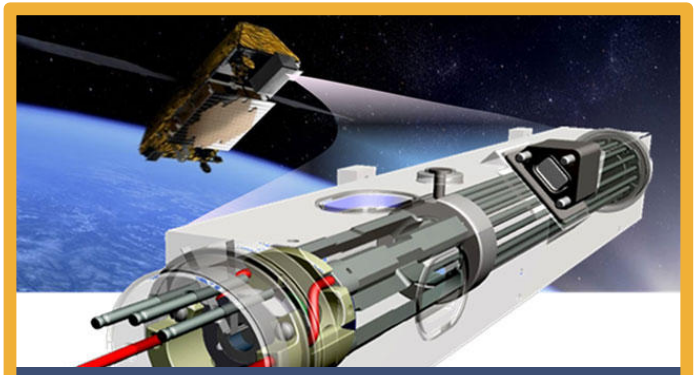
NASA Composite Technologies for Launch Vehicles

The National Aeronautics and Space Administration

Human Exploration and Operations



Space Technology

Science

Aeronautics Research

Marshall supports three of the NASA Mission Areas

Integrated Capabilities Across TRL* Range

** TRL = Technology Readiness Level*

TRL 1-3

Basic Research

Develop
New Resins
and Fibers

Pre-Pregging of New
Composite Materials

Develop Advanced In-Process,
In-Situ NDE and Fabrication
Technologies

LaRC

Technology Maturation

MSFC

Applications

Manufacture
Launch Vehicle
Structures for
NASA Missions

TRL 7-9

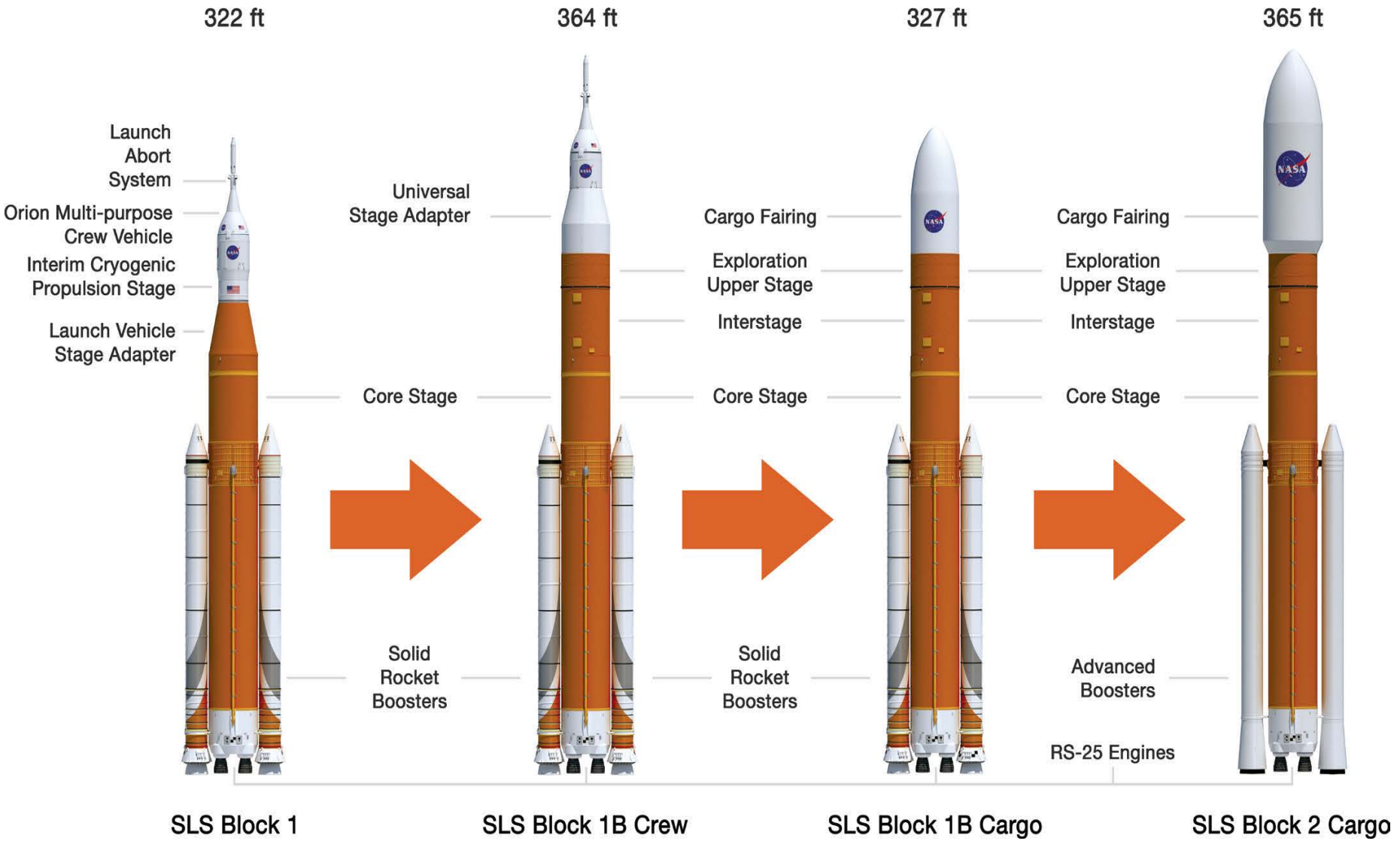
Design, Build and Test
Proto-flight Structures

Post-Cure Characterization
and NDE of Composites

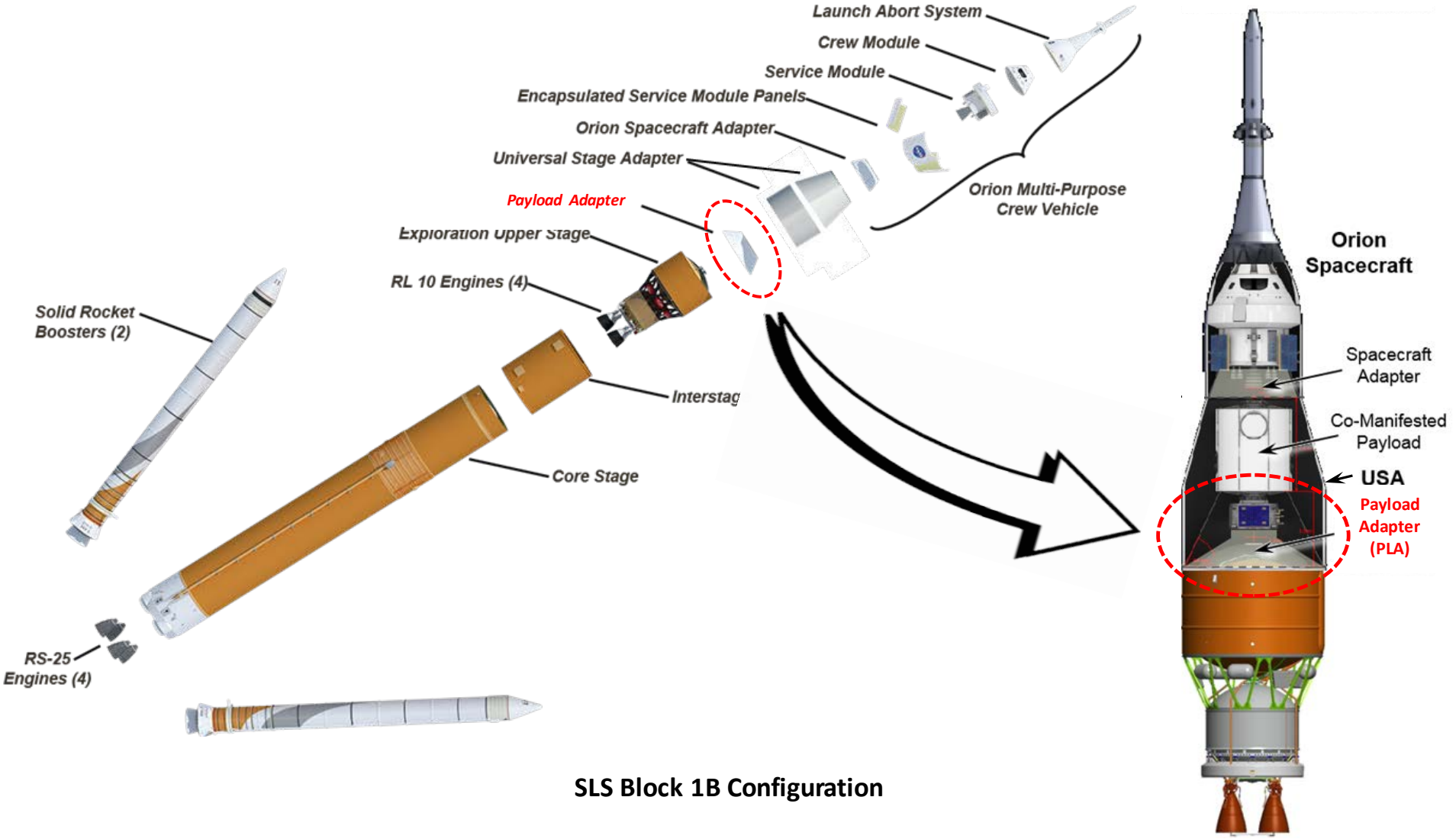
TRL 4-6

Design and Fabrication of
Advanced Structural Concepts

Structural Opportunities



Payload Adapter



SLS Block 1B Configuration

Design Challenges

- SLS Payload Adapter design presents unique challenges when compared with existing adapters
- PLA will be world's largest Payload Adapter due to diameter of Exploration Upper Stage (EUS)
- Adapter must be stiff enough to preclude dynamic coupling with EUS hung stage
- Adapter must meet human rating requirements

- Key Requirements
  - Adapt EUS diameter to Payload diameter
  - Provide structural interface for Universal Stage Adapter (USA)
  - React payload and USA loads
  - Meet minimum structural frequency value to prevent coupling with EUS hung stage
  - Accommodate cables between EUS and USA
  - Accommodate cables and fluid lines between EUS to Payload
  - Provide mounting locations for cameras
  - Incorporate provisions for venting to minimize delta pressure across adapter
  - Maximize commonality among adapters configurations while accommodating various Payloads
  - Minimize mass

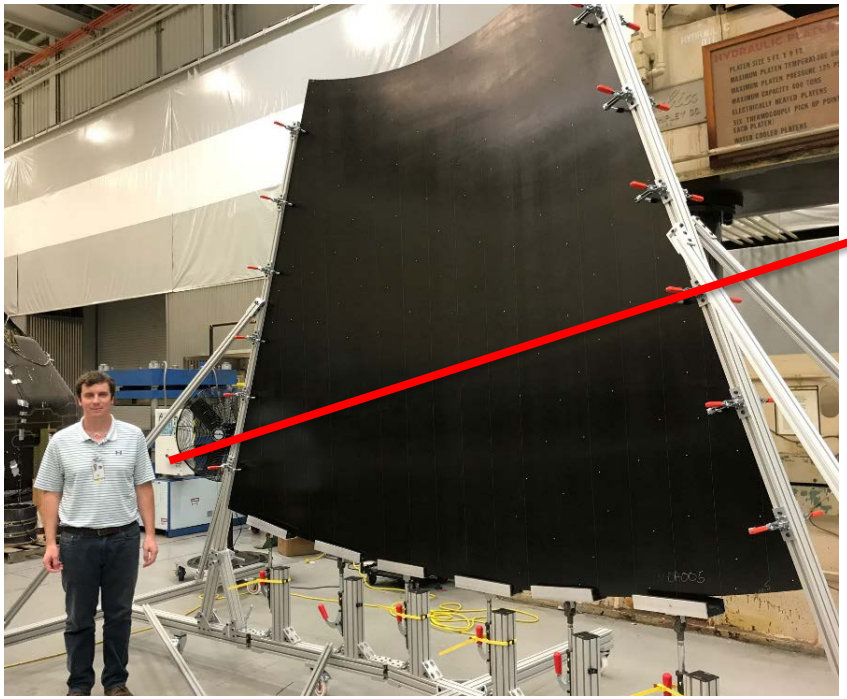
SLS Payload Adapter

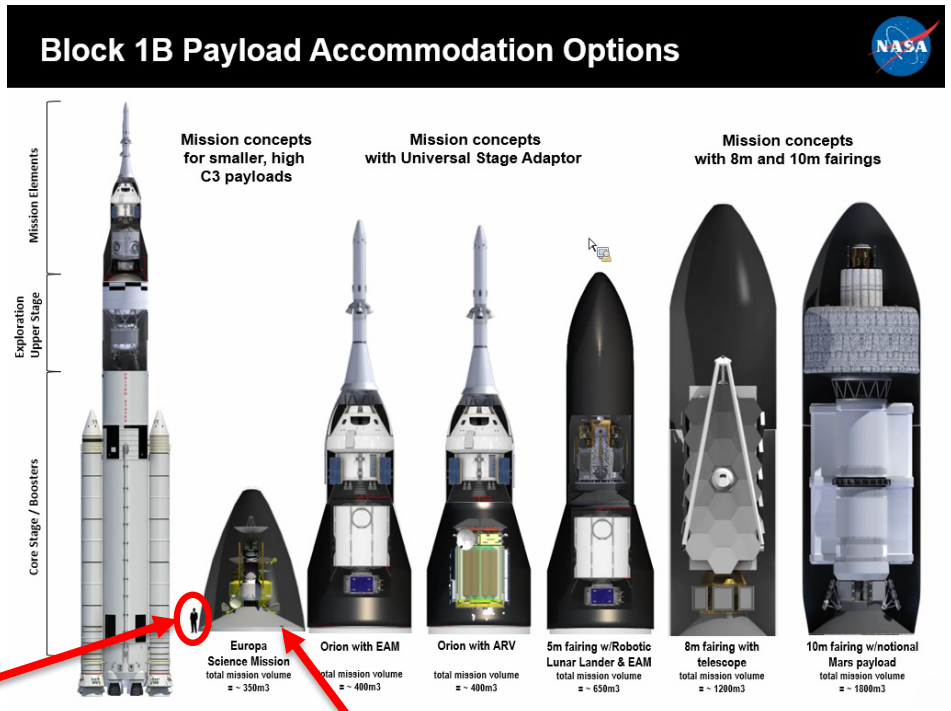
ARIANE 5 Adapter

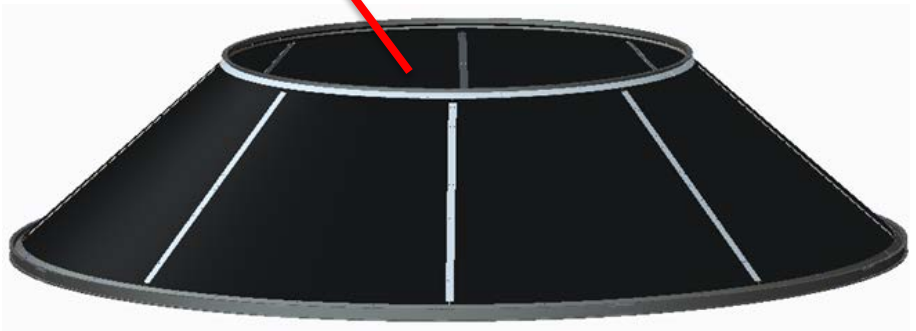
Payload Adapter

Develop & Manufacture the Payload Adapter for SLS

- Largest Payload Adapter Ever Built
- Composite Sandwich Construction
- Development of Technologies/Hardware
  - Large Scale Manufacturing
  - Bolted Joints
  - Bonded Joints
  - Inspection Techniques

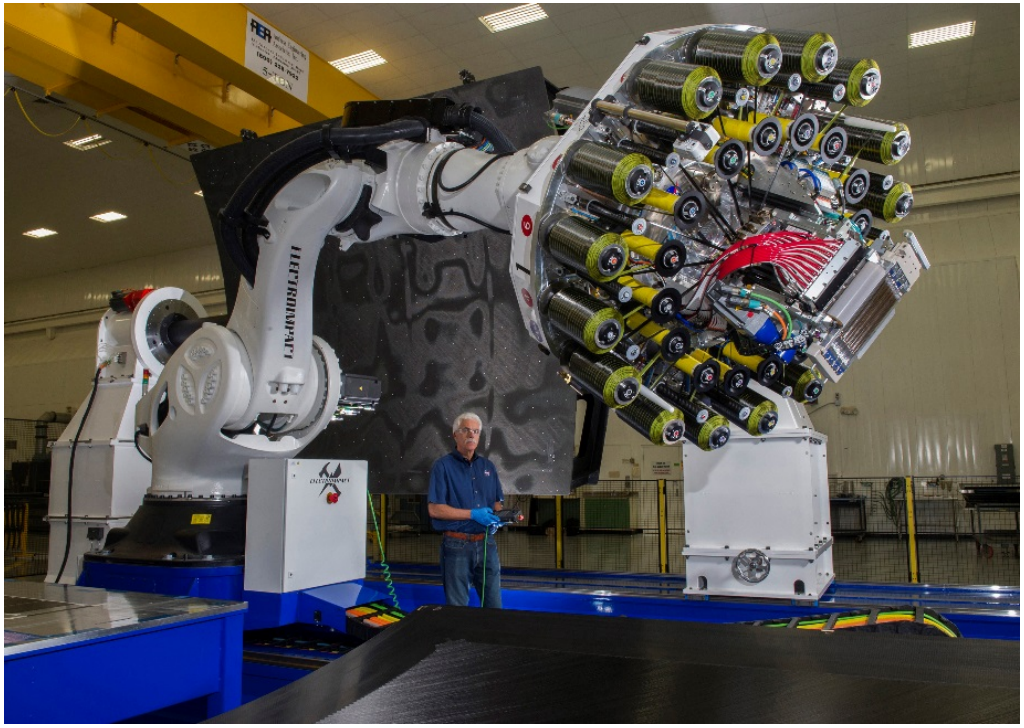




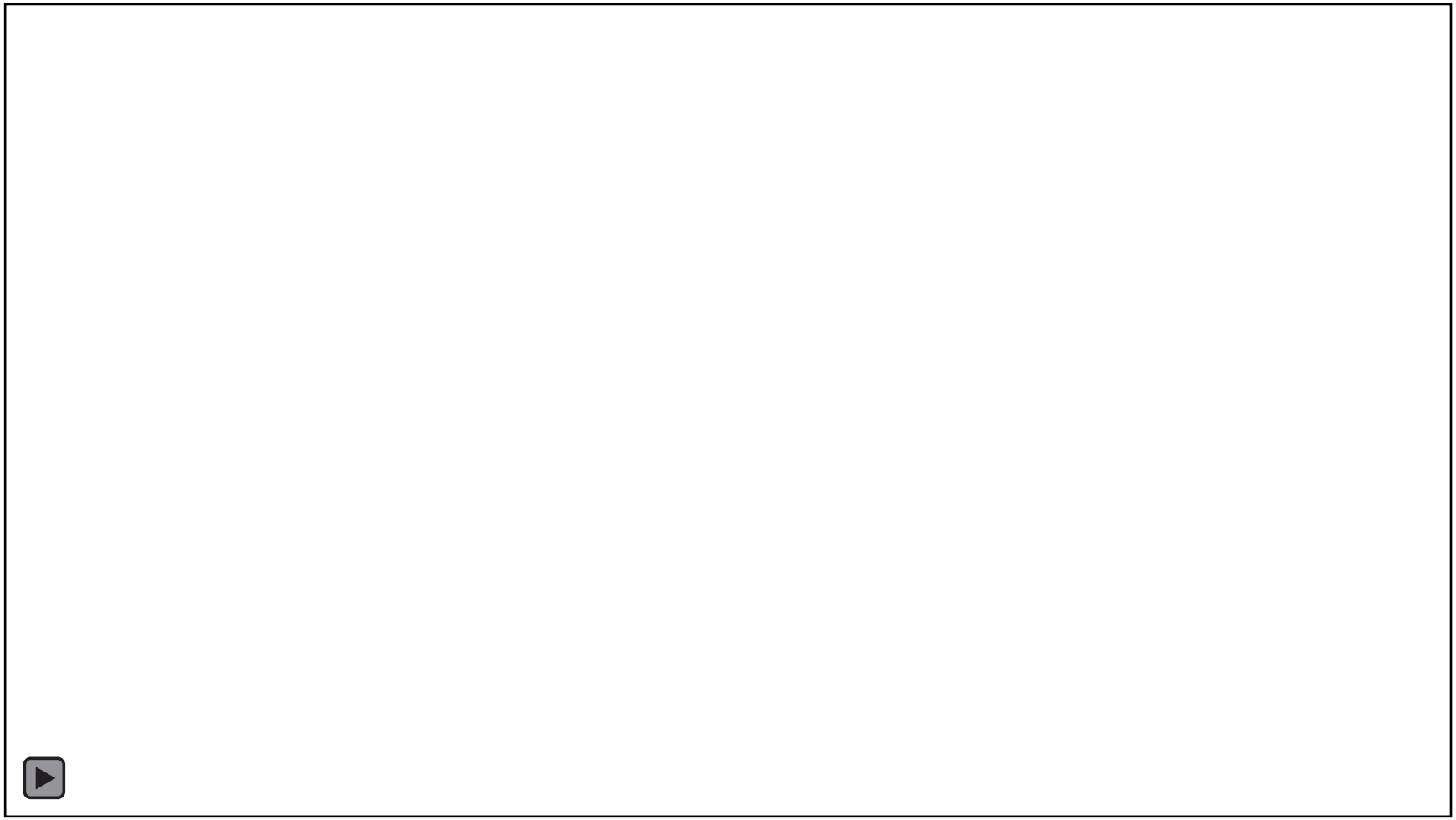


MSFC Composite Facilities

- **Our facilities allow for a wide variety of composite projects both automated and hand lay-up, with parts ranging in use from process development through demonstration and on to flight hardware. Facilities available include:**
  - Filament Winding,
  - Advanced Fiber Placement,
  - Automated Cutting Tables,
  - Large–scale Machining,
  - Tape Wrapping,
  - Cold Storage,
  - Autoclaves, and
  - Large Ovens
  - CNC Machining
  - NDE
  - Structural and Mechanical Test



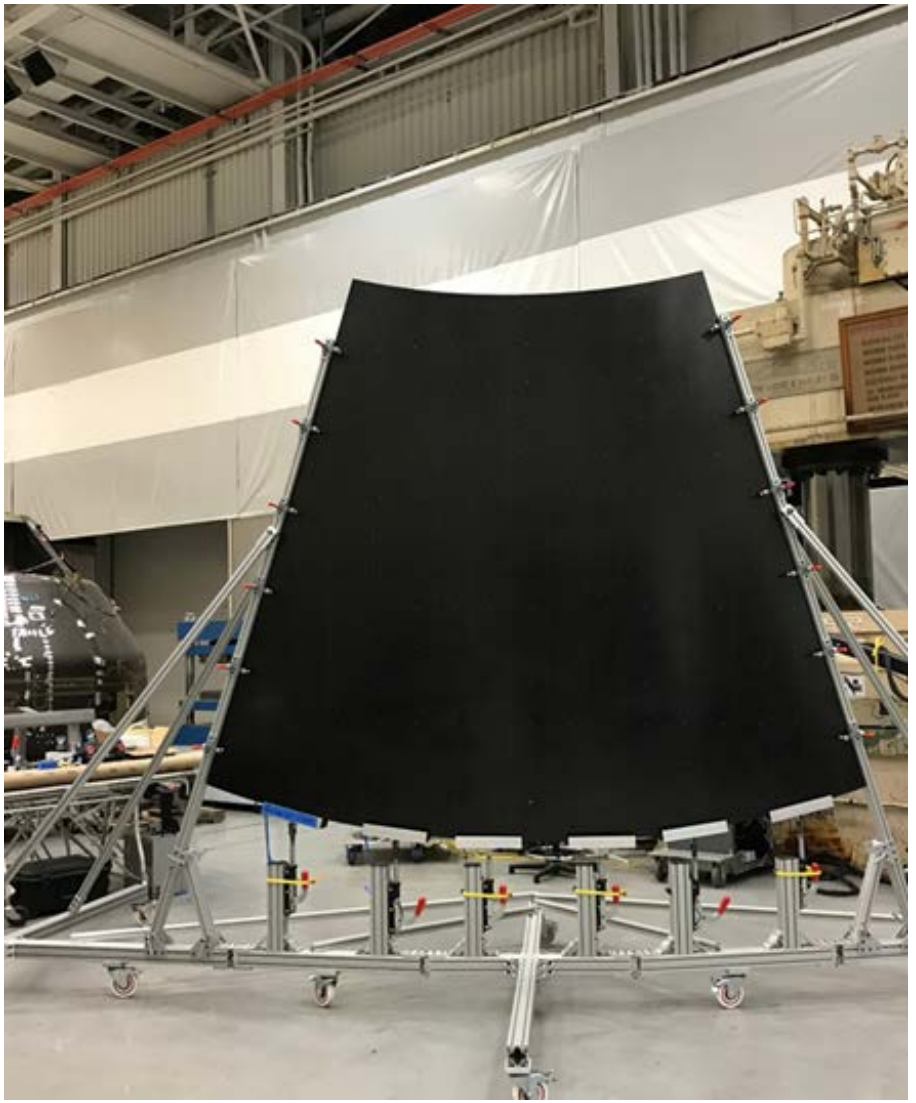
Payload Adapter



Automated Fiber Placement of Panels

Payload Adapter

NC Trimming at MSFC

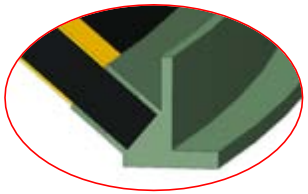
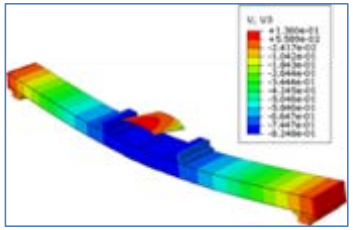
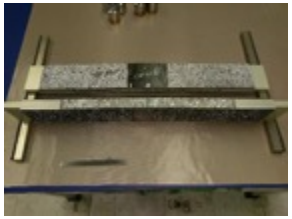


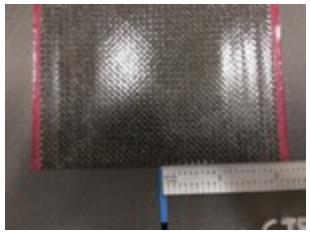
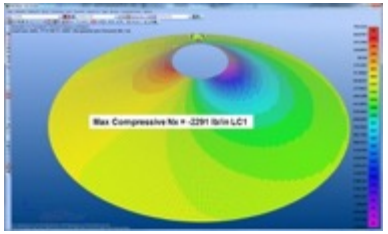
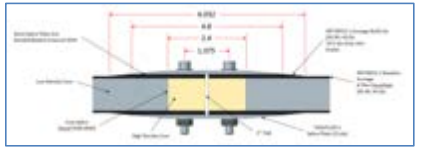
Finished Panel Section

Payload Adapter

Composite Technologies for Exploration

- Technology Product Capability
  - The CTE project will develop and demonstrate critical composites technologies with a focus on weight-saving, performance-enhancing bonded joint technology for Space Launch System (SLS)-scale composite hardware to support future NASA exploration missions.
    - Improve the analytical capabilities required to predict failure modes in composite structures.
    - Support SLS payload adapters and fittings by maturing composite bonded joint technology and analytical tools to enable risk reduction.


Key Technology Challenges

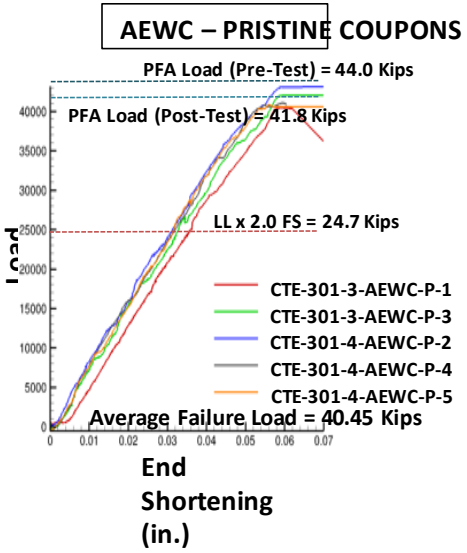
Composite Technologies for Exploration (CTE)	
Title	**Description**
Joint Configuration	Identify low mass bonded joints for fiber composite launch structures
Model Predictions	Establish modeling capabilities that failure predictions of empirical data with low engineering uncertainty.

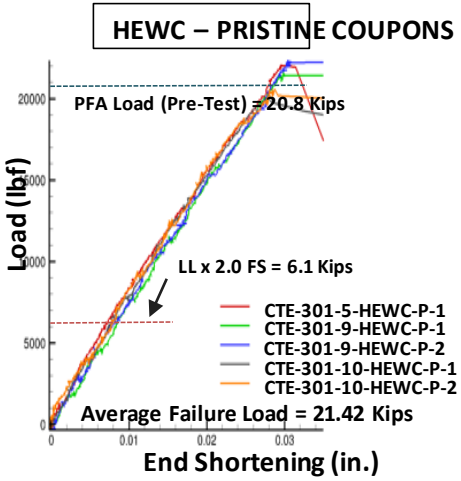
Notes: The CTE project has designed a bonded (no fasteners) longitudinal joint. Joint test coupons will be fabricated and tested and full-scale joint tests will follow. CTE has designed and fabricated a 3D woven resin infused C-channel for circumferential bonded joint applications. C-channel testing pending / upcoming.

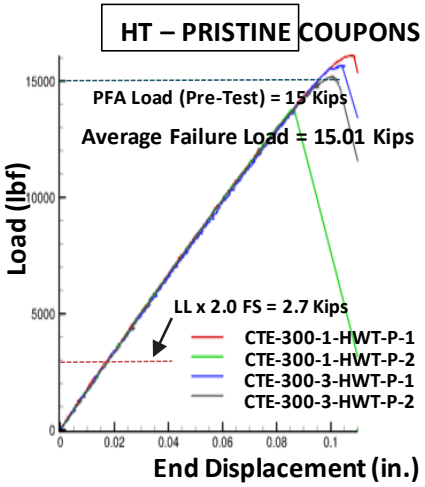
The CTE project has down-selected several analytical programs and failure theories. The project is currently analyzing joint designs with selected programs and theories. Results of joint tests will be used to evaluate analytical approaches.

Composite Technologies for Exploration

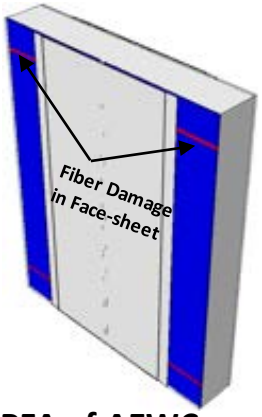
- Tested 28 pristine coupons at Southern Research.
- **All coupons (pristine) failed above CTE Point Design Limit Load (LL) with 2.0 FS.**
- Progressive damage analysis (PDA) using cohesive zone and COSTR damage model used to predict joint failure.
- Pre-test and post-test correlation achieved within 7% and 5%, respectively, of average test data for all tests.





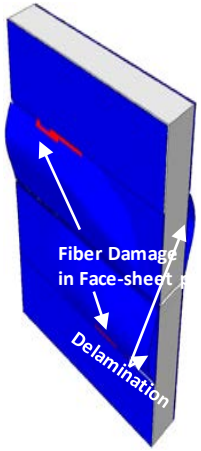


Failed AEWC Coupon



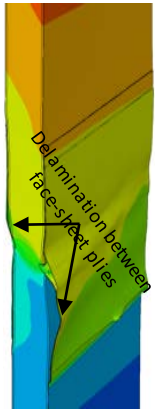
PFA of AEWC Coupon

Failed HEWC Coupon



PFA of HEWC Coupon

Failed HT Coupon



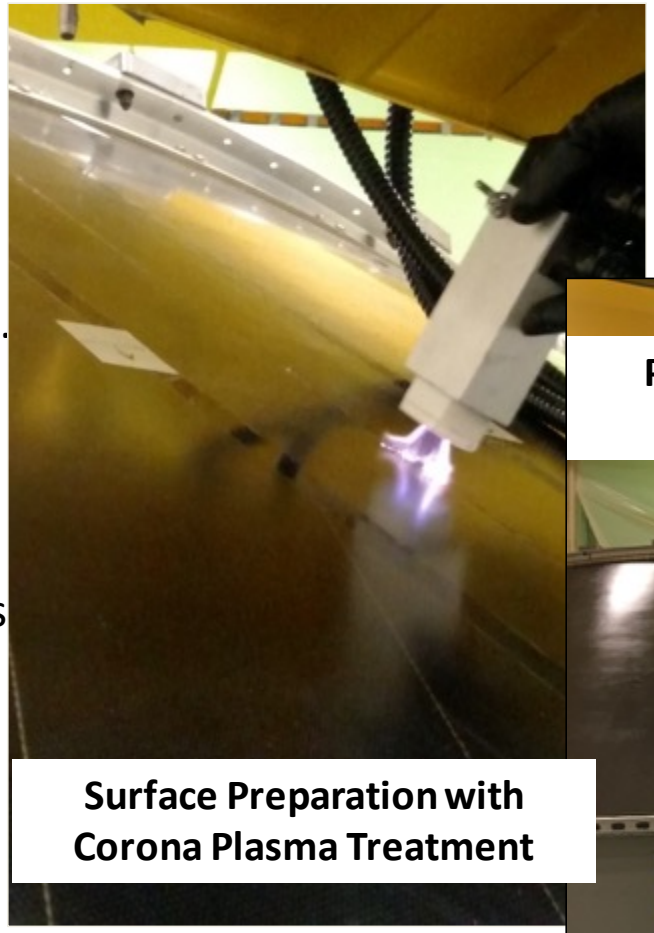
PFA of HEWT Coupon

Composite Technologies for Exploration

Procured process equipment for large-scale bonding operations.
Corona plasma treatment system for high performance, consistent surface preparation.
Multi-zone longitudinal heating blankets for improved scale-up bonding operations.

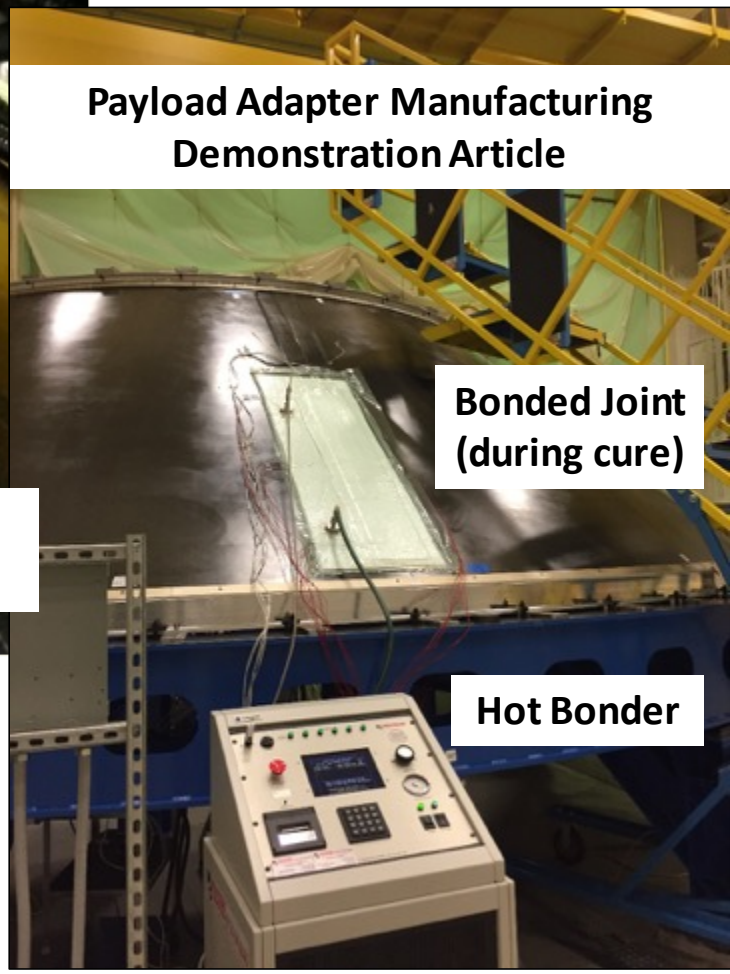
Developed process parameters for out-of-autoclave bonded joint cures with hot bonder.

Completed four full-scale joints on the Payload Adapter Manufacturing Demonstration Article (PLA MDA).



Surface Preparation with Corona Plasma Treatment

Payload Adapter Manufacturing Demonstration Article



Composite Technologies for Exploration

Aft doubler segment (on OML) after cure

Segmented OML doubler after cure

Full-length OML doubler (via scarf joint between 2 segments) after cure

Composite Technologies for Exploration

Composites Support NASA and the Nation

- All NASA Mission Directorates: Aeronautics Research, Human Exploration and Operations, Science, & Space Technology rely on composite technologies.
- Technology provides important benefits to NASA and Commercial needs plus diverse sectors of the economy/enhances global competiveness -- Composites are important materials for the future of aerospace strategic leadership.
- Composite technology growth is paramount to pushing the boundaries of space travel.