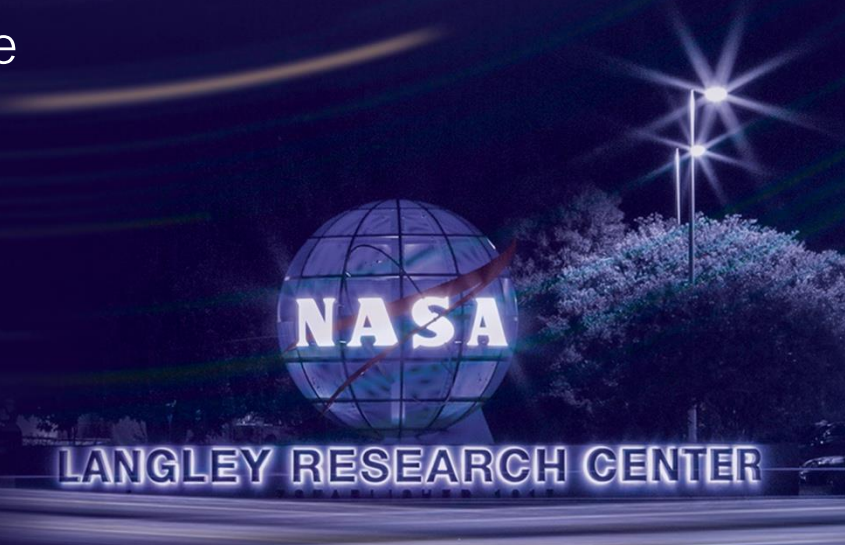
National Aeronautics and Space Administration

Together, We Discover

Structures and Materials Research at NASA Langley Research Center –

Innovating materials, structures, and concepts to enable NASA Missions today and create the technology of tomorrow

Elliott Cramer
Deputy Director for Structures and Materials, Research Directorate
NASA Langley Research Center



Tulane University – Engineering / Physics Colloquium
New Orleans, LA September 26, 2022

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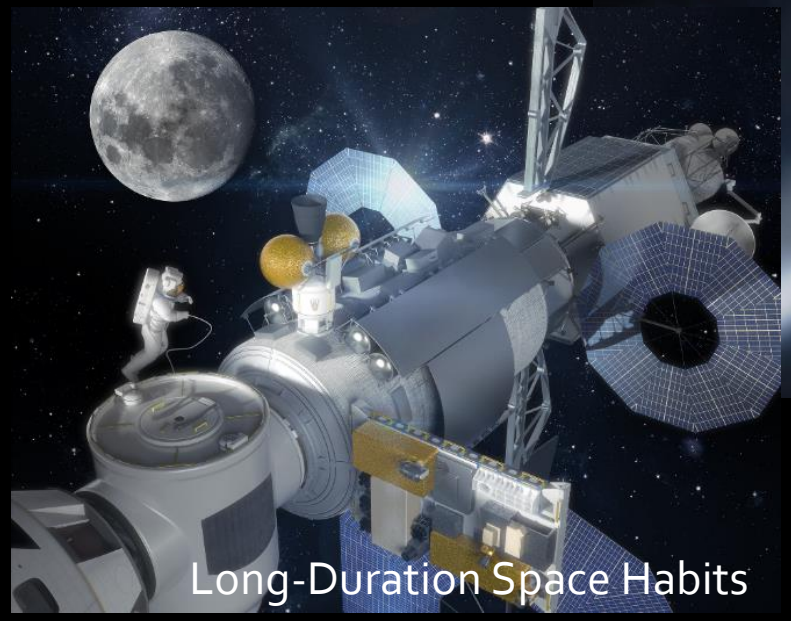
Space Launch System (SLS)
Beyond LEO
Asteroid, Mars

Commercial
Crew to ISS



Human Exploration

International Space Station

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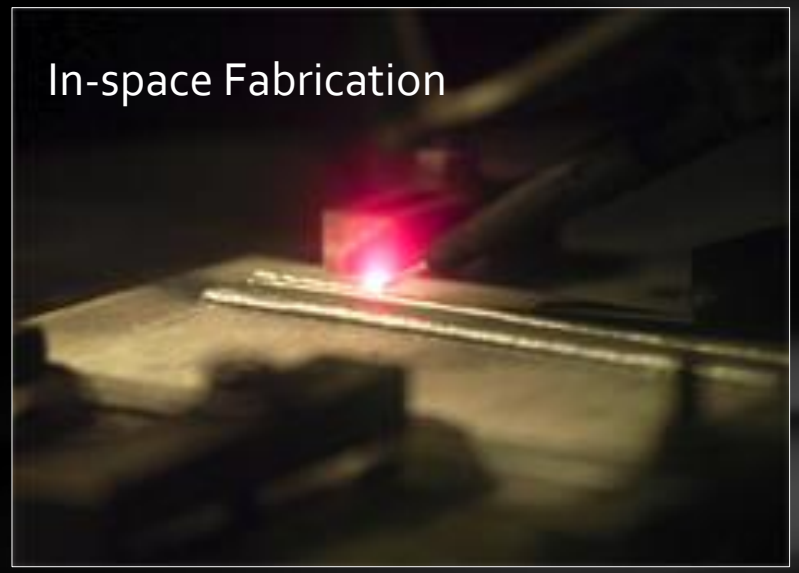

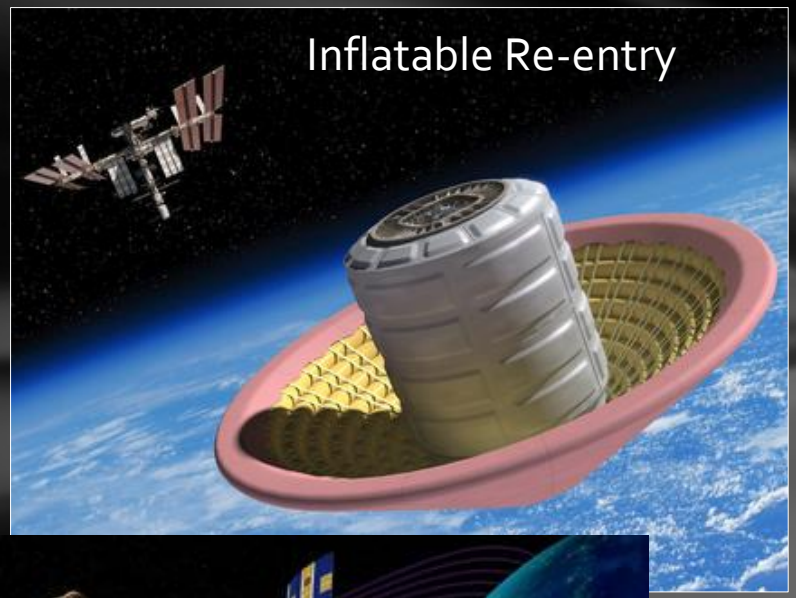

Space Technology

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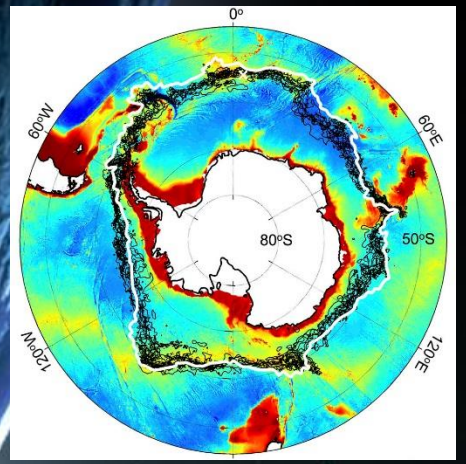
Science



Artic Ozone Hole

Eyes on the Earth

Robotic Exploration of Mars

Eyes on the Solar System

Kepler Spacecraft
more than 2,700 planet discoveries from outside our solar

Eyes on Exoplanets

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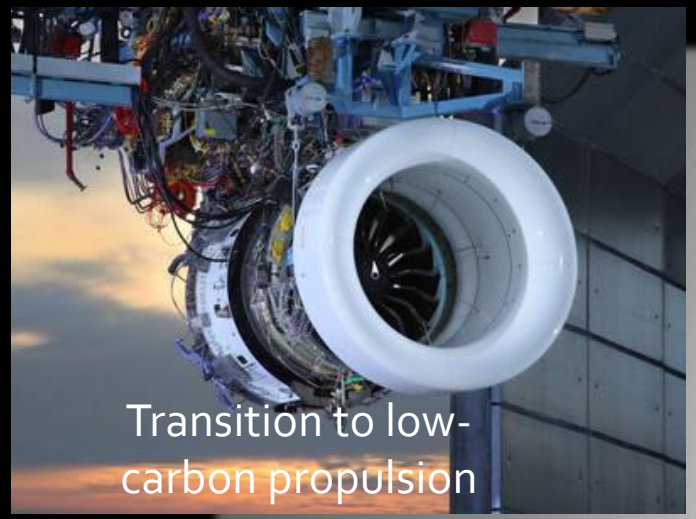
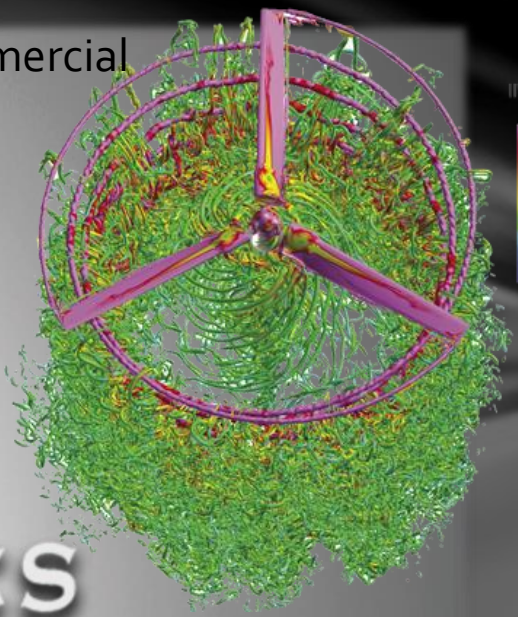


Transition to low-carbon propulsion

Ultra-efficient commercial vehicles



Safe, efficient growth in global operations

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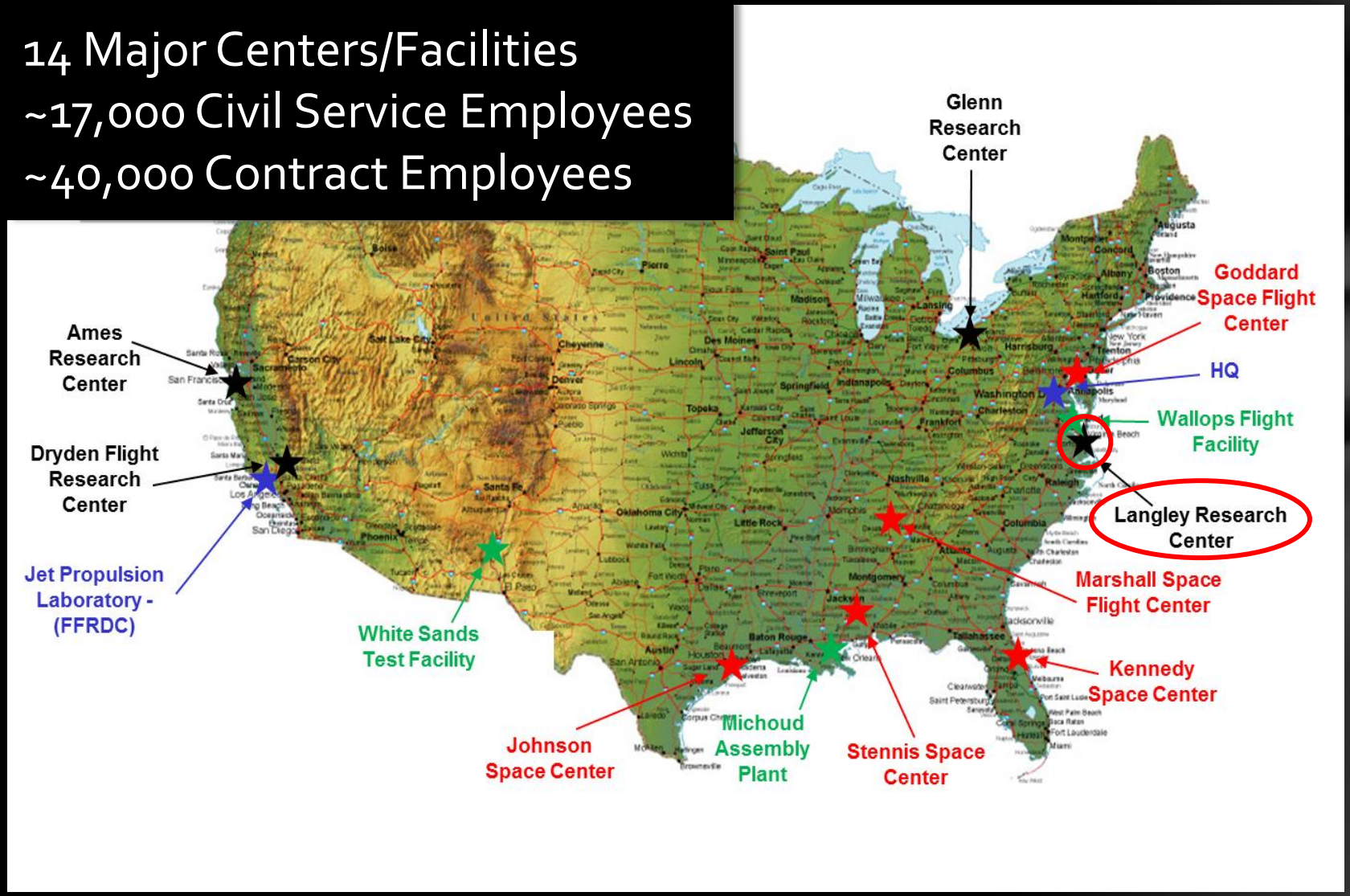
14 Major Centers/Facilities
~17,000 Civil Service Employees
~40,000 Contract Employees



Centers & Facilities:

- Ames Research Center
- Armstrong Flight Research Center
- Glenn Research Center
- Goddard Space Flight Center
- Jet Propulsion Laboratory
- Johnson Space Center
- Kennedy Space Center
- Langley Research Center
- Marshall Space Flight Center
- Michoud Assembly Plant
- NASA Headquarters
- Stennis Space Center
- Wallops Flight Facility
- White Sands Test Facility

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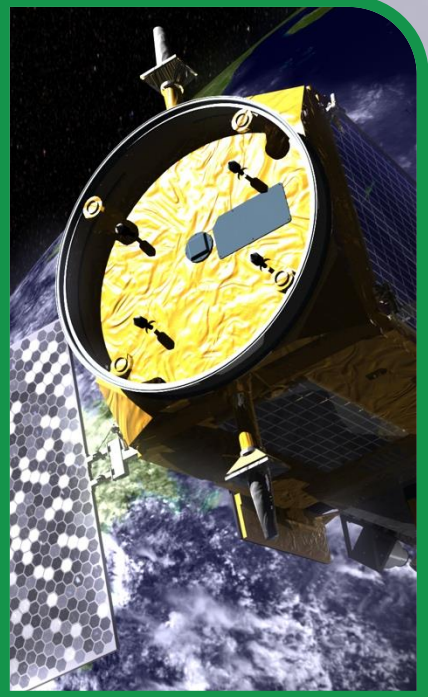
Our Role in NASA

Langley Research Center

SCIENCE



Studying Earth and worlds beyond

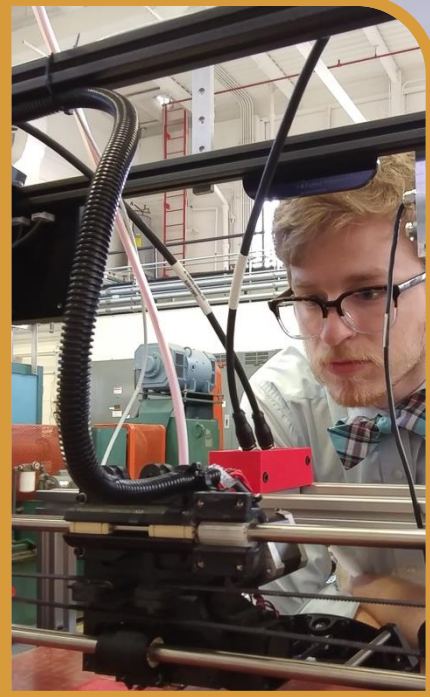
SPACE EXPLORATION

Tools to take us from Moon to Mars

AERONAUTICS

Cleaner, faster, safer air transport

TRANSFORMATION



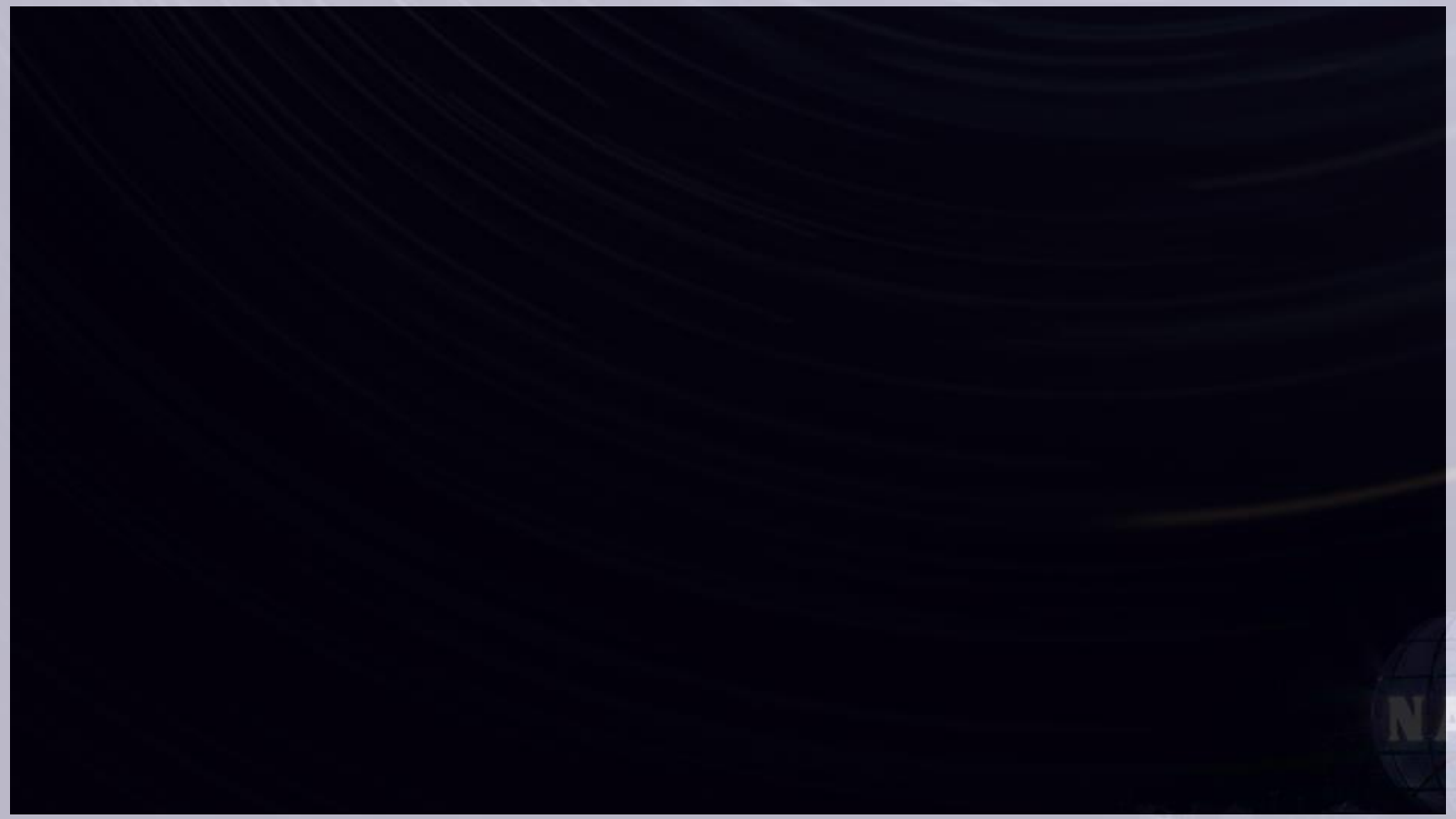
Future of Langley's work and workforce

STEM ENGAGEMENT

A new generation of explorers

National Aeronautics and
Space Administration

Our Role in NASA



LANGLEY RESEARCH CENTER

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NASA

Space Exploration

Reach to Deep Space

Build

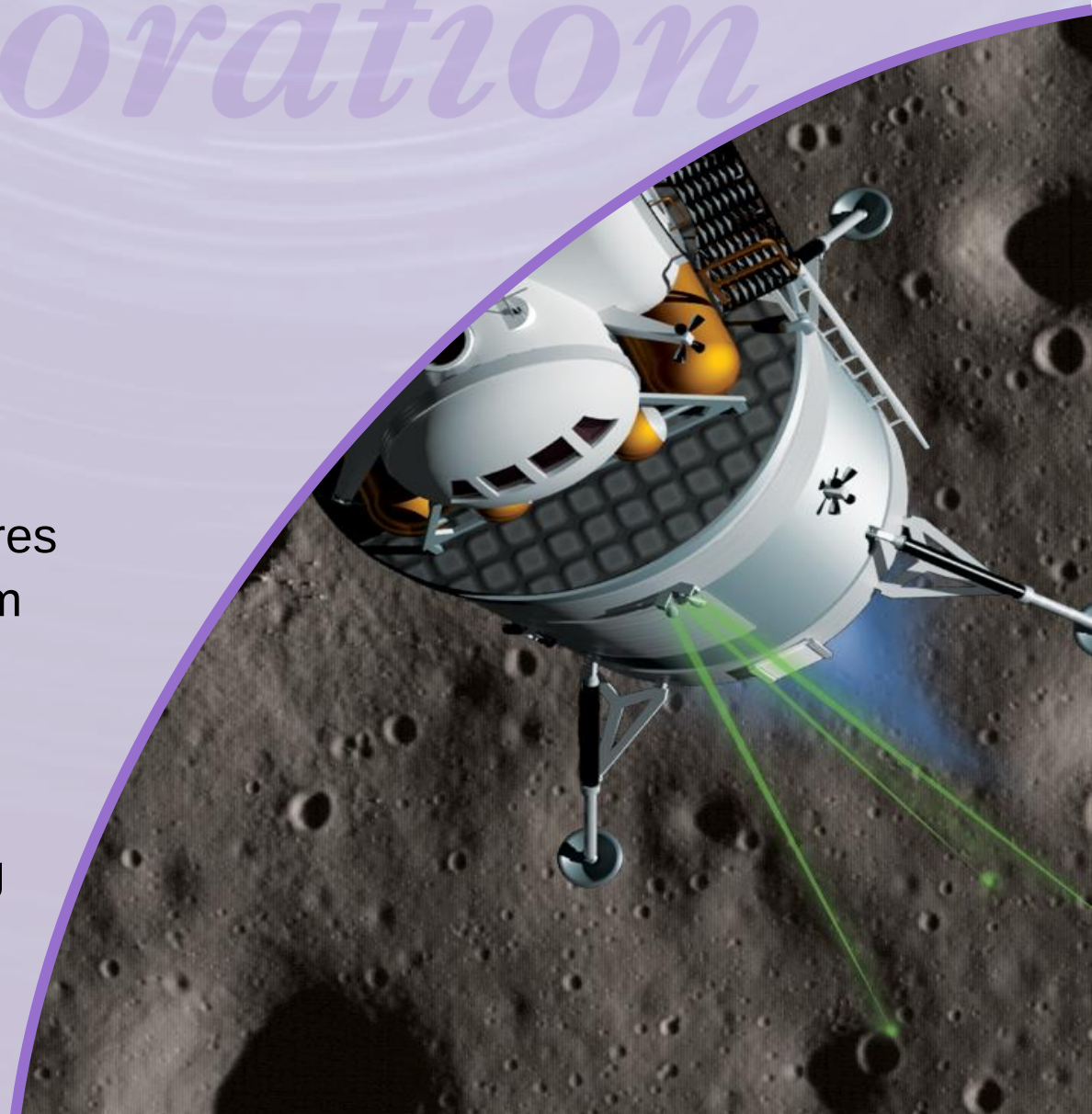
Create building blocks of Moon and Mars exploration

Fly

Envision and develop missions, vehicles and structures needed for tomorrow's exploration of the solar system

Land

Enable people and cargo to arrive safely on other worlds through mastery of entry, descent and landing



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Name that Sound!

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NASA

Space Exploration

Innovation From Moon to Mars

Langley advances science, space technology and exploration through enabling technologies, strategic partnerships and collaborations.

EXPLORE MOON to MARS

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Turning INSIGHT and INVENTION into IMPACT

Insight

Leverage external/internal research to discover, understand and predict fundamental physics to enable ourselves and others to understand the technical challenges that are barriers to advancing the future in aerospace

Invention

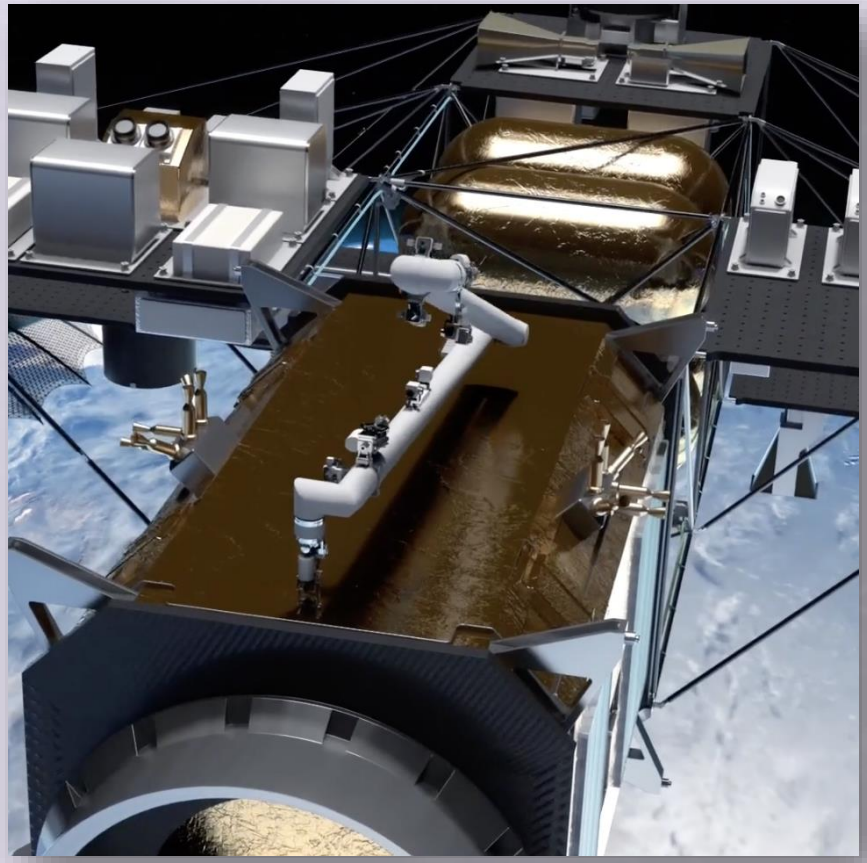
Collaborate to conceive and develop technology solutions to make our desired future real and/or an even better future possible

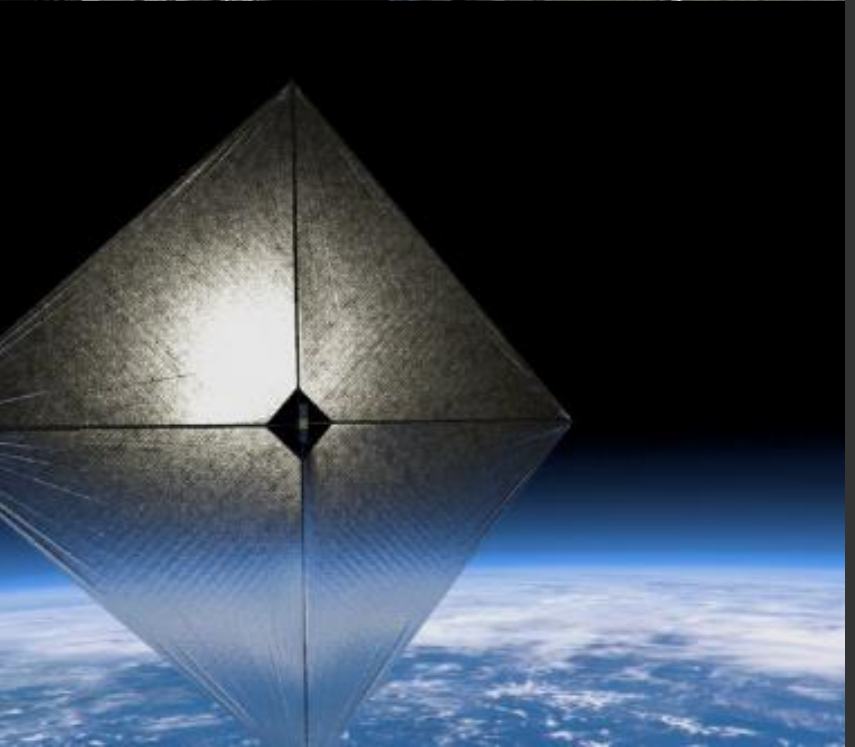
Impact

Partner to infuse technology solutions that demonstrate system-level benefits that enable the Agency's missions and solve the Nation's aerospace challenges

Autonomous In-space Assembly

Langley develops concepts for safe and reliable autonomous systems to supplement human operations, including mechanisms that can maneuver, assemble and service structures.





REPRESENTATIVE PROJECTS

- TALISMAN – Tendon-Actuated Lightweight In-Space MANipulator
- Lightweight Surface Manipulator System – robotic manipulator that can lift and precisely position equipment either on the lunar and/or Martian surface
- Assemblers – A modular and reconfigurable manipulation system for autonomous in-space assembly
- SPIDER – Enables satellites to self-assemble in orbit. Langley is developing the robotic assembly interfaces
- SAMURAI – Strut Assembly, Manufacturing, Utility & Robotic Aid, used to hand off struts to NINJAR
- NINJAR – NASA Intelligent Jigging Assembly Robot precisely positions truss members for welding after hand-off from manipulator (TALISMAN)
- Deployable Composite Booms (DCB) - enable reliable deployable structural systems for low-cost, small volume, rideshare-class spacecraft
- Advanced Composite Solar Sail System (ACS3) – demonstrates use of composites in its lightweight booms that deploy from a CubeSat

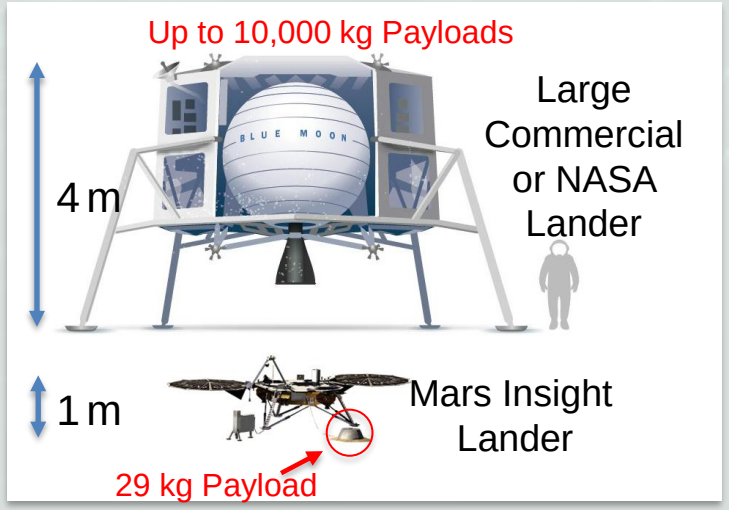
Lightweight Surface Manipulation System (LSMS)

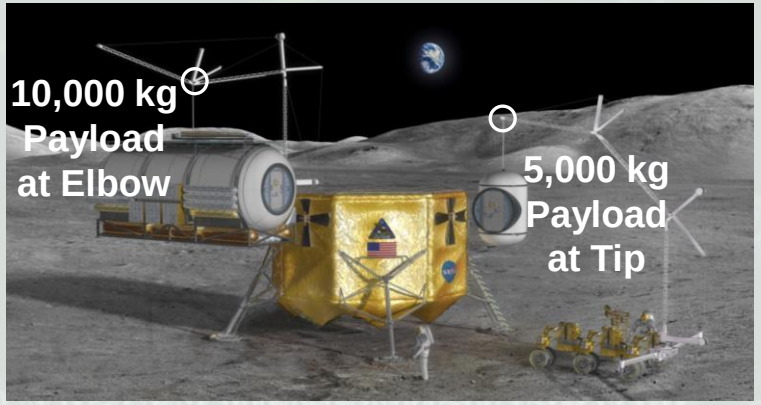
The Problem: NASA and commercial landers require a robust approach to offloading and maneuvering payloads in a wide range of masses, sizes, and shapes.

State of the Art: Planetary-surface serial manipulators do not scale to heavy payloads.

- Payload mass and size, reach required, and height and size of lander, are all significantly greater for large commercial and NASA landers.

The Solution: Lightweight, scalable and versatile, long-reach manipulator that combines the structural efficiency and robustness of commercial cranes, with the enhanced dexterity and multifunctionality of deployable robotic arm.





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Exploration Architecture and Systems Analysis

For over 30 years, Langley has provided system analysis and architecture experience to human and robotic spaceflight programs across NASA's human exploration, science and space technology portfolios.

COLLABORATIONS WITH LANGLEY’s EXPLORATION ARCHITECTURE TEAM ENABLES CUSTOMERS TO MAKE BETTER INFORMED DECISIONS THROUGH ANALYSIS PRODUCTS SUCH AS:

- Mission architectures
- Systems concept designs
- System and technology trades
- Campaign analyses
- Life-cycle cost and risk analyses
- Development of tools supporting technical, programmatic and budgetary analyses

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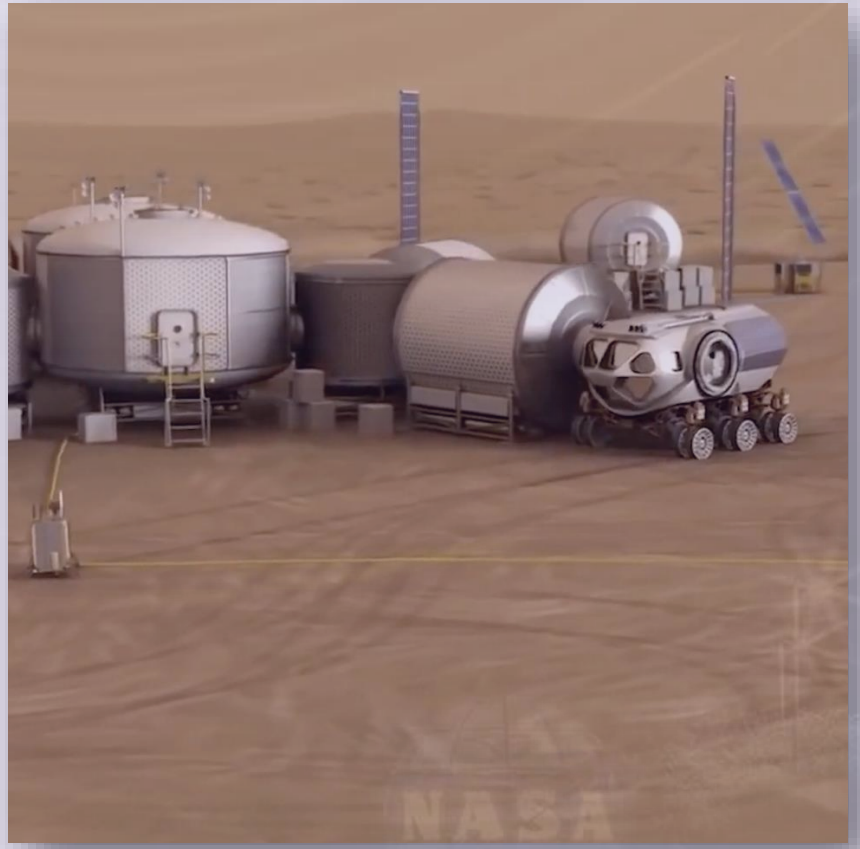
Space Habitation / Radiation Protection/ Gateway

Langley's Space Habitation Systems and Radiation Protection team focuses on the development of in-space habitation systems and radiation protection.



SPACE HABITATION SYSTEMS

Habitation and Systems Concepts:

- Supporting NASA collaborations under NextSTEP, HLS, and Gateway such as:
  - Radiation environment modeling and mitigation approaches
  - Lightweight structures and materials analysis and testing
- Analysis of habitation and radiation requirements, interfaces, and demonstration objectives

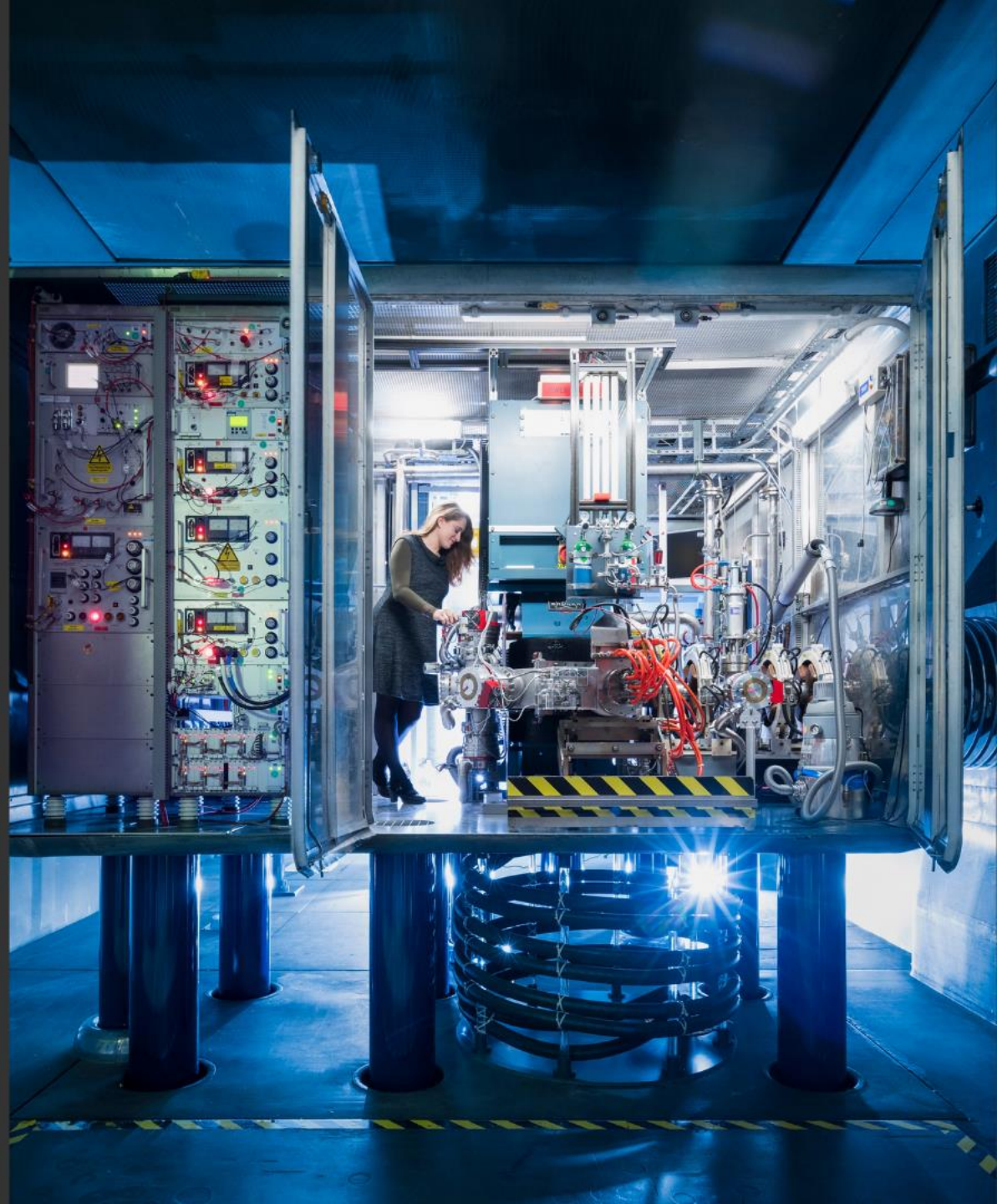
Alternative Materials for Habitat Structures:

- Assessing use and certification of composites and soft goods for habitats
- Advancing structural technologies for habitat mass and risk reduction

RADIATION PROTECTION / GATEWAY

Langley works on an array of projects designed to help limit human exposure to radiation during space exploration including:

- Advanced technologies, analysis methods, and sensors analysis for radiation mitigation approaches
- Modeling and analysis to better understand crew doses and promote safety on future missions
- The development and testing of wearable radiation protection concepts for in-space use
- Use of soft goods, composites, and advanced materials for in-space habitation systems
- Supports NASA Headquarters in the requirements, design, testing and development of space habitats



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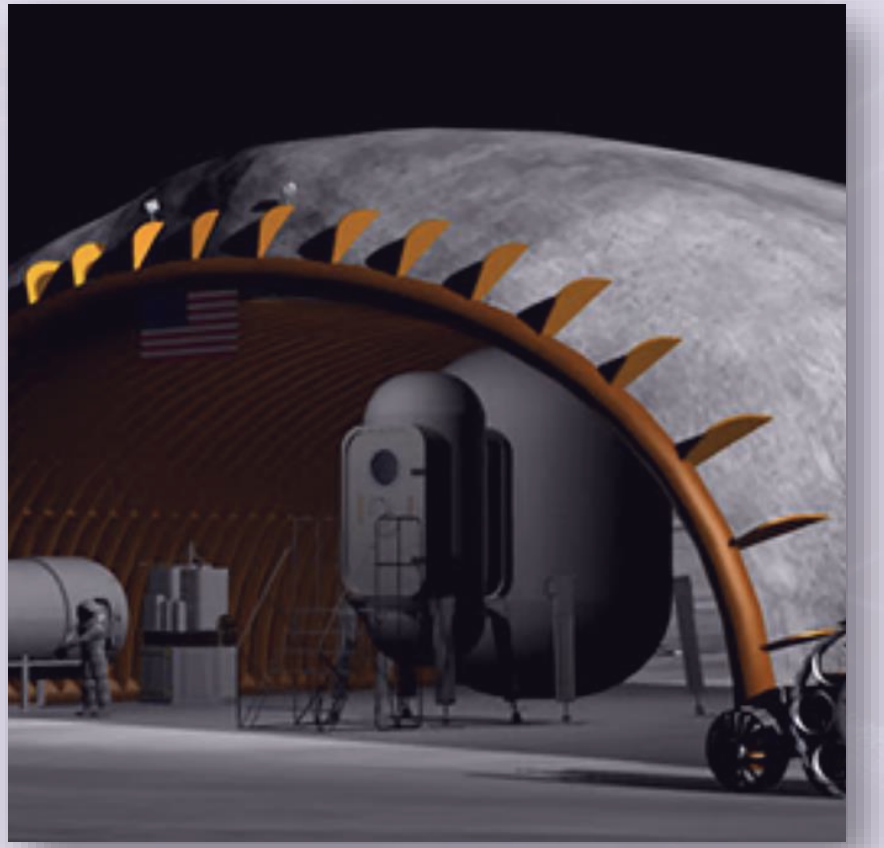
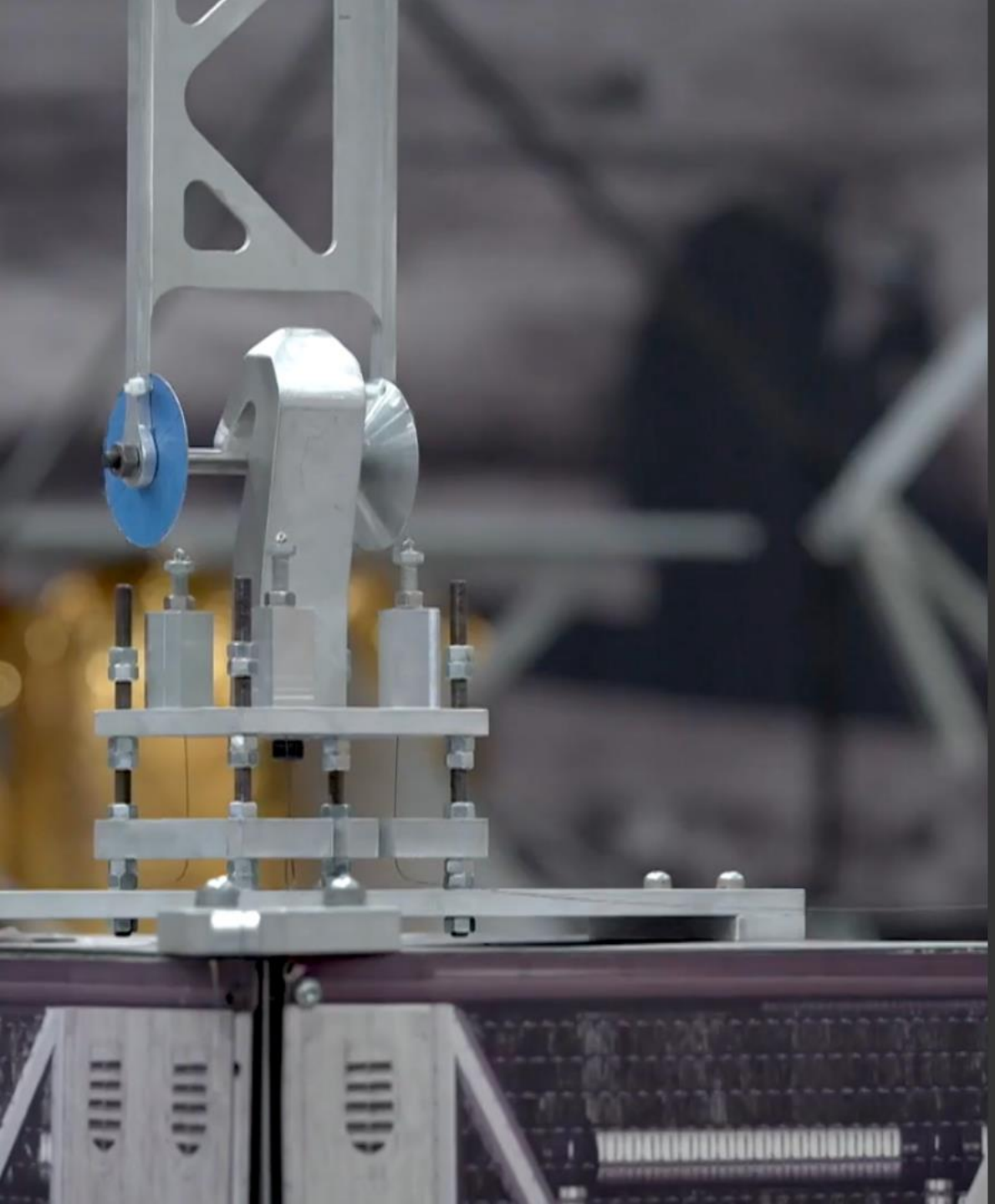
Structures and Materials, Advanced Manufacturing

Langley focuses on advancing state-of-the-art lightweight structures, materials and manufacturing methods, playing a vital role in advanced and additive manufacturing of metals and composites, high temperature composites and ceramics, hybrid metal systems, and carbon and boron nitride nanotubes.





CAPABILITIES

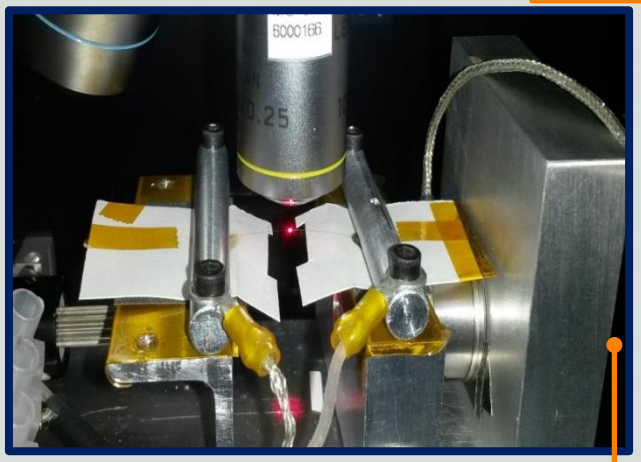
- Material synthesis, coatings, and treatments
- Process development, assessment and certification
- Advanced metal alloys, metal matrix composites, and composite structure bonding and joining
- Advanced and additive manufacturing of metals and composites, high temperature composites and ceramics, hybrid metal systems, and carbon and boron nitride nanotubes
- Recyclable, repurposeable material systems
- Inflatable and hybrid structures
- Advanced modeling, analysis and NDE tools

Process Development

Electron Beam Welding

Material Synthesis

Automatic Fiber Placement



CNT Fabrication & Characterization

- Electron Beam Freeform Fabrication with in-situ process control
- Automatic fiber placement with real-time inspection
- Multifunctional CNT fiber composites
- Characterization of optical and electronic transport properties of CNT fibers and graphene depositions

Computational Materials for Material Processing

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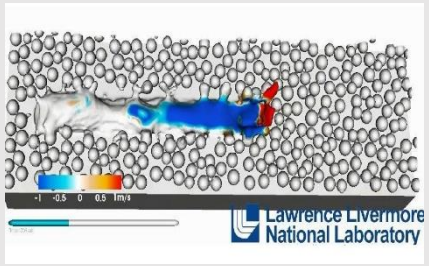
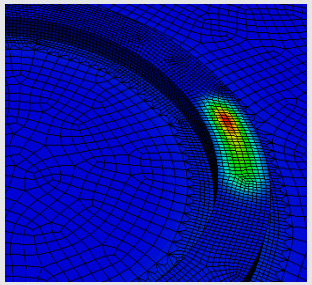


Simulation of Laser-Powder Bed Interactions



Prediction of Local Heat Distribution

Simulate Fundamental Physics Governing Processing

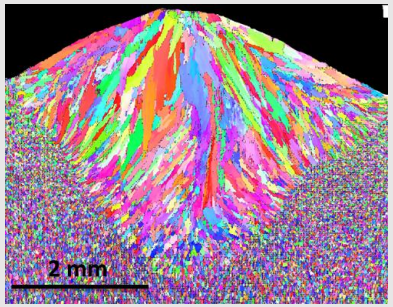
- Determine role of processing parameters and composition on microstructure
- Simulate physical processes including laser beam absorption in powder bed, heat transfer via conduction and radiation, and fluid flow at the melt pool, particle flow
- Simulate residual stress, distortion, microstructural evolution and precipitate growth

Develop Physically Correct Models Needed to Support Certification of AM Feed Stock and Manufacturing Process

Characterize Material Evolution using Experimental Methods

- Employ heavily-instrumented SLM machine and synchrotron beam lines (APS, CHESS)
- Produce coupon-size specimens using well-controlled parameters
- Understand details of the relationship between processing parameters and resulting microstructure

Selective Laser Melting



Grain Structure from Additive Process

In-situ NDE During Automated Fiber Placement (AFP)

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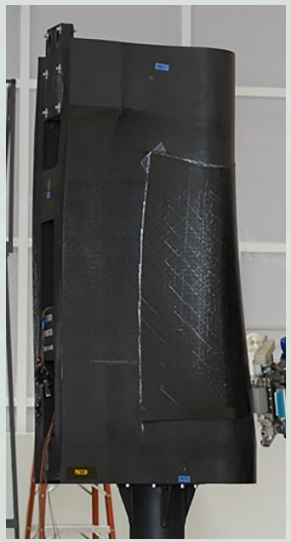
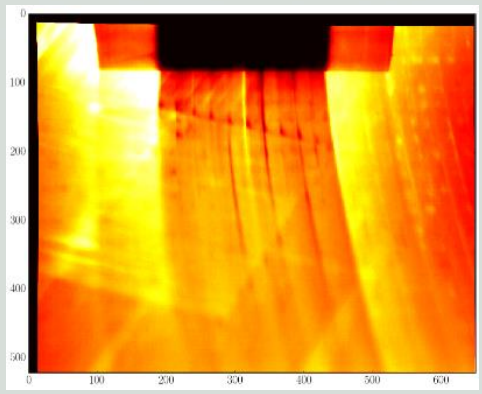
AFP Manufacturing Challenge
Current Process Time: 19% Layup vs. 42% Inspection
Goal Process Time: 76% Layup vs. 8% Inspection

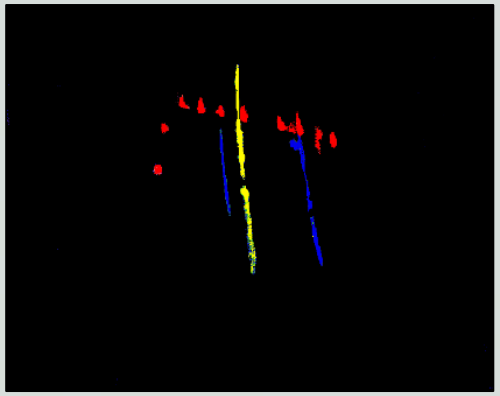


System Capabilities

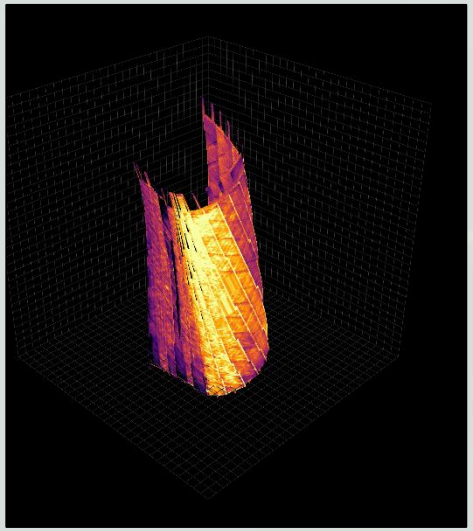
- Real time inspection with immediate defect reporting to operator
- Artificial intelligence algorithms quickly pass pristine data and only highlights discontinuities
- High accuracy/precision of inspection for better risk assessment
- Quantitative measurement of parameters that affect build quality
- Moving toward real time control of the manufacturing process



Raw Temperature Data



Automatic Feature Recognition



Temperature Data Mapped Layer by Layer

Multi-axis Automated Fiber Placement (AFP) Robot

Exploration Focus Areas

Orion and Space Launch System

Langley provides research and engineering support for the Orion and SLS Programs in the following areas:

- Aerodynamics and aerothermodynamics database development utilizing wind tunnel testing and computational fluid dynamics (CFD)
- Define vehicle controllability requirements and provide independent verification of control laws for Launch Abort Modes and for Crew Module entry
- Heat Shield structures testing and analysis
- Loads & Dynamics
- Payload Fairing and Universal Stage Adapter
- Landing impact dynamics testing and analysis
- Development Flight Instrumentation (DFI)

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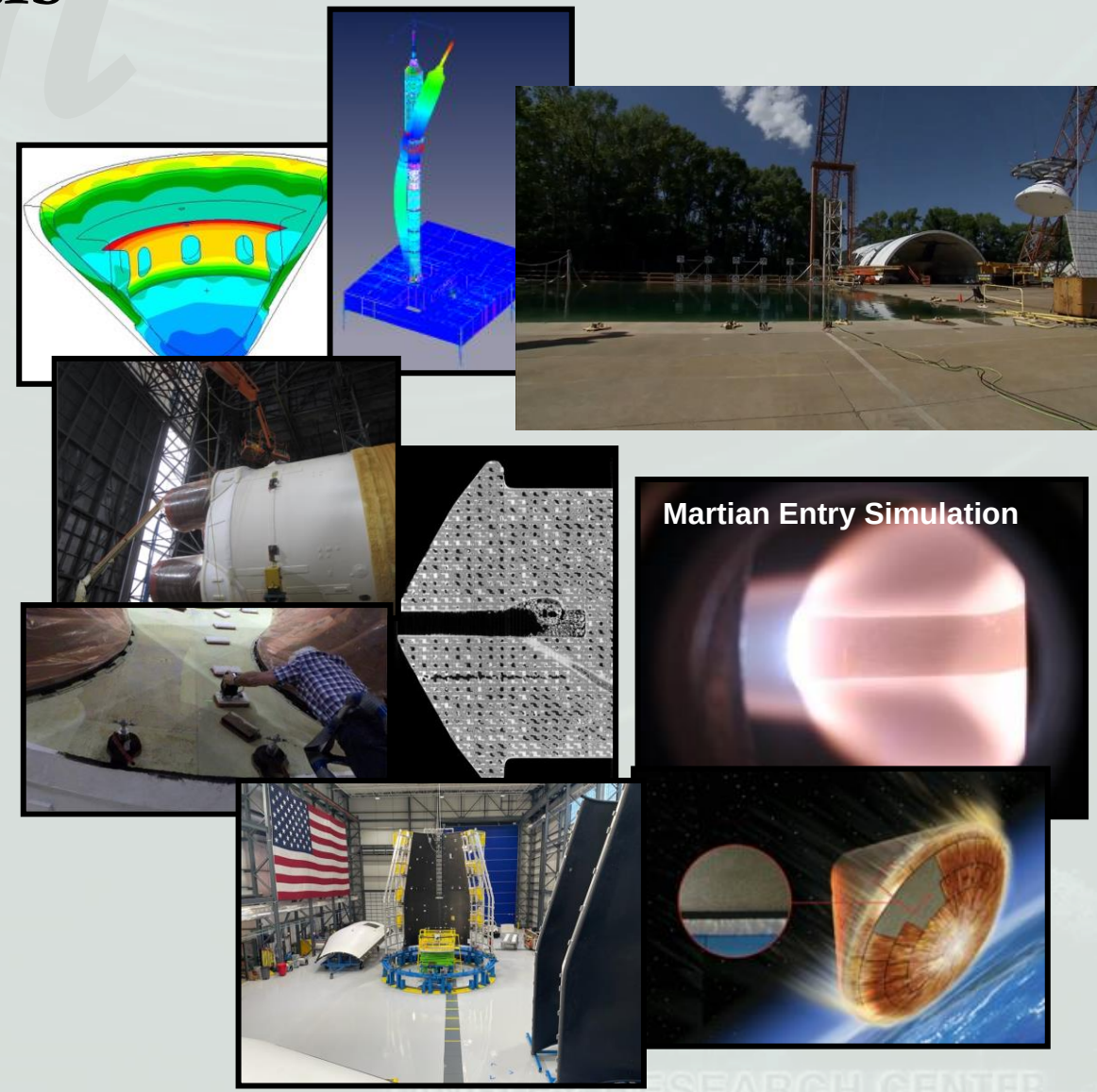
Example Structures & Materials Contributions to Artemis

- Inspection Technologies for SLS and Orion
- Structural Dynamics and Water Impact Testing
- Materials Development and Performance Characterization
- Composite Materials for Universal Stage Adapter
- Heat Shield Performance



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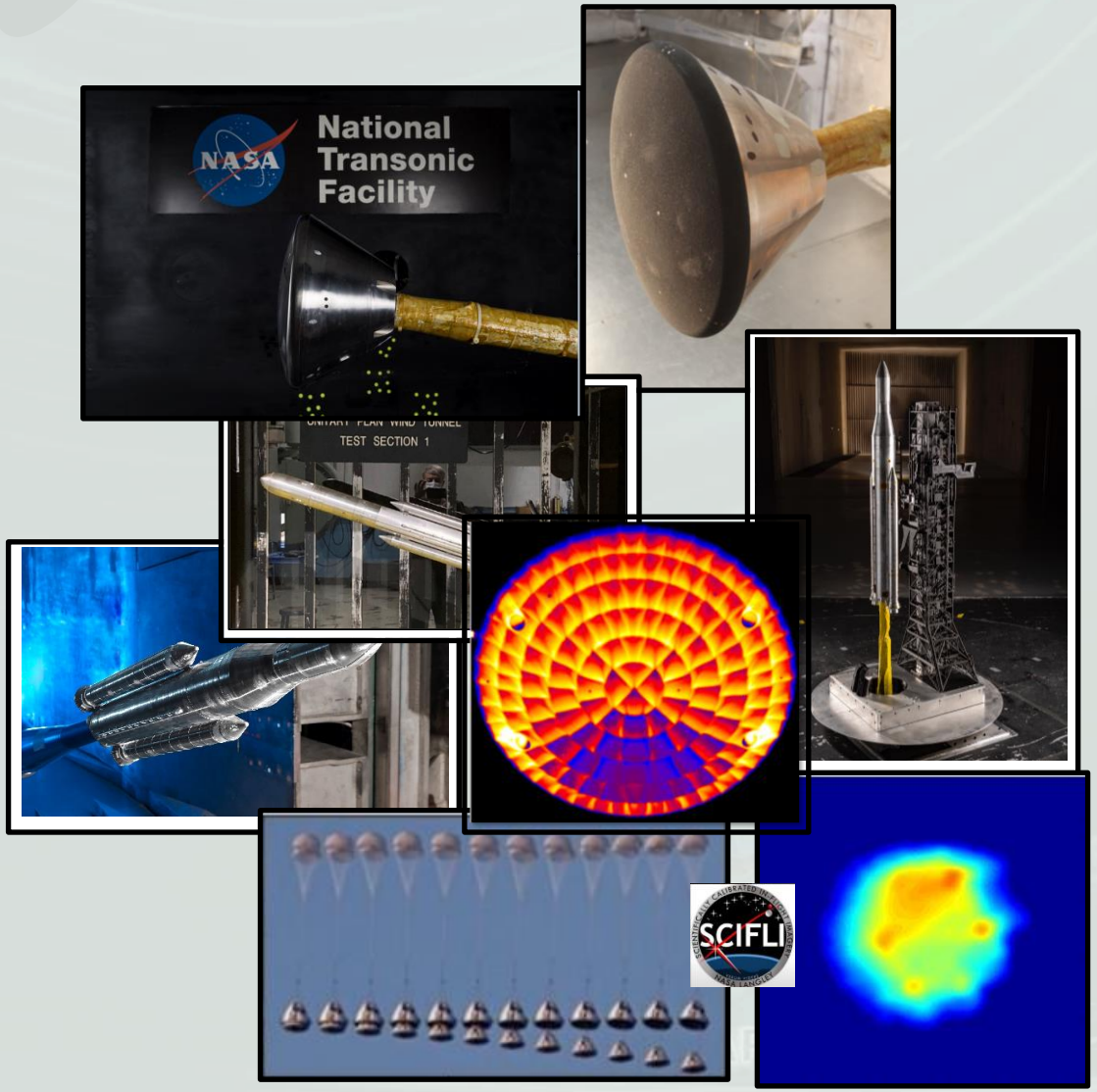
Example Aerosciences Contributions to Artemis

- Orion Crew Module Heatshield Test at the National Transonic Facility
- Orion Hypersonic Aerothermal Support
- Space Launch System Aerosciences Testing across Langley Wind Tunnels
- Scientifically Calibrated In-Flight Imagery (SCIFLI) Team



Example Intelligent Flight Systems Contributions to Artemis

- Human Landing System (HLS) Handling Qualities and Crew Interface Design Assessments
- LaRC Role in Assessment of Lunar Gateway Time-Triggered Ethernet
- Flight Dynamics Research Facilities Provide Vehicle Risk Reduction for Human Exploration
- Orion and SLS Dynamics and Controls

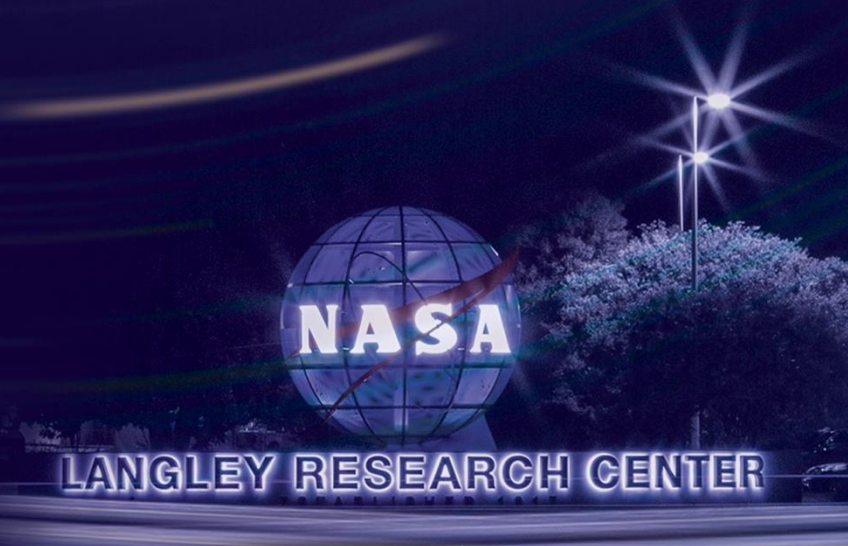

Our People
2020 Honor Award Recipient
CONGRATULATIONS!
Langley Research Center
NASA

National Aeronautics and Space Administration

NASA

Learn more at

www.nasa.gov/langley



Thank You!

EXPLORE MOON to MARS

MOON LIGHTS THE WAY

https://www.nasa.gov/offices/education/programs/descriptions/NASA_Pathway_Programs.html

https://intern.nasa.gov/

https://www.usajobs.gov/