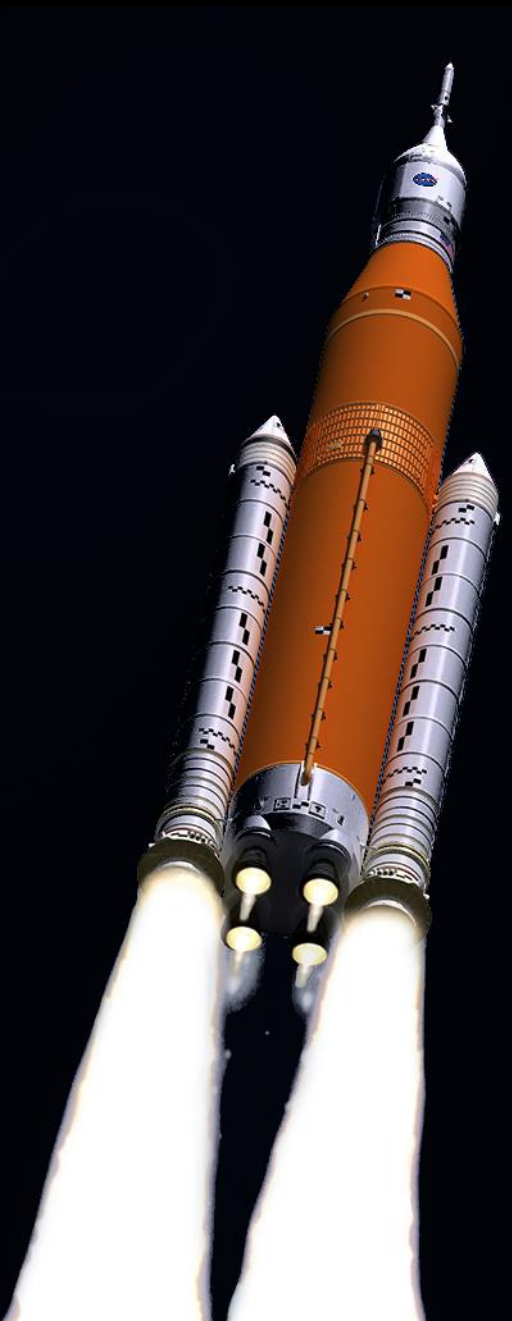
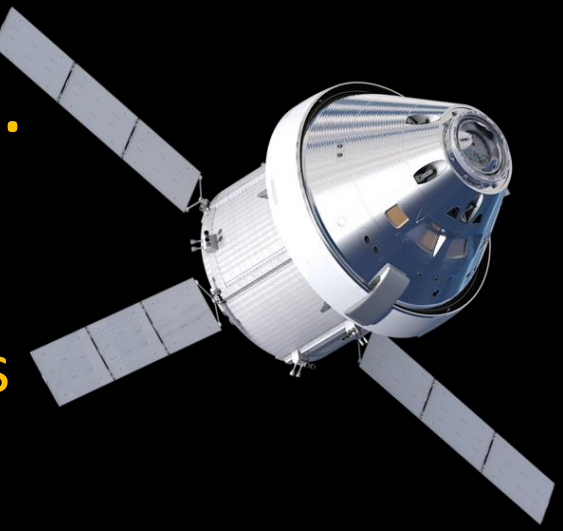
Monthly Space News

Greg Stanley

Dec. 10, 2022

This month’s news highlights…





- Artemis 1 launch to lunar orbit and return
- Oberth effect and gravity assists for Artemis
- Falcon 9 lunar launch delay
- Moon/Mars construction 3D printing
- Mars analog progress at Mars Dune Alpha
- NEO Surveyor (killer asteroid detector) revived
- Recent launches to space

Artemis 1 (SLS + Orion) launch

- Artemis 1 launched Nov. 16 to lunar orbit
  - Tests SLS (Space Launch System), Orion spacecraft
    - Orion returns at high velocity, stressing its heat shield
  - 25 day mission (without crew) to orbit the Moon and return Orion to Earth Dec. 11
  - Also deployed 10 small satellites
- Artemis 2 will follow similar path, with crew (2024? 2025?)
- SLS is now the world's most powerful operational rocket (8.8m lbs thrust)
  - Falcon Heavy (5m)
  - Shuttle (7.8m), Apollo (7.5m)
  - … Until Starship flies (17m)

Image credits: NASA (via Wikimedia commons)

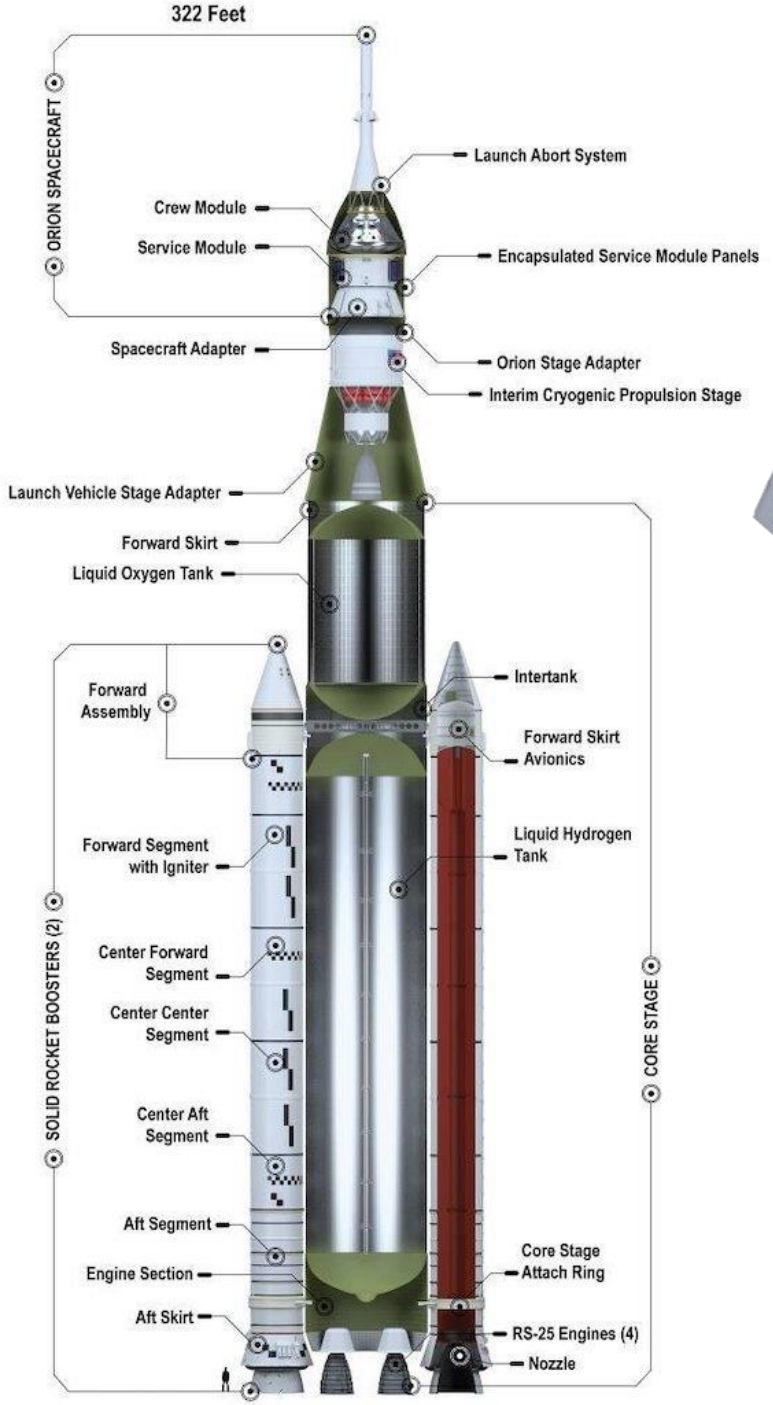
Artemis I

SLS + Orion
at launch

2 Solid Rocket
Boosters (SRBs)

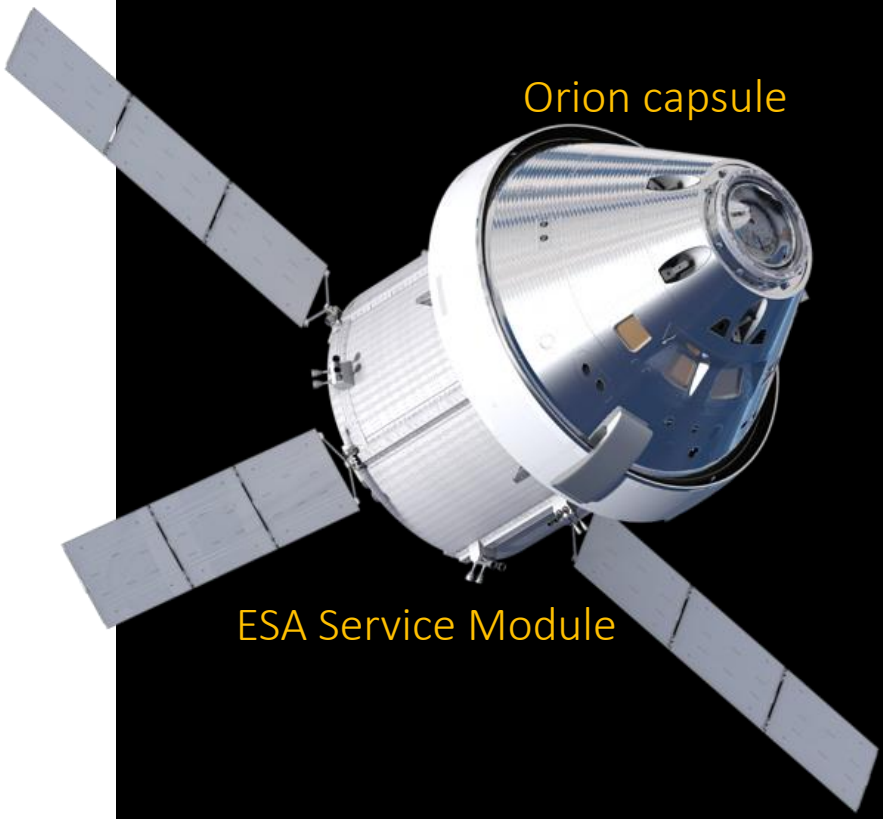
4 RS-25D engines
(Space Shuttle)

Credits: NASA



Orion, after disposal of its
propulsion stage

Orion capsule



ESA Service Module

Image credit: NASA

Orion spacecraft set a record

- Orion went farthest from Earth for a human-rated craft (270,000 miles)
  - Way past the Moon
  - Previous record: Apollo 13 (248,655 miles)

Image credit: NASA

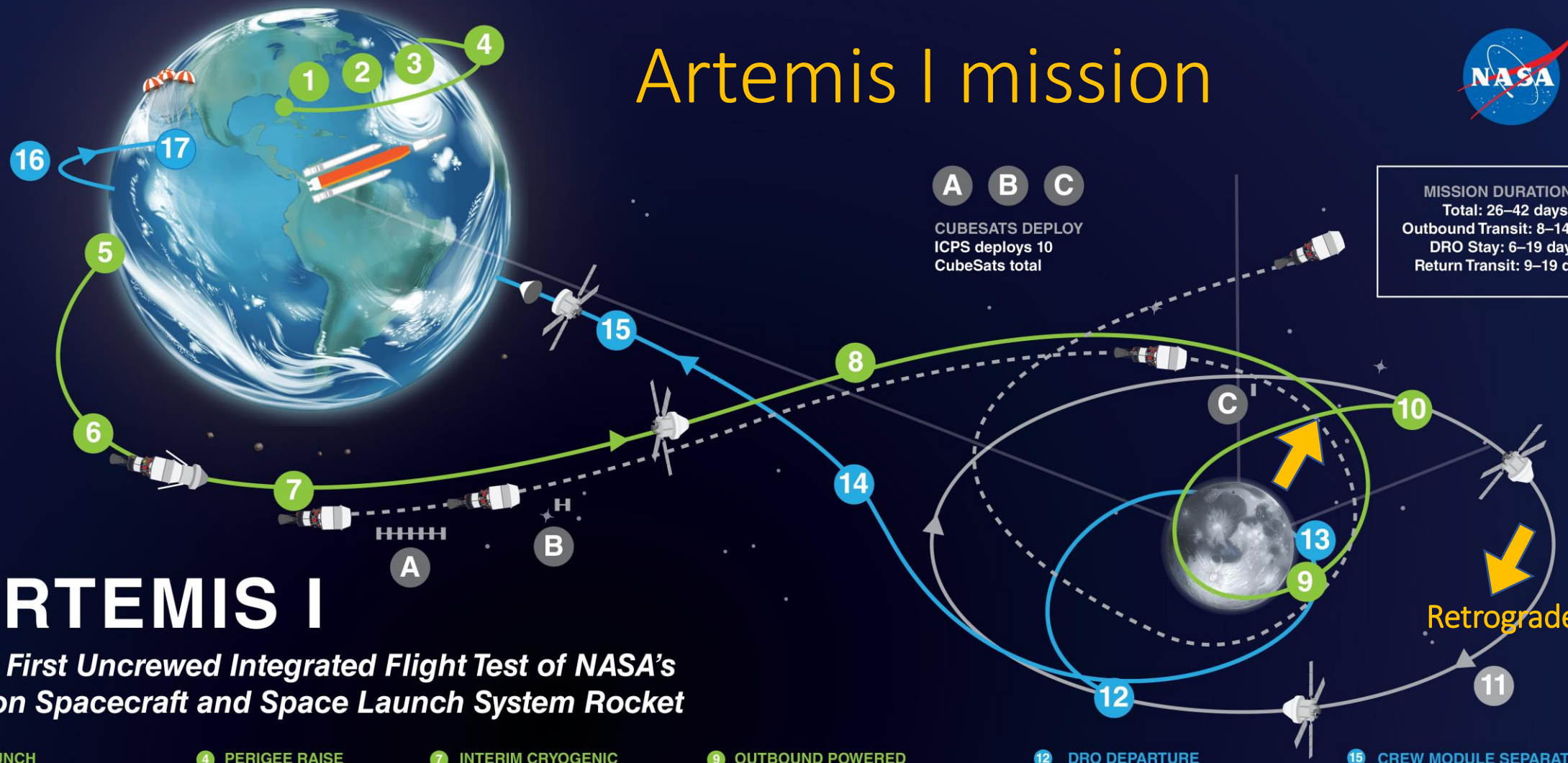
Orion spacecraft's lunar orbit (DRO)

- Distant Retrograde Orbit (DRO)
  - Distant: outside Earth/Moon Lagrange points L1 & L2
  - Very stable, influenced by both Earth and Moon
  - Would have been used in earlier SLS vision of capturing an asteroid and pulling back to nearby orbit
  - First utilized Jan. 2022 by Chinese Chang'e 5 orbiter

Image credit: NASA

- "Retrograde" meaning depends on context
  - Object by itself: retrograde burn opposes current direction
  - Object around planet: retrograde orbit is in opposite direction of planet's spin (more costly to launch from equator)
  - Object orbiting moon around planet: retrograde orbit is in opposite direction from the moon's orbit

Artemis I mission



ARTEMIS I

The First Uncrewed Integrated Flight Test of NASA's Orion Spacecraft and Space Launch System Rocket

1. **LAUNCH**
   SLS and Orion lift off from pad 39B at Kennedy Space Center.
2. **JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
3. **CORE STAGE MAIN ENGINE CUT OFF**
   With separation.
4. **PERIGEE RAISE MANEUVER**
5. **EARTH ORBIT**
   Systems check with solar panel adjustments.
6. **TRANS LUNAR INJECTION (TLI) BURN**
   Maneuver lasts for approximately 20 minutes.
7. **INTERIM CRYOGENIC PROPULSION STAGE (ICPS) SEPARATION AND DISPOSAL**
   ICPS commits Orion to moon at TLI.
8. **OUTBOUND TRAJECTORY CORRECTION (OTC) BURNS**
   As necessary adjust trajectory for lunar flyby to Distant Retrograde Orbit (DRO).
9. **OUTBOUND POWERED FLYBY (OPF)**
   60 nmi from the Moon; targets DRO insertion.
10. **LUNAR ORBIT INSERTION**
    Enter Distant Retrograde Orbit.
11. **DISTANT RETROGRADE ORBIT**
    Perform half or one and a half revolutions in the orbit period 38,000 nmi from the surface of the Moon.
12. **DRO DEPARTURE**
    Leave DRO and start return to Earth.
13. **RETURN POWERED FLYBY (RPF)**
    RPF burn prep and return coast to Earth initiated.
14. **RETURN TRANSIT**
    Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere.
15. **CREW MODULE SEPARATION FROM SERVICE MODULE**
16. **ENTRY INTERFACE (EI)**
    Enter Earth's atmosphere.
17. **SPLASHDOWN**
    Pacific Ocean landing within view of the U.S. Navy recovery ship.

Credit: NASA

Artemis exploits the Oberth effect, gravity assist

- When changing to/from lunar orbits, burns had maximum effect when closest to the Moon (periapsis)/highest speed
- Why? Oberth effect (Hermann Oberth, 1927)
  - "Powered flyby" in previous Artemis mission slide
  - Burst of thrust from expelling propellant gives rocket a fixed velocity change Δv at any rocket velocity v
  - Initial kinetic energy = ½ mv^2
  - Final kinetic energy = ½ $m(v+\Delta v)^2$ = ½ mv^2 + $mv\Delta v$ + ½ $m\Delta v^2$
  - So, Δenergy = (final – initial energy) = $mv\Delta v$ + ½ $m\Delta v^2$
    - Final kinetic energy increases more with higher velocity before the burn!
- Different than "slingshot maneuver", based only on gravity
  - Can combine: thrust (Oberth) can enhance slingshot maneuver
  - Interim Cryogenic Propulsion System uses "Lunar Gravity Assist" ("swing by") to achieve orbit around the Sun

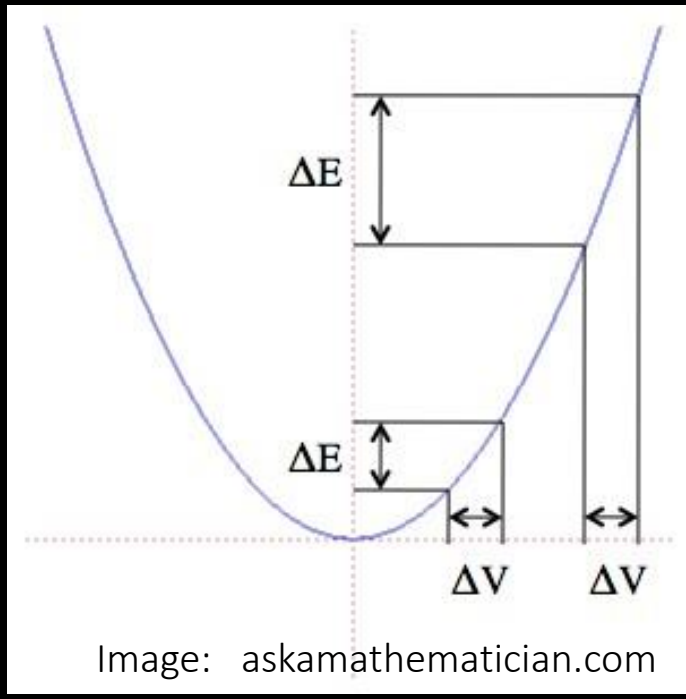
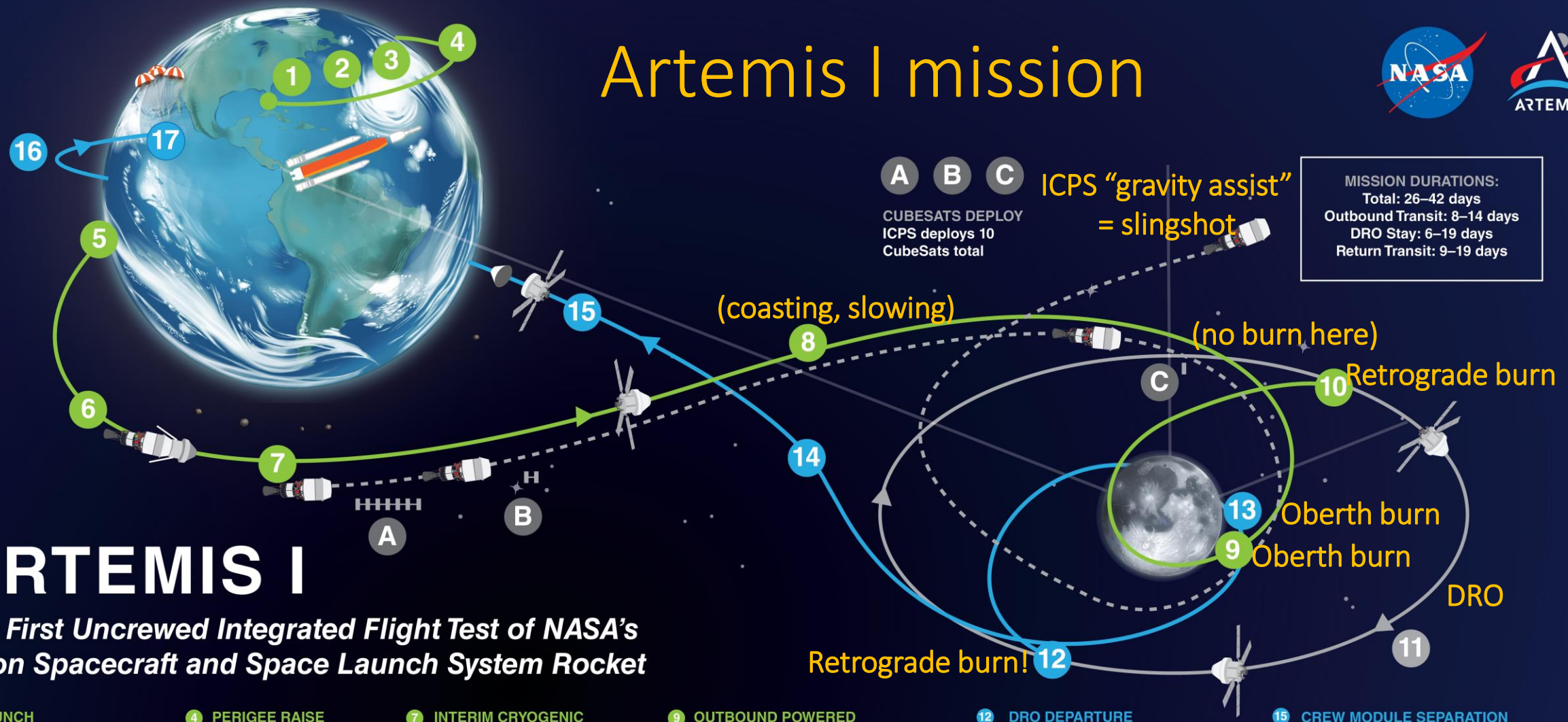


Image: askamathematician.com

Artemis maneuvers exploit the Oberth effect

- Energy and momentum for rocket + exhaust are still conserved
  - The “extra” kick beyond chemical reaction energy is because expelled propellant had kinetic energy before the burn, and some of that is transferred to the rocket
  - Imagine the propellant before and after the burn as marbles, with their own momentum and energy
- It’s just a question of where the propellant kinetic energy is transferred
  - For a rocket fixed to its launch site, all chemical reaction energy goes to the exhaust gas
  - If rocket velocity matches exhaust velocity, exhaust is dropped to 0. All energy goes to the rocket

Artemis I mission



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    Pacific Ocean landing within view of the U.S. Navy recovery ship.

Credit: NASA

A different lunar launch delayed

- Falcon 9 rocket issue
- “Lunar flashlight” surveying water ice in craters with 4 infrared beams & spectrometer
- ispace Hakuto M1 lander (Japan/private)
  - UAE Rashid-1 rover, other small payloads

Image: NASA

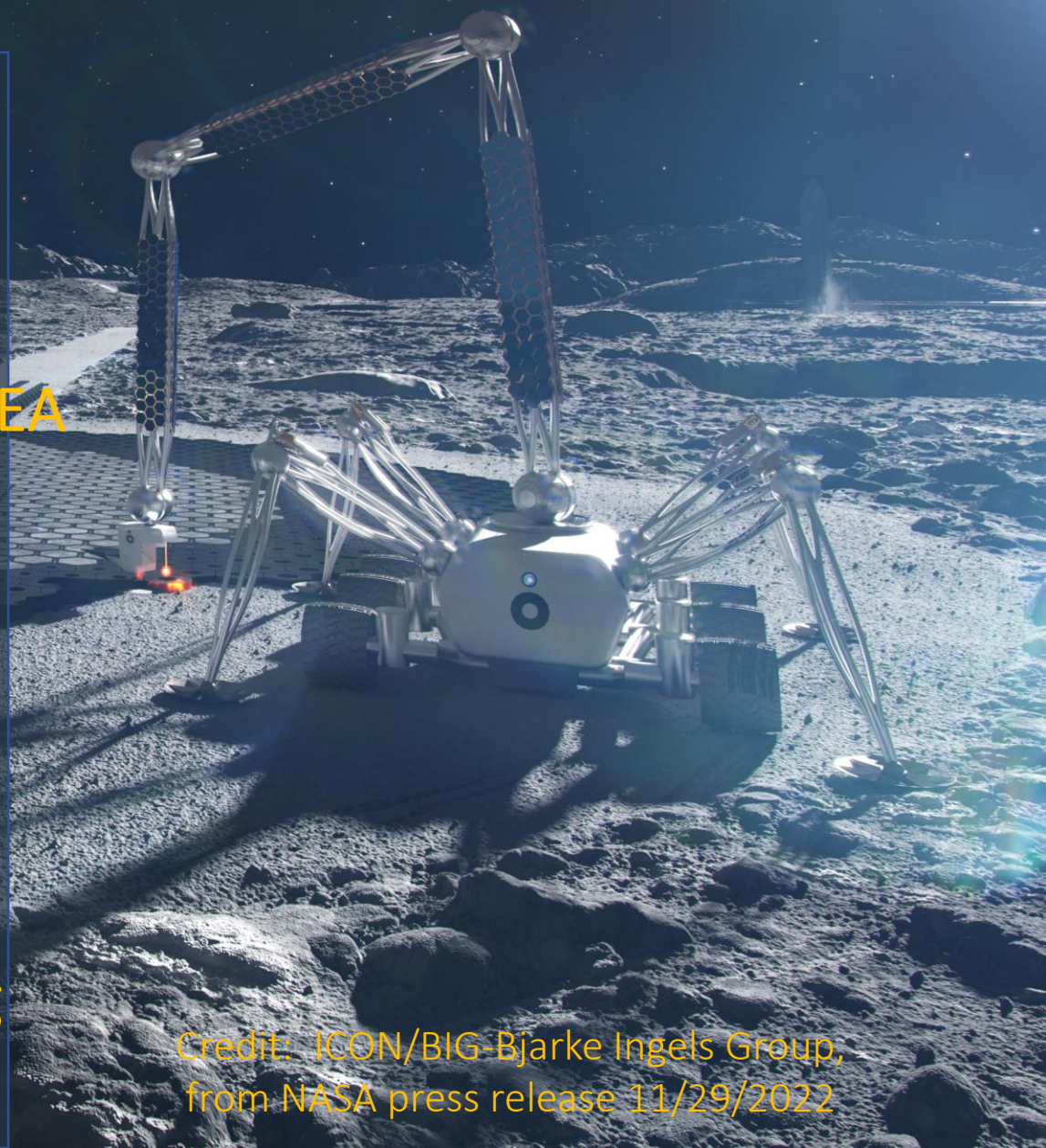
M1 lander. Credit: ispace

NASA/USAF fund ICON for Moon/Mars construction tech

Credit: ICON/BIG Bjarke Ingels Group,
from NASA press release 11/29/2022

NASA/USAF fund ICON for Moon/Mars construction tech

- 3D print: landing pads, blast shields, roads, habitats with local materials on Moon/Mars
- $57.2M SBIR (Small Business Innovation Research) Phase III award through 2028
- Austin-based ICON previously printed CHAPEA Mars Analog at NASA JSC (Oct., 2021 news)
- Probably based on laser sintering or other regolith melting, underway at ICON
- Overall NASA project: MMPACT: **M**oon-to-**M**ars **P**lanetary **A**utonomous **C**onstruction **T**echnology, including lunar testing
- Chinese have similar plans, including testing 3D printing from a lunar lander in 2028



Credit: ICON/BIG-Bjarke Ingels Group, from NASA press release 11/29/2022

What is the status of CHAPEA/Mars Dune Alpha?

- From October, 2021 News:

- Simulated Mars habitat ("analog") at JSC
  - 1,700 sq.ft. 3D printed module by ICON, designed by BIG
  - Printer extrudes Lavacrete (Portland cement + lava) using H20. Mars application should melt local regolith
- Each of 3 missions will have 4 crew members, starting in Fall 2022
  - Applications for crew for the first 1 year mission just closed Sept 17
  - Future missions in 2024 and 2025
- Testing physical operations, human behavior, food systems
  - Simulated resource limitations, equipment failure, communication delays, etc.
  - Simulated spacewalks using Virtual Reality

- Construction done 5/2022
- 3D printing issues, not all tested
  - Integrating earth-brought parts
    - Airlocks, windows, power lines,…
  - Pressurization & sealing
  - Thermal expansion/contraction
    - Special joints to avoid cracks
    - Structural reinforcement
  - Vacuum, cold conditions during construction
  - Chemicals in the regolith?
  - No water in future MMPACT work:
    - Maybe Ca-S-Al binder
    - Probably molten regolith extrusion or laser sintering
- Estimated mission start date now Summer 2023

NASA approved NEO Surveyor for development Dec. 6

- Infrared space telescope at Earth/Sun L1 point, to discover dangerous asteroids & comets
  - NEO = Near Earth Objects
  - 100 ft. diameter, within 30 million miles of Earth
- "Key decision point C" passed on December 6
  - Commitment reverses NASA's previous low priority
  - Congress originally mandated in 2005
  - Congress re-asserted in CHIPS act in August, 2022, to launch by March 2026
  - Result of lobbying by NSS, others (mentioned in October news)
- Now $1.2 billion, for launch by June 2028

Image credit: NASA/JPL-Caltech via Wikipedia

Miscellany

- Chinese space station new crew arrival: 3 overlapping 3 for the first time

Image credits: NASA

How many launches since the last meeting (Nov. 12)?

Includes failed launches if they lift off the launch pad
Only includes launches attempting Earth orbit or beyond

Artemis 1 (SLS) launch Nov. 16, 2022
Credit: NASA TV (video)

NASA ID: KSC-20221116-MH-AJN01-0001-Artemis_I_Isolated_Launch_Views-3314595

Launches since last meeting (Nov. 12), page 1


Nov 14 – Long March 4C – Yaogan-34 earth observation satellite


Nov 16 – Ceres-1 (Galactic Energy, China) – 5 Jilin-1 earth observation satellites


Nov 16 – SLS (NASA) – Artemis 1 uncrewed launch to lunar orbit


Nov 22 – Falcon 9 – Eutelsat-10B communications satellite (geo orbit)


Nov 26 – PSLV (India) – Oceansat-3 ocean monitoring satellite + 8 rideshares


Nov 26 – Falcon 9 – Cargo Dragon resupply to International Space Station


Nov 27 – Long March 2D – 3 Yaogan-36 military reconnaissance satellites


Nov 28 – Soyuz-2 – Russian GLONASS-M (GPS equivalent) satellite Kosmos-2564


Nov 29 – Long March 2F – Shenzhou-15 with crew of 3 to the Chinese space station


Nov 30 – Soyuz-2 – Russian military electronic intelligence satellite Kosmos-2565


Dec 06 – Kuaizhou 11 – test satellite for VHF Data Exchange System (maritime data)


Dec 08 – Long March 2D – another Gaofen earth observation satellite


Dec 08 – Falcon 9 – 40 OneWeb satellites! (now at 504/648 initial satellites)

Launches since last meeting (Nov. 12), page 2

Dec 09 – Jielong-3 (new solid rocket) – 14 satellites, from a mobile sea platform

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Discussion & questions?

Image: NASA

Featured speaker: Andrew Parris

- A 3 x Emmy award winning broadcast television engineer
- Lifelong dream of living and working in space.
- 13 years at NASA supporting Space Shuttle and the International Space Station operations
- Involved in aerospace educating the public as a Space communicator

TOPIC:

Our journey to the stars: A personal view

NSS North Houston Space Society