Competing for space

Power, politics, and the future beyond Earth



Roberto Battiston

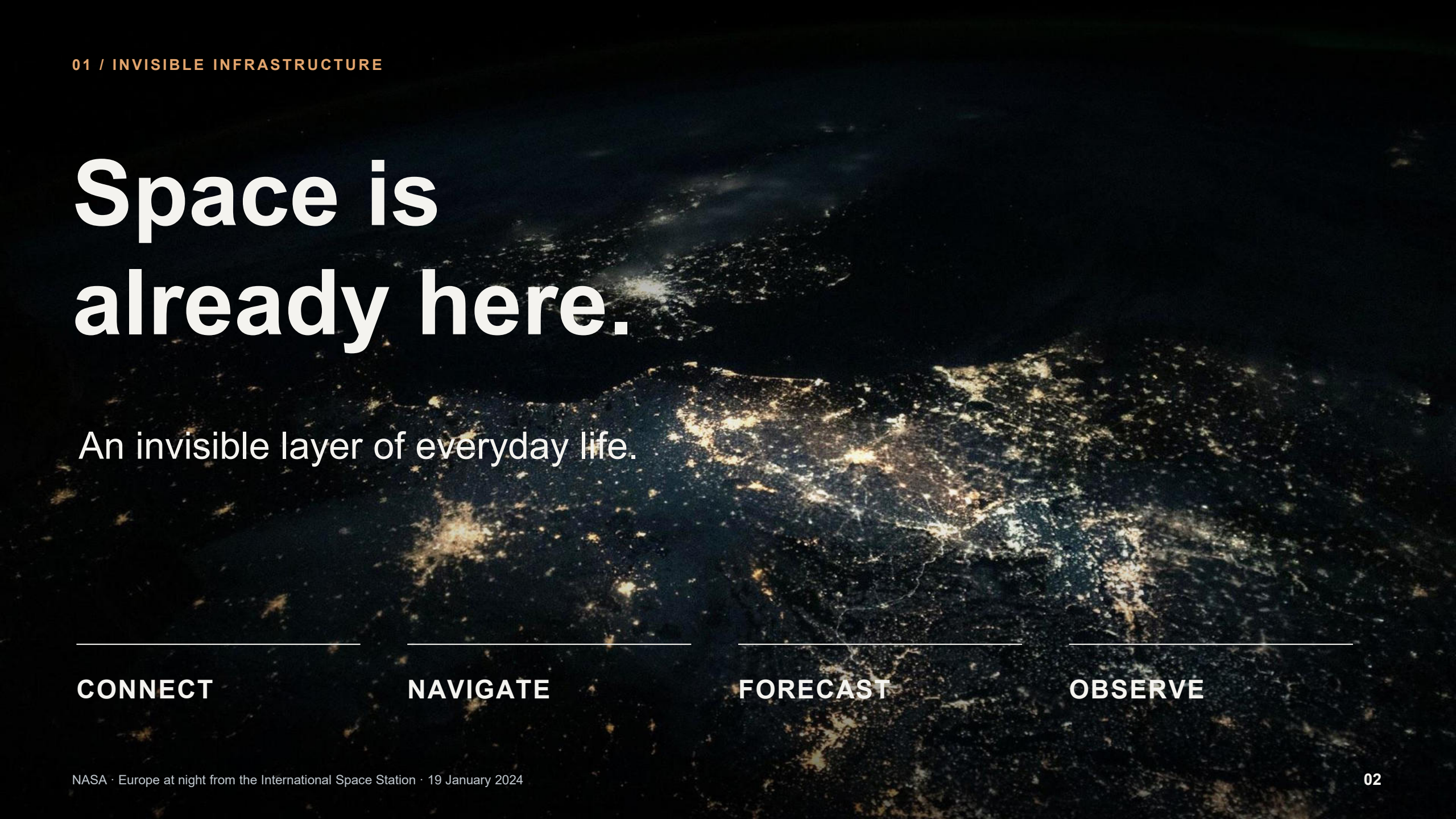
University of Trento
Former President, Italian Space Agency

NASA · Artemis II · Earthset, 6 April 2026

Space is already here.

An invisible layer of everyday life.

CONNECT | **NAVIGATE** | **FORECAST** | **OBSERVE**



NASA · Europe at night from the International Space Station · 19 January 2024

Take satellites away.

Not every service stops. Confidence and resilience fall.

07:00	08:30	12:00	18:00
Navigation	**Timing**	**Weather**	**Logistics**
Less reliable position information	More pressure on backup clocks	Less complete global observations	Less visibility across supply chains

Dependence becomes visible when the signal disappears.

Illustrative day, not a prediction of a simultaneous global outage

Navigation is really time.

1 µs → **≈ 300 m**

TIME INTERVAL

SIGNAL TRAVEL DISTANCE

$$\Delta r = c\,\Delta t$$

Shared time keeps networks, power systems and transactions in step.

c = 299,792,458 m/s · Signal-distance equivalence, not a universal position-error estimate

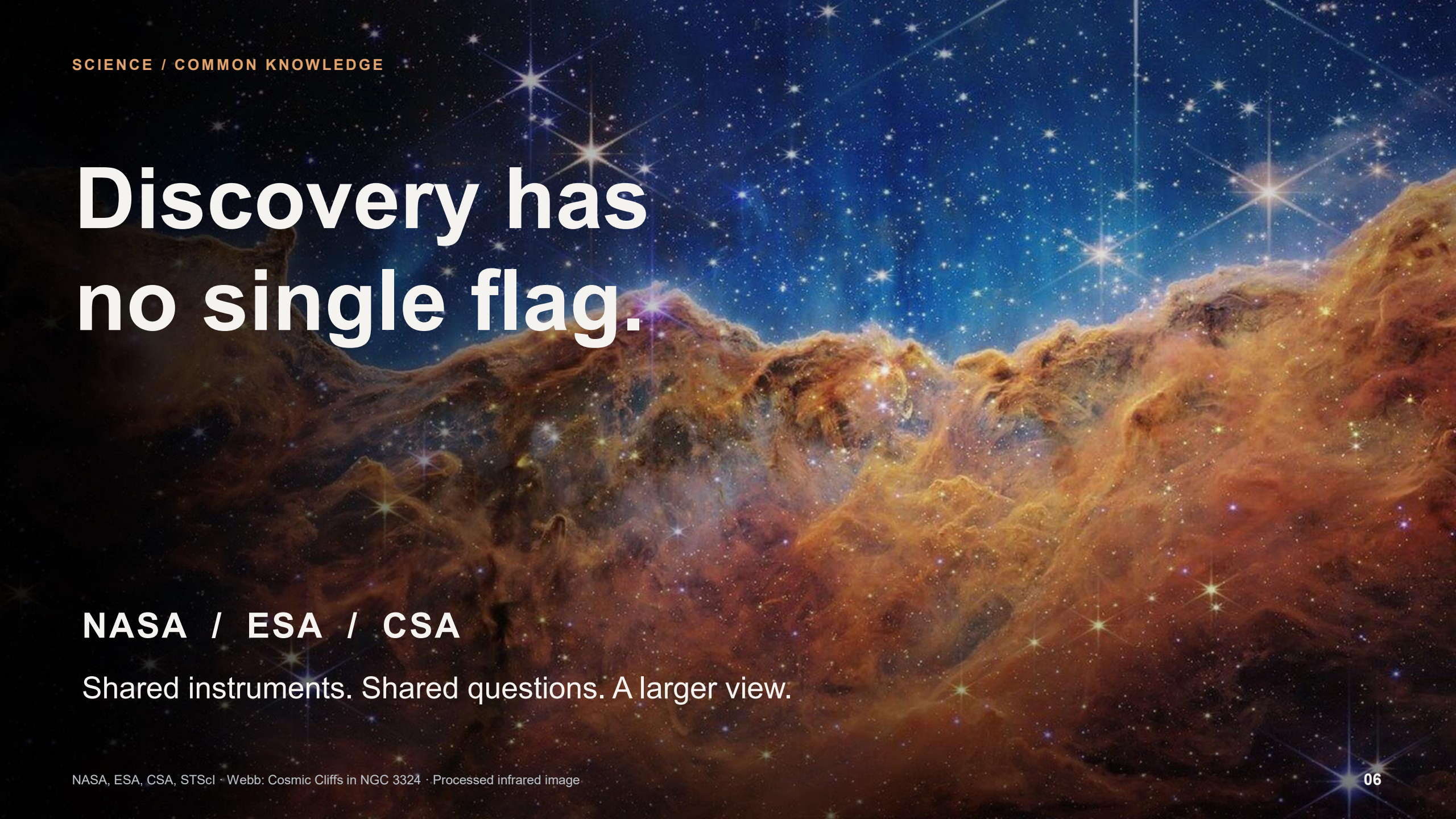
A planet with a memory.



Evidence changes the argument.

The Aral Sea:
a record of water diversion,
not just a striking image.

NASA · Aral Sea comparison, 1989 / 2014 · Water diversion for irrigation was a major driver



Discovery has no single flag.

NASA / ESA / CSA

Shared instruments. Shared questions. A larger view.

NASA, ESA, CSA, STScI · Webb: Cosmic Cliffs in NGC 3324 · Processed infrared image

A large economy. Not one market.

$613bn

GLOBAL SPACE ECONOMY / 2024

78%

Commercial activity

22%

Government budgets



A broad sector estimate — not rocket spending, profit or GDP.

Source: Space Foundation, The Space Report 2025 Q2 · 2024 estimate: $613bn; commercial share 78%

Why now?



Reuse

More frequent access



Industrialise

Hardware becomes infrastructure



Extract value

Data become services

NASA / Keegan Barber; ESA / M. Pédoussaut (CC BY-SA 3.0 IGO); NASA · Illustrative photographs

Orbit becomes infrastructure.



The frontier is becoming a system we depend on.

NASA · International Space Station · November 2021

The breakthrough is coming back.

A launch vehicle can become a reusable asset.

REUSE **CADENCE** **UNIT COST**



NASA · Falcon 9 first-stage landing, SWOT launch · 16 December 2022

From spacecraft to network.



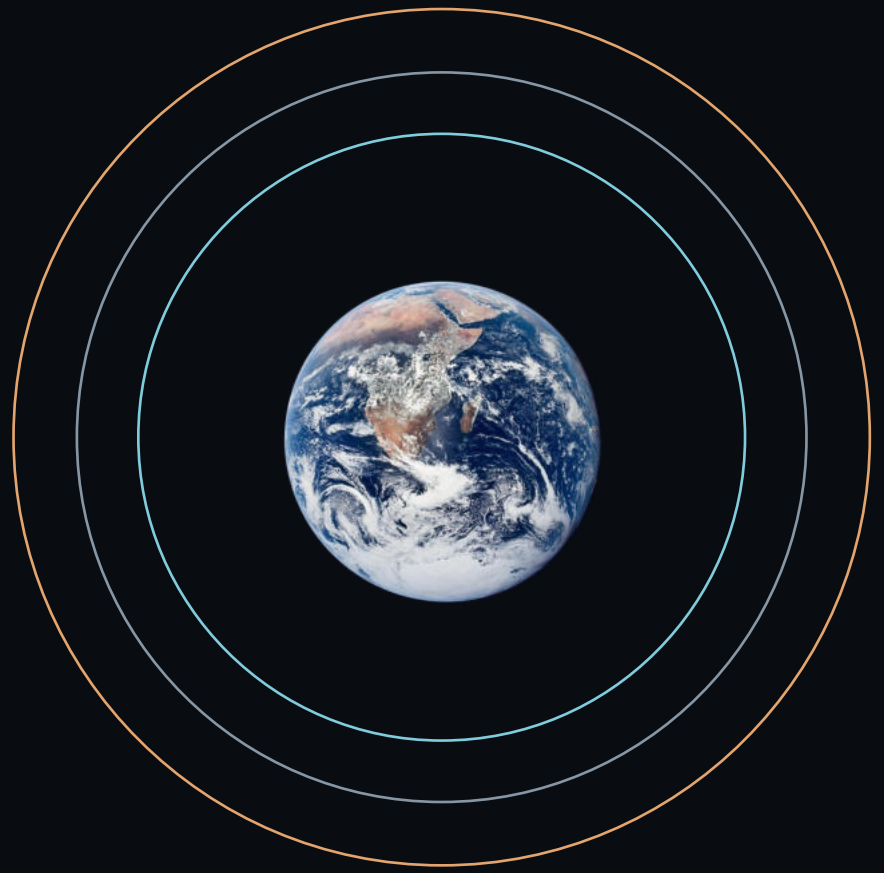
60

DEMONSTRATORS

One deployment.
A different industrial logic.

SpaceX · Starlink v0.9 demonstrators before deployment · 24 May 2019 · Historical mission

Different heights. Different jobs.



- **LOW EARTH ORBIT**

  Below about 2,000 km

  Observation · crews · connectivity

- **MEDIUM EARTH ORBIT**

  Between LEO and GEO

  Navigation and timing

- **GEOSTATIONARY ORBIT**

  35,786 km above the equator

  Continuous regional coverage

NASA Earth photograph · Orbital rings are schematic, not to scale · Altitudes: ESA, Types of orbits

Scale can become gatekeeping.

01 **Build** → 02 **Launch** → 03 **Serve** → 04 **Reinvest**

Scale can lower cost.

It can also raise the entry barrier.

Who controls the service?

- Availability
- Terms of access
- Priority in a crisis
- Credible alternatives



NASA · Europe at night · Policy questions apply to public and private infrastructure

There is no global control tower.

01

Track

Where is it?

→

02

Predict

How close might it get?

→

03

Coordinate

Who moves — and when?

→

04

Manoeuvre

Did the risk fall?

An alert is a probability. A safe response is a shared decision.

The catalogue is not the whole population.

≈ 46,120

CATALOGUED OBJECTS

Satellites and debris
Catalogue update: 31 July 2026

≈ 1.2 million

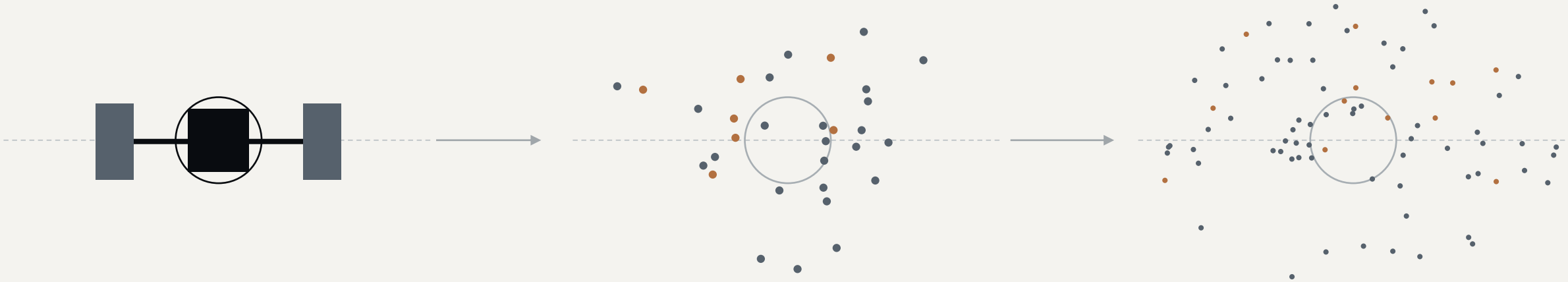
ESTIMATED SMALL DEBRIS

Larger than 1 cm, up to 10 cm
Model reference: August 2024

Too small to track can still be large enough to damage.

ESA / DISCOS / MASTER · Different definitions and dates: these numbers must not be treated as a ratio

One collision can outlive a mission.



An intact object

A cloud of fragments

Further collision risk

The mission ends. The risk may not.

Qualitative illustration of fragmentation and persistent risk · Not a numerical simulation

The sky is a scientific instrument.

Light trails change what telescopes can see.

208-minute composite exposure



A. H. Abolfath / NOIRLab / NSF / AURA · Orion, December 2019

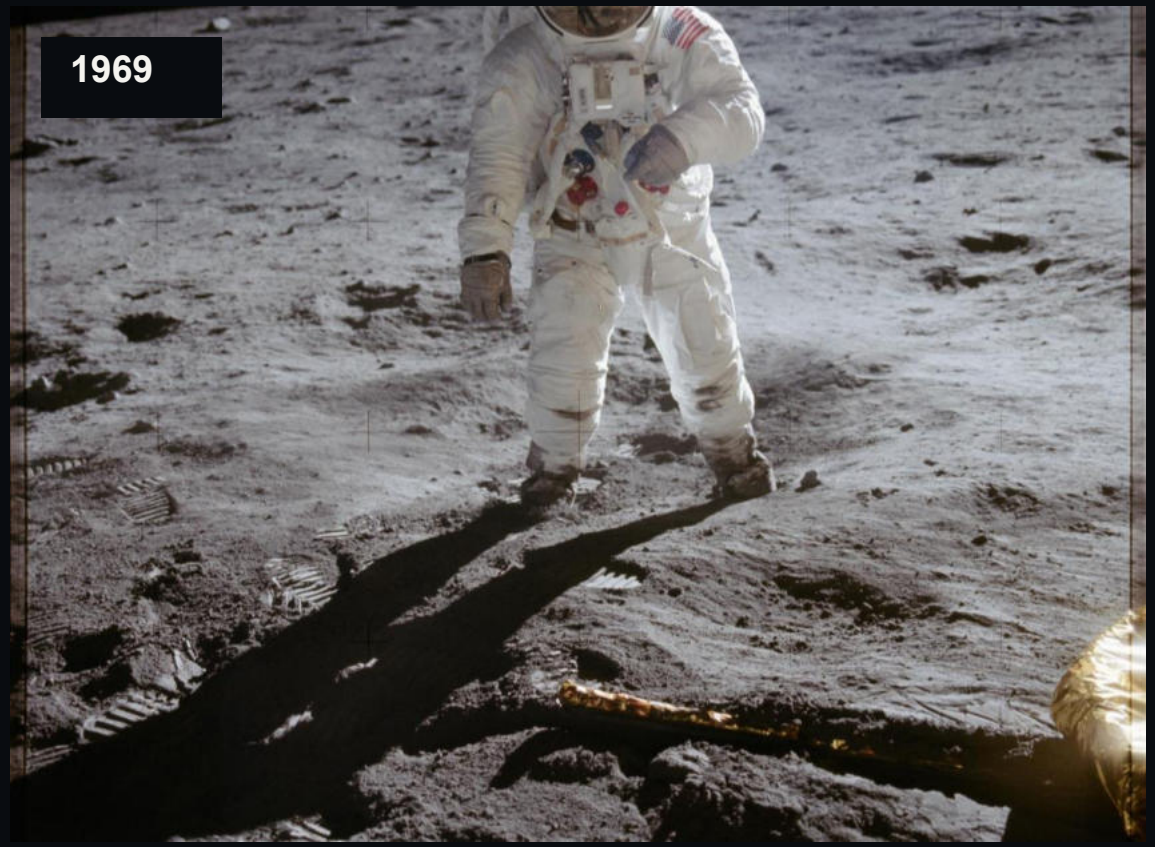
The Moon becomes a place.

Not just a destination. A geography of access, systems and rules.

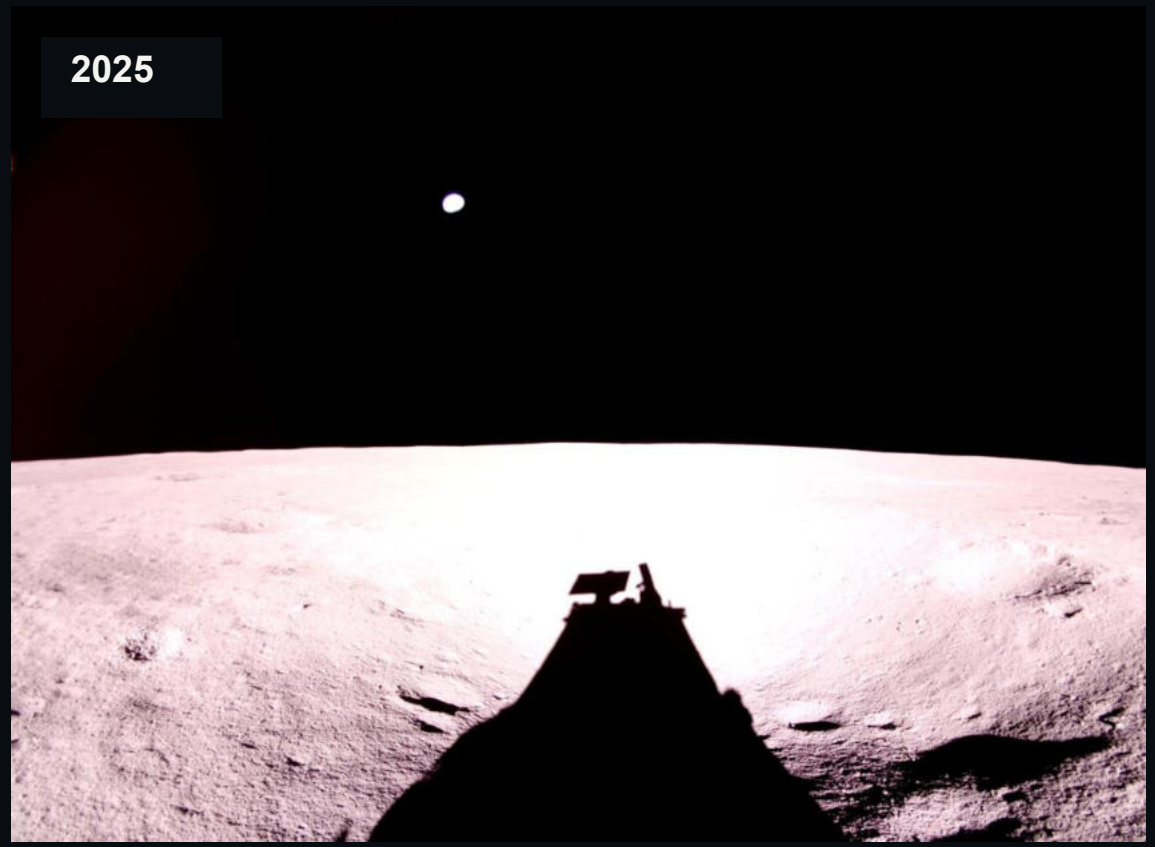


NASA · Artemis II lunar flyby · April 2026

From a visit to a presence.



APOLLO 11



BLUE GHOST MISSION 1

NASA · Apollo 11 surface photograph | NASA / Firefly Aerospace · View from Blue Ghost on the Moon

THE LUNAR SOUTH POLE

A geography of extremes.

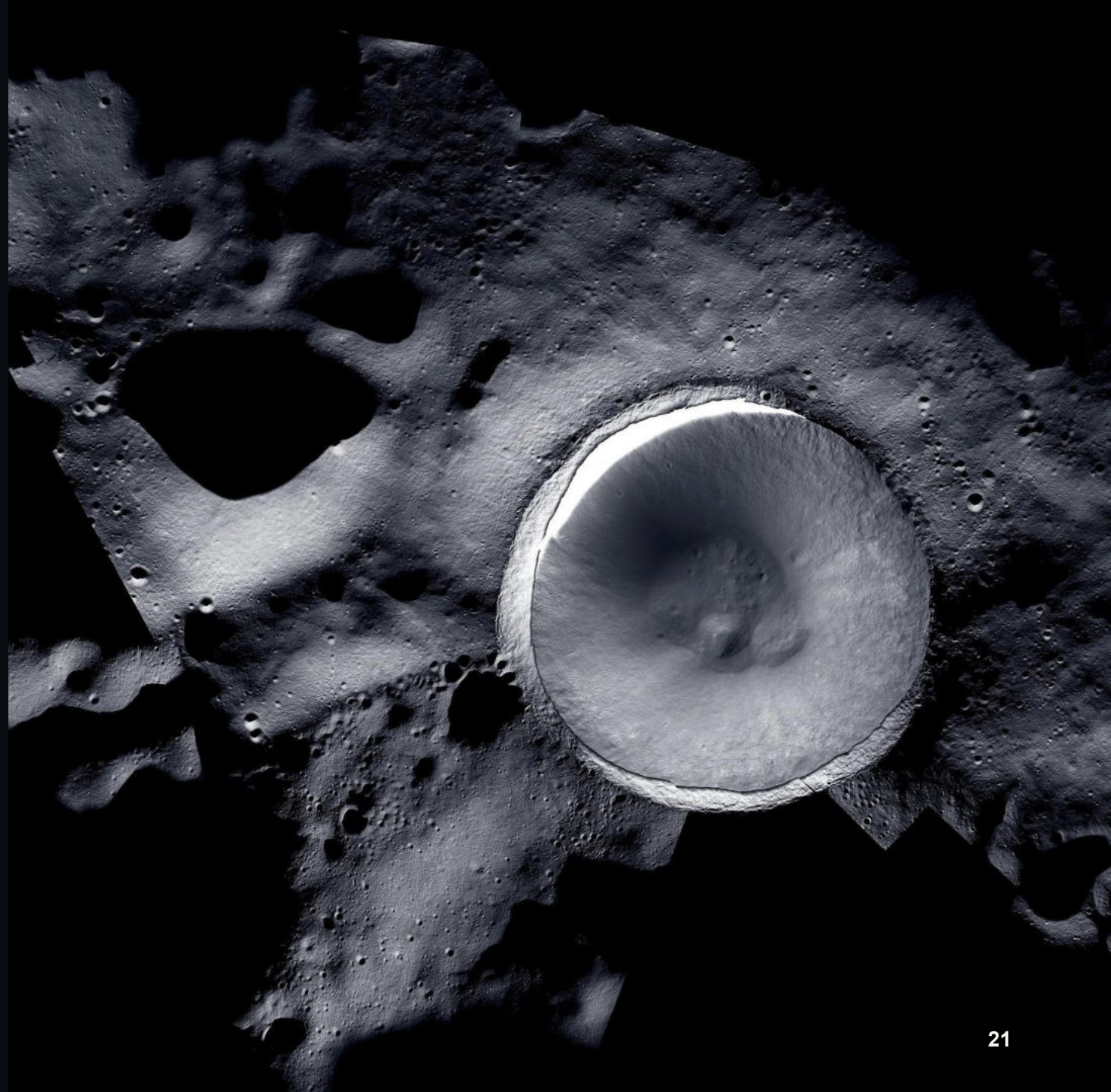
SUNLIGHT

Power and thermal conditions

SHADOW

Cold traps and potential volatiles

Evidence of ice ≠ a viable mine.



NASA / KARI / ASU · LROC–ShadowCam mosaic · Processed shadow detail, not illumination

A base is a supply chain.

The habitat is only one part of the architecture.

Power

Generation · storage

Communications

Links · timing · navigation

Transport

Landing · surface logistics

Life support

Air · water · temperature

Maintenance

Spares · repair · reliability

Resources

Local use only after proof

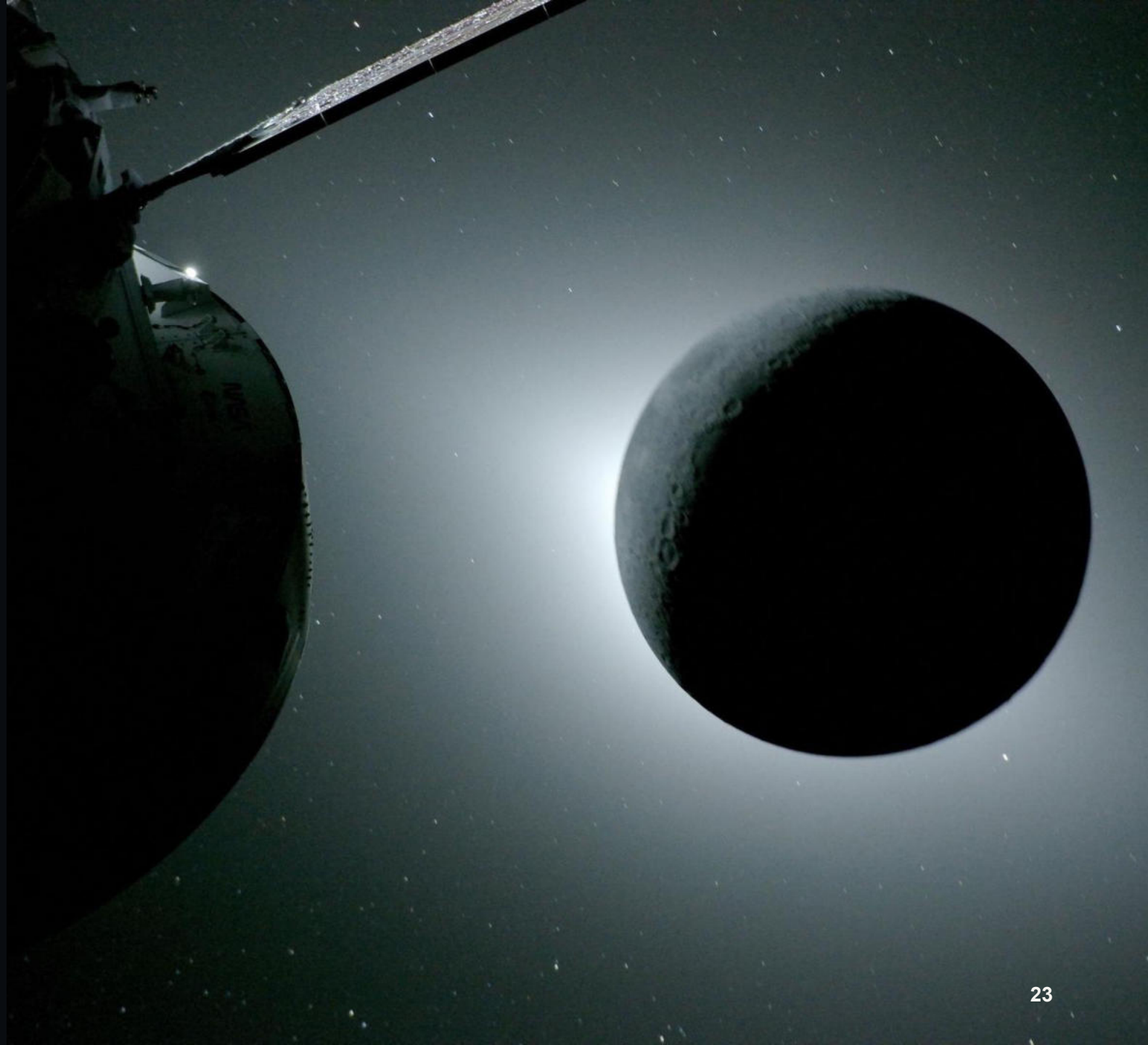
ARTEMIS II / APRIL 2026

Back to deep space.

9 days

1–10 April 2026

Crewed lunar flyby. Not a landing.



NASA · Artemis II lunar flyby · Eclipse, 6 April 2026

No nation flies this alone.

EUROPEAN SERVICE MODULE

Power. Propulsion. Crew supplies.

A partnership becomes real when systems depend on each other.

NASA · Orion during Artemis II | European contribution: ESA’s European Service Module

China is building another pathway.

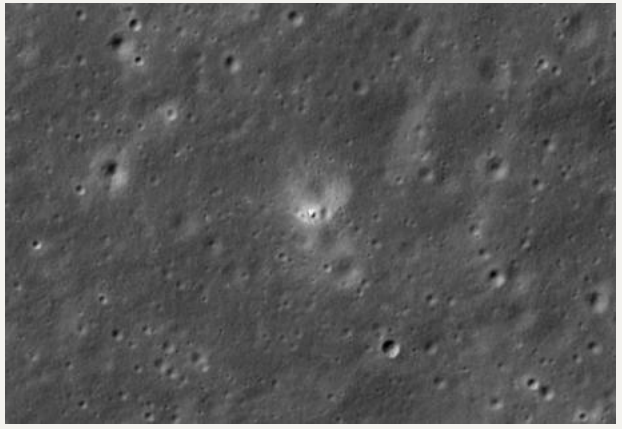
2019 First far-side soft landing

2020 Samples returned from the Moon

2024 **First far-side sample return**

Competition and scientific cooperation can coexist.





Chang’e-6 site seen by LRO

China News Service · CC BY 3.0 | Chang’e-6 site: NASA / GSFC / ASU · June 2024

The Moon will be multipolar.

United States

China

Europe

India

Japan

Commercial providers

Partnerships overlap. Capabilities are unequal. Rules still have to work.

NASA lunar photograph · Selected participants, not a ranking or a map of fixed political blocs

Buy the delivery. Keep the science.

Blue Ghost · March 2025

10 NASA science and technology payloads

COMMERCIAL TRANSPORT	PUBLIC INSTRUMENTS	SCIENTIFIC RETURN

NASA / Firefly Aerospace · View from Blue Ghost Mission 1 on the lunar surface

The first scarce resource may be access.



SUNLIGHT

SAFE APPROACHES

COMMUNICATIONS

SCIENTIFIC SITES

Coordinate hazards without turning safety into exclusion.

NASA / KARI / ASU · Processed Shackleton-region imagery · Potential conflicts, not existing territorial claims

No borders does not mean no rules.

CLEAR

No national territory.

States also authorise and supervise private national activities.

CONTESTED

Resources and access.

How extraction, ownership and benefit-sharing should work.

Owning the spacecraft is not owning the ground beneath it.

Outer Space Treaty, especially Articles II, VI, VIII and IX · Legal summary, not a claim of settled resource rules

Write the rules before the traffic.

01	02	03	04	05
Notify	**Coordinate**	**Protect**	**Share**	**Clear**

Make responsible operations the easy default.

Plans · hazards · science · useful data · end-of-life hardware



Power follows dependence.

Observe. Connect. Navigate. Coordinate.

NASA · Europe at night

The attack may happen on Earth.

24 FEB 2022

SATELLITE BROADBAND

01

Spacecraft



02

Ground network



03

Terminals

Disrupt the network. No collision required.

Viasat incident account, 30 March 2022 · EU attribution to Russia, 10 May 2022 · Schematic architecture

Disable the service, not only the satellite.

01	02	03	04	05
JAM	**SPOOF**	**CYBER**	**DAZZLE**	**DESTROY**
Block the real signal	Imitate a trusted signal	Compromise the system	Interfere with a sensor	Physically damage it

Protection has to include software, ground systems and users.

High-level threat taxonomy · Categories can overlap; this is not a ranking of likelihood or severity

Debris has no nationality.



>1,500

TRACKABLE FRAGMENTS

Initial report after Russia’s destructive ASAT test in 2021.

U.S. Space Command · 15 November 2021 initial count, not today’s surviving debris total | Earth: NASA

Not lawless.
Unevenly enforced.

Treaties	National licences	ITU coordination	Operational practice
Shared principles and responsibilities	Authorisation and supervision	Spectrum and related orbital coordination	Data exchange, norms and collision avoidance

The missing link is often practical coordination and accountability.

Europe has a choice.

From excellent missions to the ability to act.

NASA · Earth seen through the ISS Cupola

Excellent missions need a common strategy.

Copernicus	Earth observation
Galileo + EGNOS	Navigation and timing
Weather + science	Public knowledge
Industry + launch	End-to-end capability



ESA / M. Pédoussaut · CC BY-SA 3.0 IGO · Sentinel-1D integration (2025)

Autonomy means having options.

Ariane 6 · Vega-C · New suppliers

Reliability. Cadence.
The ability to choose.



ESA / M. Pédoussaut · CC BY-SA 3.0 IGO · Ariane 6 pad test photograph (2023)

Three tests for European ambition.

01

Connect

IRIS²

Secure and resilient communications

UNDER DEVELOPMENT

02

Know

EU SST

Independent awareness of the orbital environment

OPERATIONAL SERVICES

03

Preserve

ZERO DEBRIS

Responsible operations and end-of-life disposal

2030 AMBITION

European Commission / EU SST / ESA · Development, operational service and ambition are different statuses

Beyond Earth.
For Earth.



Who benefits —
and who decides?

Roberto Battiston / University of Trento

NASA / Bill Anders · Apollo 8 Earthrise · 24 December 1968