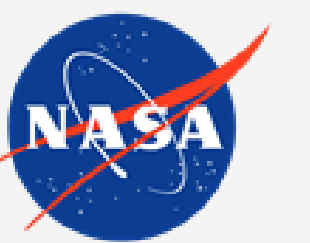


# Composite Technologies for Science Missions



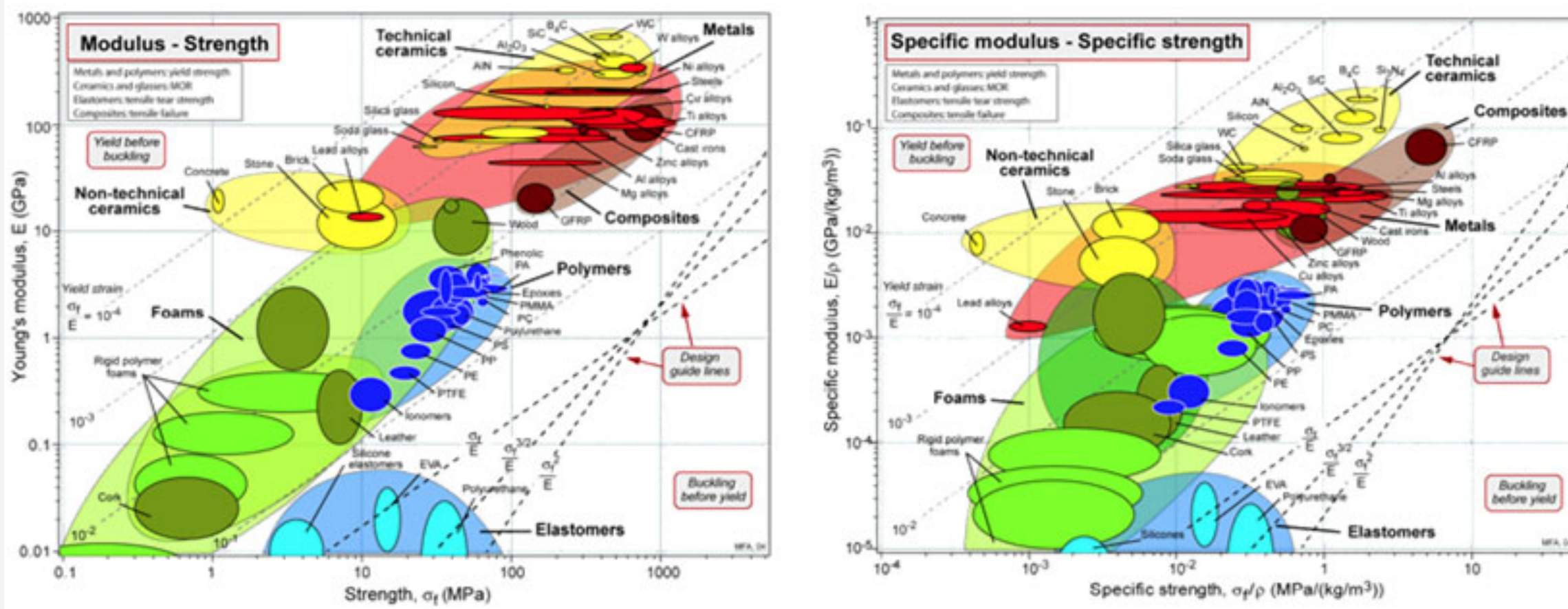
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 Non-Metallic Materials Division – Advanced Manufacturing Branch (EM42)  
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## Material Advantages

### Tailored materials properties

Composites take advantage of different material properties to minimize weight while maximizing:

- Strength } Primary (design drivers)
- Stiffness } Primary (design drivers)
- Radiation resistance } Secondary – can also be addressed with coatings (↑\$)
- Corrosion resistance } Secondary – can also be addressed with coatings (↑\$)



Graphite-based composites have **zero to little coefficient of thermal expansion (CTE)**, allowing for simple designs in dynamic conditions

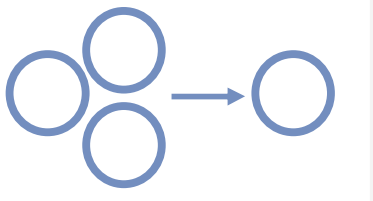


Structures can be designed to provide **protection from electrostatic discharge (ESD)**

## Design Considerations

### Monolithic design: reduce part count

- reduce cost
- reduce risk of joint failure



### Brittle behavior:

- + (pros) rigid structure with minimal creep, deflection
- (cons) low impact resistance, little warning of failure

### Natural Vibration: tailor to specific frequency to mitigate communications issues as well as mechanical effects



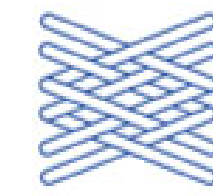
### Conformation: complex geometries are possible thanks to a large variety of textiles. No secondary/subtractive processing required.

- Note: **springback** is a potential issue but can be mitigated with layup and tool design

### Composite Textile Terminology

Layup: series of layers of 2D material  
 Preform: single 3D textile product  
 Weaves: 2D wrapping of fibers  
 Knits: 3D wrapping of fibers

Tow: bundle of fibers  
 Tape: flattened tows  
 Filament: single fiber or synonymous with tow



## Science Mission Applications



**Vehicles:** rovers, landers, flying probes

Shells and platforms can be made using automated and/or manual techniques. Sandwich composites can be designed to provide additional stiffness.

**Tanks:** fuel, hydraulics



In lieu of traditional metallic tanks, all-composite or lined composite tanks can be made using the same technique as struts: filament-winding. Composite-overwrapped pressure vessels (COPVs) are common in modern designs.

Struts and other cylindrical bodies can be made using filament-winding.

Non-metallic fuel tank and support structure can be designed for thermal isolation.

## Manufacturing

Large-spanning structures, such as vehicle bodies, fairing and battery covers using **Automated Fiber Placement**. Automation reduces cost and variation.

Cylindrical structures with high pressure requirements can be made using **filament winding**, which applies tension to the fibers during placement. Fibers are laid in helical and hoop patterns to distribute triaxial stresses.

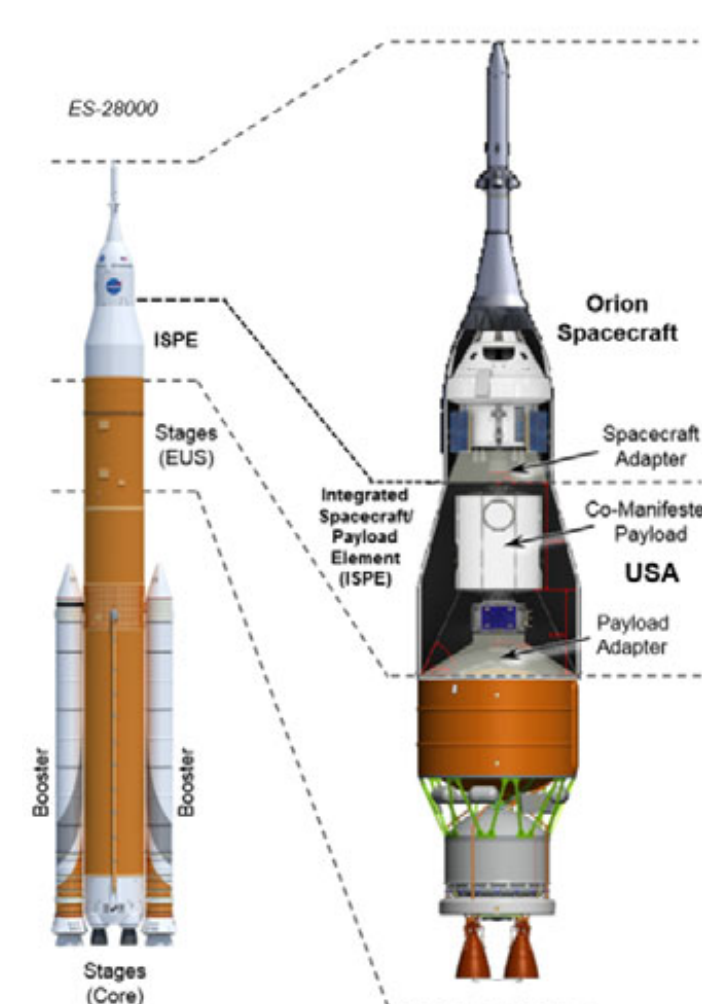
Components such as **liners** and **nozzles** can be integrated for structural and/or chemical stability.



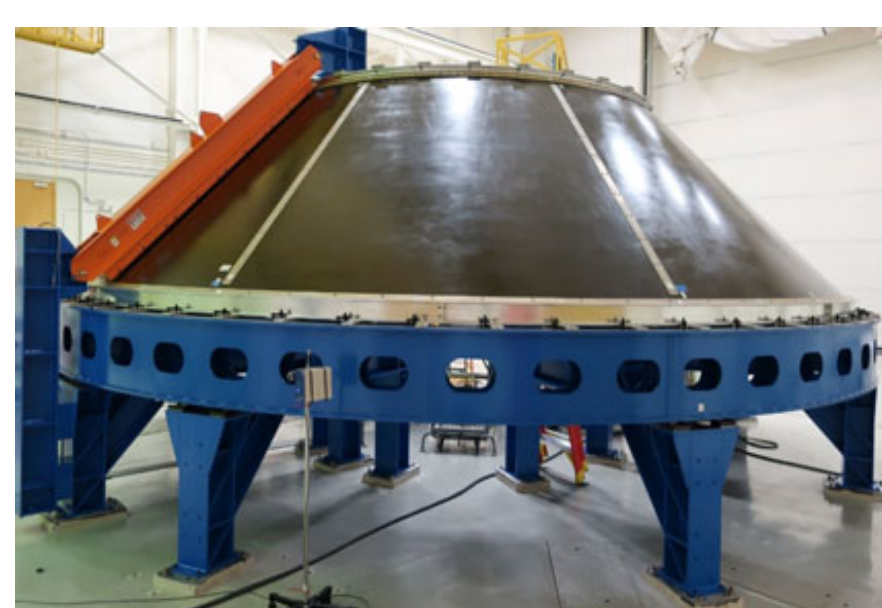
**Hand layup** facilitates use of unique designs, textiles and consolidation/cure methodology.



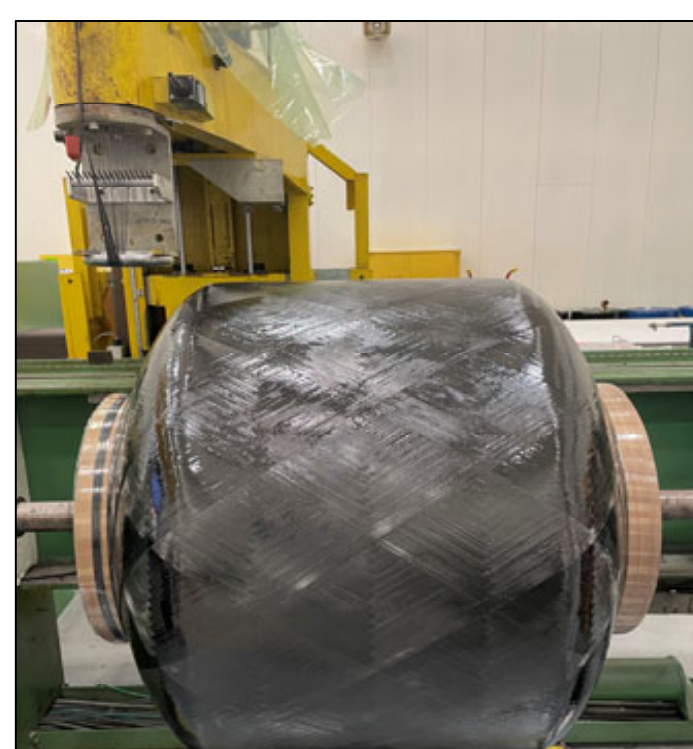
## Examples from NASA MSFC



**SLS Block 1B Payload Adapter**  
 sandwich panels assembled using bonded laminates



**SLS BOLE Segment**  
 Unlined, filament-wound case



**CTE Bonded Joints**  
 Hand-laid pi joint and preform C-channel

