

DEVELOPING VULCAN CENTAUR

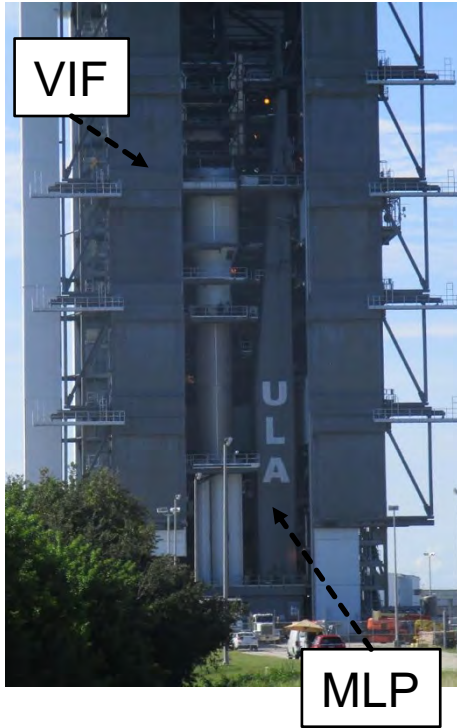


The Strategic Partnerships Powering ULA's Next-Generation
Vulcan Centaur Rocket

04.08.19

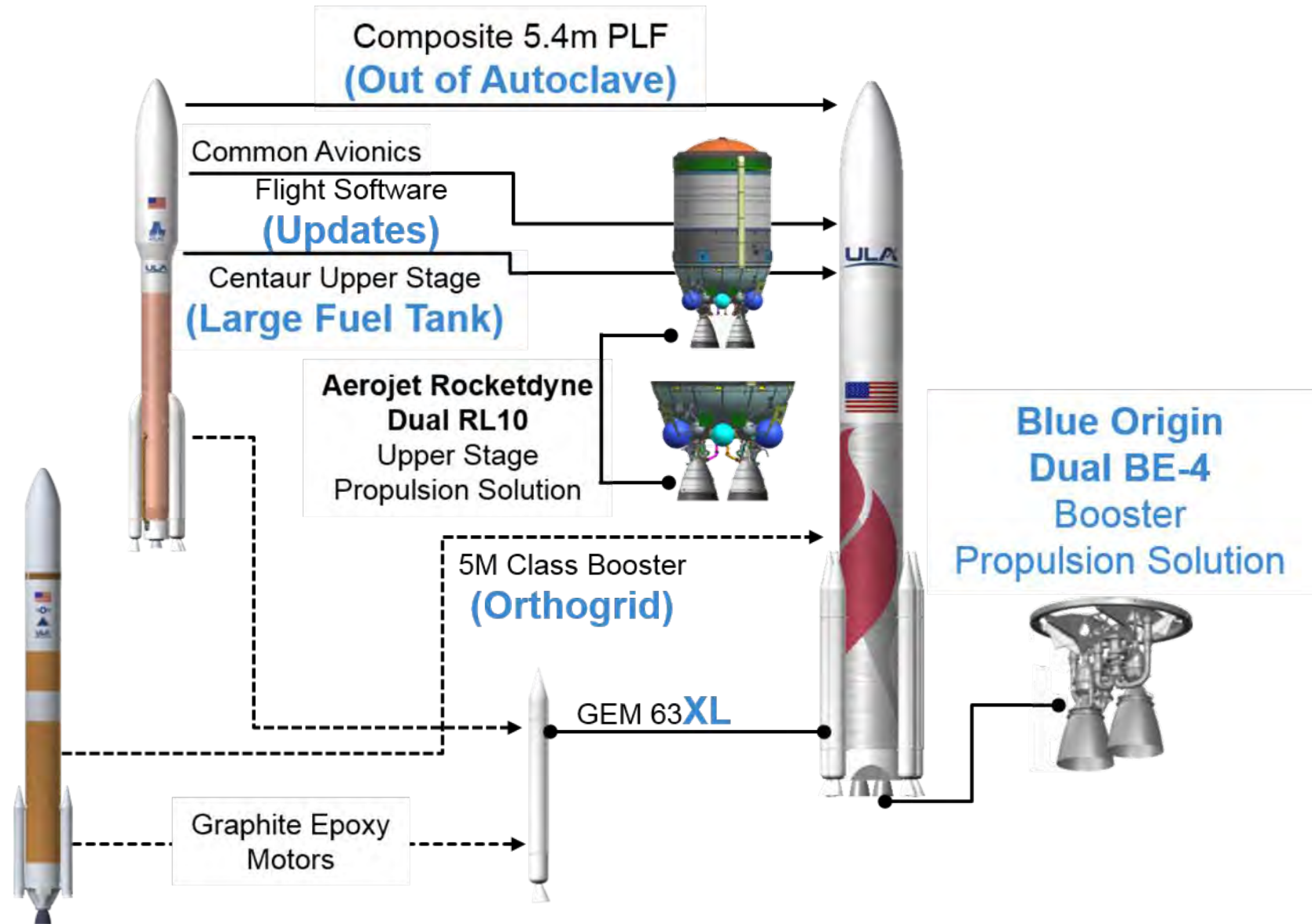


VULCAN CENTAUR EVOLUTION



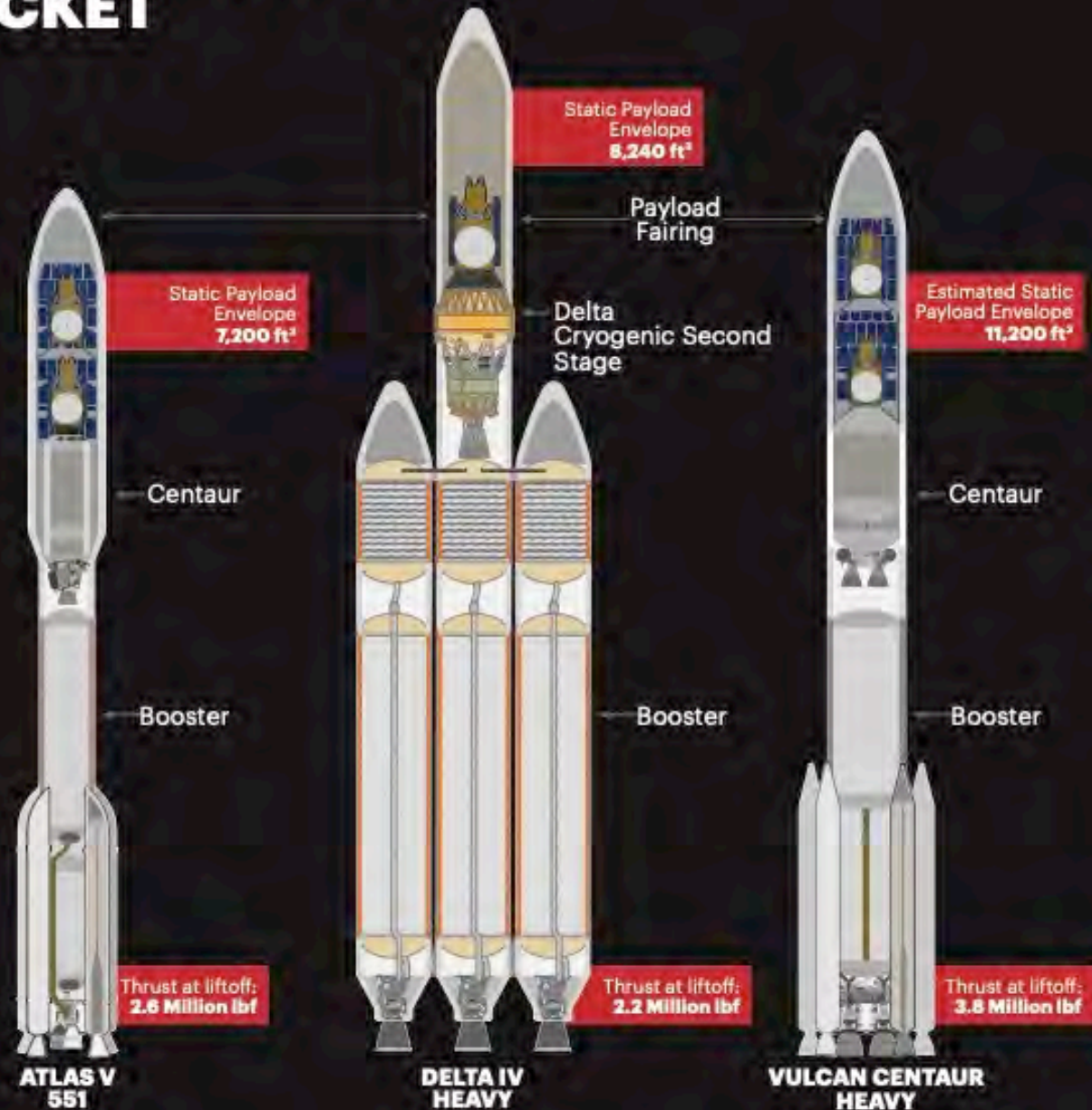
Component That Has/Will Fly Prior To Vulcan First Flight

Vulcan First Flight Component/Process

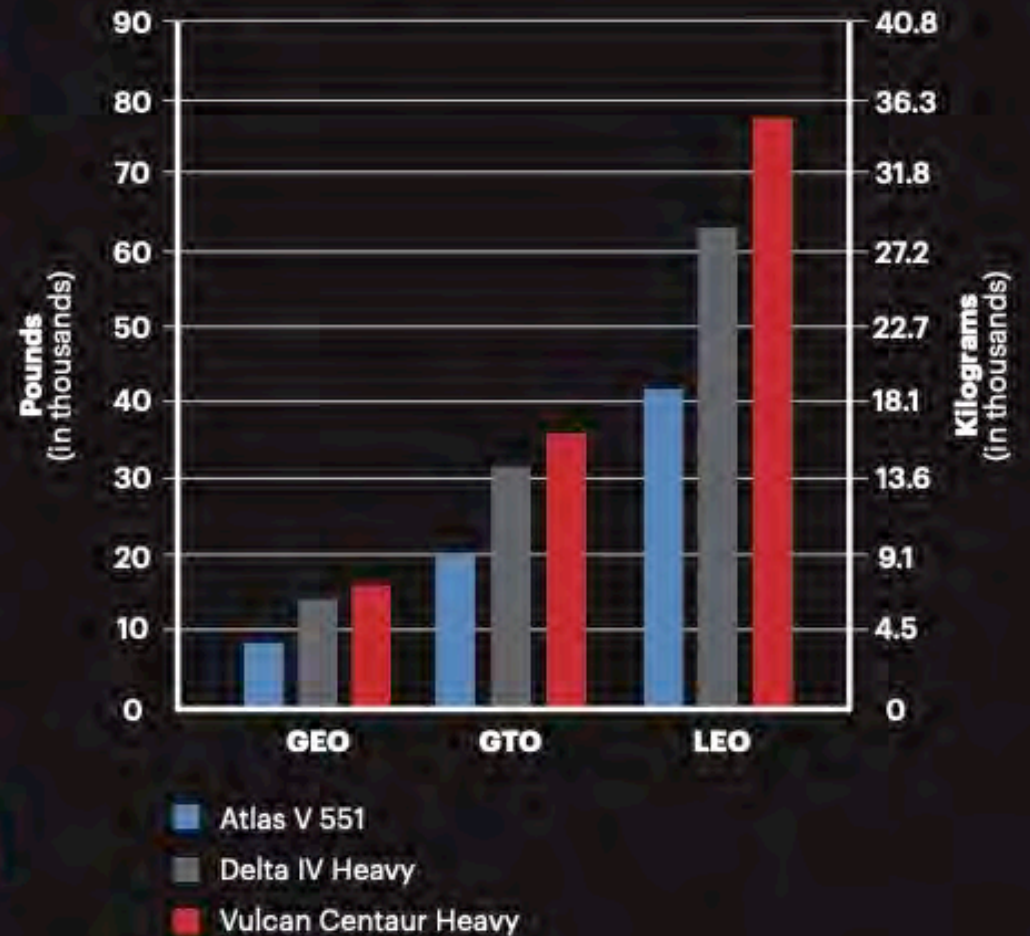


Most Vulcan Centaur Systems To Fly First On Atlas And Delta

VULCAN CENTAUR ROCKET



MASS TO ORBIT



LAUNCH SITE OVERVIEW



Launch Capability From Both Coasts
Supports Full Range of Orbits



SLC-3



SLC-41

SLC-41

**NEW Vulcan Centaur
LNG Storage Area**

**Acoustic Suppression
Water System**

**NEW Centaur LH2
Storage Area**

**NEW Centaur LO2
Storage Area**



**LAUNCH PAD
MODIFICATIONS
UNDERWAY
FIRST VULCAN
CENTAUR FLIGHT
IN 2021**

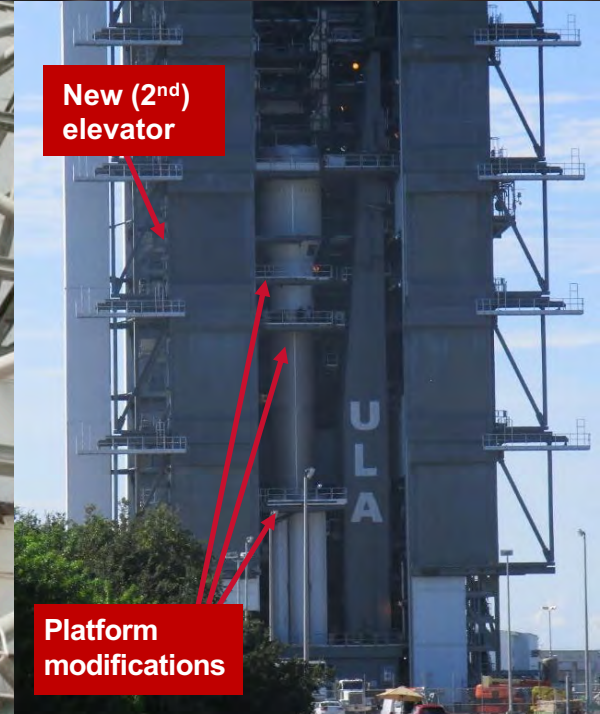
First Multi-Rocket Pad



Off-Site Fabrication of MLP Underway



Vertical Payload Integration

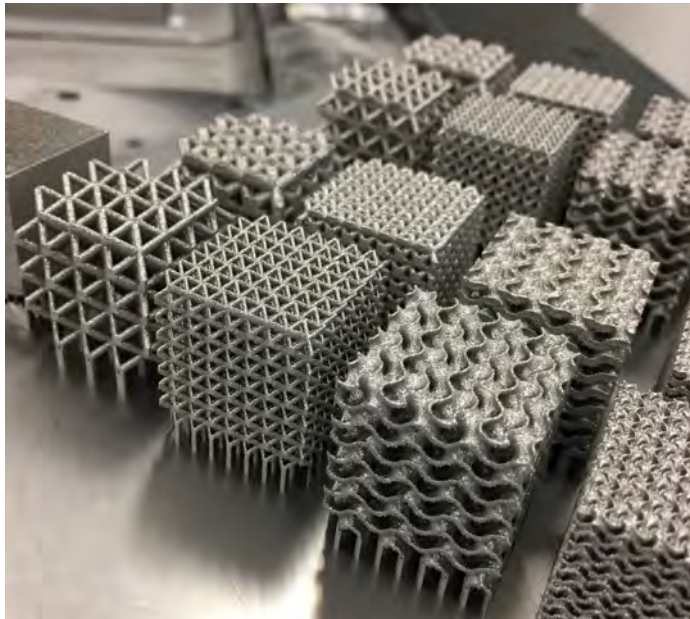


Significant VIF Mods Completed Prior to Last Atlas Launch

**MASSIVE CAPITAL
IMPROVEMENTS
COMPLETE
UP TO 20
VULCAN CENTAUR
PER YEAR**



Universal Weld System (UWS)



Additive Manufacturing (AM)



Circumferential Friction Stir Welding (CFSW)

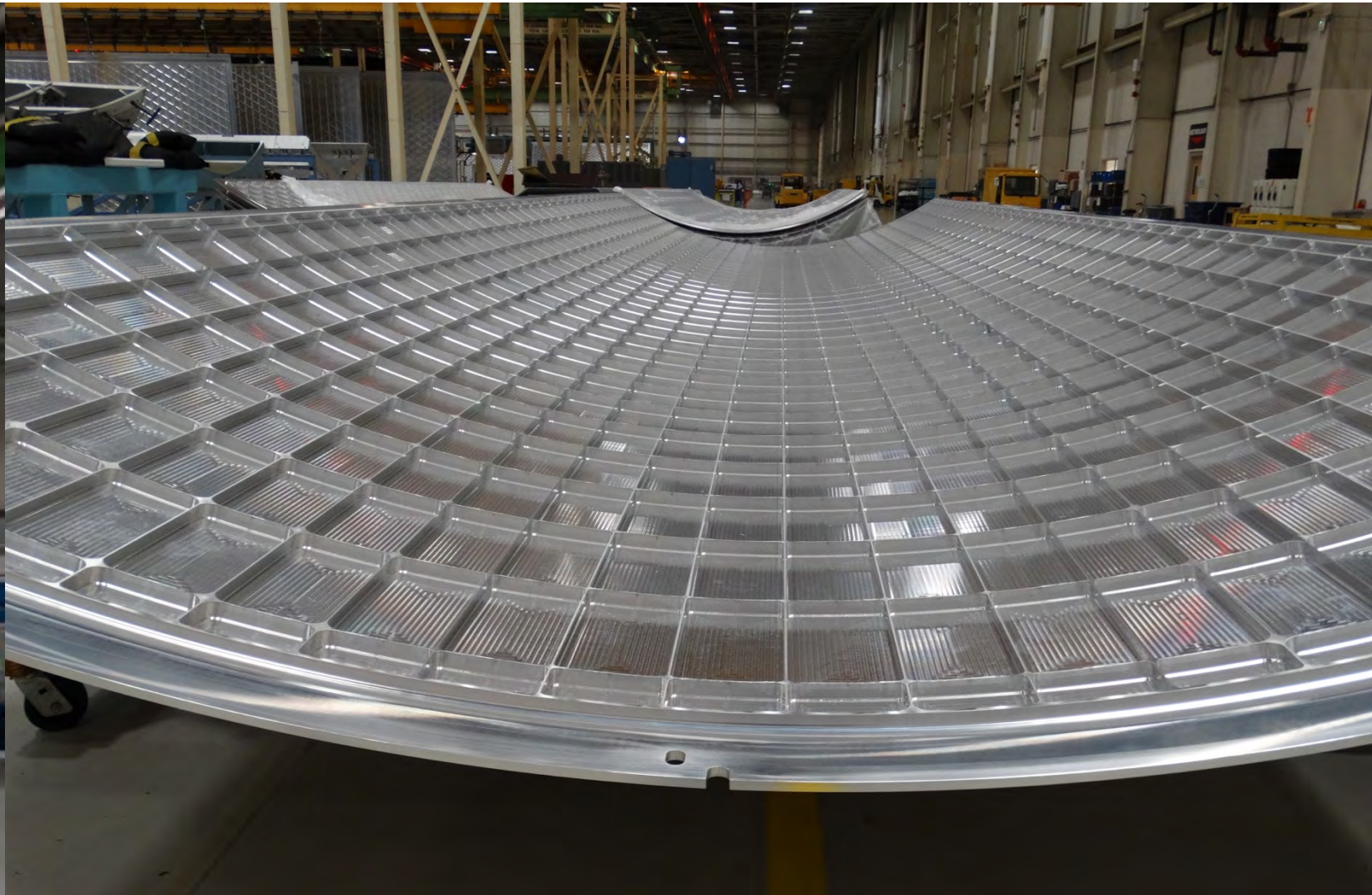
DESIGNING FOR PRODUCIBILITY AND AUTOMATING PROCESSES



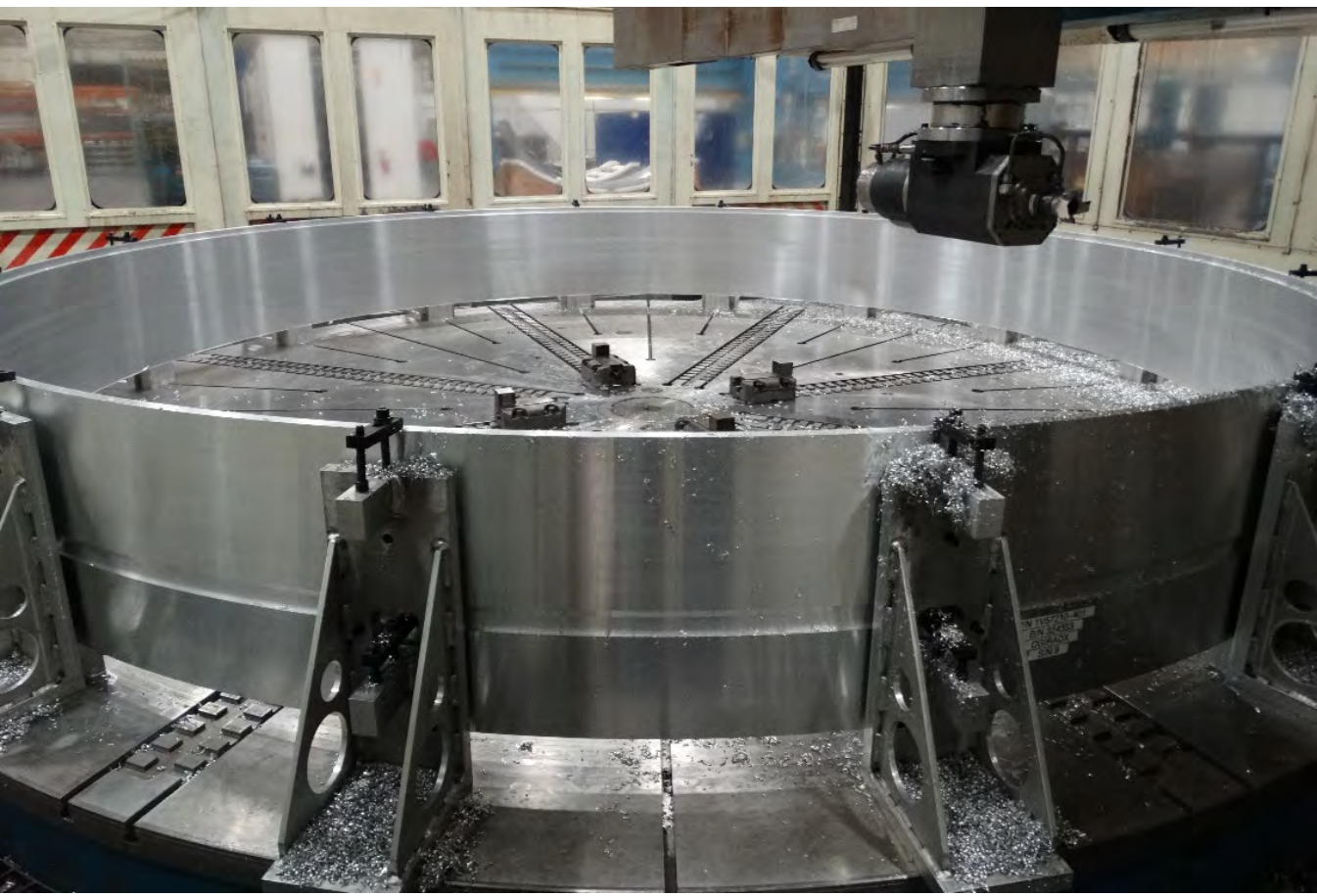
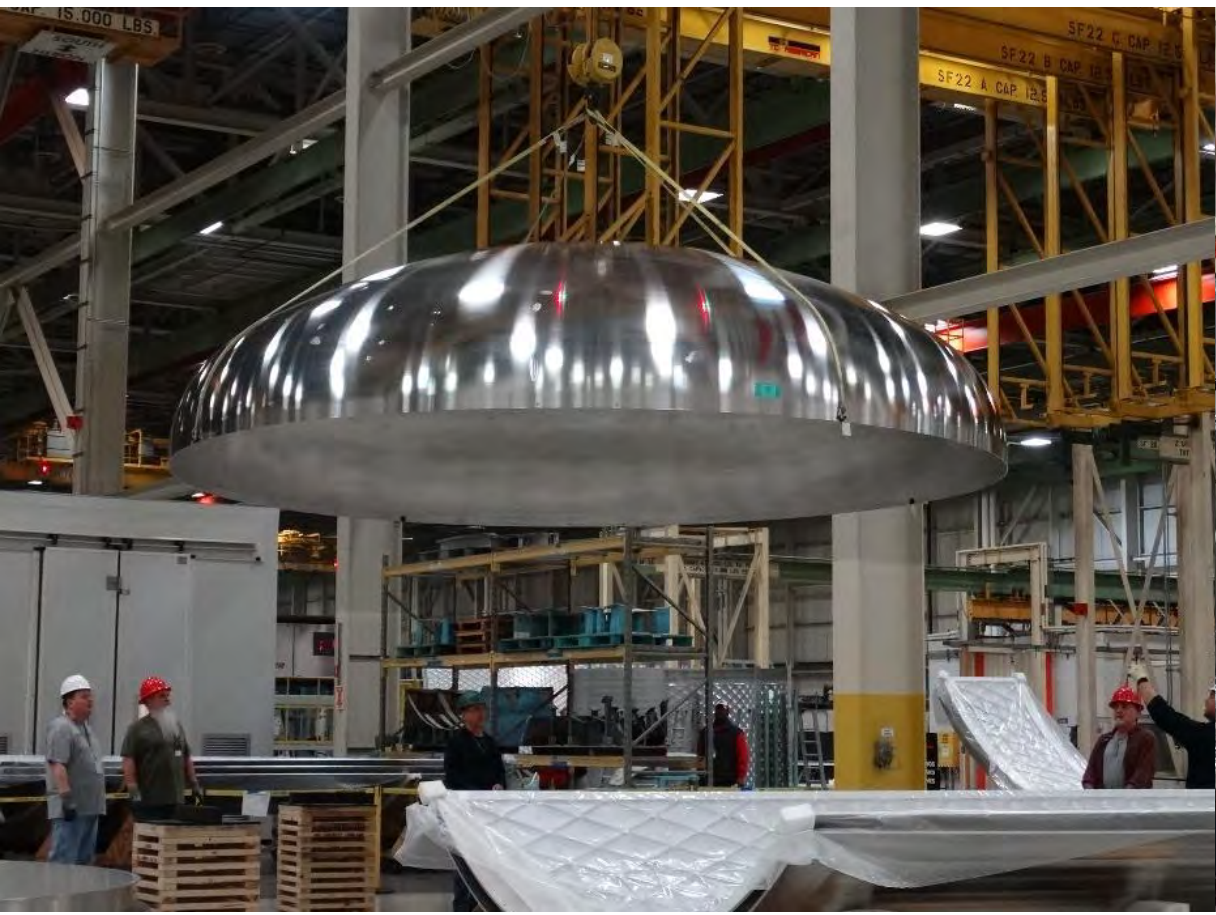
Vulcan Thrust Structure – Truss Assembly

Automated C-Gun for Welding on Centaur V

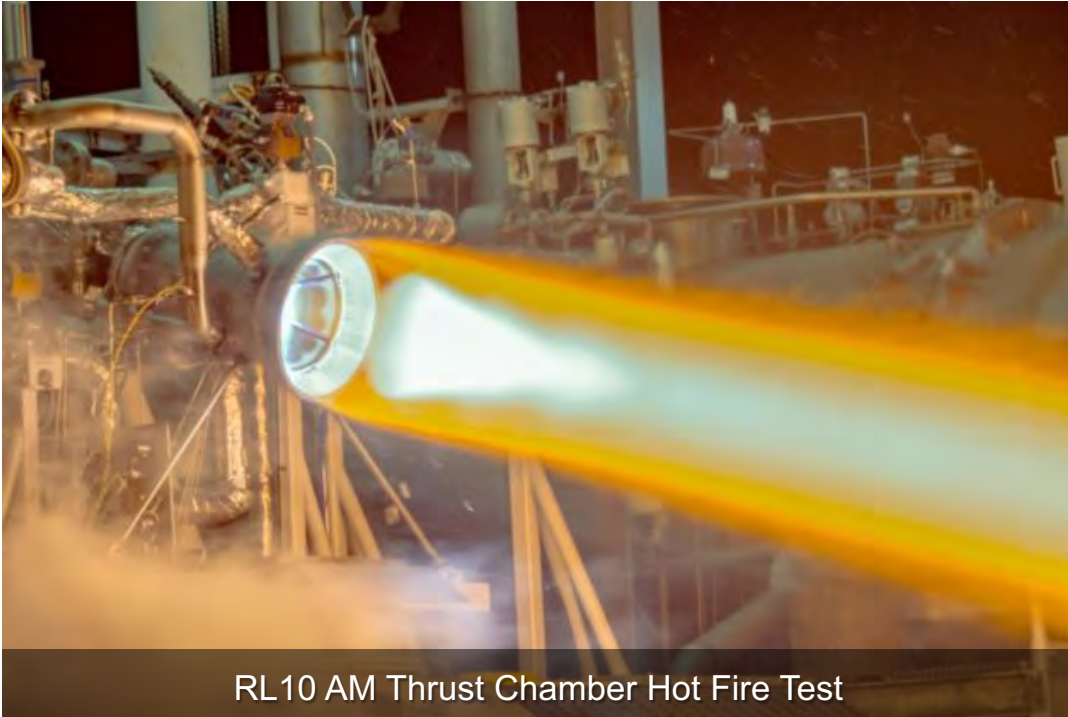
QUALIFICATION AND FIRST FLIGHT ARTICLE FABRICATION UNDERWAY



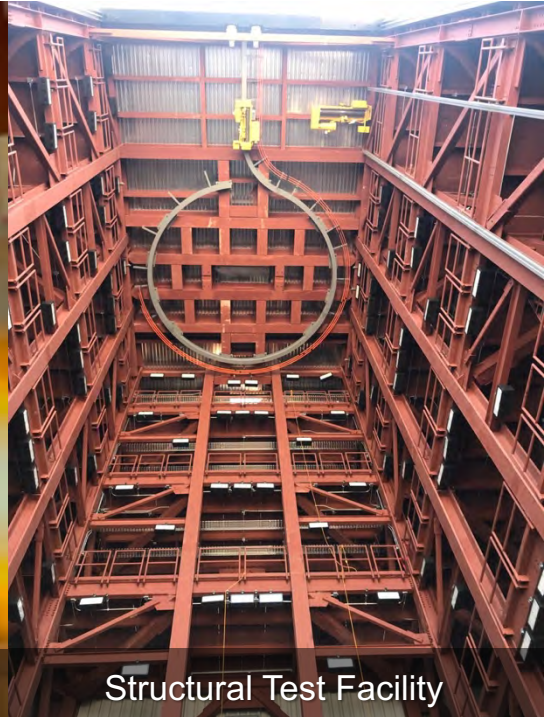
QUALIFICATION AND FIRST FLIGHT ARTICLE FABRICATION UNDERWAY



STRATEGIC PARTNERS



RL10 AM Thrust Chamber Hot Fire Test



Structural Test Facility



Composite Payload Fairing



BE-4 Hot Fire Test



GEM 63 Static Test Fire

L3

Mark Dapore
VP & General Manager, Space Avionics





OUR PARTNERSHIP WITH UNITED LAUNCH ALLIANCE IS STRONG

We have a **tested and mature Long Term Alliance Agreement**

- ✓ Serves as a **value additive roadmap** we continually build on
- ✓ Elevates both companies as we **build our integration and eliminate waste**
- ✓ As a bigger supplier, **takes advantage of economies of scale**
- ✓ ULA, L3 and our customers have **already benefited from the resulting savings**



Technologies

L3 is investing in two significant ways:

1. **Bringing new technology forward** for Vulcan to meet future launch needs, &
2. **Reducing costs** to make Vulcan Centaur more cost competitive



PURPOSE-BUILT PRODUCTS



- Our next-generation Flight Computer will fly all **advanced missions**, and serve the customer's needs for **reference missions**

- L3 is finishing **qualification for the entire suite of avionics**
- L3 and ULA are jointly exploring **future requirements and capability** under the agreement
- L3's breadth of sensors and systems will facilitate building rapid **bolt-on capability** to operate in contested environments





PURPOSE-BUILT PROCESSES

Our agreement integrates an **Avionics Ingenuity Engine**, which:

Builds a **joint-company innovation** process, and

Incorporates an **upgrade cycle** so the avionics suite always supports new vehicle capabilities



We are **vertically integrating** our processes:

- This approach **optimizes the supply chain** to get the scale needed for cost reductions, and
- **Tethers our demand systems** together to turn delivered avionics bundles when they are needed

RUAG SPACE

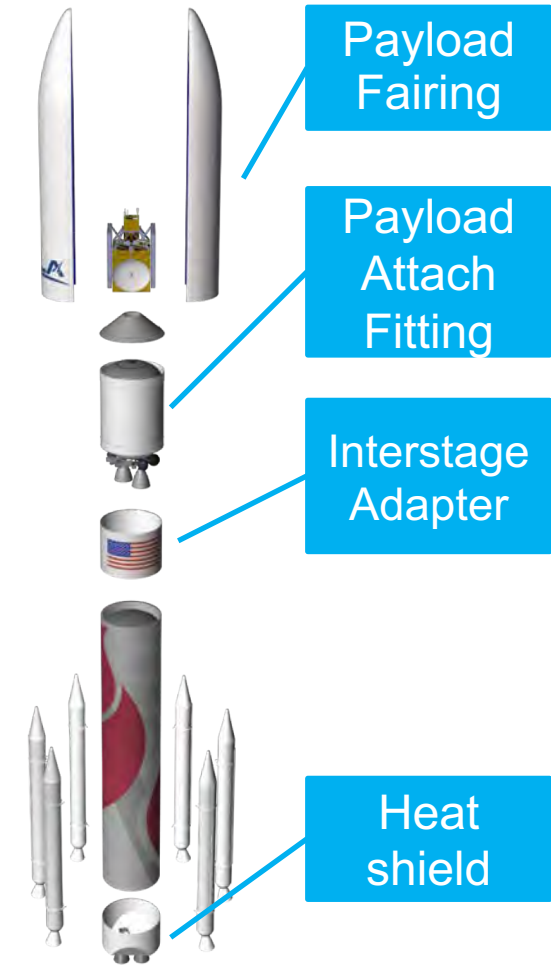
Peter Guggenbach
CEO





UPDATE ON DECATUR FACILITY

- RUAG to deliver key products for Vulcan
- Facility ramp-up in ULA's rocket factory in Decatur:
 - Planned, constructed and operational in 24 months
 - Maximum proximity to ULA
 - Twin factory in Switzerland, transfer of skills (11,000 hours training in CH; 19,000 hours of On-the-Job Training)
 - Capability to support 10 flights per year
- First demonstrators (fairings, interstage adapters) manufactured
- First actual flight hardware (for Atlas-V) scheduled for delivery Nov 2019
- All Vulcan qualification test hardware to be completed by end of year



Everything is on schedule to support first Vulcan flight

DYNETICS

David King
CEO





Systems Integration Lab Huntsville, AL



 **Dynetics**

1974 - 2019
45
YEARS
OF EXPERIENCE




Dynetics

Hardware Integration Facility at the Aerospace Structures Complex

Dynetics

1974 - 2019
45
YEARS
OF EXCELLENCE



Test Stand 1 at the Aerospace Structures Complex

 **Dynetics**

1974 - 2019
45
YEARS
OF EXCELLENCE

NORTHROP GRUMMAN

Charlie Precourt
Vice President, Propulsion Systems



VULCAN CENTAUR AND THE GEM 63XL

NORTHROP GRUMMAN

The Vulcan Centaur will use GEM 63XL strap-on boosters.

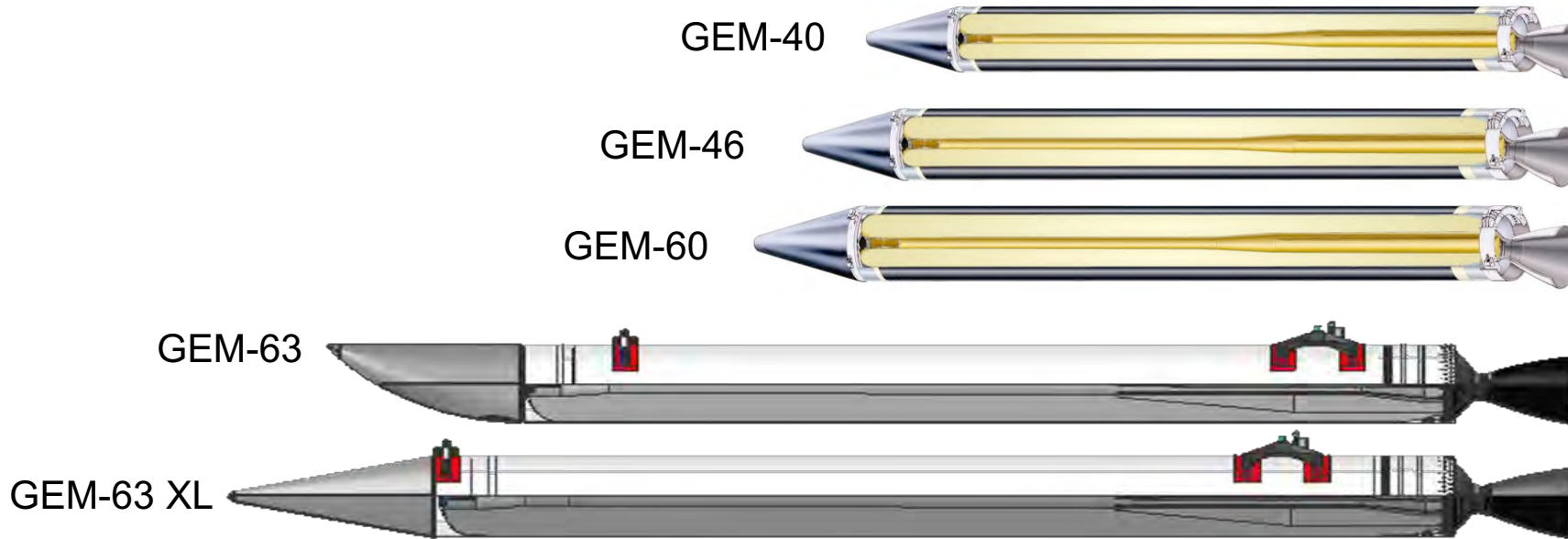


GEM 63XL



GEM FAMILY OF ROCKET MOTORS

NORTHROP GRUMMAN



GEM Family of Rocket Motors						
Motor	Diameter	Length	Propellant	Max Thrust	Burn Time	Total Made
GEM-40	40 Inch	449 in	25,940 lbs	144,700 lbf	63 sec	1030
GEM-46	46 Inch	495 in	37,180 lbs	198,800 lbf	77 sec	127
GEM-60	60 Inch	635 in	65,471 lbs	277,800 lbf	91 sec	86
GEM-63	63 Inch	792 in	97,500 lbs	373,800 lbft	94 sec	Dev
GEM-63XL	63 Inch	865 in	105,800 lbs	455,400 lbft	84 sec	Dev

GEM LAUNCH FAMILY BUILT ON HERITAGE

NORTHROP GRUMMAN

Delta II



GEM-40

Delta II - H



GEM-46

Delta III



Delta IV



GEM-60

Atlas V



GEM-63

Vulcan Centaur



GEM-63XL

VULCAN CENTAUR AND THE GEM 63XL



GEM 63 QM-1
static test, 2018.

The GEM 63XL static test is planned for February 2020 and will fly on the Vulcan in 2021.



GEM 63 QM-1
static test, 2018.



BLUE ORIGIN



Bob Smith
CEO





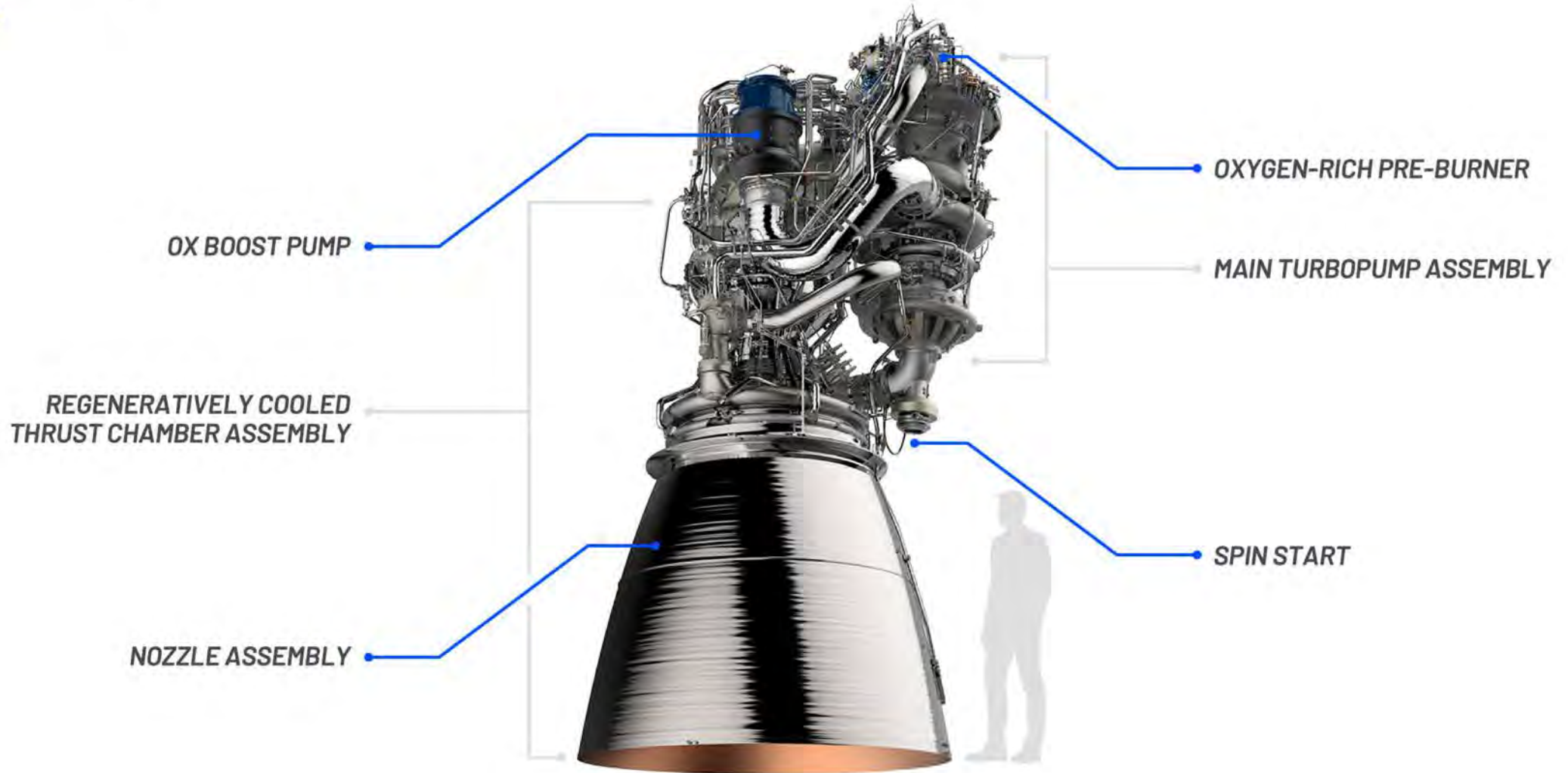


BLUE ORIGIN

HUNTSVILLE AL

HUNTSVILLE ENGINE FACILITY GROUNDBREAKING

BE-4

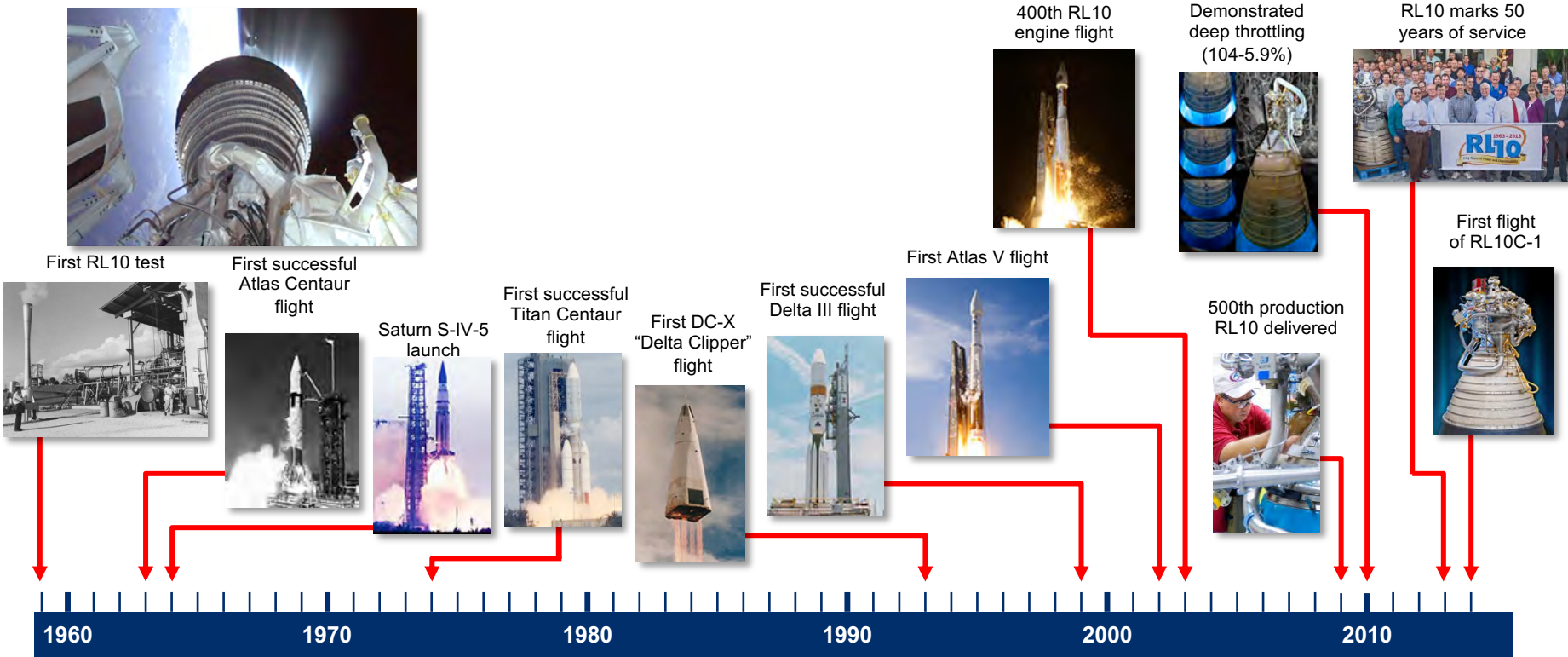


AEROJET ROCKETDYNE

Scott Ward
Vice President, Engineering



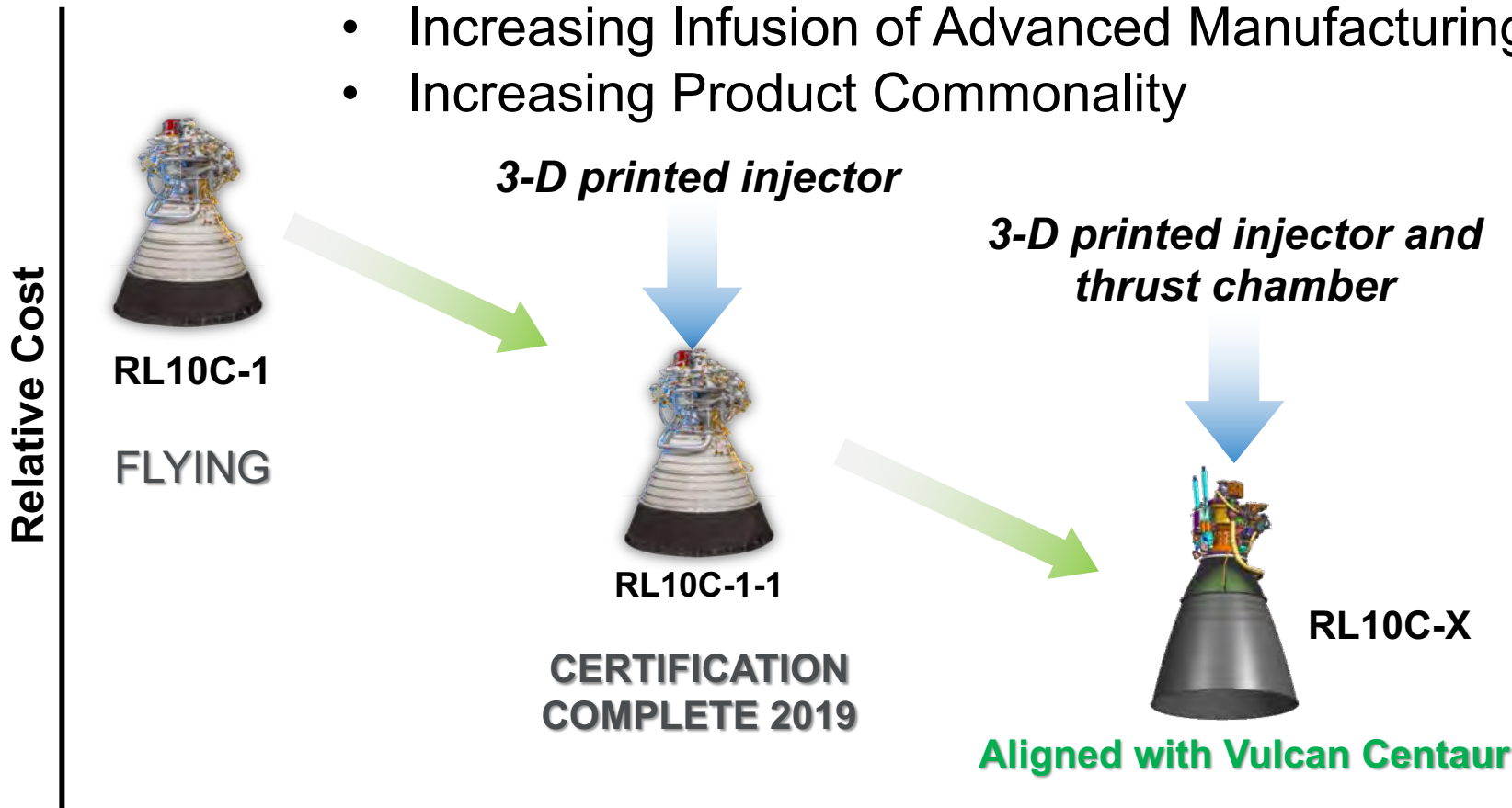
55+ YEARS OF RELIABLE PERFORMANCE



- First RL10 flight in 1963
- Propelled spacecraft to explore every planet in our solar system and Voyager 1, the first human-made object to reach interstellar space
- Engine has continuously evolved over the decades to incorporate enhancements such as an extendable carbon-carbon nozzle, upgraded avionics, active mixture ratio control and a dual direct spark ignition system

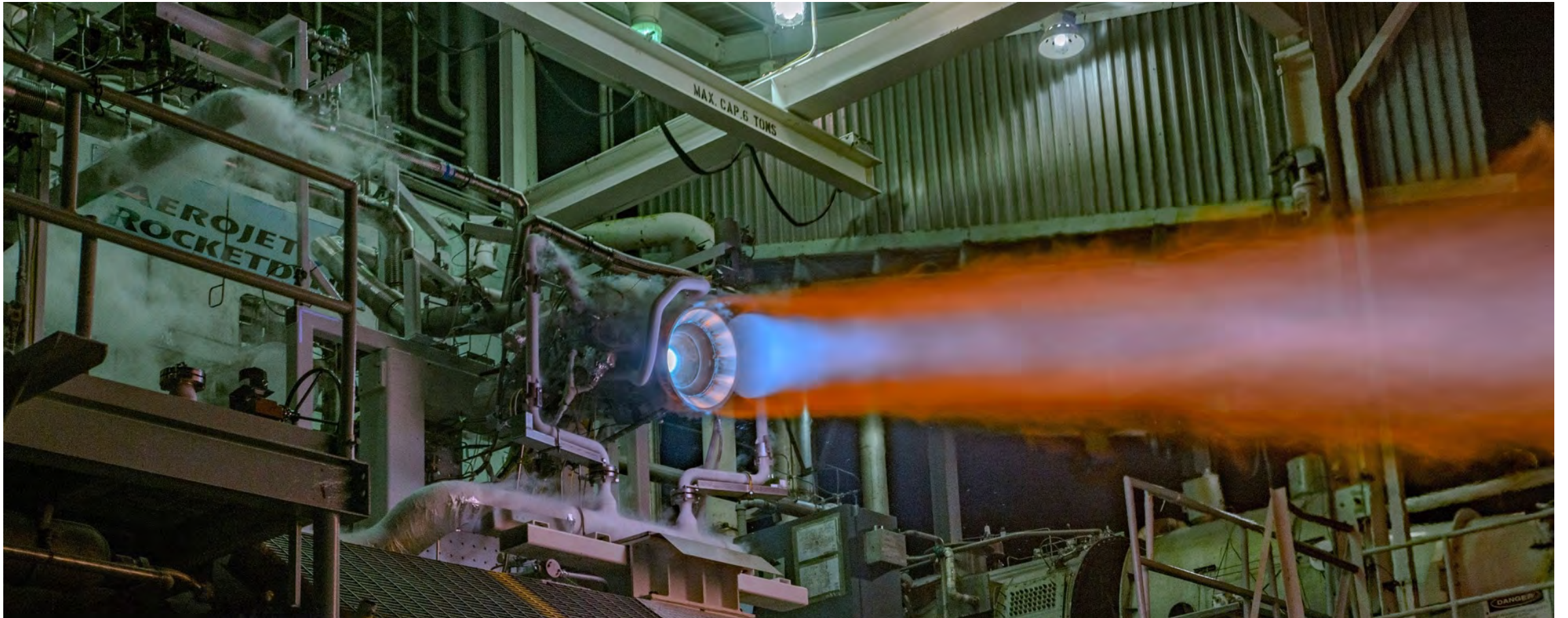
RL10 EVOLUTION

- Increasing Infusion of Advanced Manufacturing
- Increasing Product Commonality



Evolution Delivers Cost Savings While Maintaining Reliability

RECENT RL10C-X PROTOTYPE TESTING



**Testing Duration More Than 3x That Of A
Typical RL10 Mission With Multiple Restarts**

PROUD MEMBER OF VULCAN CENTAUR TEAM



**DEVELOPING A
NEXT GENERATION
ROCKET
VULCAN CENTAUR**

