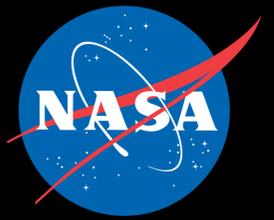


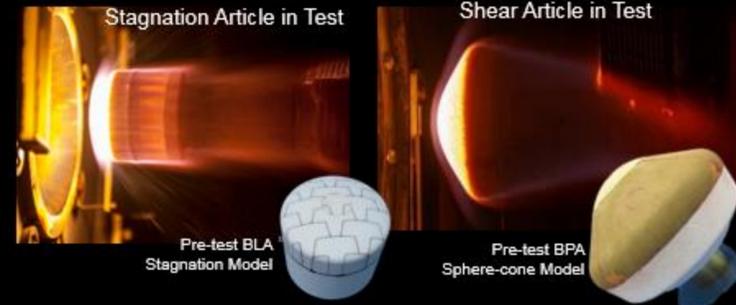
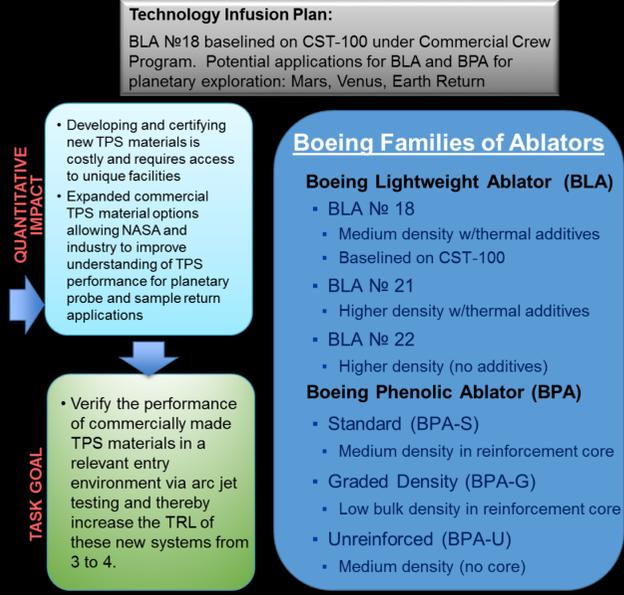
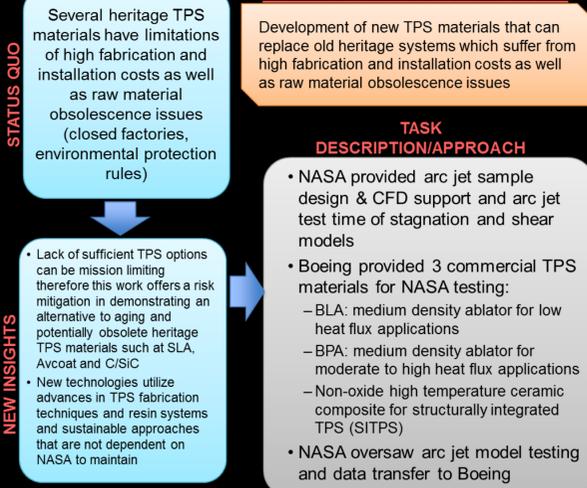
Space Technology Mission Directorate Game Changing Development Program

National Aeronautics and
Space Administration



Boeing: Arc Jet Exposure of Ablative Non-Oxide CMC TPS for Planetary Probe and Sample Return Applications

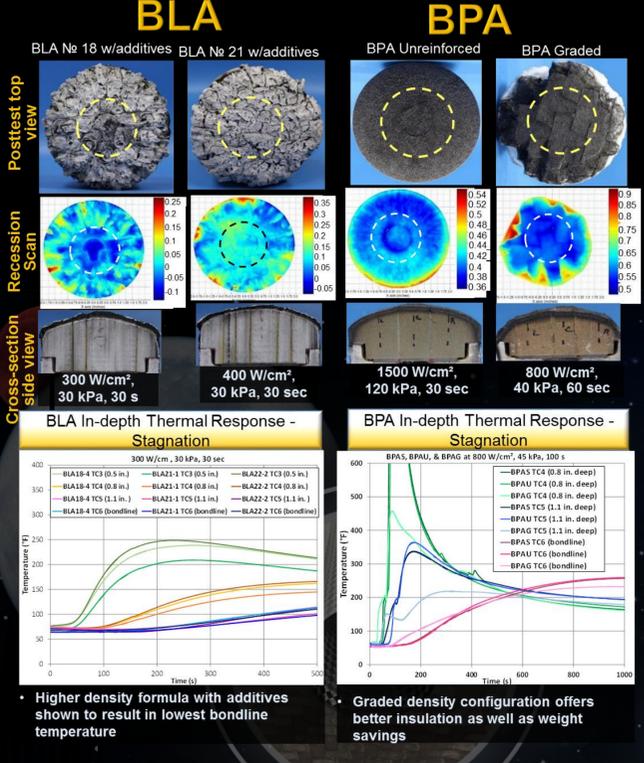
NASA making its unique testing facilities available to promote commercial space.



Ablator Test Matrix

	Heat Flux [W/cm ²]	Pressure (kPa)	BLA №18		BLA №21		BPA-S	BPA-U	BPA-G
			1" core	3/8" core	1" core	3/8" core			
Stagnation	130	30	x						
	200	30							
	300	30	x		x				
	400	30			x				
	450	50						x	x
	600	40						x	x
	800	40					x	x	x
Shear	1000	50					x	x	
	1500	120					x	x	x
	150	20	x	x					
	400	30			x	x	x	x	x

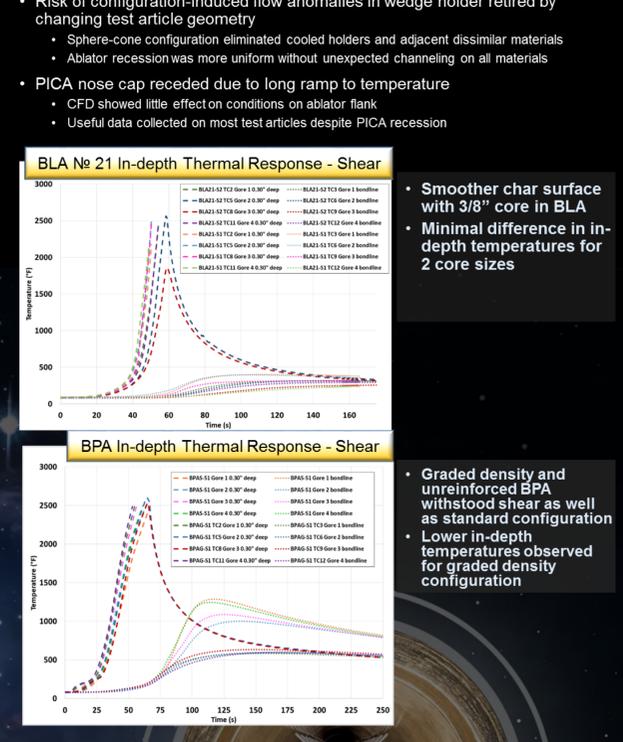
Ablator Stagnation Test Results



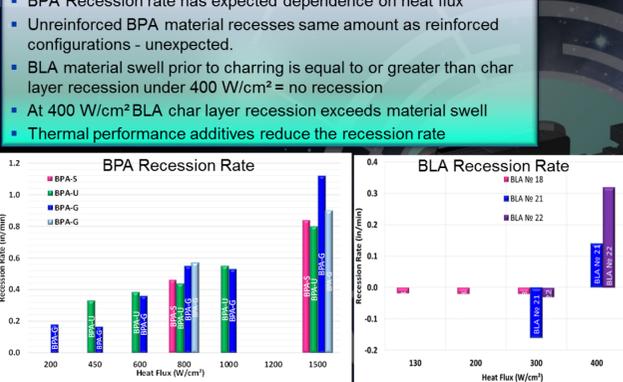
Ablator Shear Test Results



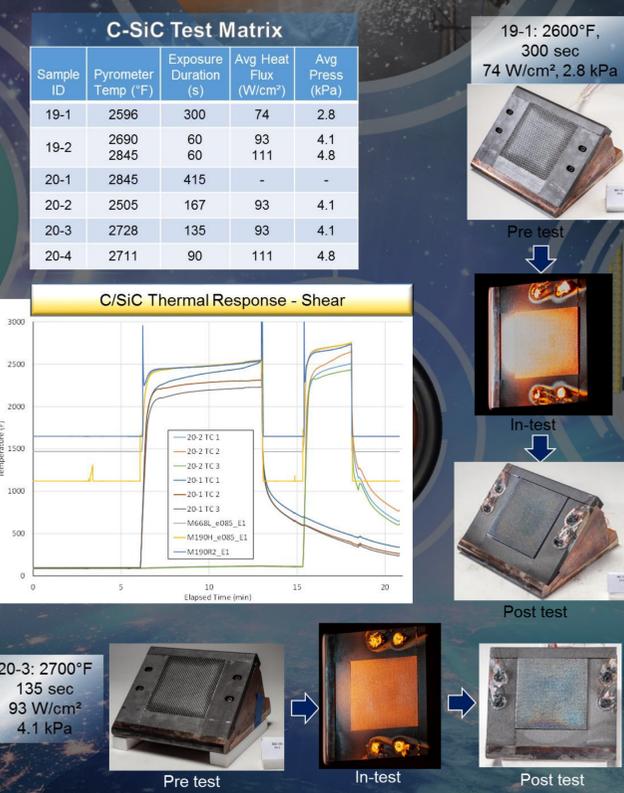
Shear In-depth Temperature Response



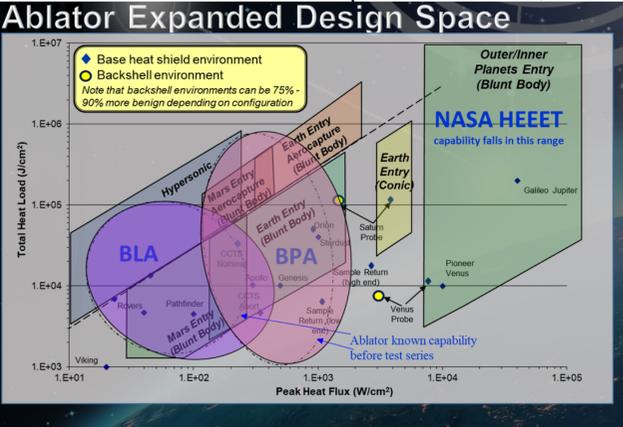
Ablator Recession



Carbon/SiC Laminate Shear Tests



Boeing TPS Material Capabilities Expanded



Successful arc jet testing to planetary probe and sample return mission relevant conditions completed

- The design space for the BLA family of materials has been expanded to heat flux up to 500 W/cm² and heat loads up to 12 kJ/cm²
 - Capability to withstand shear loads up to 370 Pa
 - Density and reinforcement core size can be tailored to mission applications
- The scalable BPA 2017 formulation has been verified for heat flux up to 1500 W/cm² and heat loads up to 80 kJ/cm²
 - Capability to withstand shear loads up to 250 Pa has been demonstrated
 - Advanced TRL of new formulation
 - Graded density configuration reduces bulk density by 26% while maintaining similar thermal capabilities
 - Reinforcement configuration can be selected based on application requirements
- Advanced the TRL of Boeing fabricated C/SiC laminate materials through successful testing at conditions representative of hypersonic flight for approximately 7 minutes
 - Longer duration testing suggested for future efforts
 - Alternative material to graphite edge closeouts will need to be used due to erosion during long durations