenable to assembly prior to infusion, after a light infusion, or after the full phenolic infusion, all options are viable and representative samples will be provided as requested.

Stitching and alternate joint enhancements will be based on the following parameters:

1. Manufacturability
2. Ease of remaining assembly processes, including resin infusion, machining, etc
3. Minimization of damage to the pristine woven material.
4. Minimization of thickness variation between post-stitched and pre-stitched material.
5. Minimization of broken threads and needles during stitching operation.
6. Pattern consistency of the automated/semi-automated/hand process proposed.

Task B. Stitching and Alternate Joining Technique Design Feasibility Study

In this trade study, stitching and joining thicker and more complex material geometries will be evaluated. Initially, batches of small-scale carbon fabric samples (~6x6 inches by 3 inch thickness) possessing the

required design features will evaluate the feasibility of stitching thick parts. Larger samples will then be provided to evaluate the feasibility of:

1. Stitching at a non-normal angle with respect to the material surface, up to 60 degrees off-normal.
2. Stitching along compound curvature shapes.

Evaluation will be based on the same parameters in the first feasibility study.

Task C. Stitch Testing Development

The goal of this task is to evaluate the stitching concepts developed in tasks A and B. The woven carbon fabric samples provided will represent longer joints with inherent compound curvature that is expected on the vehicle. The carbon fabric samples provided for this task will be representative of structural and aerothermal test models that will be used to evaluate the performance of the stitches in environments representative of flight. In addition, the identification of the key stitch design parameters along with test and evaluation methods found suitable to assess structural design quality will be identified.

NASA will provide the carbon fabric articles for design, test and evaluation of various stitch designs.

NASA will conduct a series of tests on resulting contract deliverable stitching to characterize the ultimate tensile strength and aerothermal performance of various joints. Characterizing the tensile properties will aid in the optimization of the aeroshell design. This test series will aid in the downselect of stitch designs to pursue for further development.

Additional Information

If available, provide any study results or current capabilities you have but are not mentioned in the RFI description data that you think pertinent to advancing Mechanically Enhanced joining concepts for woven TPS materials.

In addition to the information requested above, describe the extent to which existing proven manufacturing approaches can be leveraged to minimize technical and schedule risk to a space program

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NASA/ARC is seeking capability statements from all interested parties, including Small, Small Disadvantaged (SDB), 8(a), Woman-owned (WOSB), Veteran Owned (VOSB), Service Disabled Veteran Owned (SD-VOSB), Historically Underutilized Business Zone (HUBZone) businesses, and Historically Black Colleges and Universities (HBCU)/Minority Institutions (MI) for the purposes of determining the appropriate level of competition. The Government reserves the right to consider a Small, 8(a), Woman-owned (WOSB), Service Disabled Veteran (SD-VOSB), or HUBZone business set-aside based on responses hereto.

No solicitation exists; therefore, do not request a copy of the solicitation. If a solicitation is released it will be synopsized in FedBizOpps and on the NASA Acquisition Internet Service. It is the potential offeror's responsibility to monitor these sites for the release of any solicitation or synopsis.

Vendors having the capabilities necessary to meet or exceed the stated requirements are invited to submit appropriate documentation, literature, photographs/ brochures, and references.

Please provide a description of your company's manufacturing facilities and personnel, website address, number of years in business, and/or examples of previous work performed for Government or private customers that is similar to this projected NASA requirement. Please advise if the requirement is considered to be a commercial or commercial-type product. A commercial item is defined in FAR 2.101.

Following this initial feedback, NASA may conduct one-on-one meetings with potential contractors. These meetings will allow for exchange of information and will provide an opportunity for potential offerors to provide feedback on the Government's requirements and its acquisition approach.

All information received in response to this RFI that is marked "Proprietary" will be handled and protected accordingly. As applicable, NASA may provide Proprietary information to its support service contractors who are under an obligation to keep third-party Proprietary information in confidence. By submitting a response to this RFI, the responder is deemed to have consented to release of Proprietary information to such NASA support service contractors.

This synopsis is for information and planning purposes and is not to be construed as a commitment by the Government nor will the Government pay for information solicited. Respondents will not be notified of the results of the evaluation. Respondents deemed fully qualified will be considered in any resultant solicitation for the requirement.

All responses are to be submitted via email to **Marianne Shelley (Marianne.Shelley@nasa.gov)** no later than **October 2, 2013, 4:30 pm Pacific Time**. Please reference **NNA13STITCH2-L** in any response.