Back to the Moon V

Infrastructure and Testing

ARTEMIS

Jim Rauf

NASA Centers and Facilities

Ames Research Center
IT, fundamental aeronautics, bio and space science technologies

Armstrong Flight Research Center
Flight research

Glenn Research Center
Aeropropulsion and communications technologies

Goddard Space Flight Center
Earth, solar system, and universe observations, and space communications and navigation

Jet Propulsion Laboratory
Robotic exploration of the solar system and Earth observations

Johnson Space Center
Human space exploration

Kennedy Space Center
Prepare and launch missions around the Earth and beyond

Langley Research Center
Aviation, space technology and Earth science

Marshall Space Flight Center
Space transportation and propulsion technologies

Stennis Space Center
Rocket propulsion testing and remote sensing technology

Goddard Institute for Space Studies
Broad study of global climate change

Katherine Johnson Independent Verification and Validation Facility
Safety and cost-effectiveness for mission-critical software

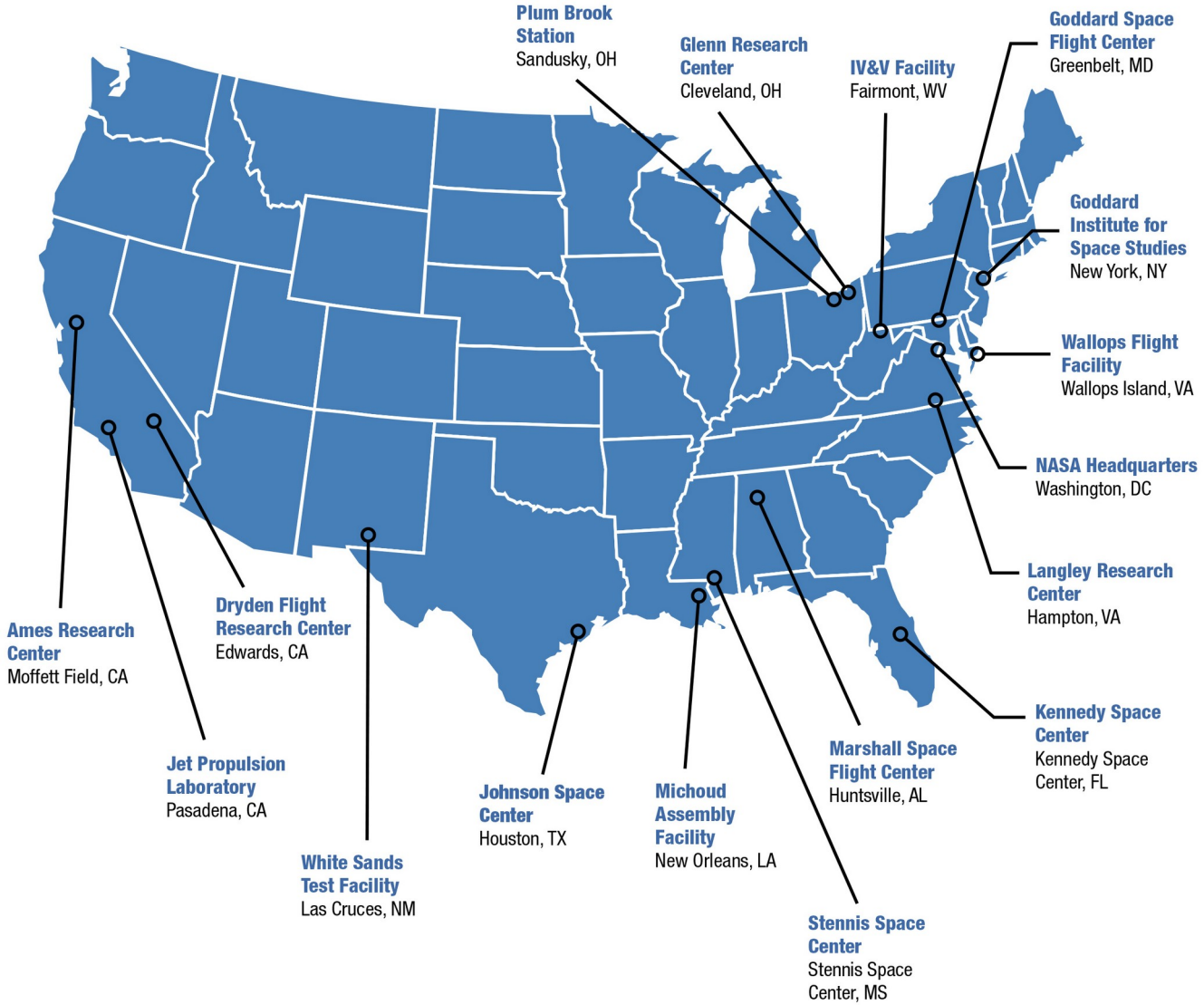
Michoud Assembly Facility
Manufacture and assembly of critical hardware for exploration vehicles

NASA Engineering and Safety Center
Independent testing, analysis, and assessments of NASA's high-risk projects

NASA Safety Center
Development of personnel, processes, and tools needed for the safe and successful achievement of strategic goals

Wallops Flight Facility
Suborbital Research Programs

NASA Centers and Facilities



Ames Research Center	Moffett Field, CA
Armstrong Flight Research Center	Edwards, CA
Glenn Research Center	Cleveland, OH
Goddard Space Flight Center	Greenbelt, MD
Goddard Institute of Space Studies	New York, NY
IV and V Facility	Fairmont, WV
Jet Propulsion Laboratory (JPL)	Pasadena, CA
Johnson Space Center	Houston, TX
Kennedy Space Center	FL
Langley Research Center	Hampton, VA
Marshall Space Flight Center	Huntsville, AL
NASA HQ	Washington, D.C.
Stennis Space Center	MS
Wallops Flight Facility	Wallops Island, VA
White Sands Test Facility	Cruces, NM

Apollo Infrastructure Vehicle Assembly Building (VAB)

The VAB is the largest single-story building in the world
Its volume of 129,428,000 cu ft make it is the eighth-largest building in the world

- **Vehicle Assembly Building (VAB),** standing 525 feet high
- **4 High Bays**
  - 2 on the East side and 2 on the West side
  - Total High Bay dimension: 442 ft L x 518 ft W x 525 ft H
  - Individually retractable doors (7 total) 456 ft high external opening
  - 2 High Bays open and lead to launch pads (East side)
  - 3 of 4 High Bays capable of handling Mobile Launch Platform (MLP) for vertical stacking/integration
- **Cranes**
  - 2 – 250-ton bridge cranes (E-W) with 460 ft hook height
  - 2 – 325-ton bridge cranes with 462.5 ft hook height
  - 1 – 175-ton bridge crane (length of transfer aisle) with 156 ft hook height
- **Communications**
  - Wireless Capability
  - Connectivity to the Launch Control Center (LCC)

Apollo Infrastructure Transporter Crawler

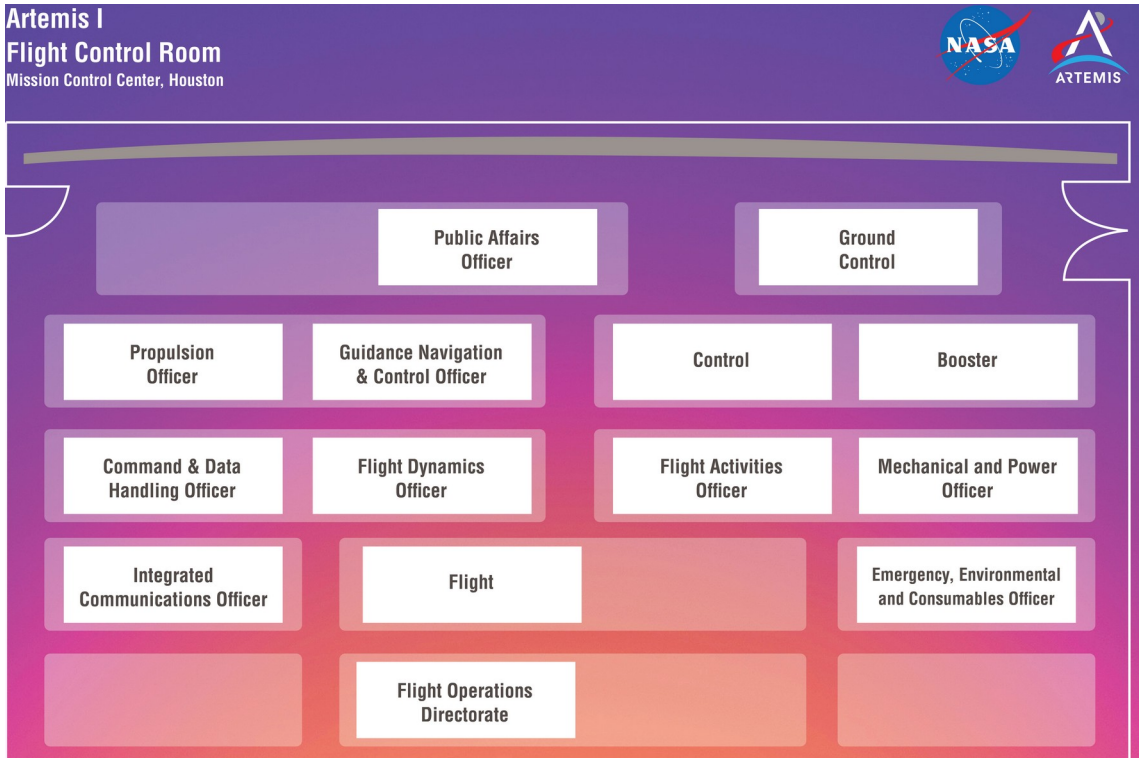
Length 131 ft
Width 114 ft
Height 20-26 ft (variable)
Weight ~5.5 million lbs
Max speed loaded 1 mph (2 mph unloaded)
Fuel consumption 150 gal/mile
Price ~ $14 million (1964)
Manufacturer Marion Power Shovel Co.
The two crawler-transporters were the largest self-powered land vehicles in the world

Apollo Infrastructure Launch Pad

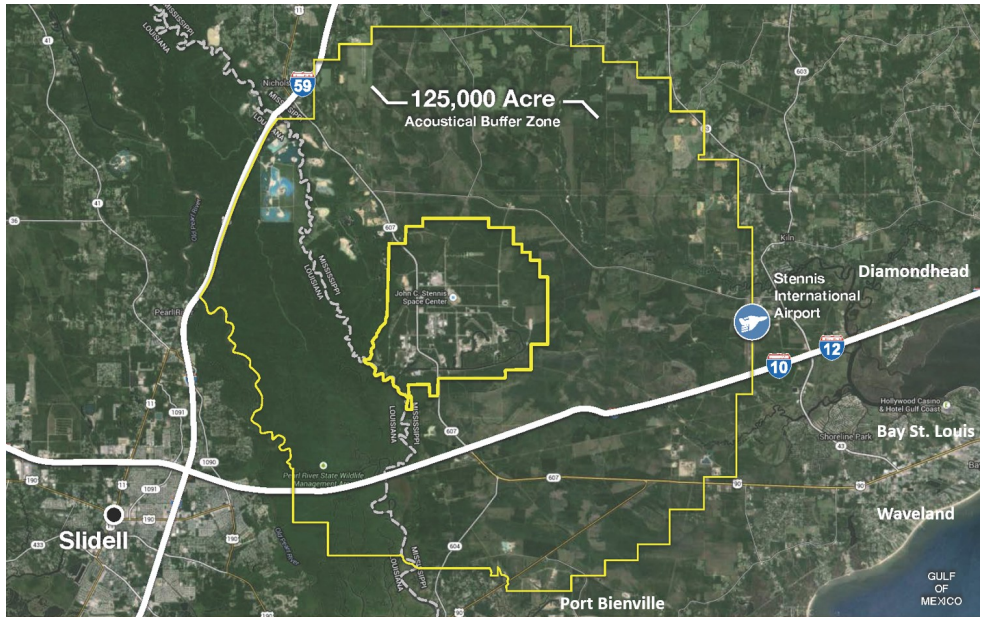
Foreground Launch Pad 39A

Background Launch Pad 39B

Artemis Mission Control Johnson Space Center



Apollo Infrastructure Mississippi Test Facility Stennis Space Center

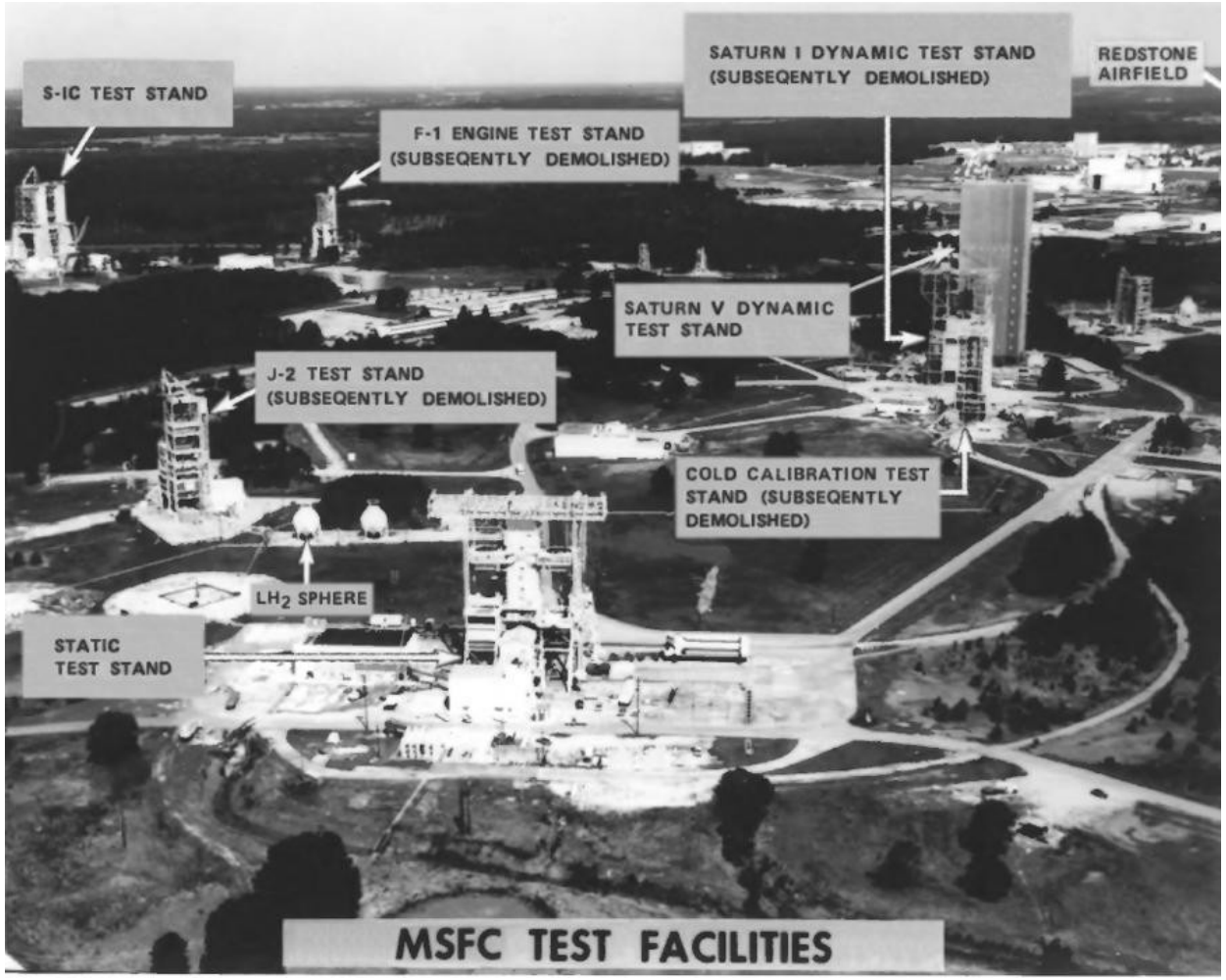


Apollo Infrastructure Mississippi Test Facility Stennis Space Center

- **High Pressure Industrial Water**
  - 66,000,000 gallon reservoir
  - Ten diesel-driven pumps with a total capacity of 330,000 gal/min
  - Piping and foundation to expand to 13 pumps
- **High Pressure Gas Facility**
  - Gaseous Nitrogen (GN2) 4,400 psig
  - Gaseous Hydrogen (GH2) 3,000 psig
  - Gaseous Helium (GHe) 4,000 psig
  - High Purity Air (HPA) 3,000 psig
- **Cryogenic Propellant Systems**
  - Storage, transfer and distribution of propellants
  - Six 100,000 gal Liquid Oxygen (LOX) barges
  - Three 240,000 gal Liquid Hydrogen (LH) barges
- **Emergency Power-Generating System**
  - Four Cooper-Bessemer diesel engines each driving a 4160 volt, 1875 KVA generator used to provide emergency electrical power.
- **Waterway Transportation**
  - 7-1/2 Miles of Canal System
  - Connecting SSC Test Complexes to the Gulf of Mexico and Connected Waterways
  - Allows Barge Transportation of Large Stages
  - Used for Delivery of Propellants to the Large Test Stands
- **Manufacturing & Assembly**
  - Over 800,000 square feet of industrial space is available
  - Over 1100 acres of greenfield space is available (400 acres shovel ready)
  - Allows co-location for manufacturing and assembly operations with test facilities

Apollo Infrastructure Marshal Spaceflight Center(MSFC)

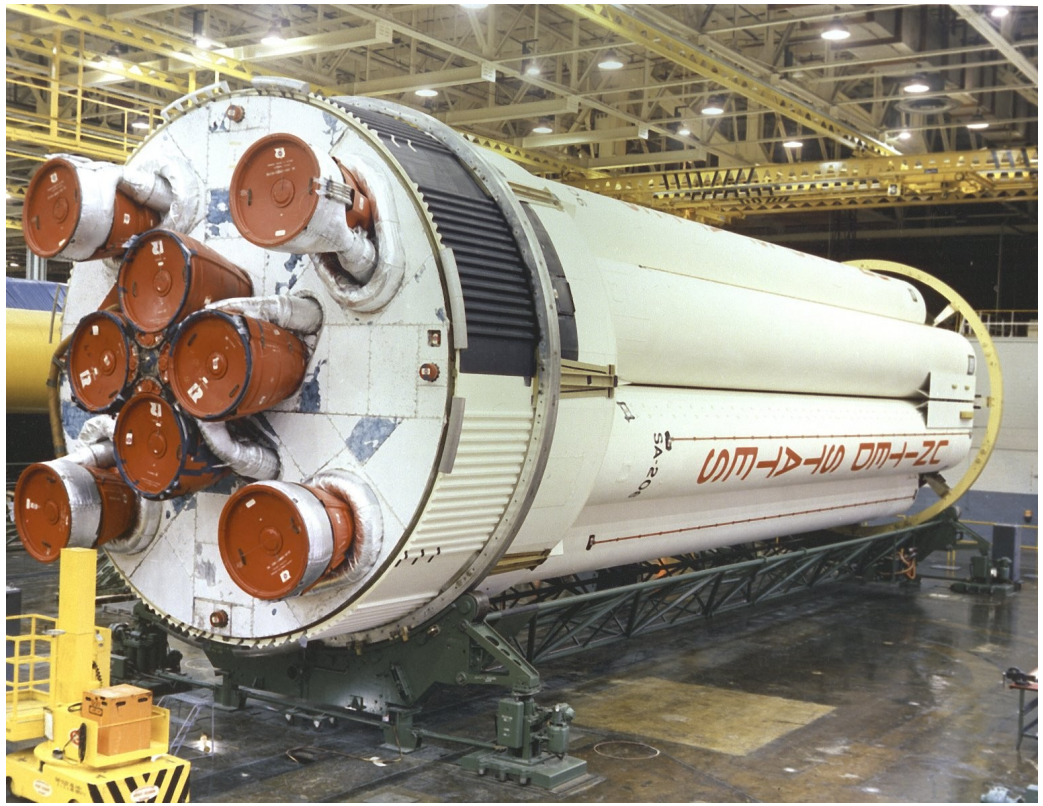
- **MSFC** provides concept and design for propulsion systems, space habitats, planetary landers
- It develops cutting-edge technology in support of scientific missions
- It manages activities at the **Michoud Assembly Facility** in New Orleans



Michoud Assembly Facility New Orleans

- **NASA's** premiere site for manufacturing and assembly of large-scale space structures and systems
- Past programs included **Apollo's Saturn I,IB** and **S-1C** boosters and **Space Shuttle** external tank
- The government owned 829 acre facility has a 43 acre manufacturing space under one roof
- **Boeing** is manufactures and assembles the **SLS** core stage
- **Lockheed Martin** manufactures **Orion** spacecraft's pressure vessel
- **Northrop Grumman** manufactures the launch abort system

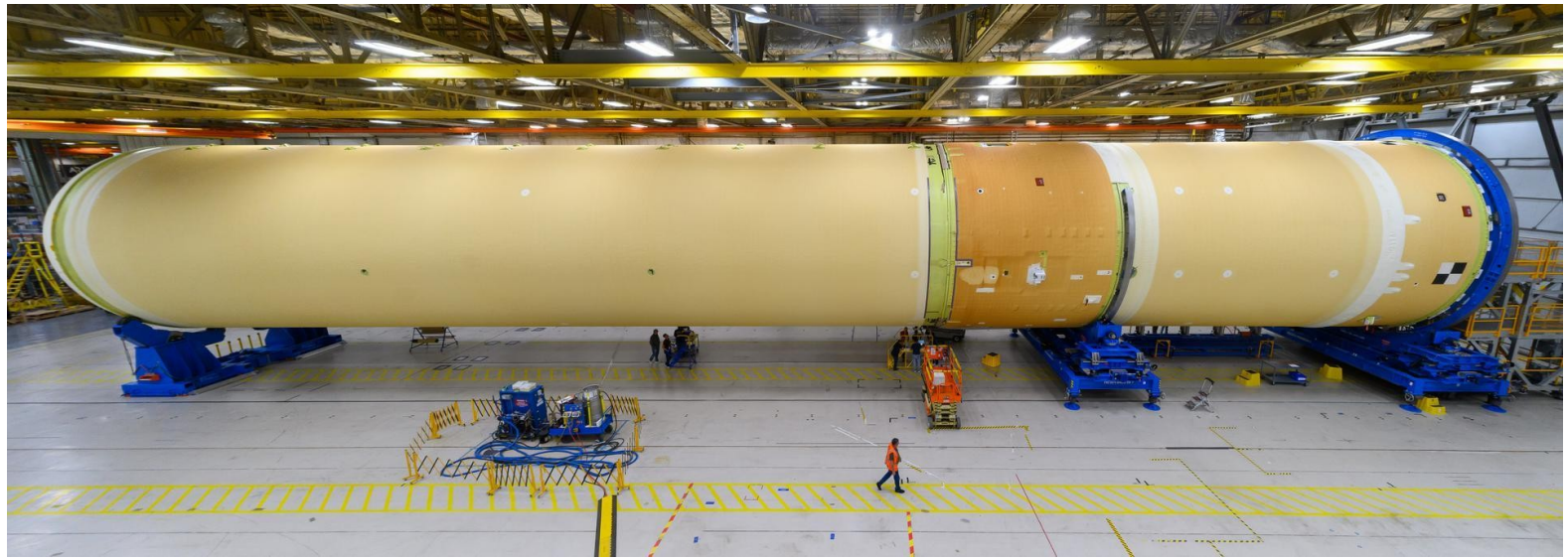
Michoud Assembly Facility New Orleans 1960s



Chrysler Saturn I B

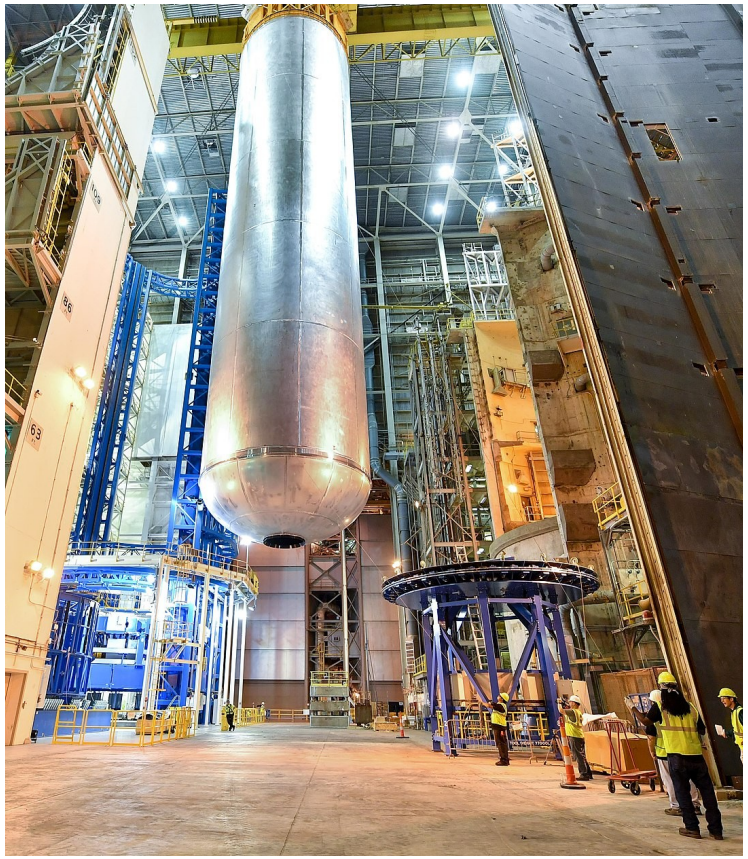
Boeing Saturn V S1- C

SLS Core Stage Manufacturing



SLS Core Stage Manufacturing

Liquid oxygen tank



Liquid hydrogen tank

Two fuel tank domes were recently finished for the SLS rocket. One is a qualification article and the other is the actual flight article for the first mission

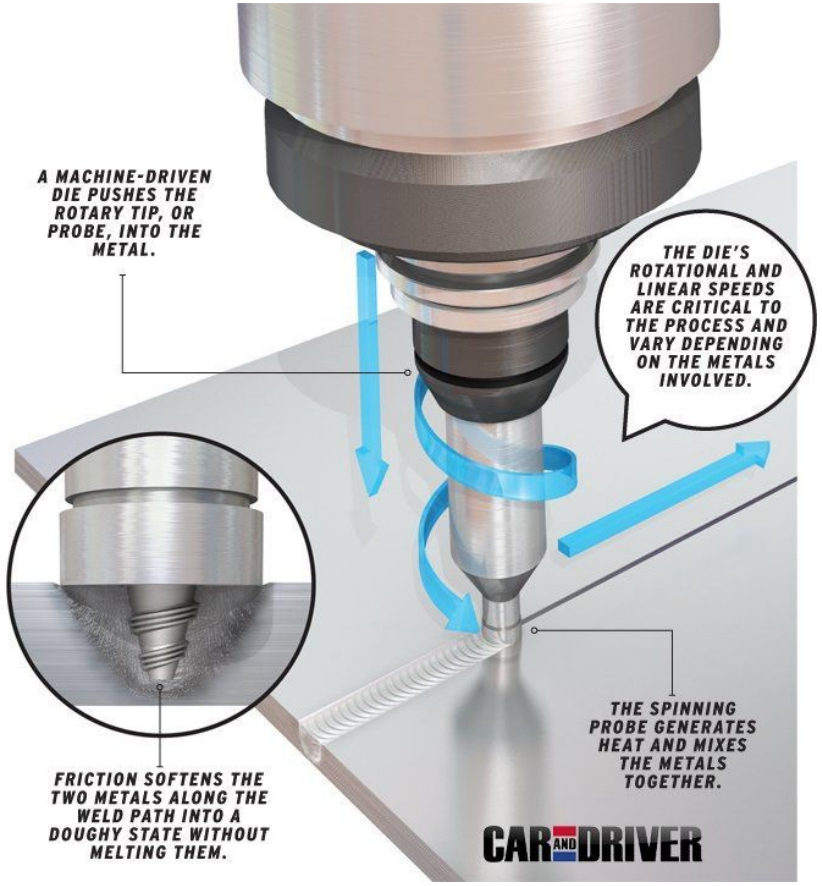
SLS Core Stage Manufacturing

The Gore Weld Tool (foreground) and Circumferential Dome Weld Tool (background) used to fabricate dome segments for the SLS liquid hydrogen and oxygen core stage tanks via vertical *friction stir welding* operations

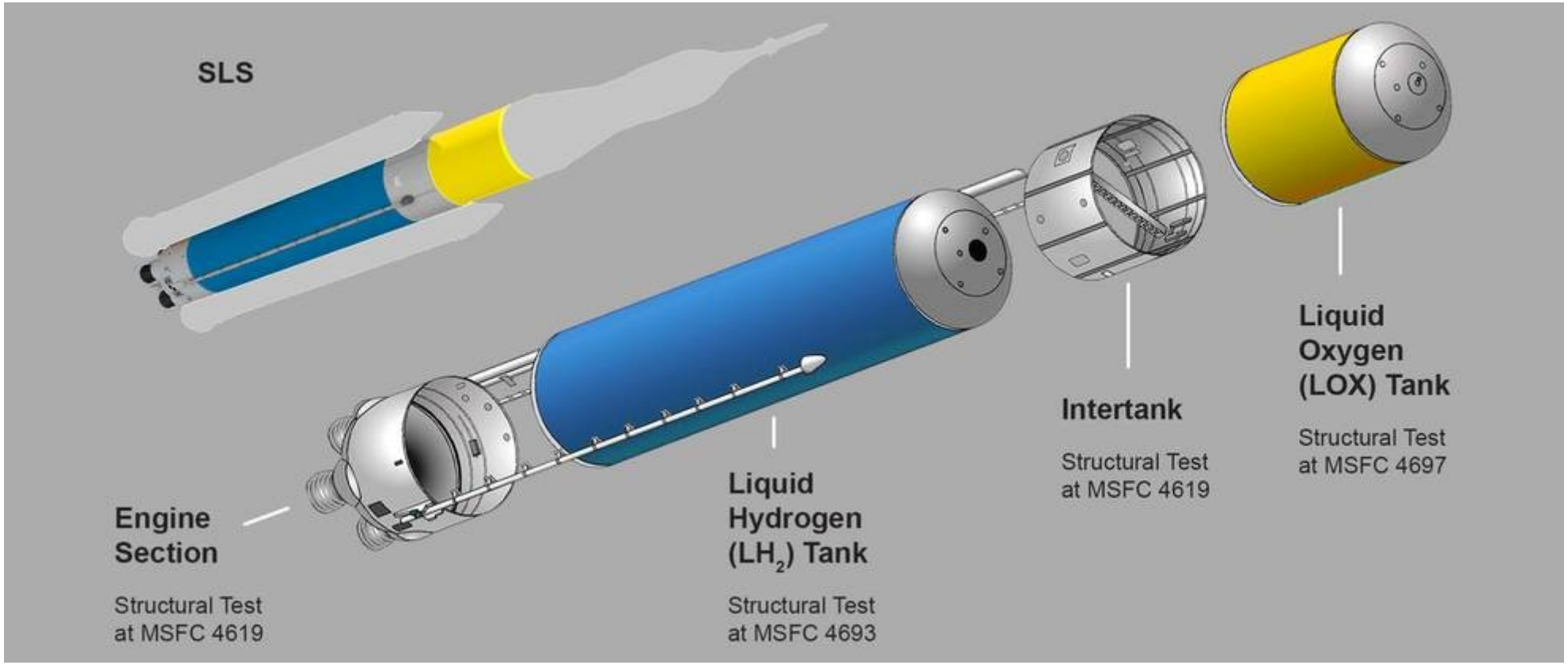
The Vertical Weld Center tool used to fabricate barrel segments for the SLS liquid hydrogen and oxygen core stage tanks via vertical *friction stir welding* operations To the right of the welder is the weld confidence barrel

SLS Core Stage Manufacturing Friction Stir Welding

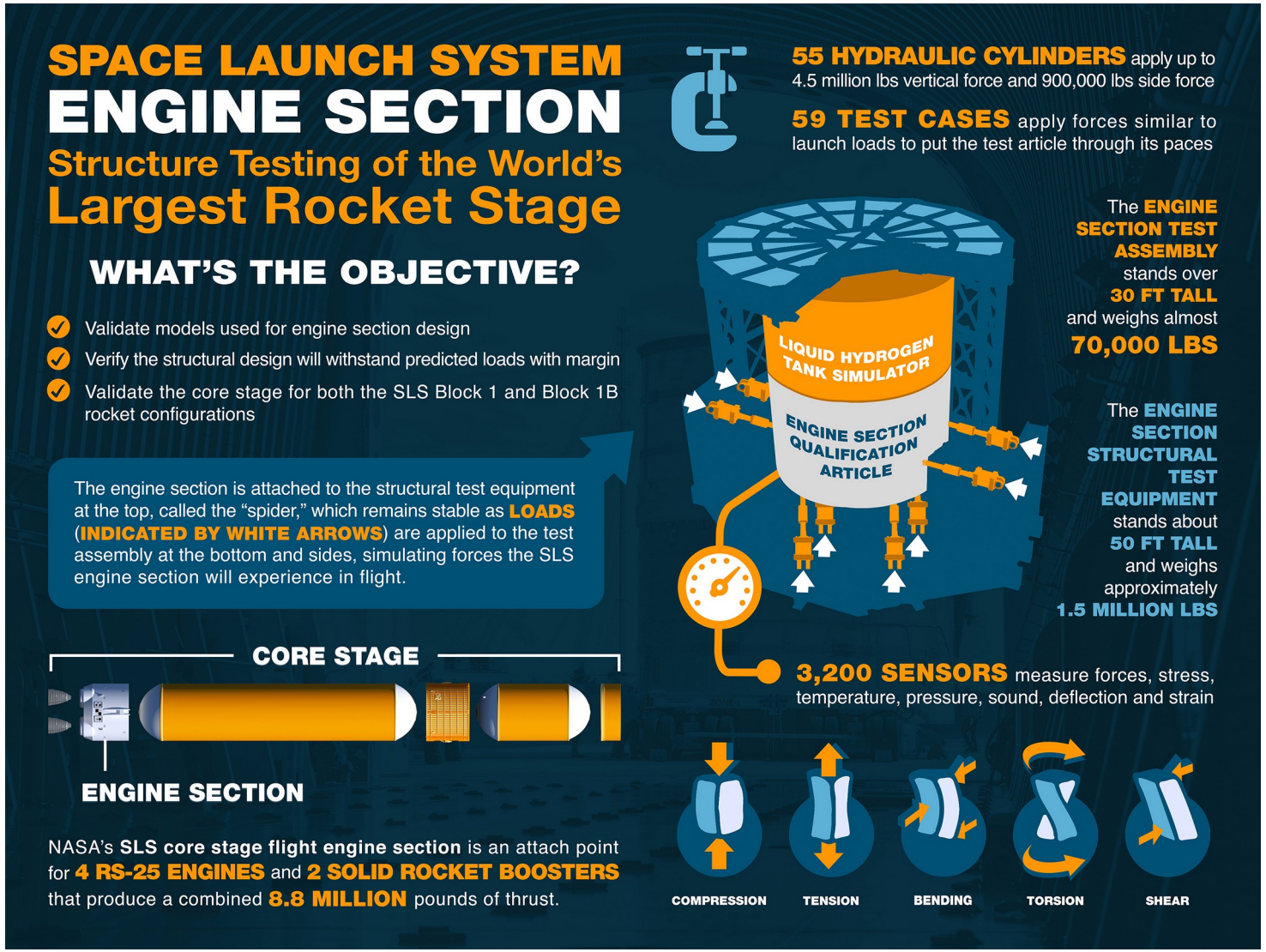
- **SLS** uses "*friction stir welding*"
- **Friction stir welding is one kind of solid-state joining that relies on a tool to combine two facing workpieces**
- **The tool is rotated and travels along the mating joint of the workpieces being welded, with the resulting friction generating the heat necessary to merge the two pieces**
- **The tool softens the two pieces of metal enough that mechanical intermixing occurs, forging the metal under the mechanical pressure**
- The result is a stronger and more defect-free weld, than traditional methods of joining materials

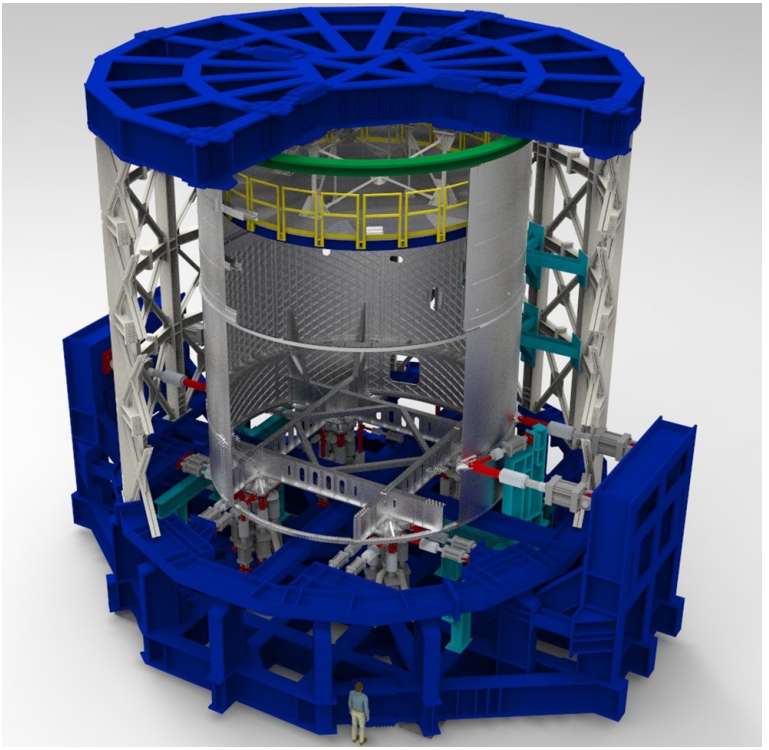


SLS Core Stage Testing at MSFC

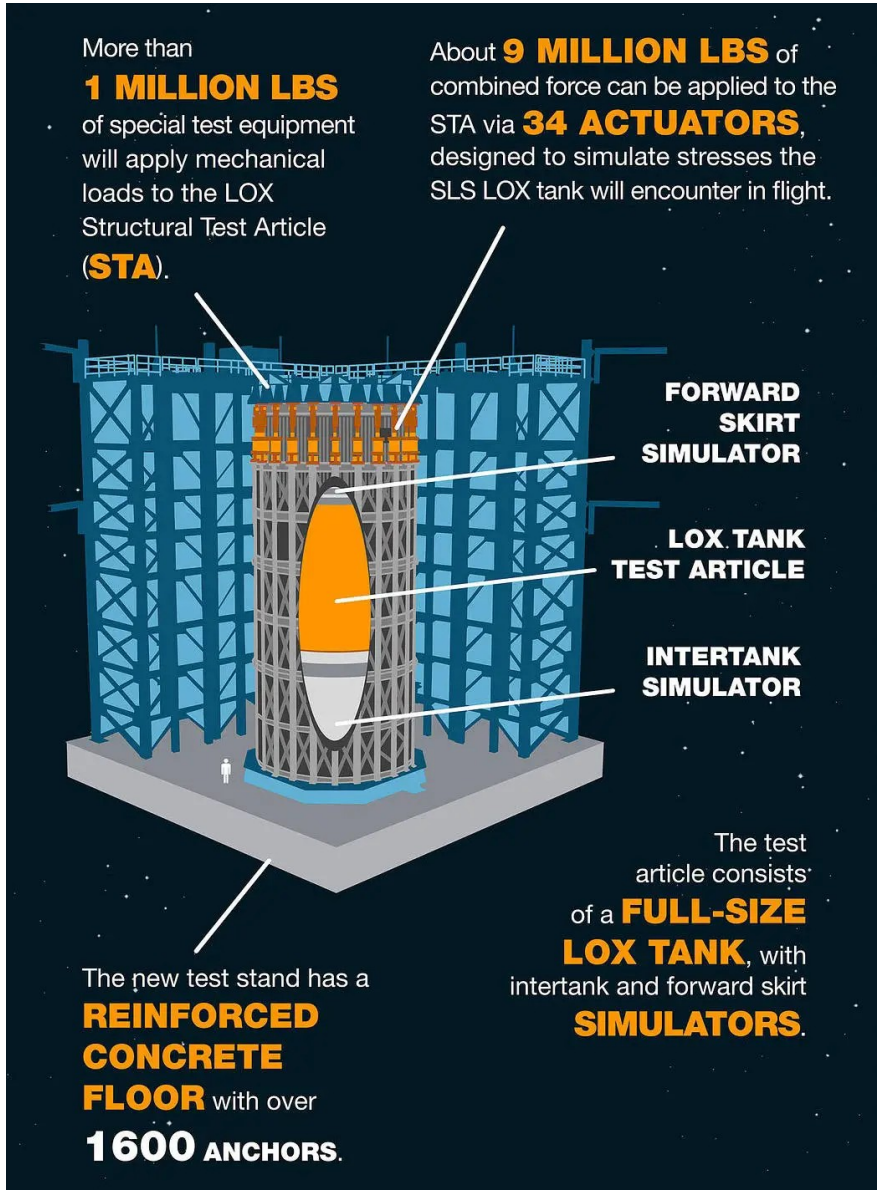


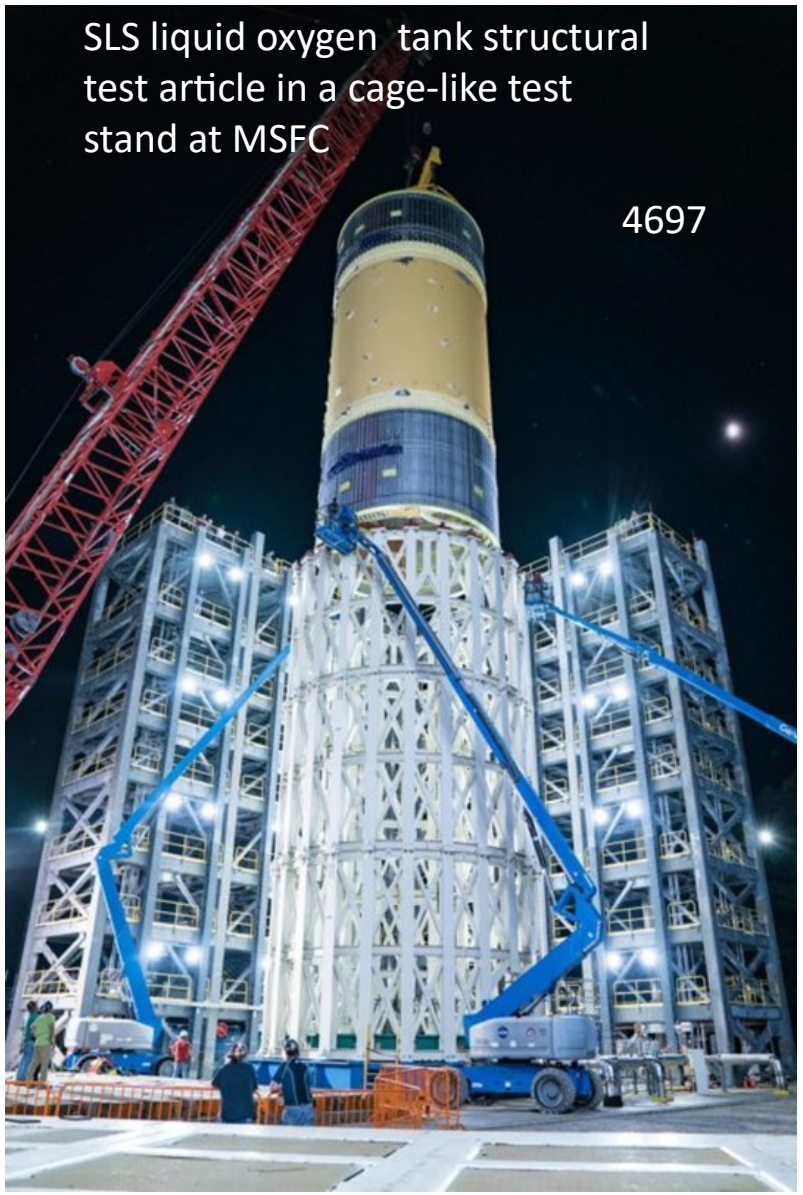
SLS Engine Section Structural Testing MSFC



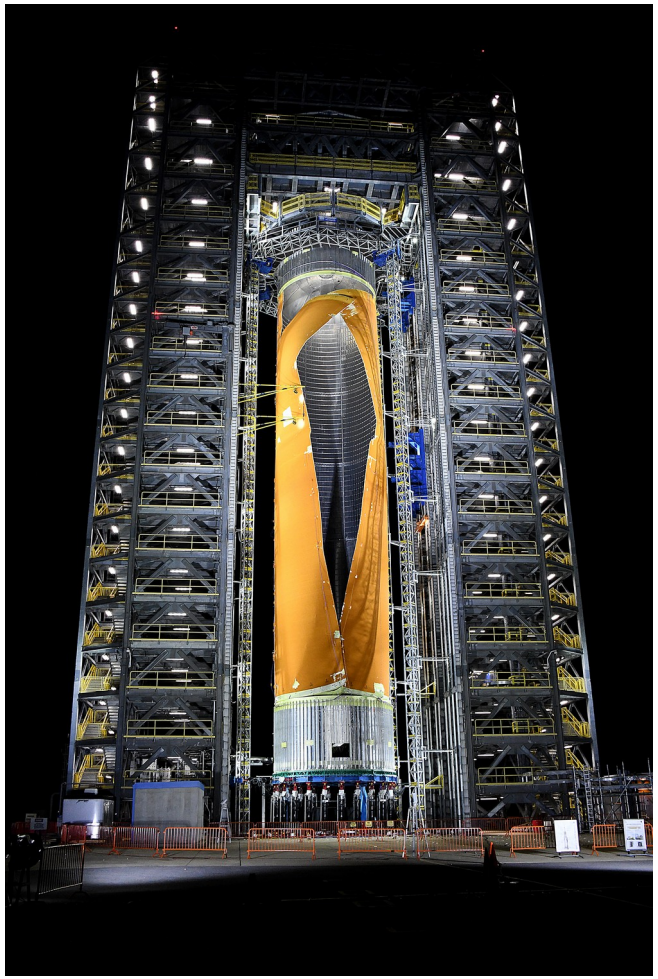


SLS Oxygen Tank Structural Testing MSFC





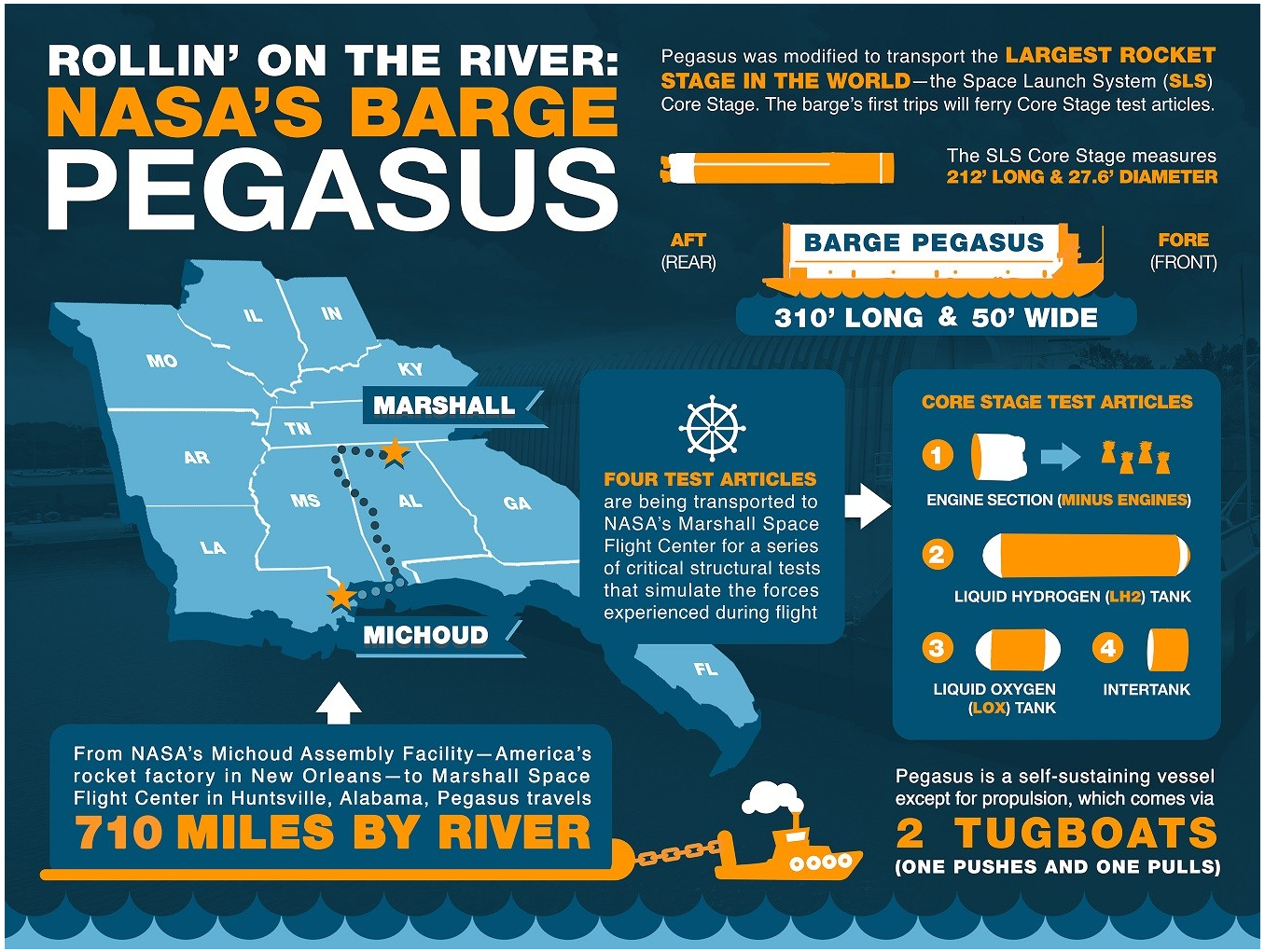
SLS Hydrogen Tank Structural Testing MSFC



The SLS liquid hydrogen tank structural test article in a cage-like test stand at MSFC

https://duckduckgo.com/?q=sls+hydrogen+tank+test&t=ffab&iax=videos&ia=videos&iai=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DoUvjZ9E_L_8

SLS Core Stage Transport

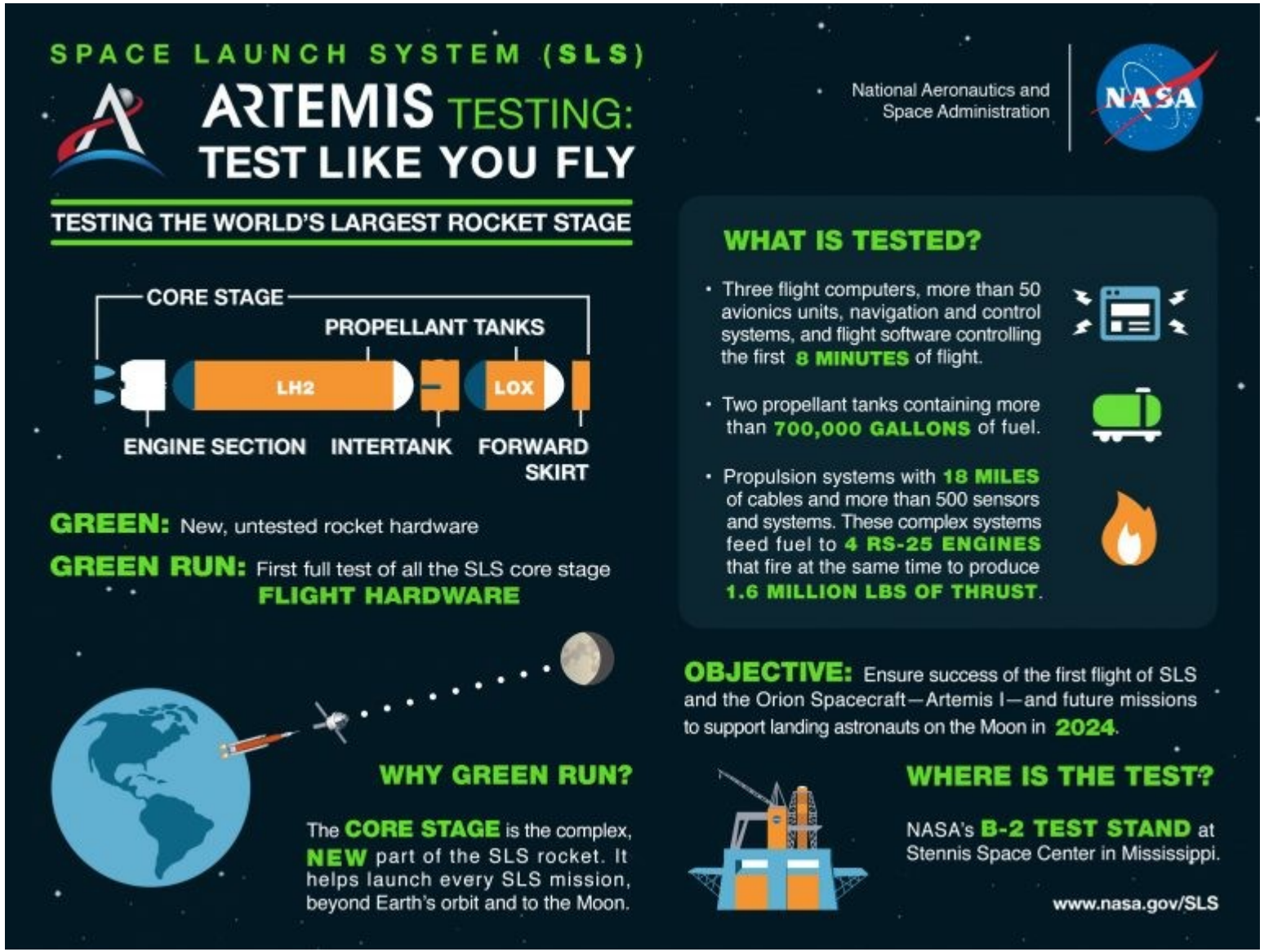


SLS Core Stage Transport Pegasus Barge

Stennis Space Center SLS Core Stage Testing

An aerial photo shows all three NASA Stennis Space Center (SSC) test complexes - the E Test Complex (foreground), the three A Test Complex stands (middle) and the B Test Complex (back).

SLS Core Stage Green Run Test

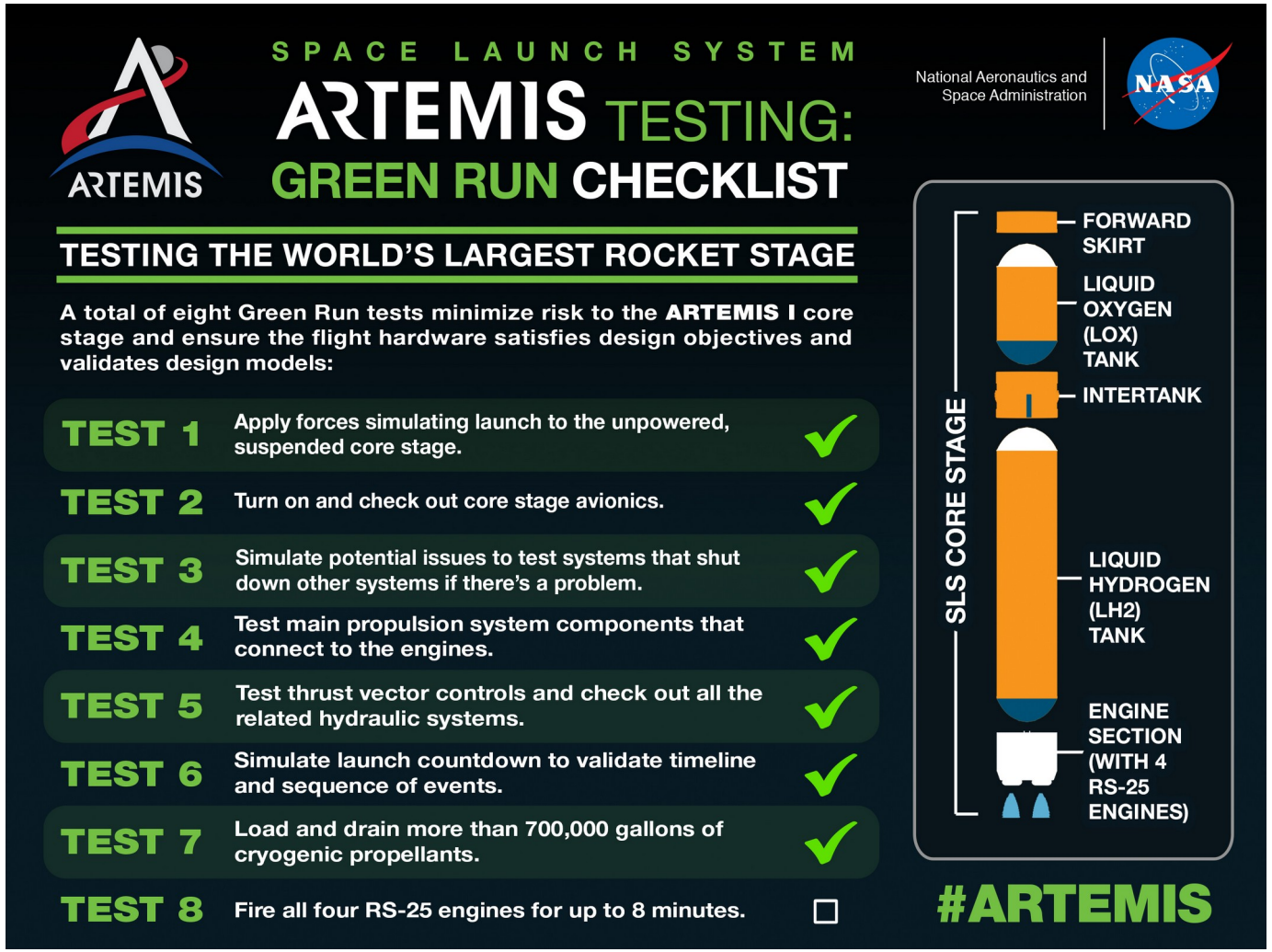


Stennis Space Center B2 Test Stand SLS Green Run Testing

SLS Core Stage is removed from **Pegasus** barge and installed in the B-2 position at the B Test Stand at the Stennis Space Center (SSC) in Mississippi

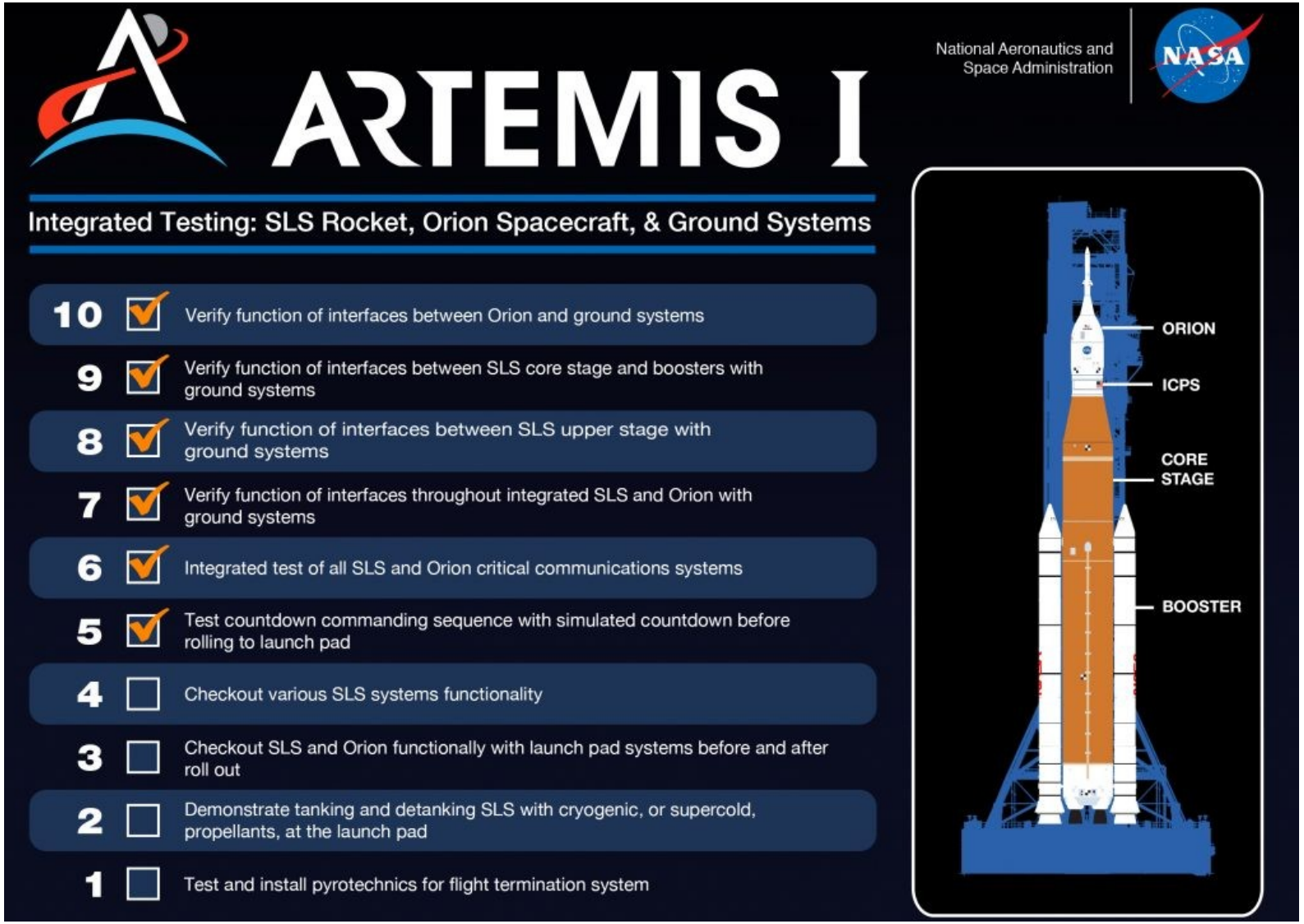
The **Green Run test** for SLS Core Stage

SLS Core Stage Green Run Test



https://youtu.be/-uiayTfW9TQ

SLS, Orion and Ground Systems Test



Space Exploration Company Launch Sites and Facilities

- Cape Canaveral FL- Space Force Station*
- Kennedy Space Center FL – NASA*
- Vandenberg CA- Space Force Base*
- SpaceX Rocket Development and Test Facility, McGregor, Texas
- SpaceX high-altitude test facility - New Mexico
- SpaceX Starbase - TX
- Floating launch platforms

*U.S. Government facility

Next Session

Artemis I Mission