

HUMAN SPACE EXPLORATION

DMGT 750: COLLABORATIVE CULTURE IN DESIGN ORGANISATIONS
SPRING 2021 | PROF. TOM HARDY

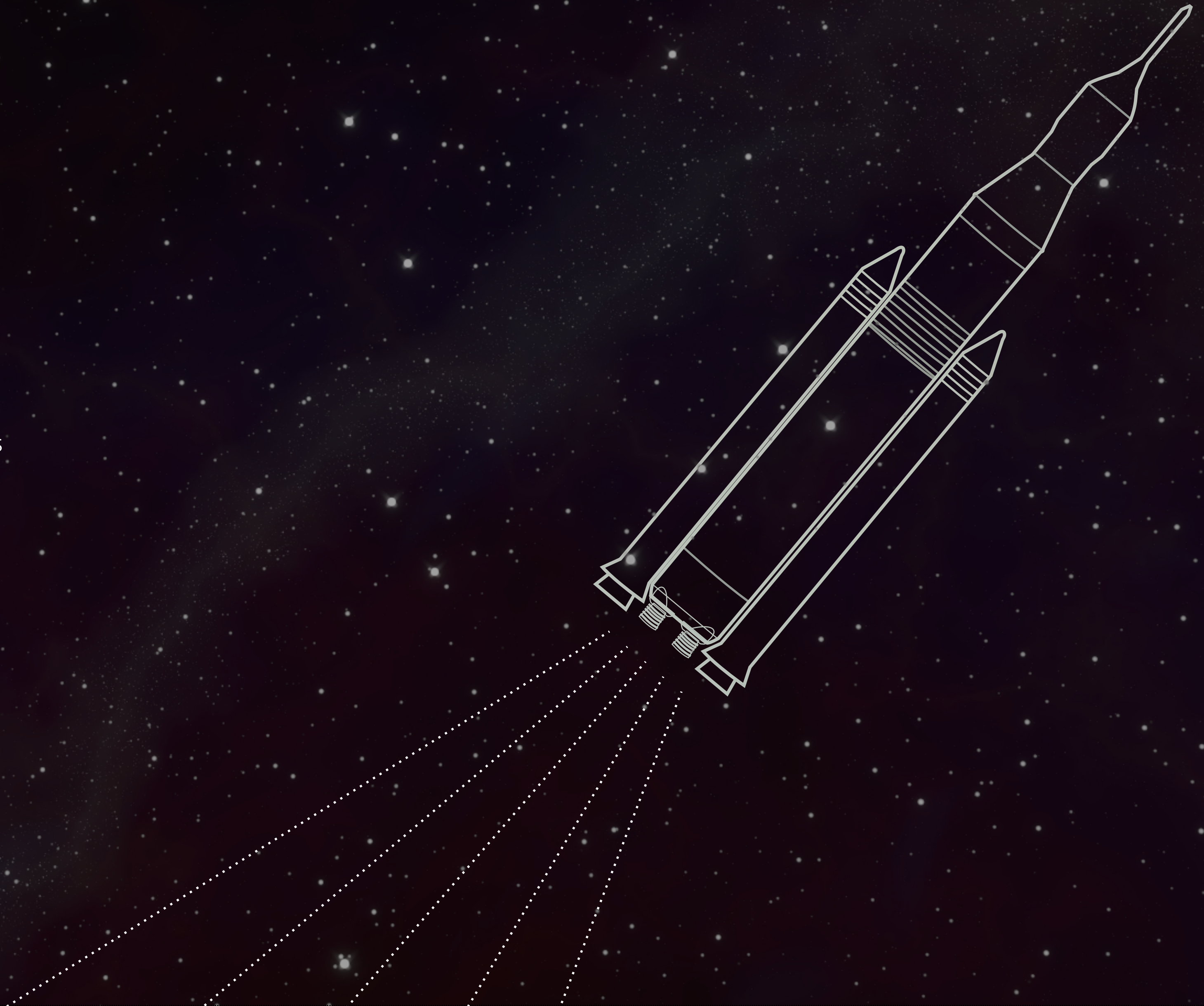
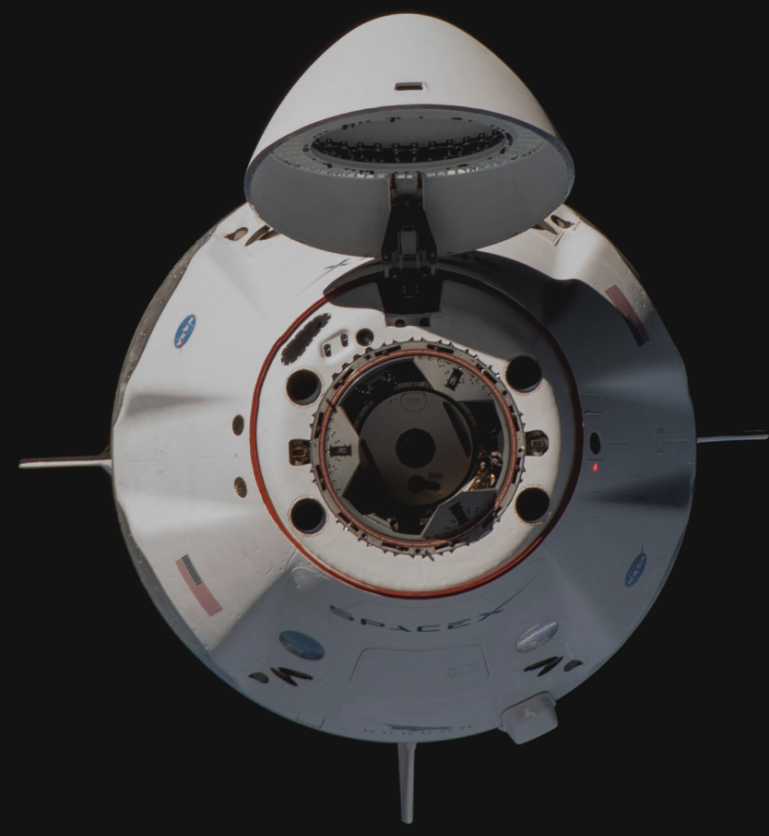


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THE TEAM



Ashley Montalvo
M.F.A. Service Design



Ayusha Mehrotra
M.F.A. Design Management



Eika Weber
M.A. Industrial Design



Hayoung Ra
M.F.A. Design Management



Kyushik Nam
M.F.A. Design Management



Lingyu Xie
M.F.A. Industrial Design



Shibo Li
M.F.A. Interactive Design

PROJECT OVERVIEW

For this design project, our team was tasked with researching and understanding the complex collaborative culture within NASA through the lens of NASA's Space Launch System (SLS).

Our overarching goal was to apply our research learnings to the field of Design Management by designing a visual model that explains the value of collaboration.

Our research learnings were developed by gaining insights on SLS's complex collaborative culture that utilizes extreme metrics and collaborates with 1,000 external partners, and by assessing the partnerships between NASA and its Human Landing System (HLS) program partners - SpaceX, Blue Origin, and Dynetics.

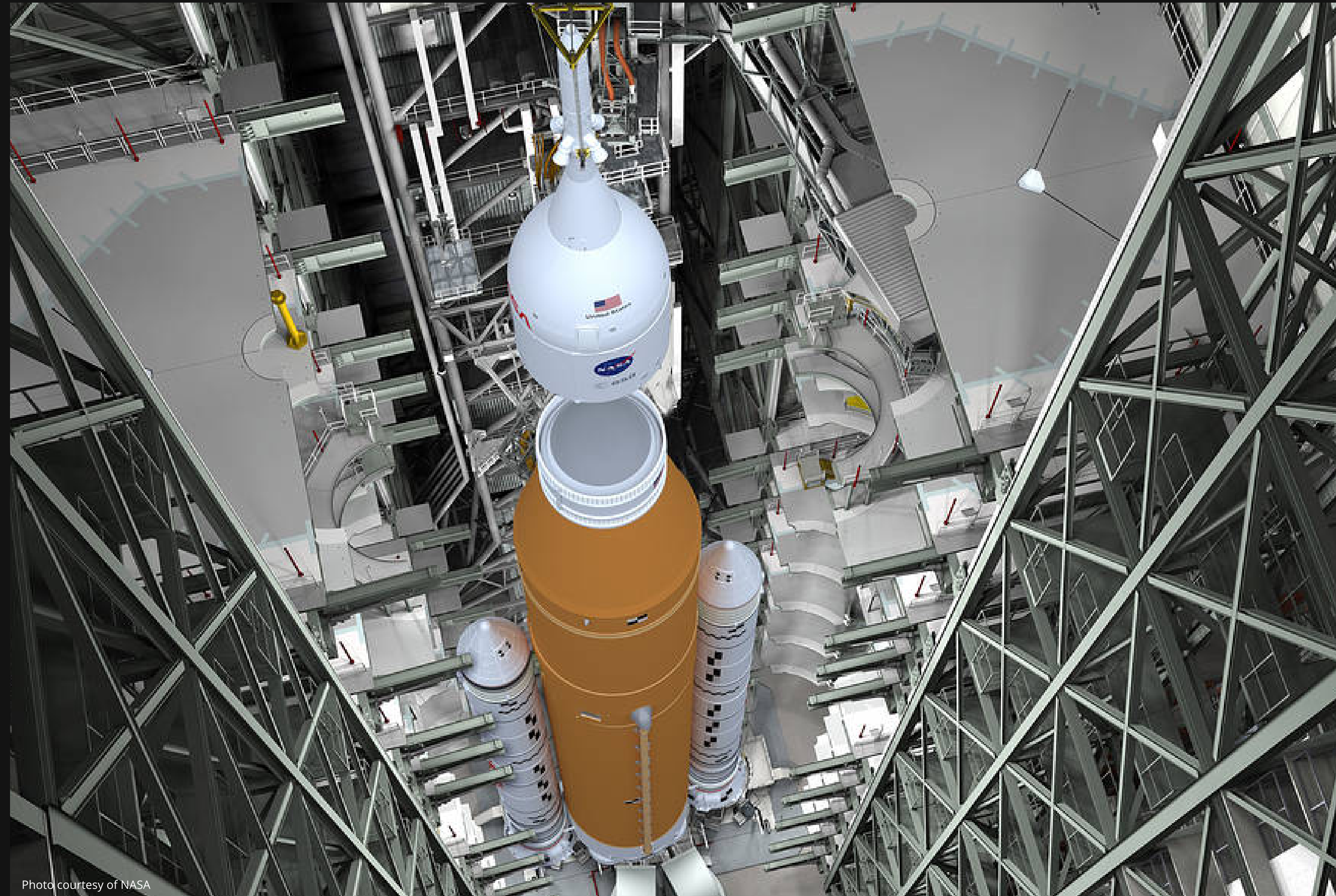
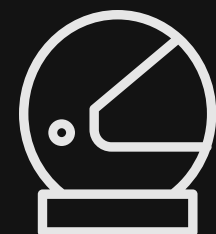


Photo courtesy of NASA

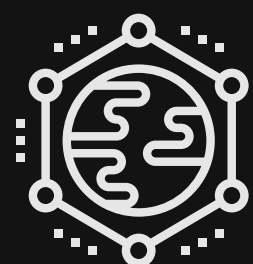
PROJECT GOALS



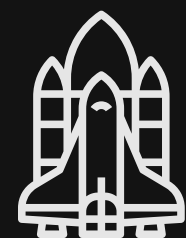
Research the collaborative culture of NASA to gain insights to enable a more effective experience in the art of design collaboration to ensure process success.



Study rigorous multi-disciplinary and multi-location collaboration process with extensive metrics.



Deconstruct collaboration processes within NASA and its partners: SpaceX, Blue Origin, and Dynectics.



Assess the NASA partnership with SpaceX and contrast collaborative cultures.



Identitfy areas where collaboration can be improved.



Brainstorm how collaboration can be implemented in the field of design and other industries.



Develop a modular collaboration framework/tool that is transferable into other industries.

RESEARCH PARTNER



The National Aeronautics and Space Administration (NASA) is America's civil space program and the global leader in space exploration.

VISION

"We reach for new heights and reveal the unknown for the benefit of humankind."

MISSION

Drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality and stewardship of Earth.

CORE VALUES

Safety Excellence
Integrity Inclusion
Teamwork

RESEARCH OVERVIEW

To gain a better understanding of the complex collaborative culture, we needed to familiarize ourselves with NASA's Space Launch System.

In order to facilitate this, we defined four main topics to guide our initial divergent research:



The value and goals of the Space Launch System program



The current status of the Artemis Program and the Space Launch System program



The main external partners of the Space Launch System program



A high-level overview of the partnership between NASA and SpaceX, Blue Origin, and Dynetics.

RESEARCH

SPACE LAUNCH SYSEM (SLS)

NASA's Space Launch System, or SLS, is a super-heavy-lift launch vehicle that provides the foundation for human exploration beyond Earth's orbit. With its unprecedented power and capabilities, SLS is the only rocket that can send Orion, astronauts, and cargo to the Moon on a single mission.

Designed to enable human exploration of deep space transformative capability for range of missions Primary purpose to enable human journey to Mars Paradigm-shifting capabilities for planners

SLS is America's rocket with more than 1,000 companies from across the US and at every NASA center supporting the development of the world's most powerful rocket.

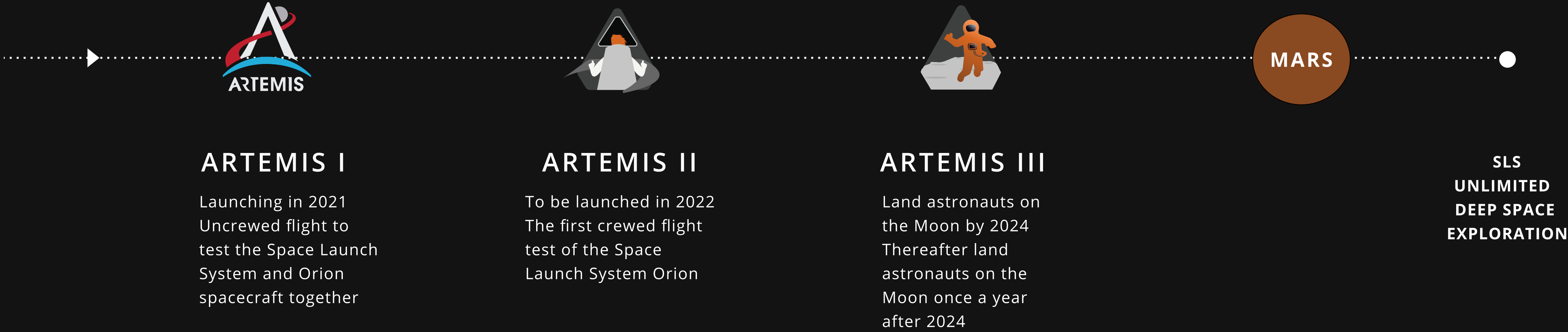
SLS program is managed at NASA's Marshall Space Flight Center in Huntsville, Alabama. It works closely with Orion Program (NASA's Johnson Space Center), Exploration Ground Systems (Kennedy Space Center), and Human Landing System (Blue Origin, Dynetics, and SpaceX).



Photo courtesy of NASA

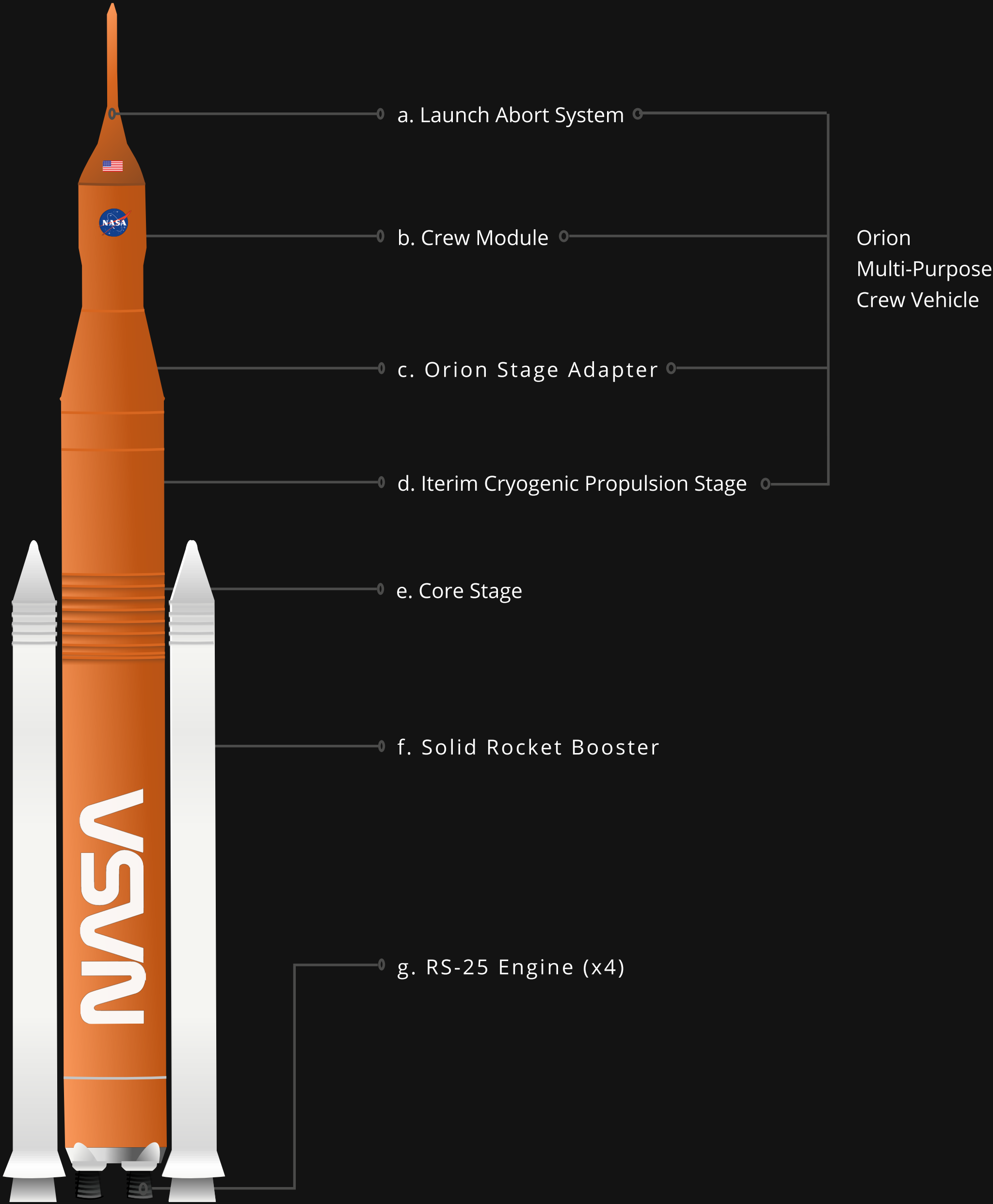
RESEARCH

ARTEMIS PROGRAM

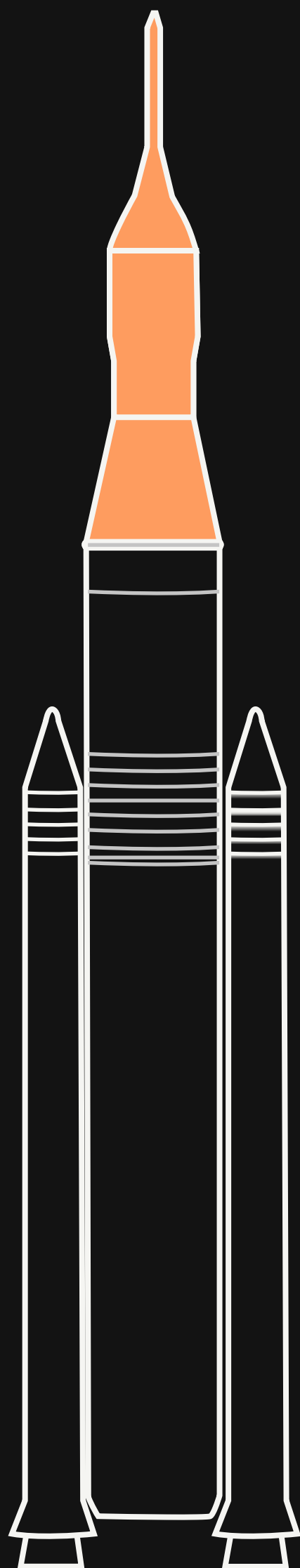


SLS BLOCK 1

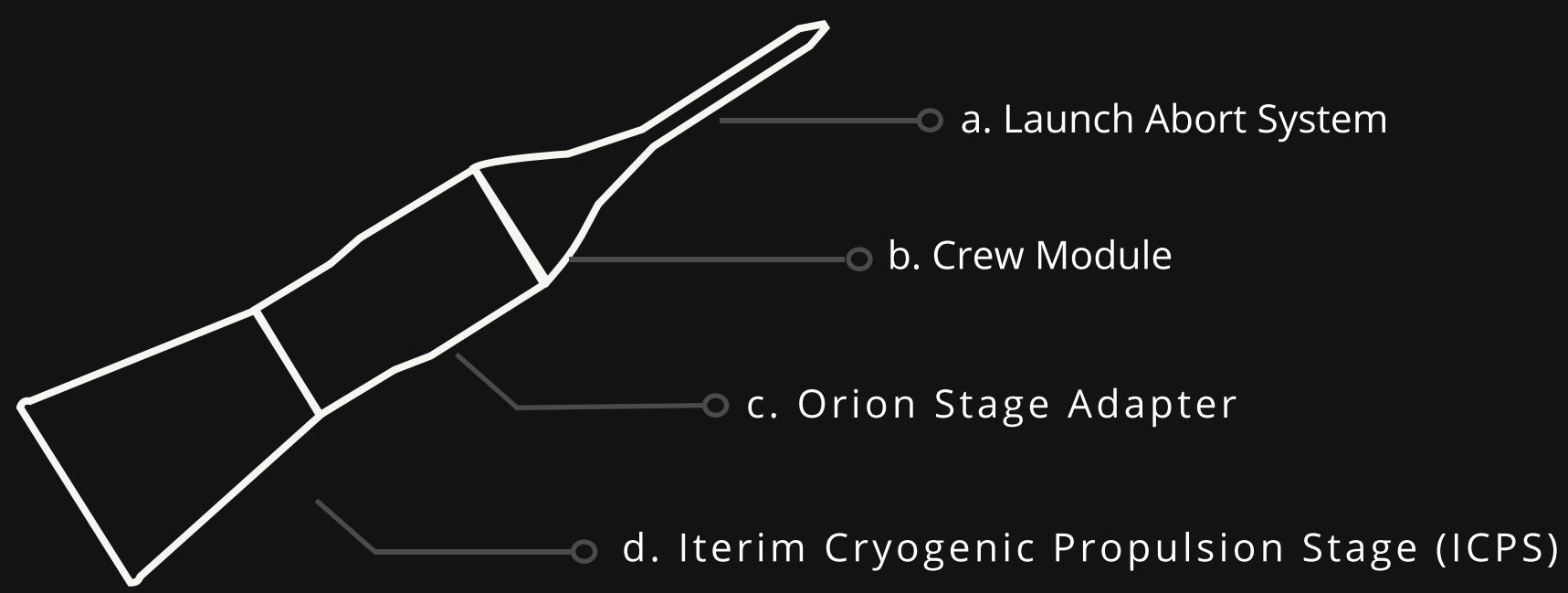
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SLS BLOCK 1



ORION MULTI-PURPOSE CREW VEHICLE



WHAT IS IT?

The Orion Multi-purpose Crew Vehicle contain various built components:

Launch Avort System; Crew Model; Service Module; Encapsulated Service Module Panels; Spacecraft Adapter; Orion Stage Adapter; Interim Cryogenic Propulsion Stage; and Launch Vehicle Stage Adapter

- a. is a crew safety system connected to a space capsule, used to quickly separate the capsule from its launch vehicle rocket in case of a launch abort emergency, such as an impending explosion
- b. Will carry astronauts to the Moon
- c. Orion stage adapter will connect Orion to the ICPS on the SLS Block 1 vehicle and is the place where small satellites will ride to space
- d. After reaching space, ICPS sends Orion out of Earth's orbit to the moon



BUILT BY

Lockheed Martin; Aerojet Rocketdyne; United Launch Alliance; Boeing; and Teledyne Brown Engineering of Huntsville



SLS MISSION CONTRIBUTION

- For missions:
- Carry up to four crew members;
 - Provide emergency abort capability;
 - Sustain the crew during multiweek missions
 - Provide a safe reentry to Earth from deep space return velocities



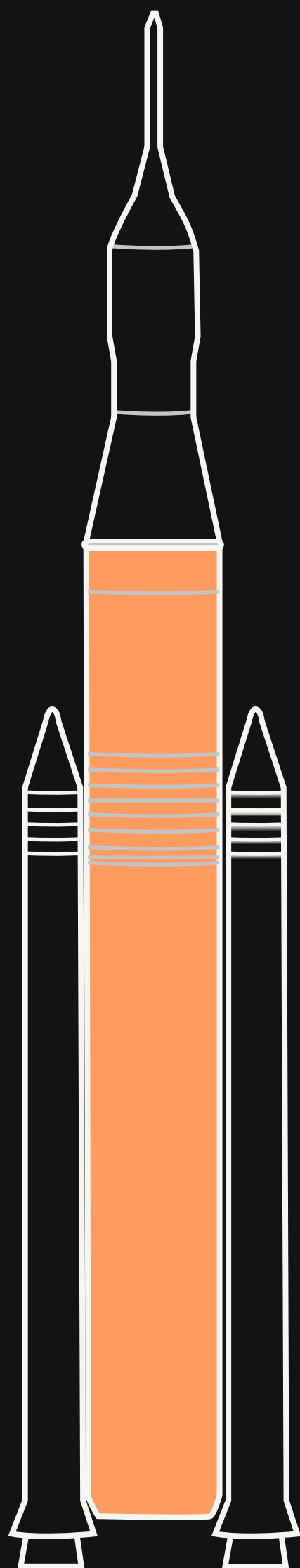
CURRENT STATUS

Has built the launch vehicle stage adapter that will connect SLS's core stage to the upper part of the rocket

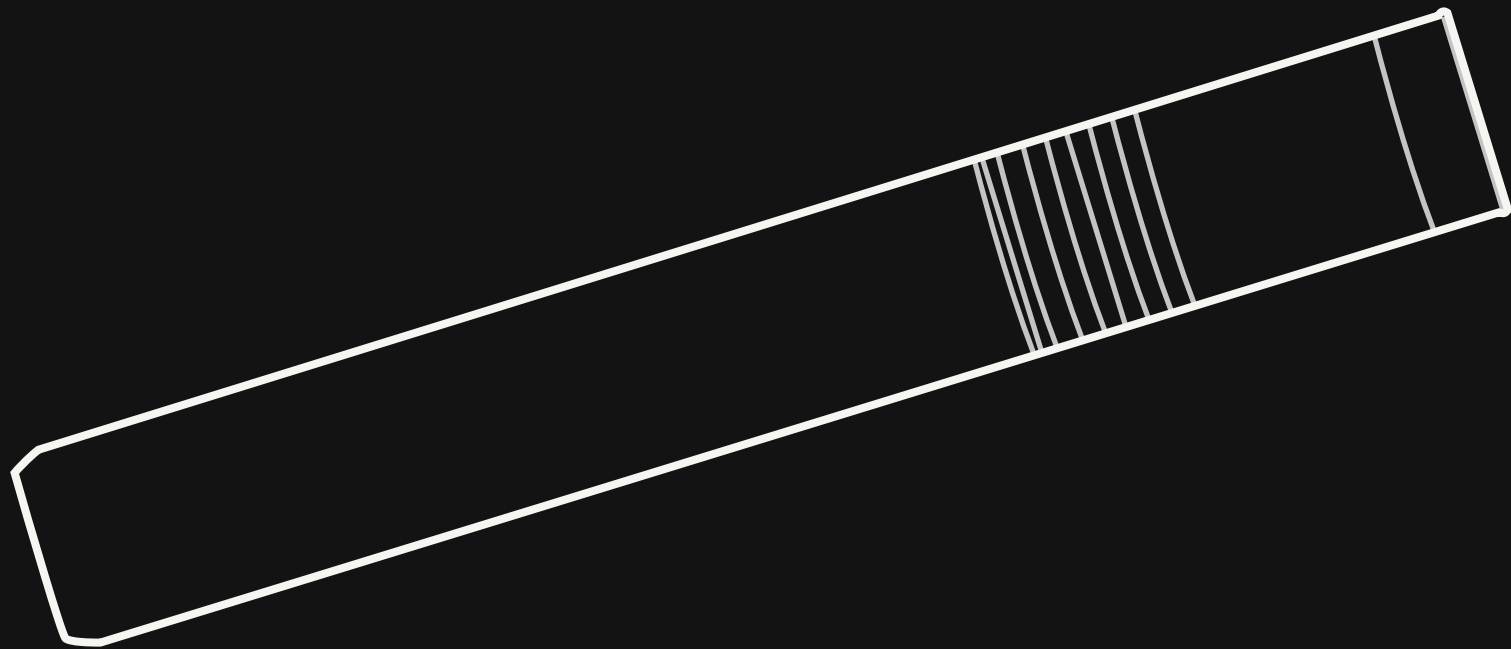
Has been delivered to Kennedy for the first launch

RL10 has been delivered to Kennedy and is ready for integration

SLS BLOCK 1



CORE STAGE



WHAT IS IT?

The SLS Core Stage towering more than 200 feet with a diameter of 27.6 feet, stores 730,000 gallons of super-cooled liquid hydrogen and liquid oxygen that will fuel the RS-25 engines



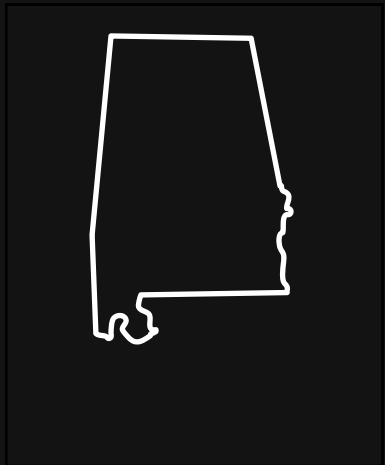
SLS MISSION CONTRIBUTION

The SLS core stage has a complex network of flight software and avionics systems designed to help fly, track, and steer the rocket during launch and flight



BUILT BY

Boing Company, Huntsville, Alabama



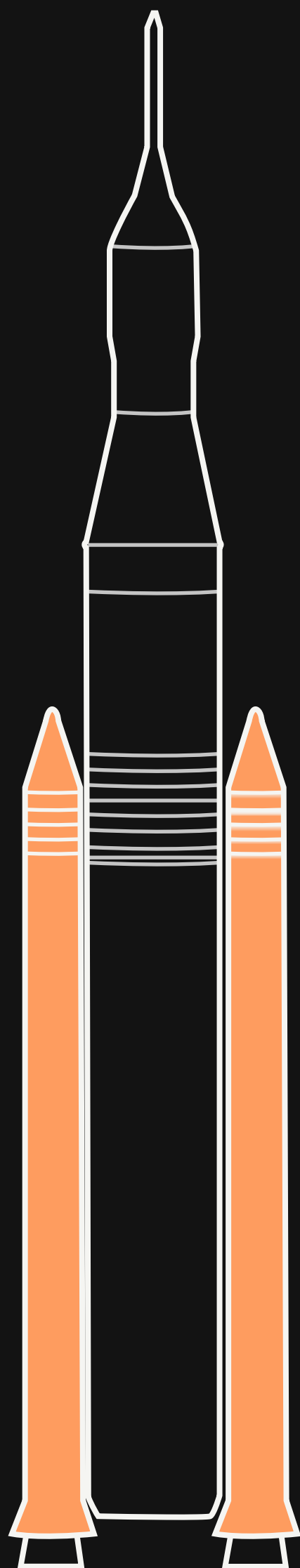
CURRENT STATUS

Build at NASA's Michoud Assembly Facility (New Orleans).

Boing Company, builds avionics computer software that controls vehicle during flight.

Avionics computer software is being developed at NASA's Marshall Space Flight Center (Huntsville)

SLS BLOCK 1



SOLID ROCKET BOOSTER



WHAT IS IT?

The SLS booster is the largest, most potent solid propellant booster ever built. The system’s actuators are the electromechanical mechanisms that direct the vehicle’s propulsion system, while the thrust vector control system controls 70% of the steering during SLS booster initial ascent



SLS MISSION CONTRIBUTION

Two shuttle-derived solid rocket boosters will power the initial flights of the SLS spaceships for the Artemis I, II, and III programs



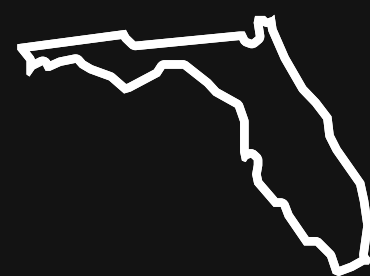
BUILT BY

Northrop Grumman
Assembled by The Booster Fabrication Facility (BFF) is a 45- acre site at NASA’s Kennedy Space Center in Florida, mobile launcher site

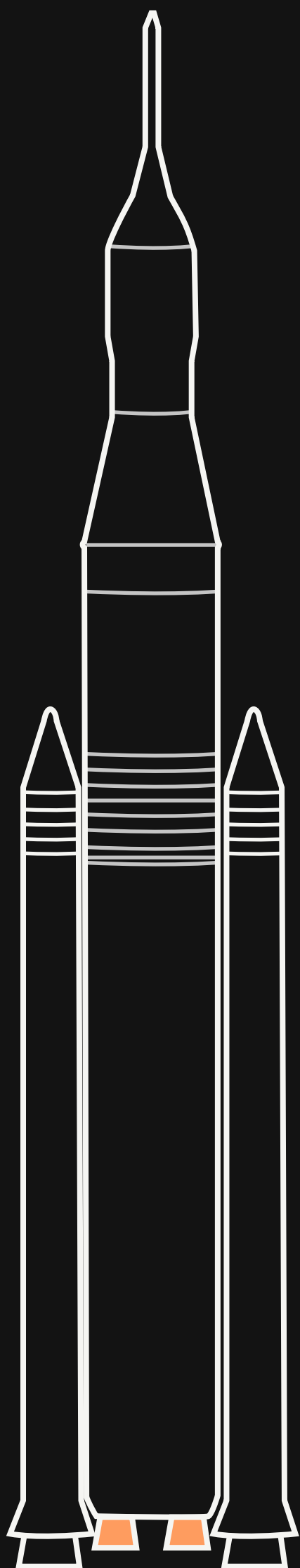


CURRENT STATUS

The booster segments have been delivered from Northrop Grumman’s Utah manufacturing facility to the Kennedy Space Center for Artemis I
The avionics systems for the rocket boosters are being tested at the NASA Kennedy and Marshall centers



SLS BLOCK 1



RS-25 ENGINE (x4)



WHAT IS IT?

Also known as the Space Shuttle main engine, RS-25 engine is a liquid-fuel cryogenic rocket engine used on NASA's Space Shuttles. RS-25 completed 135 missions.



BUILT BY

Aerojet Rocketdyne (Sacramento, California) is upgrading an inventory of 16 RS-25 shuttle engines (from Space Shuttle Program)



SLS MISSION CONTRIBUTION

One of the most tested large rocket engines more than 3000 starts / > 1 mil seconds (test and flight). Space Shuttle main engine will provide power and boost to push the rocket's Core Stage into outer space.



CURRENT STATUS

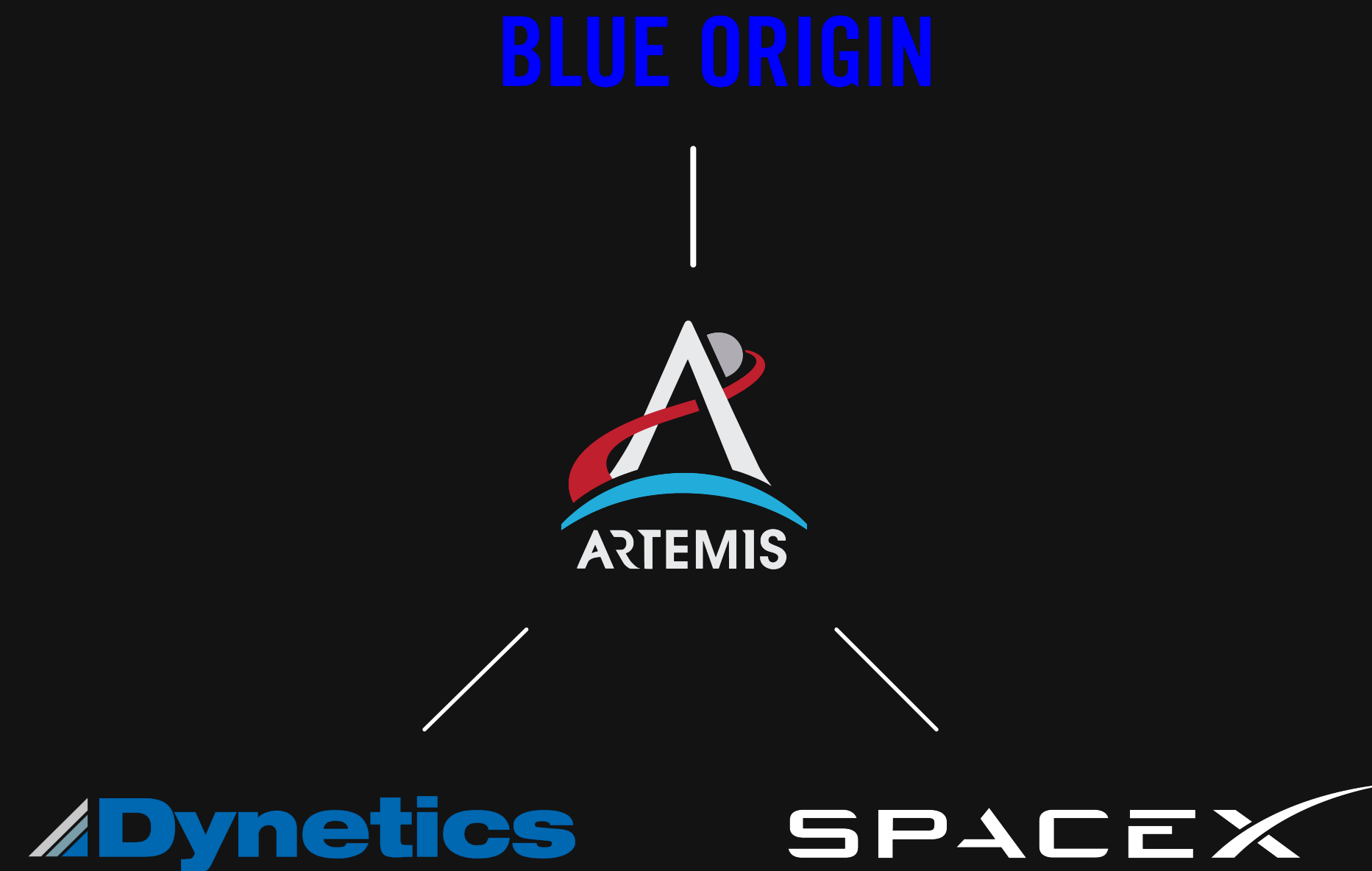
Aerojet Rocketdyne has finished testing new controllers and is assembling engines for the following four missions. They have restarted the production of new engines

Engines for Artemis I are built, tested and attached to the core stage

Pegasus barge will take the core stage to NASA's Kennedy Space Center in Florida to prepared for launch

Undergoing testing at NASA's Stennis Space Center near Bay St. Louis, Mississippi

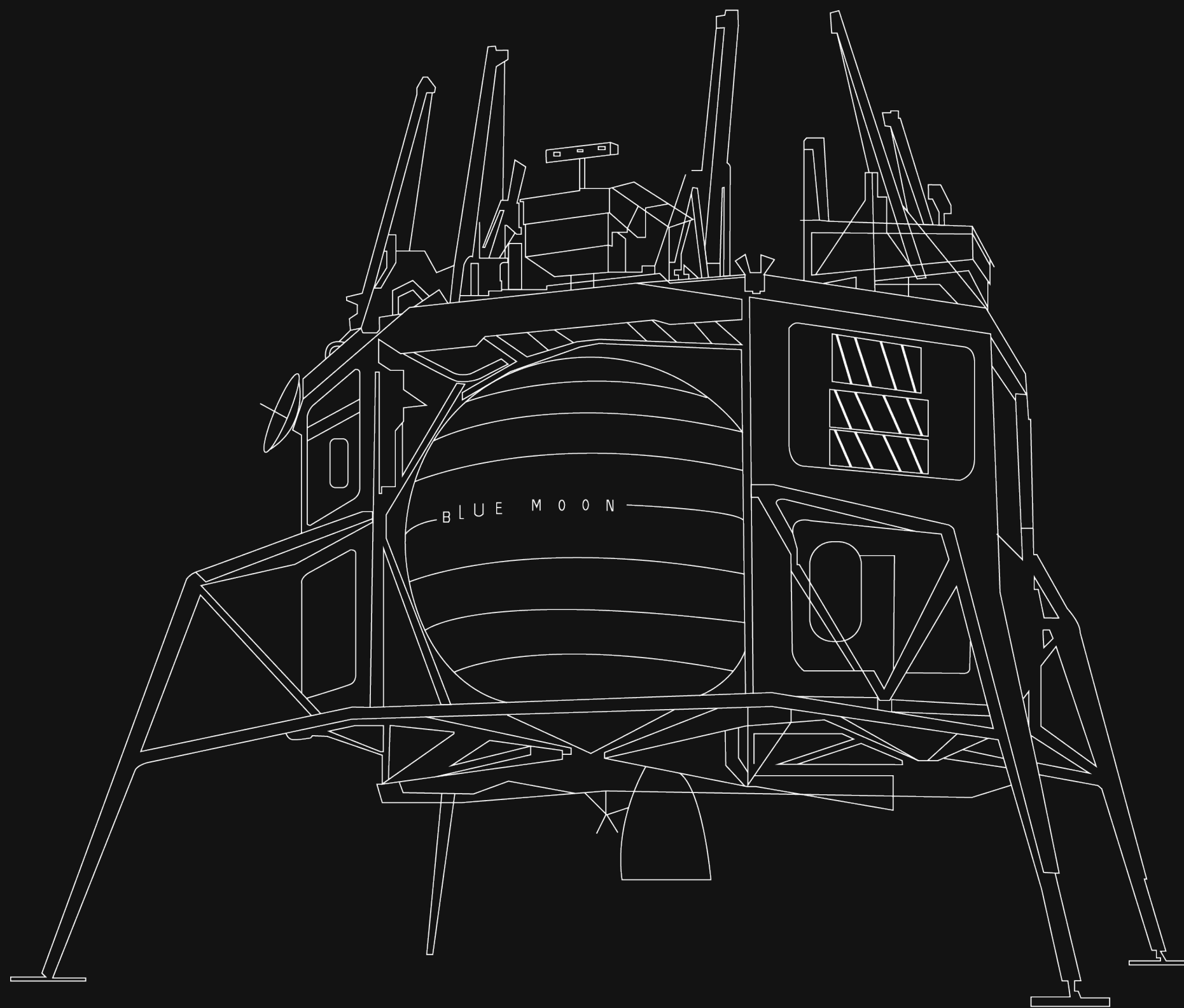
HUMAN LANDING SYSTEM



OVERVIEW

As a part of the Artemis Program, the Human Landing System (HLS) will carry astronauts to the lunar surface and launch them back to lunar orbit when their expedition is complete. Streamlining its partnering approach, NASA is working with three American companies - Blue Origin, Dynetics, and SpaceX - to begin development of their industry-led innovative designs for human landing systems. These companies offered three distinct lander and mission designs, offering dissimilar redundancy, driving a broad range of technology development and, ultimately, more sustainability for lunar surface access. All three can dock with Orion or the Gateway to receive crew in lunar orbit, providing NASA with flexibility in mission planning.

HLS PARTNER

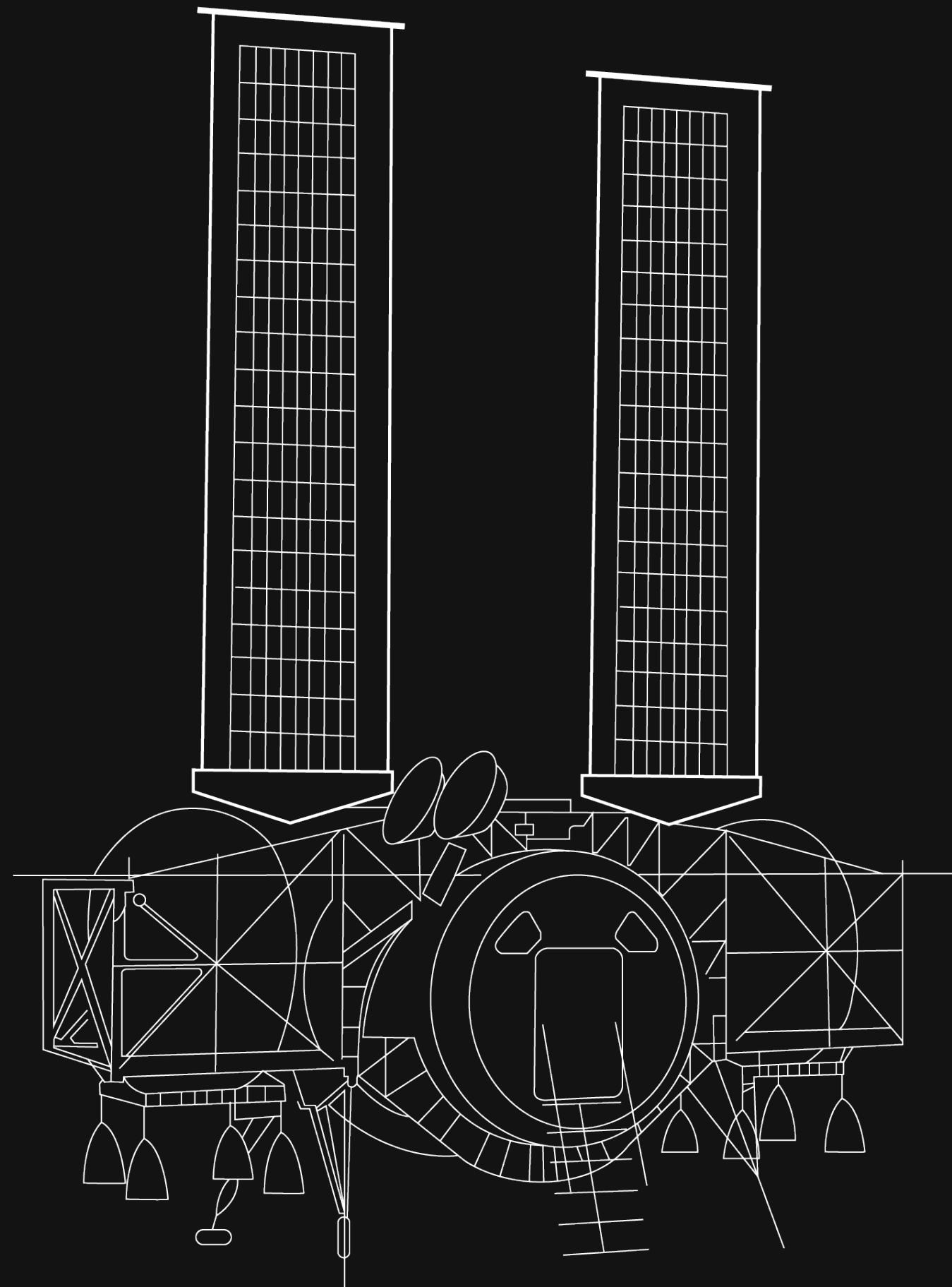


BLUE ORIGIN

Blue Origin is the leading company in the development of their specific Integrated Lander Vehicle project. It is responsible for the descent element as well as the Glenn rocket.

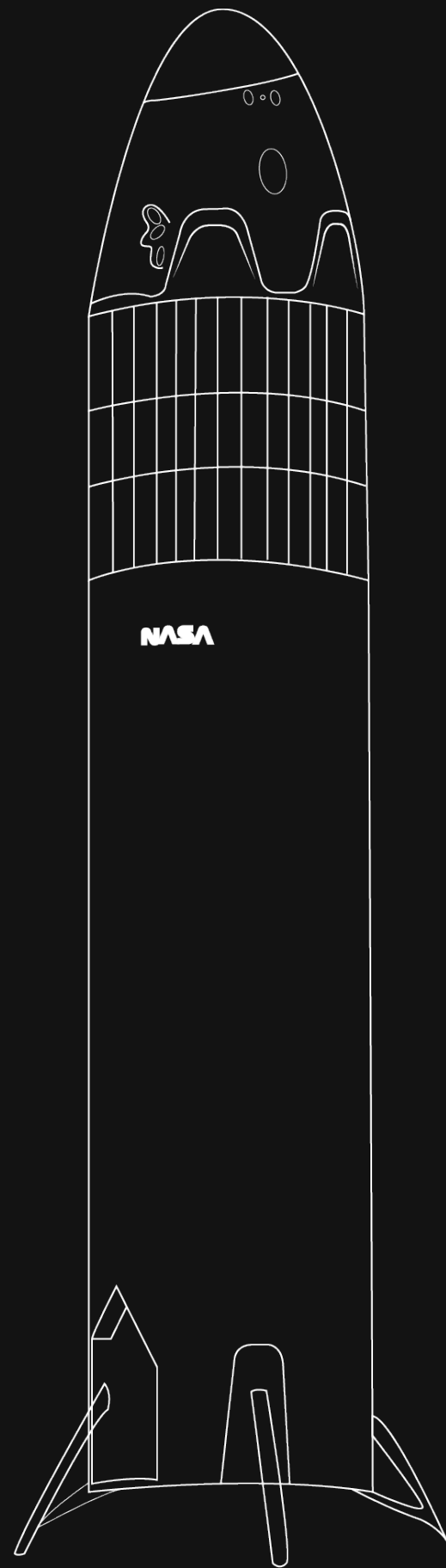
The leading company for the Integrated Lander Vehicle is Blue Origin. Blue Origin partnered with Lockheed Martin, who is responsible for the ascent element; Northrop Grumman who is developing the transfer element; Draper, who is responsible for guidance, navigation, control, avionics, and software systems, and United Launch Alliance, responsible for Vulcan heavy-lift rocket. Blue Origin themselves are working on the Glenn rocket and are responsible for the descent element

HLS PARTNER



With a broad spectrum of technical capabilities, Dynetics provides affordable, innovative, and responsive subcomponents to the full space system. Its Human Landing System includes a single element providing the ascent and descent capabilities with multiple modular propellant vehicles. It will launch United Launch Alliance's Vulcan heavy-lift rockets.

HLS PARTNER



SpaceX interplanetary transport system aims to reduce cost and improve accessibility to space. The company has been rapidly developing reusable launch systems that will be utilized for multiple purposes such as commercial and space travel to the Moon or Mars. Its Human Landing System, known as Spaceship, also consists of fully reusable launch and landing system and will launch aboard SpaceX Super Heavy Rocket.

BRAND ATTRIBUTES

NASA



BLUE ORIGIN



Dynetics



SPACEX



BRAND ATTRIBUTES



VISION STATEMENT

To discover and expand knowledge for the benefit of humanity.

RATIONAL

TEAM-ORIENTED

A brand that comes together as one to solve complex issues. Innovation is a staple, teamwork is a must and everyone’s opinion counts.

LEADERSHIP

A brand that leads a Moon to Mars exploration approach, which includes working with U.S. industry, international partners, and academia to develop new technology.

ALTRUISTIC

A brand that shares its information and knowledge with other agencies to provide a better life for people worldwide.

RESPONSIBLE

A brand that supports education efforts in STEM with an emphasis on increasing diversity in our future workforce.

EMOTIONAL

AGILE

A brand that is comfortable and flexible to grow and adapt to what the future may bring.

RESILIENT

A brand that is not deterred by obstacles or constraints, and strives to achieve its goals.

CURIOUS

A brand that continually asks questions and seeks novel solutions to “unsolvable” problems.

EXCELLENT

A brand that continuously strives to be better and know more.

PASSIONATE

A brand that is constantly embarking on a range of adventures to better understand our planet, the solar system and beyond.



BRAND ATTRIBUTES

BLUE ORIGIN

VISION STATEMENT

Building a road

RATIONAL

FUTURISTIC

A brand that believes in investing for the future generations and unleashing the hidden potential of space by tapping its unlimited resources and energy.

FRUGAL

A brand that believes operational reusability is the only way to lower the cost of access to space. High asset utilization decreases the cost and increases availability for its customers.

RELIABLE

A brand that aims to provide a safe access to space. With their various rigorous test programs, they ensure that astronauts will be safe in any phase of flight.

EMOTIONAL

EFFORTLESS

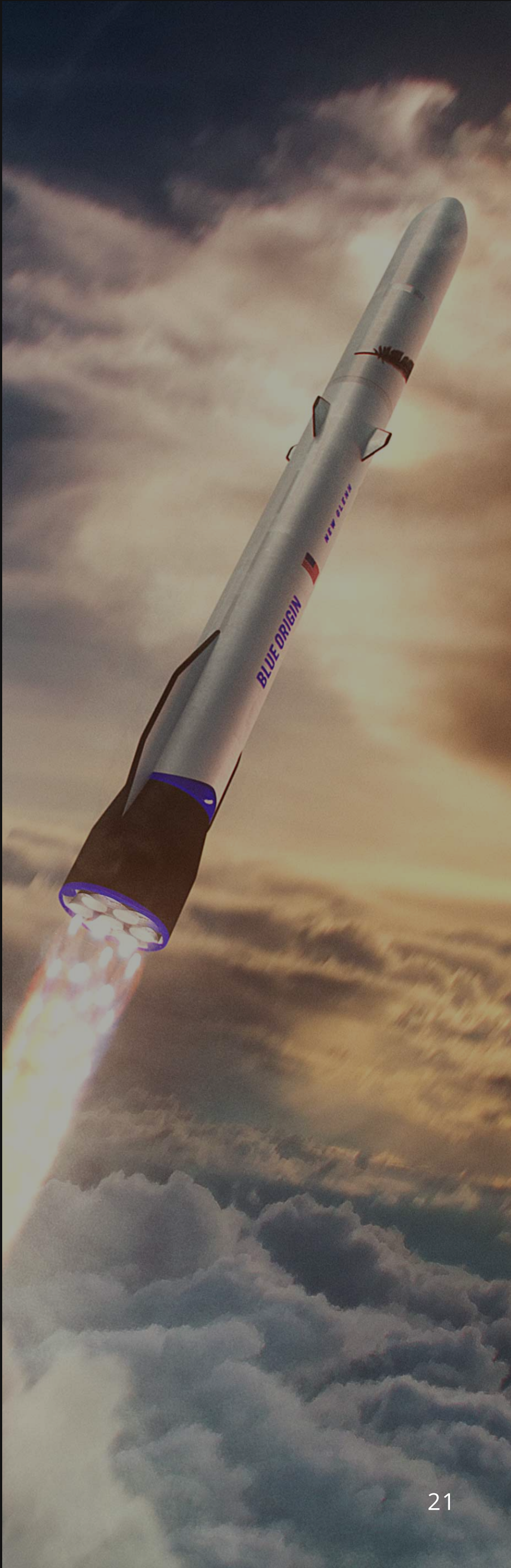
A brand that believes in taking one step at a time rather than skipping steps to reach faster.

PASSIONATE

A brand that meticulously dedicated to space exploration, thoughtful development and safety testing.

DETERMINED

A brand that aims to make space travel affordable and pragmatic for the common man.



BRAND ATTRIBUTES



VISION STATEMENT

Solving complex problems, ethically, and cost-effectively
To strengthen and enrich the communities in which we live

RATIONAL

KNOWLEDGEABLE

A brand that provide highly specialized technical services and a range of software and hardware products, including components, subsystems, and complex end-to-end systems.

HIGHLY EFFICIENT

A brand that use strategy of collaborating throughout the design, prototyping, and manufacturing process to create manufactural designs, decreasing costs and saving time.

AFFORDABLE

A brand that implements the principle of reusability and sustainability to give clients most cost-effective solutions from subcomponent to full system.

EMOTIONAL

INNOVATIVE

A brand that provide rapid prototyping and secure agile manufacturing and systems integration capabilities will further enhance innovation and help customers achieve their goals.

SOCIAL RESPONSIBILITY

A brand that have a responsibility to strengthen the communities where they live and work. A brand backs a broad range of organizations and activities through monetary investments, volunteerism, and community engagement.

FAIR-MINDED

A brand that ensure small and large businesses are given equal opportunity to compete for subcontracting opportunities. As a large business required to meet small business subcontracting goals, Dynetics encourage their staff to seek out suppliers who offer the best value, regardless of socioeconomic size.



BRAND ATTRIBUTES



VISION STATEMENT

Making humanity multiplanetary

RATIONAL

INCLUSIVE

A brand that highlights diversity and incorporates creative minds from across the globe to come up with transformative ideas to keep the company alive.

PIONEERING

A brand that has taken initiatives to be the only private company capable of returning a spacecraft from low-Earth orbit and the first commercial spacecraft to deliver cargo to and from the International Space Station.

EFFICIENT

A brand that promotes a reusable space launch vehicle to reduce the cost of space access.

EMOTIONAL

PROMISING

A brand that kindles the hope of living on other planets by valuing state-of-the-art space designs and technologies.

PERSEVERING

A brand that learns from failure and does not give up on their mission on commercial flights to outer space.

AUDACIOUS

A brand that designs an exponential scale of space mission and is willing to be a risk-taker to make it happen.



SWOT ANALYSIS

S

People: Core capabilities/corporate knowledge

Leaders in collaboration and innovation

- Good and Strong external collaborations (NSBRI, academia etc) and connections with external communities
- Open collaboration and innovation is moving to be the norm
- Integrate the international life sciences community

Risk management

- Serious approach to risk management
- Interdisciplinary atmosphere to solve problems
- Mission and risk focused to deliverables

Human Resource Planning (HRP) specific

- Well managed, structured and use of HRP ahead for optimal use of organizations

Resources & Resource management

- Clear Project Management
- Flexibility allowing the organization to evolve and survive
- Pathfinder, forward-looking
- Mature processes
- Excellent facilities for research

W

Poor project management

Technical issues, bad management and poor performances from the NASA contractors.

Over-budgeted SLS project

\$18.3 billion spent if the rocket flies in 2021

Shortcomings in quality control

Infrastructure issues

- The many NASA locations and partner locations cause inefficiencies when transporting parts for testing and launching

O

\$1.35 billion total projected economic impact

8,000 jobs nationwide

The launch vehicle's power and versatility allows for heavier payloads and opens new possibilities such as robotic missions to Mars, Saturn and Jupiter

Most powerful rocket in history

NASA's Space Launch System to **boost science** with secondary payloads

T

Time management for clearance in project launch for low casualties or negative outcomes

Space X as a competitor

● Similarities to SpaceX Startship

SWOT ANALYSIS



S	W	O	T
<p>Quality control</p> <p>Internal management of the entire product development process</p> <ul style="list-style-type: none">• Control of the R&D• Development, testing and fabrication <p>Competitive pricing</p> <p>Innovative design</p> <p>Faster development timeline than any rocket</p> <p>No competition aside from NASA SLS</p> <p>Reusable rocket system</p> <p>SpaceX being under contract by NASA for resupply missions</p> <p>Industry-leading technological prowess has allowed SpaceX to win majority of space exploration contracts from NASA</p>	<p>Capital intensive</p> <p>Lack of collaboration with other companies</p> <p>High level of uncertainty investment leading to drastic failure</p> <p>Commercial market stagnation</p> <ul style="list-style-type: none">• The global market for commercial space launches is not big. <p>Failure leading to bankruptcy</p>	<p>No restrictions on revenue opportunities</p> <p>Becoming the only service NASA uses to send things to space</p> <p>Potential future Artemis program launch contracts</p>	<p>NASA SLS as a competitor</p> <p>Potential new entrants into the untapped space market</p> <p>Threat of losing current contracts with bigger agencies</p> <p>Potential cost increase in raw materials, labor, R&D</p>

● Similarities to NASA SLS

STEEP ANALYSIS

● Similarities

	SOCIAL	TECHNOLOGICAL	ENVIRONMENTAL	ECONOMIC	POLITICAL
<div>NASA</div>	<p>Foster American pride in human space exploration</p> <p>Develop & sustain partnerships with specialized companies interested in space exploration</p> <p>Enable the first human mission to Mars</p> <p>Get more people, especially the youth, interested in a career in space exploration</p> <p>Collaborate with SpaceX, the leading private company in space exploration who also shares the same goal of human space exploration</p>	<p>Collaborate with hundreds of American companies to develop the most powerful space exploration rocket</p> <p>Test & discover new technologies in space</p>	<p>Explore planets in our solar system and learn about their atmospheres and environments</p> <p>Search for new sources of natural resources outside of Earth</p> <p>Investigate the potential for humans to live on Mars</p>	<p>Outsource rocketship development to decrease costs</p> <p>Generate and sustain jobs in the USA</p>	<p>Free from being reliant on Russian spaceships to explore Space</p> <p>Politicians want to boost the economy of their community they represent</p> <p>Presidents want to be the first country to explore Mars with US astronauts</p>
<div>SPACEX</div>	<p>Get more people, especially the youth, interested in a career in space exploration</p> <p>Private American startup company developing industry leading space exploration technology</p> <p>To send US astronauts on a U.S made spaceship</p> <p>Collaborate with NASA</p>	<p>Continue to develop and design cutting-edge space exploration technology</p> <p>Test & discover new technologies in space</p> <p>Develop the best, most powerful spaceship</p>	<p>Reduce space trash with fully reusable rockets</p> <p>Explore planets in our solar system and learn about their atmospheres and environments</p> <p>Search for new sources of natural resources outside of Earth</p> <p>Investigate the potential for humans to live on Mars</p>	<p>Generate and sustain jobs in the USA</p> <p>Generate revenue with space tourism opportunity</p> <p>Decrease costs by designing and manufacturing internally</p> <p>Operate a lean organization with no government restrictions</p> <p>Profitably explore space and develop a space exploration free market</p>	<p>Pursue commercial American space exploration interests</p> <p>Support of the US government to explore space</p>

HUMAN SPACE EXPLORATION

DMGT 750: COLLABORATIVE CULTURE IN DESIGN ORGANIZATIONS
SPRING 2021 | Prof. TOM HARDY

GOAL OF HUMAN SPACE EXPLORATION

"Humans are driven to explore the unknown, discover new worlds, push boundaries of our scientific and technical limits and then push farther."
"Human space exploration helps to address fundamental questions about our place in the Universe and the hisotry of our solar system."

PROJECT OVERVIEW

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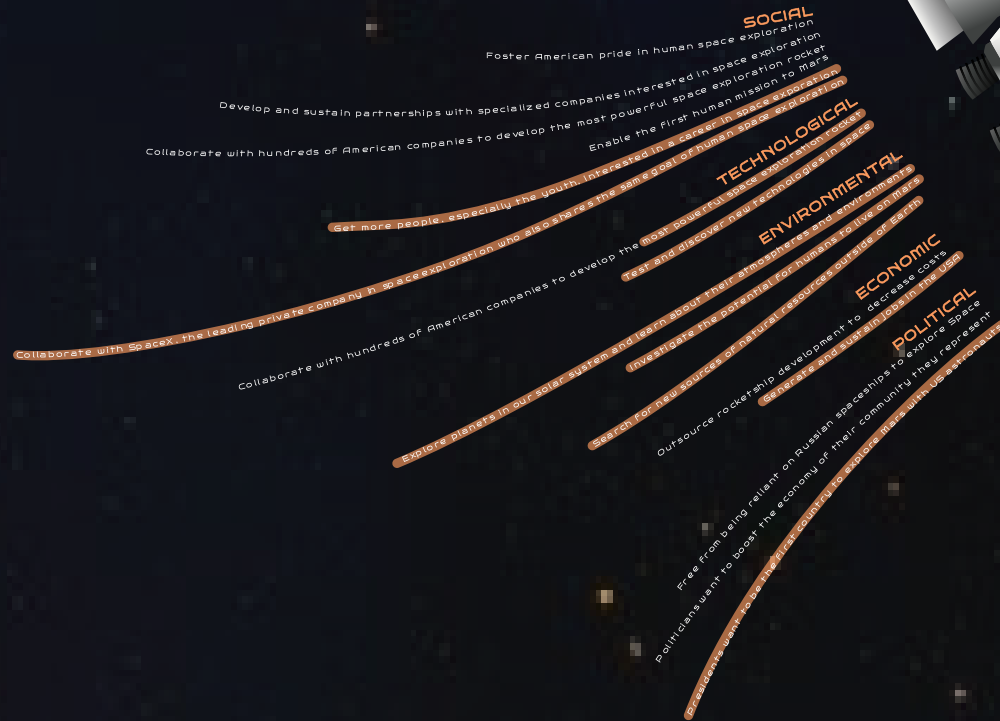
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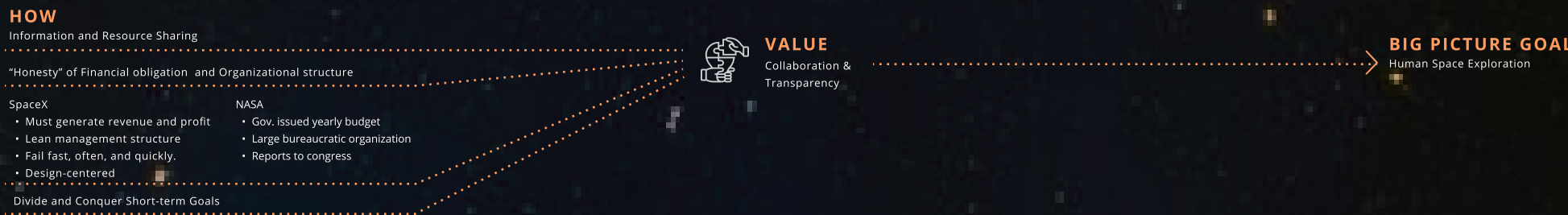
SPACEX STARSHIP

SpaceX's Starship spacecraft and Super Heavy rocket (collectively referred to as Starship) represent a fully reusable transportation system designed to carry both crew and cargo to Earth orbit, the Moon, Mars and beyond. Starship will be the world's most powerful launch vehicle ever developed, with the ability to carry in excess of 100 metric tonnes to Earth orbit.

ARTEMIS PROGRAM OVERVIEW



RESEARCH TAKEAWAY



NASA NASA SLS

People: Core capabilities/corporate knowledge

Leaders in collaboration and innovation

- Good and Strong external collaborations (NSBRI, academia etc) and connections with external communities
- Open collaboration and innovation is moving to be the norm
- Integrate the international life sciences community

Risk management

- Serious approach to risk management
- Interdisciplinary atmosphere to solve problems
- Mission and risk focused to deliverables

Human Resource Planning (HRP) specific

- Well managed, structured and use of HRP ahead for optimal use of organizations

Resources & Resource management

- Clear Project Management
- Flexibility allowing the organization to evolve and survive
- Pathfinder, forward-looking
- Mature processes
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Poor project management

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Most powerful rocket in history

NASA's Space Launch System to boost science with secondary payloads

Time management for clearance in project launch for low casualties or negative outcomes

Space X as a competitor

SPACEX SPACEX SPACESHIP

Quality control

Internal management of the entire product development process

- Control of the R&D
- Development, testing and fabrication

Competitive pricing

Innovative design

Faster development timeline than any rocket

No competition aside from NASA SLS

Reusable rocket system

SpaceX being under contract by NASA for resupply missions

Industry-leading technological prowess has allowed SpaceX to win marjotity of space exploration contracts from NASA

Capital intensive

Lack of collaboration with other companies

High level of uncertainty investment leading to drastic failure

Commercial market stagnation

- The global market for commercial space launches is not big.

Failure leading to bankruptcy

No restrictions on revenue opportunities

Becoming the only service NASA uses to send things to space

Potential future Artemis program launch contracts

NASA SLS as a competitor

Potential new entrants into the untapped space market

Threat of losing current contracts with bigger agencies

Potential cost increase in raw materials, labor, R&D

TAKEAWAY

COLLABORATION OVERVIEW

NASA and SpaceX are two of the most influential companies in the space industry, intending to advance human space exploration to and beyond Mars. According to NASA's website, "people are compelled to explore the unknown, find new worlds, test the bounds of our scientific and technological limits, and then push farther" (NASA, n.d.). Pursuing this objective will aid Earth's human civilization in answering questions about our place in the universe and the solar system's evolution. NASA and SpaceX are currently focusing their long-term plans on Mars and the possibility of human life stretching beyond Earth.

To achieve this purpose, both of these American institutions must continually collaborate remain transparent with each other over the entire course of the big picture mission of human exploration to Mars, despite their vastly different internal work processes.

We believe NASA and SpaceX should exchange knowledge and resources, divide and conquer near-term goals, and be open about their disagreements in the spirit of transparency.

We'd want to focus on their disparities in their financial structure before moving on to their contrasts in internal work procedures. Every year, congress allocates a yearly budget to NASA, which is utilized to explore space as efficiently and economically as possible. SpaceX is structured differently since they need to generate revenue and, in the long run, profit in order to sustain their human space exploration missions.

NASA and SpaceX have vastly different internal work methods. NASA is a large bureaucratic organization with several levels of hierarchy that can be inefficient at times. NASA is also required to submit reports to Congress and the American public. NASA is accountable to the government, even though it is not under any financial constraint.

SpaceX is a young company with a lean management structure. SpaceX is built to provide value to customers while consuming the fewest resources possible. Elon Musk, the CEO of SpaceX, is a brilliant product architect and master engineer who believes in failing fast, often, and cheaply.

The outside designs of their spaceships, interior designs of their crew module, and the outfit design of their spacesuits all reflect this design-centered and engineering-focused philosophy. This internal work culture has transformed the space sector and helped them gain contracts from NASA and other international governments and enterprises.

If NASA and SpaceX can maintain their transparency, they have a chance to become the first country and private firm to land on Mars.

NASA

SPACEX