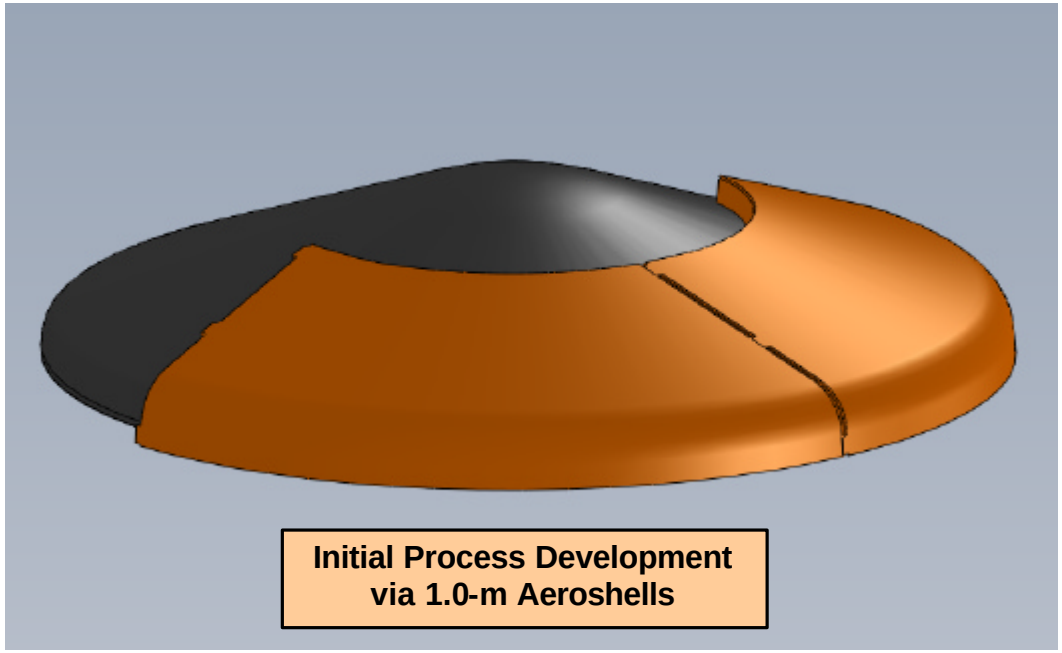
INTERNATIONAL PLANETARY PROBE WORKSHOP VIII
PORTSMOUTH, VIRGINIA, USA – 6-10 JUNE 2011
(SESSION 7A – ADVANCES IN TPS TECHNOLOGY)

MODULAR MANUFACTURING OF HONEYCOMB REINFORCED CHARRING ABLATOR SYSTEMS FOR AEROSHELLS OF LARGE EDL VEHICLES

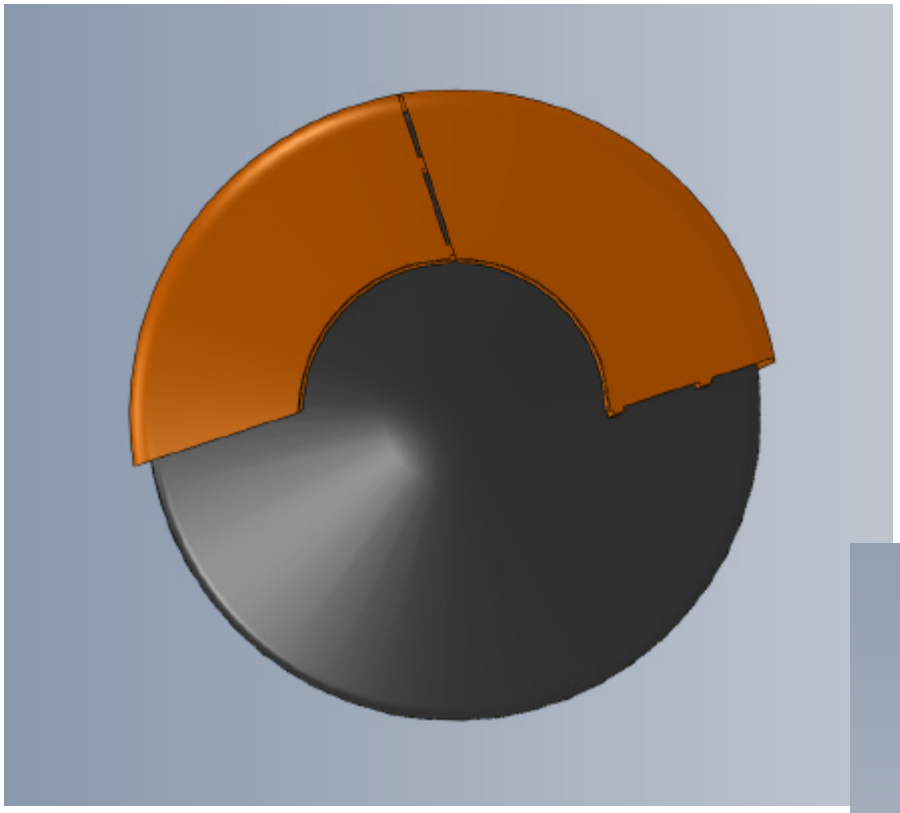


Principal Investigator:
William M. Congdon
ARA Ablatives Laboratory (ABL)
Applied Research Associates
Centennial, Colorado 80112
303 / 699-7737

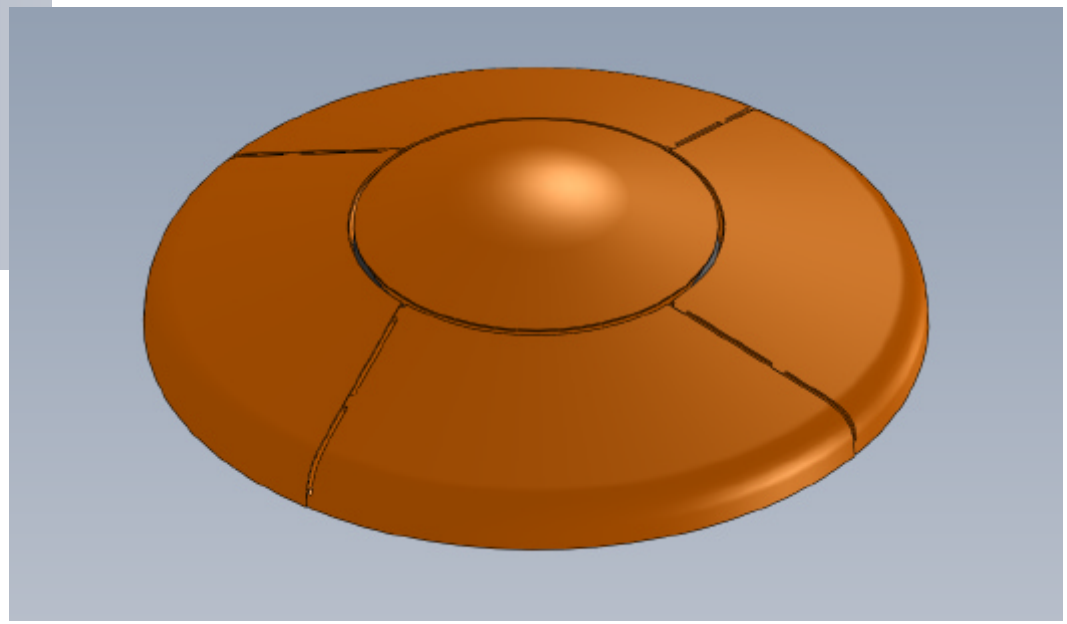
NASA ISPT Contract NNM07AA93C

MODULAR HEATSHIELD SYSTEM – HONEYCOMB PACKED ABLATOR

Five Molded and Milled Modules on 1.0-m A/S Composite Structure



- Ablator Packed into H/C Using Precision Molds
- Net Modules Produced via CNC 5-Axis Milling
- Spacers Maintain Gaps During Module Bonding
- Seams Packed with Same Ablator Compound
- Improves Producibility for Large Aeroshells
- Enhances NDI and Quality Assurance
- Facilitates Aerothermal Instrumentation
- Allows “Concurrent” Manufacturing
- Opens Door for "New Technology"



ABL Heatshield Production in 2010 and 2011

- Two 1.0-m Modular Units Finished
- One 2.65-m Modular Unit Nearing Completion

DISCUSSION OF COMPOUNDED, POLYMER-BASED CHARRING ABLATORS

Compounded with Multiple Constituents -

- Resin Binder and Matrix
- Chopped Reinforcing Fibers
- Low-Density Fillers (e.g., Microballoons)
- Adhesion Enhancers (e.g., Silanes)
- Special Transpirants

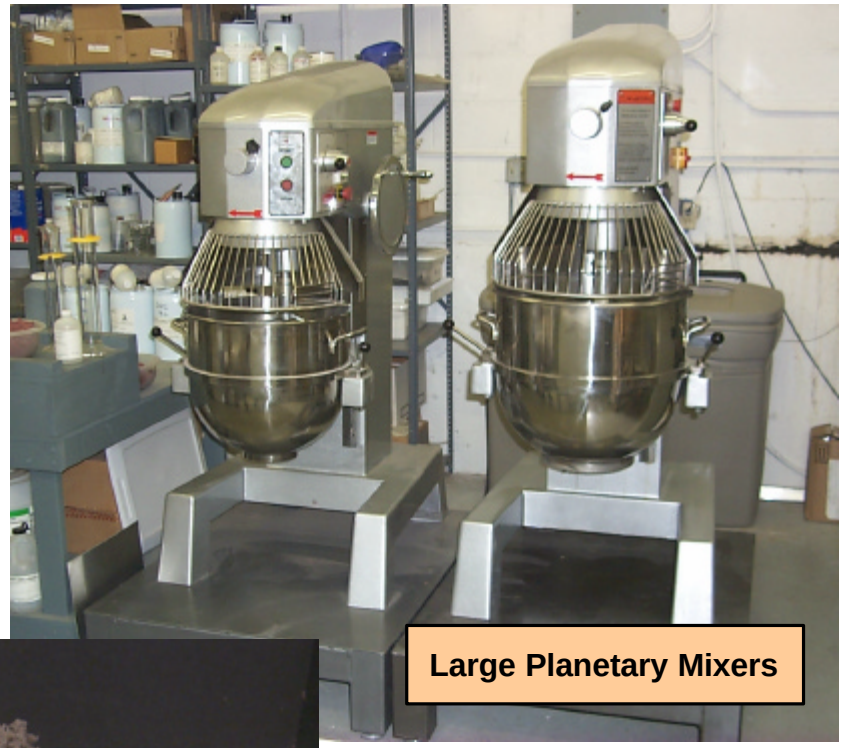
Integrated and Blended in Planetary Mixers -

Commonly Reinforced with Honeycomb -

Compacted Under Pressure -

Cured at Temperature -

Milled to Shape -



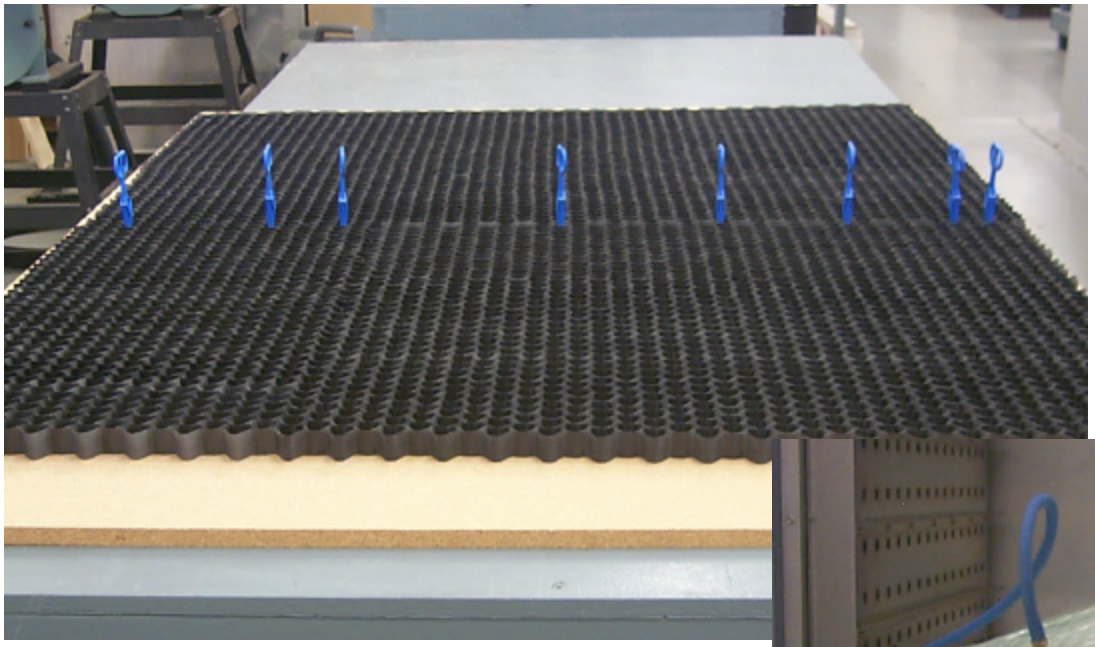
Large Planetary Mixers

Mixed Compound

ABL HONEYCOMBS MADE FROM PHENOLIC PREPREG - ~10-MIL THICK

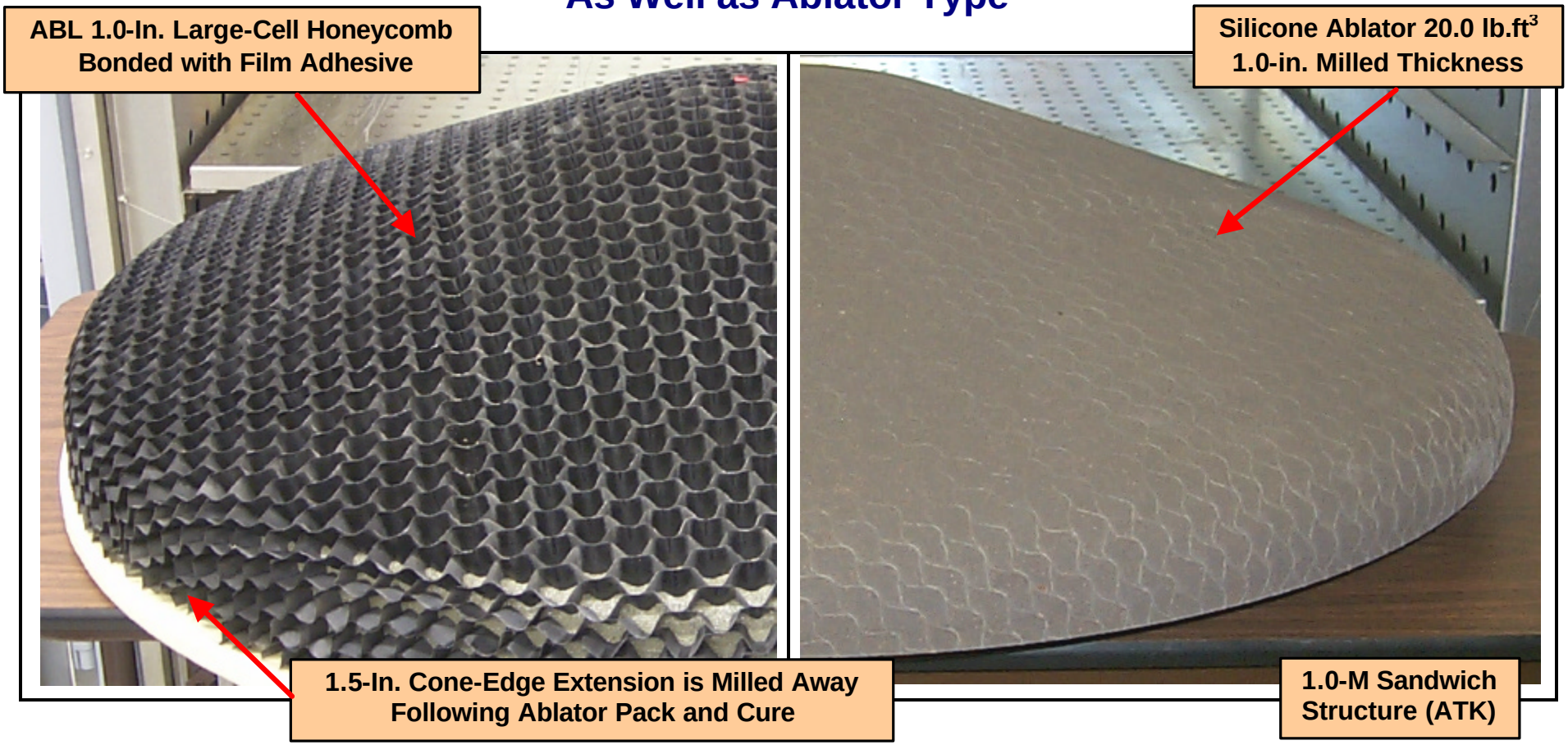
Standard Ablator H/C is 1.0-In. Cell Size, Large-Cell Quartz Honeycomb

(Also: Different Cell Size, Different Fabric Thickness, Different Fabric Material)



CONVENTIONAL H/C PACKING IS WORKABLE FOR SMALL AEROSHELLS

Practical Upper Limit for "Conventional" Depends on Ablator Density & Thickness As Well as Ablator Type

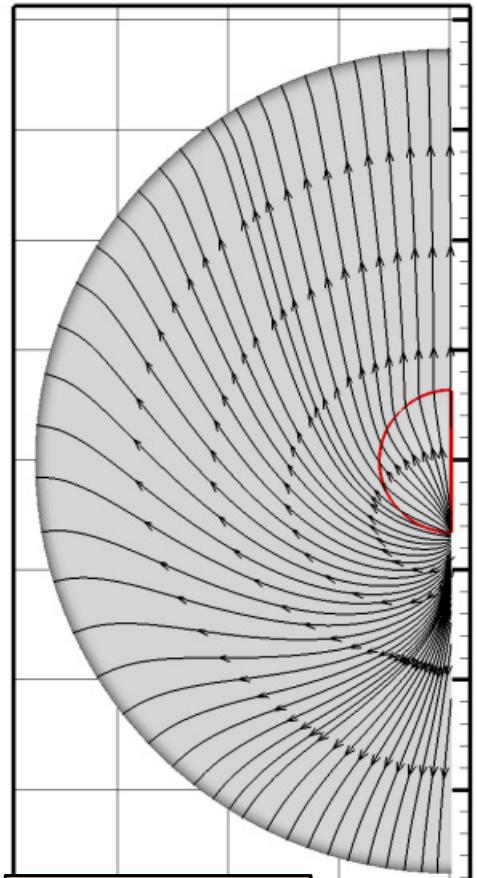


1.0-m Dia. Test Aeroshell Shown - 1.0-in. Thick Ablator – 1.0-in. Composite Structure

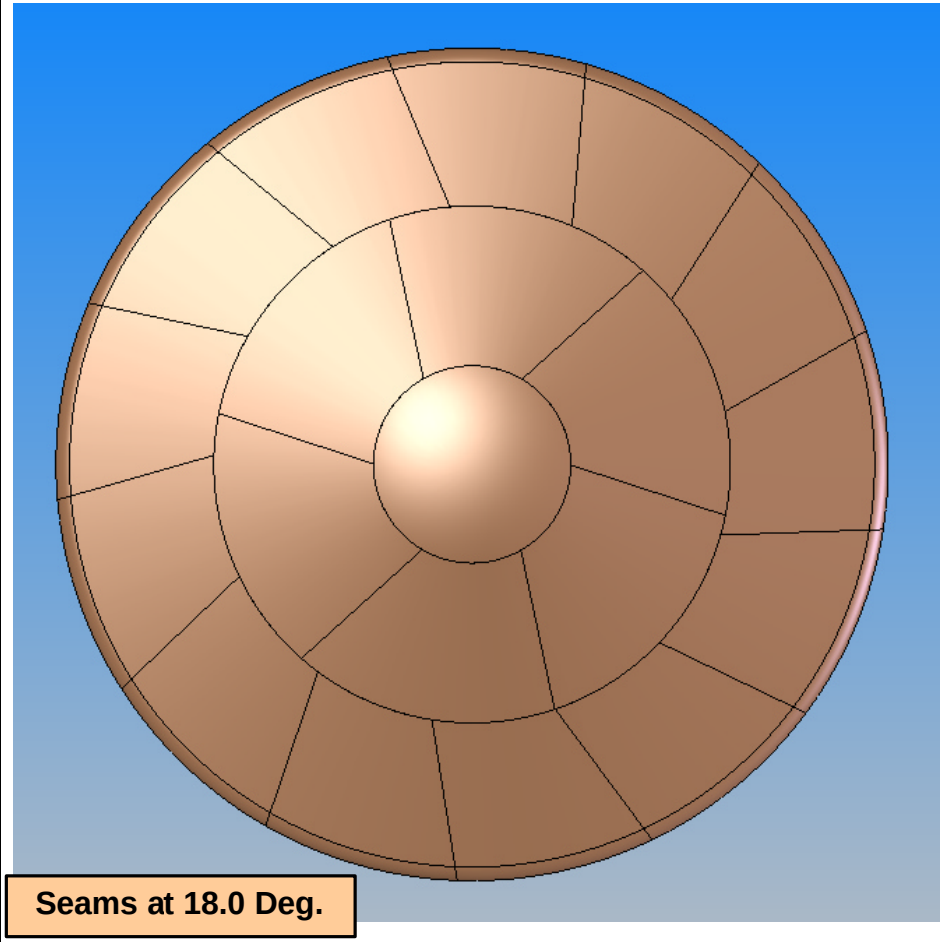
ABL MANUFACTURING CONCEPT FOR 4.5-M MARS AEROSHELL – 2005

20 H/C-Packed/Reinforced Ablator Modules – Instead of One H/C Packed Monolith

(Early 2005 MSL studies for 4.5-m aeroshell with ~45% greater heatshield surface area vs. Vikings of 1976)



AOA – 11.0 Deg.



Seams at 18.0 Deg.

20 Modules Total

Nosecap (1)

Area – 9.75 ft^2 / 0.906 m^2
Vol – 0.988 ft^3 / 0.0280 m^3
Mass – 16.8 lb / 7.62 kg

Inner Ring (6)

Area – 10.0 ft^2 / 0.929 m^2
Vol – 1.04 ft^3 / 0.295 m^3
Mass – 17.5 lb / 7.94 kg

Outer Ring (13)

Area – 9.74 ft^2 – 0.905 m^2
Vol – 0.988 ft^3 / 0.0280 m^3
Mass – 16.8lb / 7.62 kg

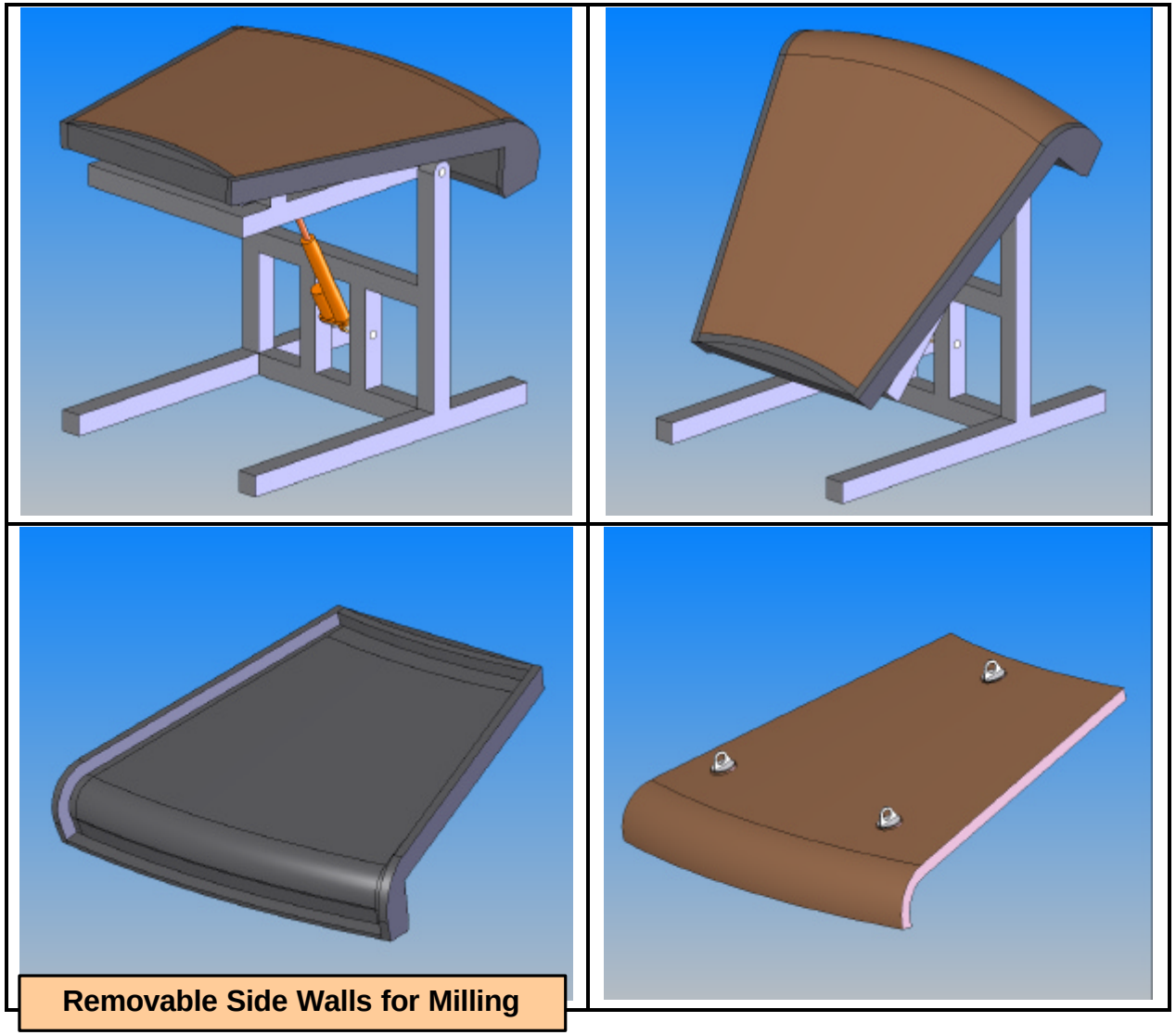
Total Mass*

322.7 lb / 146.4 kg

*17.0 lb/ft^3 Silicone Ablator (high elongation)

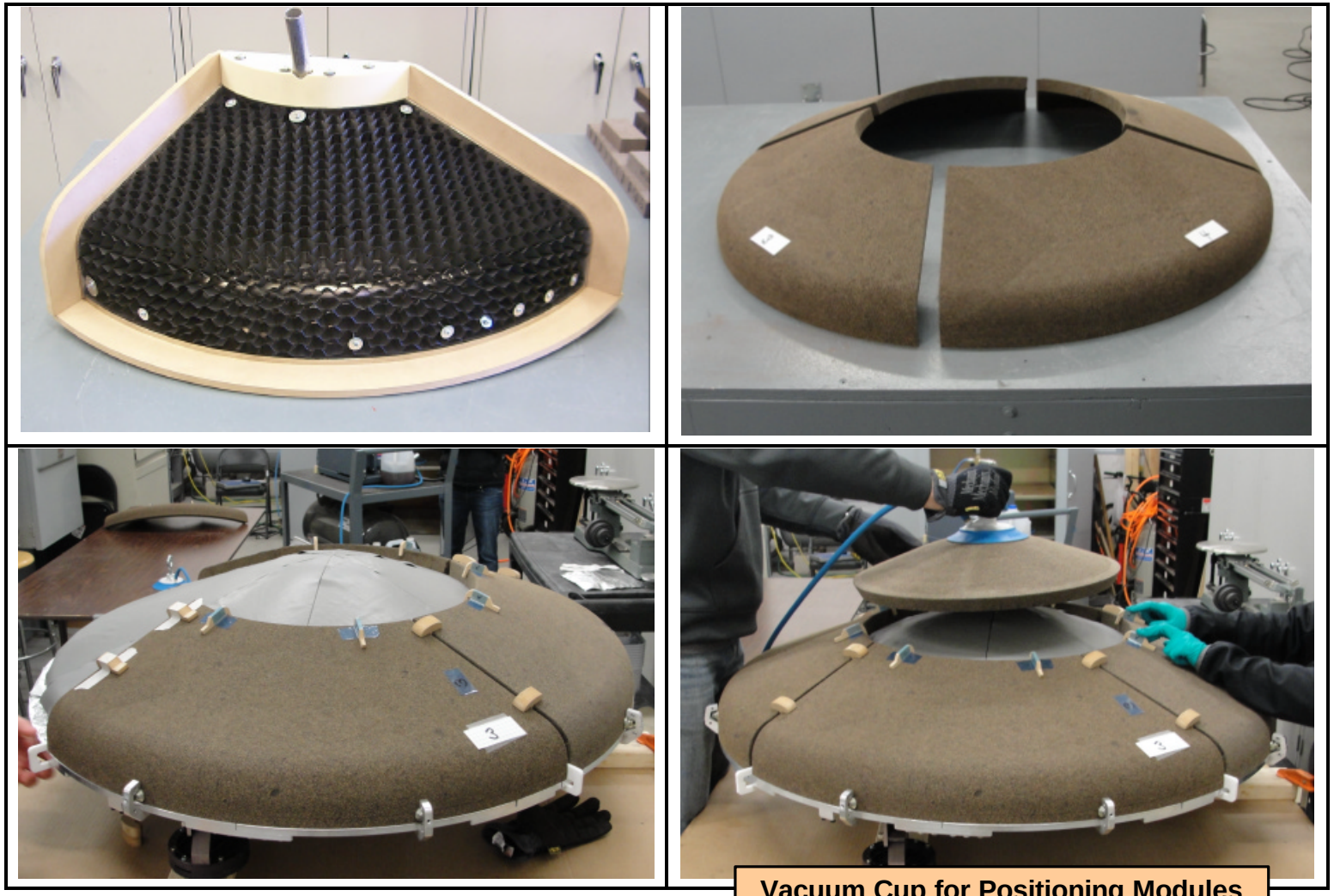
CONCEPTUAL TOOL FOR FLANK MODULE OF 4.5-M SIZE AEROSHELL

H/C Packed Ablator Molded to Near-Net then CNC Milled to “Final” Size and Shape



ABL MODULAR PROCESS DEVELOPMENT VIA TWO 1.0-M AEROSHELLS

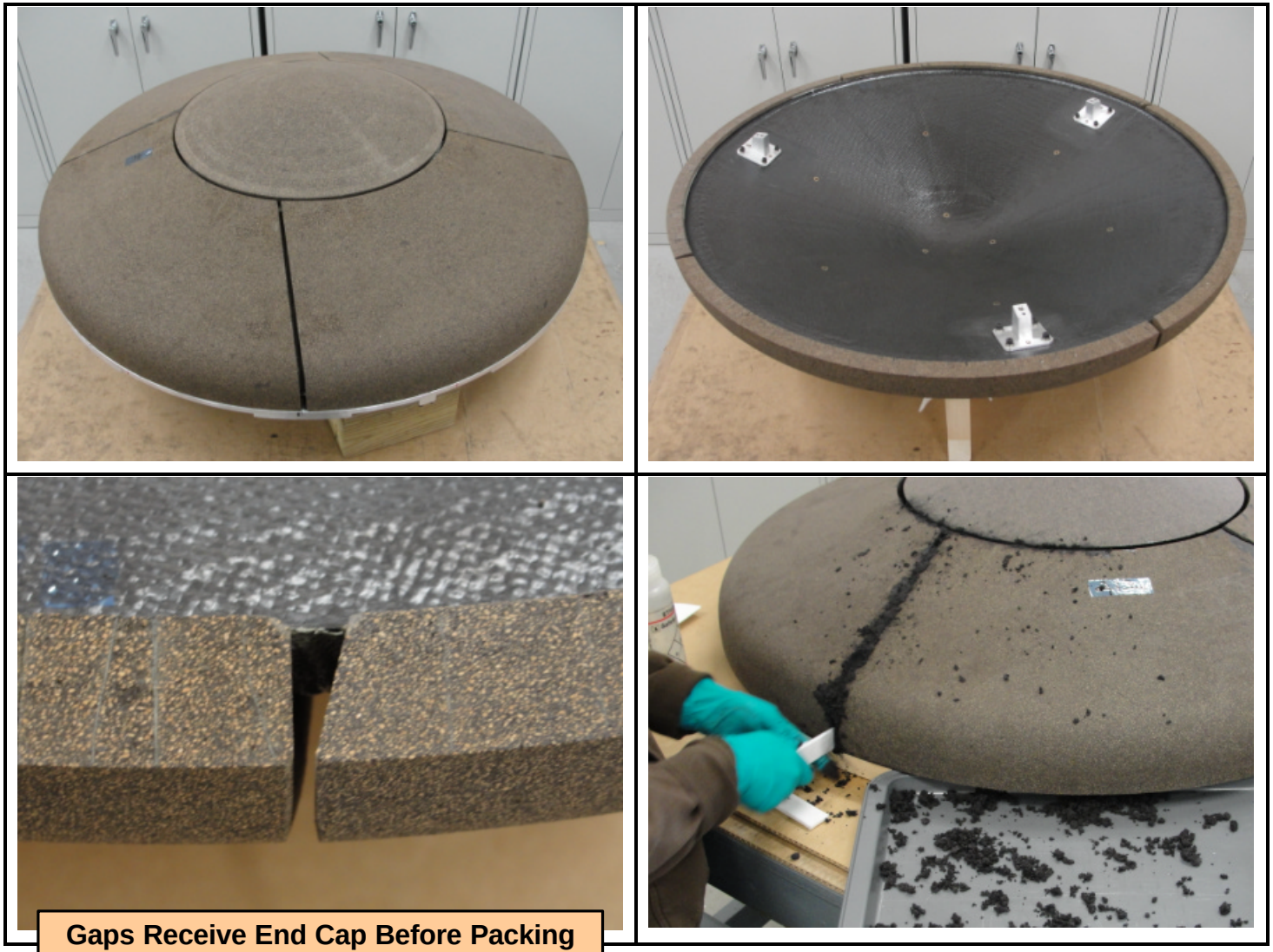
Precision Aluminum Mold with Composite Side Wall Extensions



Vacuum Cup for Positioning Modules

PRECISION "KEYSTONE" GAPS - PACKED WITH SAME ABLATOR

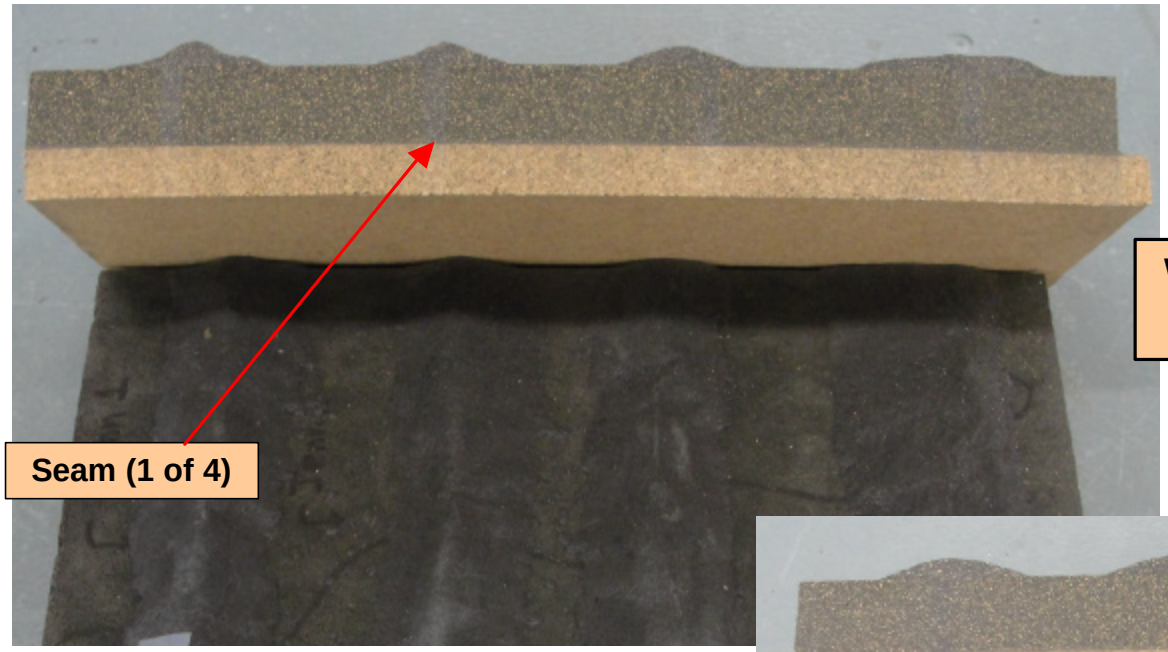
Testing to Date Showed Same Performance for Gap and Module Ablator



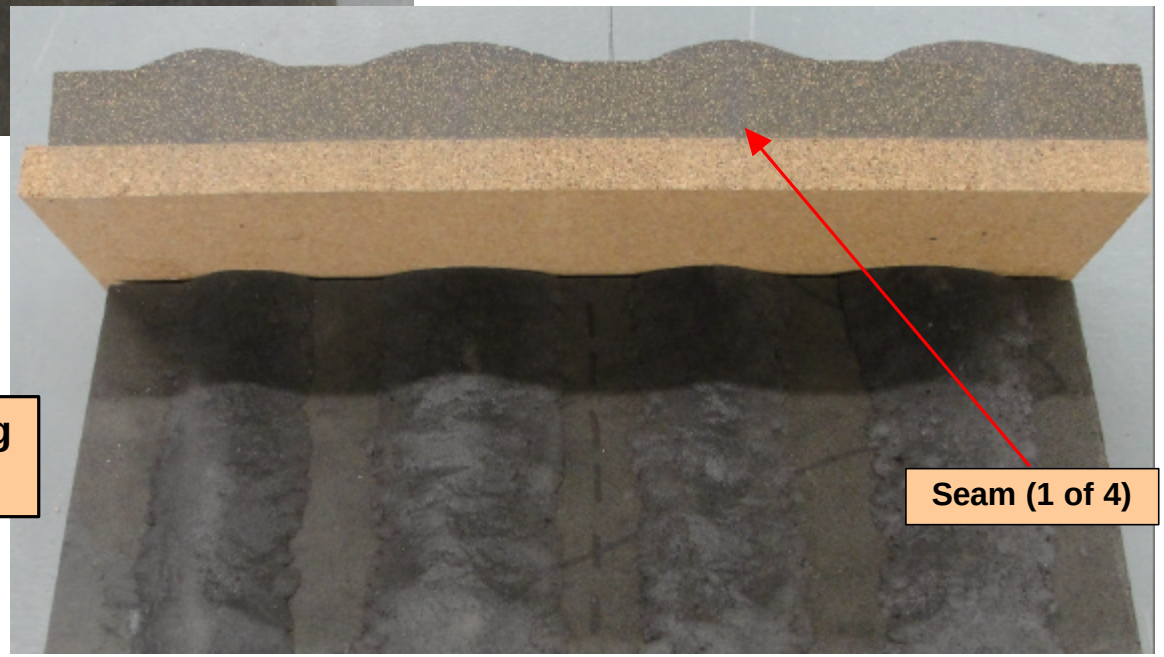
Gaps Receive End Cap Before Packing

WITNESS PANELS USED TO VERIFY GAP PACKING ON HEATSHIELDS

Under Vacuum Bag Pressure Gaps Fill Completely and Essentially "Disappear"



Witness Panel for Gap Packing
First 1.0-m Heatshield



Witness Panel for Gap Packing
Second 1.0-m Heatshield

CRITICAL FINAL STEP - PRECISION CNC 5-AXIS SURFACE MILLING

Removes Remaining Overpack & Excess Gap Ablator - Achieves Design Shape

Gap End Caps are also Milled Away

COMPLETED 1.0-M MODULAR PHENOLIC CARBON HEATSHIELD - NO.1

Entire Process Worked Superbly - Opens Door to Large Units, New Technology

Completed Aeroshell Ready for Flight!
In-Space Propulsion Technology

ABL 1.0-M PHENOLIC-CARBON AEROSHELL "IN FLIGHT" - SOLAR TOWER

Initial Seconds of Exposure at 150 W/cm^2 - Duration 195 Seconds - 25 March 2011

Primary Test Purpose: Thermostructural Integrity

Photo by Steve Moon

1.0-M PHENOLIC-CARBON AEROSHELL NEAR END OF 195 SECOND TEST

Bondline Temperature Raised to "Flight Allowable" of 250°C with Flight Gradients

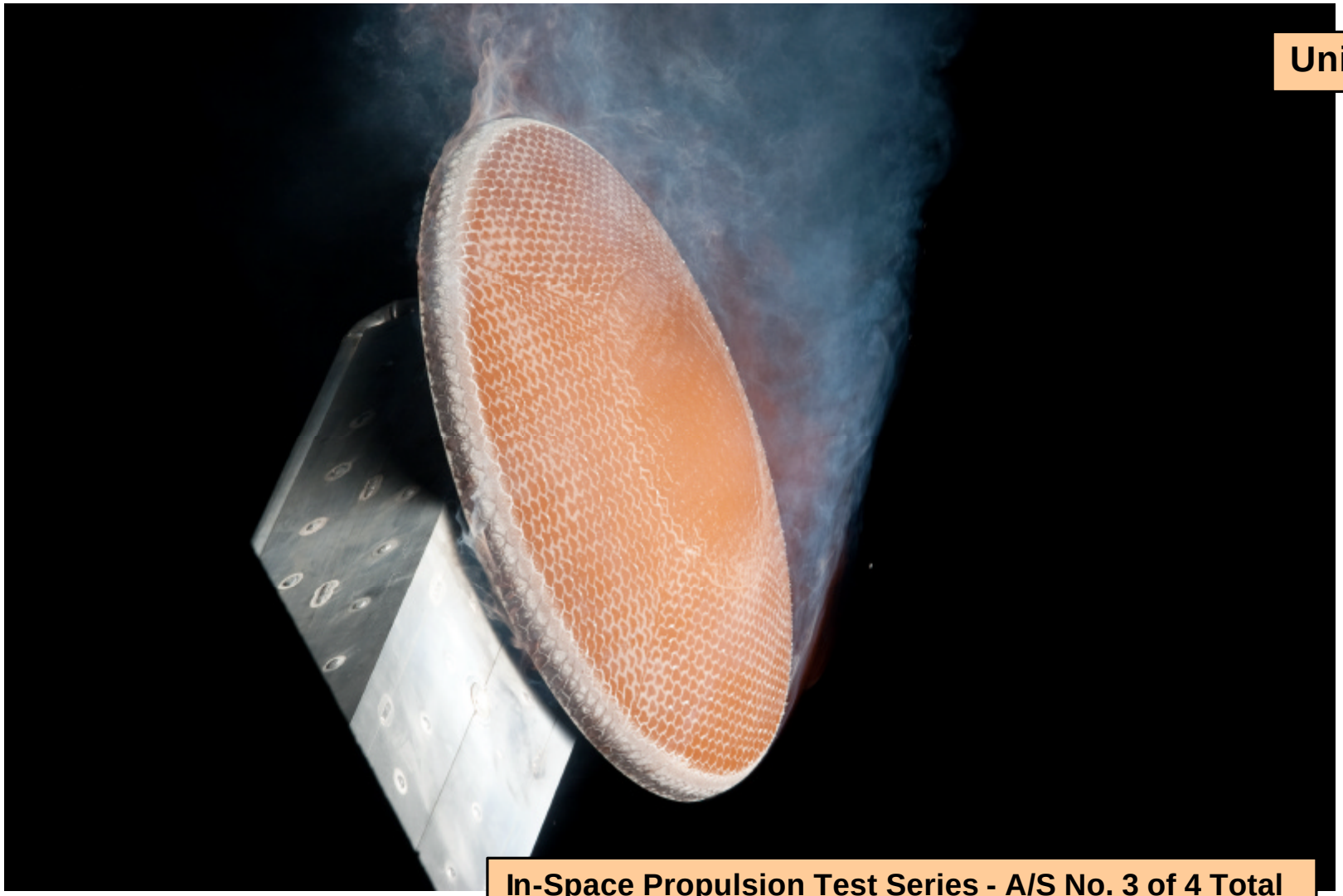


Photo by Steve Moon

ABL LARGE MODULAR 2.65-M MDU - "EQUAL" MODULES TO 4.5-M A/S*

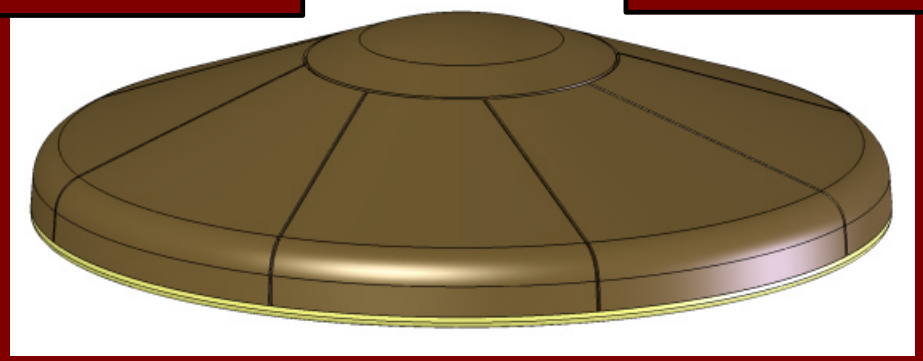
Nine Ablator Modules Produced and Currently in Preparation for Bonding (CNC)

ATK Advanced Aeroshell Structure
M55J Skins – Titanium H/C Core

Same A/S Size as MPF and MER

Nine Modules

20-lb/ft^3 Silicone

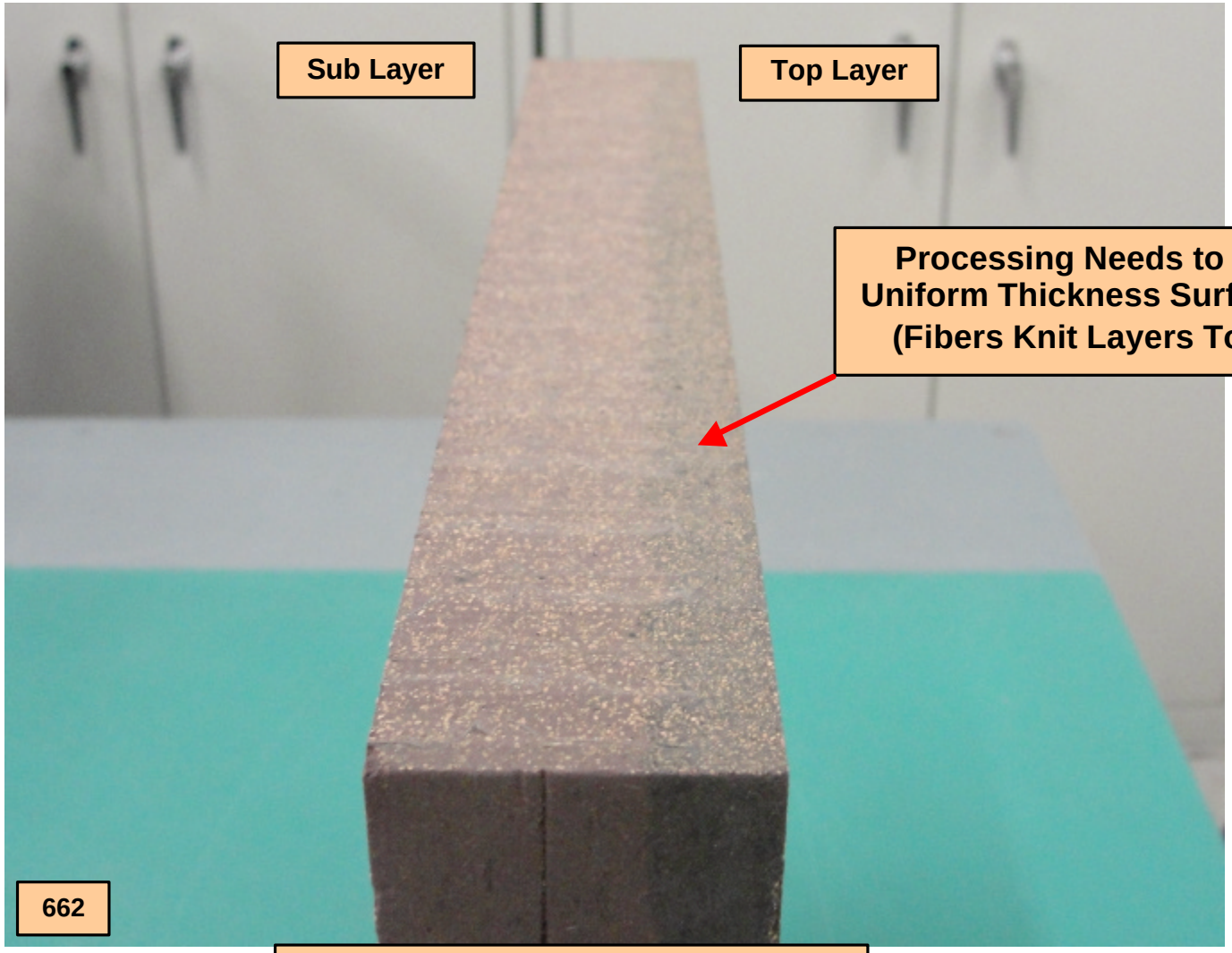


"Keystone" Gaps are Packed and Cured with Same Ablator Compound as Modules

(*Approximately Equal in Size to Modules of 4.5 A/S on Page 6)

"MODULAR" OPENS DOOR TO NEW TECHNOLOGIES - DLA IS EXAMPLE

Dual-Layer Phenolic Ablator with 28 lb/ft^3 Robust Surface Over 15 lb/ft^3 Ablator/Insulator



ABL Panel Delivered to NASA/ARC for HMMES Ablation/Mechanical Testing

(Photo 5788)

MODULAR HEATSHIELDS – SUMMARY AND CLOSURE POINTS

Modular Process Summary

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Modular Process Advantages

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William Congdon
3 June 2011