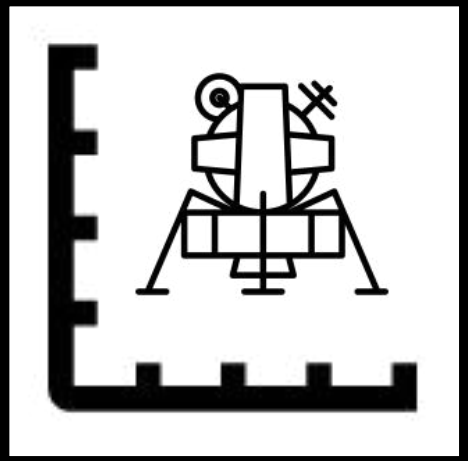
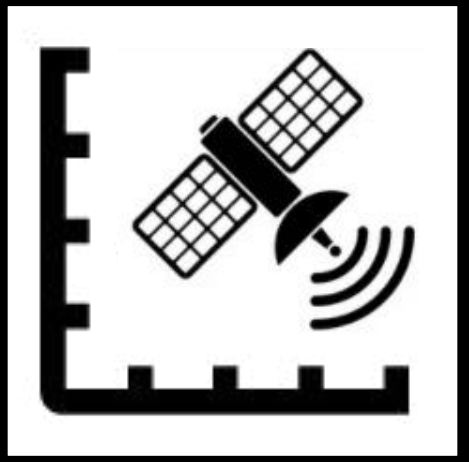
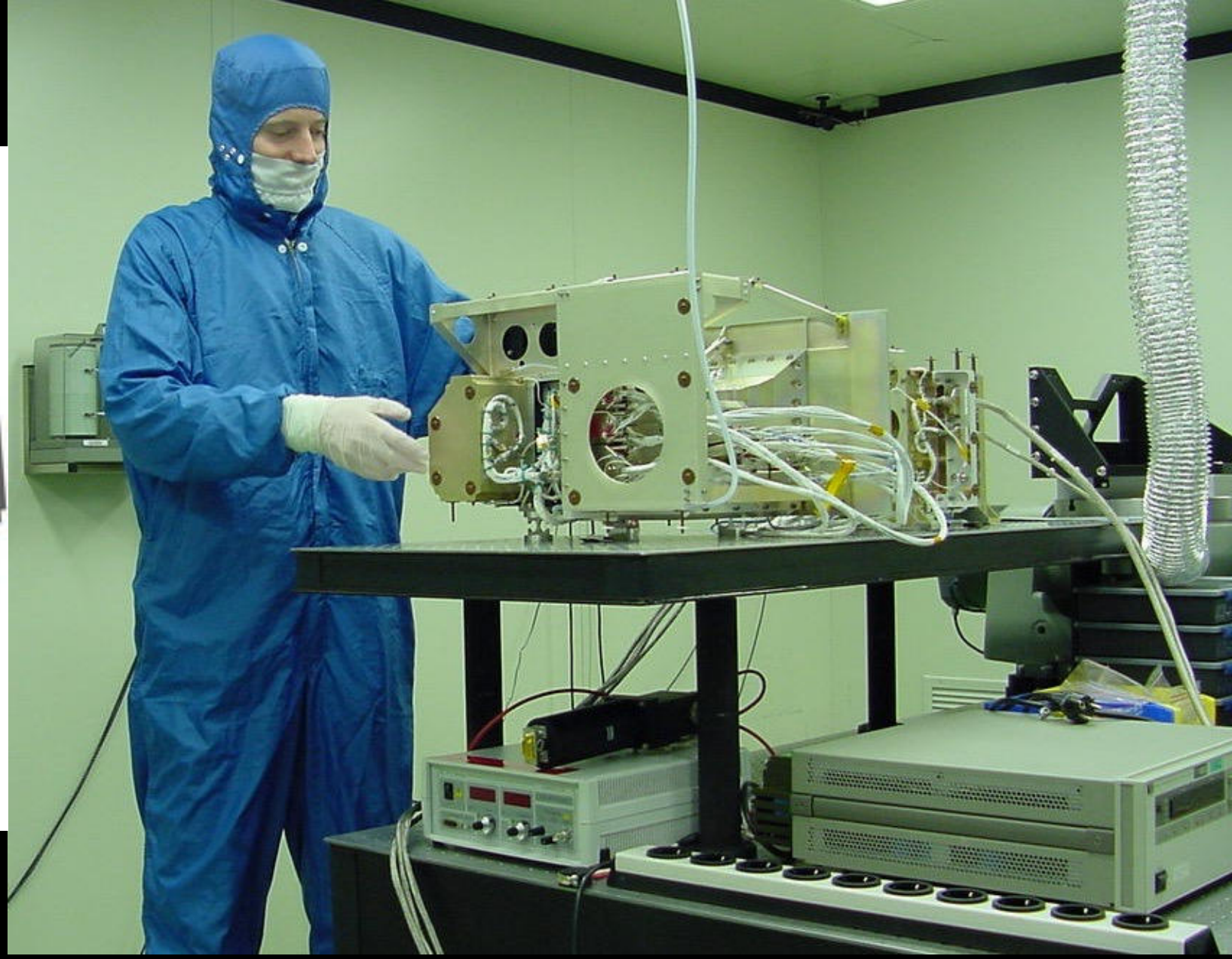
De Sterrenkunde in 2026
Les 3: Ruimtevaart: Artemis
Amersfoort
18 maart 2026

Erik Laan

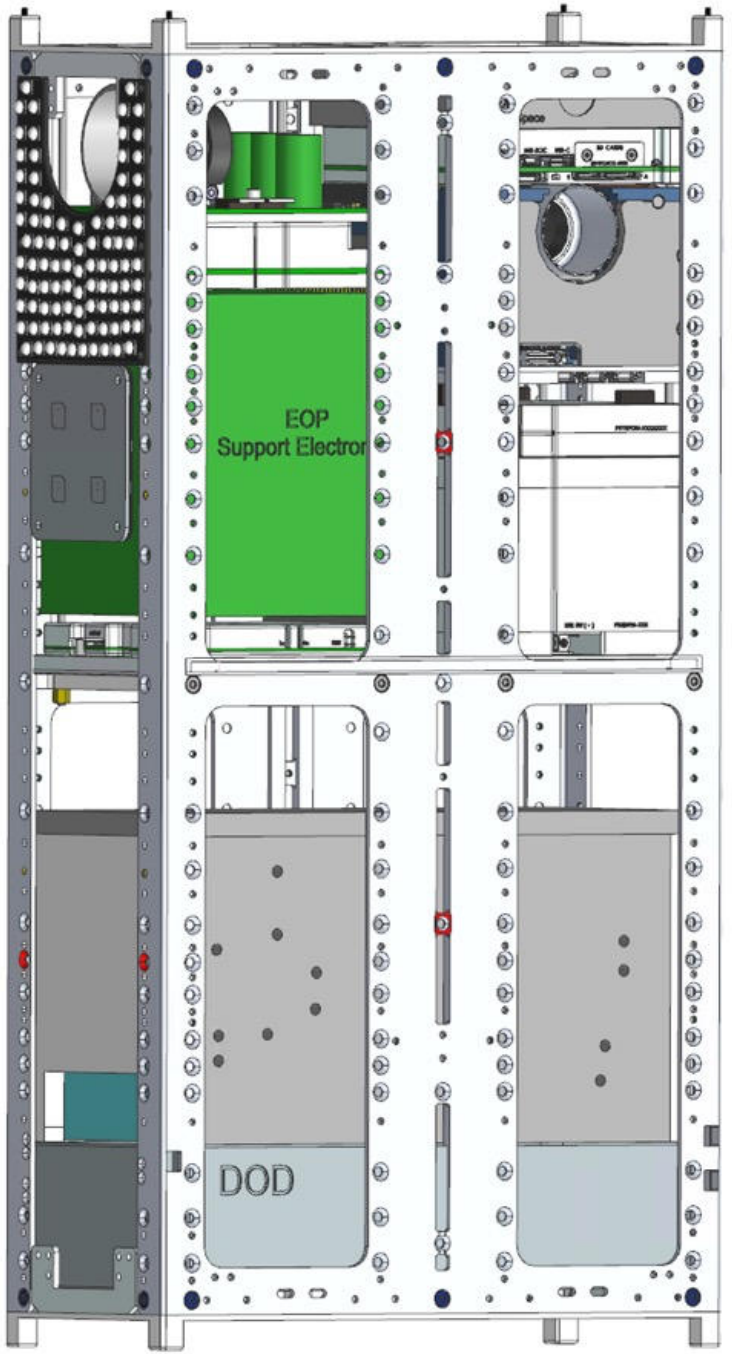


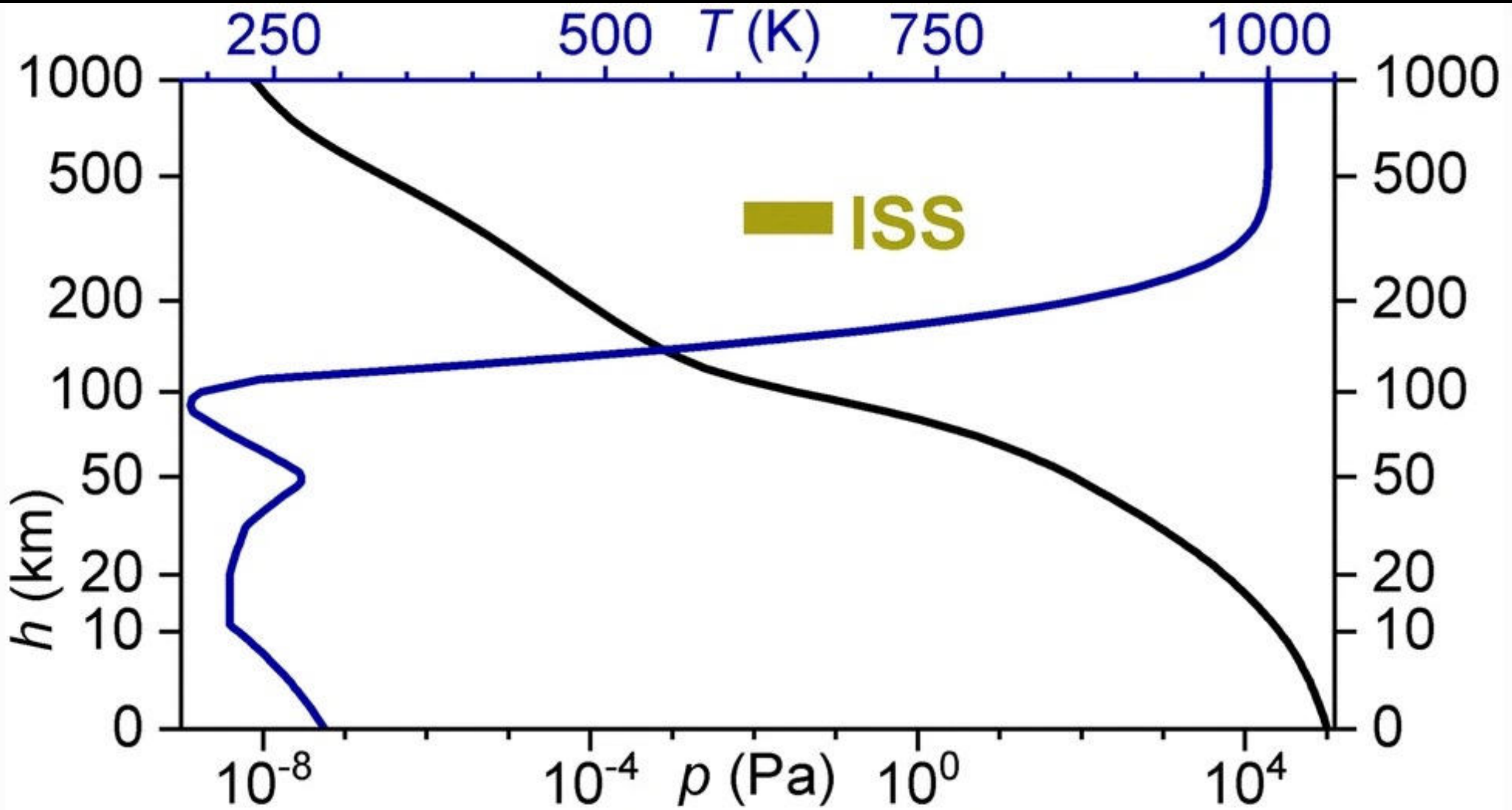


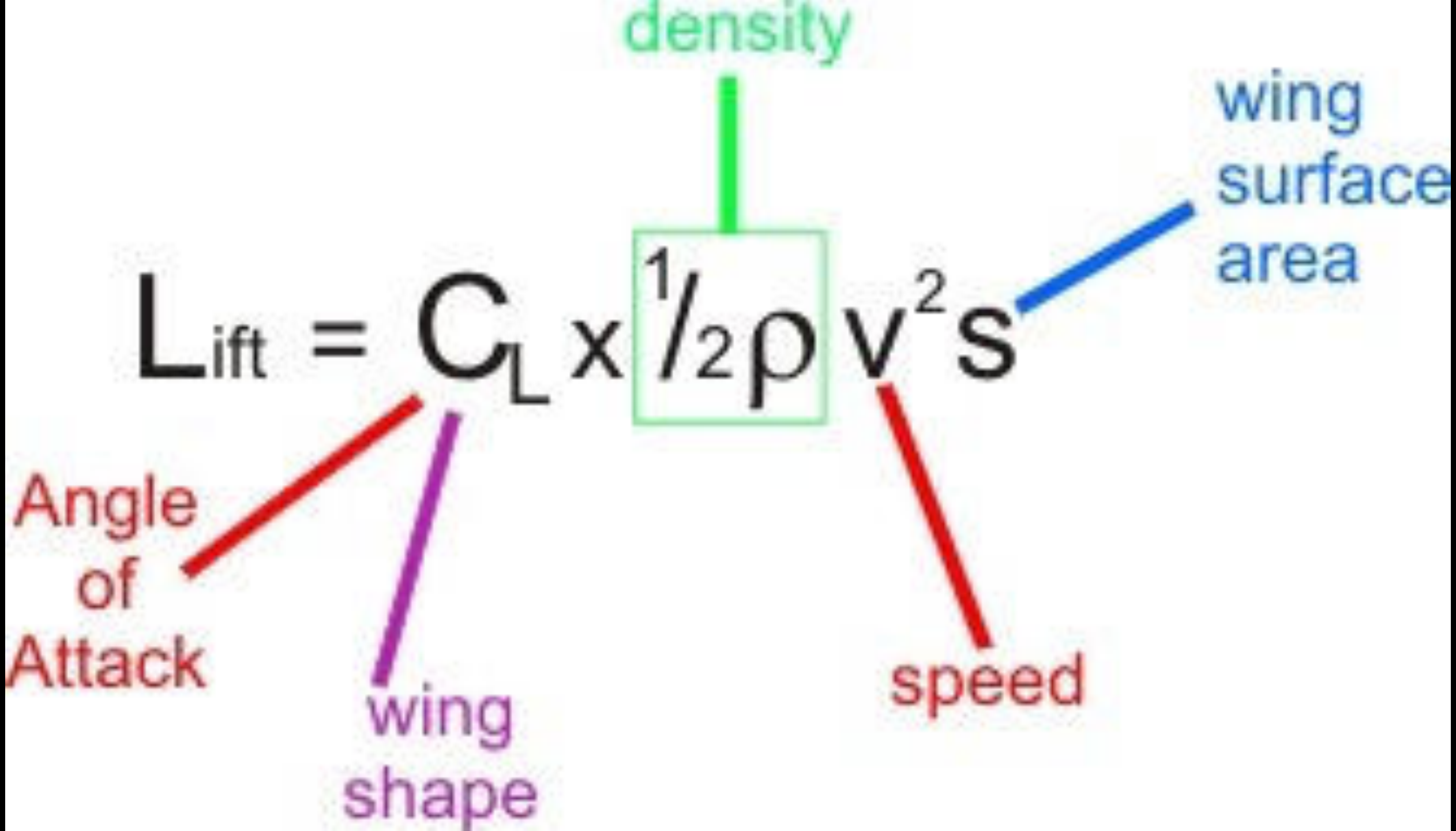


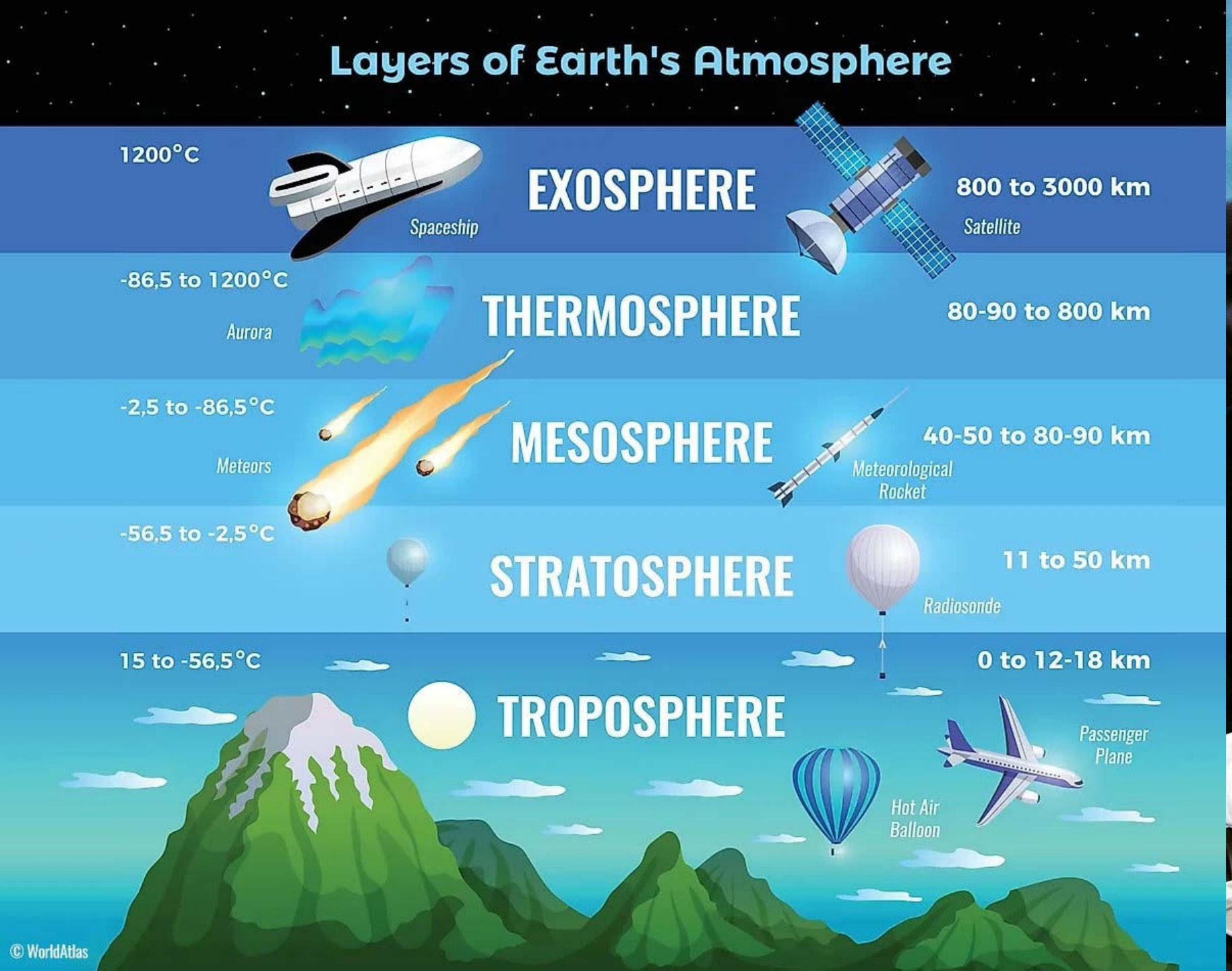
Space Engineering Lecturer Erik Laan

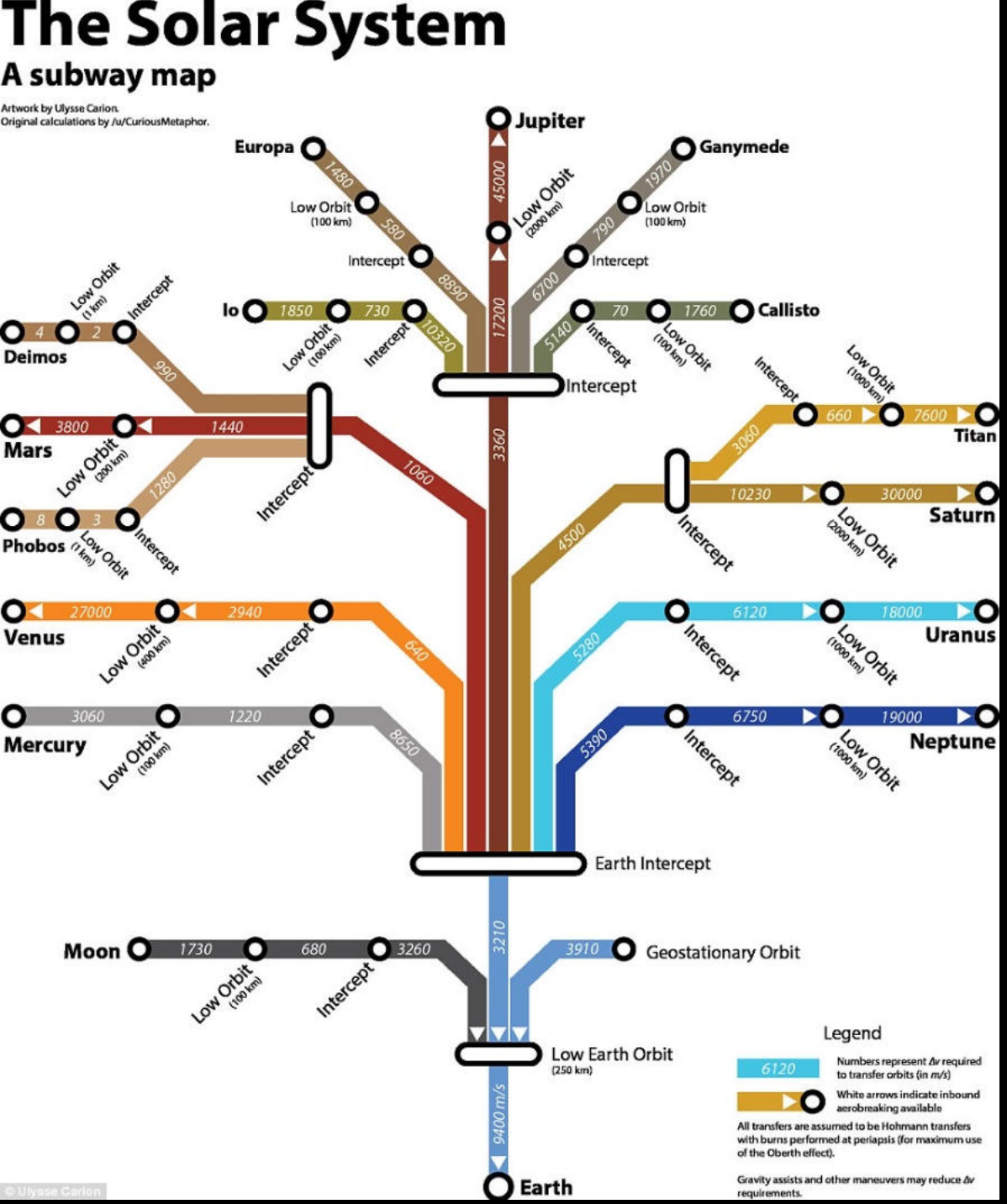

INHOLLANDSAT - 1
INHOLLAND SPACE LAB - DELFT


EOP
Support Electron
DOD


250
500
T (K)
750
1000
1000
500
200
100
50
20
10
0
h (km)
ISS
10-8
10-4
p (Pa)
100
104


density
wing surface area
$L_{ift} = C_L \times {}^{1}/_{2}\rho v^2 s$
Angle of Attack
wing shape
speed


Layers of Earth's Atmosphere
1200°C
EXOSPHERE
800 to 3000 km
Spaceship
Satellite
-86,5 to 1200°C
THERMOSPHERE
80-90 to 800 km
Aurora
-2,5 to -86,5°C
MESOSPHERE
40-50 to 80-90 km
Meteors
Meteorological Rocket
-56,5 to -2,5°C
STRATOSPHERE
11 to 50 km
Radiosonde
15 to -56,5°C
TROPOSPHERE
0 to 12-18 km
Passenger Plane
Hot Air Balloon
© WorldAtlas



Delta-V (ΔV)

- Earth surface → LEO: 9.4 km/s
- LEO → Moon surface: 5.7 km/s
- LEO → Mars surface: >6.4 km/s

Tsiolkovsky rocket equation

$$\Delta v = v_e \ln \frac{m_0}{m_f} = I_{sp} g_0 \ln \frac{m_0}{m_f}$$

Rocket engine	Fuel	Specific Impulse (s)	Thrust (N)	Thrust to weight ratio
Saturn 5 first stage (F-1)	LOX/RP1	263	6.7E6	88
Saturn 5 2nd/3rd stage (J-2)	LOX/LH2	421	4.4E6	59
SpaceX Merlin 1D	LOX/RP1	282	0.9E6	165
SpaceX Raptor 2	LOX/CH4	327	2.3E6	138
Busek BHT-6000	Xenon	2600	0.29	0.002

Konstantin Tsiolkovski 1857-1935


BIENVENUE SUR LA LUNE, MR. ARMSTRONG !
WELCOME !
?
NASA
HERGÉ


LE VOYAGE DANS LA LUNE.
EN PLEIN DANS L'ŒIL !! (9e TABLEAU)

turday Evening, October 5, 1957 (UP)—Means United Press Price: Five Cent

Russians Win Race To Launch Earth Satellite

Man On Threshold Of Space Travel

By DANIEL F. GILMORE
United Press Staff Correspondent

LONDON (UP)—The pulsating radio "beep" of the first manmade earth satellite signalled today to the world that man had crossed the threshold into the age of travel through space.

The Soviet Union announced it had won the race into space by launching an earth satellite Friday, a 184-pound, 22-inch globe now orbiting the earth at 18,000 miles an hour, 560 miles up.

Millions of persons throughout the world heard the "beep...beep... beep..." rebroadcast today by local stations and realized that man had taken his first faltering steps into the new era.

Launching of the satellite was a tremendous victory for science. It was a more tremendous victory for Soviet propaganda to be able to trumpet to the world the Russians were the first to break through the frontiers of space.

Bolsters ICBM Claims

It bolstered Russian claims to

— WEATHER —

WEST VIRGINIA—Partly cloudy with highest in the 60s today and Sunday. Lowest tonight 50 west and 40 east portions.

VIRGINIA—Fair with lowest 45 to 50 west and north and 50 to 55 southeast portions tonight, Sunday mostly sunny and a little warmer. Tides on the coast and lower bay will run a foot or two above normal.

How To Spot Satellite

By UNITED PRESS

Here's how to look for the Russian earth satellite which will be whizzing through the sky at 18,000 miles an hour.

The best time to spot it is at dawn or dusk when the sky is semi-dark. There is a chance that it could be seen if it travels across the face of the moon at night.

The best instruments to use are ordinary binoculars or telescopes. Powerful telescopes won't pick it up because of their narrow fields.

Through optical instruments, the satellite will look like the faintest star which can be seen with the naked eye.

Keep a sharp eye out. The satellite travels so fast it may appear on the horizon for only seconds and chances of spotting it have been estimated at one in a hundred.

Epic-Making

U. S. May Speed Up Satellite Program

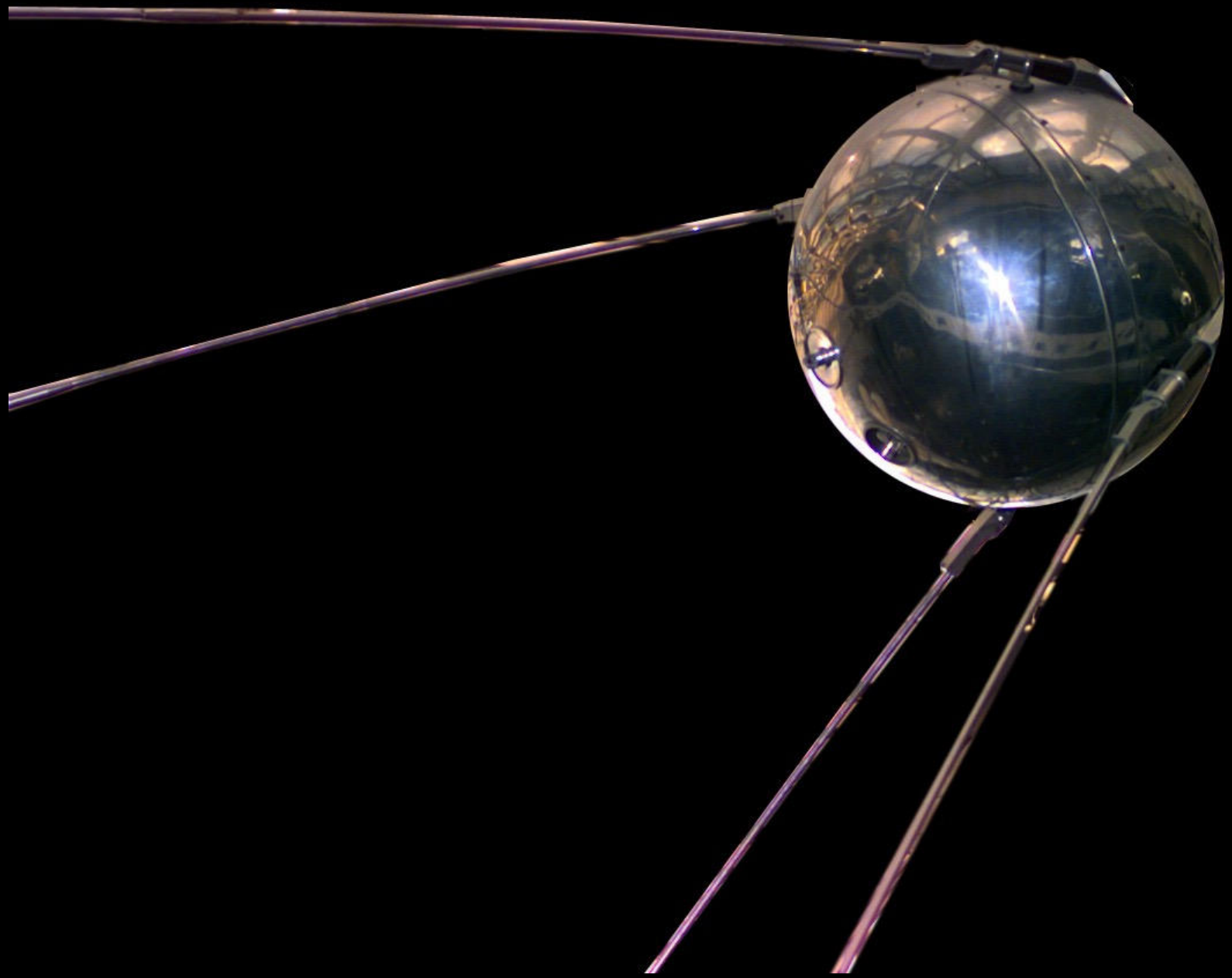
By JOSEPH L. MYLER
United Press Staff Correspon

WASHINGTON (UP)—Amer scientists, caught flatfooted Russia's epic launching of the man-made moon, indicated t the United States may spee its own earth satellite progra

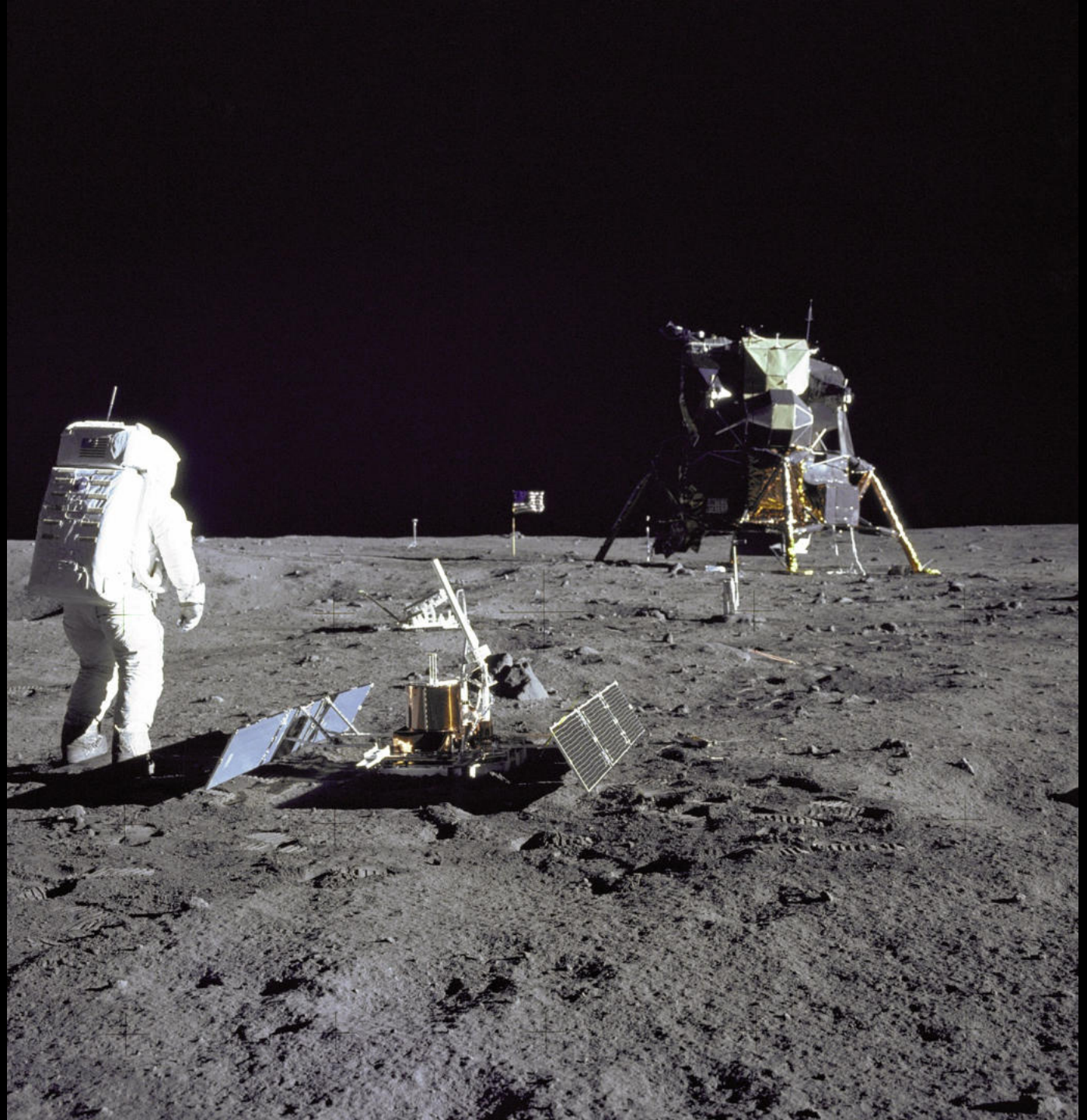
Leaders of the U.S. satellite gram also said that it ap Russia rocketed its heavy pound satellite into a globe dling orbit with a rocket to" an intercontinental ba missile.

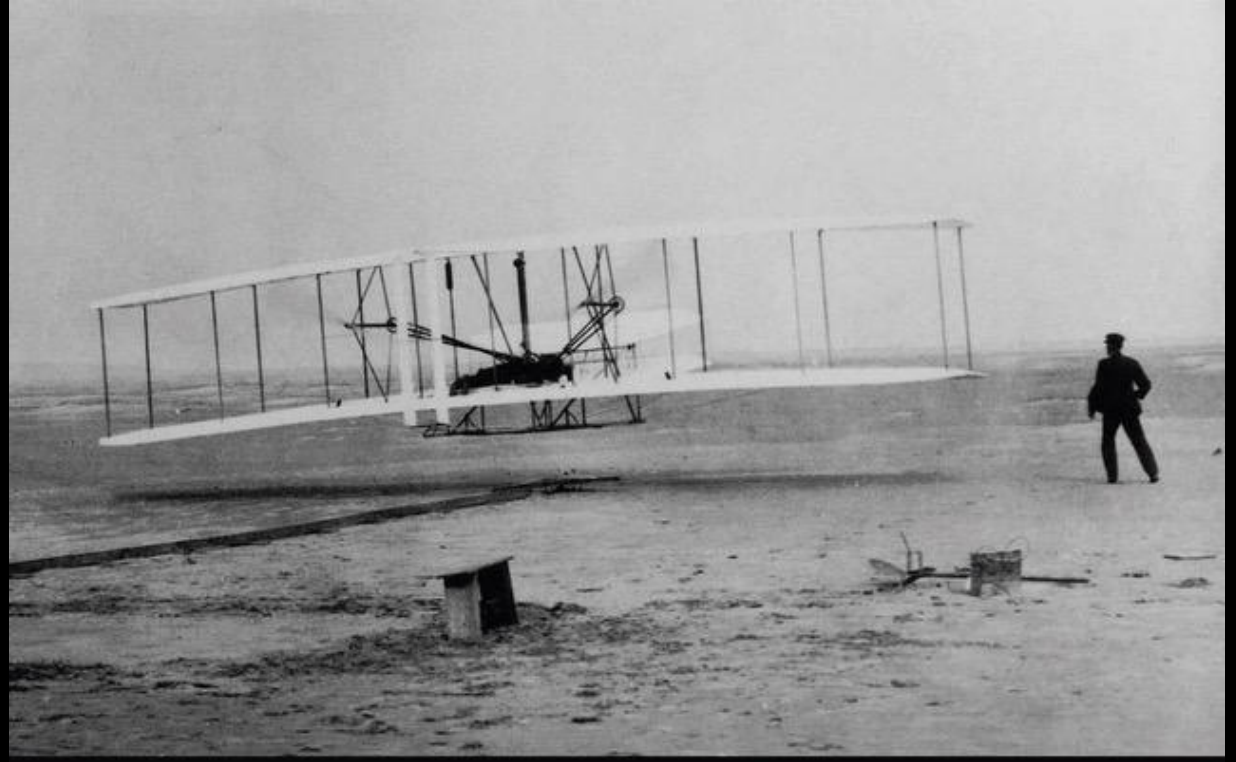
That could mean Russi only has beaten this country frontiers of space, but also t has been called the "ul weapon" for modern day wa ICBM. This country has n tested a successful ICBM.

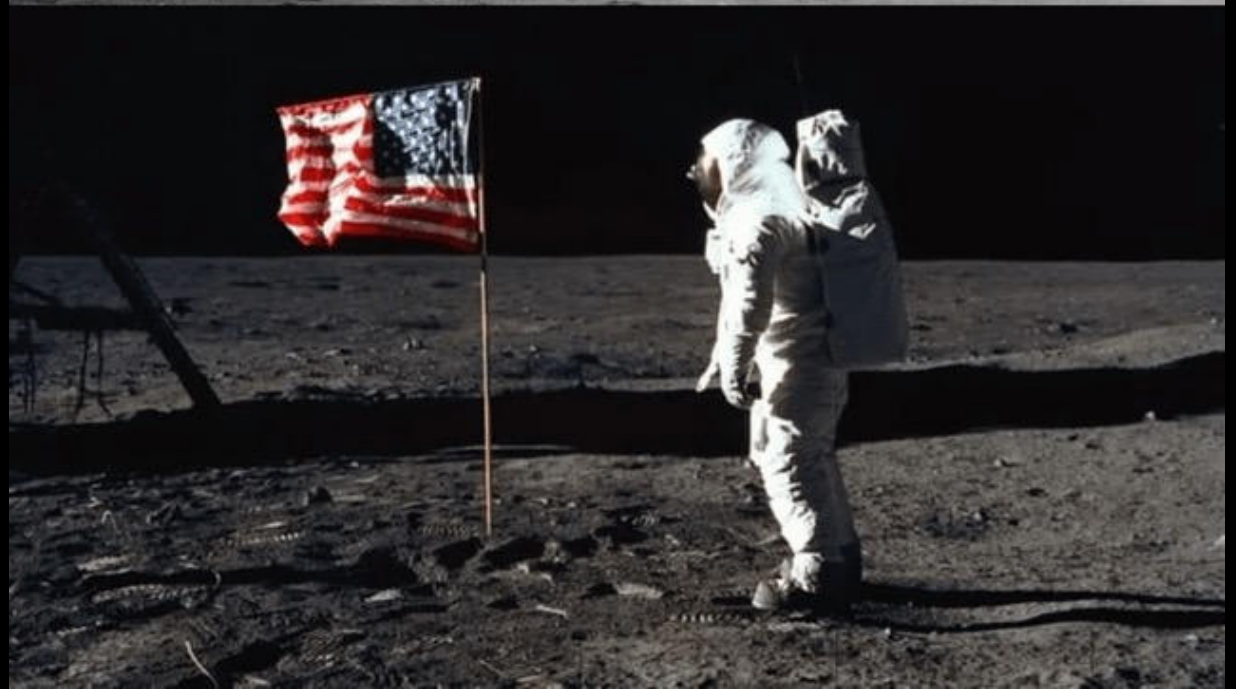
American diplomats co Russia had scored a notable aganda victory. The milita



Yuri Gagarin: 12 april 1961





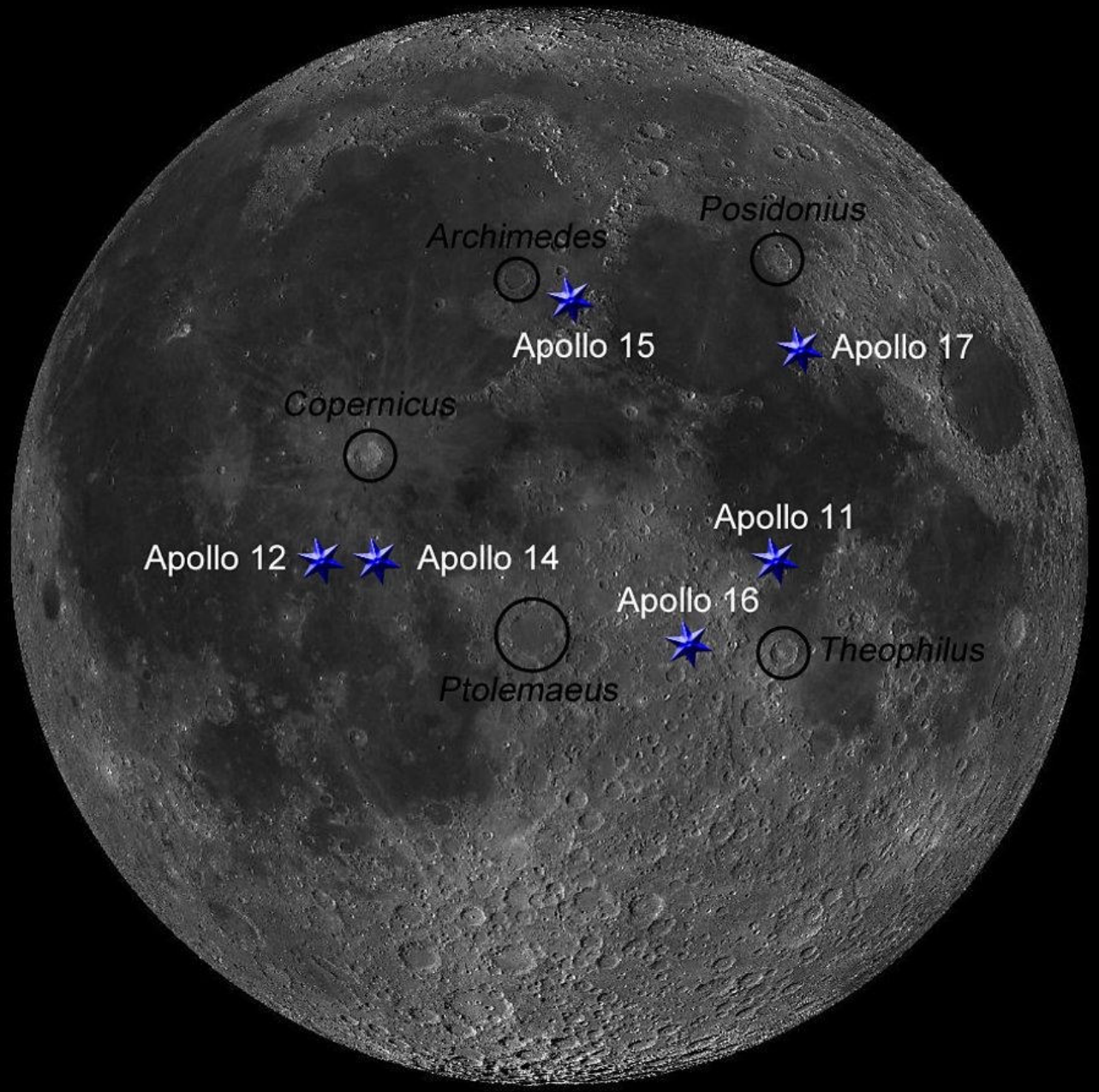



JOHNNY'S

Who was the first human that walked on the Moon?

- Louis Armstrong
- Neil Armstrong
- Lance Armstrong

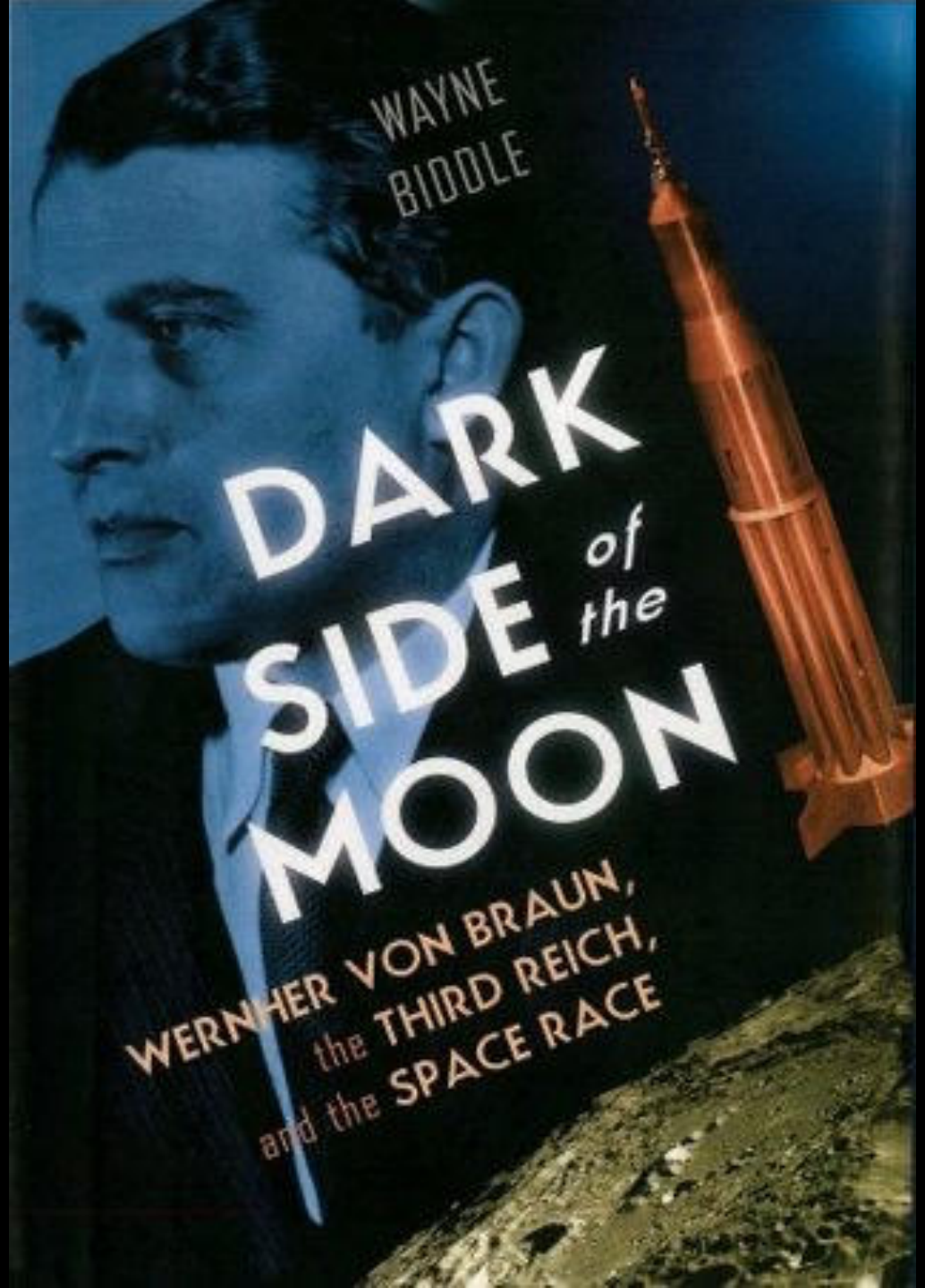
The Armstrongs

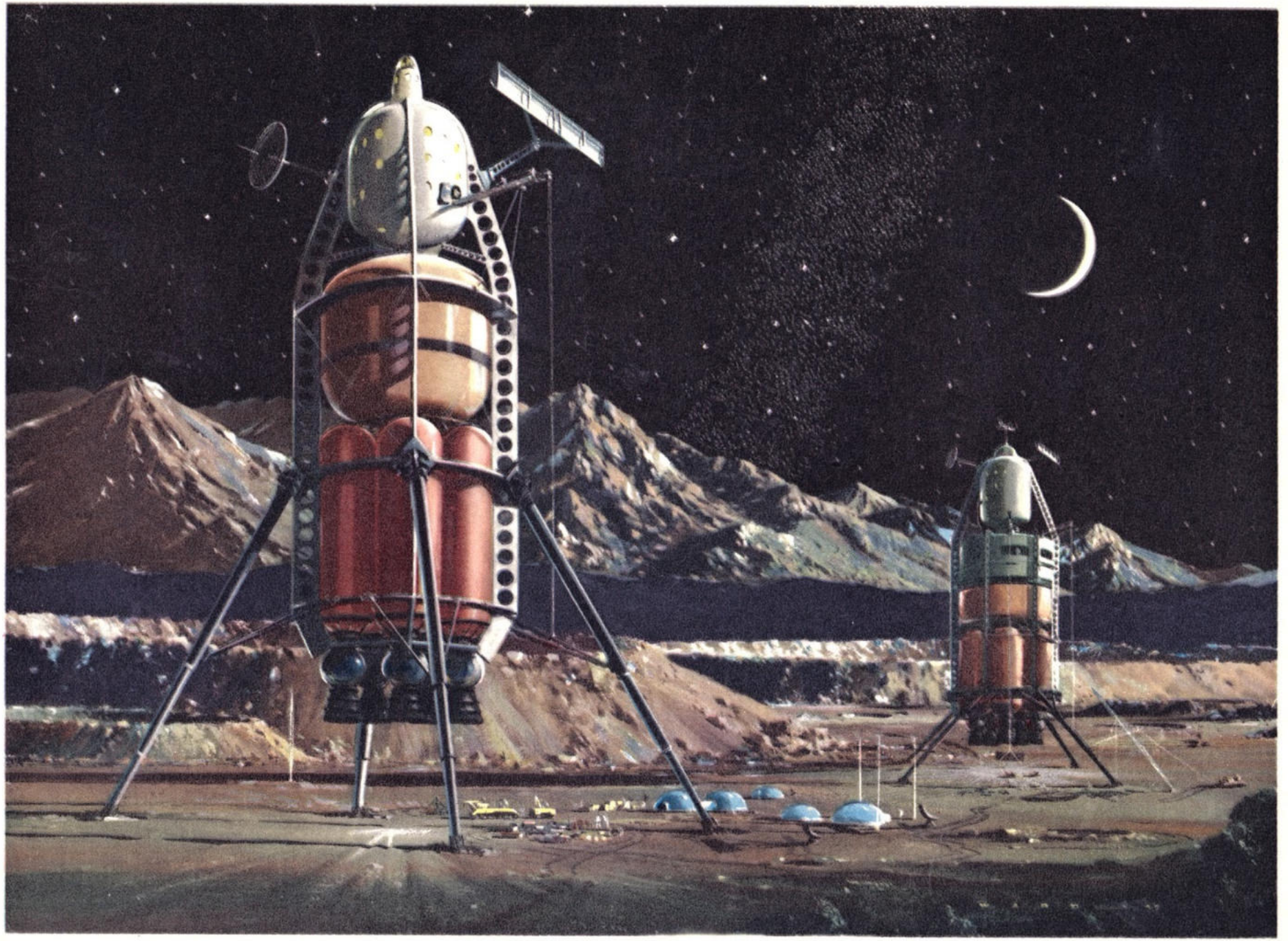

Archimedes
Posidonius
Apollo 15
Apollo 17
Copernicus
Apollo 11
Apollo 12
Apollo 14
Apollo 16
Theophilus
Ptolemaeus


NASA
HAISE

APOLLO 18

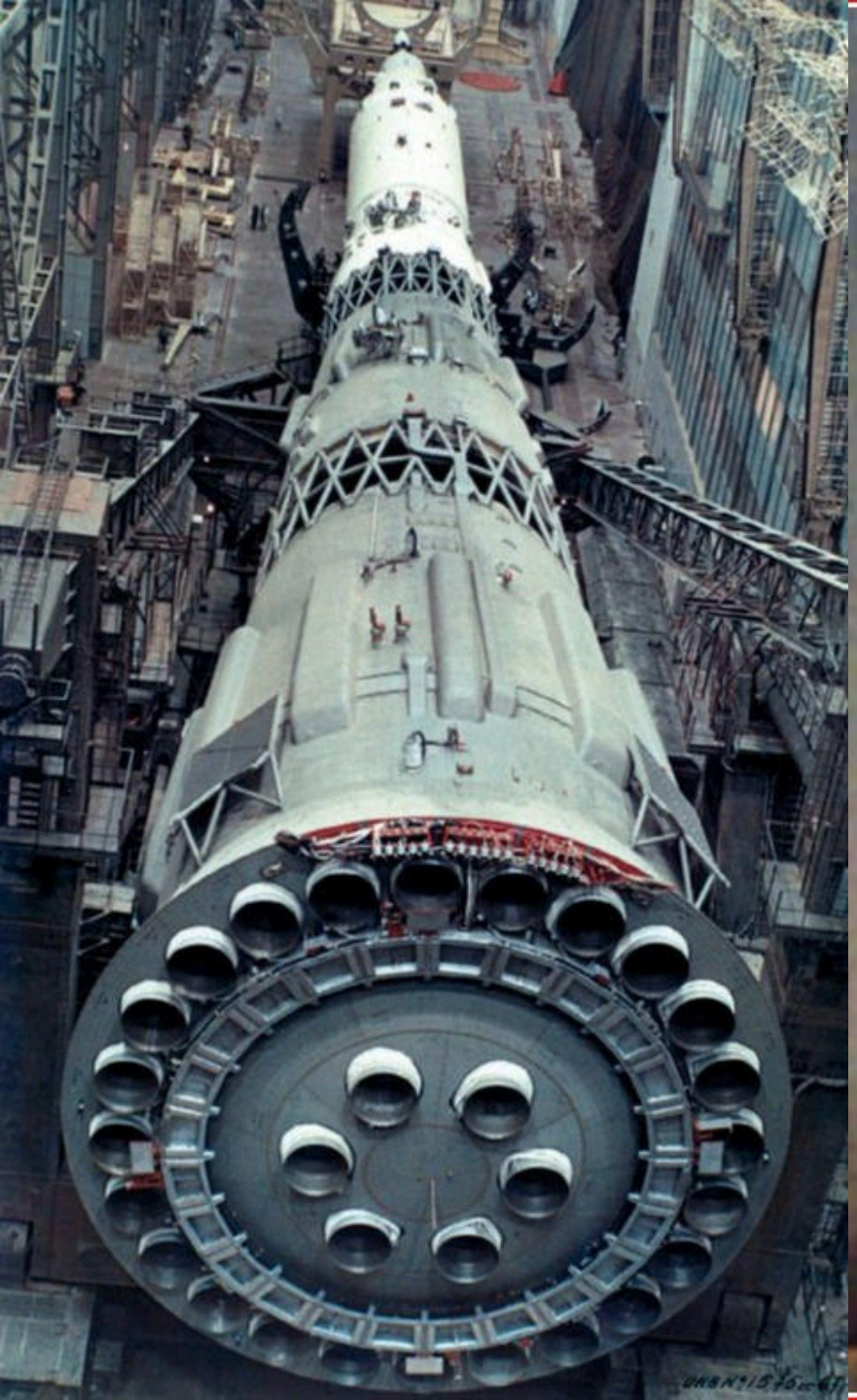
THERE'S A REASON WE'VE NEVER
GONE BACK TO THE MOON.


WAYNE BIDDLE
DARK SIDE of the MOON
WERNHER VON BRAUN, the THIRD REICH, and the SPACE RACE

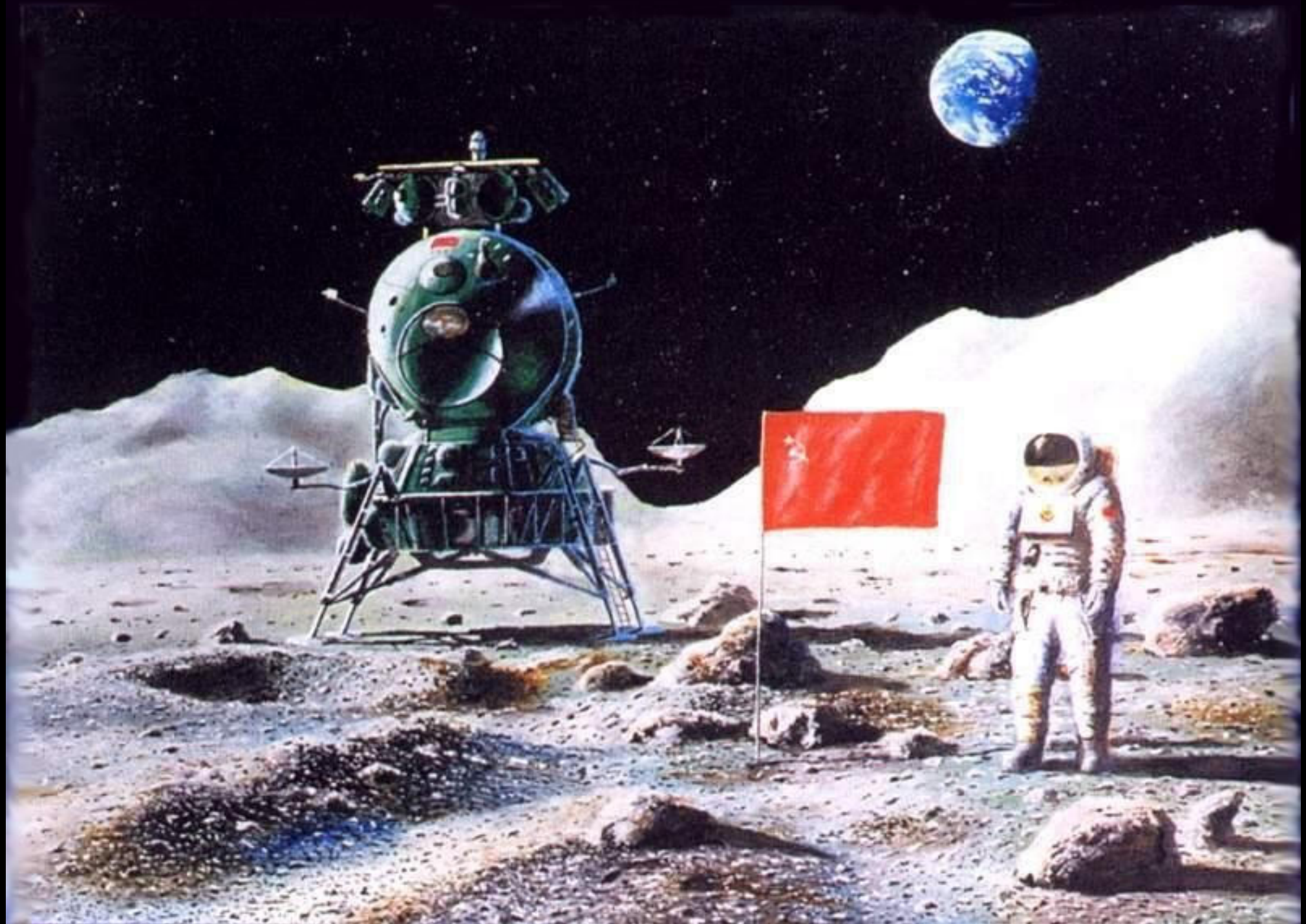


Long after the first explorers have landed in simple rockets, true space ships like these may be used to set up the first Moon base.

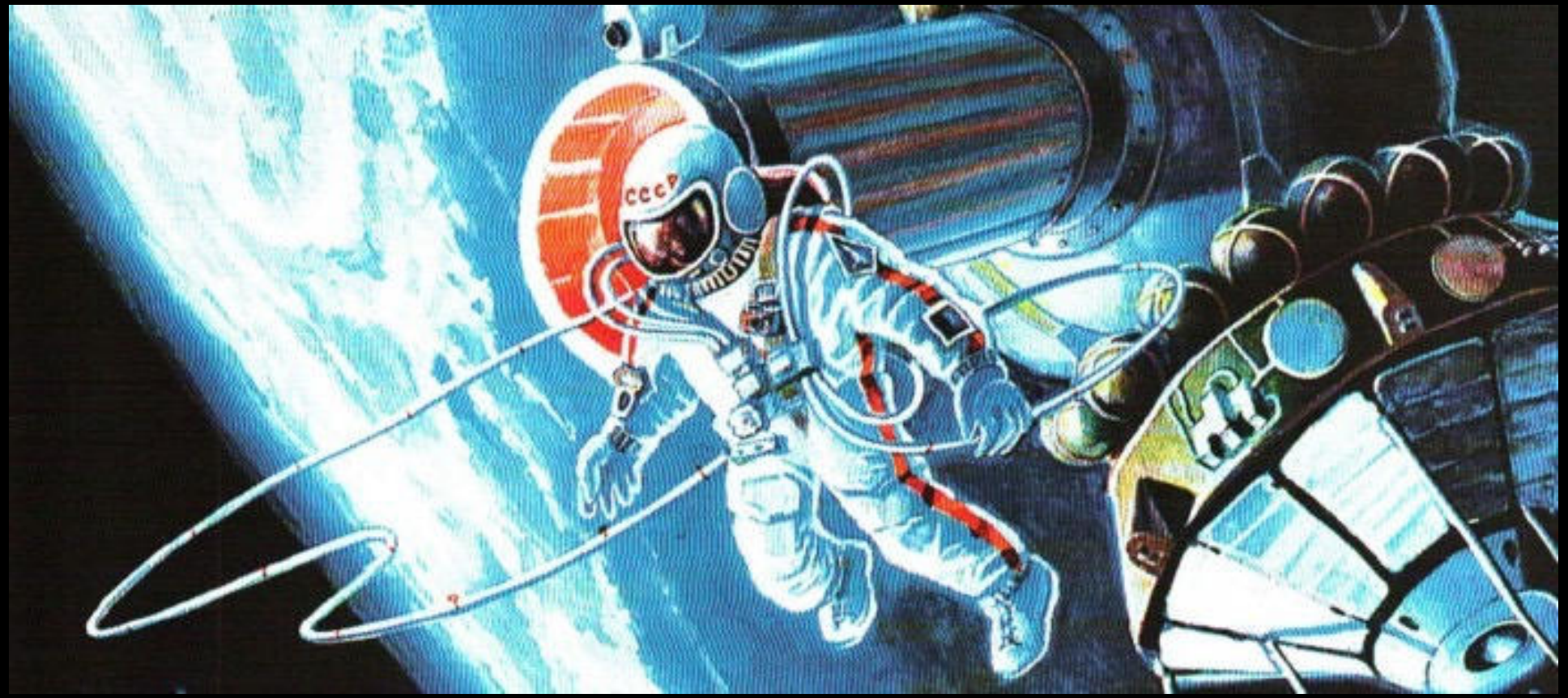

Op 8 september 1944
werd vanaf deze plek
de eerste V2 raket gelanceerd.
On September 8, 1944,
the first V2 rocketbomb
was launched from this site.



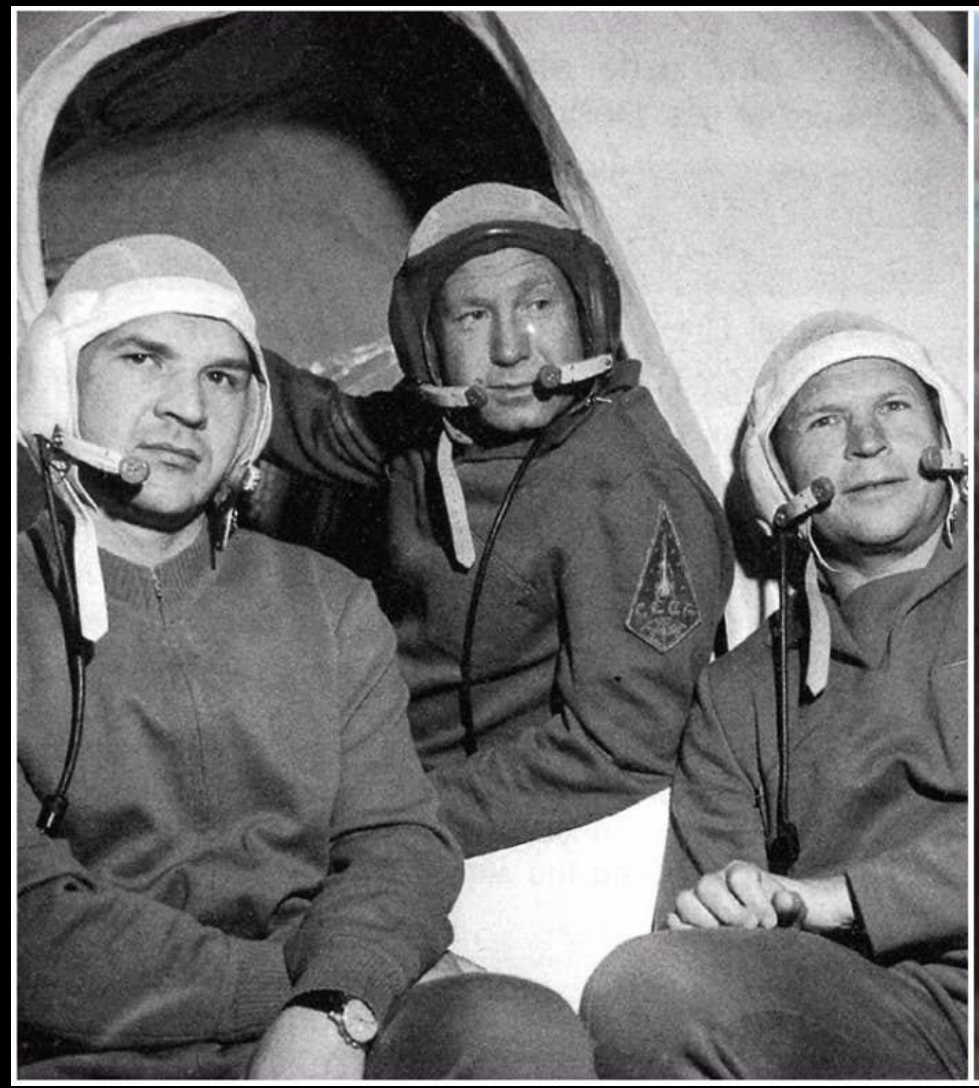

RussianSpaceWeb.com




Alexey Leonov - 1965
СССР


CCCP

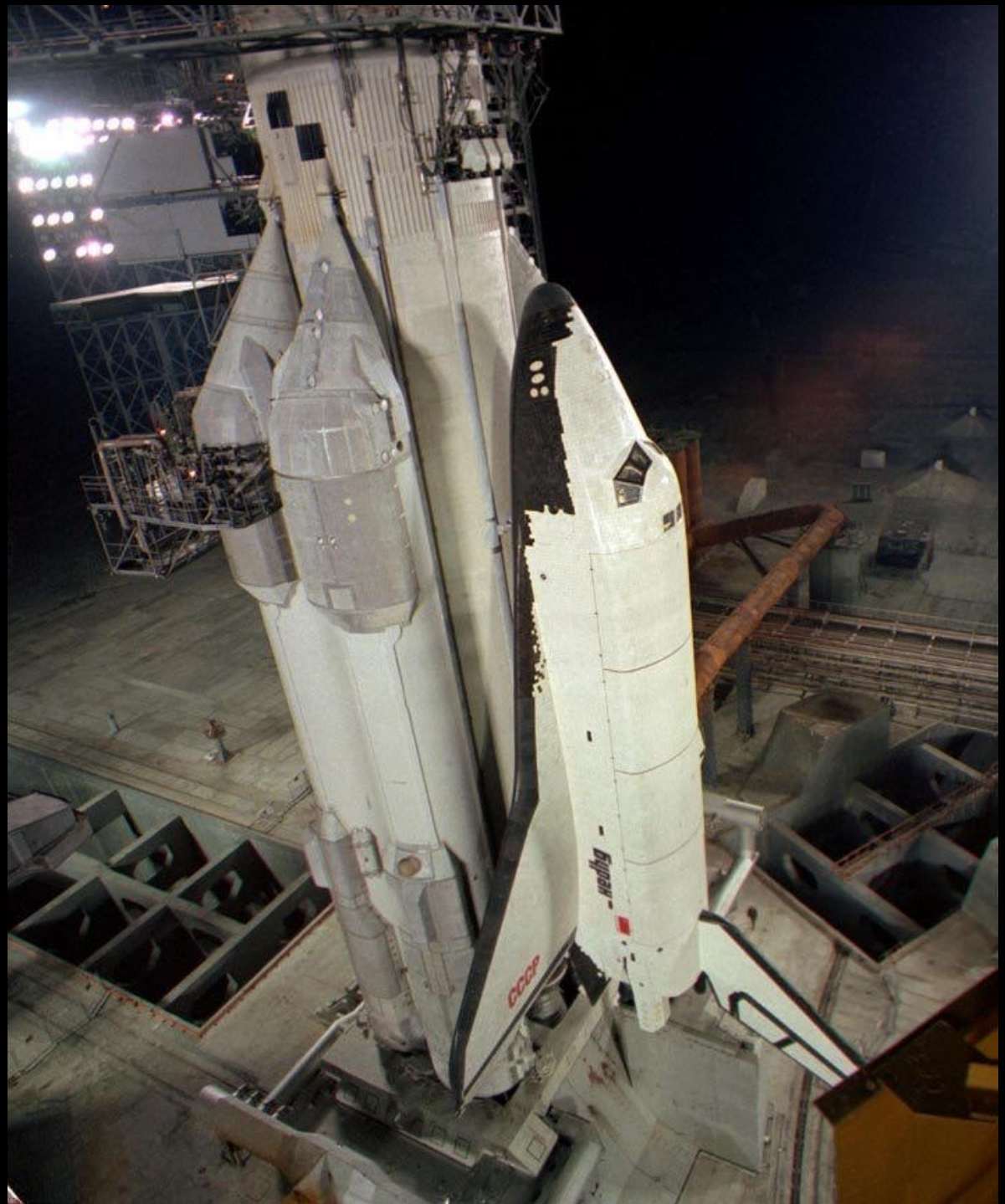
Soyuz 11 - 1971




STAFFORD
SLAYTON
BRAND
NASA
APOLLO


SALYUT ★ 7
КИНОКОМПАНИЯ СТВ, LEMONFILMS, РОССИЯ 1, производство VITA AKTIVA PRODUCTION, GLOBUS FILM при поддержке ФОНДА КИНО
В РОЛЯХ: ВЛАДИМИР ВДОВИЧЕНКОВ, ПАВЕЛ ДЕРЕВЯНКО, МАРИЯ МИРОНОВА, ОКСАНА ФАНДЕРА, АЛЕКСАНДР САМОЙЛЕНКО, ЛЮБОВЬ АКСЕНОВА, ИГОРЬ УГОЛЬНИКОВ, ВИТАЛИЙ ХАЕВ
ТАМАРА ФРИД
ТАТЬЯНА ПАТРАКАЛЬЦЕВА, НАДЕЖДА ВАСИЛЬЕВА
ПАВЕЛ НОВИКОВ, СЕРГЕЙ ТЫРИН
БОРИС ВОЙТ
СЕРИК БЕЙСЕУ, МАРИЯ СЕРГЕЕНКОВА
АЛЕКСАНДР КОПЕЙКИН
АЛЕКСЕЙ ГУСЕВ
ПАВЕЛ СЕМЕРДЖЯН
АНДРЕЙ МЕСЯЯНИН
ЮРИЙ ЛИТВИНОВ
АСТРА ИДЛИС АЛЬЯС
СЕРГЕЙ ДОЛГОШЕИН
СЕРГЕЙ АСТАХОВ, ИВАН БУРЛАКОВ
АЛЕКСЕЙ САМОЛЕТОВ
НАТАША МЕРКУЛОВА, АЛЕКСЕЙ ЧУПОВ, КЛИМ ШИПЕНКО, БАКУР БАКУРАДЗЕ
ЮЛИЯ МИШЕЙКИНЕ, НАТАЛЬЯ СМИРНОВА
СЕРГЕЙ СЕЛЬЯНОВ, БАКУР БАКУРАДЗЕ, АНТОН ЗЛАТОПОЛЬСКИЙ
КЛИМ ШИПЕНКО
СТВ Film Company
RUSSIA 1
ФК ФОНД КИНО
VITA AKTIVA
Globus film
LEMONFILMS STUDIO


МИР


СССР
Буран


Буран


TECHNIK MUSEUM SPEYER

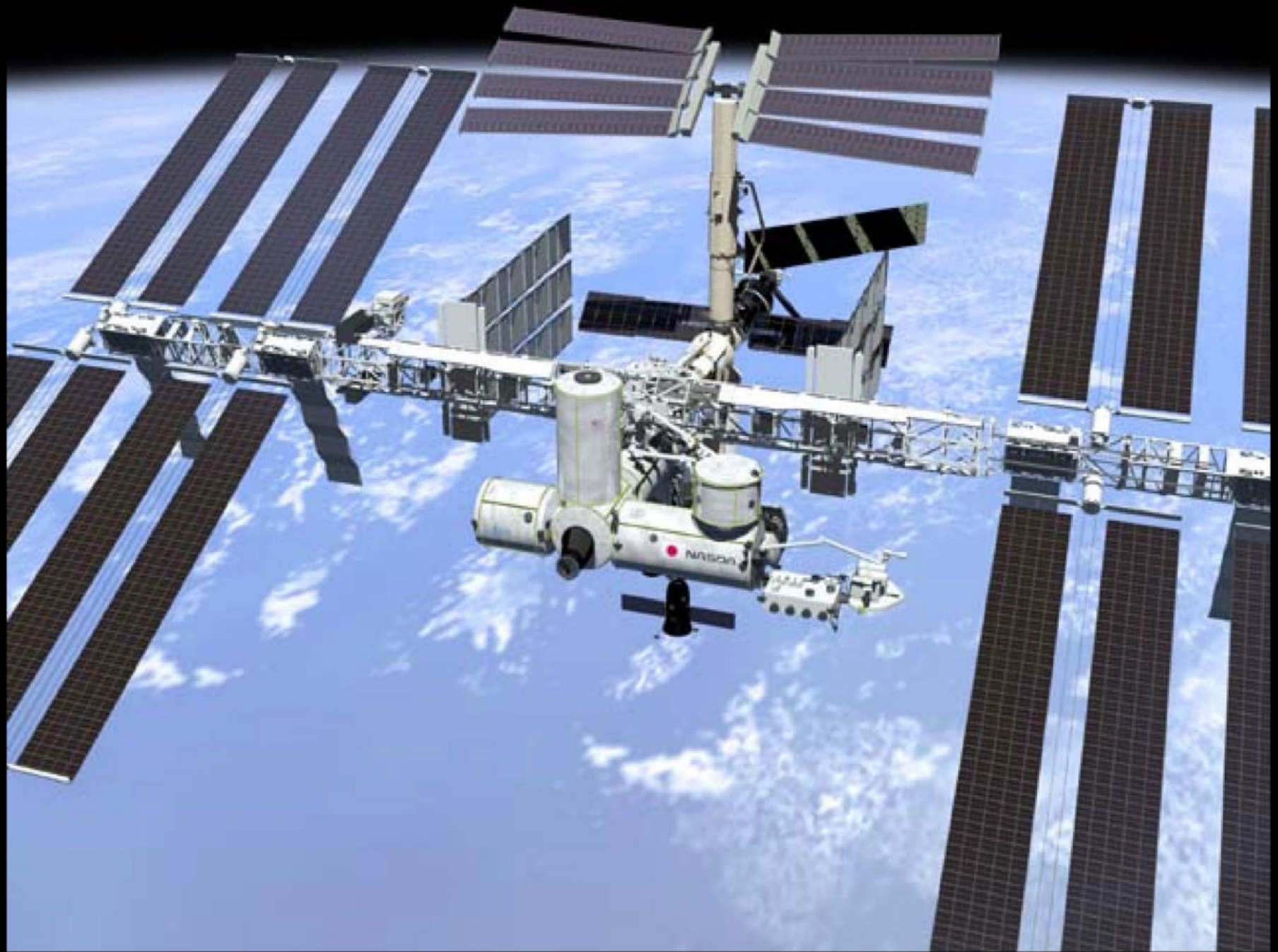
Orphans of Apollo

The Battle of the Mir & the New Space Revolution

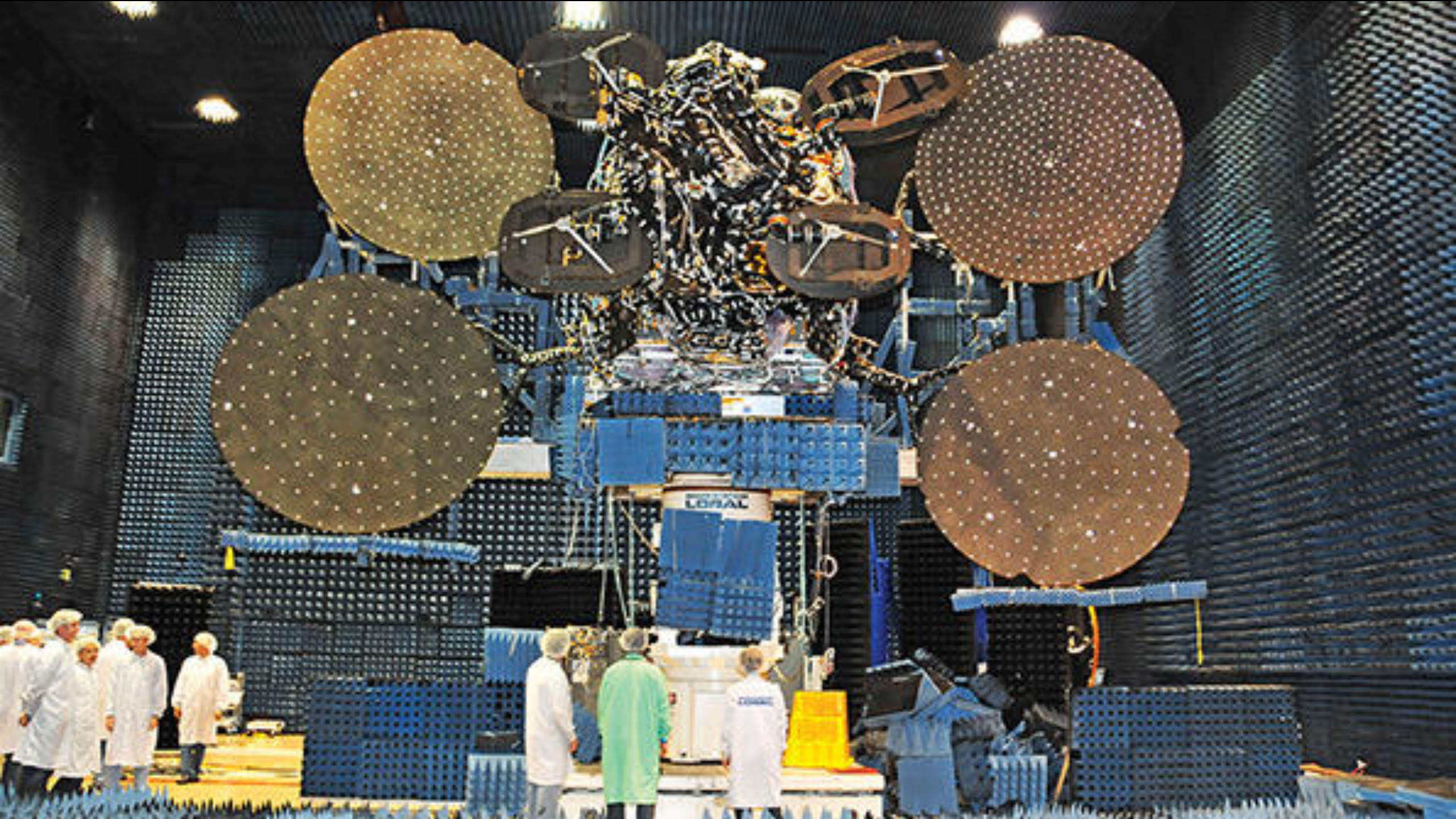
The Boldest Business Venture the Earth has Ever Seen

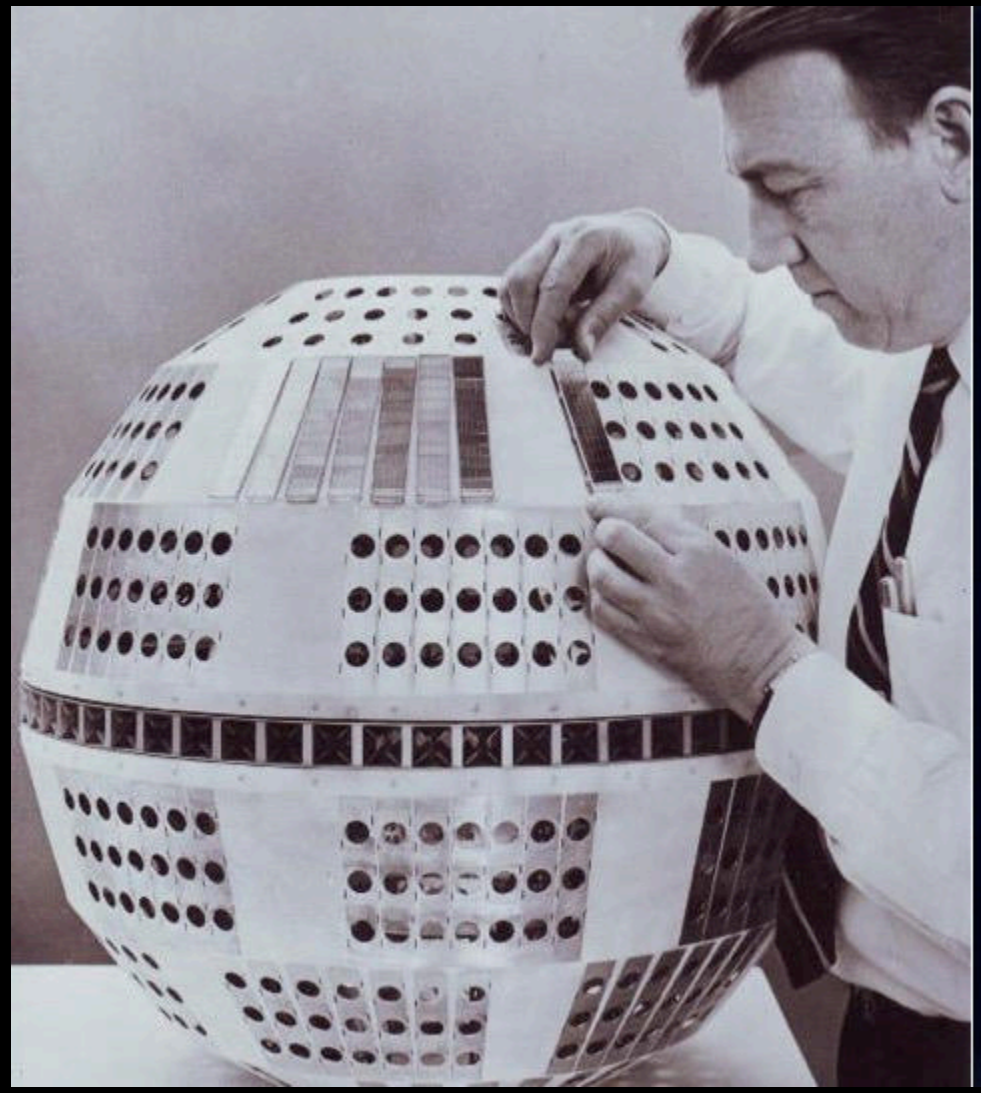
Sergei Zalyotin & Alexander Kalery

MIR CORP


NASA


DENNIS A. TITO
ДЕННИС А. ТИТО
РОССИЯ

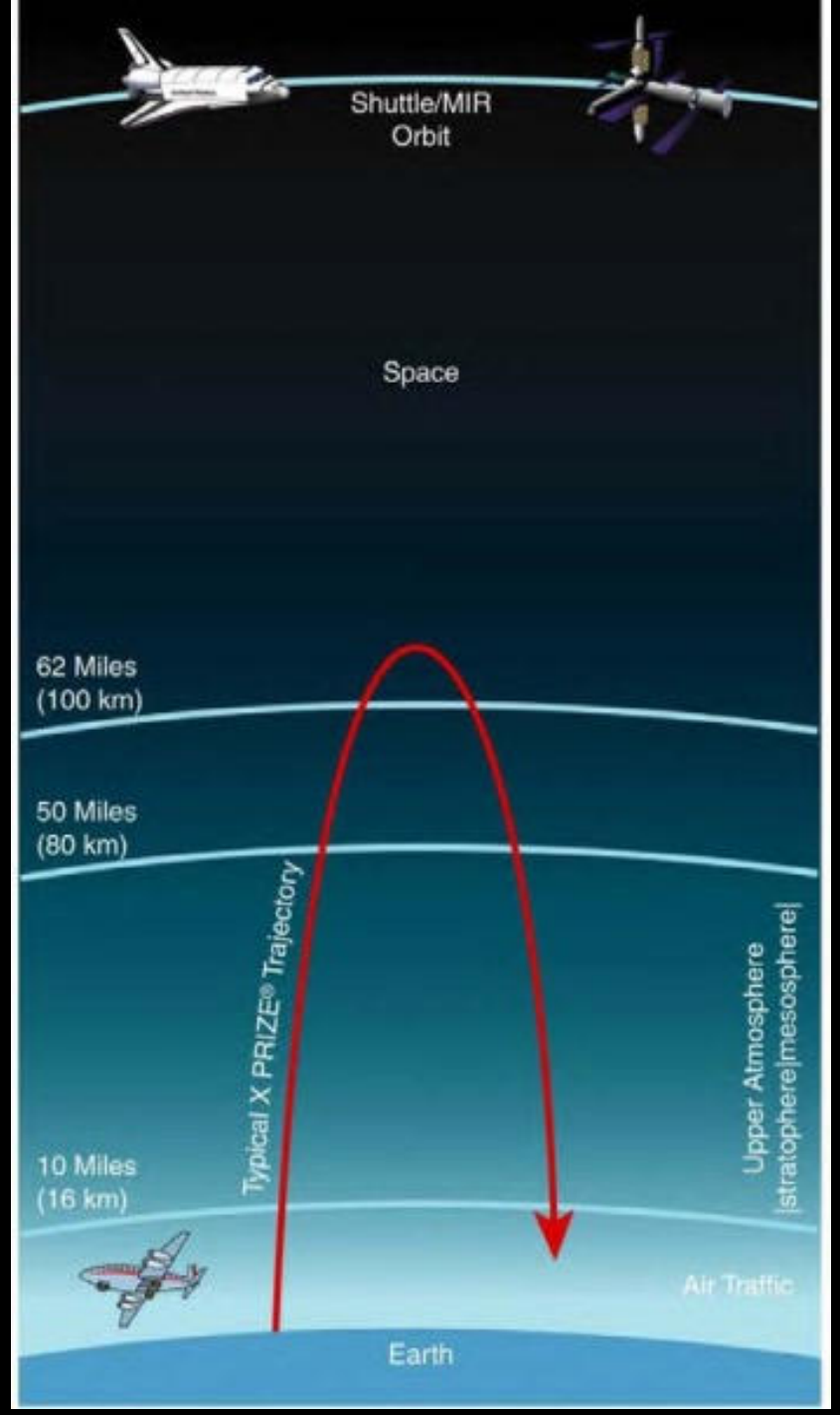

LOMAL




Virgin


BLUE ORIGIN
BLUE ORIGIN
BLUE ORIGIN

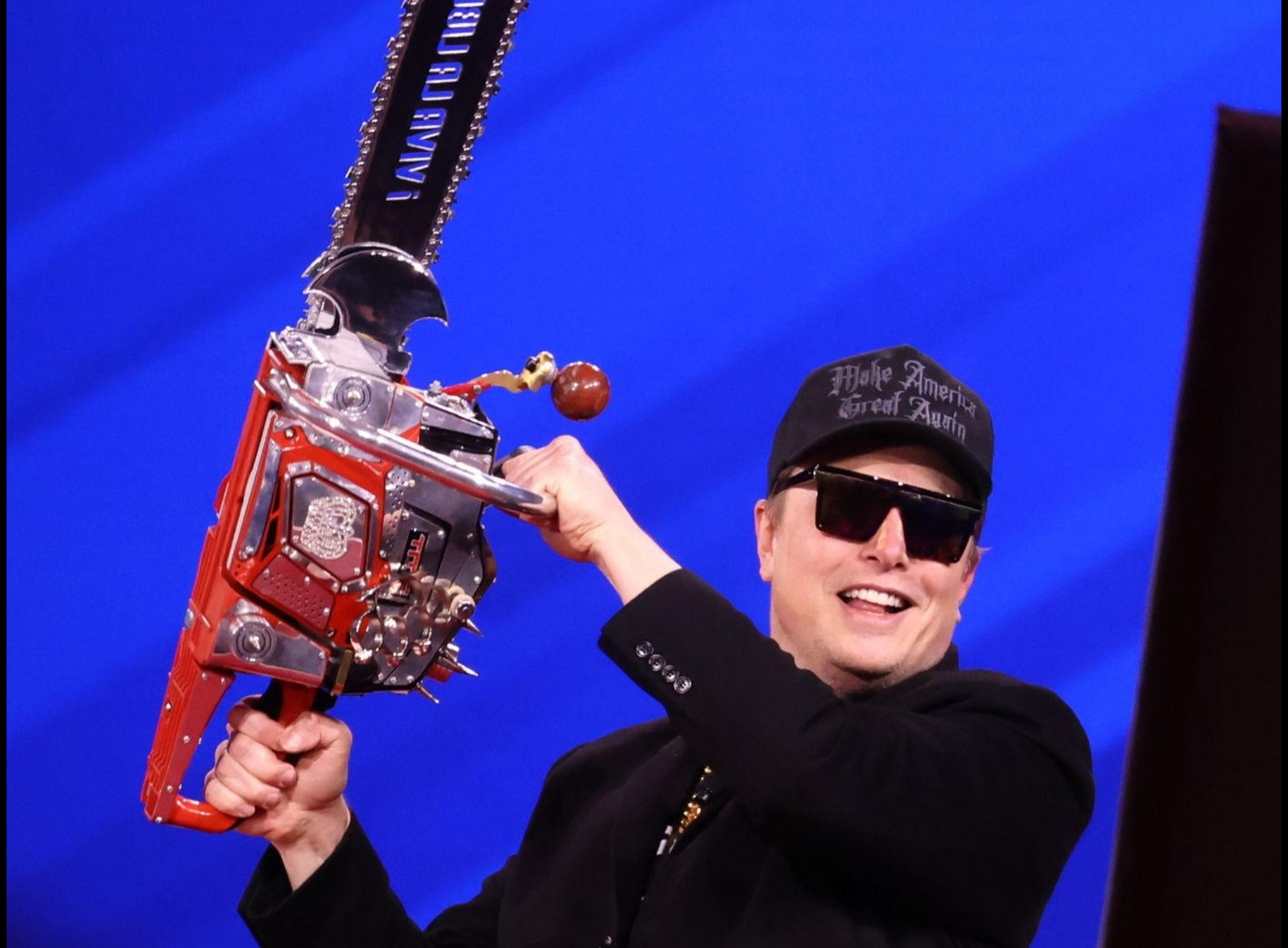

BLUE ORIGIN

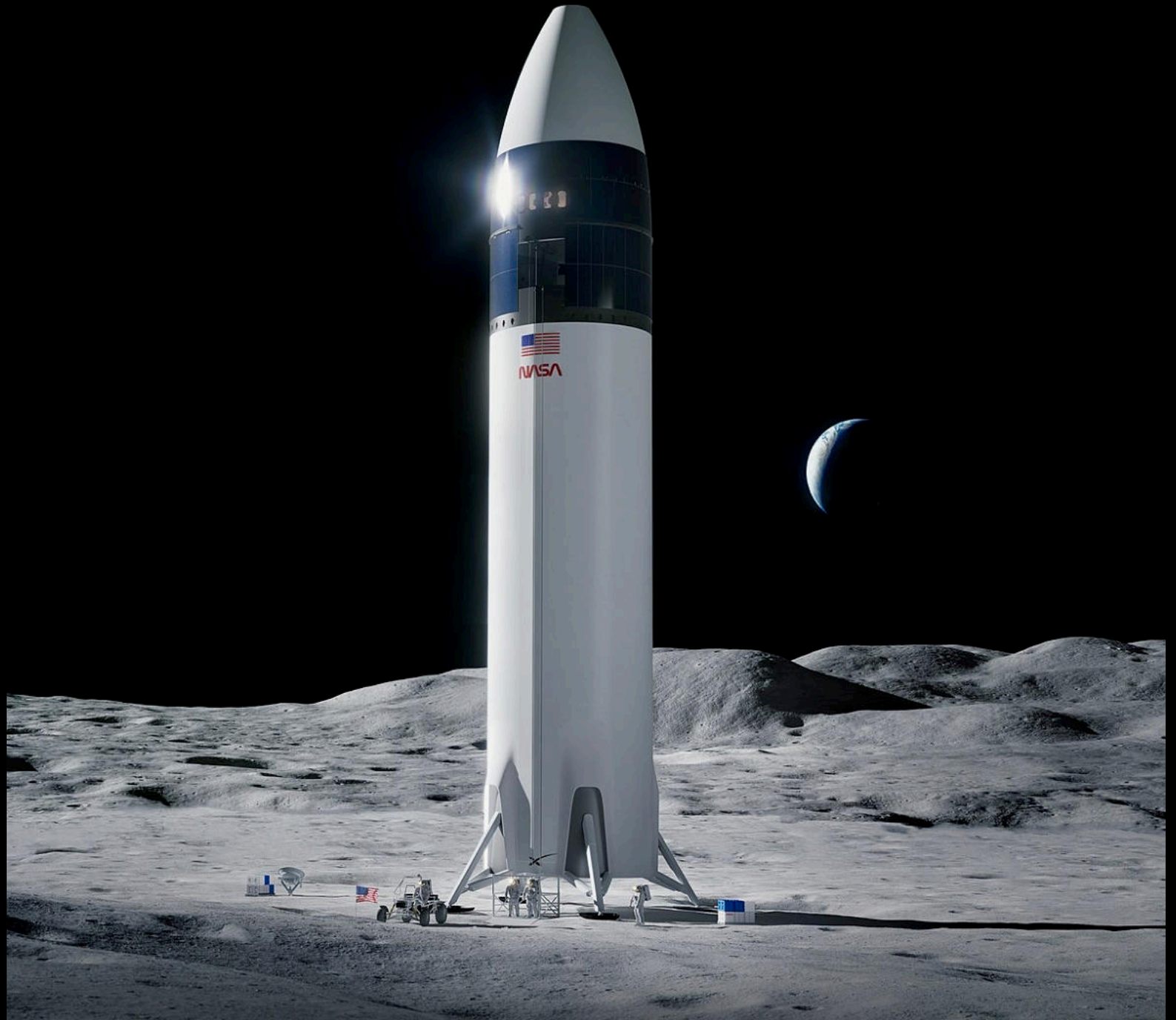


Sub-orbital vs Orbital

- Suborbital:
  - To reach 100 km, a typical speed of 1 km/s is needed
- Orbital:
  - To reach orbit, a minimum speed of 7.75 km/s is needed


FH
SPACEX

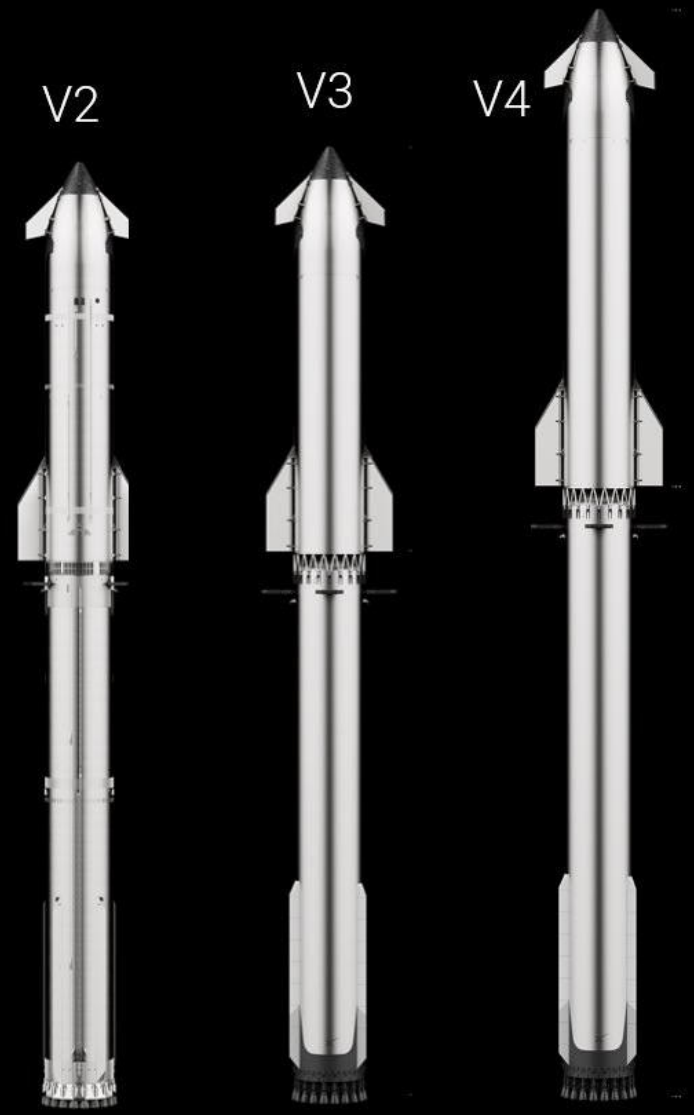

Make America
Great Again


NASA

VEHICLE SUMMARY

FULLY REUSABLE

	V1 (2023/24)	V2 (2025)	V3 (2025/26)	V4
PAYLOAD TO ORBIT (t)	~15	~35	100+	200+
BOOSTER PROP LOAD (t)	3250	3250	3650	4050
SHIP PROP LOAD (t)	1200	1500	1600	2300
BOOSTER LIFTOFF THRUST (tf)	7100	7100	8240	10000
SHIP INITIAL THRUST (tf)	1250	1400	1600	2700
SHIP SL ENGINES	3	3	3	3
SHIP VAC ENGINES	3	3	3	6
BOOSTER HEIGHT (m)	71	71	72.3	81
SHIP HEIGHT (m)	50.3	52.1	52.1	61
TOTAL HEIGHT (m)	121.3	123.1	124.4	142



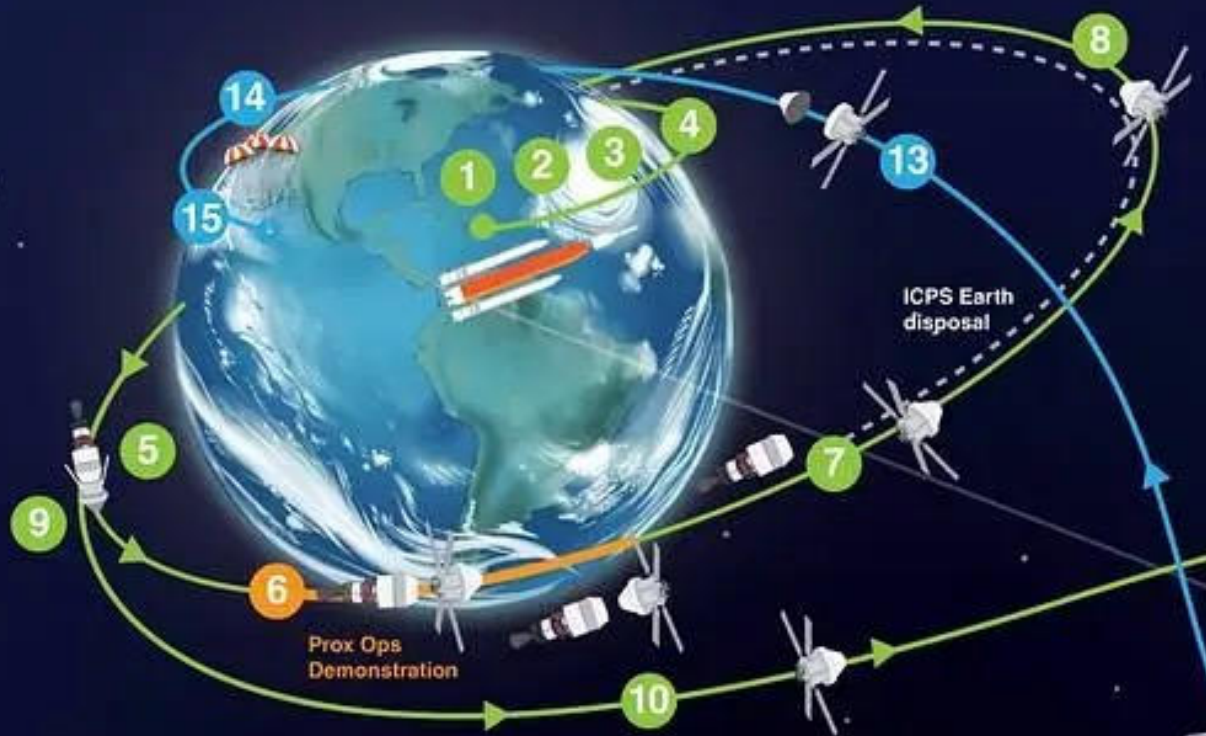
Artemis programme

Artemis I, November 16, 2022: first uncrewed launch
Artemis II, April 1, 2026: first crewed Orion flight test around the Moon.
Artemis III, 2027: crewed Earth orbital mission with Moonlander(s) docking
Artemis IV, 2028: first crewed landing.
Artemis V, 2028: second crewed landing.

10 DAYS | 685,000 MILES
AROUND THE MOON FOR ALL HUMANITY

ARTEMIS II

REID WISEMAN	VICTOR GLOVER	CHRISTINA KOCH	JEREMY HANSEN
COMMANDER	PILOT	MISSION SPECIALIST	MISSION SPECIALIST

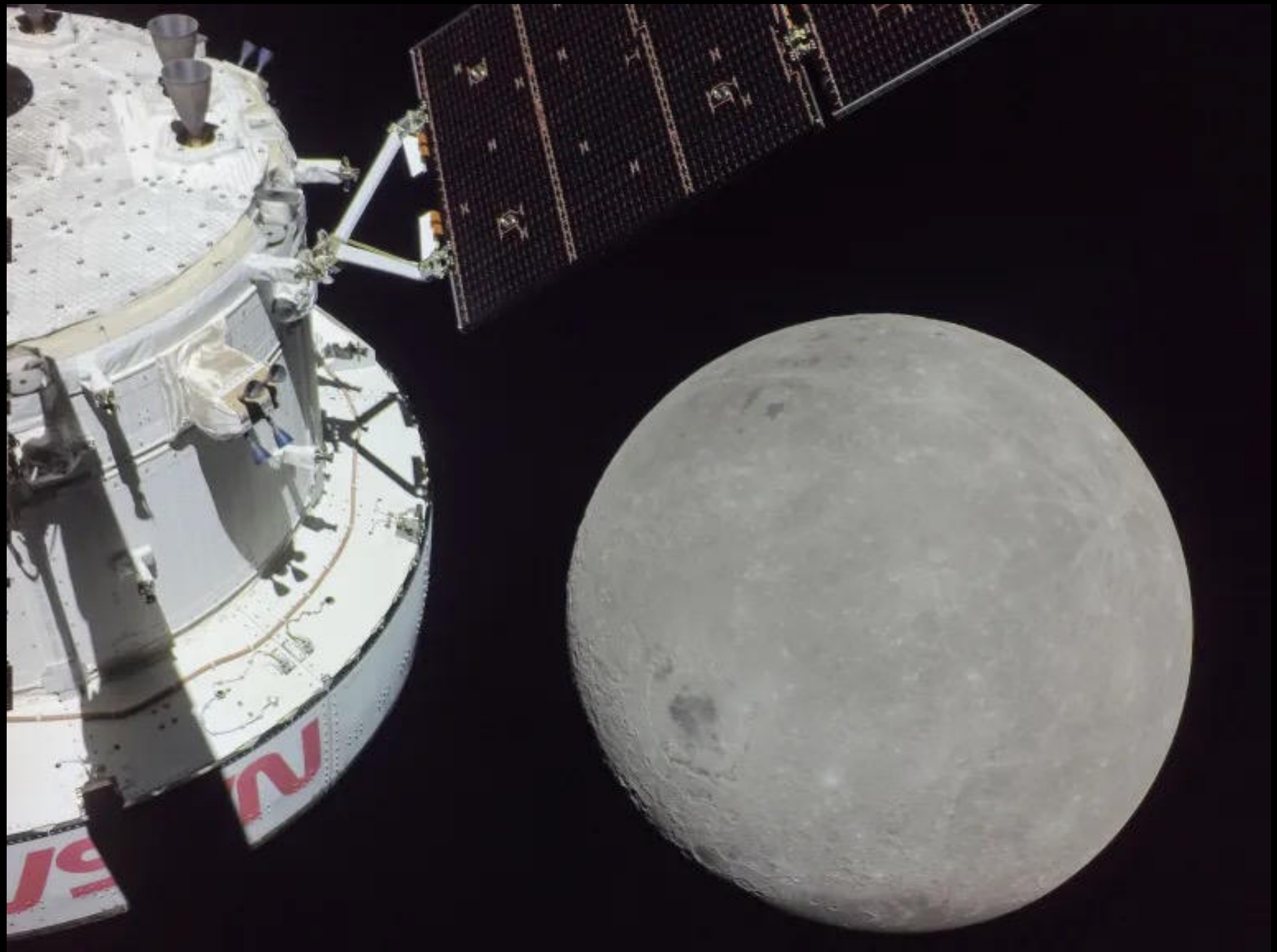


ARTEMIS II

First Crewed Test Flight to the Moon Since Apollo

1. **LAUNCH**
   Astronauts 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. **APOGEE RAISE BURN TO HIGH EARTH ORBIT**
   Begin 24 hour checkout of spacecraft.
6. **PROX OPS DEMONSTRATION**
   Orion proximity operations demonstration and manual handling qualities assessment for up to 2 hours.
7. **INTERIM CRYOGENIC PROPULSION STAGE (ICPS) DISPOSAL BURN**
8. **HIGH EARTH ORBIT CHECKOUT**
   Life support, exercise, and habitation equipment evaluations.
9. **TRANS-LUNAR INJECTION (TLI) BY ORION'S MAIN ENGINE**
   Lunar free return trajectory initiated with European service module.
10. **OUTBOUND TRANSIT TO MOON**
    4 days outbound transit along free return trajectory.
11. **LUNAR FLYBY**
    4,000 nmi (mean) lunar farside altitude.
12. **TRANS-EARTH RETURN**
    Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere; travel time approximately 4 days.
13. **CREW MODULE SEPARATION FROM SERVICE MODULE**
14. **ENTRY INTERFACE (EI)**
    Enter Earth's atmosphere.
15. **SPLASHDOWN**
    Ship recovers astronauts and capsule.

PROXIMITY OPERATIONS DEMONSTRATION SEQUENCE



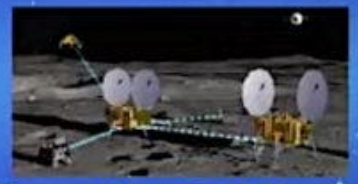

STORES
CHAMBER R
CHAMBER L

Roadmap of China Lunar & Deep Space Exploration

Queqiao-2
Cislunar communication

Chang' E-6
Sample return from far side of Moon

Chang' E-7
South pole exploration



Chang' E-8
In-situ resource utilization
Precursor of ILRS

Manned Lunar Exploration Missions

International Lunar Research Station (ILRS)

Moon

2024.3

2024

2026

2028

2030

Global partners encourage us to go far...

Asteroid

2025

Tianwen-2
Asteroid sample return

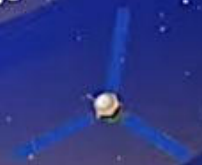
Mars

2028

Tianwen-3
Mars sample return

Jupiter

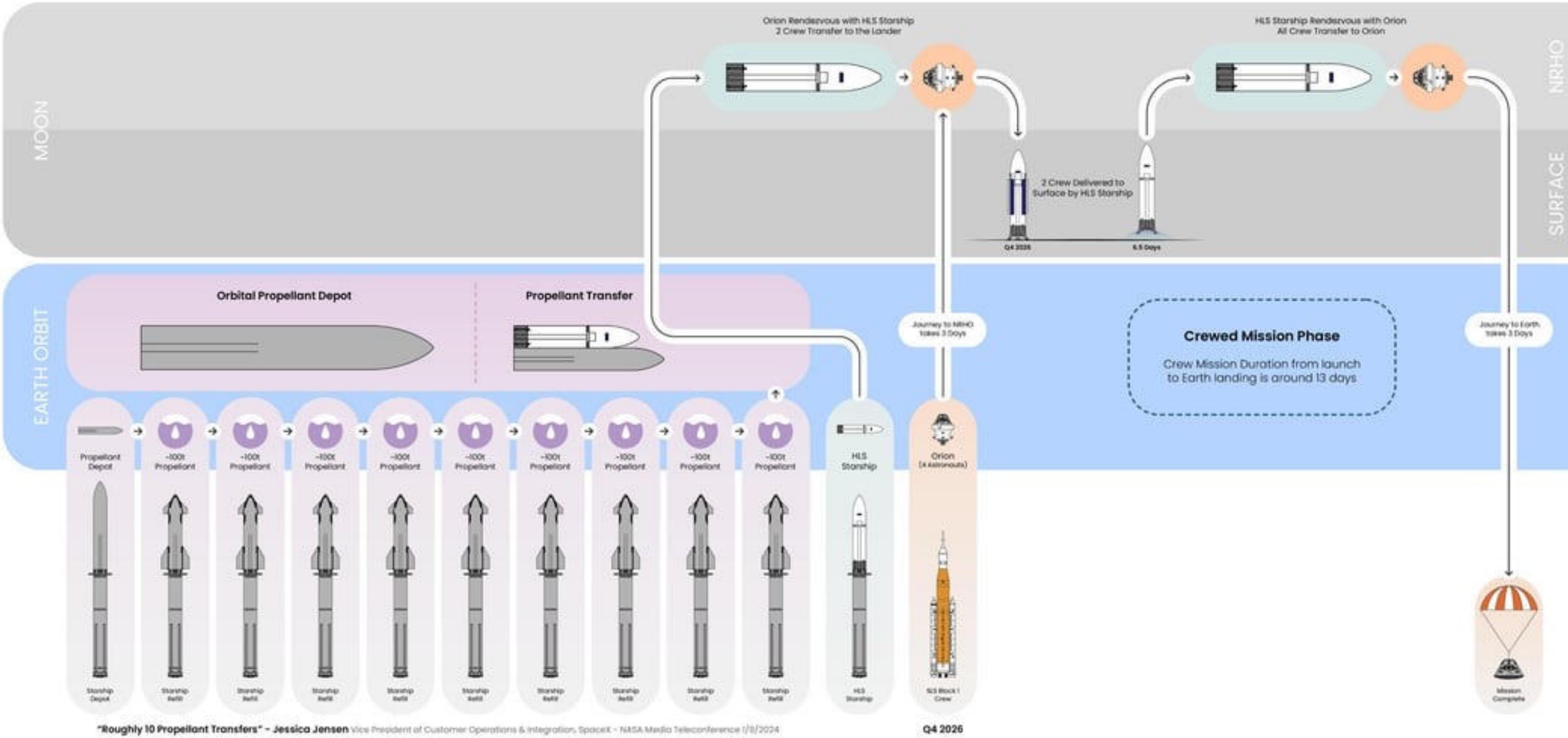
2030

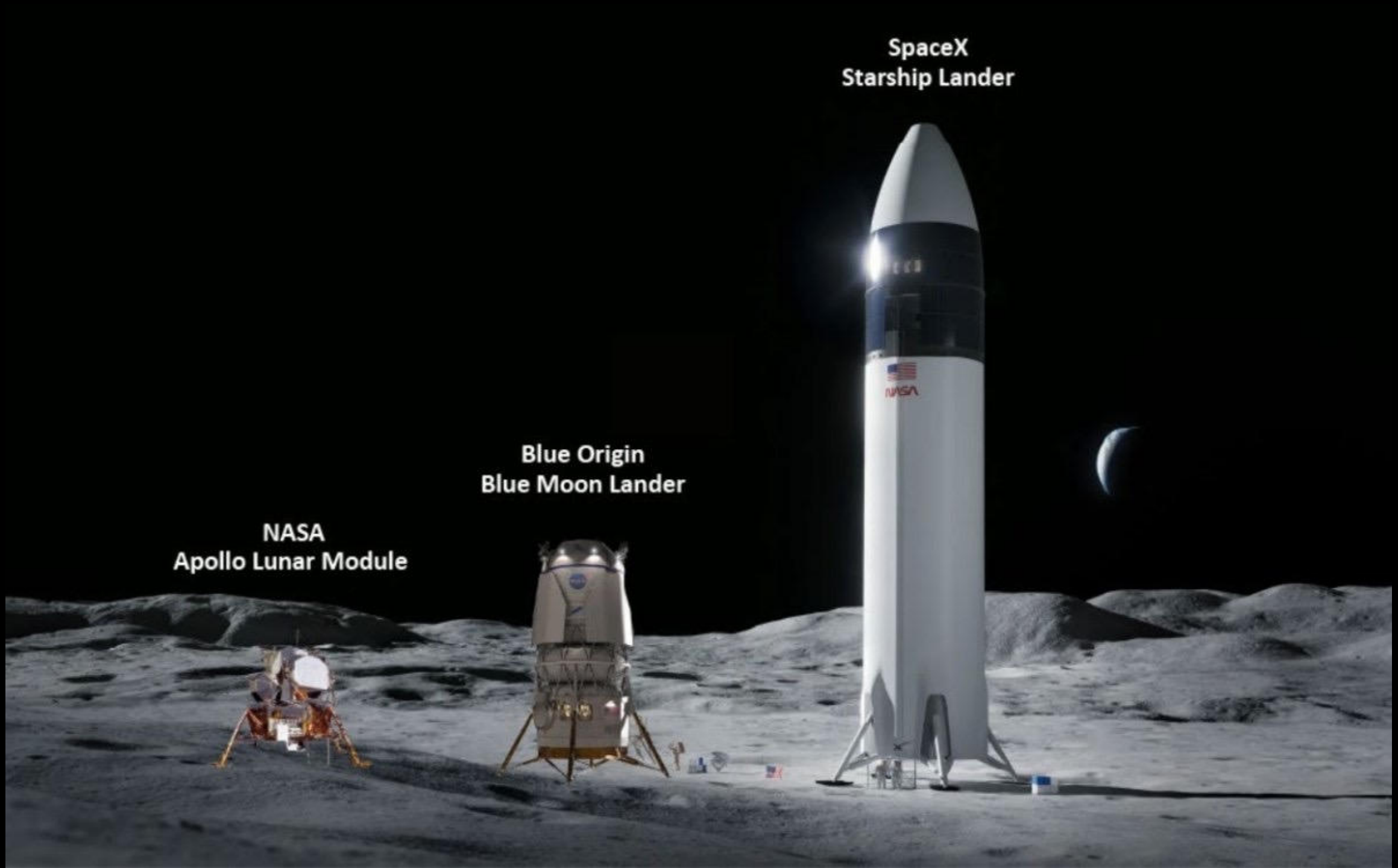


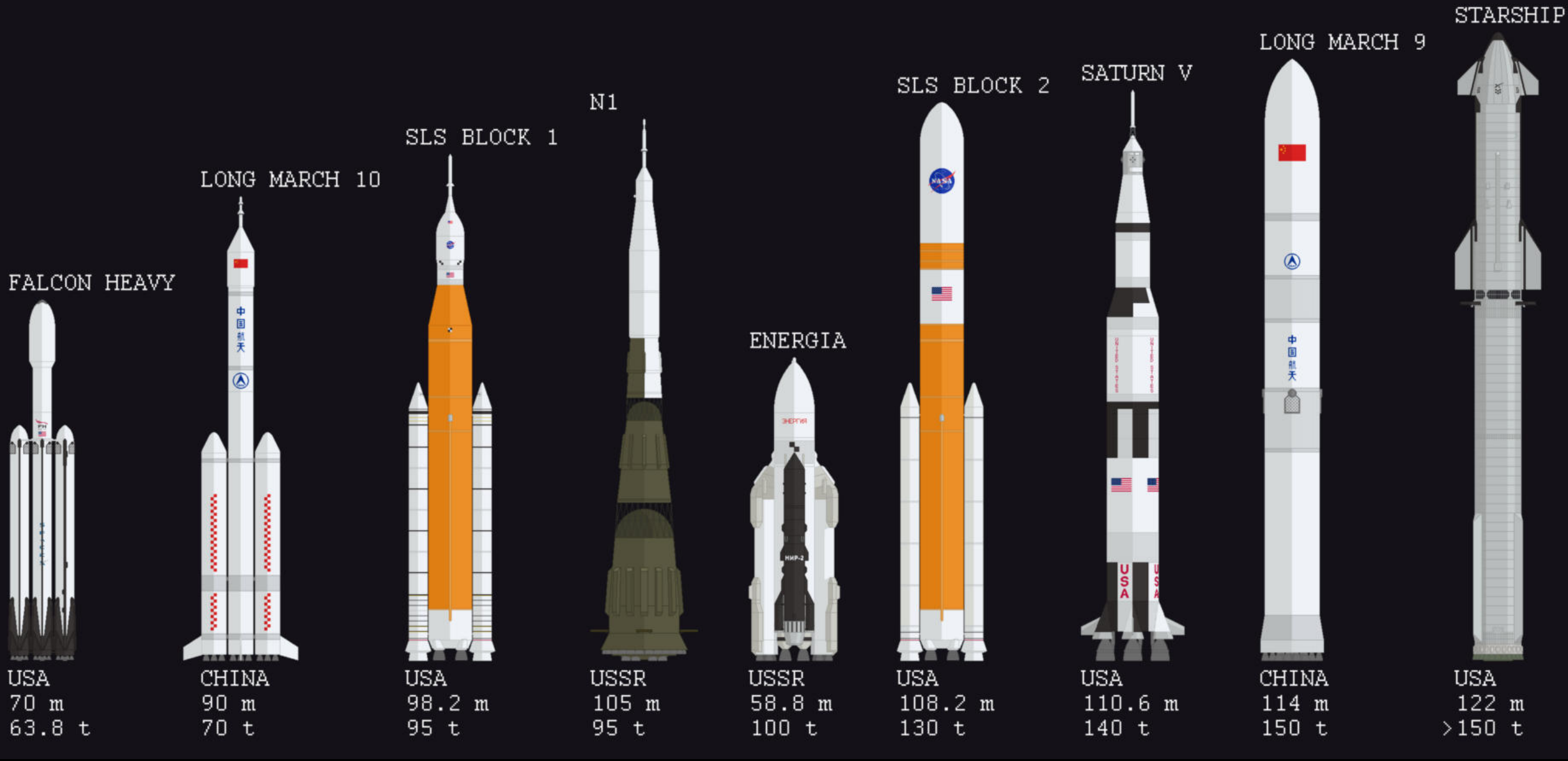
Tianwen-4
Jupiter & Interplanetary Exploration

NASA Artemis 3 Architecture (2024 Plan)

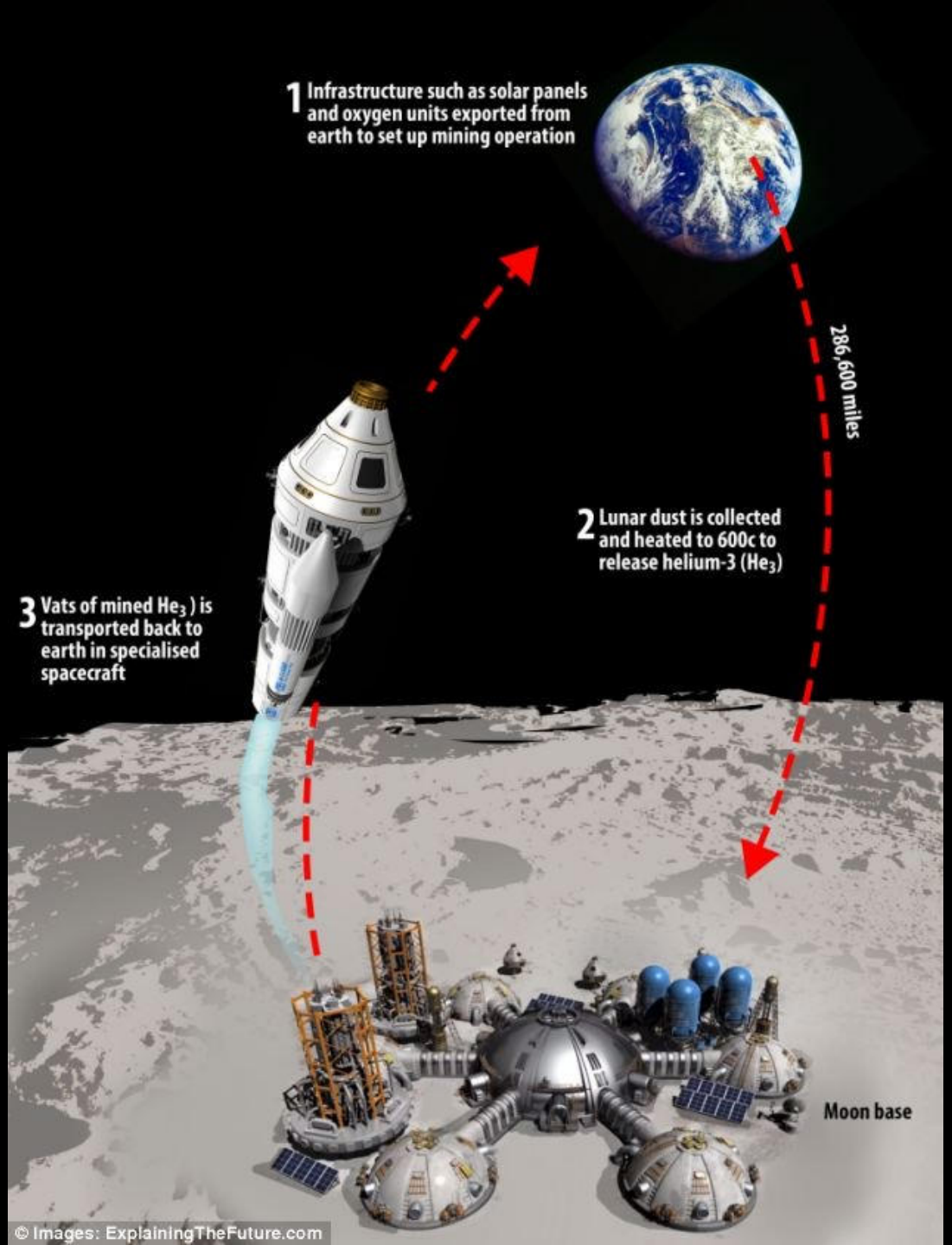
Graphic by: Ken Kirtland IV@kenkirtland17



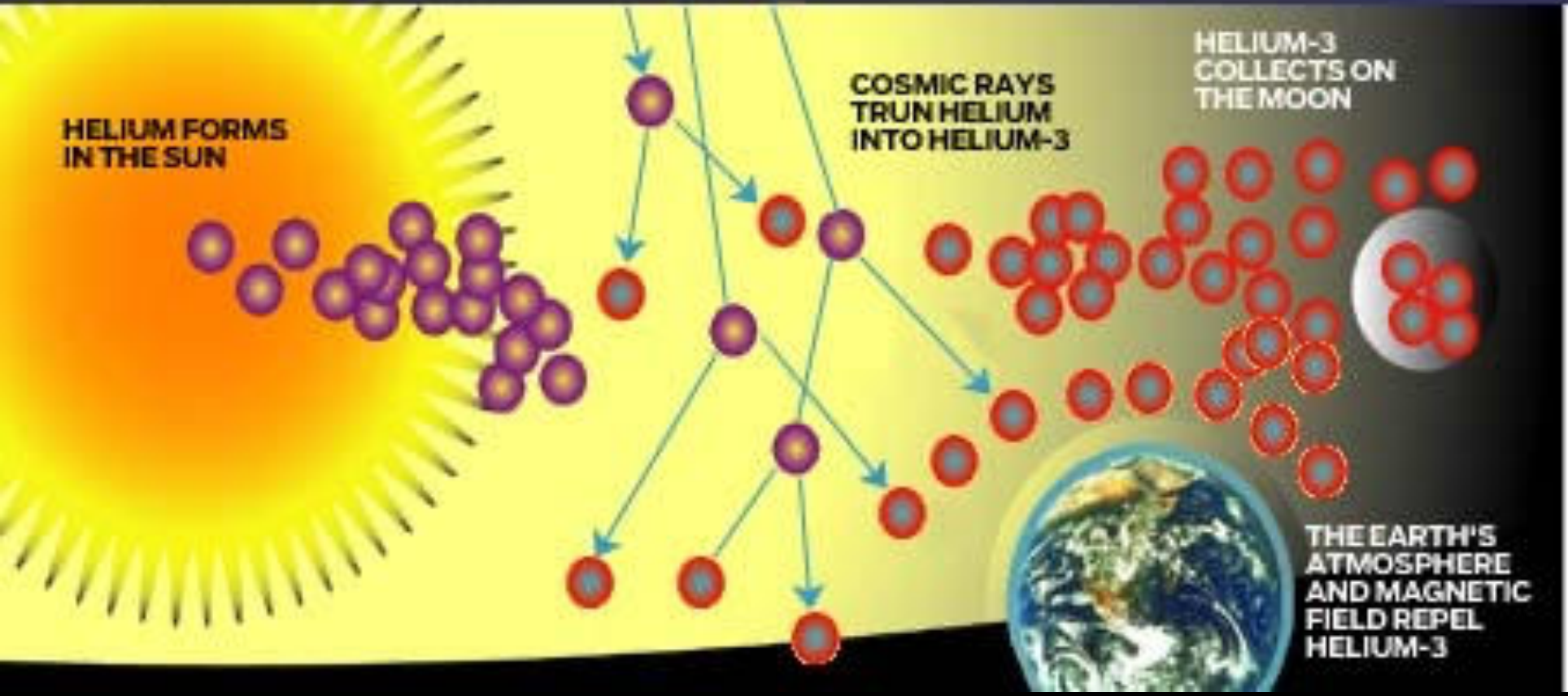

SpaceX
Starship Lander
Blue Origin
Blue Moon Lander
NASA
Apollo Lunar Module

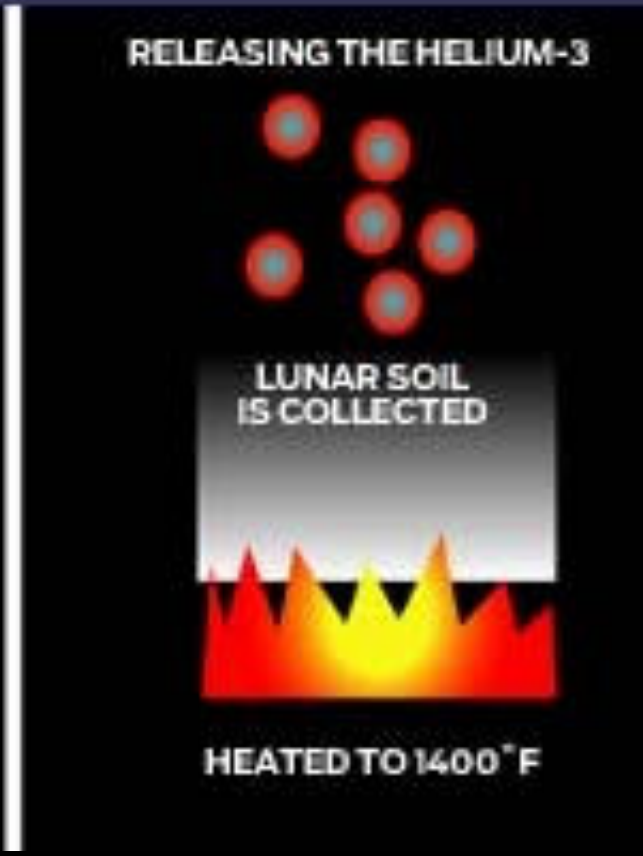

FALCON HEAVY
USA
70 m
63.8 t
LONG MARCH 10
CHINA
90 m
70 t
SLS BLOCK 1
USA
98.2 m
95 t
N1
USSR
105 m
95 t
ENERGIA
USSR
58.8 m
100 t
SLS BLOCK 2
USA
108.2 m
130 t
SATURN V
USA
110.6 m
140 t
LONG MARCH 9
CHINA
114 m
150 t
STARSHIP
USA
122 m
>150 t

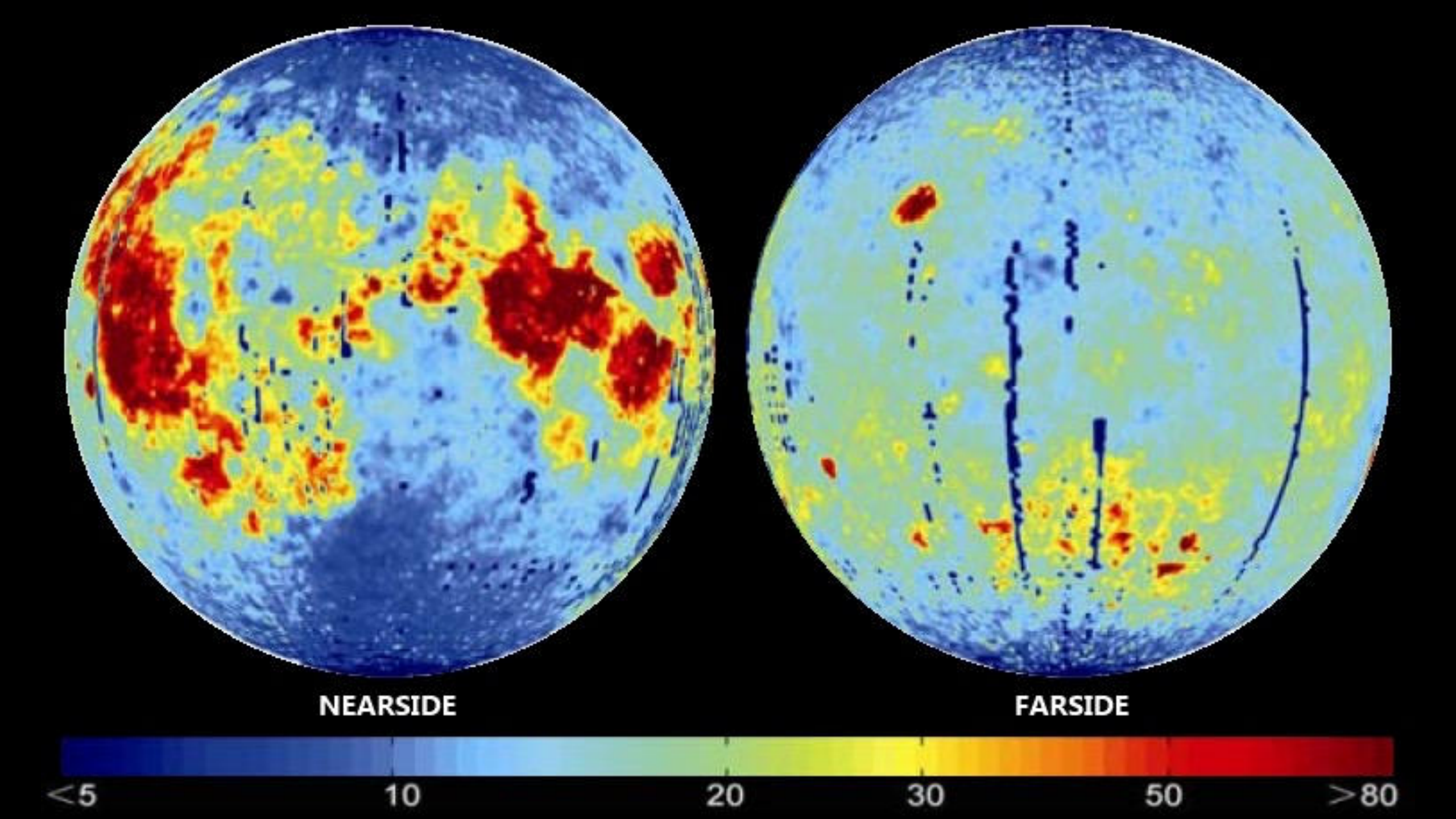

Malapert Mountain
C
B
A
Shackleton
D
de Gerlache
© JAXA/NHK


1 Infrastructure such as solar panels and oxygen units exported from earth to set up mining operation
286,600 miles
2 Lunar dust is collected and heated to 600c to release helium-3 (He_3)
3 Vats of mined He_3) is transported back to earth in specialised spacecraft
Moon base
© Images: ExplainingTheFuture.com

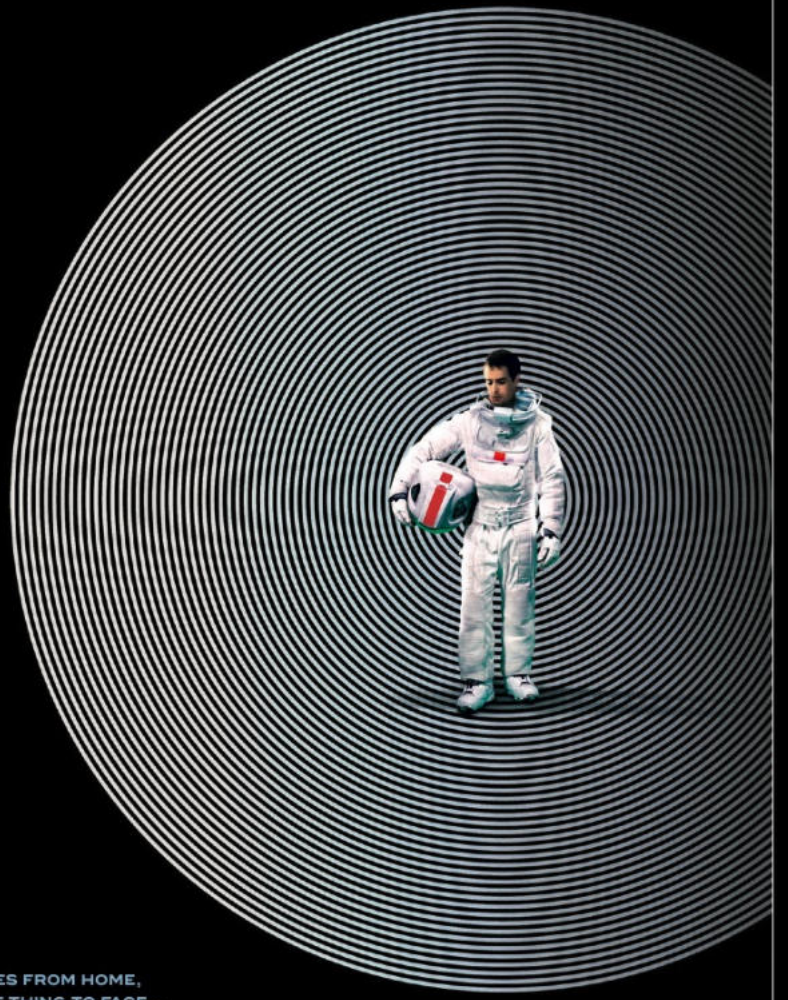
THE ORIGINAL FUSION REACTOR






NEARSIDE
FARSIDE
<5
10
20
30
50
>80

SAM ROCKWELL



950,000 MILES FROM HOME,
THE HARDEST THING TO FACE...
IS YOURSELF.

MOON

A SONY PICTURES CLASSICS RELEASE A LIBERTY FILMS PRODUCTION IN ASSOCIATION WITH XINGU FILMS AND LIMELIGHT SAM ROCKWELL "MOON" DOMINIQUE McELLIGOTT KAYA SCODELARIO BENEDICT WONG MATT BERRY MALCOLM STEWART CASTING DIRECTORS JEREMY ZIMMERMANN AND MANUEL PURO MAKE-UP AND HAIR DESIGN KAREN BRYAN DAWSON COSTUME DESIGNER JANE PETRIE CONCEPTUAL DESIGN GAVIN ROTHERY PRODUCTION DESIGNER TONY NOBLE VFX & CHARACTER ANIMATION BY CINESITE DIRECTOR OF PHOTOGRAPHY GARY SHAW MUSIC BY CLINT MANSELL EDITOR NICOLAS GASTER LINE PRODUCER JULIA VALENTINE EXECUTIVE PRODUCERS MICHAEL HENRY BILL ZYSBLAT TREVOR BEATTIE BIL BUNGAY CO-PRODUCERS NICKY MOSS ALEX FRANCIS MARK FOLIGNO STEVE MILNE STORY BY DUNCAN JONES WRITTEN BY NATHAN PARKER PRODUCED BY STUART FENEGAN TRUDIE STYLER DIRECTED BY DUNCAN JONES

R RESTRICTED MPAA FOR LANGUAGE

LIMELIGHT

SONY PICTURES CLASSICS

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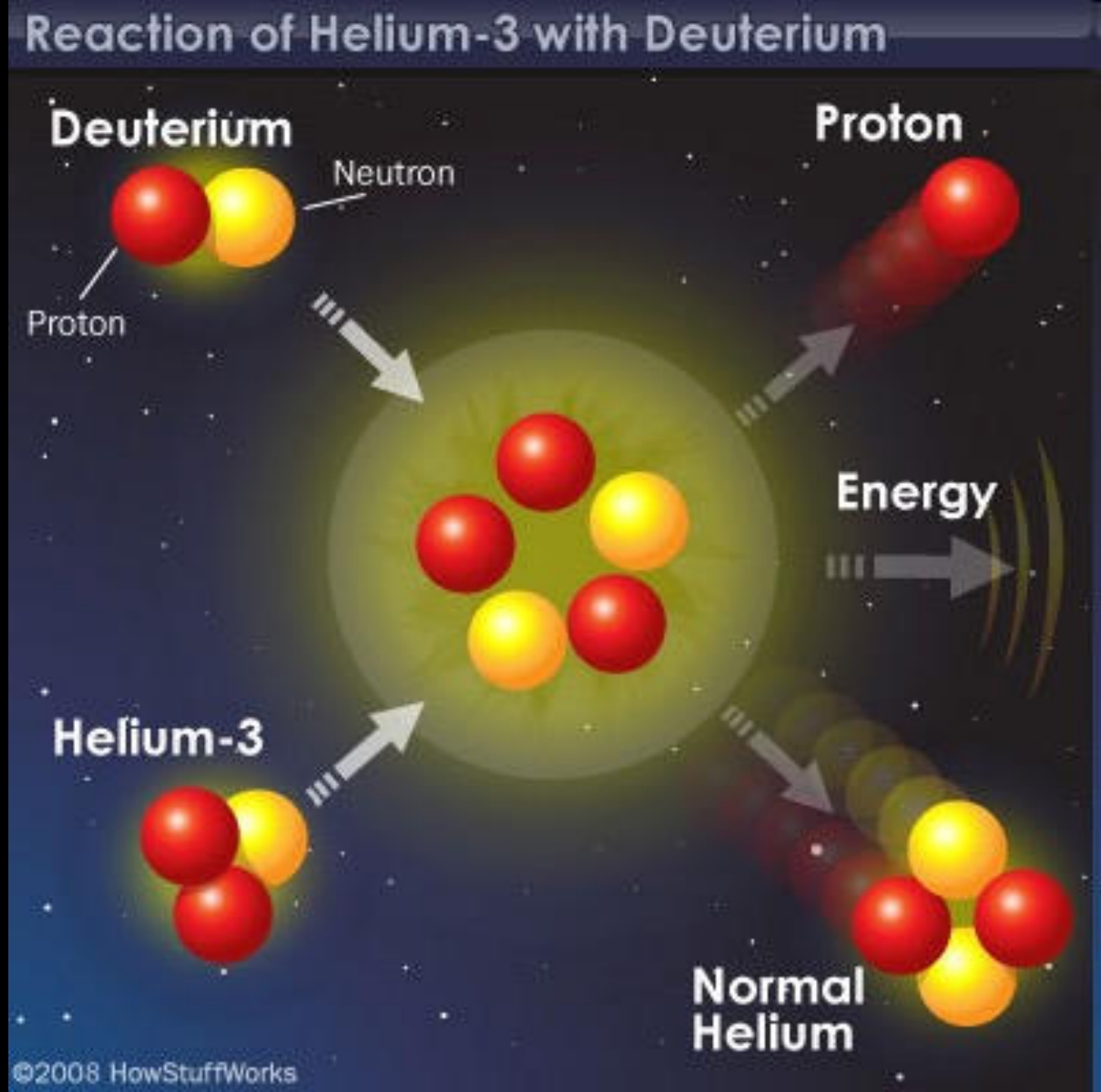
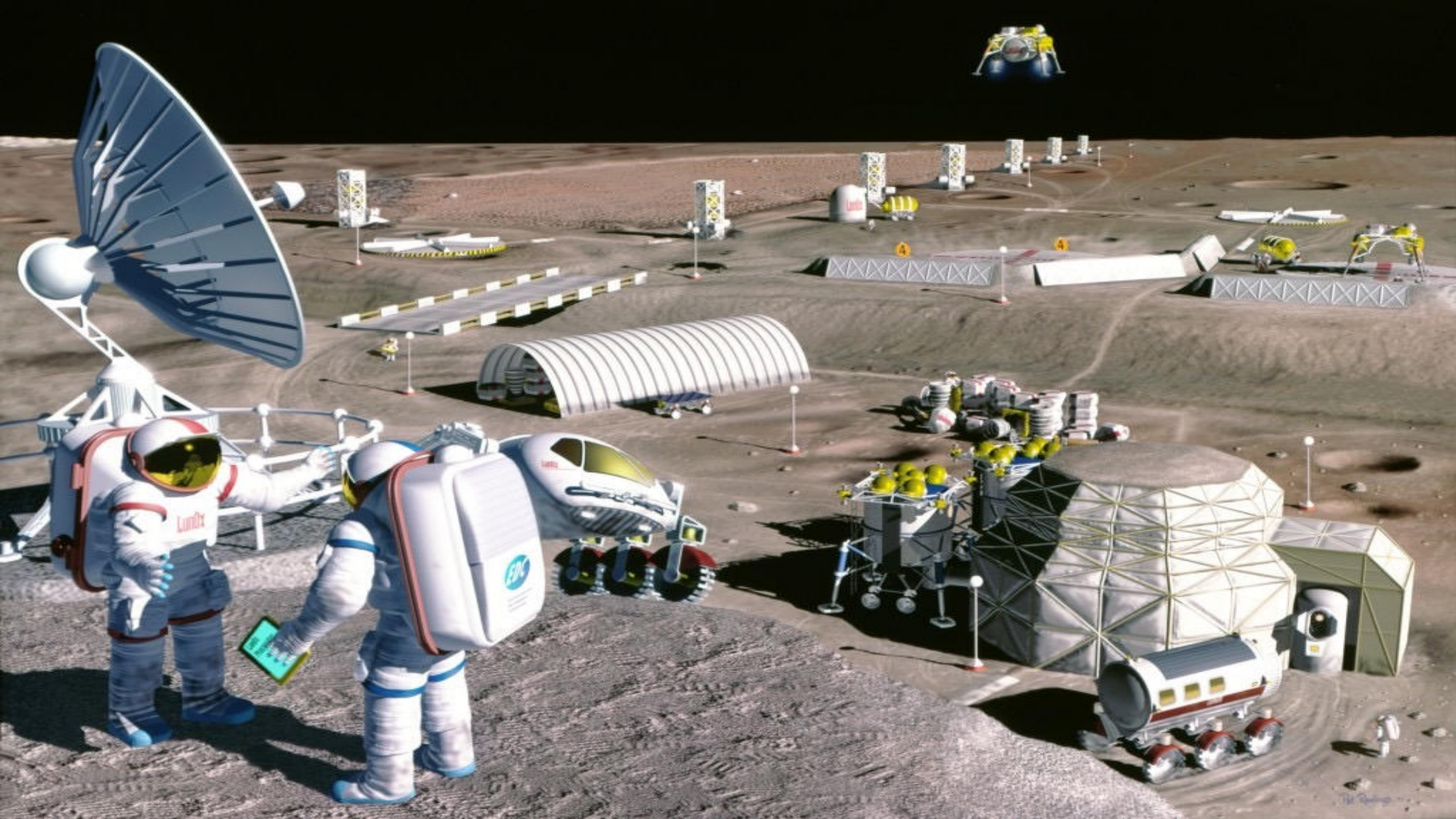
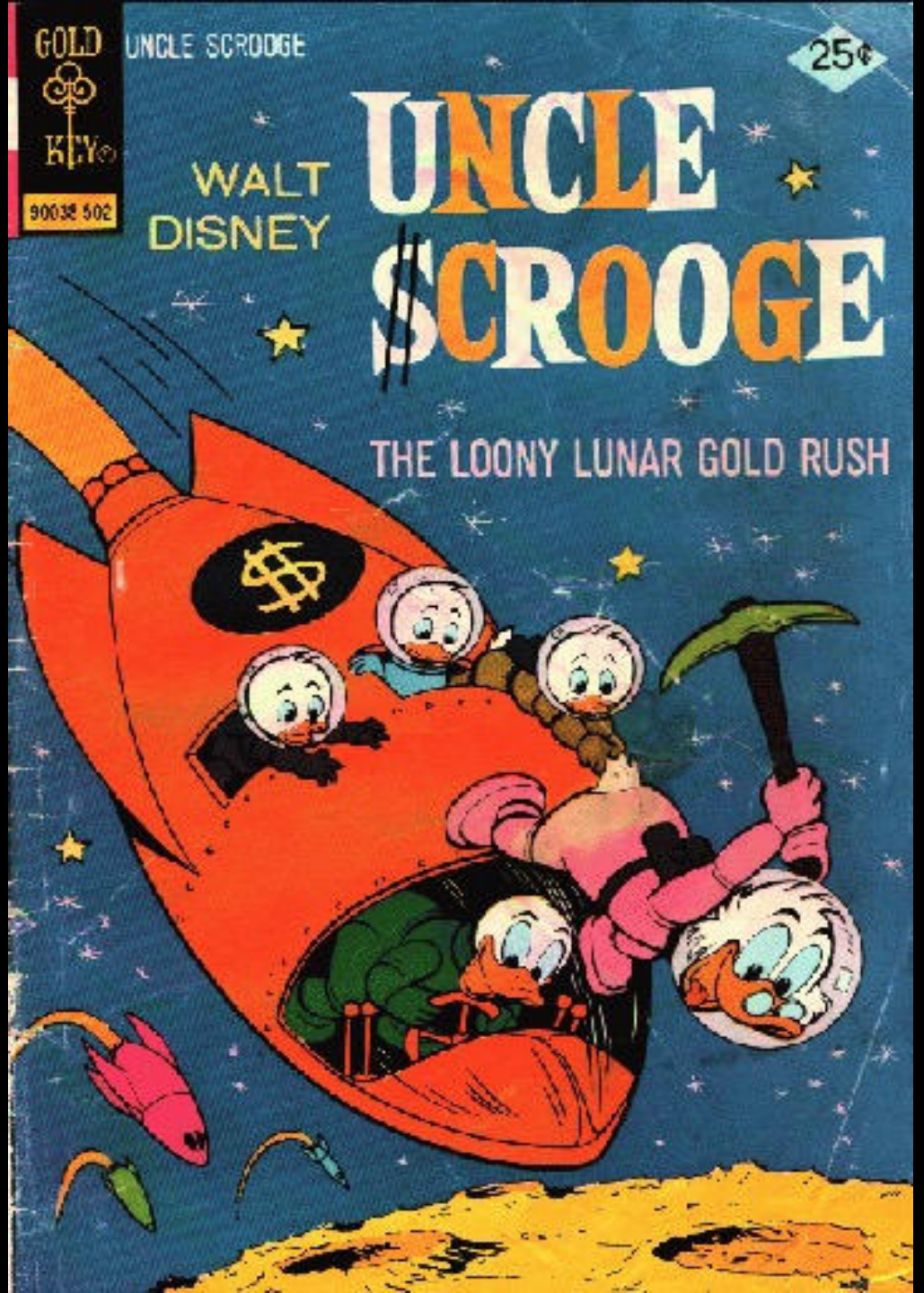
At 0.10$/kWh,
He-3 value is 3M$/kg
(VanCleve et al.)



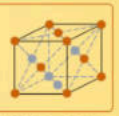



GOLD KEY
UNCLE SCROOGE
25¢
WALT DISNEY
UNCLE SCROOGE
THE LOONY LUNAR GOLD RUSH

Rhodium element

Atomic number: 45
Symbol: Rh
Name: Rhodium
Electron configuration: [Kr] $4d^8$ $5s^1$
Atomic mass (u): 102.91
Atomic radius (van der Waals): 195 pm
Electrons arrangement: [2,8,18,16,1]

Ionization energy: 7.459 eV
Electronegativity (Pauling): 2.28
Standard state: Solid
Crystal structure: FCC



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Get all **details, facts, properties, uses** and **lots more** about the Rhodium element from the table given below.

JANUARY 27, 1967

Outer Space Treaty

OUTER SPACE TREATY

Moon is for Peaceful Exploration Only
No weapons or military bases on the Moon.

Non-appropriation
The Moon is not subject to national appropriation by claim of sovereignty

Activities on the Moon must Benefit all Humankind
Not just individual nations. There shall be freedom of scientific investigation in outer space.

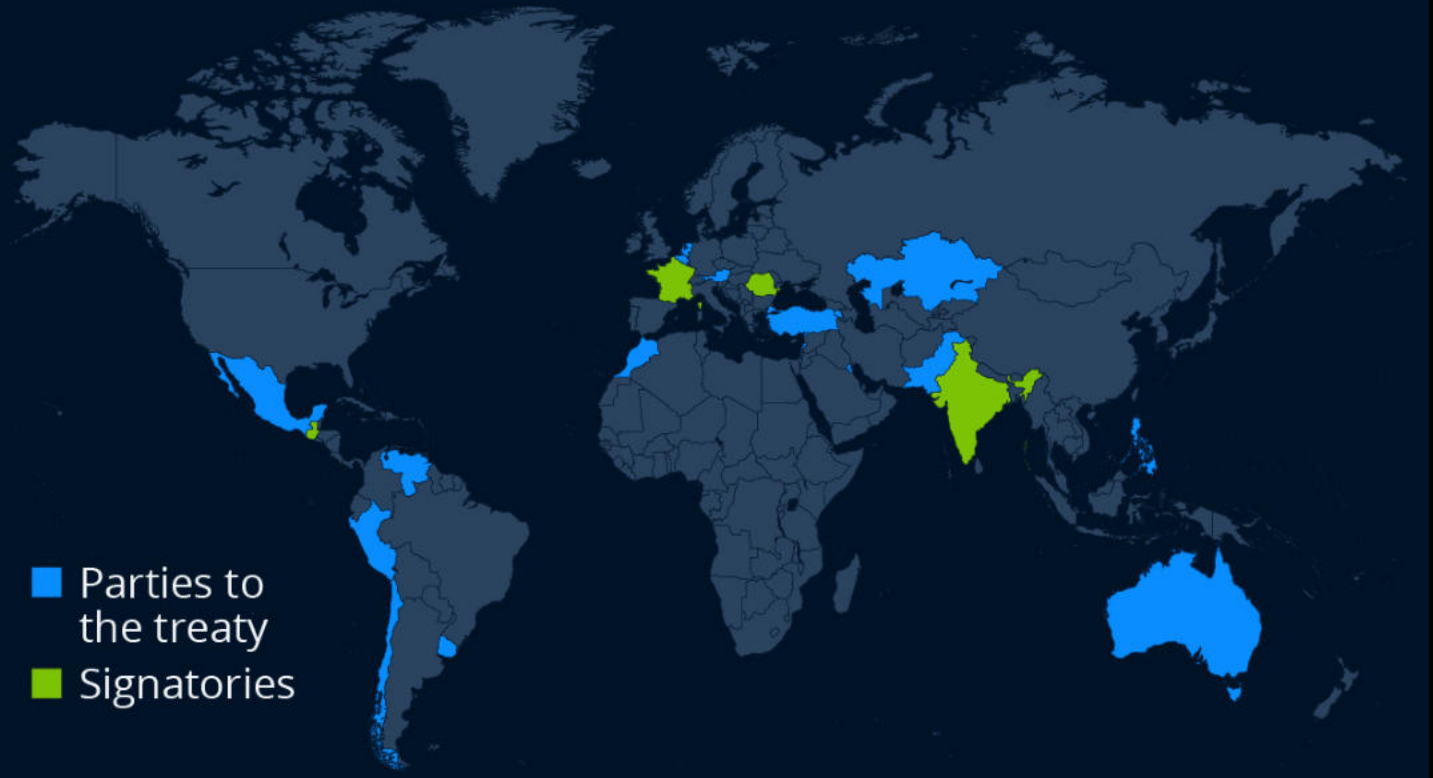
International Cooperation
International Cooperation - States must promote transparency, share information, and avoid harmful interference.

Freedom of Exploration
The use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies shall also not be prohibited.

Private Entities
Require authorisation and continuing supervision by the appropriate State Party to the Outer Space Treaty.

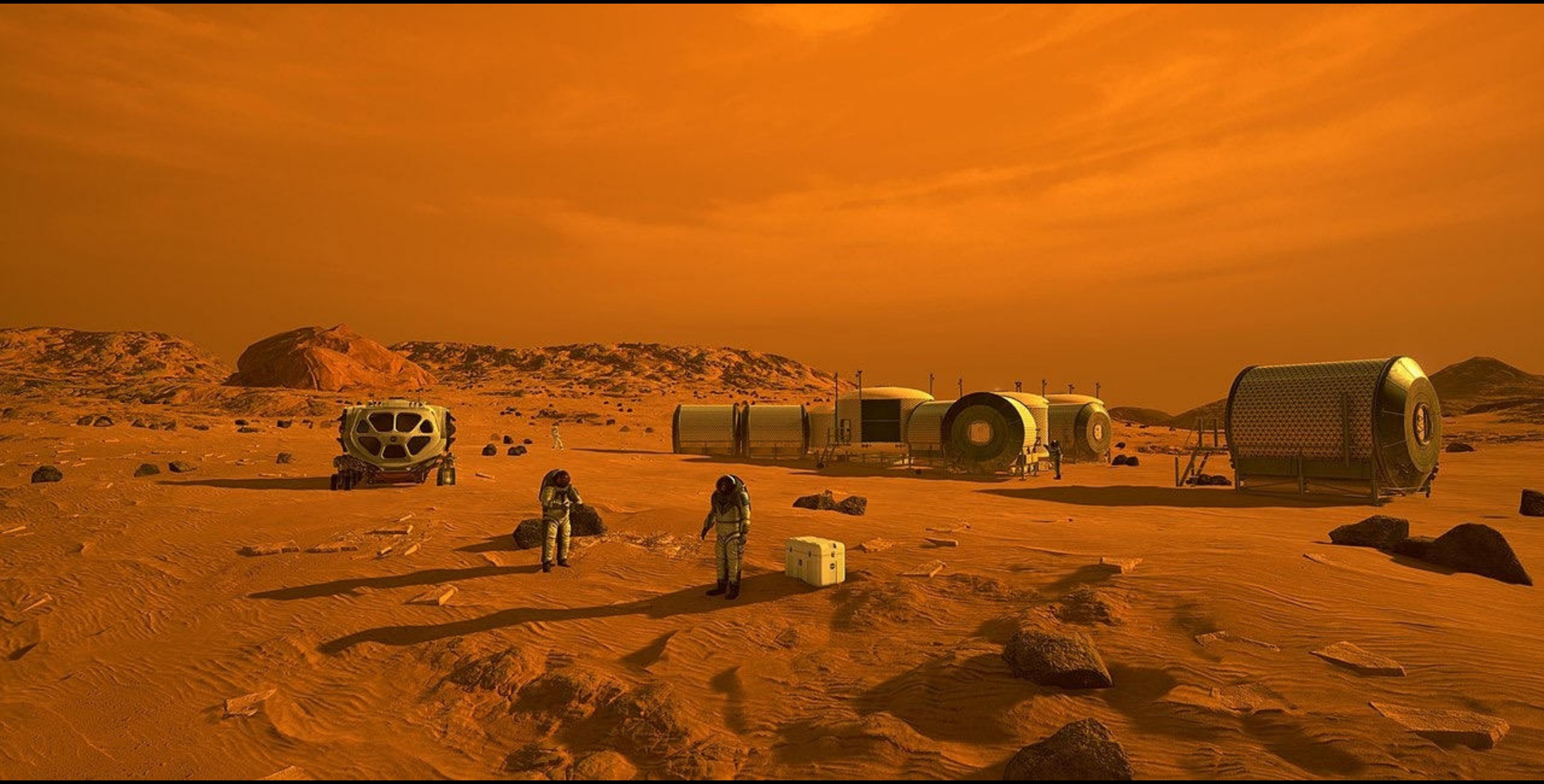
The Countries That Signed the Moon Treaty

Countries that are signatories/parties to the 1979 UN Moon Treaty (as of August 2023)

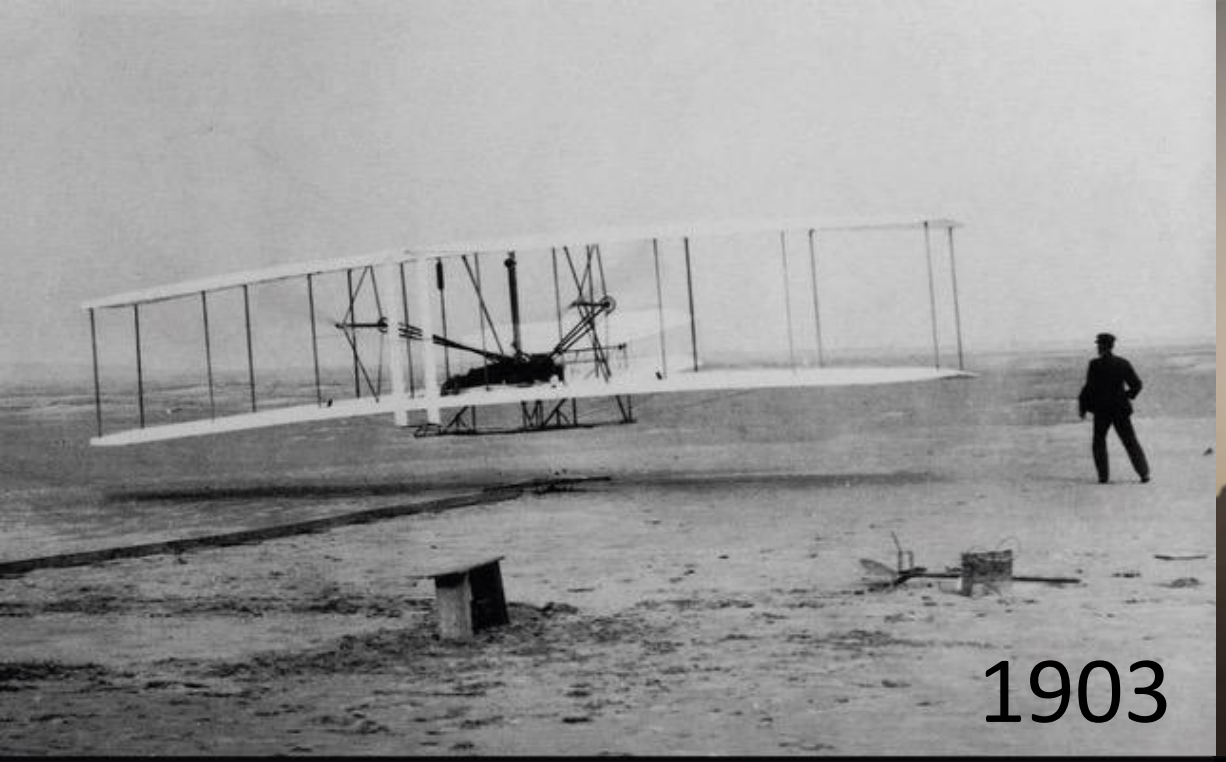


Saudi Arabia withdrew from the treaty in Jan. 2023 (effective Jan. 2024).
Source: United Nations Office for Outer Space Affairs

statista

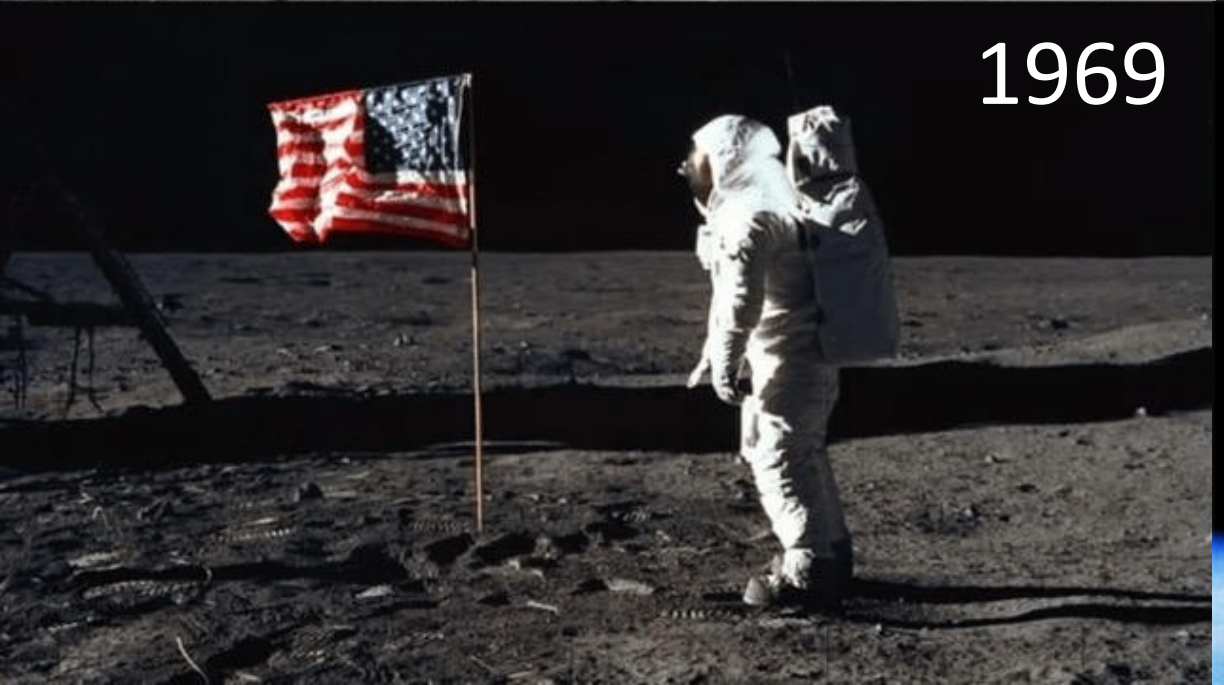


	Moon	Mars
Proximity		
Delta-V required from LEO	5.7 km/s	6.4 km/s
Oxygen production	Energy intensive metaloxide processing	CO2 and H20 in atmosphere and polar caps
Nitrogen production	Bring from Earth	In atmosphere
Water production	In dark craters	In atmosphere and polar caps
Day/Night cycle	14 days	1 day



1903

2035



1969

2101

De Sterrenkunde in 2026

Les 3: Ruimtevaart: Artemis

Dank voor uw aandacht!

Vragen?: Nu of e-mail erik.laan@inholland.nl