



INNOVATING NASA ENTRY SYSTEMS: ADDRESSING NEEDS AND EXPLORING THE FUTURE

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Prelude

Global Changes underway will impact our EDL / Probe community.

This talk is my personal observations and reflection on “the challenges and opportunities” in Entry and Thermal Protection Systems areas.

Presentation Outline

- Emerging Big Picture and Anticipated Changes
- Entry and Thermal Protection Systems Innovations, Contributions and Collaborations at NASA
- Concluding Remarks

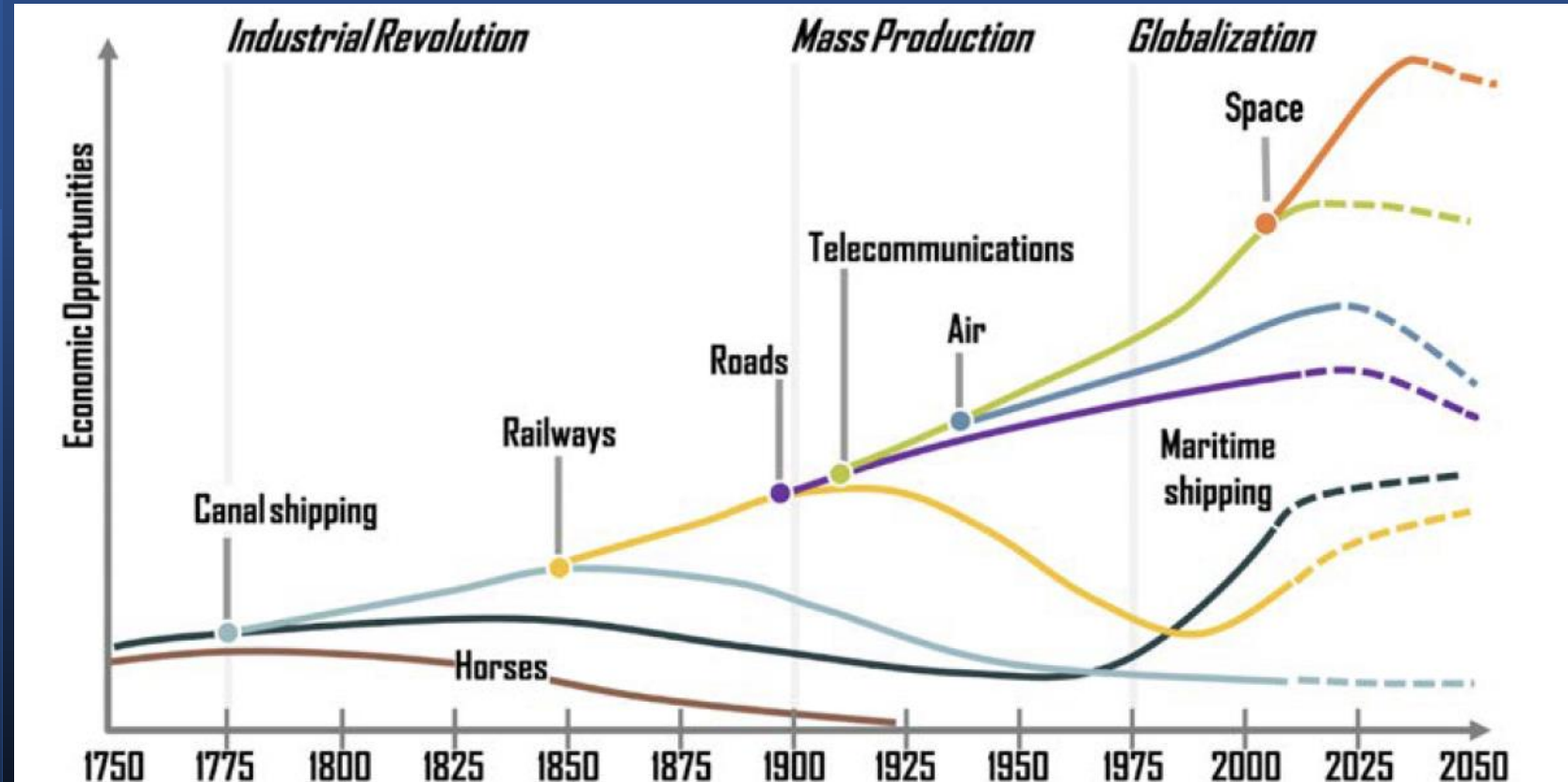
Acknowledgements

This presentation is a result of my interactions over the years with my colleagues at NASA centers, Industry and community forums such as IPPW and more so with the ones at NASA Ames. My gratitude to all.

New Transportation Modalities Drive Economic Prosperity

Throughout human history, the greatest advancements in economic opportunity can be intrinsically linked to the introduction of new transportation modalities that have forever changed the economic Opportunities.

We are in such a period.



From: State of the Space Industrial Base 2021 report

Space Economy:

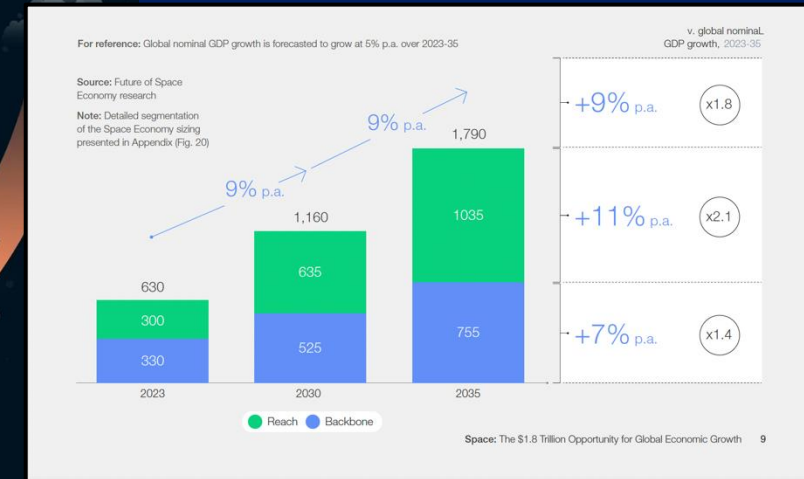
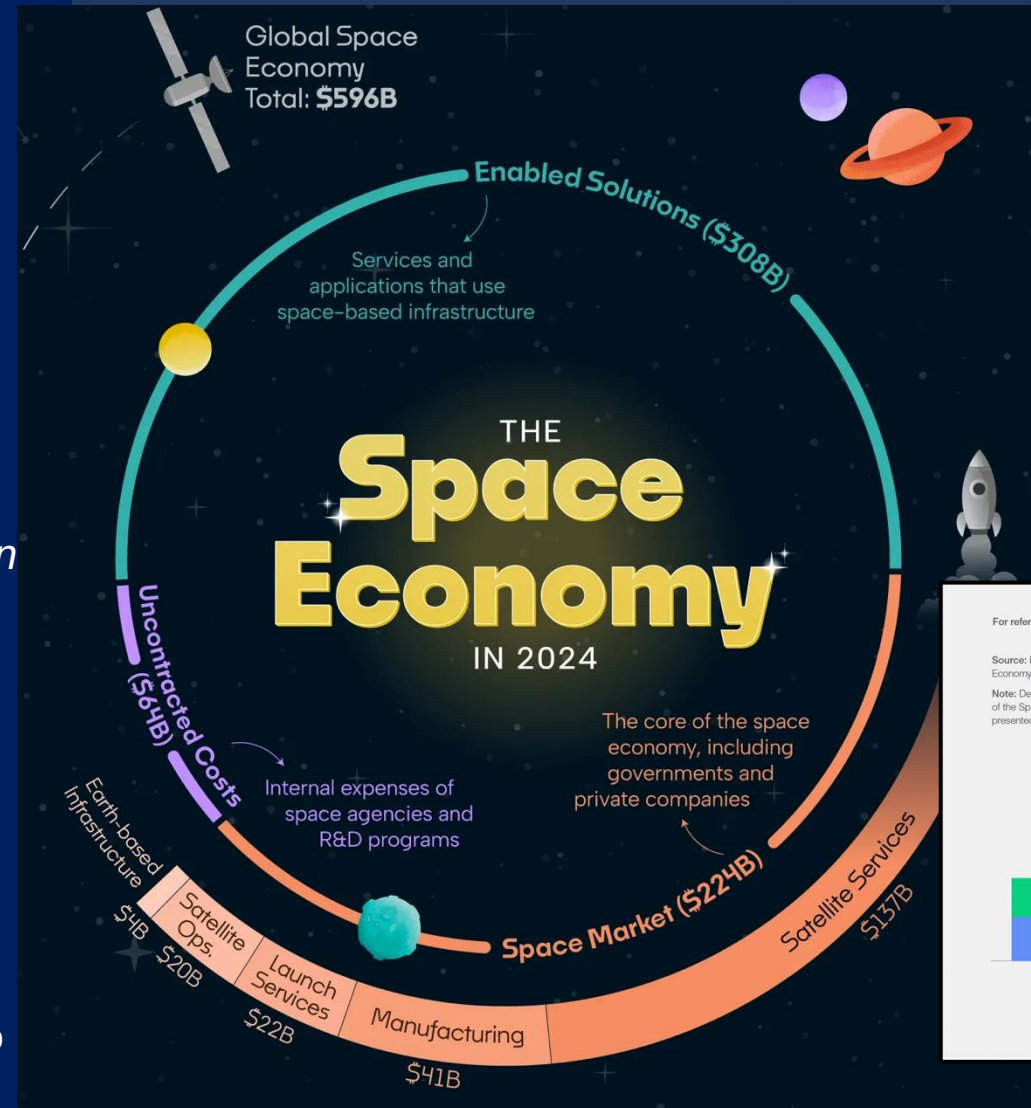
\$185 Billion in 2005
\$300 Billion in 2015
\$596 Billion in 2024
\$1.8 Trillion in 2035

-- *Space Report* by Space Foundation

Credits:



1. <https://www.visualcapitalist.com/visualized-which-countries-are-dominating-space/>
2. <https://www.thespacereport.org/topics/economy/>
3. World Economic Forum Insight Report on "Space: The \$1.8 Trillion Opportunity for Global Economic Growth," 2024.



The Space Economy is Expected to Grow to 1.8 Trillion by 2035

Cumulative Number of Objects Launched into Space

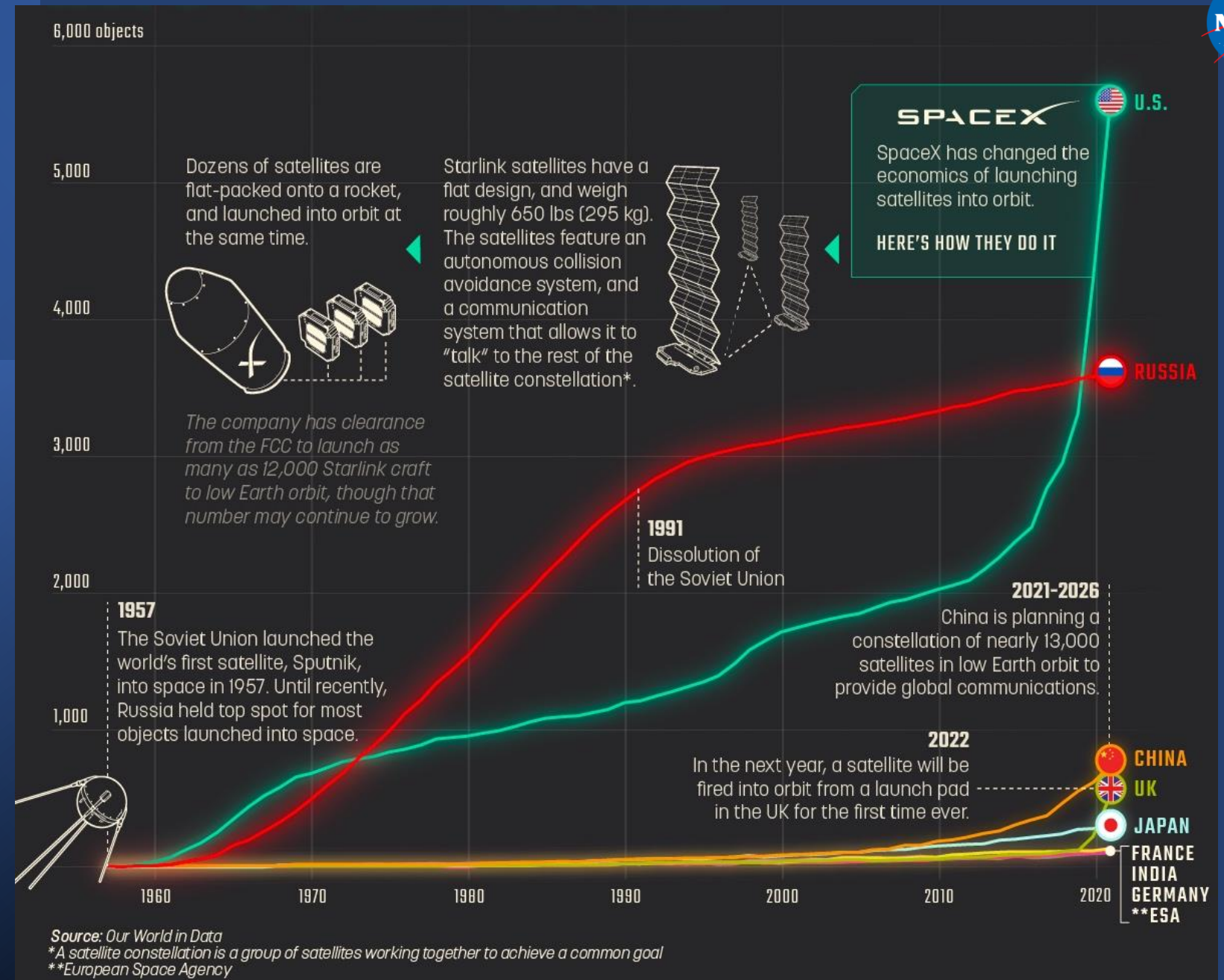
Number of objects launched by U.S., primarily by Space X, far exceeded that of other nations due to Falcon launch cost and cadence.

Blue Origin with its New Glenn, and Rocket Lab's Neutron are expected to increase the U.S. launch capabilities significantly.

Credit:



<https://www.visualcapitalist.com/visualized-which-countries-are-dominating-space/>



Cost of Space Flight

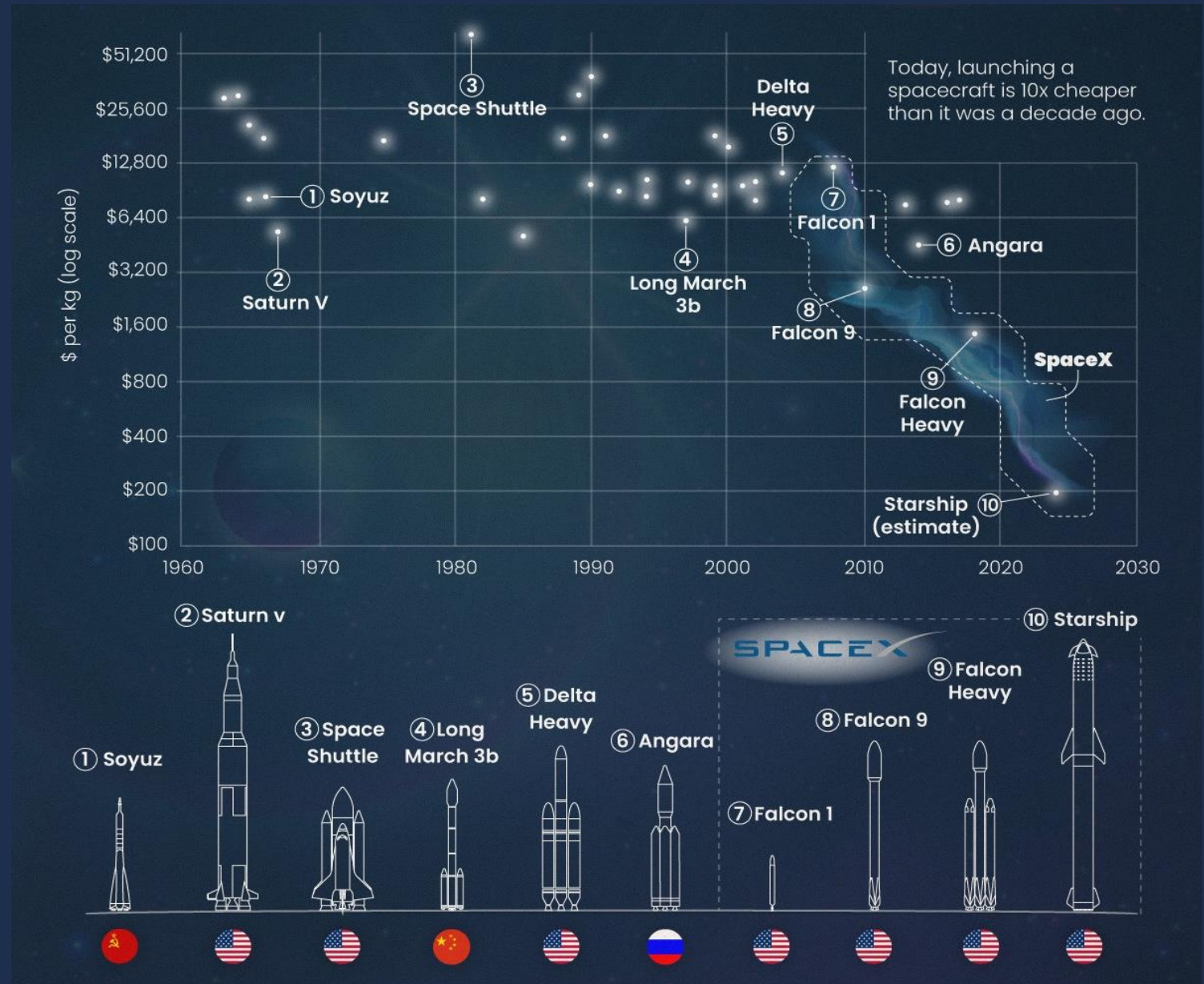
SpaceX's dominance with Falcon 9 and Falcon Heavy is reflected in both reduction in launch cost/kg and number of objects launched in space between 2010 and 2020

Blue Origin with New Glenn is expected to be competitive with a projected cost of \$1500/kg similar to that of Falcon 9.

Credit:



<https://i.sstatic.net/f8wOR.jpg>



Future Focus for NASA

Jared Isaacman's Priorities:

(NASA Administrator Nominee)

1. Strategic Exploration of Human Spaceflight
2. Commercial Expansion and Thriving Space Economy
3. Scientific Growth and Technological Development
4. Mission-First Culture and Addressing Challenges

Sending American astronauts to Mars, and Moon step along the way

- NASA can pursue both the Artemis program (Moon) and Mars missions concurrently

Earth Orbit Commercialization, and Partnership with Private Industry and International Partners

Expanding Scientific Missions and Developing Next Generation Technologies

Reinvigorating NASA's Commitment to getting Artemis Program back to Ensuring NASA's commitment to sending humans to the Moon.

Administration's Focus for NASA

Advancing Human Space Exploration

Public-Private Partnership

Return to the Moon, ahead of China, and on the path to **landing the first human ever, an American, on Mars.**

- *Transitioning to commercial services beyond Artemis III*

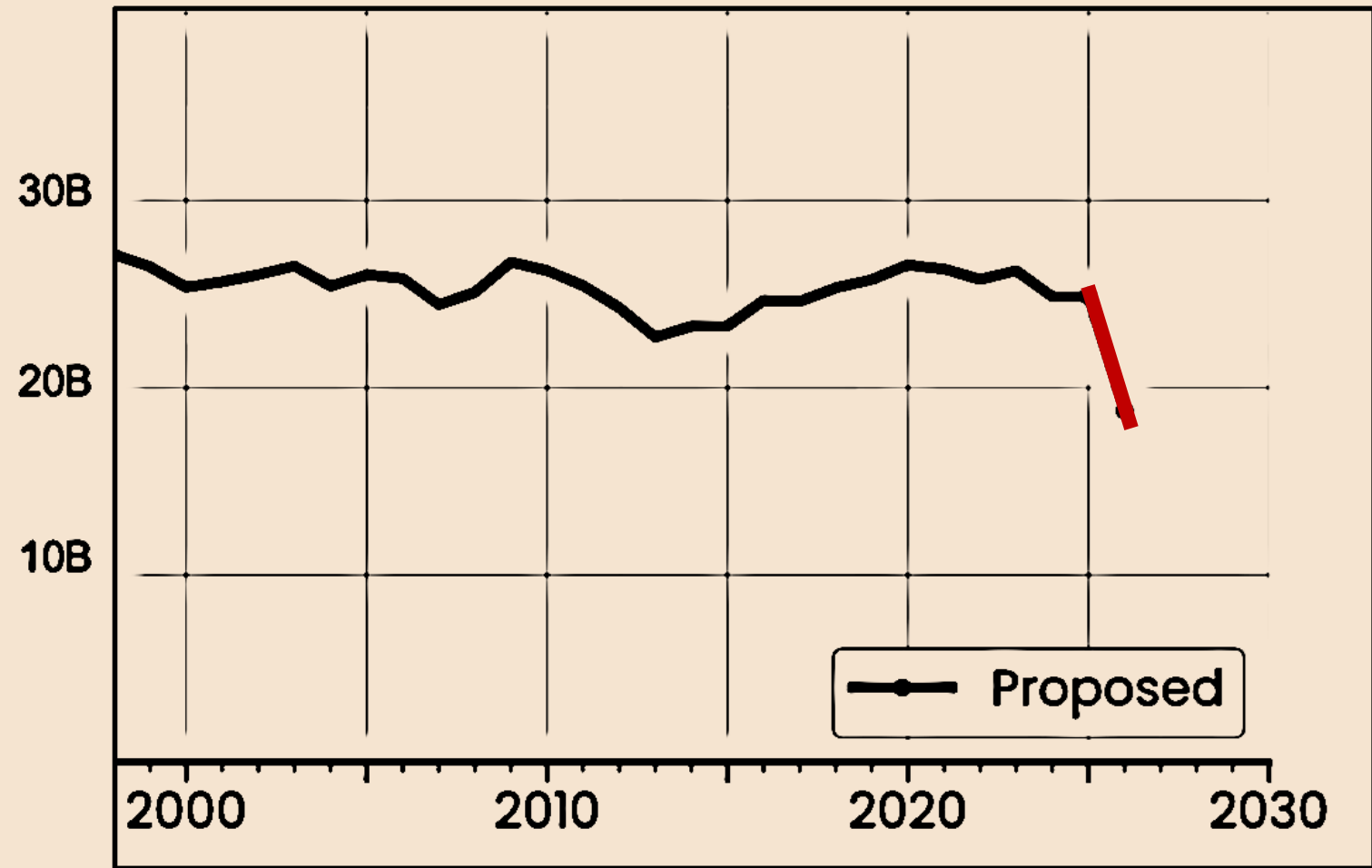
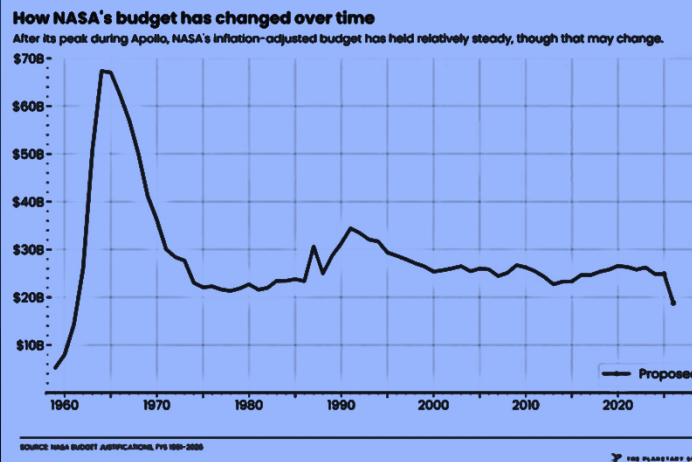
Aligns the science and technology portfolios to missions and technologies essential for **human exploration of the Moon and Mars.**

Continued collaboration with **commercial partners to lower costs and build on the capabilities** of U.S. industry.

Optimizes NASA's organizational structure, enhancing mission delivery by reducing barriers and empowering project teams.

The Challenge: President's Proposed Budget

Historically ~ 75% NASA budget goes out to support contracts, and grants with commercial, educational and non-profit institutions



Source: NASA Budget Justification, FY1961-2026.

Planetary Society

Ref: Dreier, Casey; "Your guide to NASA's budget. The Planetary Society."
<https://www.planetary.org/space-policy/nasa-budget>

NASA & New Space

NASA's Approach:

Dictated by President's vision

Congressional laws/budget

Constrained - Government Agency

Risk-averse culture

Deliberated mission implementation

Low mission cadence

New Space Approach:

Private investment,

Higher risk tolerance &

Learning culture

Resilience in the face of mishaps

Pursuit at scale

Longer term return on investment

- **NASA led missions** from Apollo followed by Viking, Pioneer-Venus and Galileo probes, and sample return missions were primarily built and integrated by **legacy space** companies.
- **Human Mars missions**, unlike Lunar, will demand new architecture and innovations across many disciplines including EDL.
- **NASA's expertise and innovations** has been and are integral part of laying the foundation for commercial space success today.
- **New Space Companies**, are focused on commercial opportunities and establishing capabilities to offer end-to-end tailored services, whether for robotic science exploration or for human missions.
- **Emerging LEO and Lunar Economy** will be a result of public-private partnership. A combination of proven technologies and new innovations are required to mitigate the risks.
- **Emerging role for NASA**, commensurate with the budget, need to focus on innovations in low TRL technologies and sustaining expertise so industry can benefit.

Future: Public-Private Partnership

Public-private partnerships create not only new opportunities but also new risks.

New Space is both too useful and necessary for states to simply avoid utilizing.

The flow of government funding to New Space, on top of market growth, has greatly empowered these actors.

- Public-private partnerships does not guarantee an alignment of public and private interests, leaving much room for divergences.
- These divergences become especially problematic as integration blurs the boundaries between public and private sectors, posing a challenge for international space law and global governance.

The globalization of New Space partnerships risks vastly expanding these concerns internationally.

Each challenge requires concerted attention, domestically and internationally, to limit the inescapable costs of incorporating New Space.

Melamed, Avishai, et al., "Going to outer space with new space: The rise and consequences of evolving public-private partnerships," *Space Policy* 68 (2024).

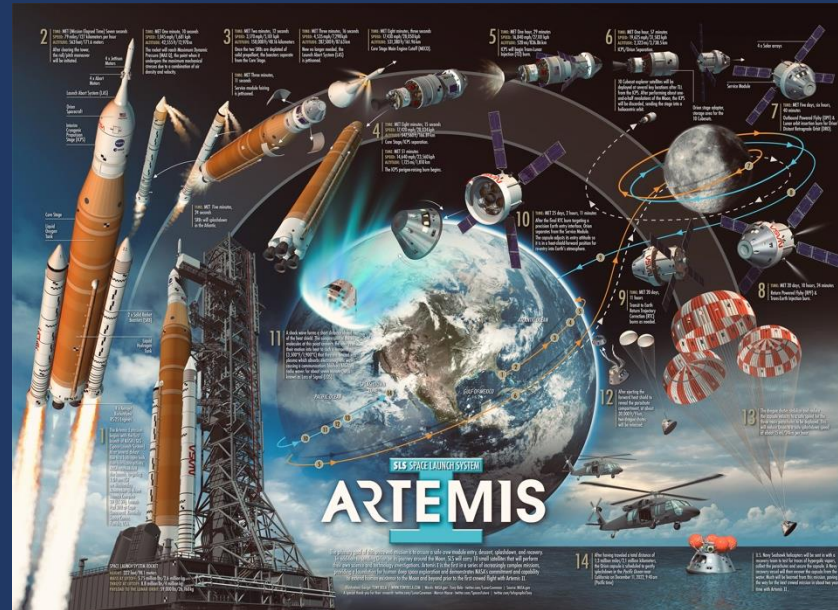
SOA Missions and Entry, Descent and Landing (EDL)

NASA has successfully executed Missions across Solar System

Planetary Probes and Landers, Sample Return and Human Missions (LEO and Lunar).

EDL is more complex:
Requires one or more Parachute during descent and landing a payload adds additional complexity and considerations.

SpaceX furthered the EDL
Cost-effective and reusability
16 Crewed Dragon Missions
32 Cargo Dragon Missions



SOA Missions and Entry Systems Constructs



Missions		Entry System
Human	LEO	Low L/D Blunt Body
	Lunar Return	Low L/D Blunt Body
	Mars Entry	TBD (Large/Heavy Lifting Body)
	Mars Return	TBD (Low or Mid L/D Lifting Body)
Robotic Science	Planetary	Blunt Body - Ballistic or low L/D
	Sample Return	Blunt Body - Ballistic
	Aerocapture	Blunt - Low L/D or Drag Modulated
Commercial (Cargo)	Trans Atmospheric/Hypersonics	Mid L/D Lifting Body
	LEO return	Blunt Body - Ballistic
	Lunar return	Blunt Body - Ballistic
	Sample Return	Blunt Body - Ballistic
	Inner Solar System	Blunt Body - Ballistic



NASA Entry Projects Supported by Ames

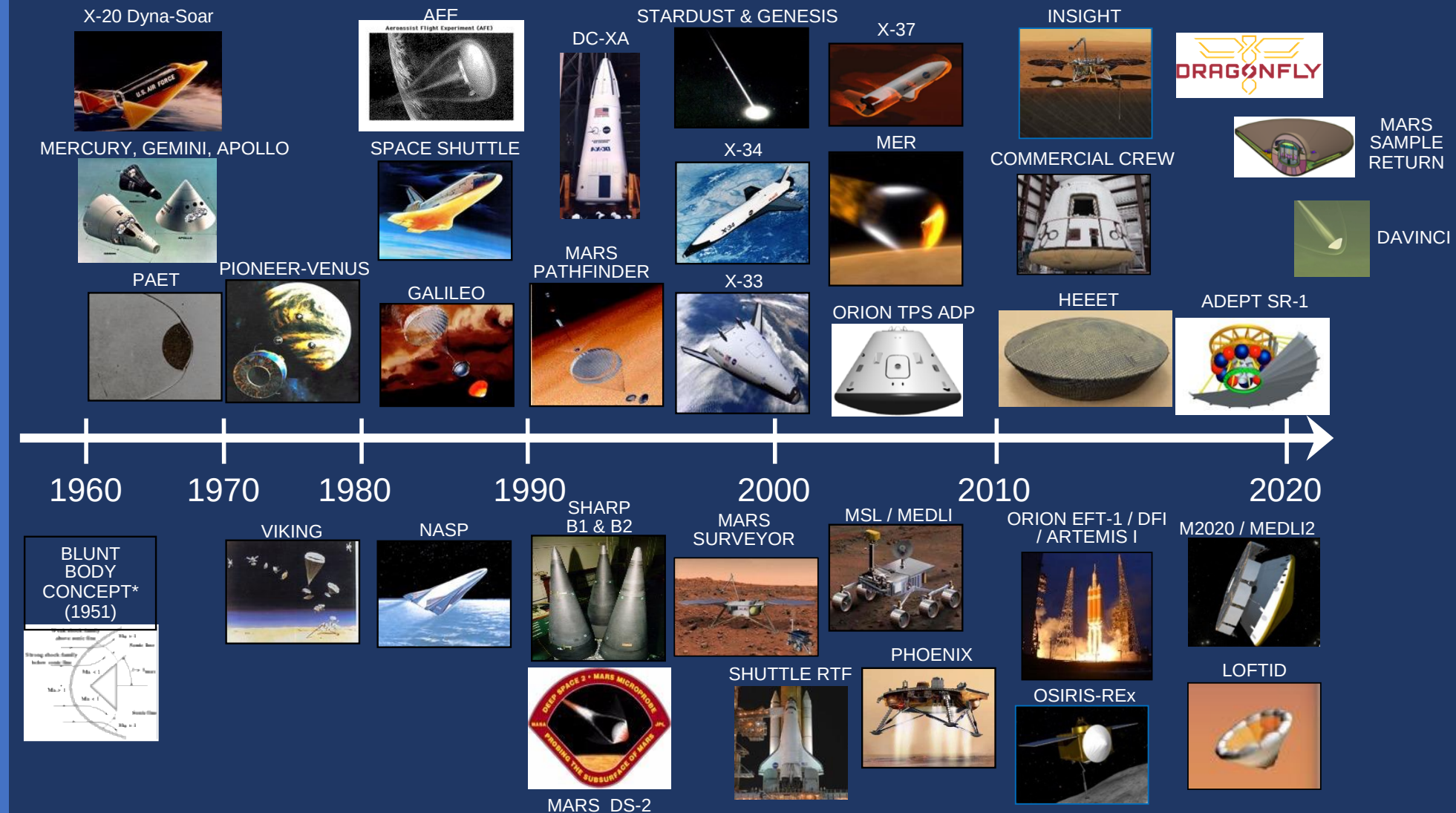
Robotic Science and Human Missions

Technology Demonstrators

Ballistic as well as Lifting Configuration

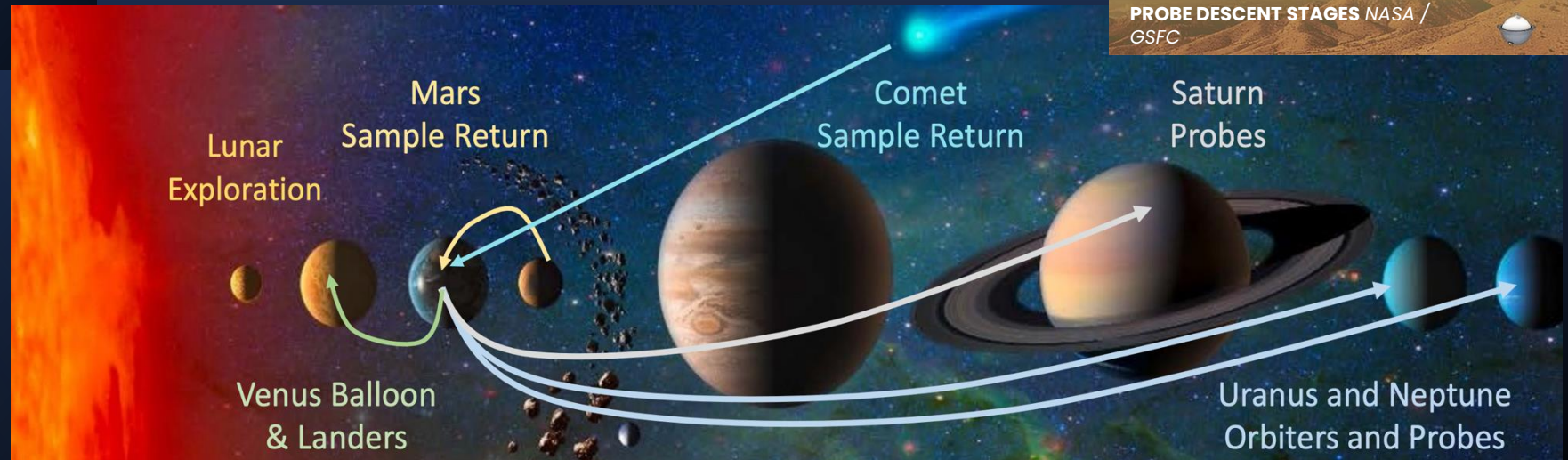
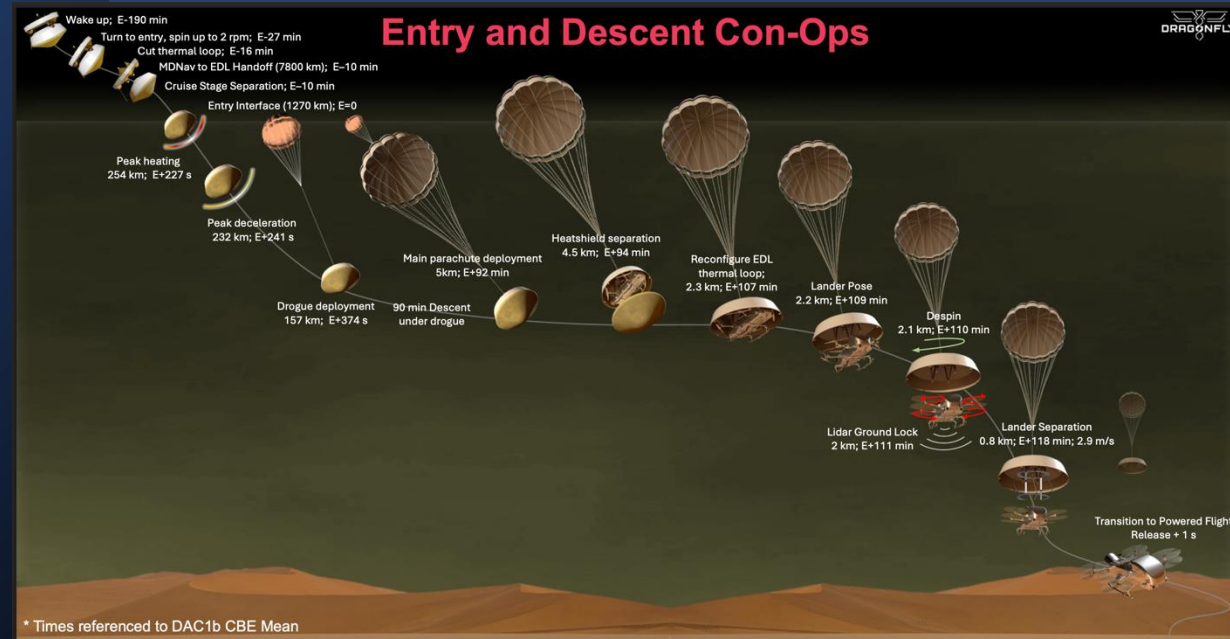
Ablative and Reusable Thermal Protection Systems

Innovative Entry System



Science Missions

- Dragonfly:
PICA-D
- DAVINCI (?)
ACC
- Mars Sample Return (?):
3MDCP
- New Frontiers:
3D Woven
Conformal PICA
- Uranus Orbiter and Probes
3D Woven
Conformal PICA



Commercial Space

Agreements with NASA Ames (2020-2025)

In the last five years, partnerships for entry systems and TPS hardware have grown significantly.

New Space Companies seek NASA expertise and capabilities in Entry Systems not available elsewhere

NASA provided support includes TPS hardware for first few flights based on NASA innovations

NASA technology transfer includes design and analysis tools as well as TPS manufacturing know-how

Partner	Notes
Rocket Lab	Venus Aeroshell
Stratolaunch	Entry Systems Design Analysis
Blue Origin	TPS Material Design
Varda Space Industries	Re-entry Capsule Support
Inversion Space	Re-entry Capsule Support
Canopy Aerospace	TPS Technology Transfer
LANL	Calypso-1 Flight Test – ADEPT Mechanical Deployable
Relativity	Re-entry Capsule Support
Blue Origin	Entry Tech Development – ADEPT
Outpost	Entry Tech Development – ADEPT

Commercial: STRATOLAUNCH

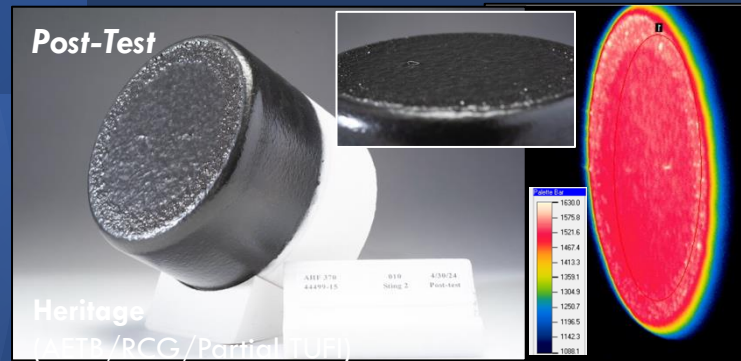
Bringing Shuttle Orbiter TPS into the 21st Century

Challenge:

- Shuttle TPS atrophy due to raw material supply

Solution:

- Modern AETB, TUFI, RCG with new raw materials
- FRSI with a new supplier
- Alternative felt material



Commercial: VARDA

Founded in 2021

Public-Private Partnership

- NASA technology transferred Conformal PICA to Varda under
- Two flight demonstration missions (AFRL & NASA)

Varda's missions leveraged NASA Ames Conformal PICA

1st Reentry February 21, 2024

2nd Reentry February 27, 2025

3rd Reentry May 13, 2025

Capt. Ashwin Rao, PI, (AFRL) designed OSPREE recorded spectral measurement of the plasma in the reentry environment



Inversion Space

Founded in 2021

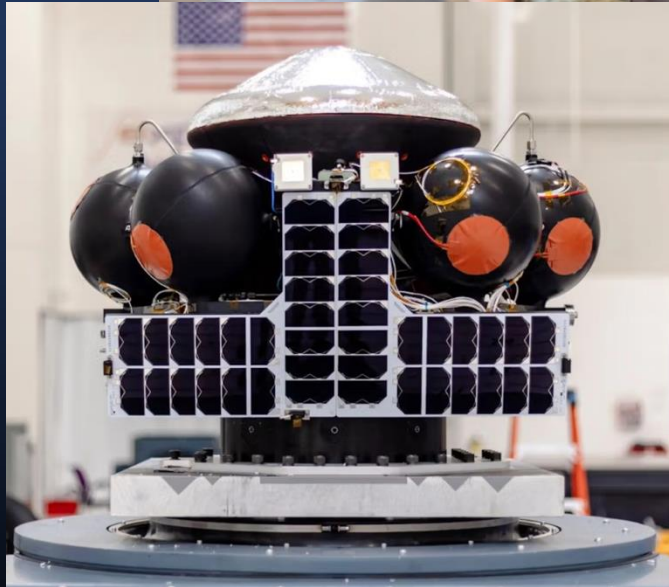
First Mission: Small Probe (Ray)

Approached NASA for TPS

- Conformal PICA heat shield
- Conformal SIRCA back shell
- Launched Jan 2025 on Falcon 9 as rideshare
- Did not de-orbit due to propulsion system malfunction

Second Mission:

- Fully autonomous re-entry vehicle to enable rapid, precision delivery from space
- Inversion has established a Space Act Agreement with NASA Ames to provide expertise in TPS and flight hardware.



Mission to Venus

Rocket Lab

Dec. 2026

First Private Mission to Venus
with NASA support

Science team led by Prof.
Sara Seager, MIT

NASA led the TPS selection
and design

HEEET heat shield and
Conformal SIRCA back shell

NASA Ames manufactured
and integrated



Outpost Deployable Concept

Leveraging NASA developed ADEPT Deployable Heat Shield Technology

Goal is to store supplies in orbit, ready to be deployed on-demand for rapid, precise delivery of critical cargo, such as medical supplies, battlefield equipment, and surveillance drones

Mission Manifest		
Mission	Date	Availability
Ferryall Mission 1	Q4 - 2026	FULLY BOOKED
Ferryall Mission 2	Q4 - 2027	FULLY BOOKED
Ferryall Mission 3	Q2 - 2028	Partially Booked
Ferryall Mission 4	Q3 - 2028	Booking Now
Ferryall Mission 5	Q4 - 2028	Partially Booked
Carryall Mission 1	Scheduling	TBD

Ferryall

Rapid missions to space and back for R&D, TRL raising, and miniature factories

Carryall

Multi-ton returnable platform for full-scale factories and point to point delivery around the world

Breaking News

Outpost selected by US Space Force for \$33.2M Earth return mission program

Learn more

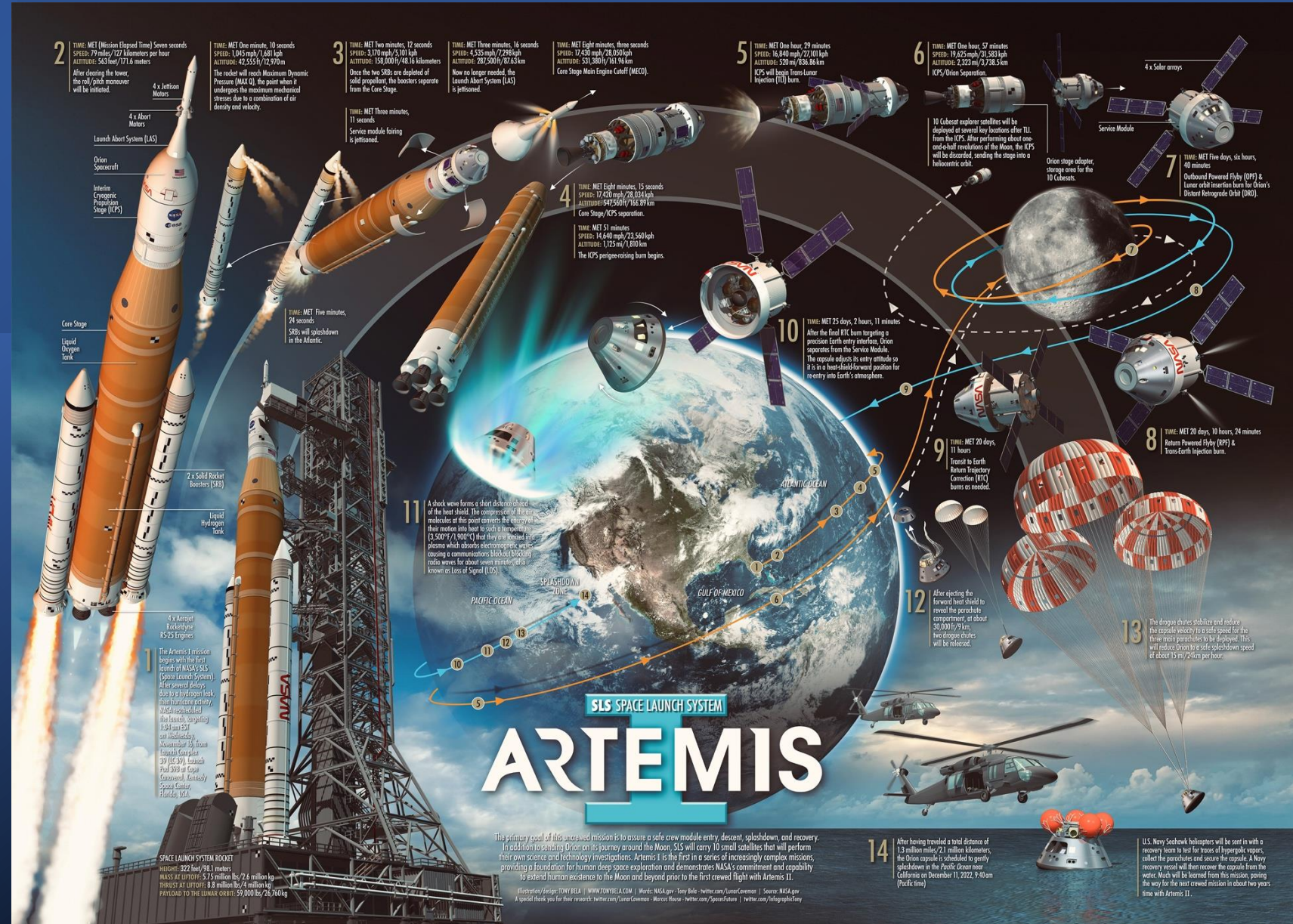
Human Mission

Moon: Human Landing Systems (HLS)

NASA funded SpaceX to develop a crewed lunar lander, specifically the Starship HLS, for the Artemis program.

Orion is designed to bring Astronauts back to Earth.

With SLS and Orion cancellation beyond Artemis III, Artemis mission will use commercial launch and compatible crew return systems.



Human Mission to Mars

EDL Challenges

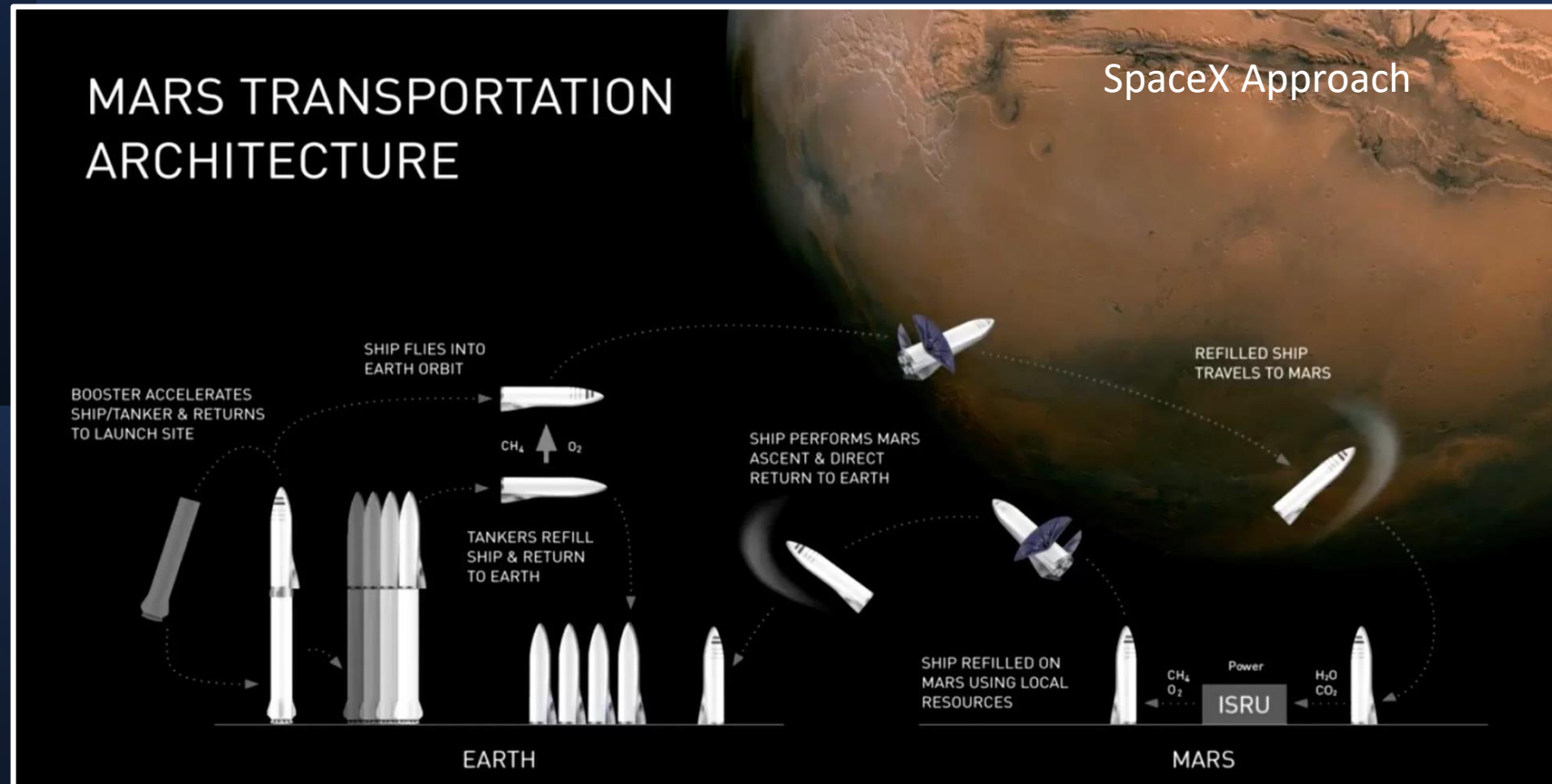
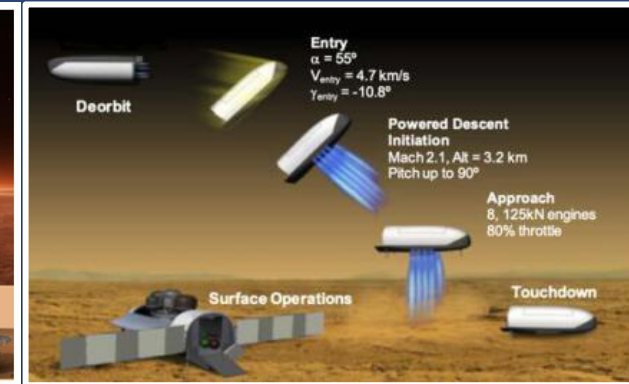
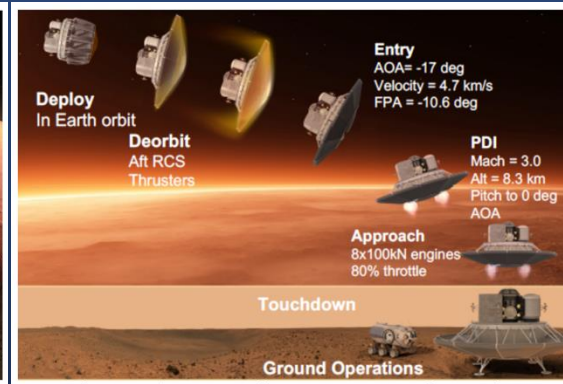
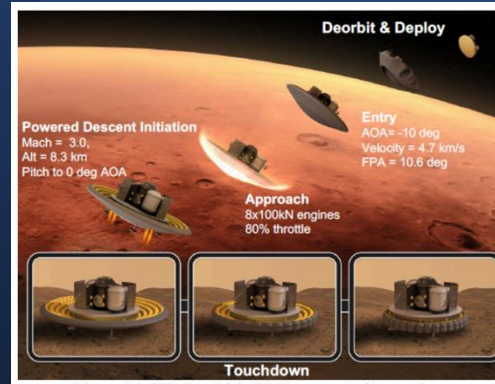
- Entry
- Supersonic Retro Propulsion
- Plume Surface Interaction

NASA Concepts Studied (Entry)

- Inflatable ~ 16m scale
- Deployable
- Mid L/D

SpaceX Approach: Starship

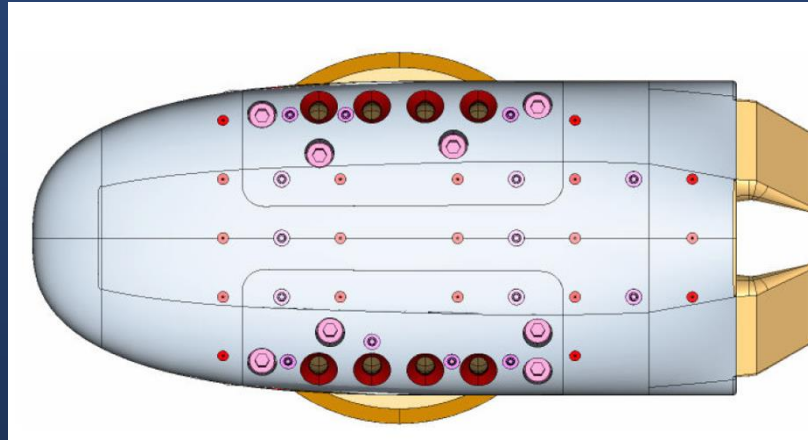
- Refueled in LEO
- Propulsive Landing at Mars
- ISRU fuel for Mars Ascent and Earth Return



NASA's Approach to Mid L/D Concept

Supersonic Retro Propulsion:

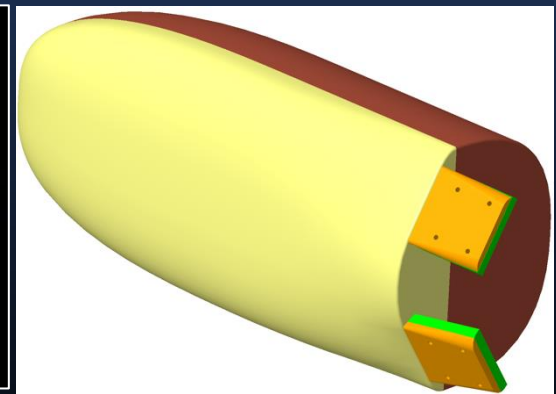
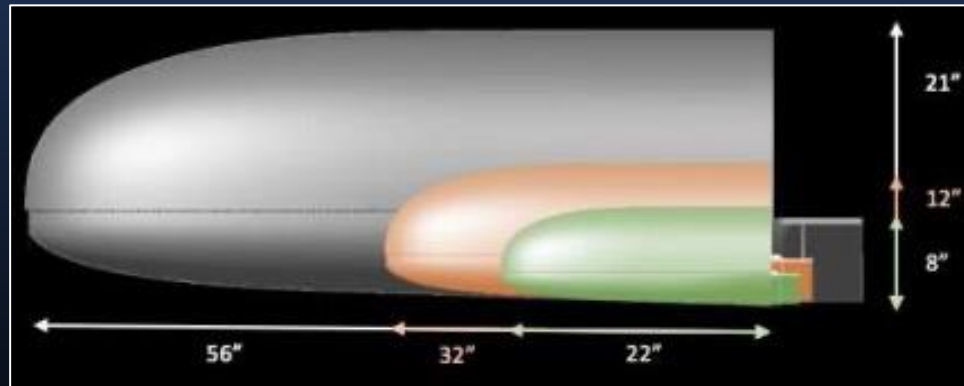
Edquist, Karl T., et al. "Computational Analysis of Two Mars Powered Descent Vehicle Concepts Tested in the Langley Unitary Plan Wind Tunnel." AIAA AVIATION FORUM AND ASCEND 2024. 2024.



HyperStep: A Sub-scale Demonstrator / Test-bed

Breanna Johnson, JSC (PI/PM)

- LEO/ Lunar Return with Precision Landing, DoD Hypersonics, Human Mars, Sustaining NASA Expertise
- Conformal PICA & HEEET





President's Proposed FY 2026 Budget

Advancing Human Space Exploration

Public-Private Partnership

EDL Community is in a better place to address the challenges and adapt to changes.

1. NASA's demonstrated EDL expertise will continue to be needed for Lunar return, Mars exploration and Mars return in the near- and longer-term.
2. Commercial (New) Space Companies see the benefit of leveraging NASA developed technologies in TPS and Entry Systems and are adopting them.
3. NASA developed TPS, and yet to be demonstrated Aerocapture, Deployable and Inflatable novel entry system concepts will benefit Commercial, Human Mars and Science missions.
4. NASA's EDL community is better prepared to address the challenges, once the vision towards Mars is firmed up and the approach is articulated.

Concluding Remarks

- Global investment in Space and New Space Commercial Companies are altering the pace of development and will attract more investment.
- NASA's vision need to be reconciled with anticipate budget (reduction) and a success-oriented implementation plan need to be developed.
- The future presents both opportunities and challenges for the EDL community.
 - NASA's expertise in entry systems and TPS technologies are sought after by commercial space today.
 - Emerging role for NASA, commensurate with the budget, need to focus on innovations in low TRL technologies and sustaining expertise/capabilities

ESI - Advancement of Additive Manufacturing Techniques for High Temperature Materials



- **Early-Stage Innovations (ESI)** accelerate the development of groundbreaking, high-risk/high-payoff space technologies.
- **ESI Topic : Advancement of Additive Manufacturing Techniques for High Temperature Materials**
 - Develop additive manufacturing processing techniques for refractory metals and alloys.
 - Three awards - TAMU, CMU, and CU Boulder.
- **Potential Application Areas:**
 - High temperature thermal management systems are a potentially disruptive technology to a broad range of applications.
 - High temperature two phase heat transfer devices have a broad application to a variety of NASA technologies and missions, many of which are enabled by additive manufacturing. Some applications include:
 - **Hypersonic wing leading edges**
 - Plasma-Facing Components (PFC's) in magnetic confinement fusion devices
 - Nuclear Thermal Propulsion

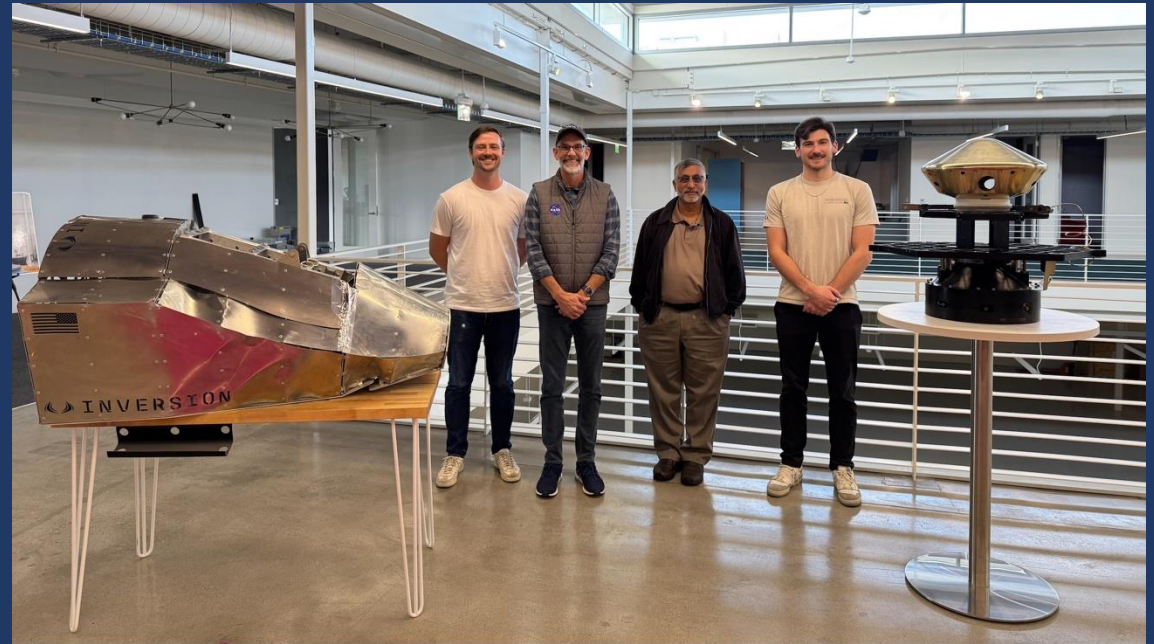


Inversion Space

- **Justin Fiaschetti approached us through LinkedIn on January 7, 2021.**
- Inversion Space was founded on January 22, 2021 by Austin Briggs and Justin Fiaschetti. In April 2021, it had only 3 employees; Austin, Justin, and Daniel Bradford.
- Inversion currently has a capsule in orbit with a heatshield and back shell provided by Ames.



Austin Briggs and Justin Fiaschetti



Austin Briggs, Matt Gasch (NASA ARC), Raj Venkatapathy (NASA ARC), and Daniel Bradford on February 28, 2025

ACO - Additively Manufactured TPS Arc Jet Performance Evaluation



- TPS prototypes from 9 vendors evaluated in a collaborative ACO led by Cornerstone Research Group
 - Partners: Nanosonic, KAI Inc / Univ of Delaware, Sporian, Goodman Technologies, TX Research Inst. / Texas State Univ, Northrop Grumman, Re:3D, Raven3D, NASA-ARC/JSC & ORNL
- Exploratory activity to assess baseline materials developed under an STTR Phase 1, perform under representative entry conditions
- Lessons learned from the first round of testing used to refine materials and processes



June 9, 2025



Pre-Test



Post-Test

TPS Products and Services Supporting Commercial Space



Support commercial space in TPS design, TPS selection, technology demonstration hardware fabrication, integration approach development, tools transfer (e.g. sizing tools), TPS technology transfer and capability establishment at commercial partner facility

Ames Low and Mid Density Ablator Products

- Low density carbon phenolics – PICA family
 - PICA – Phenolic Impregnated Carbon Phenolic
 - C-PICA – Conformal PICA
 - PICA-FLEX – low density flexible carbon phenolic
 - Material Classes (Flexibles, Conformables, Woven)
- Mid density carbon phenolics – 3-D woven
- HEEET 3-D woven
- 3MDCP – 3D woven

Ames Reusable TPS Products

- Silica-based Reusable Tiles and coatings (derived from shuttle heritage)
- TUFROC

Other TPS Product

- SIRCA – oxide-based ablator
- 3D-MAT – high density ablator suited for structural/TPS applications
- Flight Instrumentation & Hardware

Ames Entry System Services

- Material Selection, TPS manufacturing and integration support
- TPS Sizing, Aerothermal, Thermo-mechanical Analysis
- Materials Characterization & Testing
- Systems Analysis & Margins
- Arc Jet Testing support – model design to extract needed information during test
- Agreements, IP, Licensing, & Technology Transfer



Supported Inversion Space first mission – provided provided the C-PICA and SIRCA TPS materials and integrated the TPS onto the Inversion provided structure under a Reimbursable Space Act Agreement

SBIR - Novel Diagnostic Tools for Production of 3-D Woven TPS

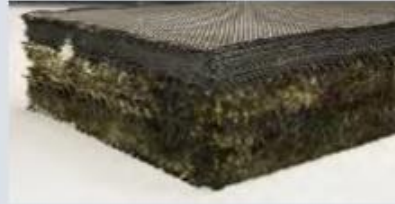


HEEET

Dual-or
Single-Layer
24" Wide
Preform



Dual Layer Preform



Bally Ribbon Mills



Tiles and Seams



1m diameter (ETU)

- Bally Ribbon Mills (BRM) developed a diagnostic tool to measure and monitor the motions of a loom to detect problems early so defective material is kept to a minimum.
- Advancement valuable for scale up - critical to understand the dynamics of the 3D weaving equipment
- Loom capable of diagnosing variables and automatically adjust to ensure consistent high quality preforms

Stratolaunch: Bringing Shuttle Orbiter TPS into the 21st Century

- Arc Jet testing of modernized tile material variants (AETB/TUFI/RCG), modernized FRSI blankets and alternative blanket material

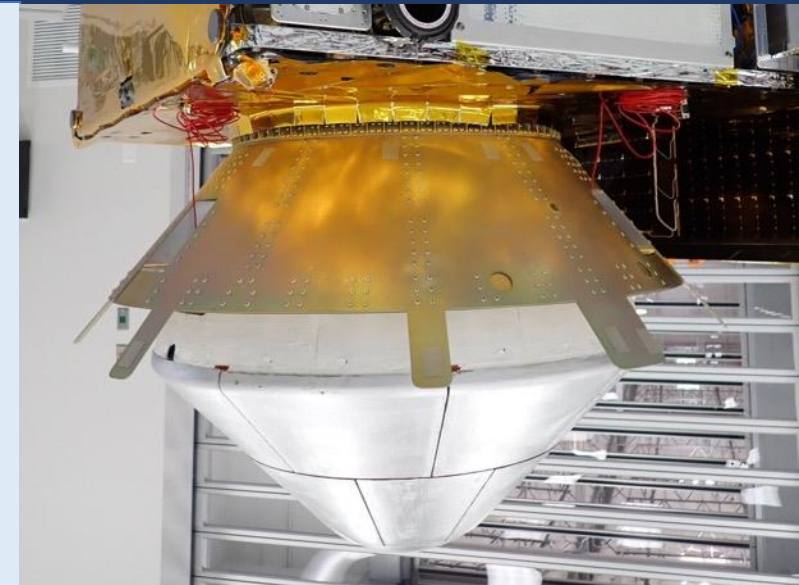
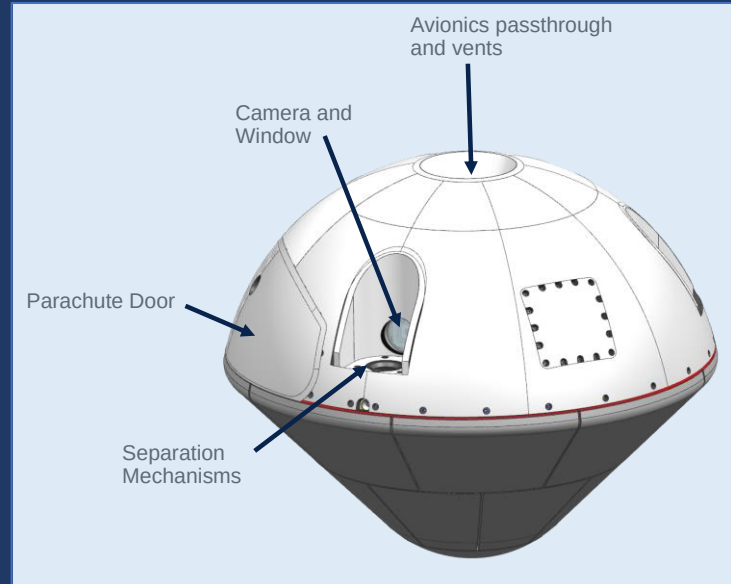


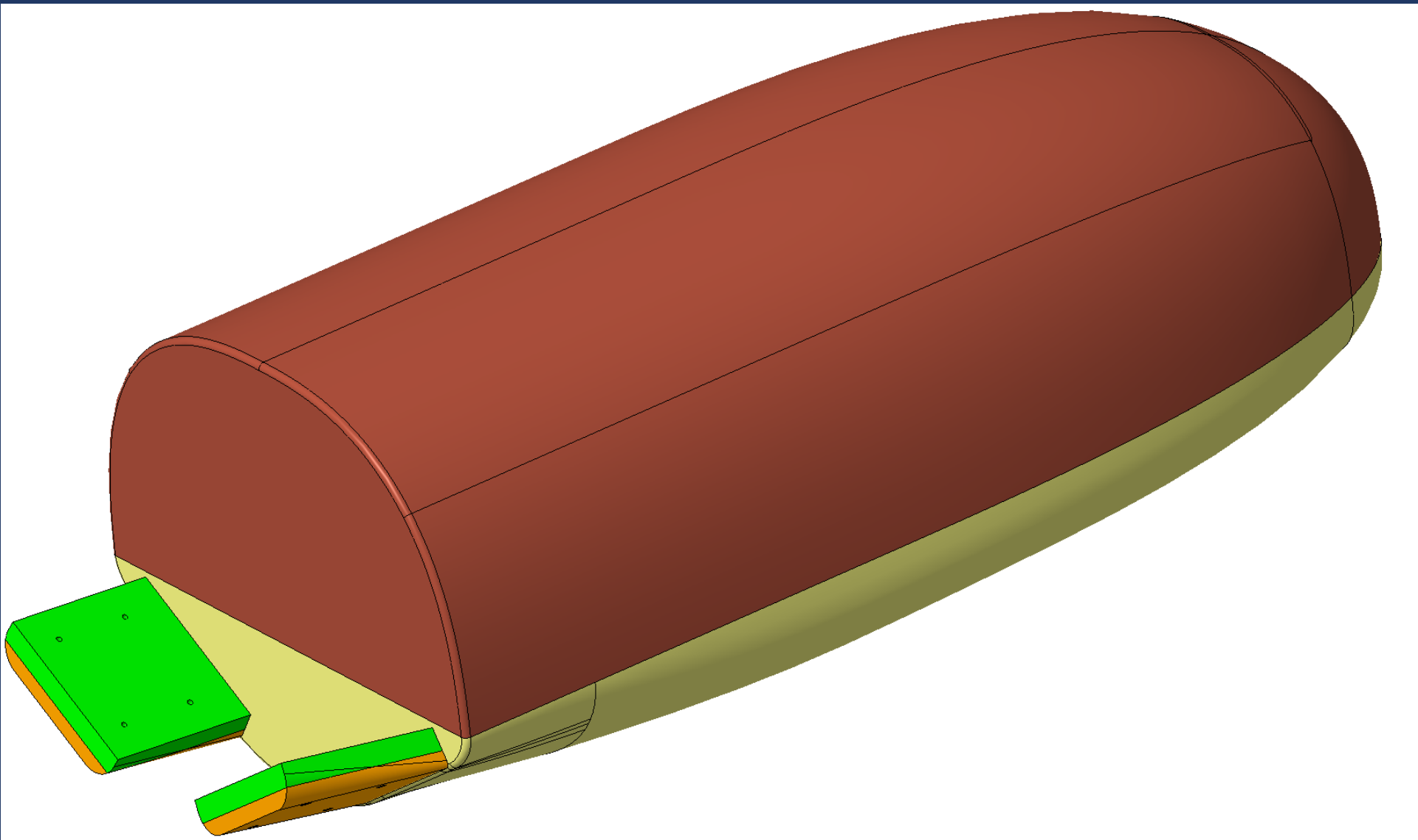
- Demonstrated the viability of modern AETB, TUFI, RCG made with new raw materials and FRSI made via a new supplier plus an alternative felt material
- Stratolaunch is flying the modernized versions tested in this ACO on Talon-A
- NASA's Orion program can leverage these results as Shuttle raw material supplies dwindle and run out during Orion's lifetime
- NASA partners for Commercial Cargo and Human Landing System, plus other aerospace companies using these materials, can leverage the results

SAA, Tipping Point and IAA- Varda Space Industries Hypersonic Testbed

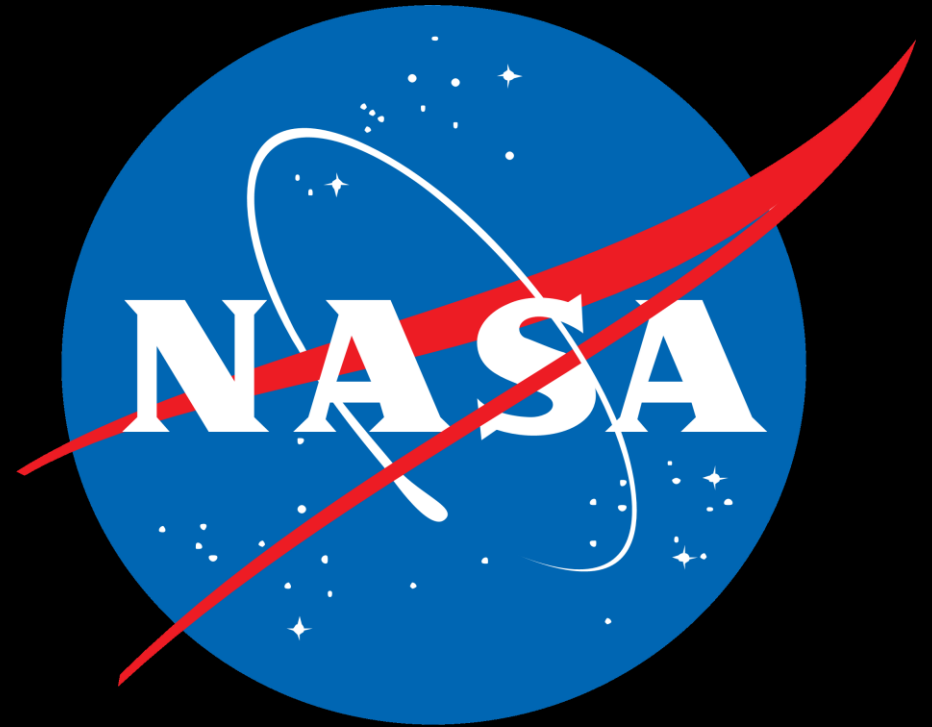


- Varda Space Industries, founded in 2021, launched their first commercial mission in 2023 and returned an in-space manufactured pharmaceutical product in 2024 at UTTR.
- NASA Ames manufactured and provided Conformal-PICA to Varda and enabled the first successful reentry technology demonstration.
- NASA Ames then technology transferred C-PICA to Varda via an STMD Tipping Point.
- AFRL STRATFI: Varda is flying two demonstration missions in CY25 and CY26 under a NASA-AFRL-Varda public-private partnership at a total value of \$60M.
- NASA providing instrumented TPS and collecting performance data. The information will help refine thermal protection systems, sensor designs, and aerodynamics for hypersonic vehicles.





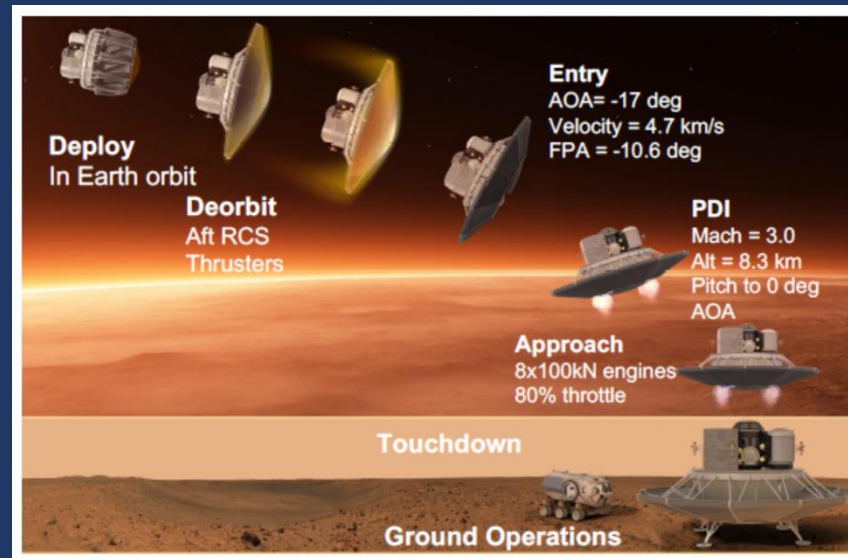
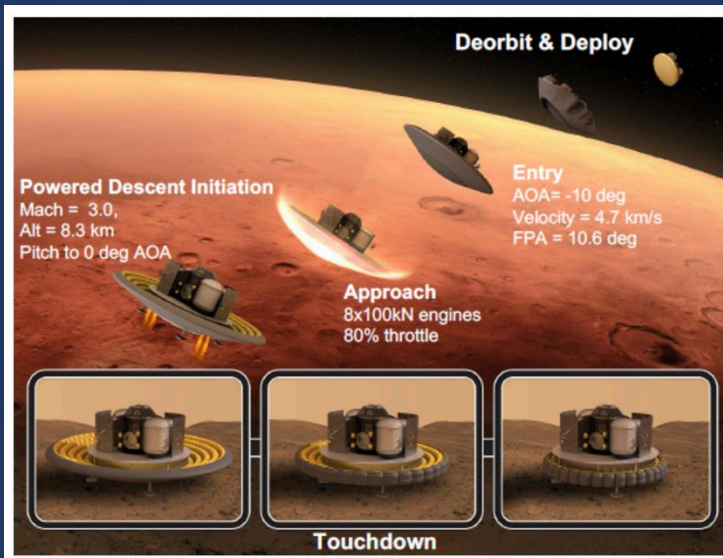
National Aeronautics and Space
Administration



Ames Research Center
Entry Systems and Technology Division



Human Mars: EDL Architectures



Polsgrove, Tara, et al. "Human mars entry, descent, and landing architecture study: Deployable decelerators." *2018 AIAA SPACE and Astronautics Forum and Exposition*. 2018.

Missions and EDL Architecture



Future : Public-Private Partnership

Public-private partnerships create not only new opportunities but also new risks.

- **The flow of government funding to New Space, on top of market growth, has greatly empowered these actors.**
 - However, their participation in public-private partnerships does not guarantee an alignment of public and private interests, leaving much room for divergences that we have already begun to observe.
 - These divergences become especially problematic as New Space's integration blurs the boundaries between public and private sectors, posing a challenge for international space law and global governance.
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"Going to outer space with new space: The rise and consequences of evolving public-private partnerships,"
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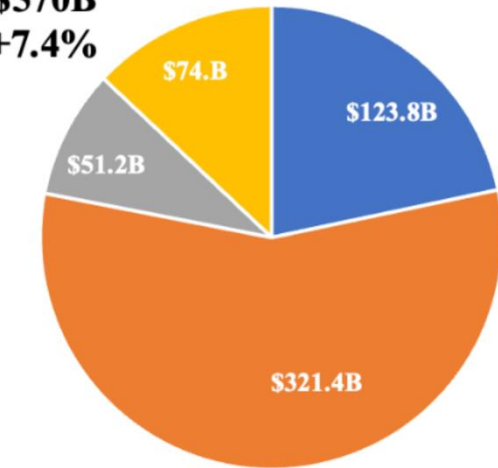
Emerging Paradigm – Public-Private Partnership



- With \$15B a year going into start-up space companies as of **2021**, there were growing signs of a likely paradigm shift in NASA's role for the country.

Global space activity by category, 2023

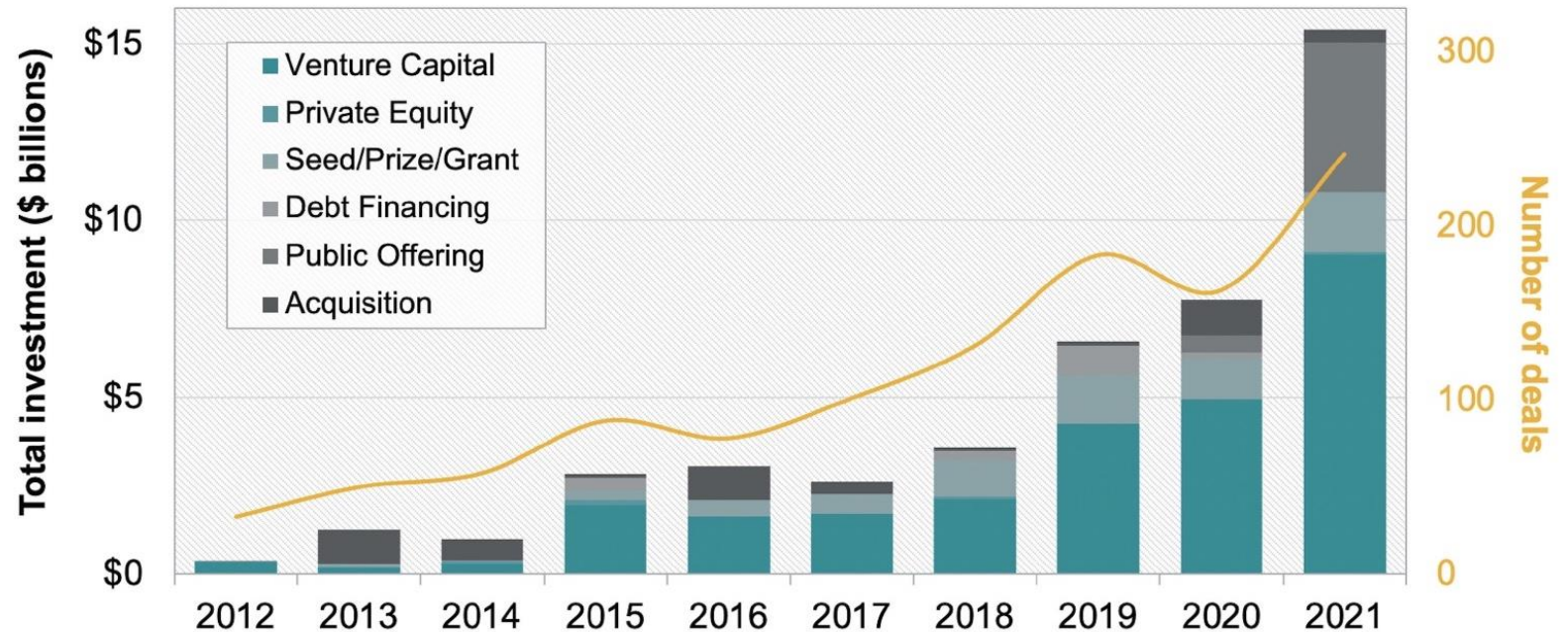
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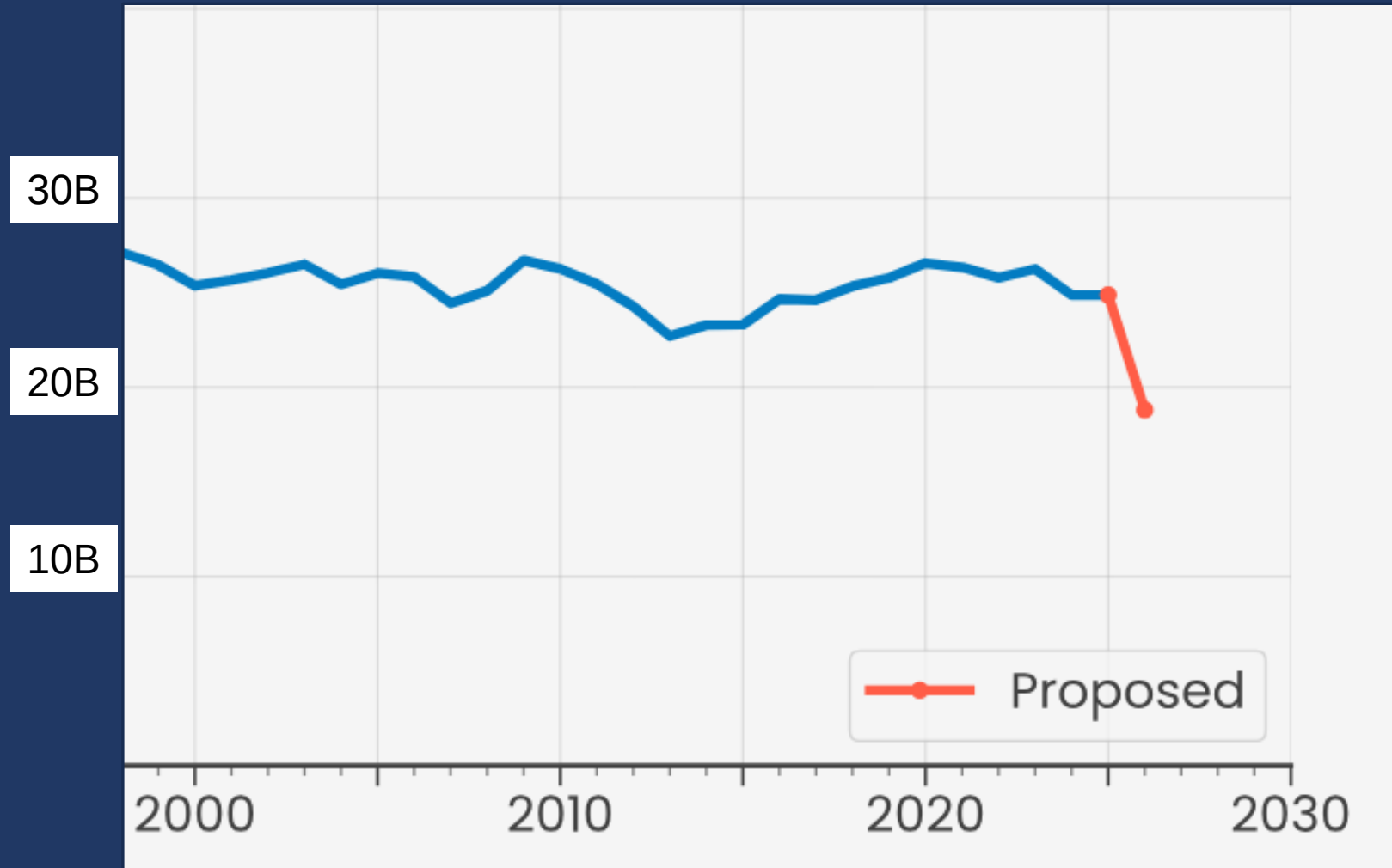
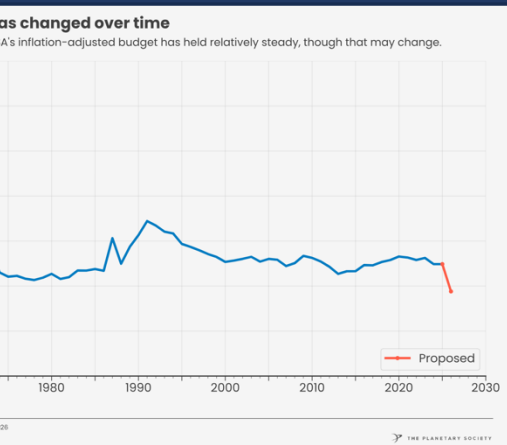
- Commercial Infrastructure and Support Industries
- Commercial Space Products and Services
- Non-U.S. Government Space Budgets
- U.S. Government Space Budgets

Source: Space Foundation database

Investment in Start-Up Space Companies
2012 to 2021, by Investment Type



NASA Budget



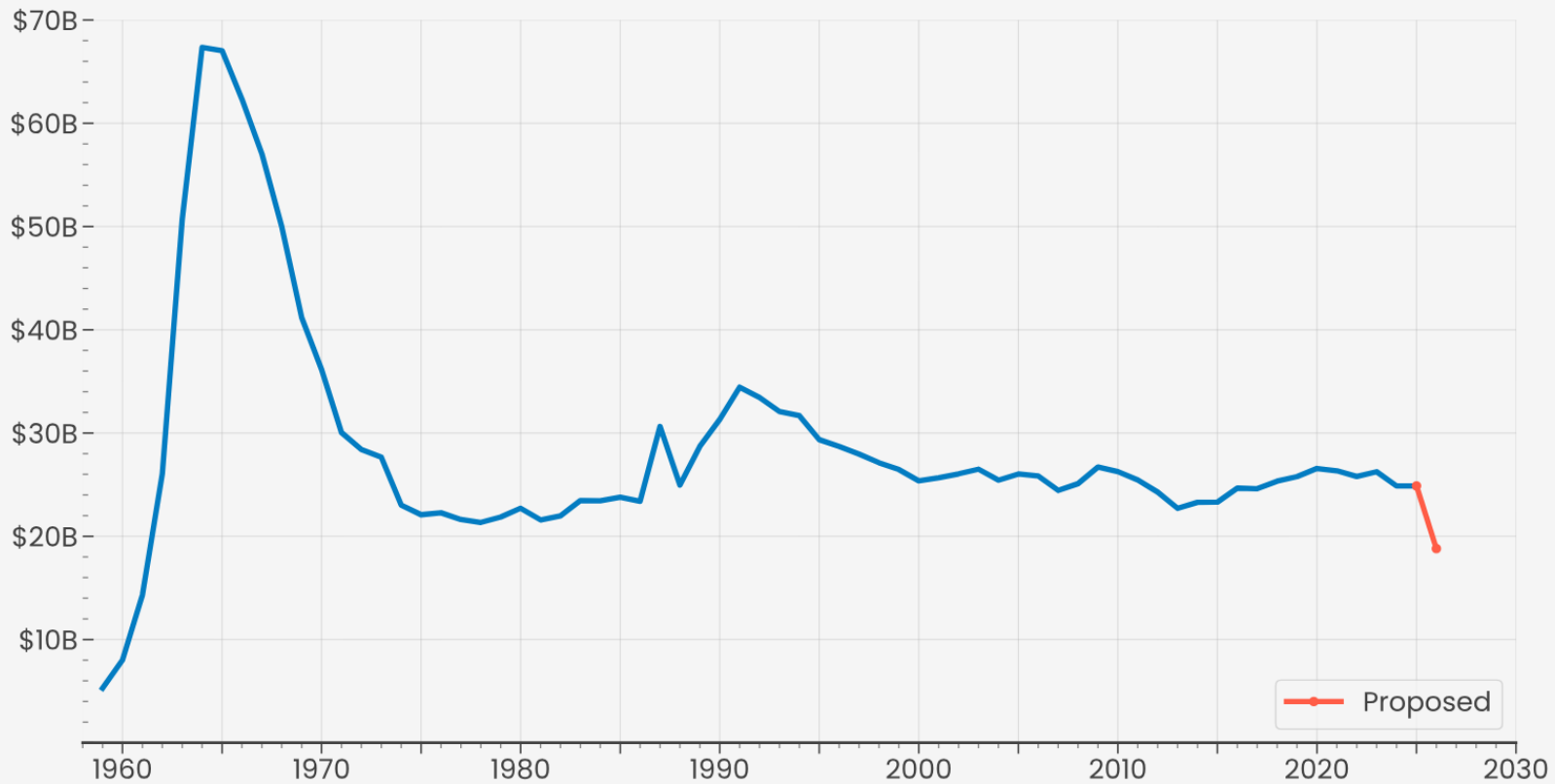
Source: NASA Budget Justification, FY1961-2026.

Planetary Society

- NASA Budget

How NASA's budget has changed over time

After its peak during Apollo, NASA's inflation-adjusted budget has held relatively steady, though that may change.

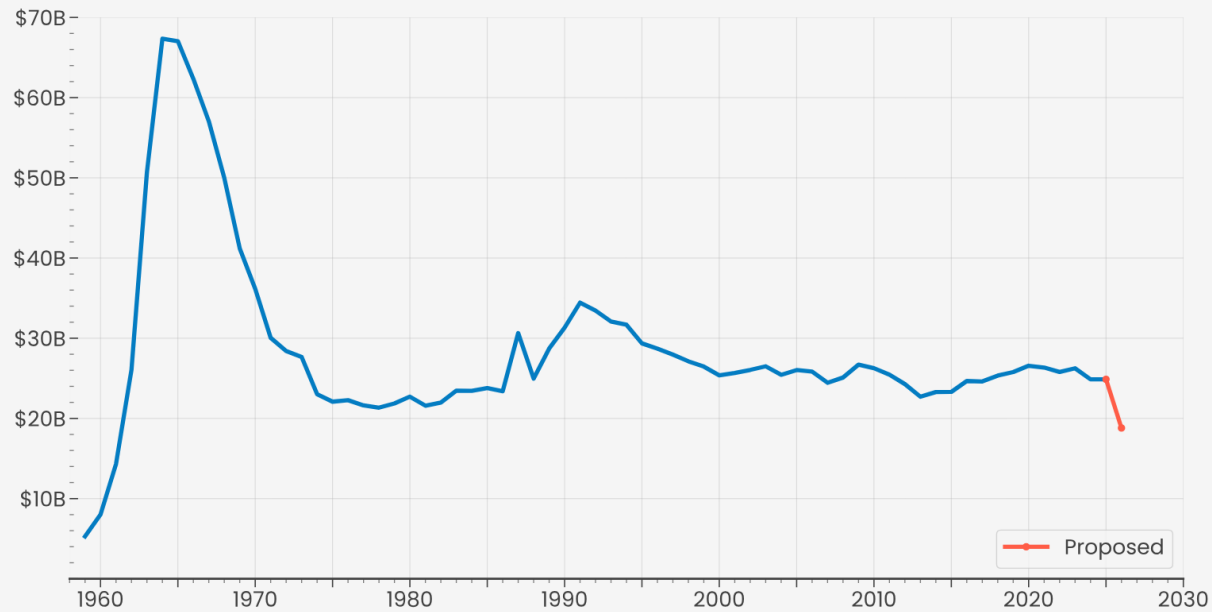


SOURCE: NASA BUDGET JUSTIFICATIONS, FYS 1961–2026

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How NASA's budget has changed over time

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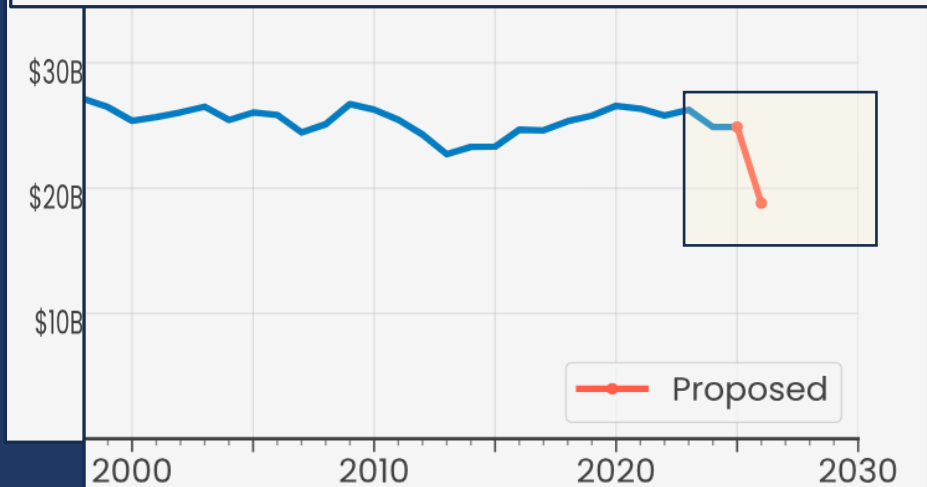


SOURCE: NASA BUDGET JUSTIFICATIONS, FYS 1961-2026

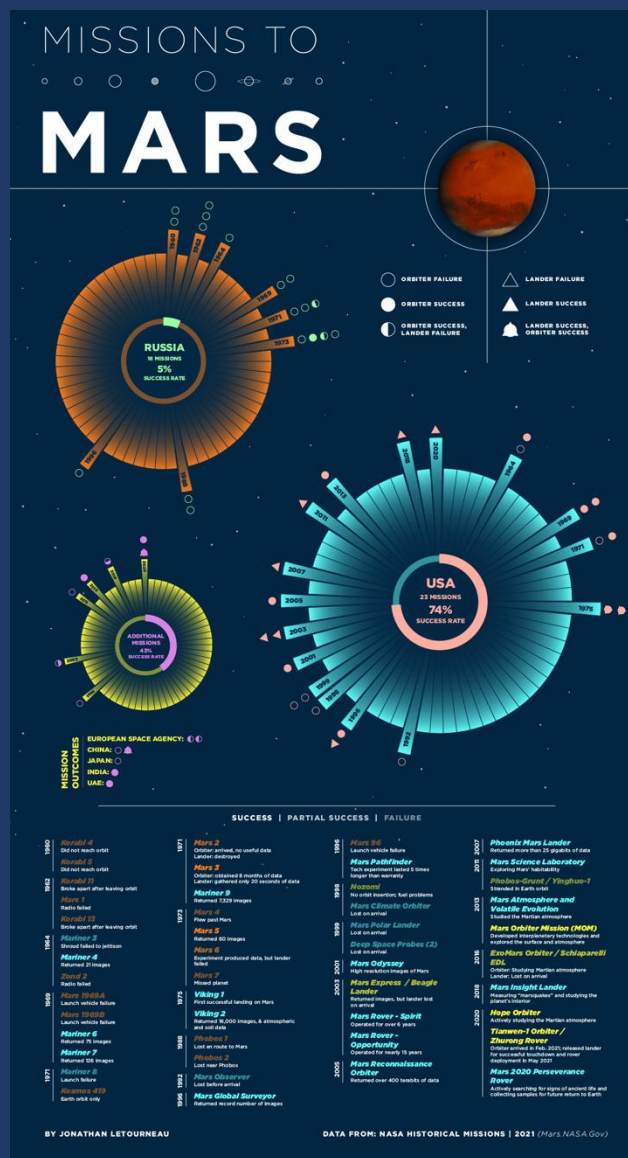
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How NASA's budget has changed over time

After its peak during Apollo, NASA's inflation-adjusted budget has held relatively steady, though that may change.



THE PLANETARY SOCIETY



<https://www.visualcapitalist.com/cp/every-mission-to-mars/>

MOON LANDINGS

United States Soviet Union China India
★ → Significant events



Significant Events

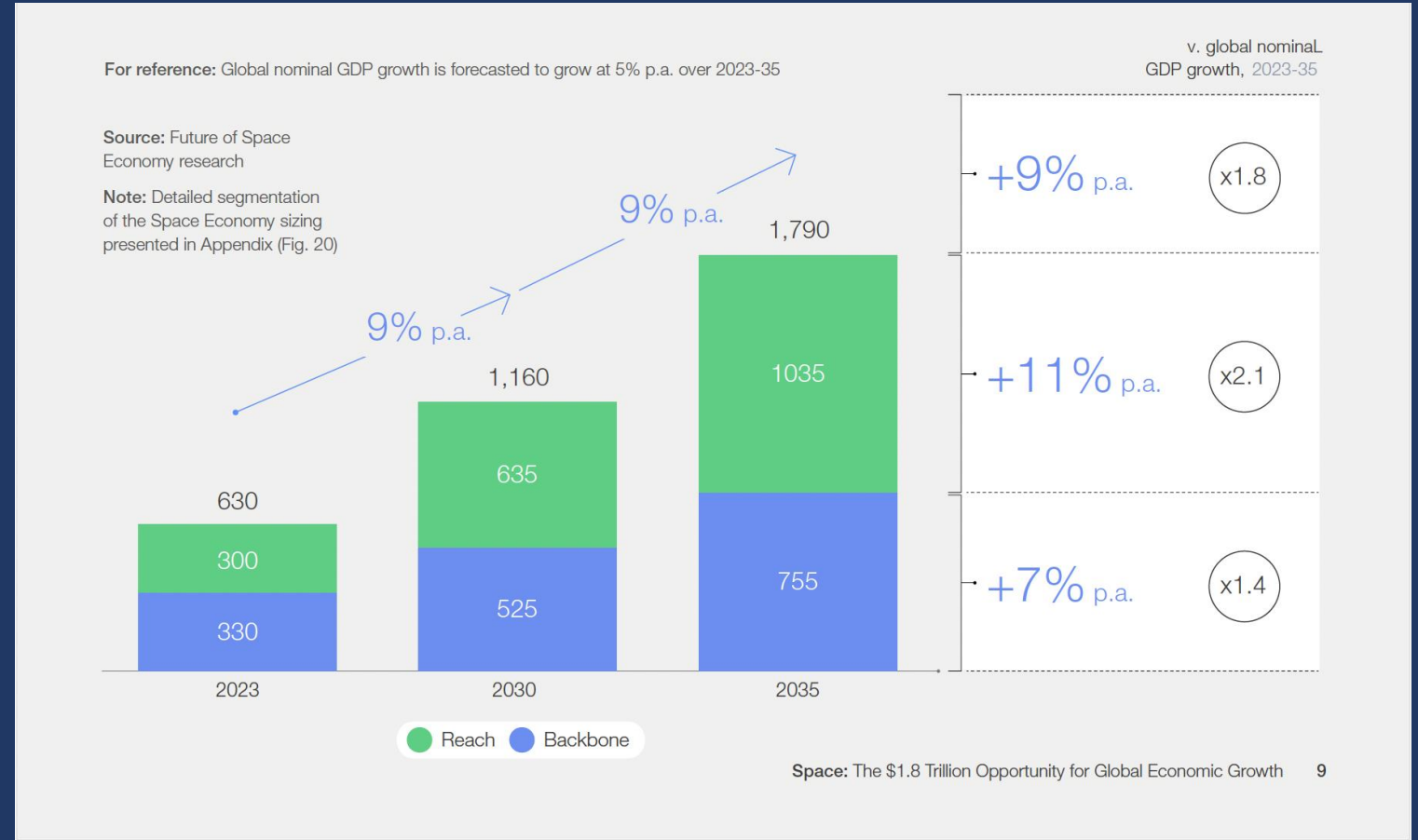
Soviet Union Luna 9 First spacecraft to land successfully on the Moon. Touchdown on 3 February 1966 at 18:45:30 UTC.	United States Surveyor 1 Landed in Oceanus Procellarum on 2 June 1966. First lunar soft lander by NASA.	United States Surveyor 7 Final Surveyor mission. Landed 28 kilometres (18 mi) from Tycho crater on 10 January 1968.
United States Apollo 11 First crewed landing on the Moon. The Lunar Module Eagle landed at 20:17 UTC on 20 July 1969.	Soviet Union Luna 16 First robotic sampling mission.	United States Apollo 17 Sixth and last crewed lunar landing and last use of the Lunar Roving Vehicle; the orbiting command module included five mice.
Soviet Union Luna 24 Entered orbit on 11 August 1976 and landed in Mare Crisium on 18 August 1976. Final mission to the Moon from the Soviet Union.	China Chang'e 4 First spacecraft to soft land on the far side of the Moon. Landed 3 January 2019 and deployed the Yutu-2 rover.	India Chandrayaan-3 Launched on 14 July 2023, landed on 23 August 2023 at 12:32 UTC. First mission to soft land near the lunar South Pole.

Landing Attempts

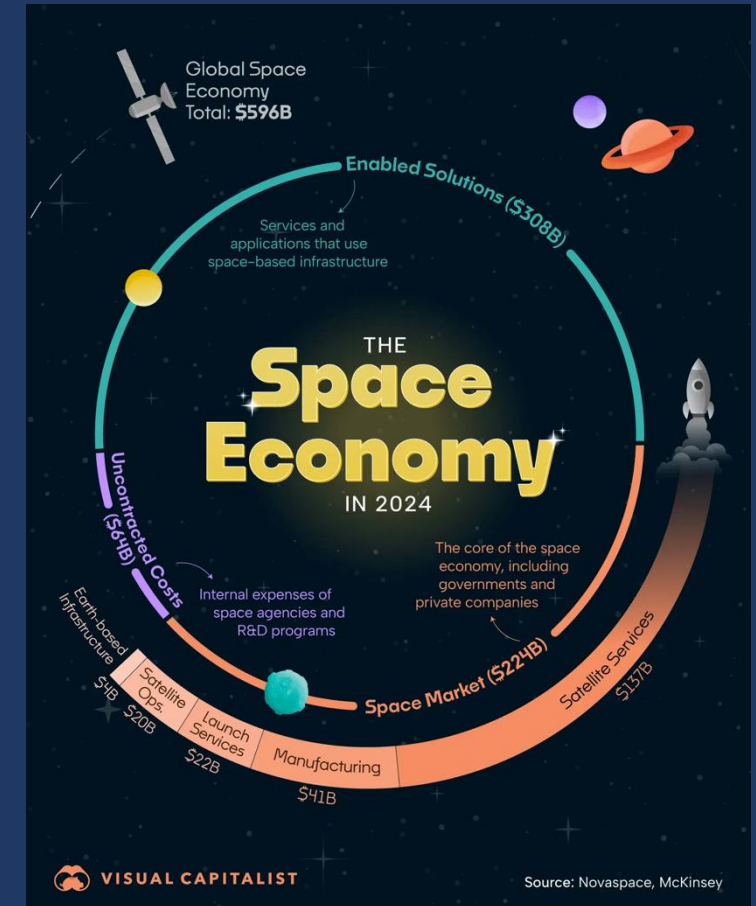
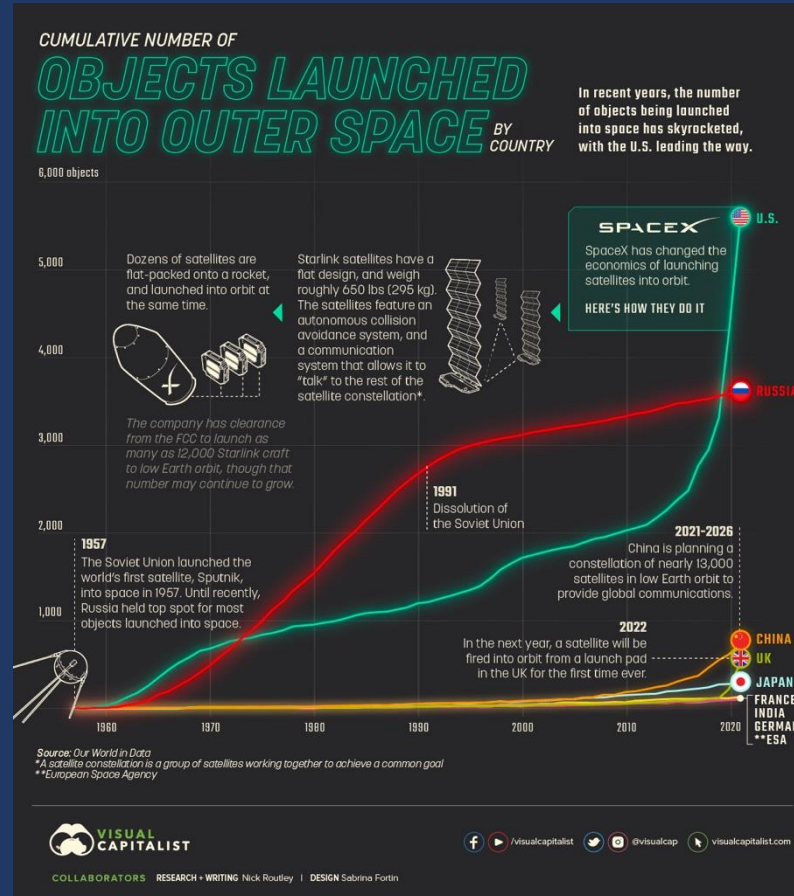
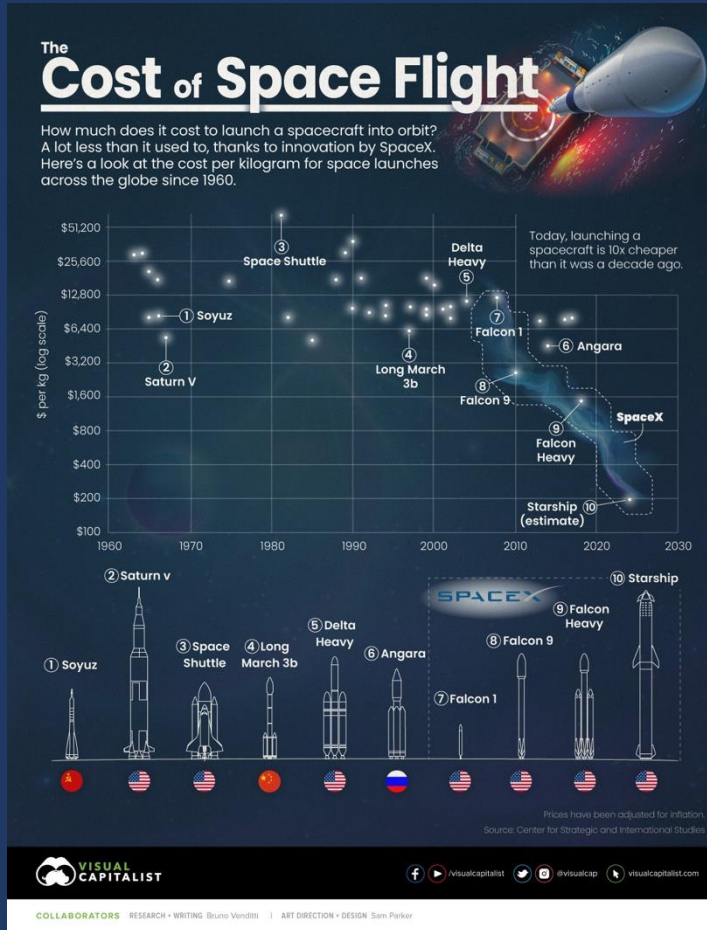


<https://www.visualcapitalist.com/cp/visualizing-all-attempted-and-successful-moon-landings/>

- \$630 billion annual revenue in 2023, growing to \$1.8 trillion per year by 2035 at a 9% p.a. overall growth rate.
- Investments in space startups rose 12% to \$8.1 billion in the 12 months to March, with the number of deals in Europe rising nearly 50% in the first quarter on bigger European Union budgets and a renewed focus on self-reliance.



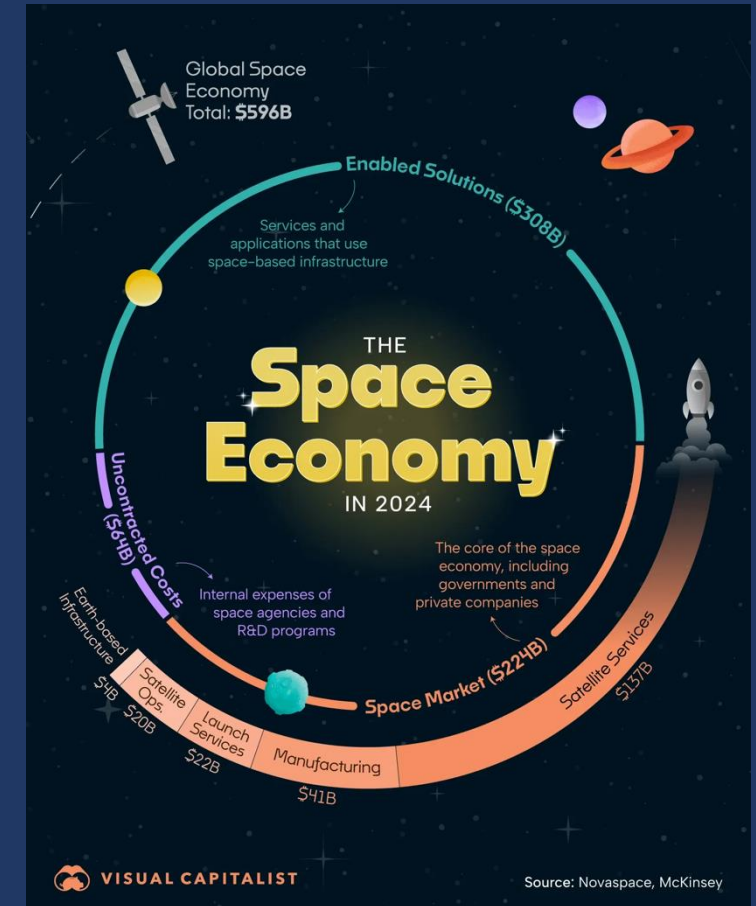
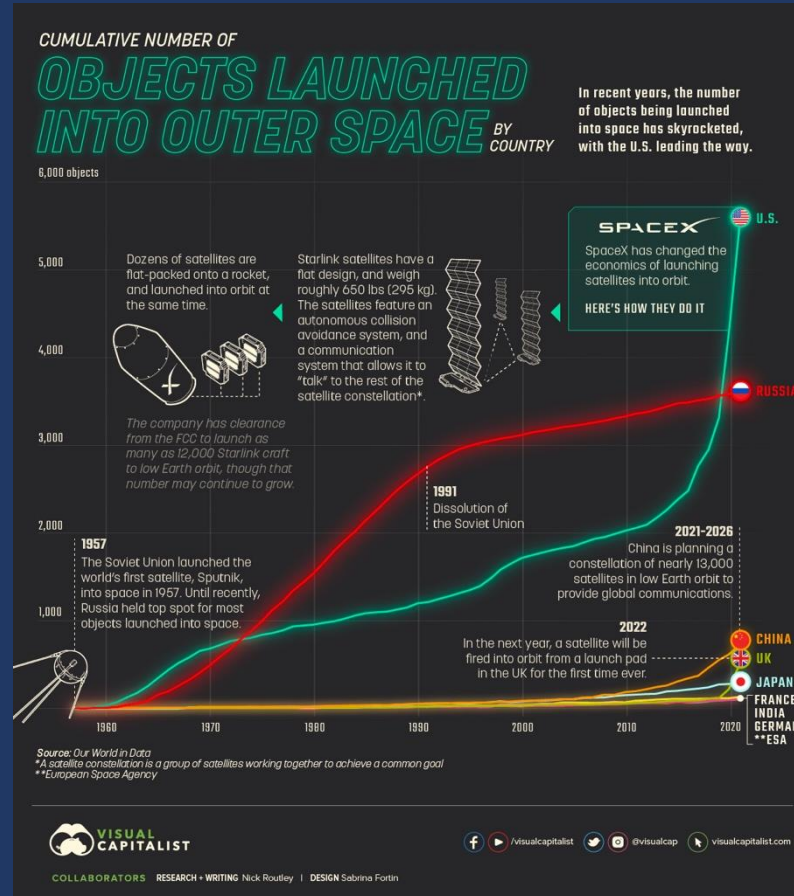
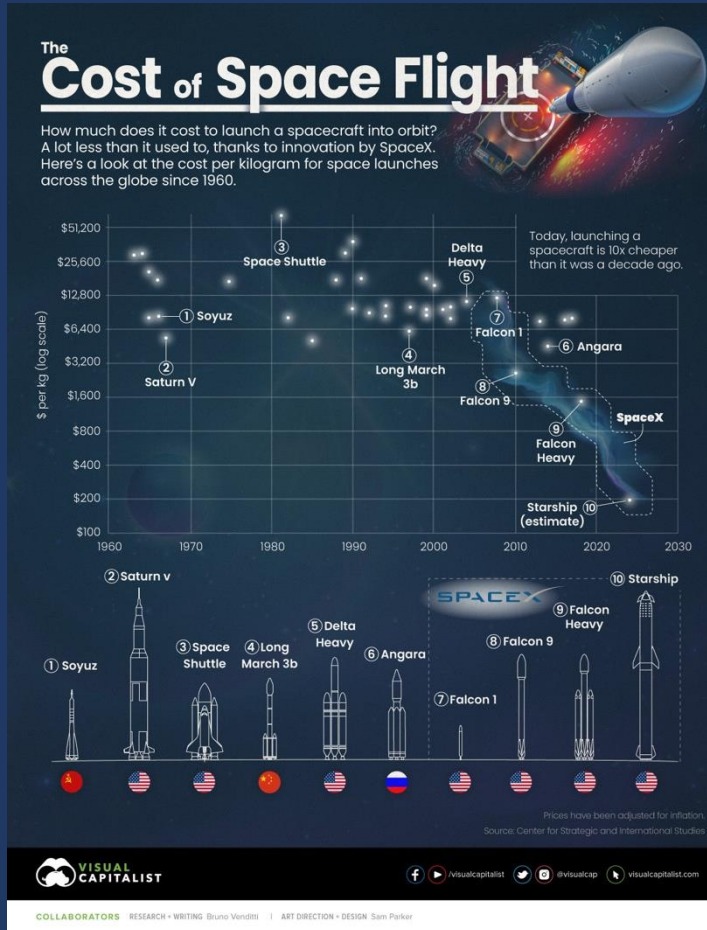
From: World Economic Forum Report on Space: The \$1.8 Trillion Opportunity for Global Economic Growth INSIGHT REPORT APRIL 2024



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- <https://www.visualcapitalist.com/visualized-which-countries-are-dominating-space/>

<https://www.voronoiaapp.com/space/How-Big-Is-the-Space-Economy--3979>



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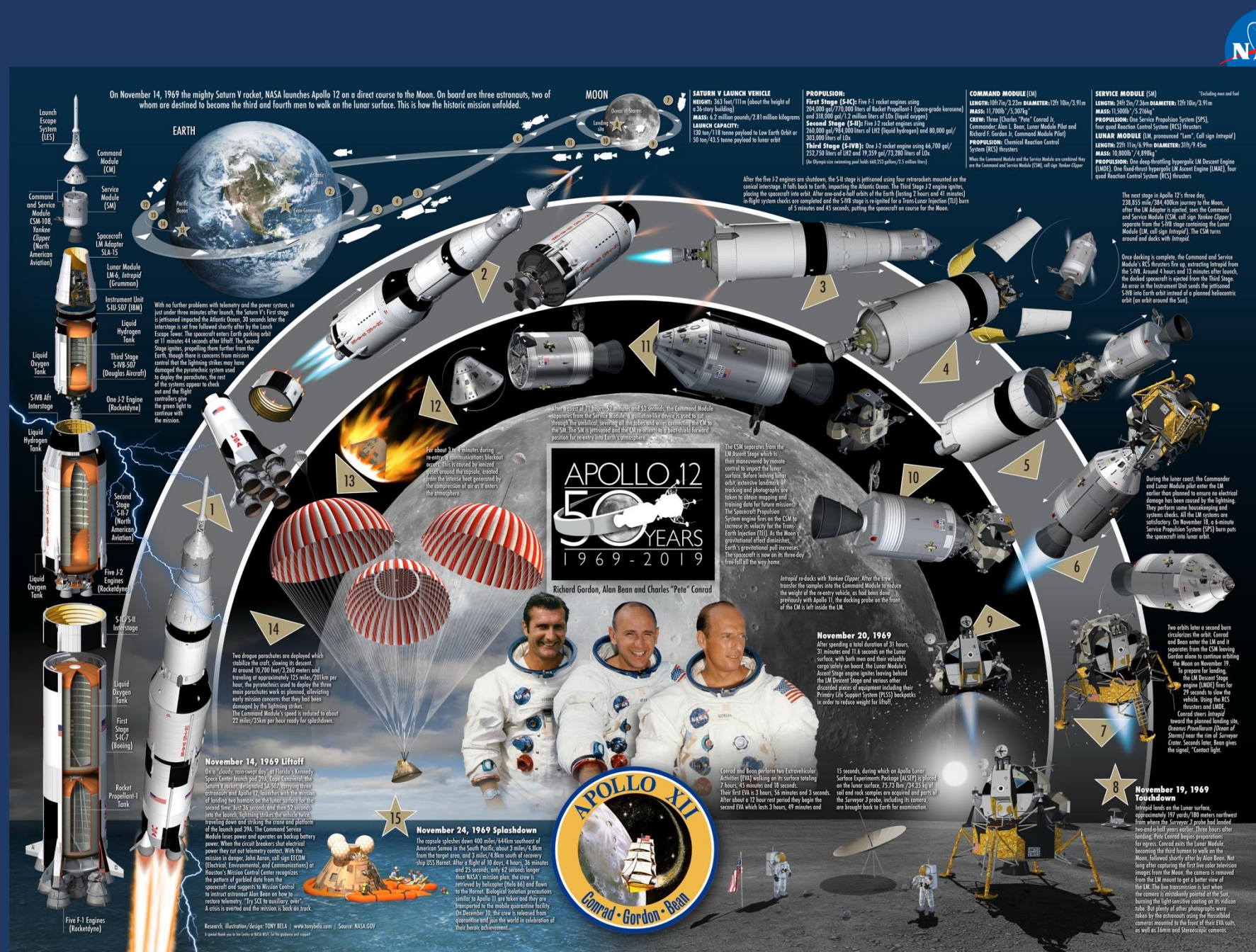
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Entry Systems and TPS Technologies for Science Missions

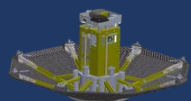
Entry System:

- Ballistic Entry Probe missions
- Aerocapture with low, mid or high L/D for Flagship
- Drag Modulated Aerocapture with Deployable Entry System – Venus/Mars

Thermal Protection System:

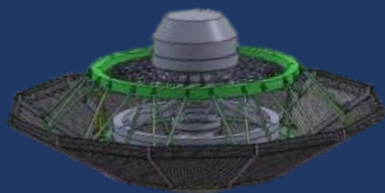
- Low Density: PICA Family: PICA-D and Conformal PICA,
- Mid Density: 3-D Woven (3MDCP, HEEET)
- Novel: Flexible TPS (HIAD) and 3-D Woven Carbon (ADEPT)

SR-1



0.7m

Venus Lander



6 m

Mars Exploration



6 m

Outpost Deployable Concept

Leveraging NASA developed ADEPT Deployable Heat Shield Technology

Goal is to store supplies in orbit, ready to be deployed on-demand for rapid, precise delivery of critical cargo, such as medical supplies, battlefield equipment, and surveillance drones

Reentry can also be used for hypersonic testing and safely returning payloads for assessing material performance in extreme conditions

Outpost is currently funded under U.S. Strategic Funding Increase (STRATFI), an Air Force SBIR initiative (Public-Private Partnership) to Demonstrate the Technology

