TO: Aerospace Community

FROM: NASA Ames Research Center (ARC)

SUBJECT: Request for Information: Carbon Phenolic Thermal Protection Systems for Atmospheric Entry Heat Shields.

PLEASE NOTE: This is a request for information only and does not constitute a commitment, implied or otherwise, that NASA Ames will take procurement action in this matter. Further, neither NASA Ames nor the Government will be responsible for any cost incurred in furnishing this information. NASA is issuing this Request for Information (RFI) to gain a better understanding of industry capabilities and to assess the current state of the technology.

RFI Description and Requirements

The National Aeronautics and Space Administration (NASA) invites you to submit a response to this inquiry to assist in planning for the long-lead development of Thermal Protection Systems (TPS) for future robotic scientific missions. The missions include exploration of Venus, the Outer Planets (OP) and the return samples from Mars that require highly reliable heat shields for Earth atmospheric entry. As discussed in a series of three “white papers” [1-3] the TPS community believes that the primary candidate for these missions is the DoD-developed FM 5055 carbon phenolic that was used for both the Pioneer-Venus (PV) and Galileo entry probes. Herein, this material is referred to as “Heritage” carbon phenolic (HCP) and is considered to be the baseline for future developments. Two forms of HCP were used on the PV and Galileo Probe (used for exploration of the Jovian atmosphere [4]): Chopped Molded (CM) for the nose and Tape Wrapped (TW) for the flank of the heat shields. HCP was made from CCA-3 carbon fabric derived from Avtex rayon. NASA Ames has a small supply of CCA-3 carbon cloth that would be provided as government furnished equipment (GFE) in any possible future manufacture of HCP.

As explained above, no commitment is made herein for future Requests for Proposals (RFP), but NASA Ames is in the early stages of developing a plan to support re-establishment of the industrial capability to manufacture CM and TW carbon phenolic blunt-cone heat shields with ~ (1 m - 3.5 m) base diameters and a range of thickness typically 1 – 6 cm. In addition to exploring heat shields made of HCP, there is also interest in **alternate carbon phenolic composites** that would have performance capability and robustness to meet NASA’s future mission requirements.

NASA’s goal is to have industry establish a standing capability to provide heat shields for its multiple exploration missions across the next several decades. To

this end, information is requested from vendors that can help us understand their current capability to provide all elements of entry grade carbon phenolic including raw materials, manufacture of test articles, material testing capabilities and full scale manufacturing demonstration units (MDUs). This exercise is critical in the development of processes and vendors qualified to provide flight hardware.

Table 1 specifies atmospheric flight conditions [5,6] of interest for this RFI.

Table 1 Range of Entry or Aerocapture Conditions

Mission	Total (convective + radiative) peak heat rate, W/cm^2	Peak surface pressure, atm
Venus, hyperbolic entry	~ 5000	~10
Saturn, hyperbolic entry	~ 5000	~3
Mars Sample Return (hyperbolic)	1000 – 2000	0.2 – 0.4

Responses to this RFI should address these specific questions:

1. What is your past experience in providing entry grade carbon phenolic heat shields including those made of FM 5055 HCP?
2. What is your current capability in heat shield relevant TPS manufacturing?
    i. Personnel experienced in making heat shield grade CP
    ii. Associated product assurance and processing equipment necessary to do so?
    iii. Certifiable process procedures and specifications
3. Can you make FM 5055 test coupons of ~ 6 cm thickness?
4. If so, can you make CM and/or TW?
5. What are the sources of your raw materials and how would you ensure their traceability to those of HCP?
6. What is the probability of providing sustained supplies of the raw materials, and what are the alternates?
7. Can you make prepregs for others to manufacture heat shields?
8. Can you make full scale MDU?
9. Can you make flight hardware?
10. What methods have you used to attach CP to various substructures? What substructure would you recommend and why?
11. If you have an alternate CP to HCP, please describe it. Can you make both TW and CM? Why do you believe its performance would be comparable to HCP?

12. If you are a raw material provider, please describe your products, specifications, quality assurance, and their use in the manufacture of CP.
13. If you provide materials testing for CP what experience do you have relevant to the development of heat shields?
14. Do you have HCP relevant material property data that can potentially be shared with NASA? If so, please summarize what is available.

References:

[1] White Paper to the NRC Decadal Survey Inner Planets Sub-Panel: "Thermal Protection System Technologies Enabling Future Venus Exploration," Ethiraj Venkatapathy Helen H. Hwang, Bernard Laub, Joseph L. Conley, James Arnold, Christine E. Szalai, and 90 Co-authors. URL:
http://www8.nationalacademies.org/ssbsurvey/publicview.aspx
(page 4 on the website will allow you to down load the paper)

[2] White Paper to the NRC Decadal Survey Outer Planets Sub-Panel: "Thermal Protection System Technologies Enabling Future Outer Planet Missions," Ethiraj Venkatapathy, James Arnold, Bernard Laub, Helen H. Hwang ,Christine E. Szalai, Joseph L. Conley and 90 Co-authors. URL
http://www8.nationalacademies.org/ssbsurvey/publicview.aspx
(page 4 on the website will allow you to down load the paper)

[3] White Paper to the NRC Decadal Survey Primitive Bodies Sub-Panel; "Thermal Protection System Technologies for Enabling Future Sample Return Missions," Ethiraj Venkatapathy (Lead), Christine E. Szalai, Bernard Laub, Helen H. Hwang, Joseph L. Conley, James Arnold, and 90 Co-authors. URL
http://www8.nationalacademies.org/ssbsurvey/publicview.aspx
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[4] F.S. Milos, Y-K. Chen, T.H. Squire and R.A. Brewer, "Analysis of Galileo Probe Heatshield Ablation and Temperature Data," Journal of Spacecraft and Rockets, Vol. 36, No. 3, 1999, pp. 298-306.

[5] E. Venkatapathy, B. Laub, G.J. Hartman, J. O. Arnold, M. J. Wright and G. A. Allen, Jr. " Selection and Certification of TPS: Constraints and Considerations for Venus Missions", International Planetary Probe Workshop-6, Atlanta GA, June 2008.

[6] E. Venkatapathy, B. Laub, G.J. Hartman, J. O. Arnold, M. J. Wright and G. A. Allen, Jr. " Thermal Protection Systems Development, Testing and Qualification for Atmospheric Probes and Sample Return Missions: Examples for Saturn, Titan and Stardust-Type Sample Return", Advances in Space Research, V 44, Issue 1, July 2009, pp 138-150.