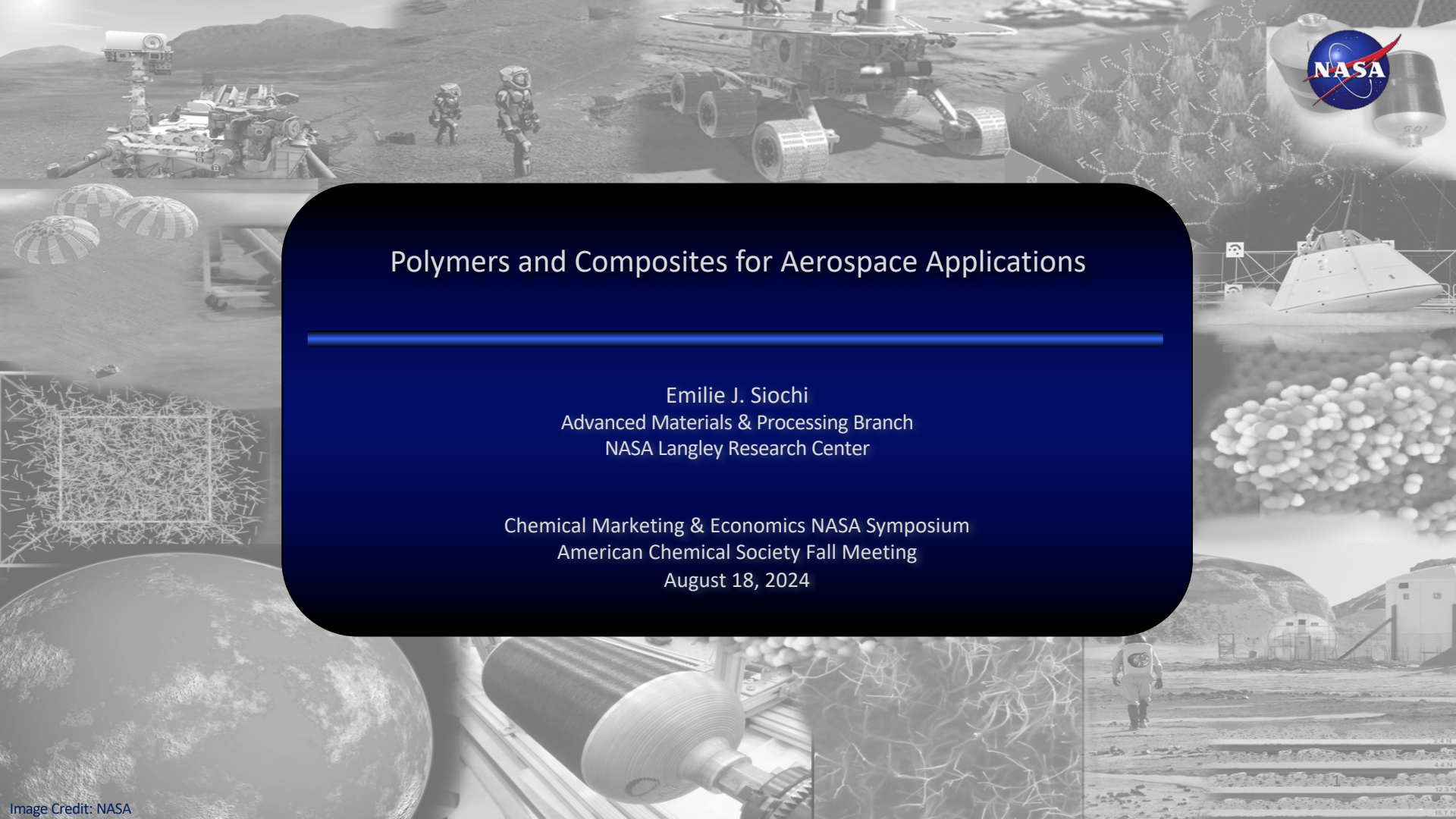
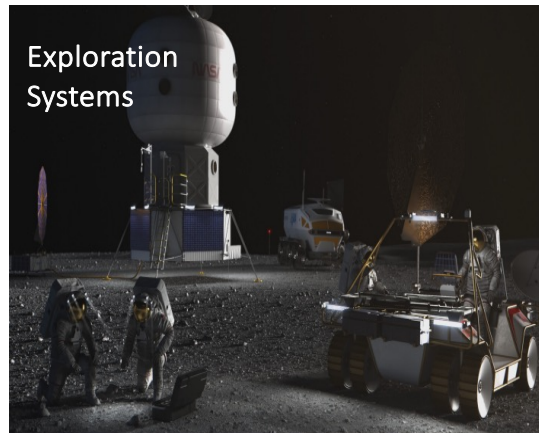




Polymers and Composites for Aerospace Applications

Emilie J. Siochi
Advanced Materials & Processing Branch
NASA Langley Research Center

Chemical Marketing & Economics NASA Symposium
American Chemical Society Fall Meeting
August 18, 2024





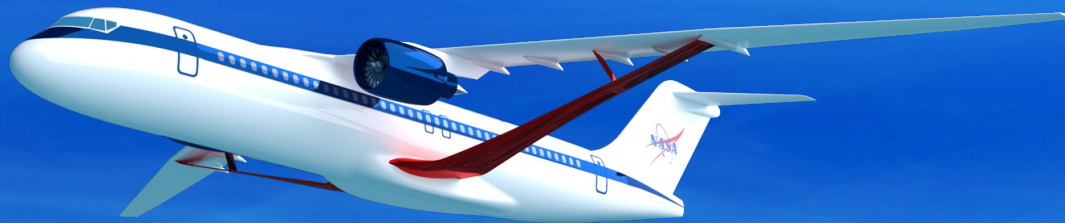
Polymer Materials Across NASA Missions

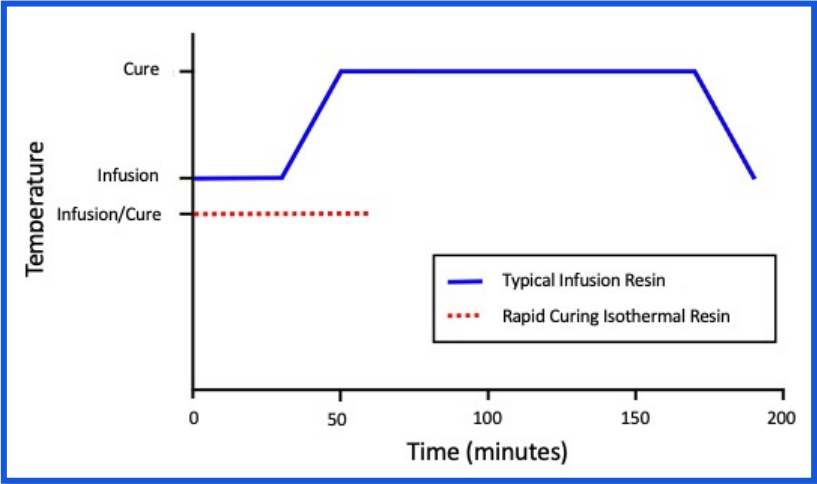
- Aeronautics
 - Hi-Rate Composite Aircraft Manufacturing
- Science
 - Dimensionally Stable Structures
- Space Technology for Exploration Systems
 - Lightweight Structures
 - Sustainable Off-Earth Infrastructure

Hi-Rate Composite Aircraft Manufacturing

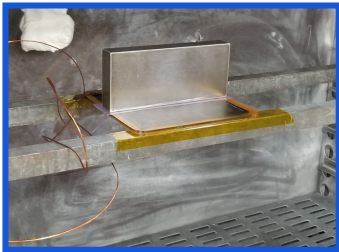
Objective: 4x to 6x increase in composite aircraft production rate

- Market Outlook for Single Aisle Aircraft
- More than 40,000 deliveries by 2040
- Historic aircraft production rates per month
 - Metallic: 60
 - Composite: 10-14
- Target production rate of 80 per month

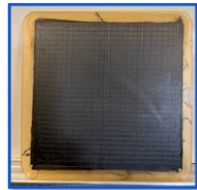




Infusion & Cure



Postcure



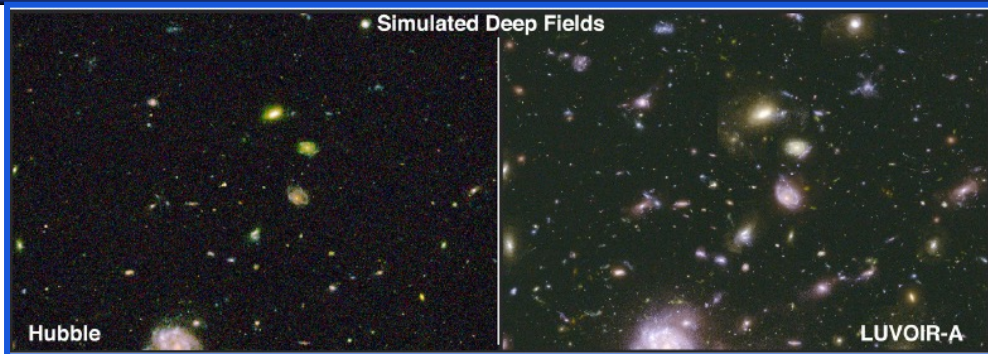
6" x 6" Composite Panel



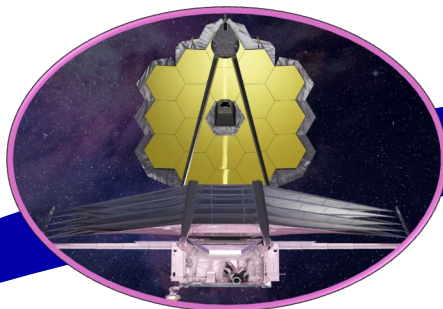
Polymer Materials Across NASA Missions

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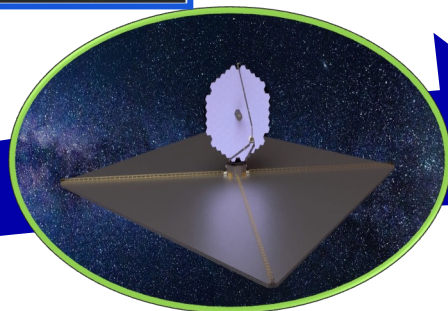
Advanced Space Telescopes



Hubble Space Telescope



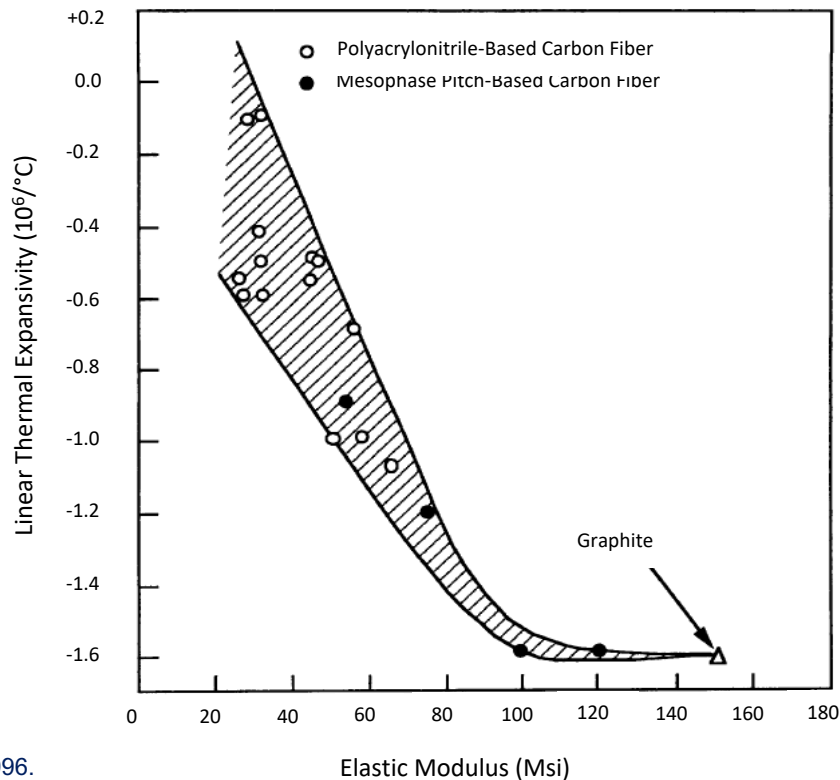
James Webb Space Telescope



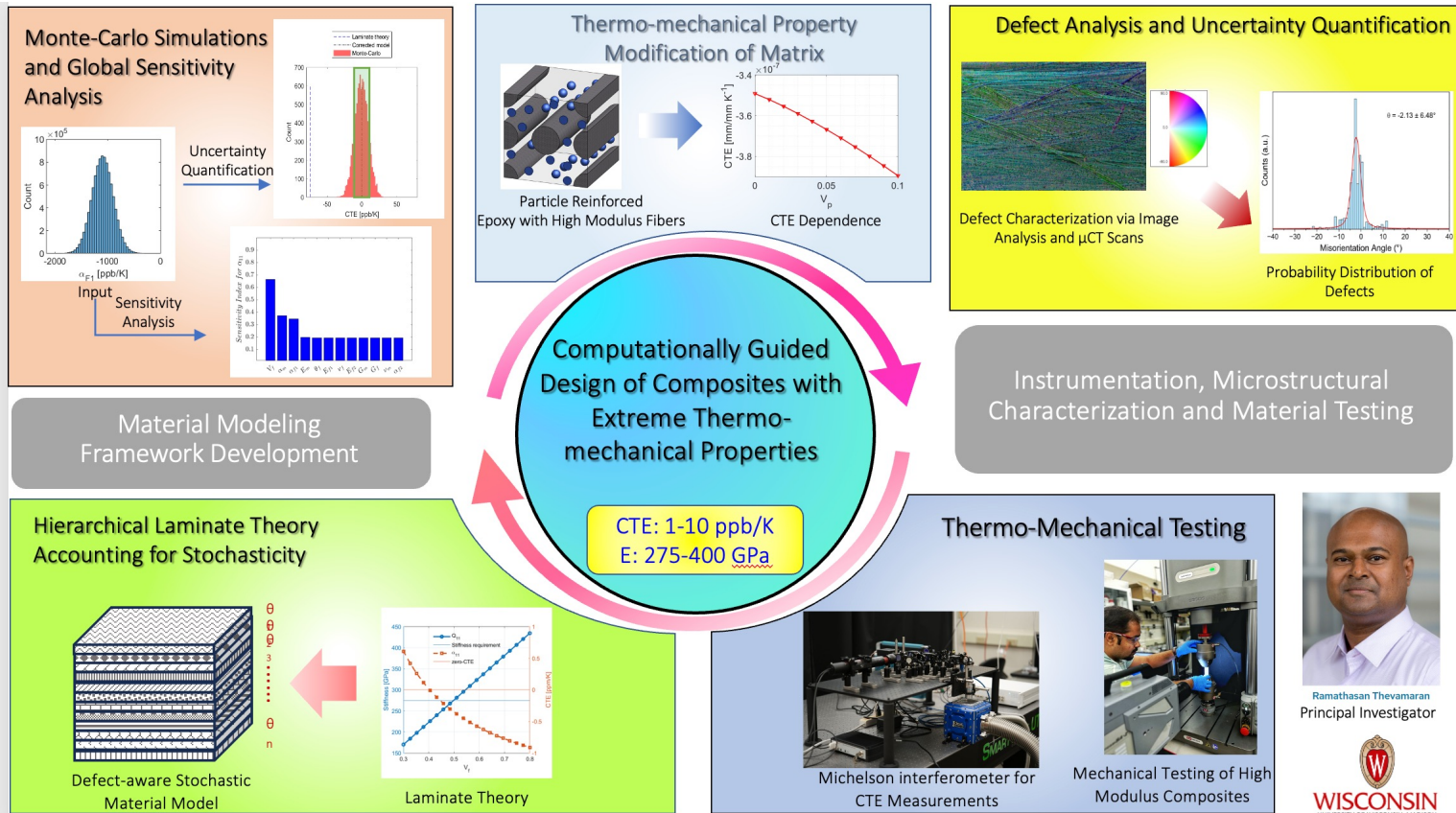
LUVOIR Telescope

Structural Material Challenge

Longitudinal Thermal Expansion and Modulus of Carbon Fibers



Computationally Guided Materials Design



Ramathanan Thevamaran
Principal Investigator





Polymer Materials Across NASA Missions

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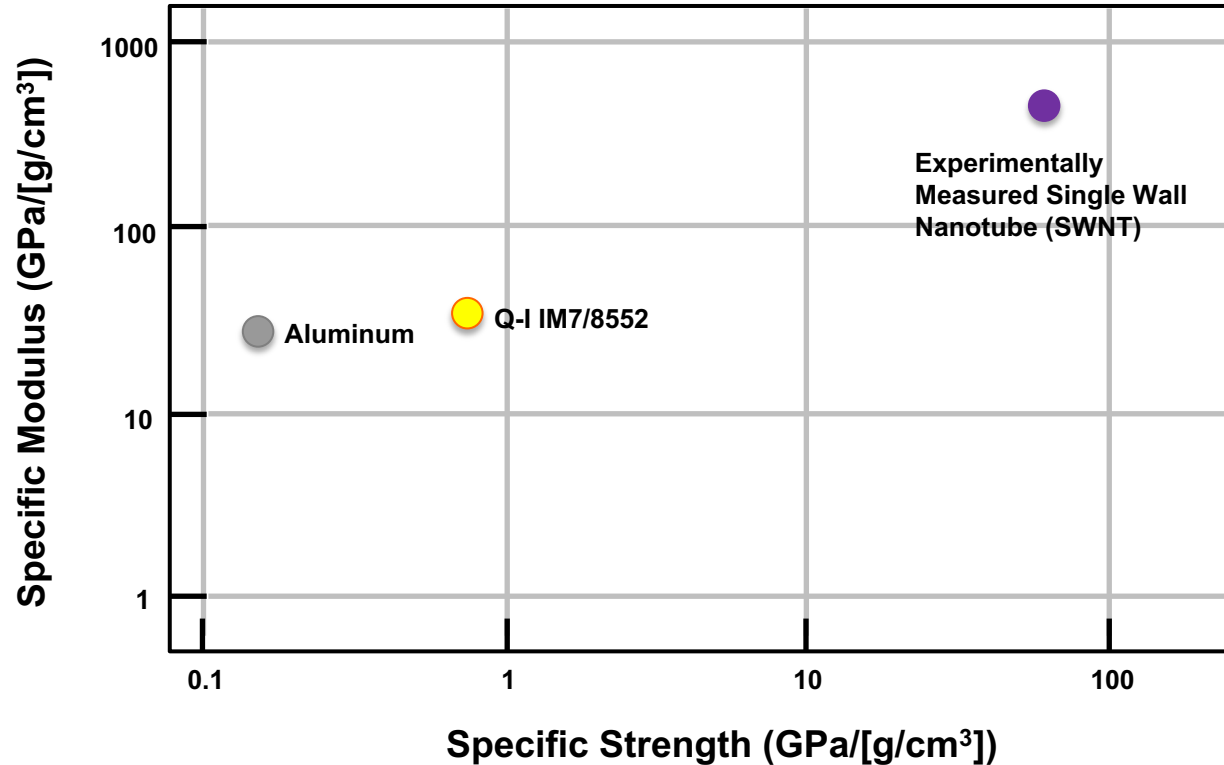
Motivation

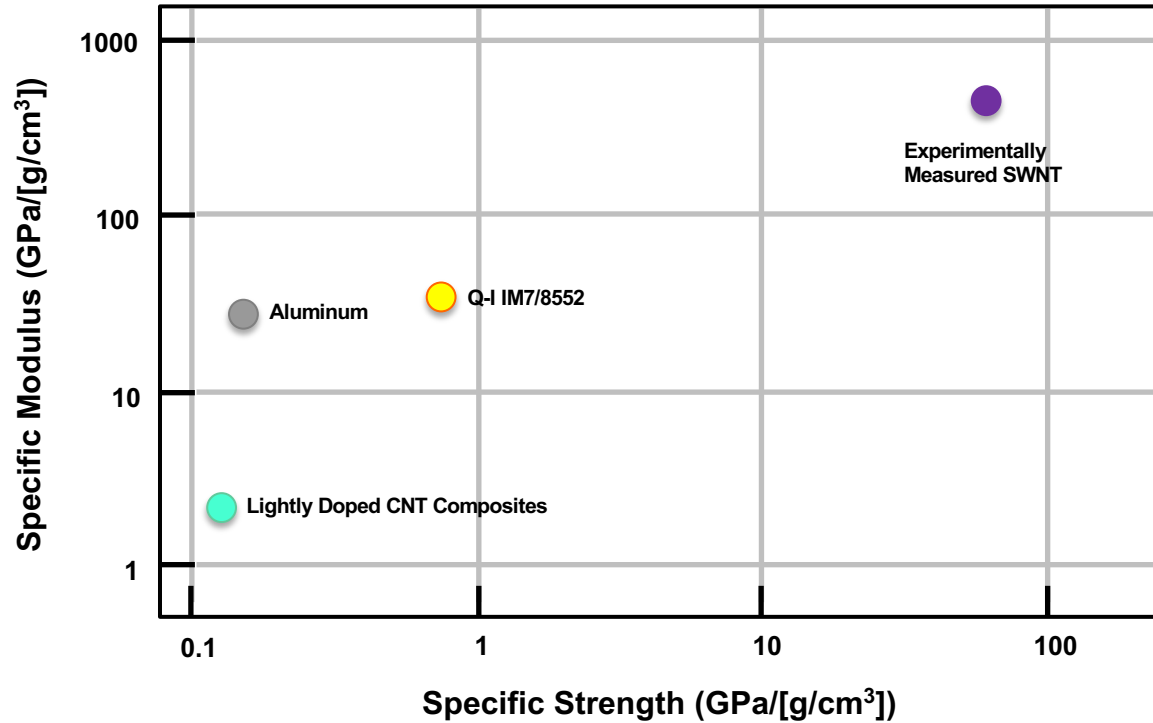
Summary of the Problem

- Cost increases in proportion to the mass ratio.
- Mass ratio increases linearly with the dry mass and exponentially with Δv .
- Reducing structural mass reduces mission cost at constant payload or increases mission capability at constant cost.

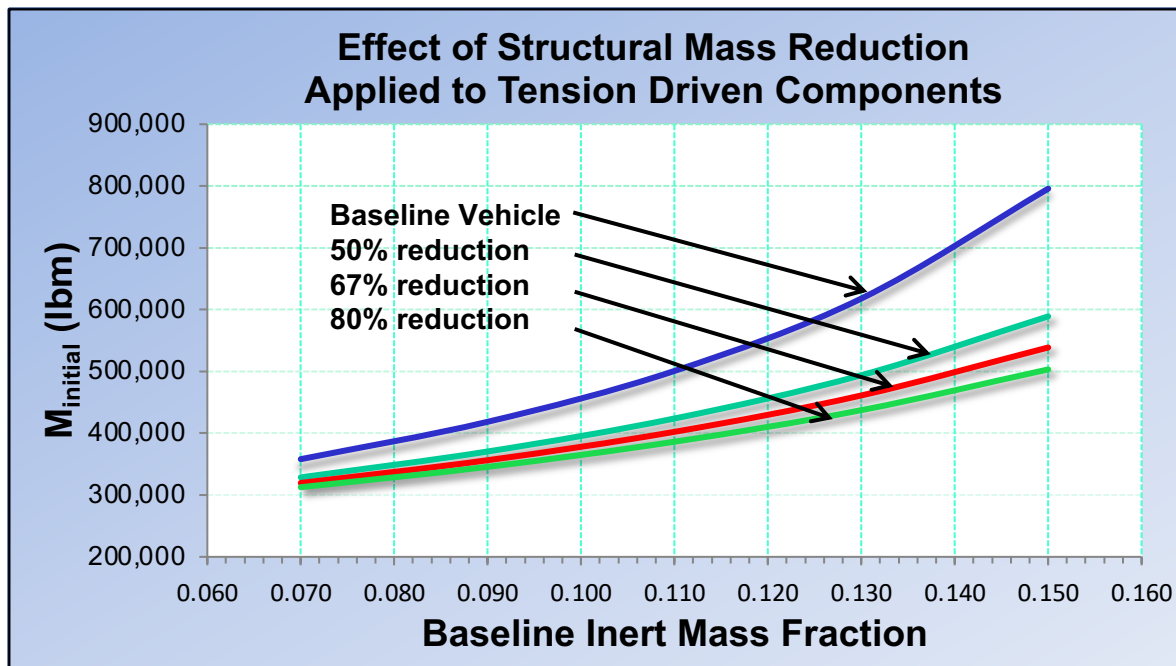
	Mass Ratio*	Cost per pound*
Low Earth Orbit	20	\$4,000
Earth to Moon	200	\$40,000
To Moon, Return to Earth	500	\$100,000
Earth to Mars	500	\$100,000
To Mars, Return to Earth	5000	\$1,000,000

Motivation





Setting Goals using Systems Analysis



- A 2-3x improvement in specific mechanical properties will permit substantial mass reduction in structural and non-structural components.

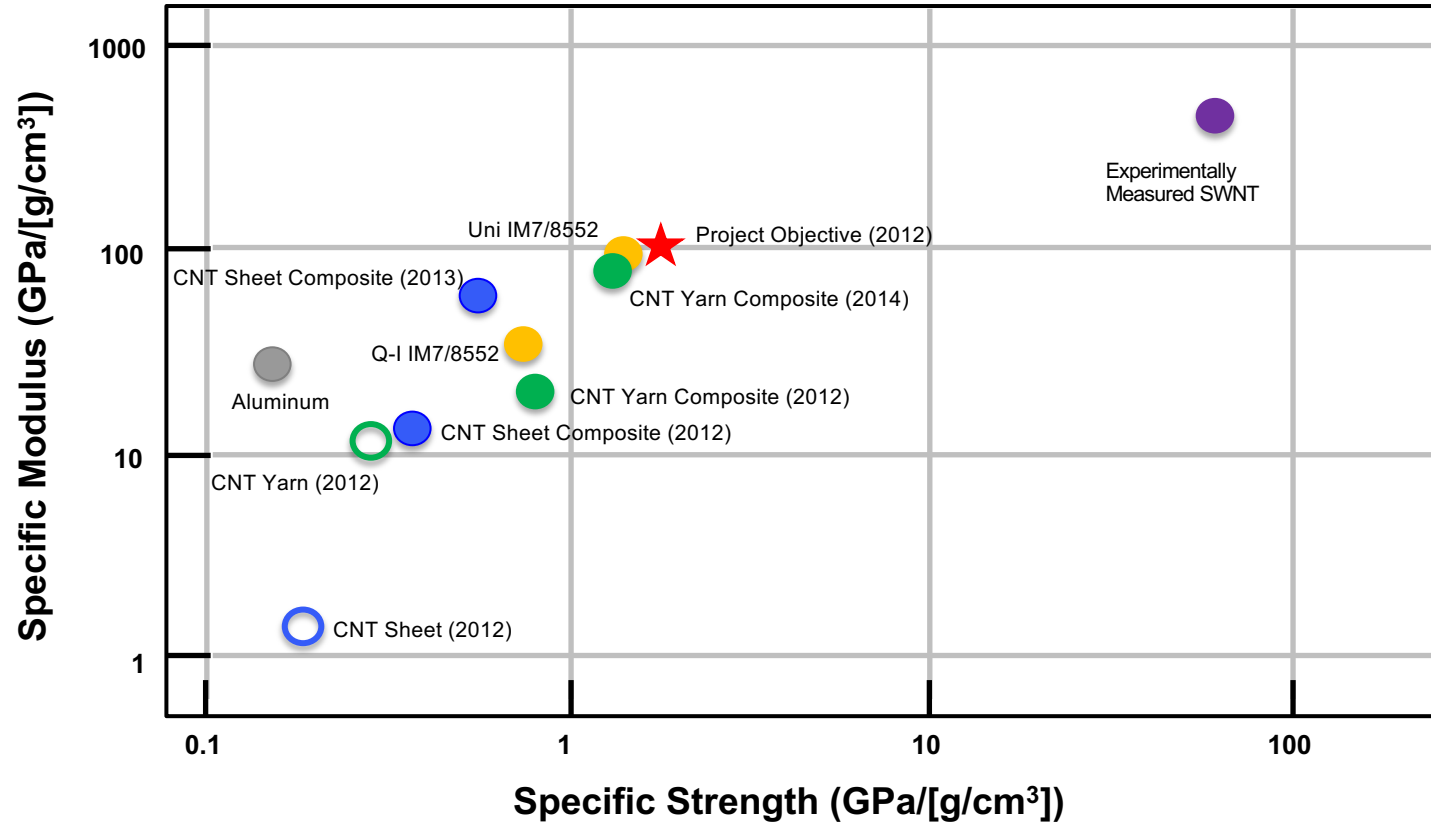
State-of-the-Art Lightweight Structural Material



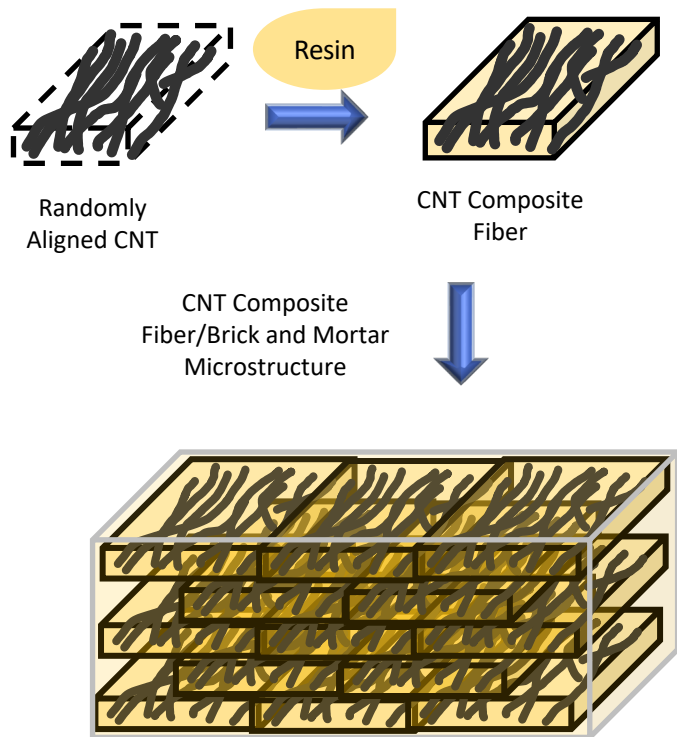
Image Credit: NASA

6 ft x 10 ft PETI-5/IM7 Skin Stringer Panel from High-Speed Research (HSR) Program

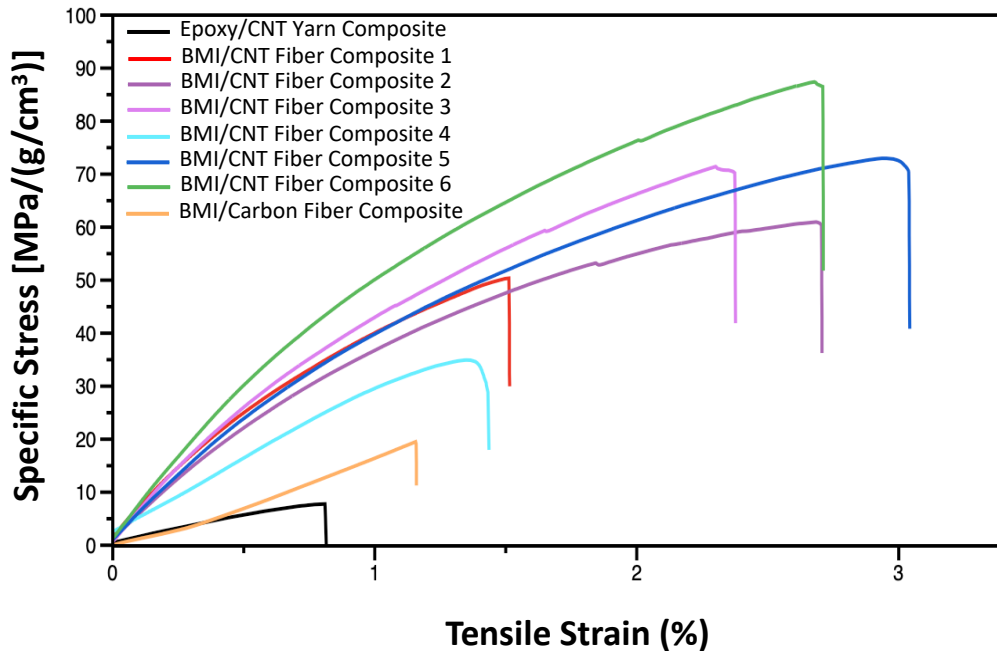
Nano to Macro Challenge



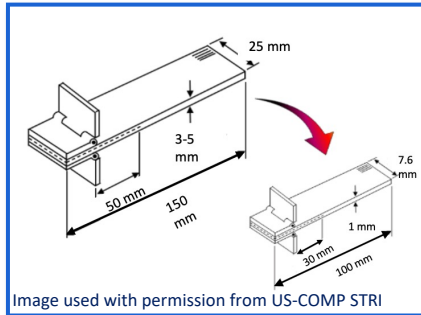
Multiscale Hierarchical CNT Composite Fabrication



Transverse Tensile Test Results



CNT Composite Fracture Toughness

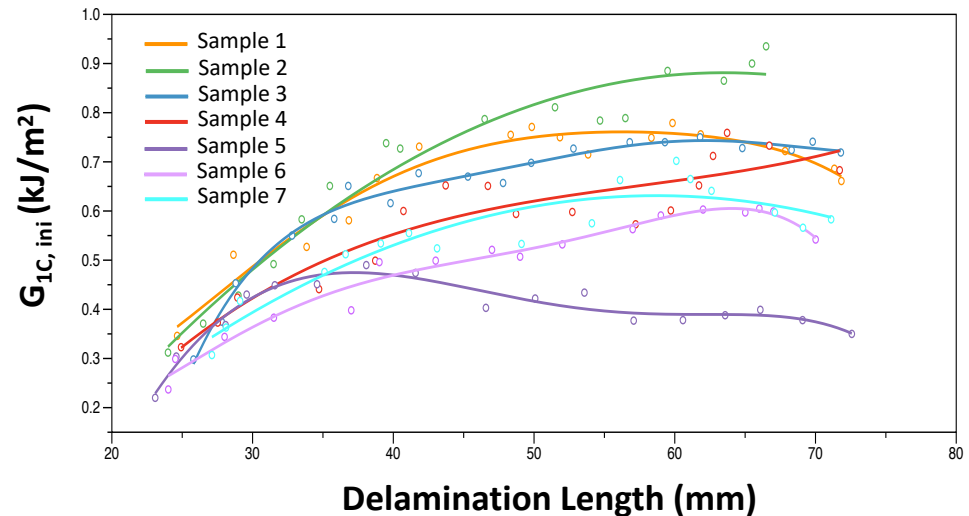


Based on ASTM D5528
Double Cantilever Beam (DCB) Test

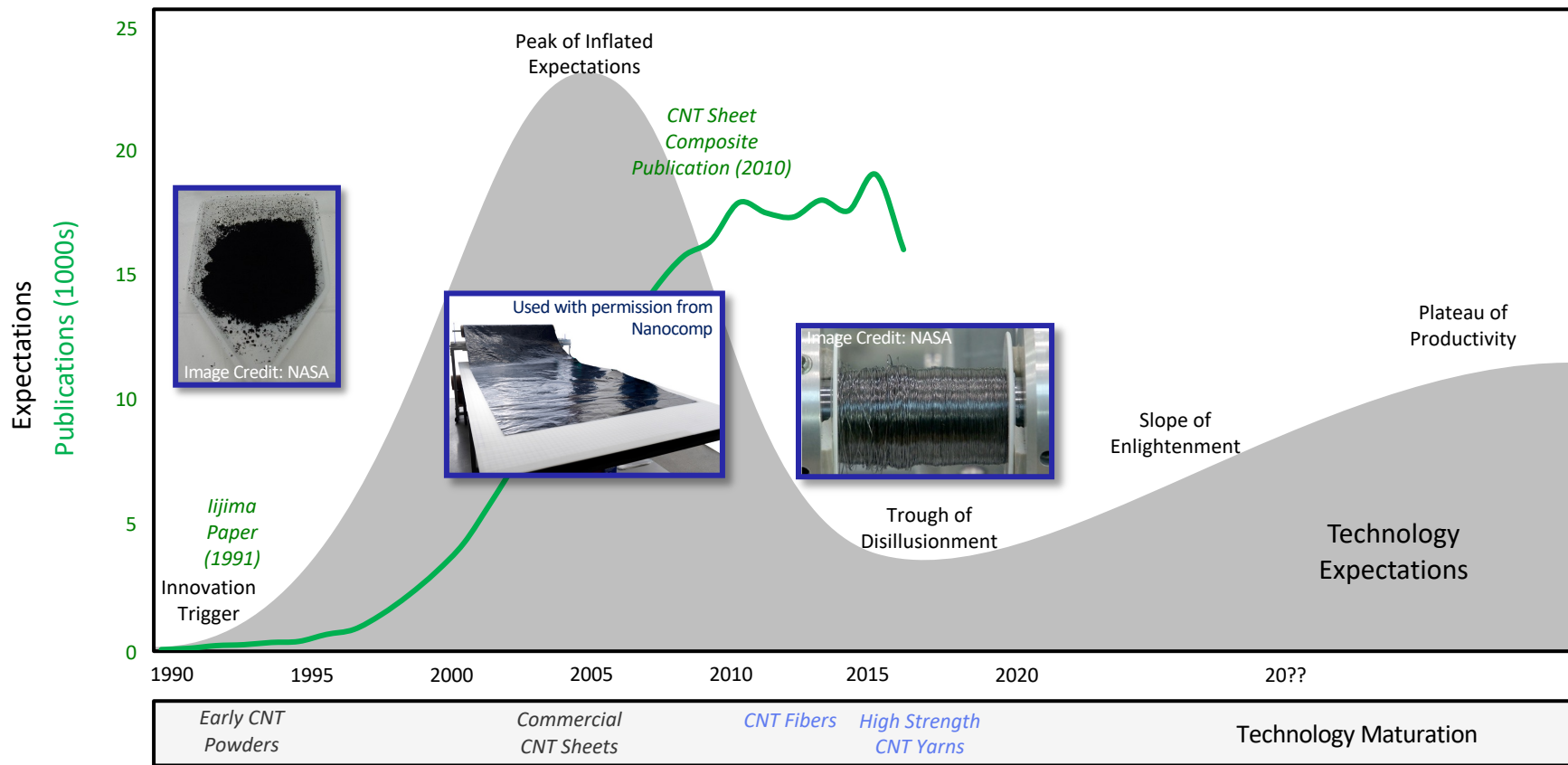


CNT Composite DCB Samples

Fracture Toughness Data



Use Driven Technology Maturation





Polymer Materials Across NASA Missions

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Sustainable Off-Earth Infrastructure

Excavation for In-Situ Resource Based Production



Excavation for Construction



Construction
and Outfitting





In-Situ Resource Utilization

