Artemis mission: An SMA perspective

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TRISMAC

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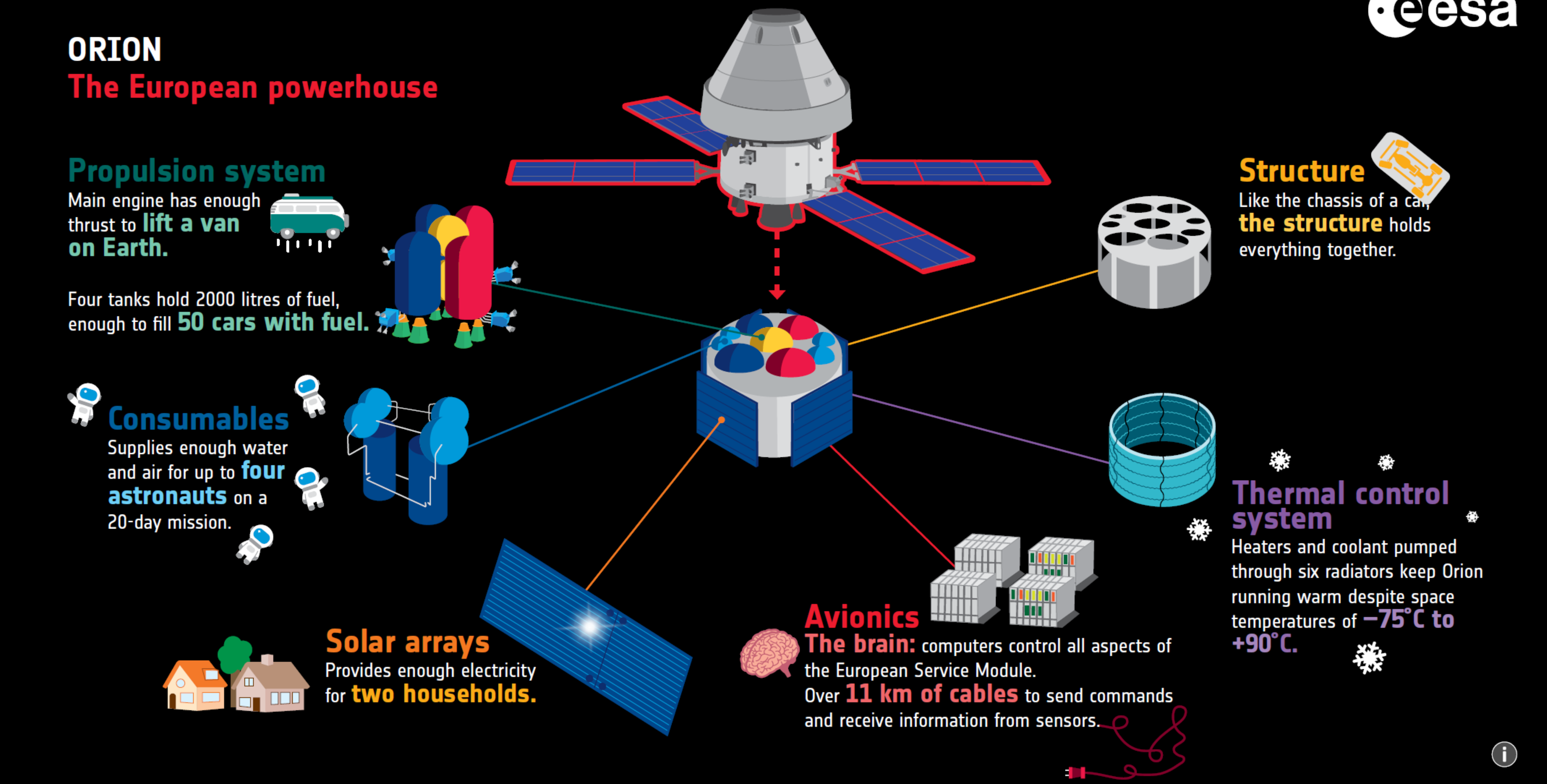


→ THE EUROPEAN SPACE AGENCY

Artemis: A Foundation for Deep Space Exploration

Space Launch System (SLS)

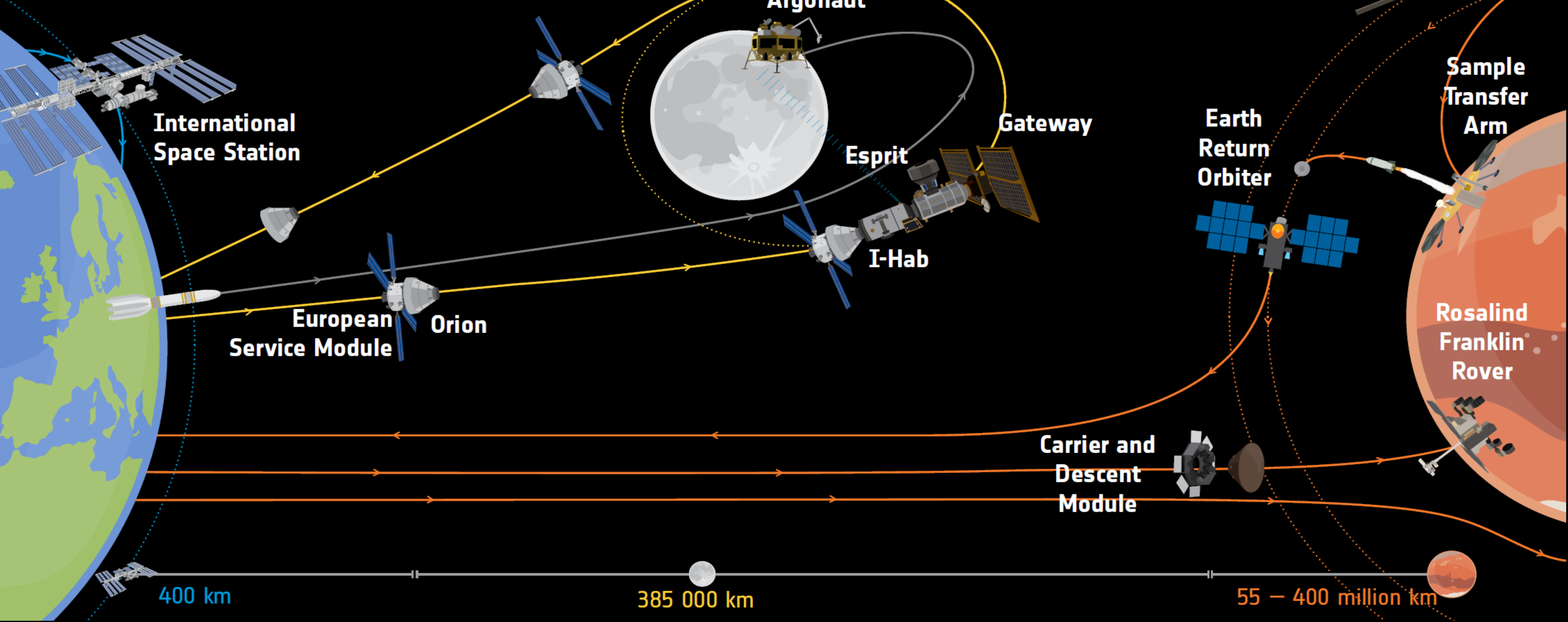
Orion Spacecraft

Human Landing System (HLS)

Gateway (Space Station in Lunar Orbit)

ESA'S HUMAN AND ROBOTIC EXPLORATION DESTINATIONS

ESA's Human and Robotic Exploration programme will see astronauts and robots explore low Earth orbit on the International Space Station, the Moon and Mars, to bring knowledge and benefits to Earth.



Orion stack

Orion – European Service Module

Germany
- Prime contractor
- European Service Module assembly integration and verification
- Propulsion and propulsion drive electronics
- Centralised parts procurement agent
- Data network harness for Qualification Module
- Reaction control thrusters

Italy
- Structure
- Thermal control system
- Consumable storage system
- Power control and distribution unit
- Photovoltaic assembly
- Meteoroid and debris protection system

USA
- Gas tank
- Valves, pressure regulators and pumps
- Data network harness for Flight Module
- Main and auxiliary engines
- Solar cells

Switzerland
- Secondary structure
- Solar array drive assembly
- Solar array simulator
- Mechanical ground support equipment

France
- System tasks
- Avionics qualification
- Direct current harness
- Electronics
- Helium filters

Belgium
- Tank bulkhead
- Electrical ground support equipment
- Pressure regulation units

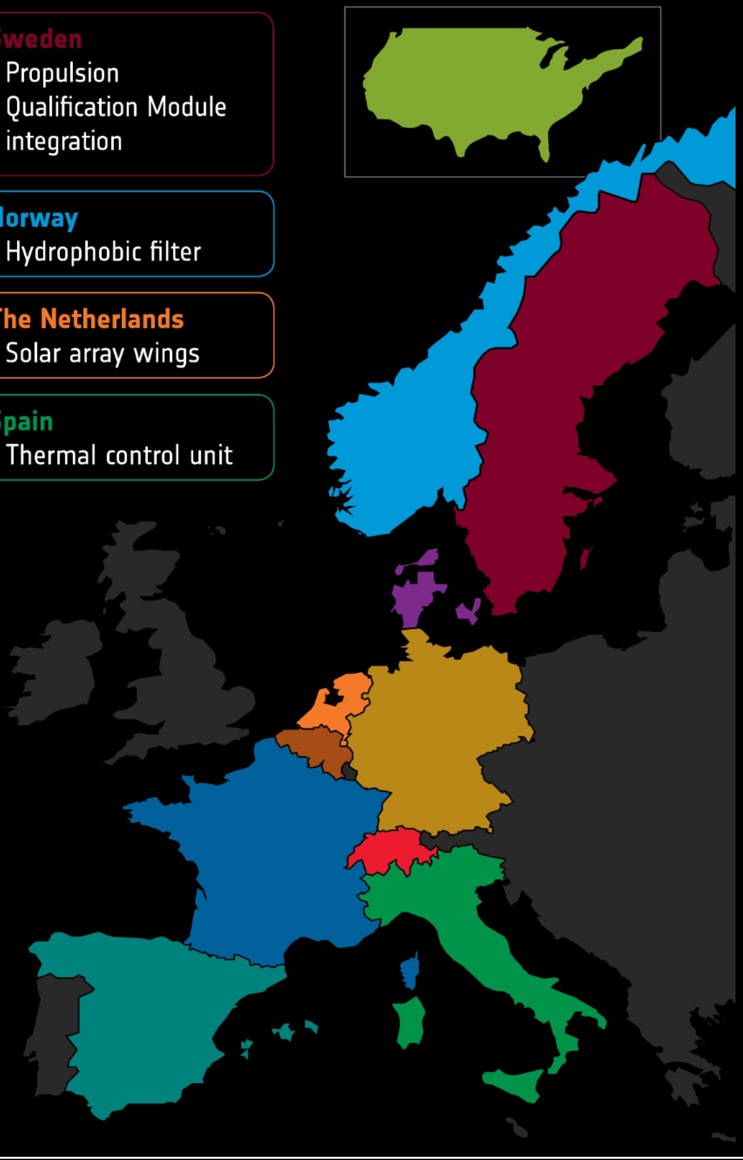
Denmark
- Electronics
- Electrical ground support equipment

Sweden
- Propulsion Qualification Module integration

Norway
- Hydrophobic filter

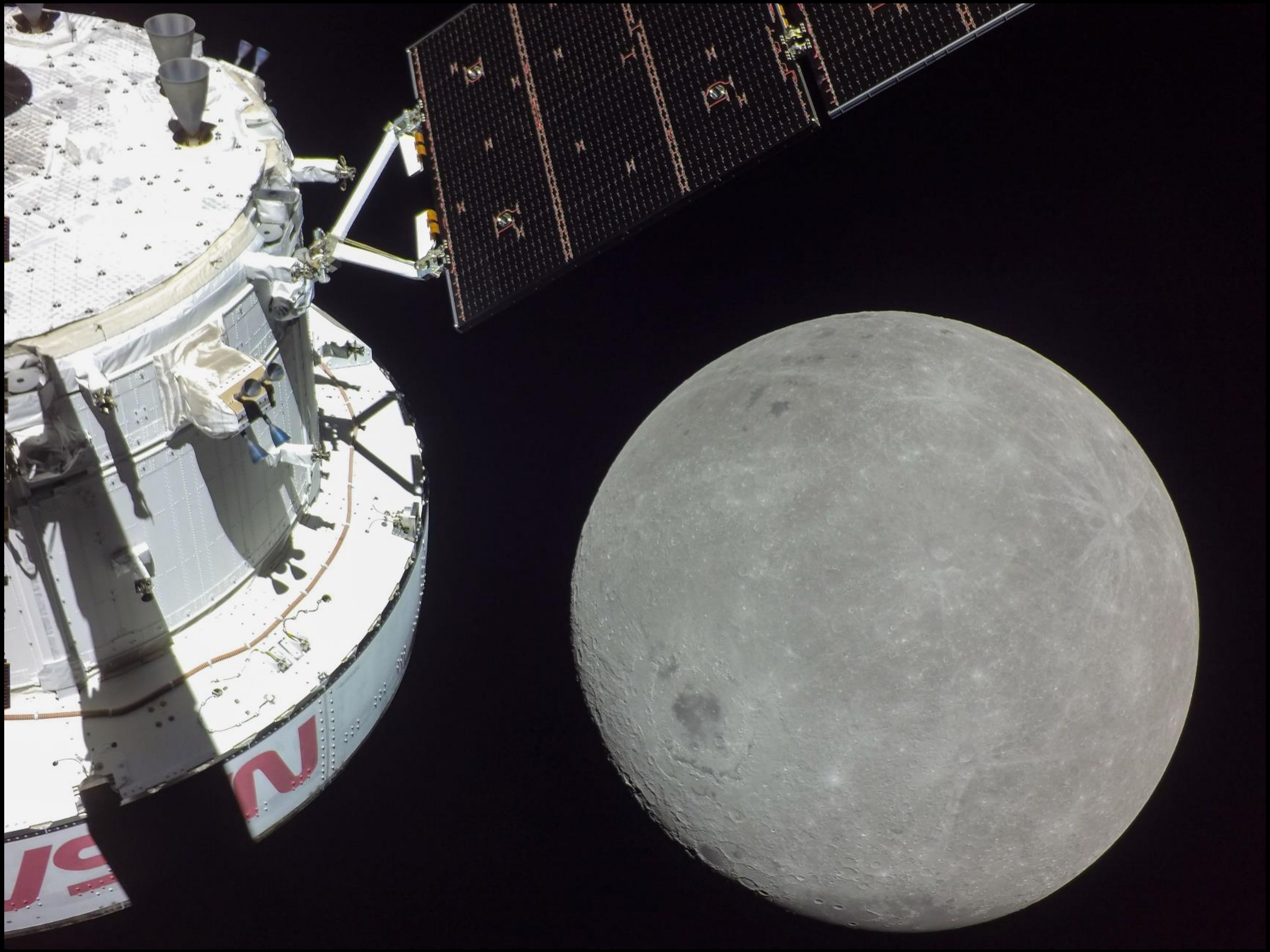
The Netherlands
- Solar array wings

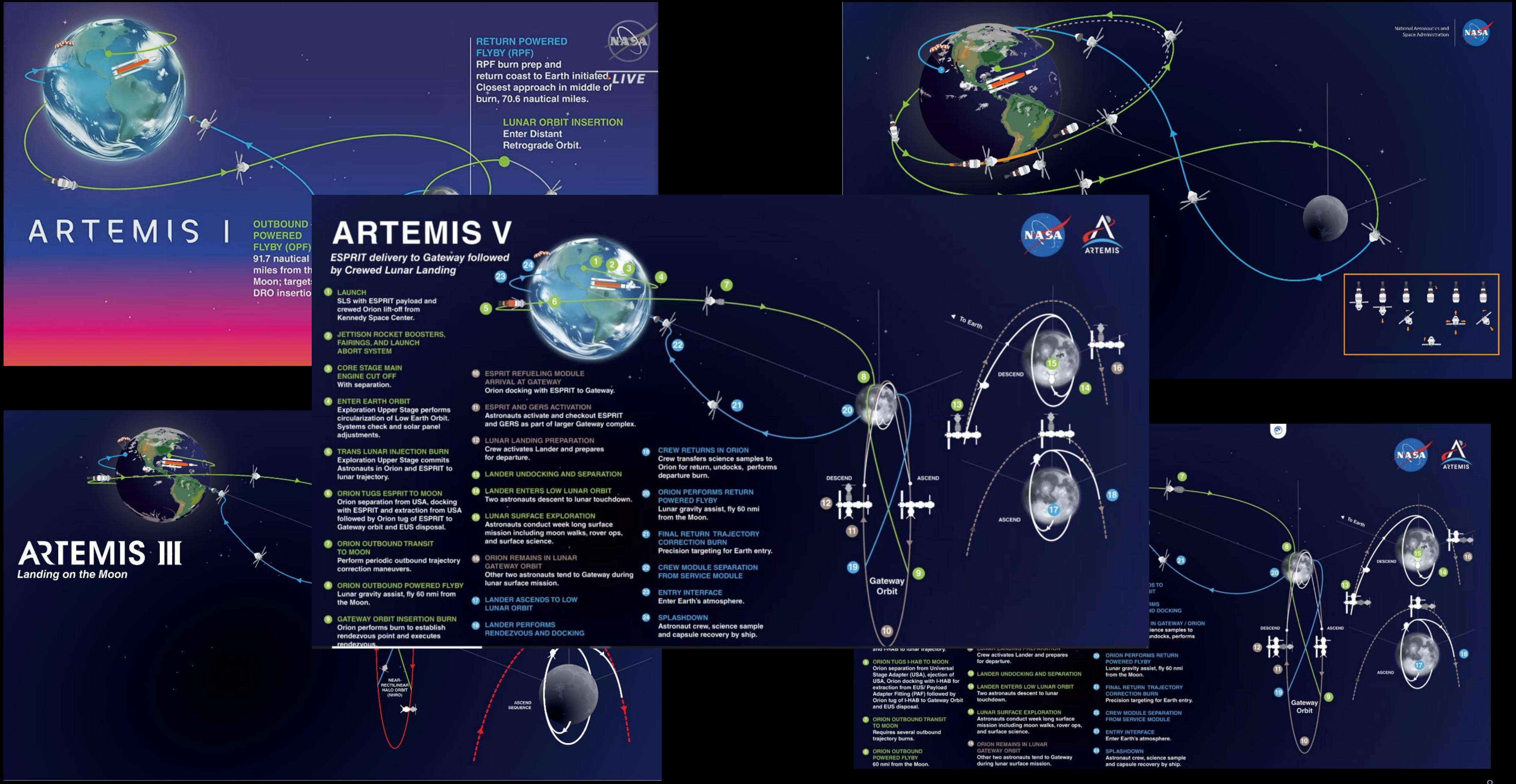
Spain
- Thermal control unit



- Components from 10 ESA Member States plus USA
- Integration at Airbus in Bremen, Germany
- Shipment to Kennedy Space Center in USA
- Final tests and integration with Crew Module at KSC
- Launch with SLS

Arrival at the Moon




RETURN POWERED FLYBY (RPF)
RPF burn prep and return coast to Earth initiated. Closest approach in middle of burn, 70.6 nautical miles.
LUNAR ORBIT INSERTION
Enter Distant Retrograde Orbit.
LIVE
ARTEMIS I
OUTBOUND POWERED FLYBY (OPF)
ARTEMIS III
Landing on the Moon
ARTEMIS V
ESPRIT delivery to Gateway followed by Crewed Lunar Landing
1 LAUNCH
SLS with ESPRIT payload and crewed Orion lift-off from Kennedy Space Center.
2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM
3 CORE STAGE MAIN ENGINE CUT OFF
With separation.
4 ENTER EARTH ORBIT
Exploration Upper Stage performs circularization of Low Earth Orbit. Systems check and solar panel adjustments.
5 TRANS LUNAR INJECTION BURN
Exploration Upper Stage commits Astronauts in Orion and ESPRIT to lunar trajectory.
6 ORION TUGS ESPRIT TO MOON
Orion separation from USA, docking with ESPRIT and extraction from USA followed by Orion tug of ESPRIT to Gateway orbit and EUS disposal.
7 ORION OUTBOUND TRANSIT TO MOON
Perform periodic outbound trajectory correction maneuvers.
8 ORION OUTBOUND POWERED FLYBY
Lunar gravity assist, fly 60 nmi from the Moon.
9 GATEWAY ORBIT INSERTION BURN
Orion performs burn to establish rendezvous point and executes
10 ESPRIT REFUELING MODULE ARRIVAL AT GATEWAY
Orion docking with ESPRIT to Gateway.
11 ESPRIT AND GERS ACTIVATION
Astronauts activate and checkout ESPRIT and GERS as part of larger Gateway complex.
12 LUNAR LANDING PREPARATION
Crew activates Lander and prepares for departure.
13 LANDER UNDOCKING AND SEPARATION
14 LANDER ENTERS LOW LUNAR ORBIT
Two astronauts descent to lunar touchdown.
15 LUNAR SURFACE EXPLORATION
Astronauts conduct week long surface mission including moon walks, rover ops, and surface science.
16 ORION REMAINS IN LUNAR GATEWAY ORBIT
Other two astronauts tend to Gateway during lunar surface mission.
17 LANDER ASCENDS TO LOW LUNAR ORBIT
18 LANDER PERFORMS RENDEZVOUS AND DOCKING
19 CREW RETURNS IN ORION
Crew transfers science samples to Orion for return, undocks, performs departure burn.
20 ORION PERFORMS RETURN POWERED FLYBY
Lunar gravity assist, fly 60 nmi from the Moon.
21 FINAL RETURN TRAJECTORY CORRECTION BURN
Precision targeting for Earth entry.
22 CREW MODULE SEPARATION FROM SERVICE MODULE
23 ENTRY INTERFACE
Enter Earth's atmosphere.
24 SPLASHDOWN
Astronaut crew, science sample and capsule recovery by ship.
To Earth
DESCEND
ASCEND
Gateway Orbit
NASA
ARTEMIS
National Aeronautics and Space Administration

Baseline/Tools/Facilities

Baseline

- Constellation/Orion specifications→Airbus Spec→Subcos Reqs
- NASA and ESA standards: IPC/NASA STD vs ECSS/ESCC
- LLI (Life Limited Items) list kept updated at milestones and tests (from as-runs)

Tools

- ITAR limitations, shared repositories, RID tools, configuration tools
- Need for centralized state-of-the-art IT platform, optimized for mission development data management in serial production:
  Achieving quality consistently is a matter of process

Facilities

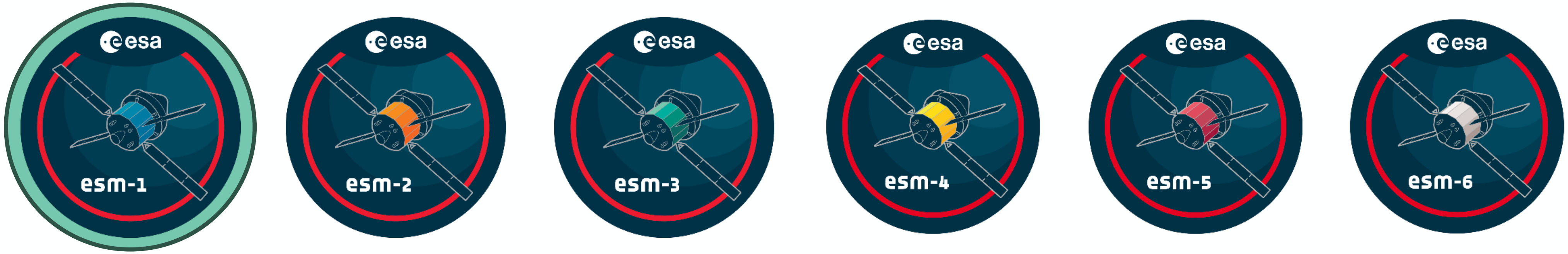
- Access to Facilities and documentation – Increased trust
- Test consoles (JMEWS/AMEE)
- Test labs (PB/KSC/WS)
- Qualification facilities (ITL/PQM/QF)

People/Schedule

- Team Colocations for Integration and Tests (ATLO/Bremen/ITL/JSC Op room): SMA team continuous presence during main test campaign, with independent view, focus on risk mitigation and ensuring continuous improvement with every lesson learned.
- Schedule (SMA team flexibility and redundancies, with Subsystem responsibility and backups, mission availability, personal time management)
- Retain People Expertise
- Flat structure and task delegation
- F2F powerful for reviews/crash actions/burn down/tiger teams
- Daily coordination and daily reporting with sharing tools/coediting.
- Discipline of suppliers in meeting description and notification time.
- Lesson Learned/ad hoc workshop
- Weekly MMPP coordination (internal and with NASA/industry)
- Complexity of Meetings (4 or 5 parties, with subcos, at different levels: NRBs/ERB/IST/MPCB...)
- CM Incremental: CIDL/ABCL/Work Items/Procedure review to speed up milestone review (dedicated 3-party team)

Future missions: Artemis I to IX and beyond

- **Series production: Design, Process and Qualification stability**
- **Parallel production: Anomaly impact on production (present) and design (future)**
- Delegation to industry/subcos (mature: delegated, troubled: visit)
- Retrieval of past experience/anomalies/LL: tools/procedure/proper documenting and reporting, coherent approach.
- Use of AI technology (e.g. Copilot vs meeting attendance)
- Parallel Design/Procurement for challenging technologies (e.g. valves, pump)



Safety aspects

Evolutions from AR-I

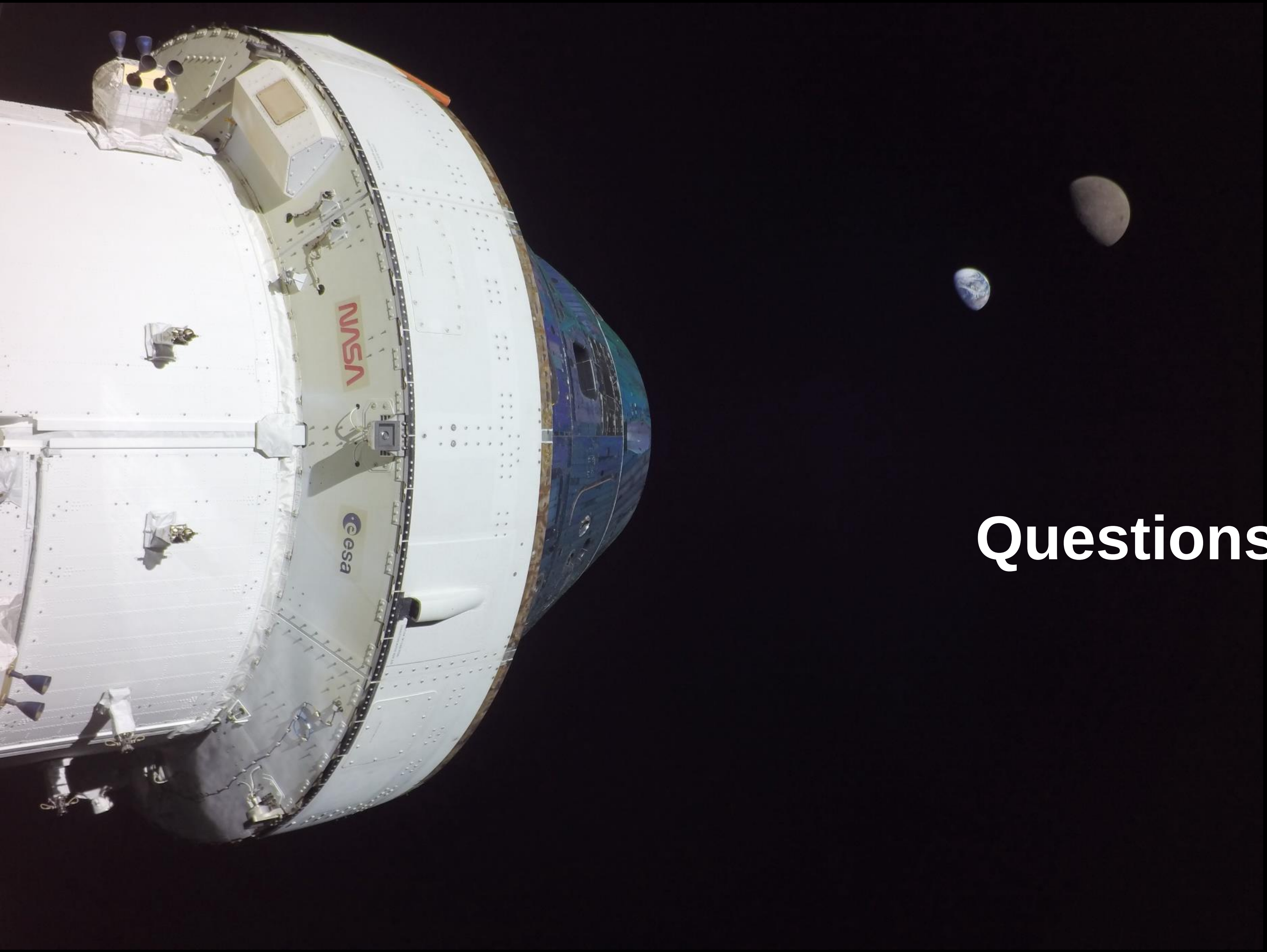
- Focus shift from development to as-built/anomalies.
- AR-II+ Phase 2 (design and qual) based on baseline of AR-I.
- Parallel certification of two builds, with strong dependencies

Old vs New approach

- ISS approach: deterministic safety requirements (2 Fault Tolerance approach)
- ESM/Orion approach: Deterministic (1FT)+Probabilistic (risks assessment impact on certification and design)
- PRA method is needed (new to ESA)

LLs

- Safety certification is still design centered. Could better evolve towards a specific mission focus.
- PRA is also too generic (based on baseline design, not missions)
- Risk tuning to the mission specific hazards (e.g. # and duration of critical burns/flyby)
- Risk monitoring to predict in flight risks and support in flight UAI decisions.
- Risk updating based on anomalies and resolutions



Questions?