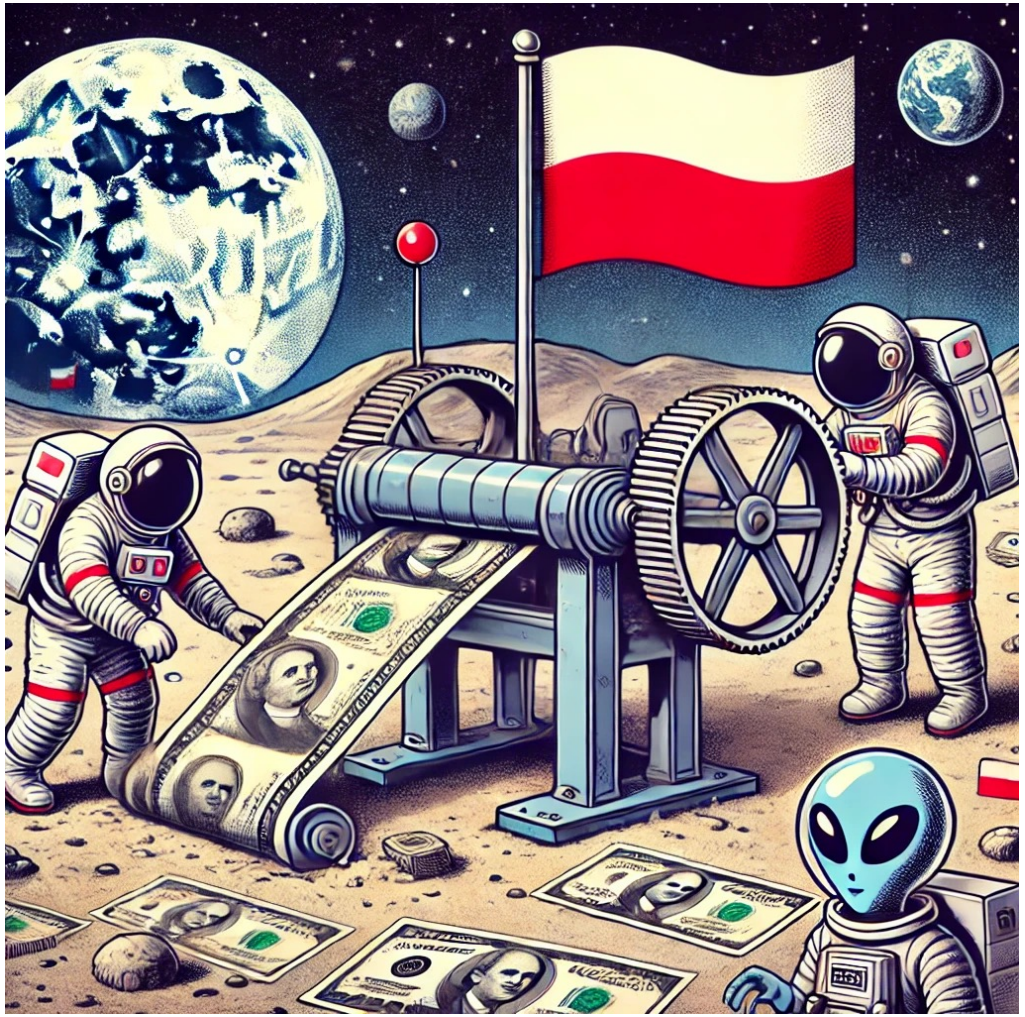
Is There Money on the Moon? The Emerging Lunar Economy

David H. Lehman

NASA / Jet Propulsion Laboratory, Project Manager (Retired) and

Volunteer Solar System Ambassador



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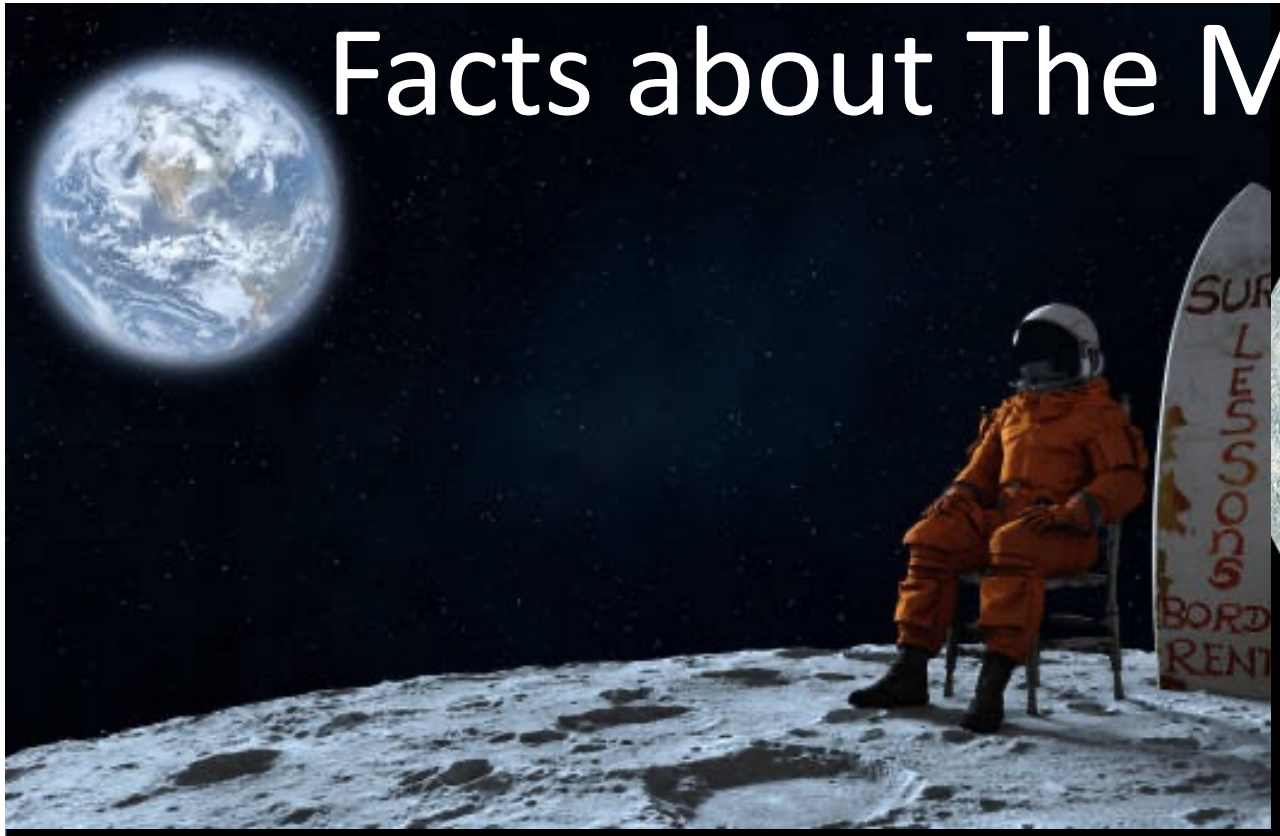
Agenda

A. Facts about the Moon
B. Why would you want to go to the Moon?
C. The emerging lunar economy
D. NASA's ARTEMIS Program
E. NASA's Commercial Lunar Payload Services (CLPS) initiative
F. Some Recent Attempts to Land on the Moon
G. China's Lunar Exploration Program
H. Some ideas for Polish companies to make money on the ARTEMIS and CLPS Programs
I. Summary

Facts about The Moon



- To date no astronauts have surfed on the Moon
- The Moon is 385,000 km (239,000 mi) from Earth
- The Moon is ¼ the width of Earth's

- The Moon was made when a rock smashed into Earth
- There is water ice on the Moon
- There are also minerals to be mined (rock, Helium-3)

Why would you want to go to the Moon?

A. National and/or Corporate Prestige
B. Science: Outposts for lunar exploration and astronomy
C. Use as a steppingstone for further space exploration (i.e. Mars)
D. Tourism: Lunar visits for economic gain
E. Mining/Manufacturing: Off-world resources (water, Titanium, Platinum, rare earth elements, Helium-3) to feed into Earth's economy

The Emerging Lunar Economy

- The Moon is transitioning from a national/scientific frontier to a **commercial destination**, driven by governments and private companies investing in **space exploration, resource utilization**, and **infrastructure development**
- The "**lunar economy**" is still in its infancy, but it's gaining serious momentum

Key Drivers of the Lunar Economy

1. NASA's Artemis Program

1. Goal: Return humans to the Moon, establish a **sustainable presence**, and prepare for Mars.
2. Includes the **Lunar Gateway** (a space station in lunar orbit) and **Artemis Base Camp**.

2. NASA's Commercial Lunar Payload Services (CLPS) Initiative

1. NASA contracts with private companies to **deliver payloads** (rovers, instruments) to the lunar surface.
2. Companies like **Astrobotic**, **Intuitive Machines**, and **Firefly Aerospace** are involved

3. International Collaboration

1. **Artemis Accords**: Over 50 countries (e.g. Poland, Japan, UK, UAE, Canada, Australia) are aligning on peaceful exploration, standards, and commercial participation

4. Private Sector Expansion

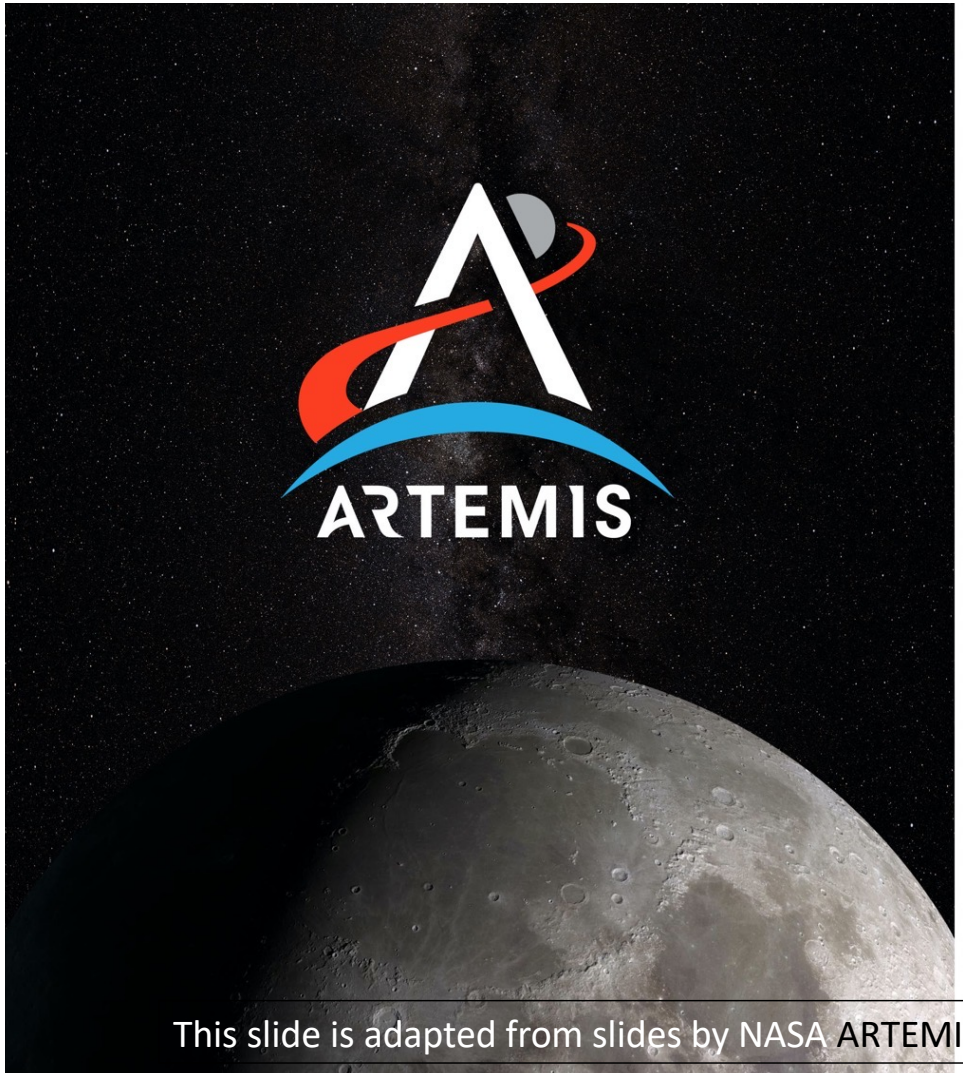
1. Companies like **SpaceX, Blue Origin, ispace (Japan), Axiom Space, and Lunar Outpost** are developing landers, rovers, and infrastructure
2. SpaceX's **Starship** aims to be a lunar cargo and crew vehicle

5. Other International Programs: China, India, Japan

NASA Deputy Administrator Pam Melroy and Polish Space Agency (POLSA) President Grzegorz Wrochna pose following an Artemis Accords signing ceremony in Dubai, United Arab Emirates, Oct. 26, 2021.

Emerging Lunar Markets

#	Market Segment	Description
1	**Transportation**	Launching and landing cargo/humans. Players: SpaceX, Blue Origin
2	**Science & Data Services**	Lunar data products, research instruments, private observatories
3	**Telecommunications**	Lunar relay networks (e.g., ESA's **Moonlight**, NASA's **LunaNet**)
4	**Tourism & Habitats**	Lunar fly-by and orbital missions. Early research stages: lunar hotels, science outposts, survival tech
5	**In-Situ Resource Utilization (ISRU)**	Extracting water ice, oxygen, and regolith for fuel, life support, and construction
6	**Energy Production**	Solar farms on the Moon for local use and, eventually, power beaming
7	**Mining & Manufacturing**	Focus on regolith-based bricks, oxygen, water; longer-term: titanium, platinum, rare Earth metals, Helium-3



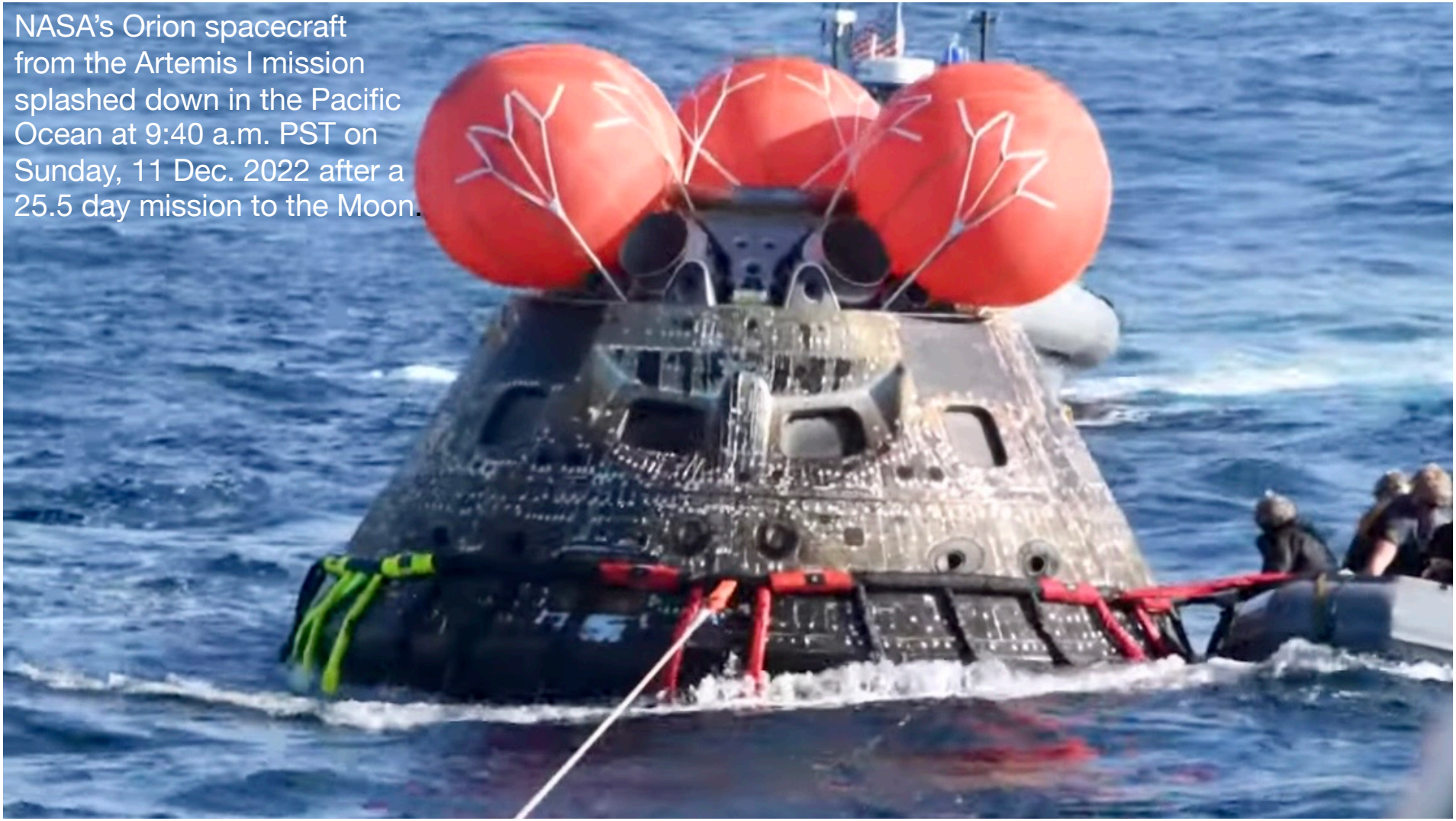
ARTEMIS

Twin sister of Apollo and goddess of the Moon in Greek mythology. With Artemis missions, NASA will:

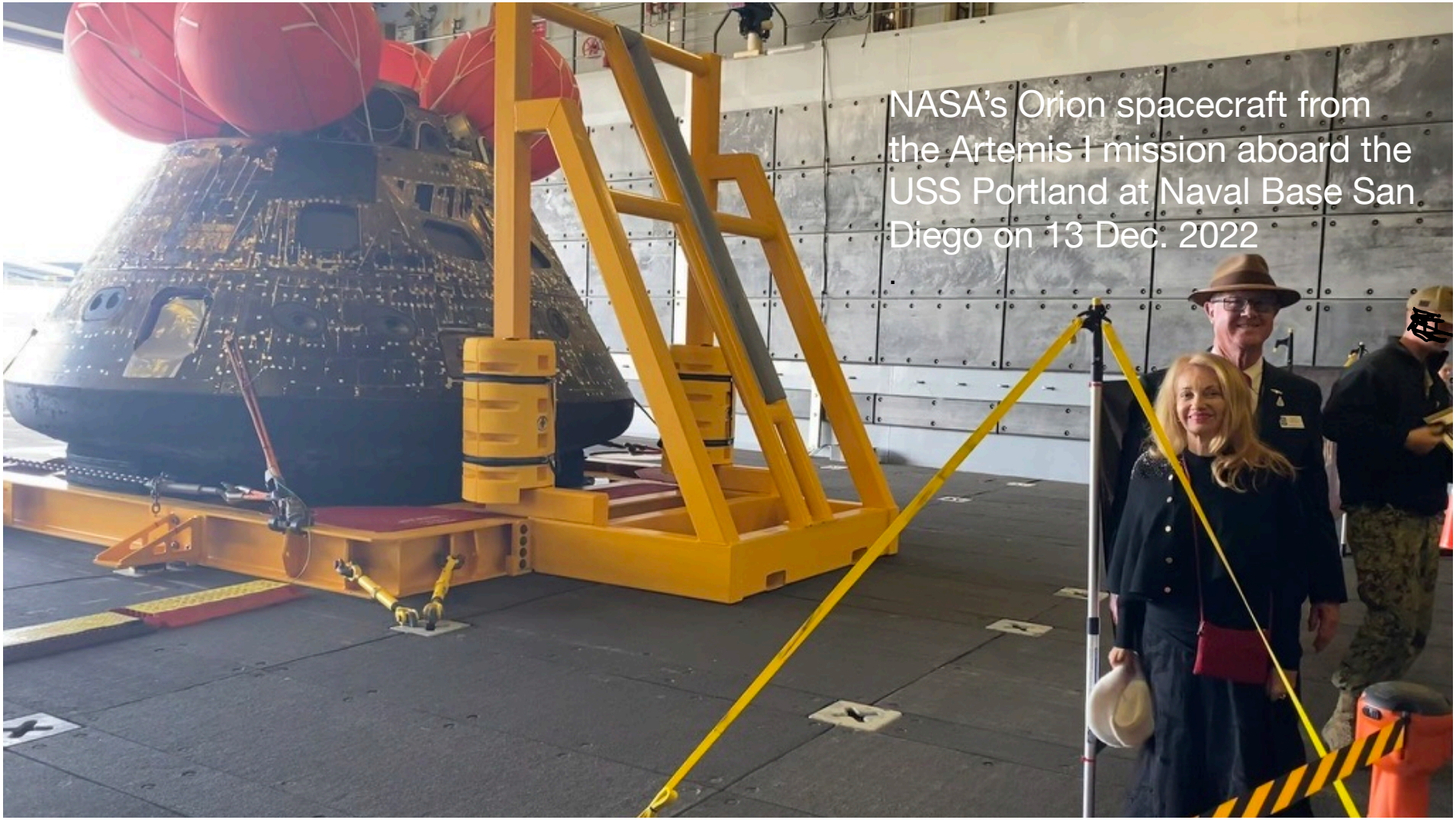
- Collaborate with international and commercial partners to establish the first long-term presence on the Moon, and
- Use what we learn on and around the Moon to take the next giant leap: sending the first astronauts to Mars.

This slide is adapted from slides by NASA ARTEMIS Chief Nujoud Merancy, dated Oct. 21, 2021.

NASA's Space Launch System rocket carrying the Orion spacecraft launches on the Artemis I flight test, Nov. 16, 2022, from Launch Complex 39B at NASA's Kennedy Space Center .



NASA's Orion spacecraft from the Artemis I mission splashed down in the Pacific Ocean at 9:40 a.m. PST on Sunday, 11 Dec. 2022 after a 25.5 day mission to the Moon.



NASA’s Orion spacecraft from the Artemis I mission aboard the USS Portland at Naval Base San Diego on 13 Dec. 2022

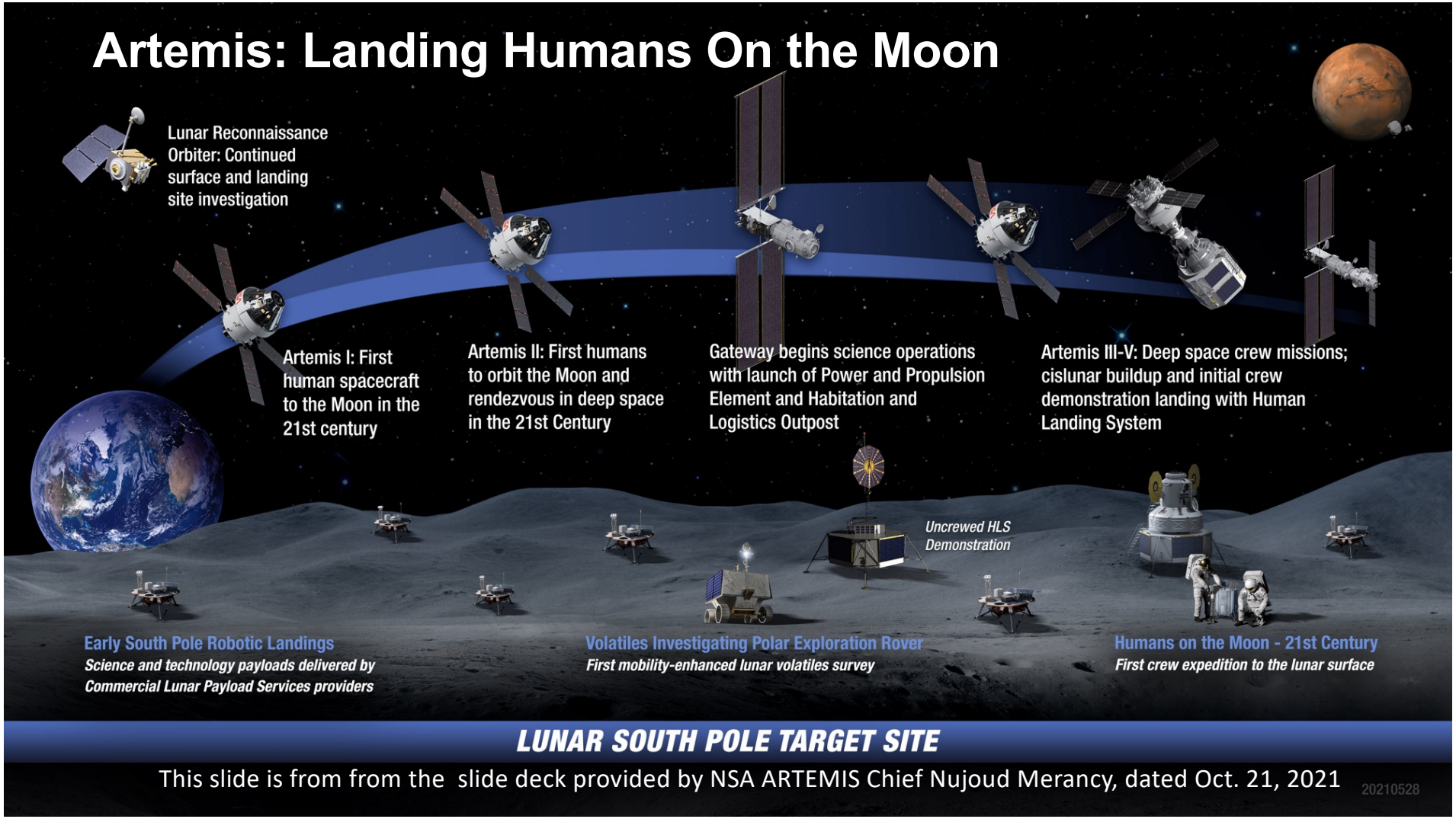

CLT

ARTEMIS II

The Artemis II Lunar Flyby Mission Crew Members announced on April 3, 2023

Include (from left): NASA astronauts Christina Koch, Victor Glover, Reid Wiseman (foreground) and Canadian Space Agency astronaut Jeremy Hansen

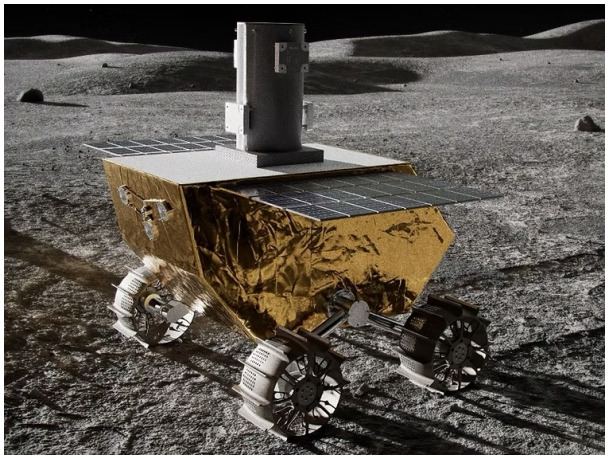
ARTEMIS III



This slide is from from the slide deck provided by NSA ARTEMIS Chief Nujoud Merancy, dated Oct. 21, 2021

NASA's Commercial Lunar Payload Services (CLPS) Initiative

- NASA is working with American companies to deliver science and technology to the lunar surface through the CLPS Initiative
- These companies bid on delivering payloads for NASA
  - This includes everything from launching from Earth to landing on the Moon, and performing science experiments, testing technologies, and demonstrating capabilities to help NASA explore the Moon
  - CLPS contracts began in 2023 with a cumulative maximum contract value of $2.6 billion through 2028



Graphic of Lunar Outpost's Voyage 2 Rover

Some Recent Attempts to Land on the Moon

- **ISPACE:** The HAKUTO-R Mission 1 Lunar Lander was scheduled to touchdown on the surface of the Moon. As of 8:00 a.m. JST, April 26, 2023, the communication between the lander and the Mission Control Center was lost, and it has been determined that Success 9 of the Mission Milestones is not achievable
- Russia – Luna 25 mission – FAILED ON 8/19/2023 – target was South Pole
- India – The landing of Chandrayaan – 3 occurred ion Aug. 23, 2023 near the South Pole.
- On 28 January 2024 the Japan Aerospace Exploration Agency (JAXA) re-established contact with the Smart Lander for Investigating Moon(SLIM), which touched down on the slope of a crater near the Moon's equator on 20 January 2024
- On 22 February 2024, Intuitive Machine's Odysseus via NASA's CLPS program successfully landed on the Moon after taking off on a SpaceX Falcon 9 liftoff on 15 February 2024 in a mission between NASA, SpaceX, and Intuitive Machines, marking the United States' first soft unmanned moon landing in over 50 years. The lander is now considered to be permanently faded after it toppled over and lost power due to its orientation after landing.
- Reentry module of China's historic Chang'e-6 lunar mission touched down on Earth on June 25, 2024. China's Chang'e-6 moon mission returns to Earth with historic far side samples

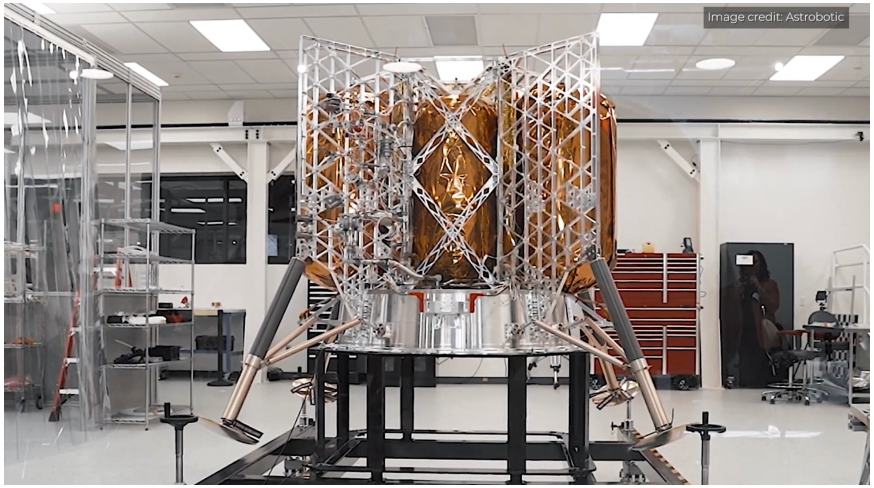
China's Lunar Exploration Program*

Mission	Launch date	Launch vehicle	Mission type	Notes
Phase 4				
Chang'e 7	2026	Long March 5	Lunar surface survey	Lunar orbiter, lander, rover, and mini-flying probe; expected to perform in-depth exploration of the lunar south pole to look for resources.[22]
Chang'e 8	2028	Long March 5	Lunar surface survey	Full mission details are currently unknown; will test ISRU and 3D-printing technologies, ahead of future crewed exploration of the Moon.[22]
1st crewed lunar mission	2029-2030	Long March 10	Human landing on lunar surface	2 launches using the Long March 10 to place two astronauts on the lunar surface via the Mengzhou crewed lunar spacecraft and the Lanyue crewed lunar lander.[1]

- Reference: https://en.wikipedia.org/wiki/Chinese_Lunar_Exploration_Program

Astrobotic: CLPS Supplier

- **Astrobotic's Griffin lander will deliver an Astrolab rover to the Moon as part of Astrobotic's Griffin Mission One (Griffin-1). The rover will be deployed at the Nobile Region of the lunar south pole. The Astrobotic mission is scheduled for delivery at the end of 2025.**
- **Astrobotic Lunar Lander Users guide:**
  - **Lunar Orbit: $300,000/kg**
  - **Lunar Surface: $1,200,000/kg**
  - **Delivery of Rover: $4,500,000/kg**



Astrobotic's Lunar Lander

Web site: https://www.astrobotic.com

Recent CLPS attempts to Land on the Moon

- **March 6, 2025 – A 2nd Intuitive Machines landed on the Moon via CLPS. Officials at the Houston-based Intuitive Machines, announced on March 7 that the mission is officially over after Athena missed its planned landing mark by over 800 feet and fell over**
- **NASA's CLPS Program Firefly 'Blue Ghost' lunar lander touches down on the moon on March 2, 2025.**
  - **Firefly has become only the 2nd private-sector company ever to achieve a soft lunar landing.**
  - **The commercially-developed lander is equipped with 10 NASA-sponsored instruments designed to collect data needed for the Artemis program**

Photo of Firefly's 'Blue Ghost' lunar lander

Firefly Blue Ghost Lunar Lander Science Instruments

1. **Lunar GNSS Receiver Experiment (LuGRE):** Determine if GPS and Galileo signals works at the Moon
2. **Lunar PlanetVac (LPV):** Collect samples of lunar soil for analysis
3. **Regolith Adherence Characterization (RAC):** Determine how lunar soil sticks to materials
4. **Electrodynamic Dust Shield (EDS):** Active dust mitigation technology to move dust from surfaces and to prevent dust accumulation on surfaces
5. **Stereo Cameras for Lunar Plume-Surface Studies (SCALPSS)** Determine how the lander's descent engine plumes interact with the lunar surface

Graphic of Firefly's Blue Ghost Lunar Lander

Web Site: https://fireflyspace.com/company/

Blue Ghost lunar lander captured a solar eclipse displaying a “diamond ring” effect, when light from the sun started to shine through after being blocked by the Earth. Firefly Aerospace. 13 March 2025

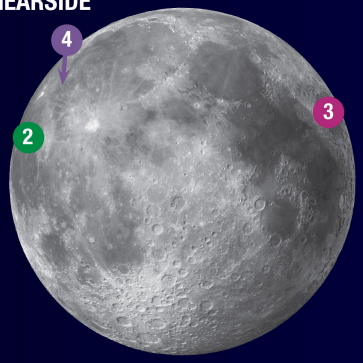
Lunar Tourism

"…The wedding of Astronauts Larry and Linda…"

COMMERCIAL LUNAR PAYLOAD SERVICES **LANDING SITES**

National Aeronautics and Space Administration

NEARSIDE



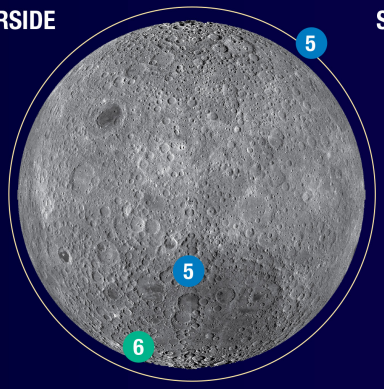
1 **Astrobotic Peregrine Mission-1**
LANDER NAME: Peregrine
CLPS CONTRACT AWARD: TO 2-AB
STATUS: Completed. Did not land on the Moon

2 **Intuitive Machines IM-3**
LANDING SITE: Reiner Gamma
LANDER NAME: NOVA-C
CLPS CONTRACT AWARD: TO CP-11

3 **Firefly Blue Ghost Mission 1**
LANDING SITE: Mare Crisium
LANDER NAME: Blue Ghost
CLPS CONTRACT AWARD: TO 19D

4 **Firefly Blue Ghost Mission 3**
LANDING SITE: Gruithuisen Domes
LANDER NAME: Blue Ghost
CLPS CONTRACT AWARD: TO CP-21

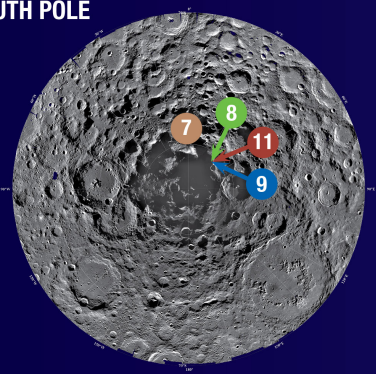
FARSIDE



5 **Firefly Blue Ghost Mission 2**
LANDING SITE: Lunar Farside and Orbit
LANDER NAME: Blue Ghost
CLPS CONTRACT AWARD: TO CS-3 and CS-4

6 **Team Draper**
LANDING SITE: Schrödinger Basin
LANDER NAME: ispace-U.S. APEX®1.0 Lunar Lander
CLPS CONTRACT AWARD: TO CP-12

SOUTH POLE



7 **Intuitive Machines IM-1**
LANDING SITE: Malapert A
LANDER NAME: NOVA-C
CLPS CONTRACT AWARD: TO 2-IM
STATUS: Completed

8 **Astrobotic Griffin Mission-1**
LANDING SITE: Mons Mouton
LANDER NAME: Griffin
CLPS CONTRACT AWARD: TO 20A

9 **Intuitive Machines IM-4**
LANDING SITE: Mons Mouton
LANDER NAME: NOVA-C
CLPS CONTRACT AWARD: TO CP-22

10 **Blue Origin Blue Moon MK1 Pathfinder**
LANDING SITE: South Polar region
(specific location still being identified)
LANDER NAME: Blue Moon Mark 1 (MK1)
CLPS CONTRACT AWARD: CT-3

11 **Intuitive Machines IM-2**
LANDING SITE: Mons Mouton
LANDER NAME: NOVA-C
CLPS CONTRACT AWARD: TO PRIME-1

NP-2025-03-006-JSC

Commercial Lunar Payload Services (CLPS) Timeline

2024: Astrobotic's Peregrine Mission One – Completed, did not land on the Moon.

- Intuitive Machines' IM-1 Mission – Completed, delivered six NASA payloads to Malapert A in the South Pole region of the Moon.

2025: Firefly's Blue Ghost Mission One will carry 10 payloads to Mare Crisium, a basin on the Moon's near side.

- IM-2, Intuitive Machines' second mission, will deliver three NASA payloads including the PRIME-1 drill and two NASA-funded technology demonstrations to the Moon's South Pole.

- **IM-3, Intuitive Machines third mission, will deliver four payloads to Reiner Gamma.**
- **Draper's first mission will deliver PRISM science investigations to Schrödinger Basin, landing in volcanic terrain in the far side South Pole region.**
- **Astrobotic's second mission will deliver their Griffin One lander to the lunar South Pole.**
- **Blue Origin's Blue Moon Mark 1 lander will deliver one NASA payload to the lunar South Pole.**

2026

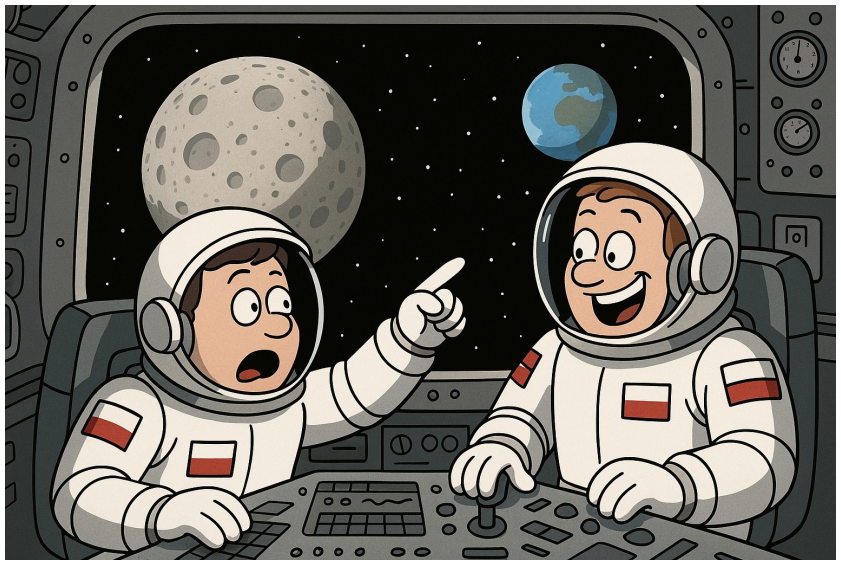
- **Firefly's second mission, Blue Ghost Mission 2, will deliver two NASA payloads to the far side of the Moon and deliver a communications and data relay satellite into lunar orbit, which is an ESA collaboration with NASA. As part of Blue Ghost Mission 2, Firefly will also deliver a radio frequency calibration service to LuSEE-night (Lunar Surface Electromagnetics Experiment – Night) from lunar orbit.**

2027

- **IM-4, Intuitive Machine's fourth mission, will carry six NASA payloads to the lunar South Pole.**

Some ideas for Polish Companies to make Money from the ARTEMIS and CLPS Programs

- Work with Polsa and ESA to determine their plans for potential work supporting ARTEMIS and CLPS
- Attend relevant conferences:
  - VIIIth Space Resources Conference – Path to Lunar Sustainability, 21-23 May 2025 at AGH University of Krakow, Poland
- Set up US office to secure ARTEMIS/CLPS contracts:
  - Contact: Star Linker: www.star-linker.com
- Work with ARTEMIS and CLPS US companies to obtain funding on subcontracts:
  - ARTEMIS: SpaceX, Blue Origins, Axiom Space
  - CLPS: Intuitive Machines, Draper, Astrobotic, Firefly, Blue Origins, Lunar Outpost, ispace



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Summary

- The “lunar economy” is still in its infancy, but it’s gaining serious momentum
- Maybe some day you can buy Lunar Pierogi on the Moon

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Thank you for being here

David Lehman

Backup Charts

- Presentation Requirements
- ARTEMIS Astronaut's Biography
- Polish Astronaut Sławosz Uznański-Wiśniewski’s Biography
- Do you have what it takes to become an astronaut?
- CADRE project
- Gateway
- How do you get a Job in the Polish Space Business?

Presentation Requirements

- Date: April 25 at 5pm. The meetings will last ~1.5 hours, consisting of a 30-minute introductory presentation, followed by a one-hour interactive discussion with participants
- Sponsor: Prof. Michał Wolański, Head, Institute of Infrastructure, Transport, and Mobility, SGH Warsaw School of Economics. Address is: al. Niepodległości 162 02-554 Warsaw, Poland. Web site is: https://www.sgh.waw.pl/en
- Title: "Is there Money on the Moon? The Emerging Lunar Economy"
- Abstract: This presentation will focus on the emerging lunar economy, which is still in its infancy, but gaining serious momentum. The Moon is transitioning from a national/scientific frontier to a commercial destination, driven by governments and private companies investing in space exploration, resource utilization, and infrastructure development. The presentation will begin with an overview of facts about the moon, followed with a discussion about why one would want to go to the moon. It will highlight NASA's ARTEMIS program that intends to send astronauts back to the moon, followed by a summary of NASA's Commercial Lunar Payload Services (CLPS) initiative with its plans to send numerous small missions to the moon to prepare for the return of astronauts. Finally, the presentation will address some ideas for companies to make money on the ARTEMIS and CLPS Programs.

Astronaut Reid Wiseman

Reid Wiseman, 47, is from Baltimore, Maryland. He earned a bachelor's degree in engineering from Rensselaer Polytechnic Institute in New York and an engineering master's from Johns Hopkins University in Baltimore.

Wiseman is a military man. He was designated a Naval Aviator in 1999 and was deployed twice to the Middle East as a fighter pilot, with the second deployment occurring in 2003, according to his official NASA biography(opens in new tab). He has two children with his wife Carol, who died of cancer in May 2020.

NASA selected Wiseman as one of the nine members of its 2009 astronaut class. He finished training in 2011 and in May 2014 launched on his first and (to date) only spaceflight, a 165-day mission to the International Space Station (ISS). He served as a crewmember on the orbiting lab's Expedition 40 and Expedition 41 missions before returning to Earth in November 2014.

Wiseman served as chief of NASA's astronaut office from December 2020 to November 2022. And now he can start training for Artemis 2, the first-ever crewed mission of NASA's new deep-space transportation system, which consists of the Orion capsule and Space Launch System rocket.

"This is a global effort, Artemis 2, and it's only going to get larger with Artemis 3 and beyond as we get private spaceflight involved; SpaceX is building our lander for Artemis 3," Wiseman said during the crew announcement ceremony on Monday. (Artemis 3 will land astronauts near the moon's south pole, perhaps as soon as 2025.)

"So to the NASA workforce, to our program managers, our center directors that are here, the amazing political support that we feel right now to bring our country together, to bring our entire world together to go explore to get to Mars and beyond, we say a huge thank you," Wiseman said.

Astronaut Victor Glover

Victor Glover, 46, is from Pomona, California. He received a bachelor's degree in engineering from California Polytechnic State University in San Luis Obispo and then earned three engineering master's degrees — one apiece from Air University at Edwards Air Force Base in California, the Naval Postgraduate School and Air University in Montgomery, Alabama.

Glover was a fighter pilot in the U.S. Navy and was deployed multiple times. According to his NASA biography(opens in new tab), Glover logged "3,000 flight hours in more than 40 aircraft, over 400 carrier arrested landings and 24 combat missions." He and his wife Dionna have four children.

Glover was chosen in NASA's 2013 astronaut class, the next one after Wiseman's, and finished training two years later. He has one spaceflight under his belt — Crew-1, the first operational mission to the International Space Station that SpaceX flew for NASA.

Crew-1 launched in November 2020 and returned to Earth in May 2021, spending a total of 168 days in orbit. Glover participated in four spacewalks during that stretch.

"We need to celebrate this moment in human history," Glover said of Artemis 2 on Monday. "Because Artemis 2 is more than a mission to the moon, and it's more than a mission that has to happen before we send people to the surface of the moon. It is the next step on the journey that gets humanity to Mars."

NASA aims to put boots on the Red Planet in the late 2030s to early 2040s. It views the moon as a stepping stone along this ambitious path; the skills and knowledge gained via the Artemis program will help humanity make the leap to Mars, agency officials have said.

Astronaut Christina Koch

Christina Koch, 44, grew up in Jacksonville, North Carolina and earned bachelor's and master's degrees in engineering from North Carolina State University.

She worked as an electrical engineer at NASA's Goddard Space Flight Center in Maryland and the Johns Hopkins University Applied Physics Laboratory, contributing to the development of science instruments for multiple robotic NASA missions, including the Juno Jupiter orbiter and the Van Allen Probes, which studied the radiation environment near Earth. She is married to husband Robert Koch.

Koch also performed scientific field work in remote locations such as Antarctica, Greenland and far northern Alaska, as a research associate in the U.S. Antarctic Program and a field engineer for the National Oceanic and Atmospheric Administration.

She joined NASA as a member of the 2013 astronaut class. She finished training in 2015 and a few years later was assigned to her first spaceflight, a long-duration mission to the ISS.

"Long-duration" is an understatement, in fact: The mission launched in March 2019 and didn't return to Earth until the following February. Koch spent 328 days aboard the orbiting lab, longer than any other woman has on a single mission. And in October 2019, Koch and Jessica Meir performed the first-ever all-female spacewalk outside the ISS. That pioneering excursion was one of six that Koch conducted during her time aboard the orbiting lab.

Artemis 2 will be Koch's second spaceflight.

"Am I excited? Absolutely. But my real question is, Are you excited?" Koch said during Monday's, April 3, 2023 announcement event, which was broadcast live on NASA TV. "And I ask that because the one thing I'm most excited about is that we are going to carry your excitement, your aspirations, your dreams with us on this mission. Artemis 2: your mission."

Astronaut Jeremy Hansen

Jeremy Hansen, 47, is from London, Ontario. He earned a bachelor's degree in honours space science and a master's degree in physics from the Royal Military College of Canada in Kingston, Ontario.

He's a colonel in the Royal Canadian Air Force who served as a fighter pilot from 2004 to 2009, according to his official Canadian Space Agency (CSA) biography(opens in new tab). He is married to wife Catherine and has three children.

Hansen was one of two people chosen as a CSA astronaut in 2009, in the agency's third recruitment campaign. He completed astronaut training in 2011 and prepped for spaceflight further by participating in a subterranean expedition of the European Space Agency's CAVES program in 2013 and an underwater excursion in 2014 via NASA's NEEMO program. In 2017, Hansen was selected to lead the training of NASA and CSA astronaut candidates, becoming the first Canadian to hold this post.

SŁAWOSZ UZNAŃSKI BIOGRAPHY

Slawosz Uznanski is a Polish scientist and electronics engineer currently working at the

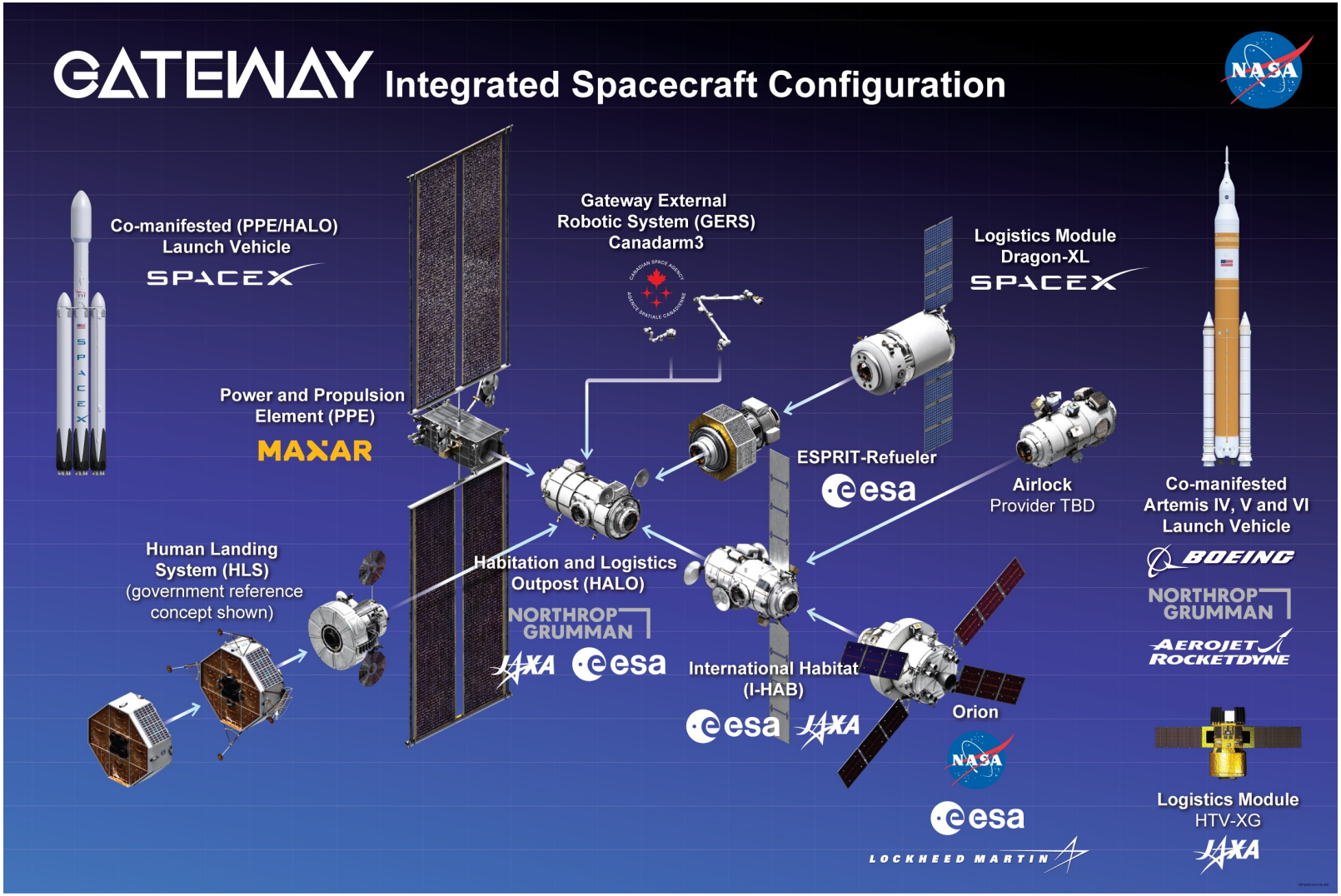
European Organization for Nuclear Research (CERN). His research focuses on the design and realisation of reliable electronic systems and operating complex scientific machines including the Large Hadron Collider (LHC) at CERN. One of his most notable projects in this domain was the creation of a radiation-tolerant power converter control system which has been a core part of the LHC since 2017.

DO YOU HAVE WHAT IT TAKES TO BECOME AN ASTRONAUT?

- Citizenship of an ESA member state or associated member state
- Minimum of a Master's degree from a recognized academic institution in natural sciences, medicine, engineering or mathematics/computer sciences.
- At least three years of professional experience after graduation.
- Fluent in written and spoken English. Good knowledge of another foreign language and any other additional language is a plus.
- Strong motivation and ability to cope with irregular working hours, frequent travel, and long absences from home, family and regular social life.
- Flexible with regard to place of work.
- Able to remain calm under pressure.
- Physically and mentally fit and healthy.
- Willing to participate in life science experiments.
- Excellent communicator, able to act as an advocate for ESA.
- All applicants to the astronaut vacancy must also hold a medical certificate issued by an aviation medical examiner that shows they are medically certified for a private pilot license (PPL) or higher (e.g. commercial pilot license).

NASA's Network of Small Moon-Bound Rovers Is Ready to Roll.


CADRE
Cooperative Autonomous Distributed Robotic Exploration
NASA


GATEWAY Integrated Spacecraft Configuration
NASA
Co-manifested (PPE/HALO)
Launch Vehicle
SPACEX
Gateway External
Robotic System (GERS)
Canadarm3
Logistics Module
Dragon-XL
SPACEX
Power and Propulsion
Element (PPE)
MAXAR
ESPRIT-Refueler
esa
Airlock
Provider TBD
Co-manifested
Artemis IV, V and VI
Launch Vehicle
BOEING
NORTHROP GRUMMAN
AEROJET ROCKETDYNE
Human Landing
System (HLS)
(government reference
concept shown)
Habitation and Logistics
Outpost (HALO)
NORTHROP GRUMMAN
JAXA
esa
International Habitat
(I-HAB)
esa
JAXA
Orion
NASA
esa
LOCKHEED MARTIN
Logistics Module
HTV-XG
JAXA

How do you get a Job in the Polish Space Business?

- If you are in high school:
  - Study physics and chemistry not for grades but for understanding
  - Study programming and computer science
  - Build something, anything
- If you are in college:
  - Go to a university that builds rovers or cubesats
  - Get a summer job with a small company and build something, anything
  - Apply for a summer job with ESA
- If you graduated:
  - Try to find personal connections
  - Go to engineering conferences
  - Talk to an alumni of your school and ask for an interview

Source: Artur.B.Chmielewski@jpl.nasa.gov