ISAAC Advanced Composites Research Capability

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ISAAC
Integrated Structural Assembly of Advanced Composites
NASA Langley Research Center

ACCIS CDT
University of Bristol
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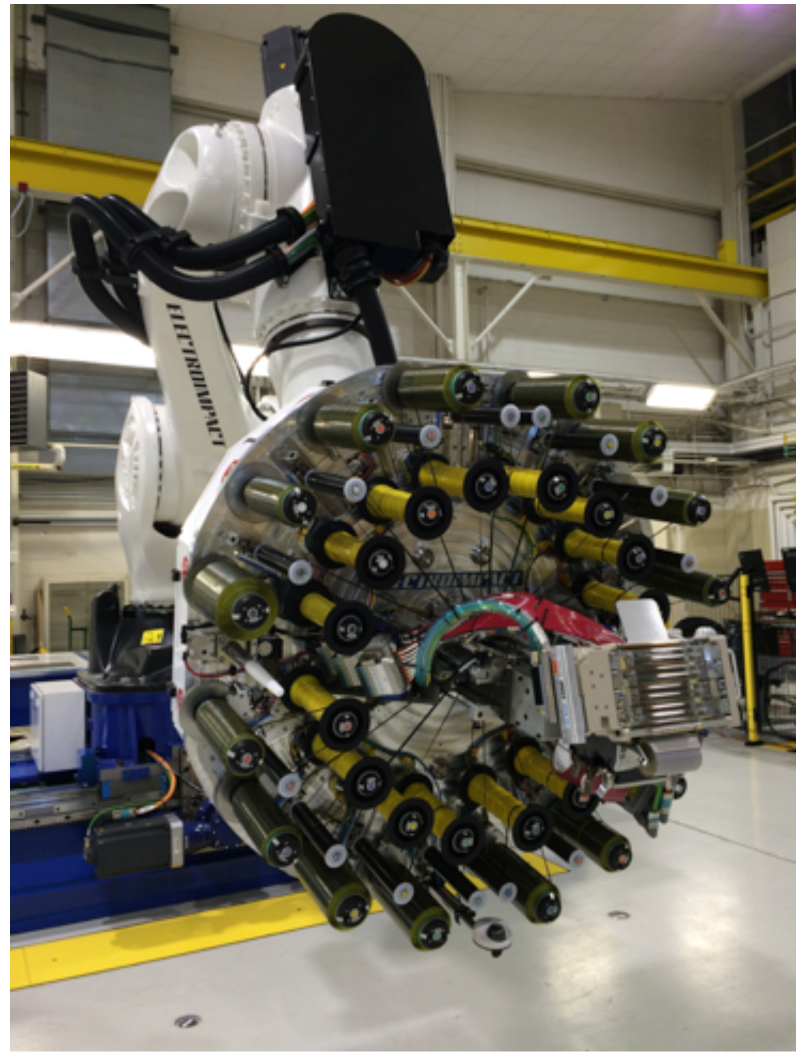
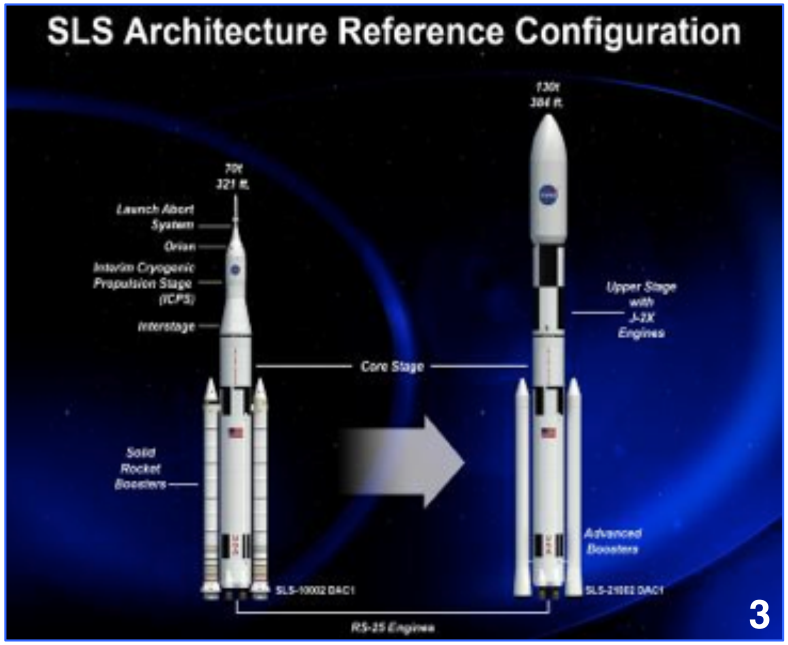
Outline

- **Motivating factors**
  - National
  - Agency
  - Langley
- **Composite Cryotank Tech. Dev. (CCTD)**
- **ISAAC description and capabilities**
- **Future work**
- **Summary**



Composites Research Supports Agency and National Needs

- Supports all NASA Mission Directorates: Aeronautics Research, Science, Human Exploration and Operations, Space Technology
- Supports Advanced Manufacturing National Initiative, and National Network for Manufacturing Innovation
- Supports other Government Agencies: DOD, DARPA, DOE
- Identified in NASA Space Technology roadmap Technology Area 12 (Materials, Structures, Mechanical Systems & Manufacturing)
- Spans multiple NASA Centers and disciplines
- Engages both Industry and Research communities



Composite Cryotank Tech. Dev.

- **Point designs built by Boeing for NASA**
- **Full extent of trade space of design and process variables still to be explored**
  - Laminate optimization
  - Mechanical joints
  - Material out-life studies
  - Material development, selection & evaluation
  - Out-of-autoclave, thin-ply materials
  - Access points
  - Tank penetrations
  - Bonding
  - Softening strip development
  - And many others…

- **Need better understanding of entire trade space**
- **Need to be a smarter buyer and a more effective, more relevant partner to the entire Aerospace Industry**
- **Need to make smarter investments in advanced composite systems, and leverage knowledge for future projects**

Initial Operational Capability

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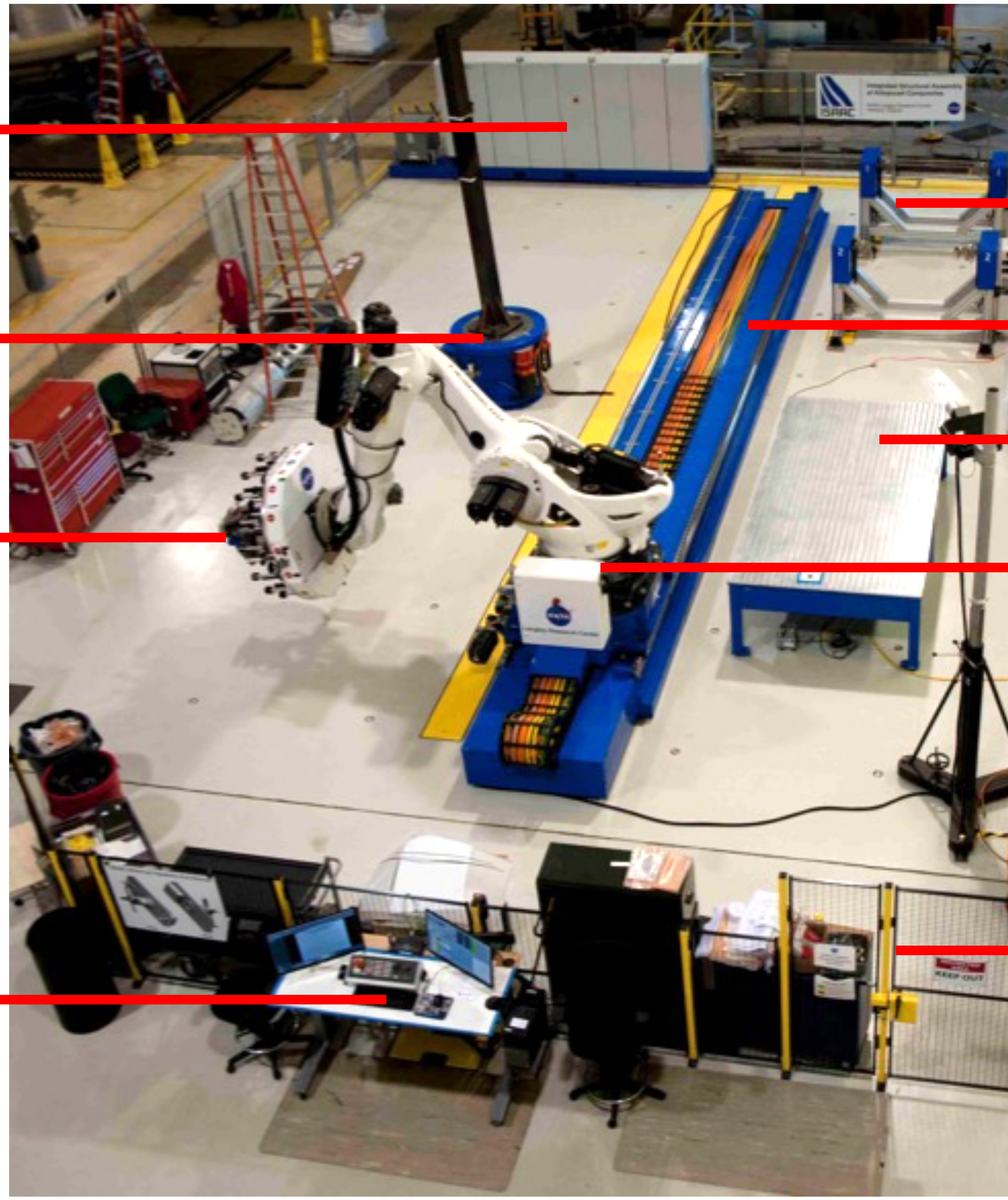
Power/Data/Air
Siemens CNC

Rotator

Automated fiber placement (AFP) end effector

Operator station



Transfer stands

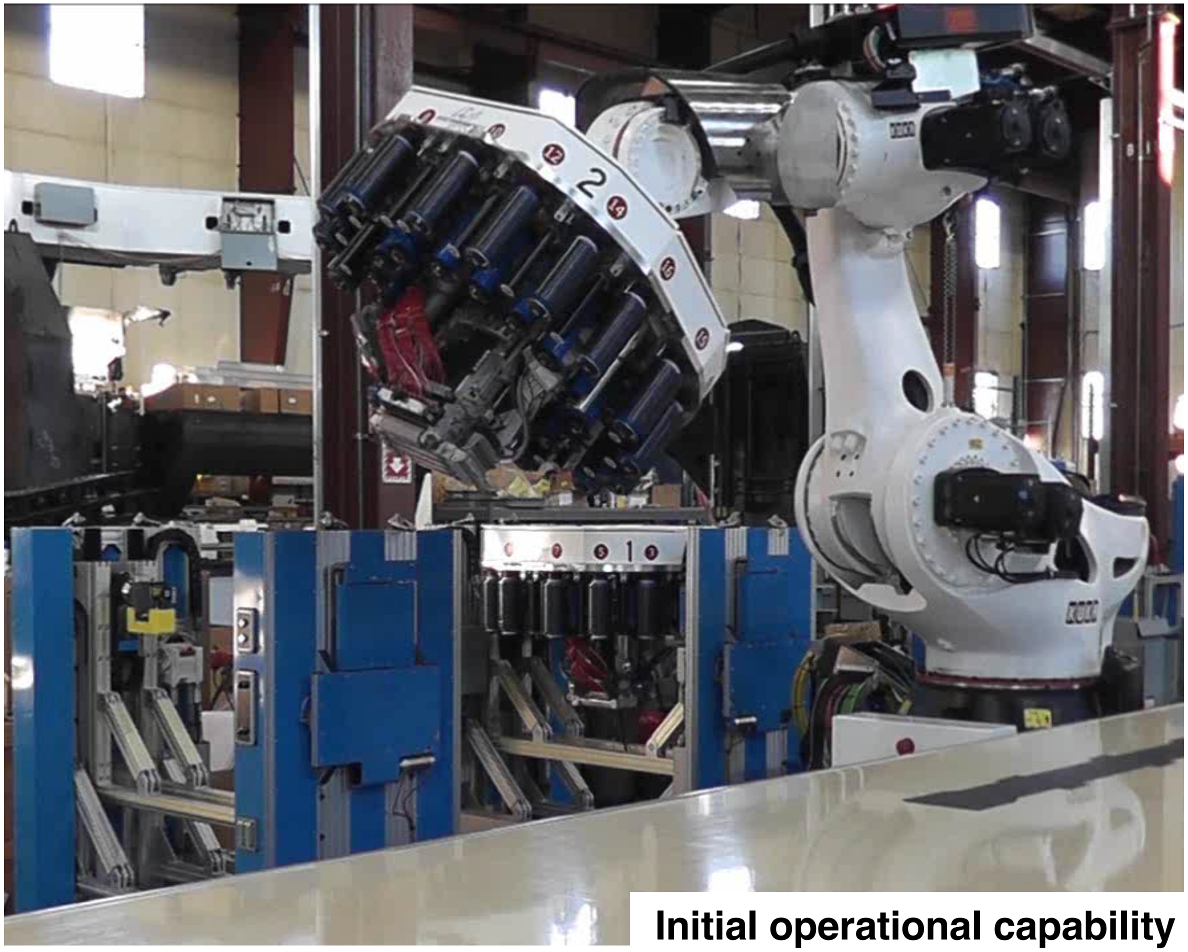
12 meter track

Layup table

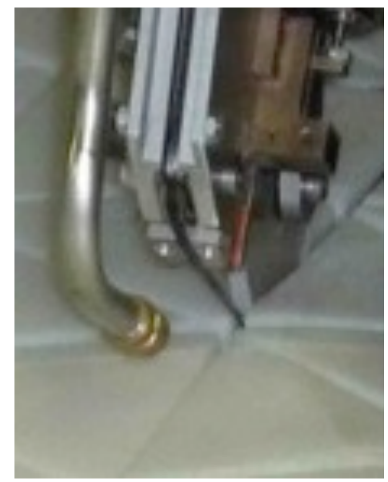
Modified KUKA KR1000 L750 Titan robot

Safety fencing

Flexible System Architecture



Initial operational capability



Robot-based system allows multiple end effectors for assessing composite materials, processes, structural concepts, manufacturing, and inspection techniques

Proposed end effectors include (clockwise from top): machining, grid-stiffening, and stitching capabilities

Integrated Capabilities Across TRL* Range

** TRL = Technology Readiness Level*

TRL 1-3

Basic Research

Applications

Develop
New Resins
and Fibers

LaRC ISAAC

MSFC AFP

Manufacture
Launch Vehicle
Structures for
NASA Missions

Pre-Pregging of New
Composite Materials

Technology Maturation

TRL 7-9

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

Design, Build and Test
Proto-flight Structures

Post-Cure Characterization
and NDE of Composites

TRL 4-6

Design and Fabrication of
Advanced Structural Concepts

A Mature, Scalable Research Platform

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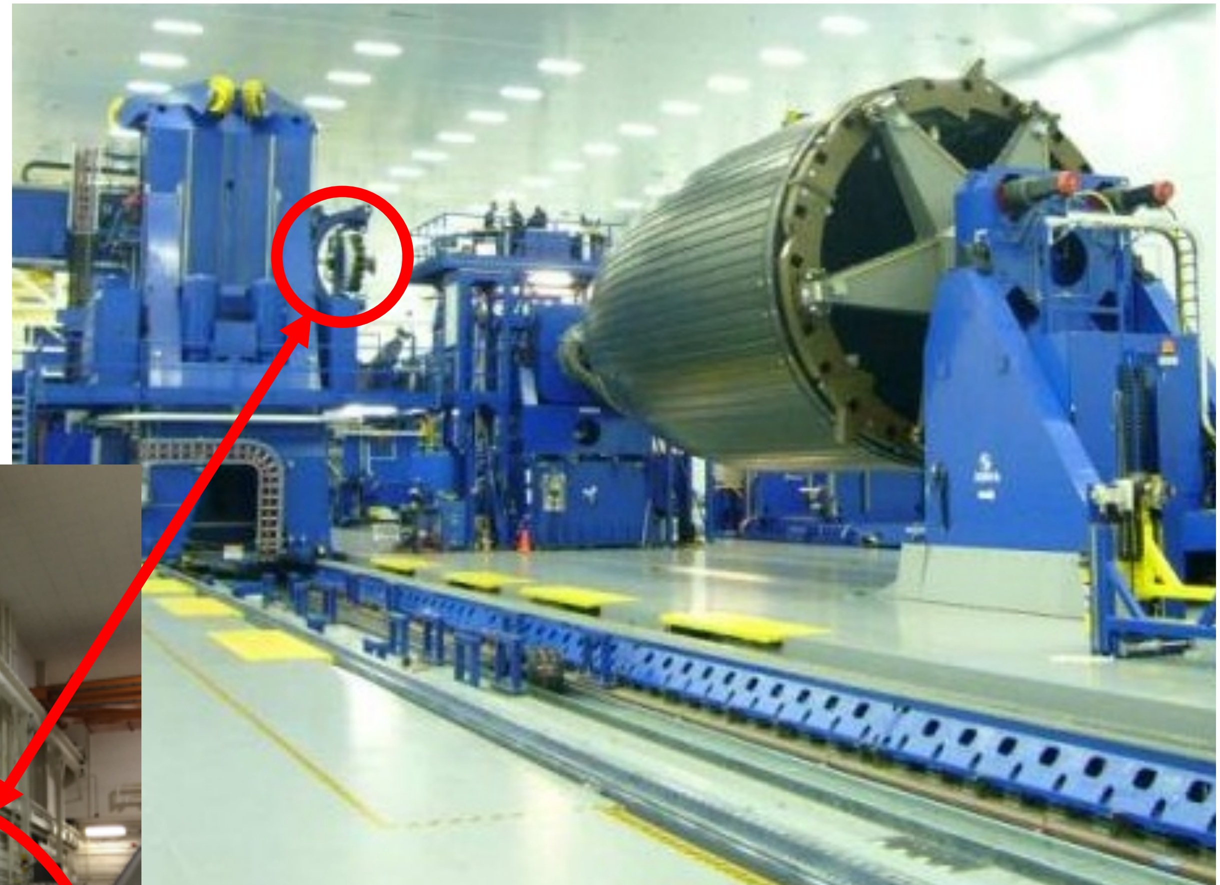
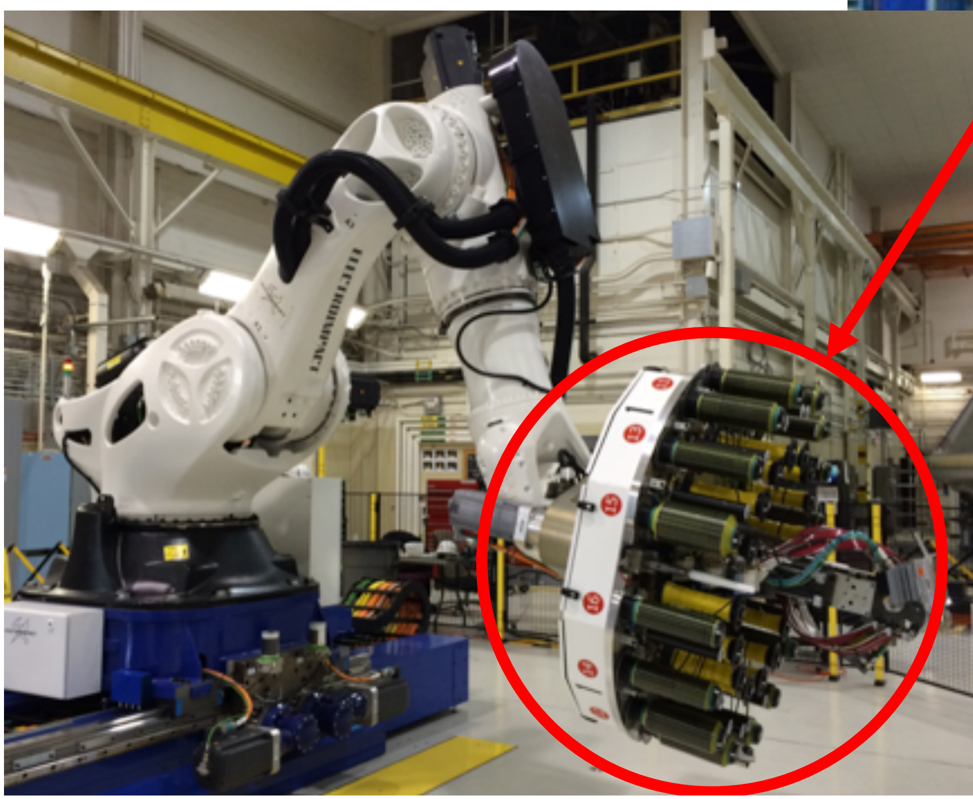
- **Very different mobility platforms, physical scales and costs**
- **Appropriate to support NASA & LaRC missions**





- **Common AFP end effectors and software used**
- **Direct path for scale-up from lab to factory (TRL 4-6)**

ISAAC Agency Project Support

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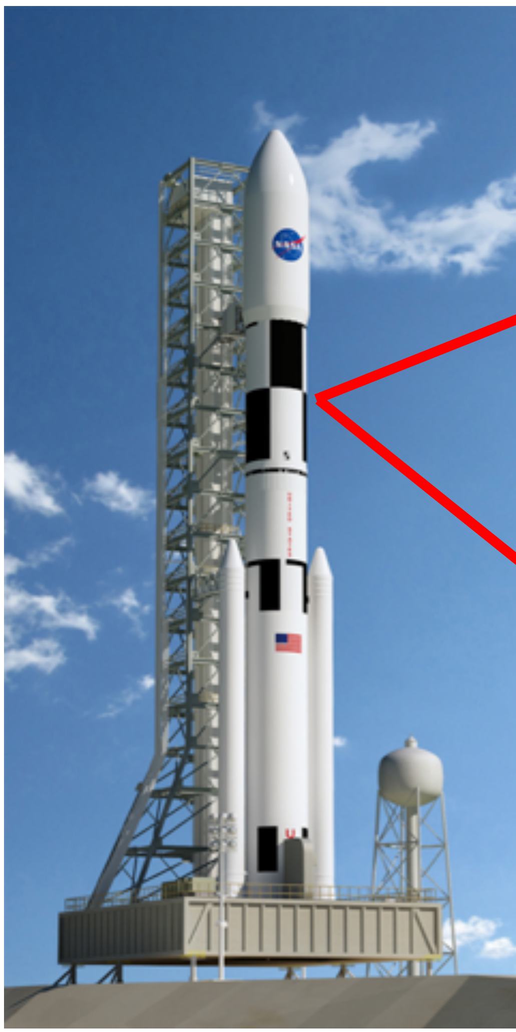
Composites for Exploration Upper Stage (C-EUS) Project



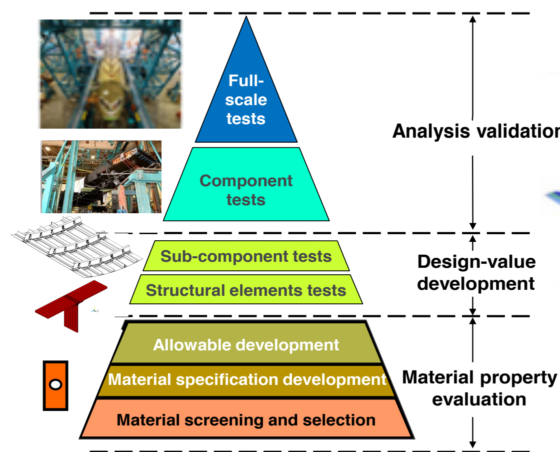
Built flat panels for joints tech. dev. and tests at LaRC

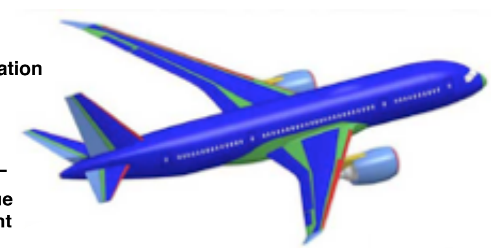
Advanced Composites Project

Proposed testbed for
- AFP process characterization for physics-based process model development, and validation
- Design for manufacturability (DFM) optimization software development and validation
- Fabrication of test panels for secondary-bonding surface preparation technology development

Develop, integrate and mature in-situ/in-process NDE technology into AFP process flow

Proposed testbed for manufacturing barrels for NDE and structural comparison with industry manufactured barrels using the same tooling





Advanced Composite Tow-Steered Structures

Highly Integrated Digital Manufacturing

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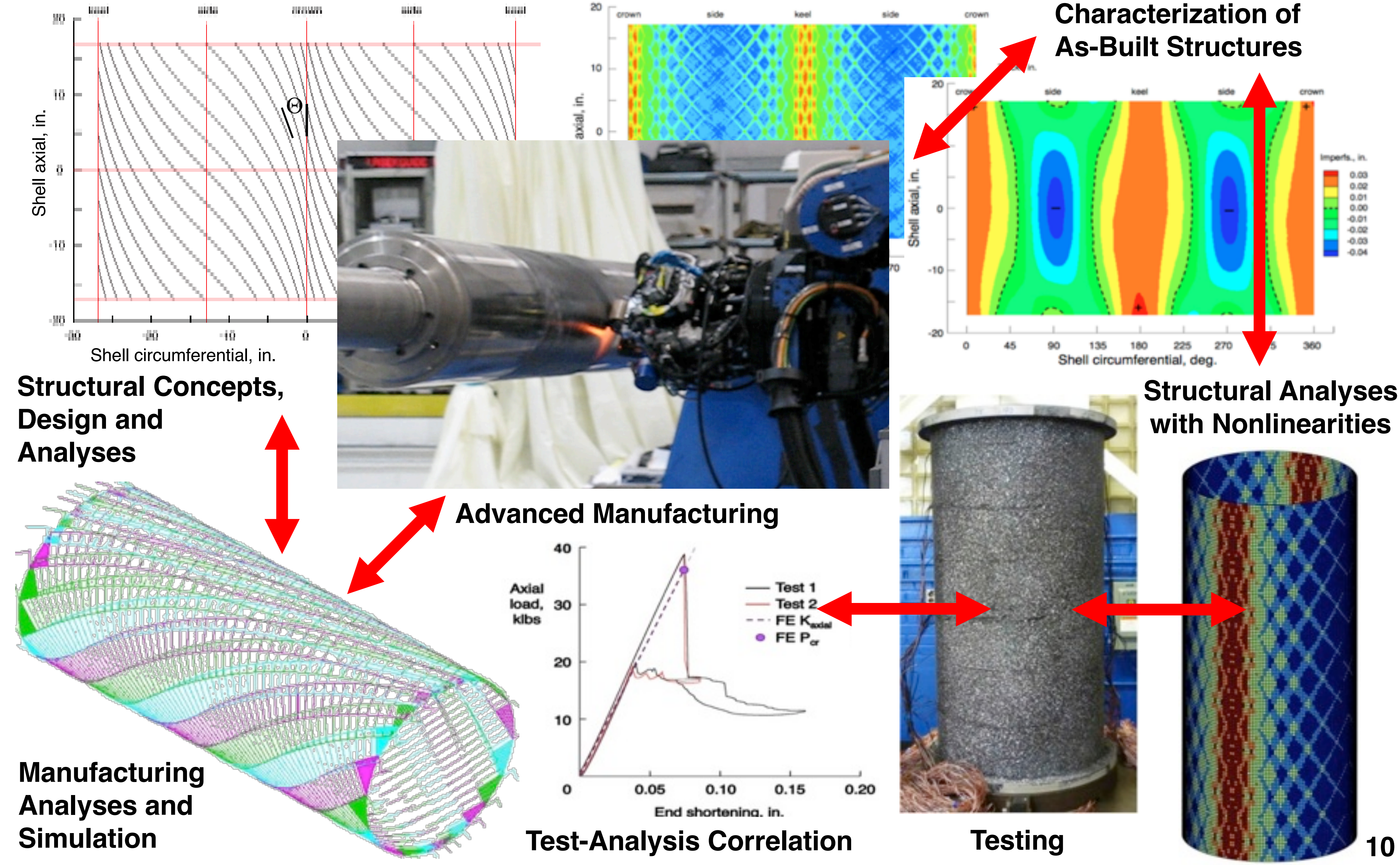

Extended System - Cleanroom

Cleanroom open

- 5 ton overhead crane access (40 x 40 ft.) for tooling and parts
- 20-ton air conditioning unit
- Closed-loop temperature control between 65 and 85 (±2) deg. F
- Closed-loop humidity control, RH between 50 and 80 (±5) pct.

Cleanroom closed

- Particulate contamination control spec'd as ISO Class 7 standard, and certified to almost Class 6
- Approx. 50k cu. ft. internal volume, with 30 air changes per hour
- Can now *vary* these quantities and *assess* their impact

Advanced Capability End Effectors

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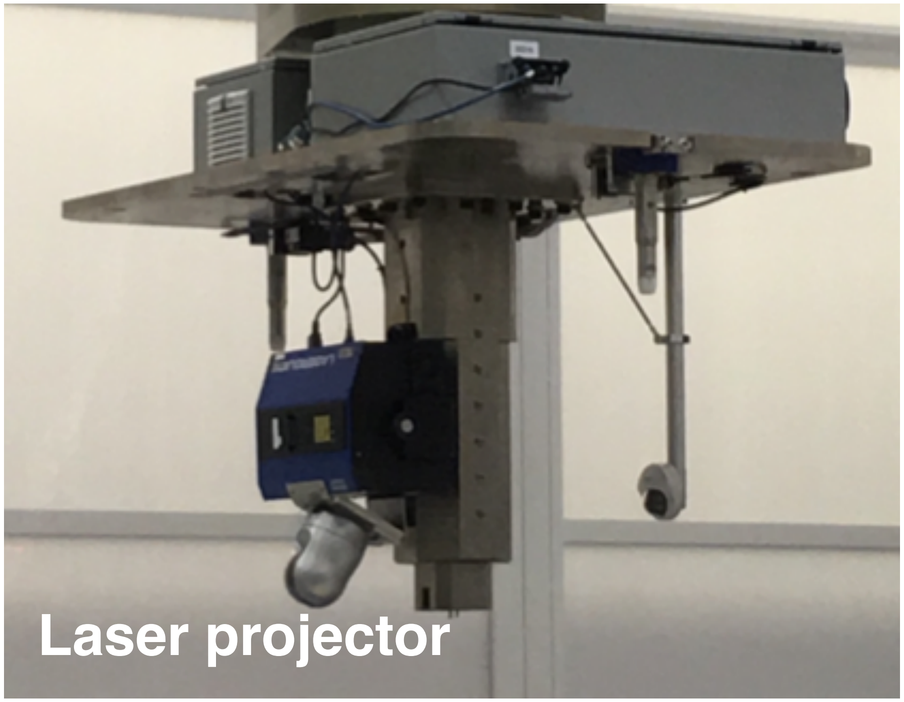

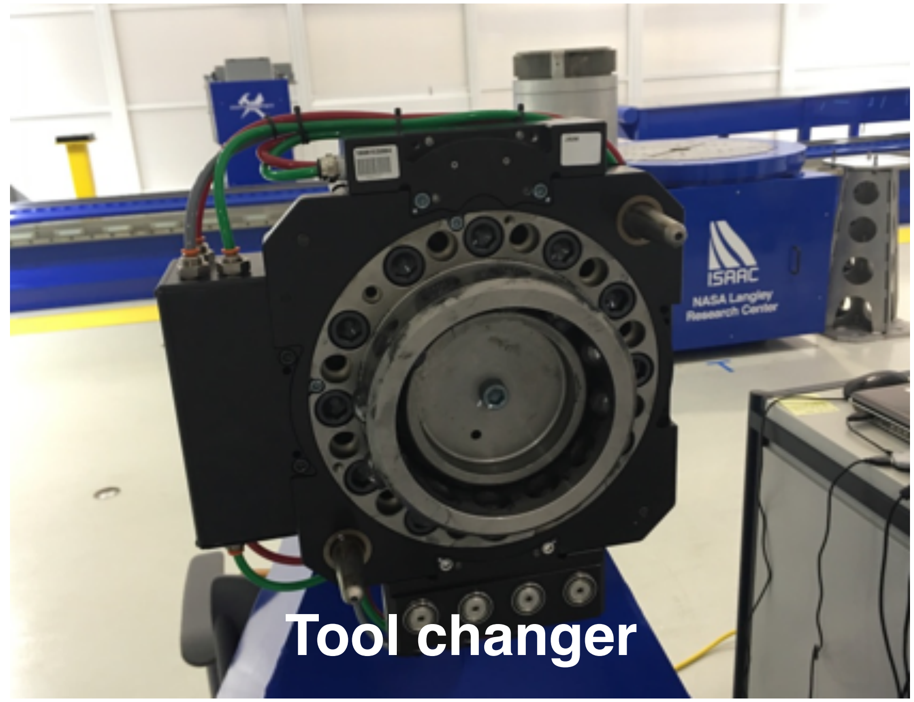

Current ACEEs

- Ultrasonic knife capability
    - Cut thru max. 1 in.-thick layup
- Laser projection capability
    - Optimal positioning over layup
- Single- and double-sided stitching heads ordered

Proposed ACEEs

- Ultrasonic metal foil lamination
    - Have sonotrode, electronics
- In-process, in-situ NDI / NDE
- Friction-stir welding
- Z-pinning for thru-thickness reinf.
- Continuous tow shearing?

Capability Development Timeline

- Started advocacy ($0): September 2012
- Authority to proceed ($550k): August 2013
- AFP system ordered (~$1M): September 2013
- Bldg. 1232A facility mods.: June-September 2014
- AFP system delivered (~$2M): September 2014
- System install, check-out: October-December 2014
- System commissioning: January 2015
- Begin project work: February 2015
- Advanced Capability EE's ordered (+$400k): July 2015
- Started cleanroom install (+$750k): April 2016
- ACEE heads delivered: June 2016
- Completed cleanroom: July 2016

ISAAC Is Now Operational!

Summary

- ISAAC provides a state-of-art composites capability for NASA
- ISAAC composites research platform scales directly to industry practice
- ISAAC system architecture is highly flexible, allowing development and implementation of alternate process end effectors
- ISAAC can span the full TRL range from ideation (low TRL), to maturation (mid-TRL), to implementation (high TRL, as applicable)

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Questions?