TPS Ablator Technologies for Interplanetary Spacecraft

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TPS ABLATIVE MATERIALS TODAY – TOO FEW, TOO COSTLY, WRONG PERFORMANCE LEVELS

Problem – NASA does not have adequate TPS ablatives and sufficient selection for planned missions

- –Limited active ablatives R&D since 1960's
- –Apollo Era" materials, largely unavailable today
- –Older ablators heavy, costly, not-state-of-the-art (SOA)
- –Labor-intensive, drawn-out manufacturing, e.g. Honeycomb filling, trimming, packing
- –Wrong performance for future interplanetary missions

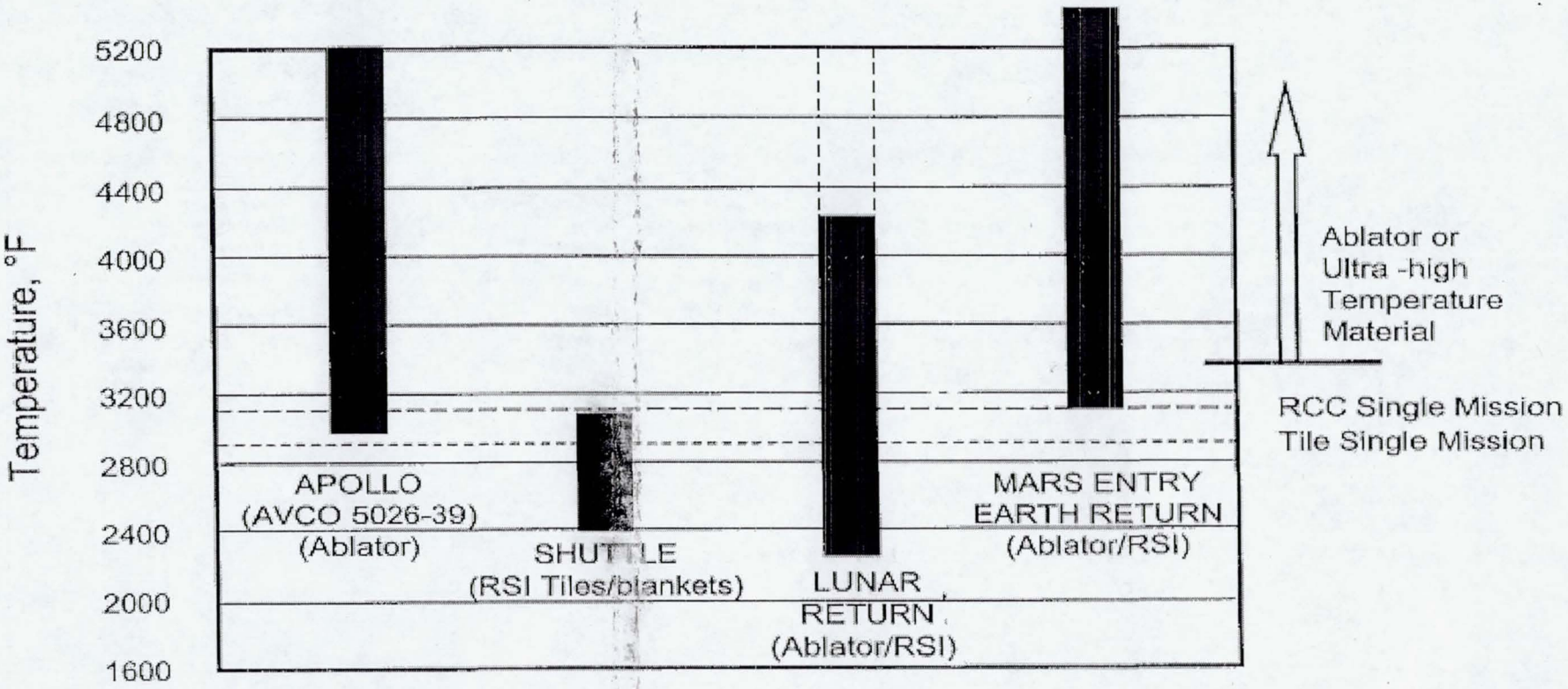
Needs – Broad selection of well-characterized ablators with wide range of performance, robustness, and weight with low cost, SOA manufacturing

Progress – Limited JSC sponsored SBIR for new ablator technology

COMPARISON OF SHUTTLE AND INTERPLANETARY TPS REQUIREMENTS

	Shuttle	Lunar Return	Mars Entry/Return
• PEAK CONVECTIVE HEATING BTU/FT^2-SEC	60	200	50 – 300
• PEAK RADIANT HEATING BTU/FT^2-SEC	<2	200	40-200
• PEAK VELOCITY, KM/SEC	7	11	7-13
• PEAK DYNAMIC PRESSURE, PSF	300	1000	250-1000
• TURBULENT HEATING	YES	YES	YES
• ENTRY HEATING TIME, SEC	1200	<400	<400
• EXPOSURE TO ADVERSE ENVIRONMENTS			
- RAIN/WEATHER	YES	NO	NO
- AEROACOUSTICS (dB)	160+	146	146
- DEBRIS IMPACT			
- LAUNCH	YES	NO	NO
- ON-ORBIT/IN-FLIGHT	LESS	MORE	MORE

TPS Temperature Requirements for Various Programs



STATUS OF MAINLINE TPS CHARRING ABLATOR MATERIALS

MATERIAL	SUPPLIER	DENSITY LB/CUFT	HEAT FLUX-BTU/SQFT-SEC	REMARKS
AVCO-5026-39	TEXTRON SPECIALTY MATERIALS	32	300	FLIGHT CERTIFIED/APOLLO NOT IN PRODUCTION
SLA561V	LOCKHEED-MARTIN	16	175	FLIGHT CERTIFIED/MARS IN PRODUCTION
ACUSIL I	AEROTHERM	30	250	NON-FLIGHT CERTIFIED IN PRODUCTION
ACUSIL II	AEROTHERM	16	60	NON-FLIGHT CERTIFIED IN PRODUCTION
HYPERLITE-A	APPLIED RESEARCH ASSOCIATES	13	100	NON-FLIGHT CERTIFIED DEVELOPMENTAL
SRAM-17	APPLIED RESEARCH ASSOCIATES	17	175	NON-FLIGHT CERTIFIED DEVELOPMENTAL
SRAM-20	APPLIED RESEARCH ASSOCIATES	20	225	NON-FLIGHT CERTIFIED DEVELOPMENT
PCA – 28	APPLIED RESEARCH ASSOCIATES	28	300	NON-FLIGHT CERTIFIED DEVELOPMENTAL
SIRCA	NASA-AMES	15	175	NON-FLIGHT CERTIFIED DEVELOPMENT
PICA	NASA-AMES	15	260-1100	NON-FLIGHT CERTIFIED DEVELOPMENT

SBIR ADVANCED ABLATOR FAMILY

ABLATOR	DENSITY LB/FT^3	RESIN SYSTEM	FILLERS	HEATING RANGE BTU/FT^2-SEC
SRAM-14	14	Silicone	Silica/Others	80 - 140
SRAM-17	17	Silicone	Silica/Others	100 – 160
SRAM-20	20	Silicone	Silica/Others	125 - 200
SRAM-24	24	Silicone	Silica/Others	170 – 284
PhenCarb-20	20	Phenolic	Carbon/Others	200 – 284
PhenCarb-24	24	Phenolic	Carbon/Others	300 – 700
PhenCarb-28	28	Phenolic	Carbon/Others	400 – 900
PhenCarb-32	32	Phenolic	Carbon/Others	500 – 1100
Hyperlite-C	11	Silicone	Silica/Others	10 – 30
Hyperlite-B	12	Silicone	Silica/Others	30 – 50
Hyperlite-A	13	Silicone	Silica/Others	50 - 100

Summary of JSC SBIR Accomplishments – Advanced Charring Ablators

- Developed Promising New, Low-Cost Heat Shield Manufacturing Process ("SCBA")
- Developed Family Systems of Advanced Silicone and Phenolic Ablators (10 to 40 Lb/Ft^3)
- Completed Two Major Arc-Jet Tests in FY2000 and FY-2001
- New Silicone Ablators are Lightest Reliable Materials Available Today for Mars Missions
  - S-13 "Hyperlite A" 13 Lb/Ft^3 Net (12.0 Lb/Ft^3 Ablator with 1.0 Lb/Ft^3 Reinforcement)
  - S-12 "Hyperlite B" 12 Lb/Ft^3 Net (11.0 Lb/Ft^3 Ablator with 1.0 Lb/Ft^3 Reinforcement)
- "Hyperlite A" Offers >20% Weight Savings Compared to Mars Pathfinder TPS (SLA-561V)
- New Phenolic Ablators Offer Weight Savings of >33% Compared to Apollo TPS (SLA-561V)
- Small Subscale Ellipsled Heat Shields Fabricated for "SCBA" Demonstration

SBIR ABLATOR/FABRICATION TECHNOLOGY BENEFITS

- New Lightweight, Low Cost, Robust and Efficient heat shields
- TPS Performance That Satisfies Multi-mission Needs
- Enables Heat Shield Fabrication At Low Cost
  - Efficient, semi-automated production
  - CNC milling produces "KIT" of ablator parts
  - Provides a better, more uniform TPS
  - Works well for thick (3-4 in.) Or thin (0.8 in.) TPS
  - Provides for TPS thickness tapering for weight savings
  - Allow NDI of cured ablator prior to assembly
- Facilitates Greater NASA/Industry Technology Partnership
  - Arc-jet characterization testing
  - Thermal ablation response models
  - Flight-response predictions

CONCLUDING COMMENTS

- NASA ISPT Technologies Funding JSC SBIR Results
- Establish New "TPS Technology Team" Within NASA
- Select Team Members To Integrate Needed Technologies
  - Thermal and mechanical analysis
  - Materials engineering
  - Advanced manufacturing
- Pursue In-House NASA TPS Design and Fabrication Capability
  - Opens door to new industry partnerships
  - Allows space robotic-mission teaming with JPL
  - Puts NASA in driver's seat for best TPS materials and design