Composite Technologies for Science Missions

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Material Advantages

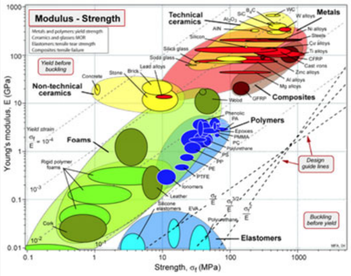
Tailored materials properties
Composites take advantage of different material properties to minimize weight while maximizing:

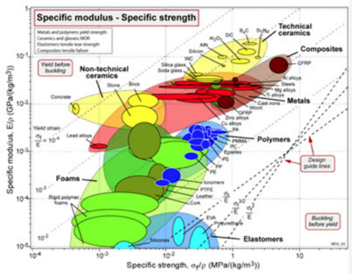
- Strength
- Stiffness

Primary (design drivers)

- Radiation resistance
- 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.

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

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.

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

Manufacturing

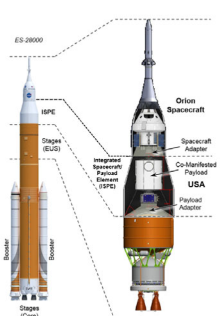
Large-spanning structures, such as vehicle bodies, fairing and battery covers using **Automated Fiber Placement**. Automation reduces cost and variation.

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

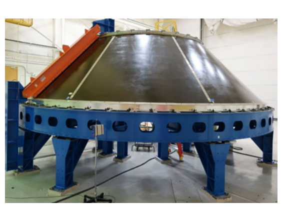
Cylindrical structures with high pressure requirements can be made using **filament winding**, which applies tension to the fibers during placement. Fibers are laid in helical and hoop patterns to distribute triaxial stresses.

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

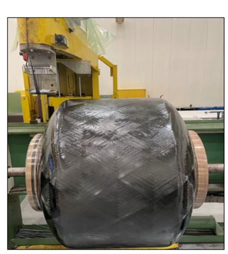
Examples from NASA MSFC

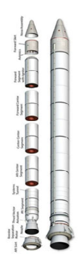


SLS Block 1B Payload Adapter
sandwich panels assembled using bonded laminates

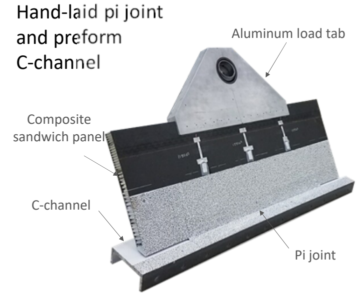


SLS BOLE Segment
Unlined, filament-wound case





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



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