Conformal PICA TPS – Enabling Future NASA Planetary Science Missions

Initial development of Conformal Phenolic Impregnated Carbon Ablator (C-PICA) ablative TPS occurred under NASA's Hypersonics Project in the 2000's and demonstrated very low through-the-thickness thermal conductivity compared to state-of-the-art Phenolic Impregnated Carbon Ablator (PICA). PICA, which was first demonstrated on Stardust, has some inherent limitations that C-PICA improves on, primarily strain to failure. More recently C-PICA has been further matured and a family of C-PICA materials are now ready for consideration as an enabling technology for New Frontiers and other NASA missions. C-PICA has several improvements compared to PICA including:

- **Higher strain to failure and lower thermal conductivity (up to 55% less than PICA depending on C-PICA variant)**
- **CTE comparable to typical composite carrier structures and also suitable for metallic substructures given high strain to failure**
- **Temperature independent mechanical properties**
- **Suited for single piece (up to ~ 1.5m) or tiled configurations**
- **Larger tiles leading to reduced integration complexity compared to tiled PICA**
- **Reduced mass compared to PICA due to reduced thermal conductivity**

C-PICA has been tested at heat fluxes ranging from 250-1850 W/cm², and shear pressures of 200Pa at 400W/cm² with excellent performance. Expertise on manufacturing and integration of C-PICA reside at NASA, and NASA can transition the technology to interested parties via technology transfer.

Conformal Phenolic Impregnated Carbon Ablator (Conformal PICA)

"Low" Density < 0.3 g/cm³

Conformal PICA
With and without Seam

Loose Carbon Fibers

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Flexible Carbon Felt

↓

Molded as Single Piece < 1.5m
Tiles >1.5m

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Phenolic Infusion and Curing
(FMI or NASA Performs Currently)

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Conformal PICA (TRL 4+)

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C-PICA Manufacturing Development Unit in partnership with ARA

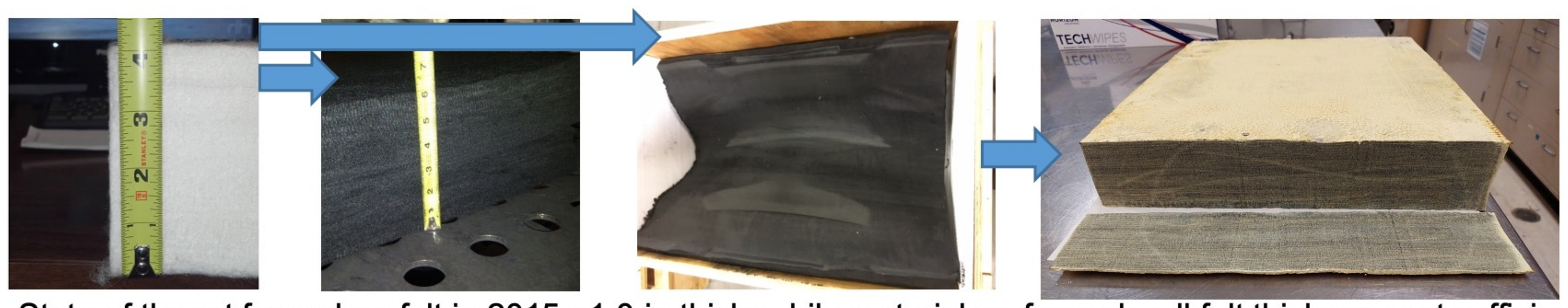
Single curvature C-PICA billet partnership with ARA

C-PICA has much better performance in flexure testing than PICA

3-point bend tests

4-point bend tests

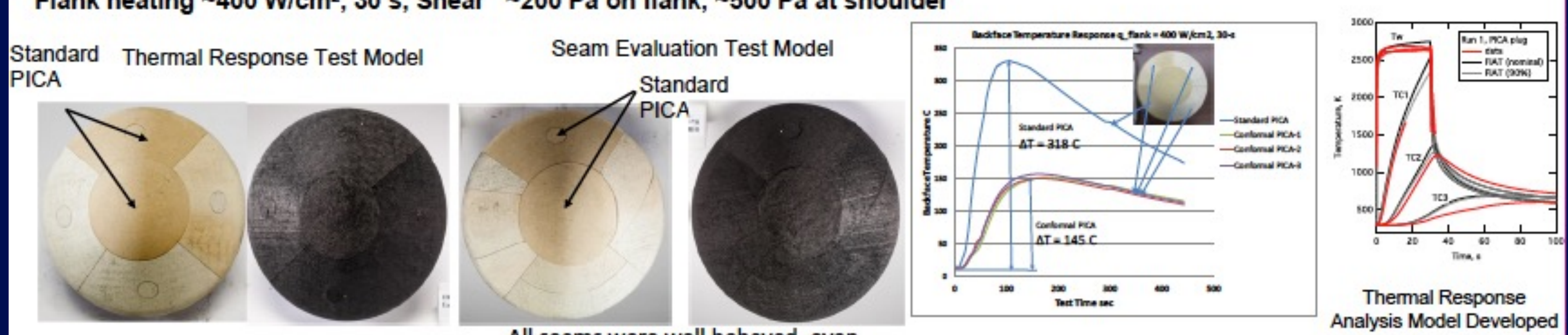
Felt Scale-up successful for thick C-PICA
4" Rayon Felt yields ~3" Carbon Felt



- State of the art for carbon felt in 2015 ~1.0-in thick: while material performed well felt thickness not sufficient for all applications
- Recent demonstration of thick felts (~4-inch) demonstrated - enabling C-PICA to be demonstrated at flight relevant thicknesses

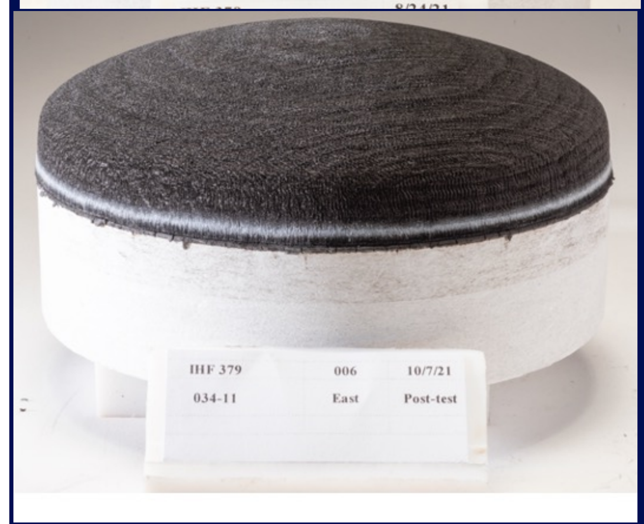
C-PICA has similar recession and much lower thermal penetration than PICA

Flank heating ~400 W/cm², 30 s, Shear ~200 Pa on flank, ~500 Pa at shoulder



All seams were well behaved, even 90º butt joints between test segments

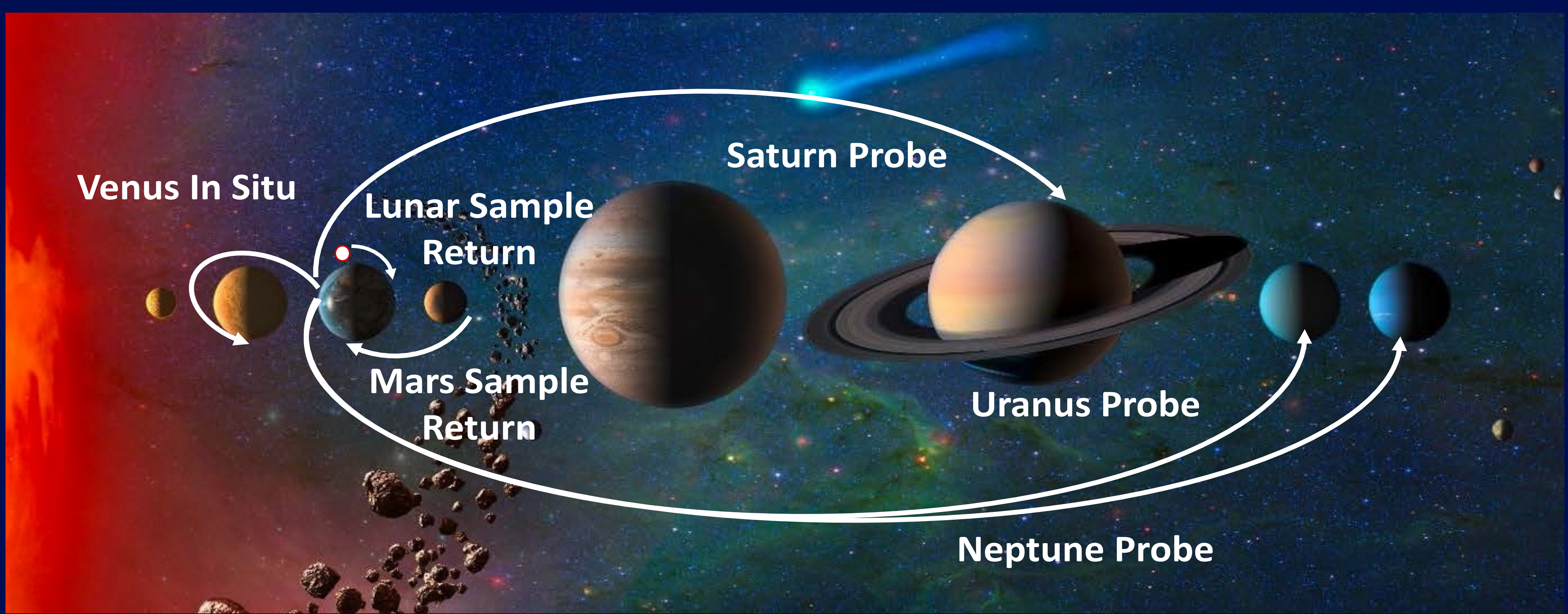
Thermal Response Analysis Model Developed



2021 era instrumented thermal response models used to develop material model for TPS sizing

Standard PICA

SPRITE model geometry allows assessment of a range of conditions and rapid evaluation of material capability including material compositions and seam designs (Flank heating ~400 W/cm², shear ~ 200Pa on flank and ~500Pa on shoulder



Outer Planets		
	Mission Abstract	**Comment/Application**
1	New Frontiers Titan Orbiter	Aerocapture requires a mass efficient TPS suite - Conformal PICA is very suitable
2	Small Next-Generation Atmospheric Probe (SNAP) For Ice Giant Missions	Conformal PICA for backshell TPS
3	Uranus Orbiter and Probe (UOP)	Conformal PICA for backshell TPS
4	Saturn Probe	Conformal PICA for backshell TPS
Venus		
	Mission Abstract	**Comment/Application**
5	SAEVe: Seismic and Atmospheric Exploration of Venus	Conformal PICA for backshell TPS
6	V-BOSS: Venus Bridge Orbiter and Surface System	Conformal PICA for backshell TPS
7	Venus In Situ Explorer (VISE)	Conformal PICA for backshell TPS
8	Cupid's Boomerang	Conformal PICA for backshell TPS
Small Body Sample Return		
	Mission Abstract	**Comment/Application**
9	Ceres Sample Return	Conformal PICA is an alternate to PICA forebody TPS with improved mass efficiency
10	Comet surface sample return (CSSR)	Conformal PICA is an alternate to PICA forebody TPS with improved mass efficiency