

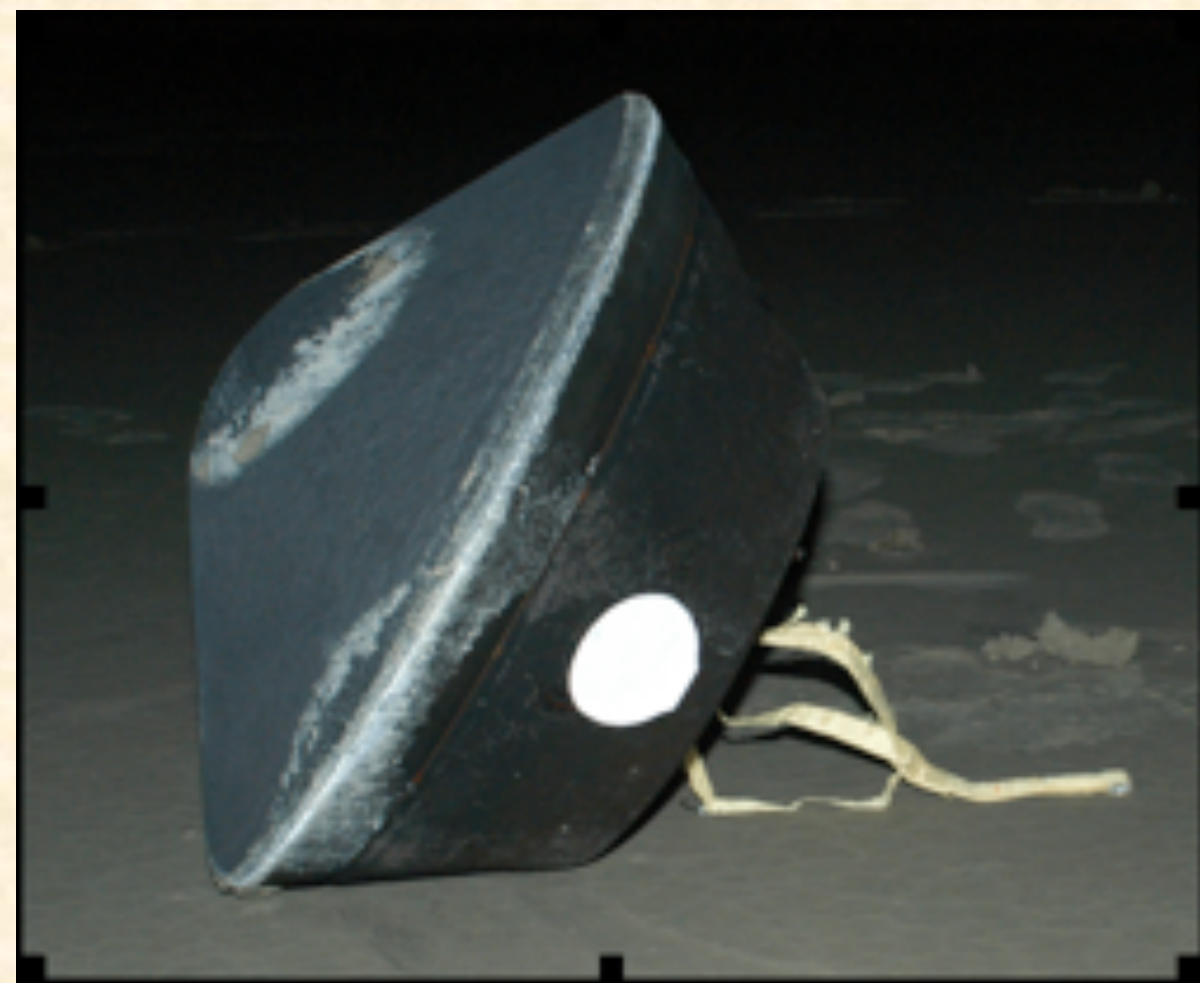
# Progress Report on PICA Sustainability Activities in Support of New Frontiers Missions

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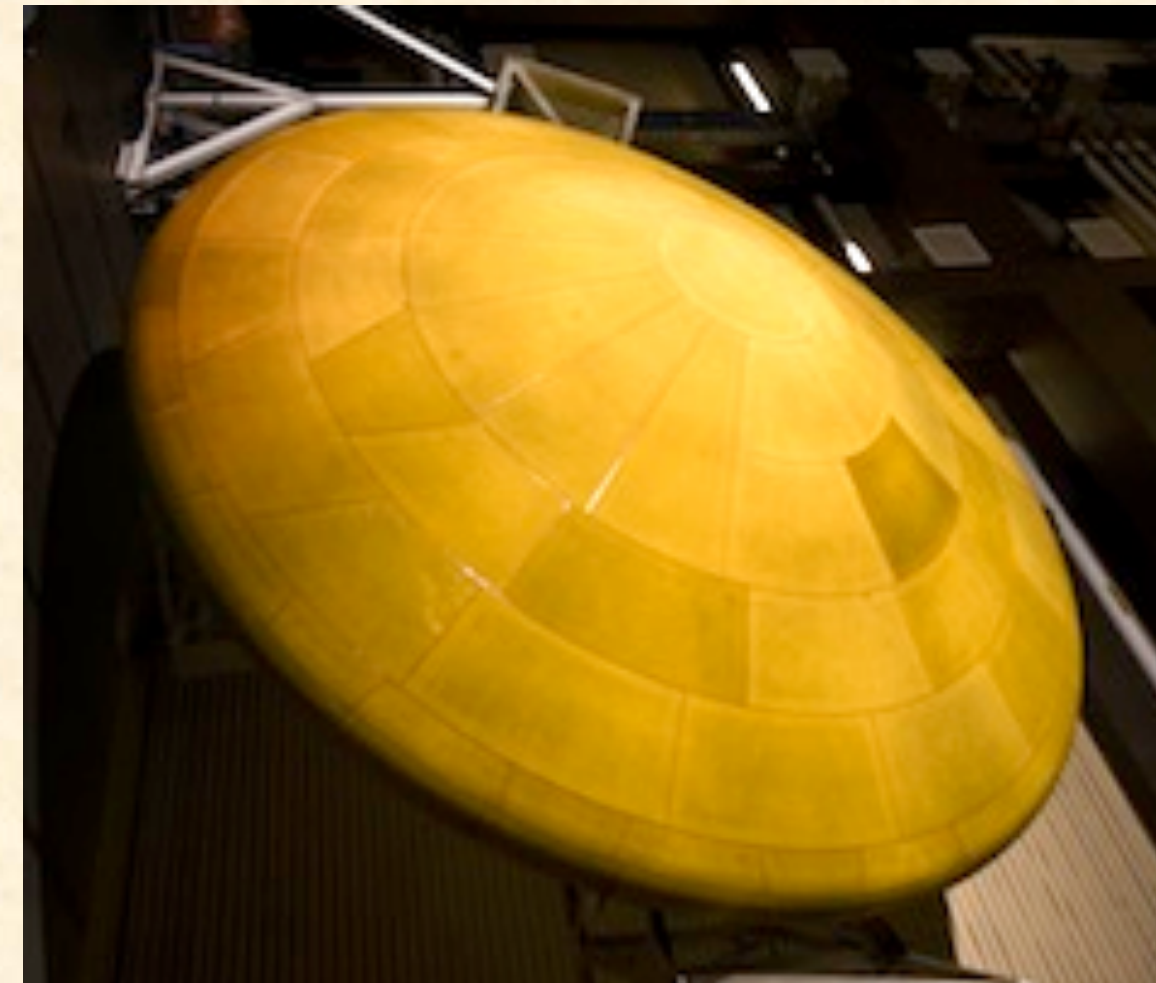
## Background – What is PICA

### State of the Art Low Density Carbon Phenolic Ablators

- Phenolic Impregnated Carbon Ablator (PICA) is a low density (~ 0.27g/cm<sup>3</sup>) ablator first used as the forebody heatshield for the Stardust sample return capsule where it was used as a single piece heatshield.
- Since Stardust, PICA has also been used on the Mars Science Lab (MSL) in a tiled configuration.
- More recently, the OSIRIS-REx sample return capsule used PICA and PICA will be used on Mars 2020.



Stardust SRC post flight with PICA forebody heat shield (0.8m max. diameter)



MSL heat shield (4.5m diameter)

### PICA FiberForm<sup>®</sup> substrate uses a **rayon derived** carbon preform

- Stardust era PICA used Liberty rayon derived FiberForm<sup>®</sup>, which ceased production over a decade ago.
- The NASA Crew Exploration Vehicle Advanced Development Project qualified an alternative rayon source (Sniace), which was used on MSL and OSIRIS-REx and will be used on Mars 2020.
- NASAARC recently learned that Sniace rayon has stopped production leading to the second flight-qualified PICA sustainability challenge. The quantity of remaining heritage Sniace rayon has been determined.
- NASAARC is now funded by SMD to address PICA rayon sustainability – two approaches are being pursued:
  - **Secure the remaining heritage (Sniace) rayon.**
  - **Develop and implement plans for certifying an alternate rayon based PICA**

## Securing Remaining Heritage (Sniace) Rayon

- NASAARC funded by SMD has procured and graphitized all remaining heritage rayon through FMI. FMI is retaining the carbonized fibers in bonded storage for future mission use to be decided by SMD-PSD.
- **There is a sufficient quantity of heritage rayon available to support a single mission (~ OSIRIS-Rex scale) thereby providing a flight unit, spare unit and material for manufacturing process development.**
- The quantity of heritage rayon available is not sufficient to support fabrication of PICA needed for larger (>> 1 m) heat-shield or back-shell applications.

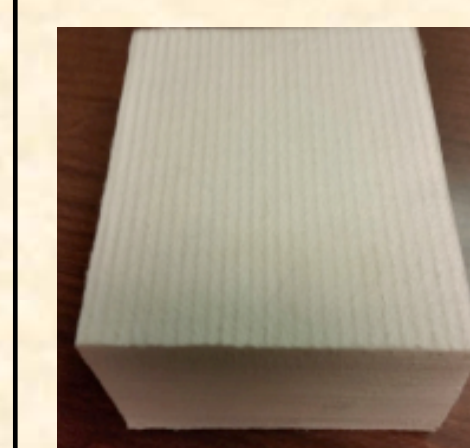
## Lyocell Derived PICA Tasks in 2017

SMD-PSD has funded ARC to manufacture and perform limited property and aerothermal characterization of Lyocell based PICA.

- PICA billets and a near net shape heatshield will be fabricated using Lyocell derived FiberForm<sup>®</sup>. Activity supports both tiled heatshield and smaller scale single piece heatshield designs.
- Characterization includes thermal /mechanical properties and arc jet testing.
- NASAARC will work with NF proposing organizations to ensure arc jet testing is at mission relevant conditions – arc jet testing of Lyocell based PICA will tentatively begin in August 2017 and the evaluation will be completed before the end of the calendar year (2017)

## Qualification of an Alternative Based FiberForm<sup>®</sup> Precursor

### Role of Rayon/Lyocell in PICA Manufacturing



Rayon or Lyocell



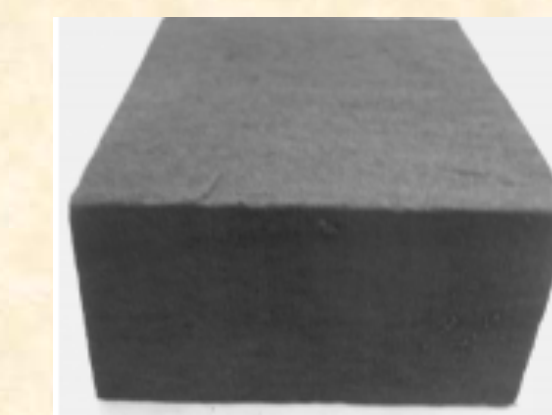
Conversion to carbon



Near net shape preform



Single piece PICA heatshield (< 1.25m max diameter)



FiberForm<sup>®</sup> billet preform



Tiled PICA heat shield (> 1.25m max diameter)

### **Lyocell will be evaluated as a “rayon alternative” FiberForm<sup>®</sup> precursor – previous work indicates Lyocell is a feasible alternative:**

- FMI completed a limited study on FiberForm<sup>®</sup> made with Lyocell in 2005
- Preliminary mechanical and thermal properties were evaluated
- Properties characterized included:
  - density
  - porosity
  - through-thickness thermal conductivity
  - in-plane thermal expansion
  - room temperature through-thickness compression
  - room temperature in-plane compression
- Study concluded that the ‘Lyocell derived’ FiberForm<sup>®</sup> was comparable to baseline ‘rayon derived’ FiberForm<sup>®</sup>.
- Study did not complete infusion of the Lyocell derived FiberForm<sup>®</sup> to make PICA, also, study did not address near-net-shape casting with Lyocell derived carbon fibers.

## Summary

- NASAARC is working with SMD-PSD to address PICA rayon sustainability concerns
- Remaining Sniace heritage rayon has been procured by NASA and is being stored for future SMD-PSD mission – enough heritage rayon available to support a single mission (OSIRIS-REx scale)
- NASA is also evaluating a domestic rayon alternative (Lyocell) for qualifying a replacement PICA thereby providing a sustainable domestic source that is more certain for long-term availability.
- Contract in place with FMI to complete Lyocell derived PICA qualification tasks including:
  - Fabrication of PICA billets and near net shape cast forms
  - Completion of limited property testing and arc jet testing (arc jet testing completed by Sept 2017 prior to New Frontiers Phase A selection date of Nov 2017)
- NASA will work with proposing organizations to help define relevant Lyocell derived PICA arc jet testing conditions in April-May 2017
- Proposers will have the final report detailing findings from this study by Jan of 2018 to make assessments.
- Effort anticipates demonstrating that performance risks from a Lyocell precursor are negligible for missions proposing alternate to heritage PICA.

## Acknowledgements

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