



ARES Detector for Radiation Monitoring on the HLS and Gateway Vehicles

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ARES



Active Radiation Environment Sensor (ARES) is designed to be a radiation monitor for vehicles in Artemis Program lunar mission, primarily HLS and Gateway.

- Funded by the NASA Mars Campaign Office to
 - Provide monitoring of vehicle real-time space environment radiation incident from Solar Particle Events (SPE) and Galactic Cosmic Radiation (GCR).
 - Meet the absorbed dose, the charged particle flux, LET distribution requirements for Artemis Program vehicles, per NASA-STD-3001.
 - Provide alarm information for high dose rate radiation events
 - Have minimal-interface operation requirements for connection to a vehicle computer
 - Be compatible with Artemis Program vehicles...crewed vehicles

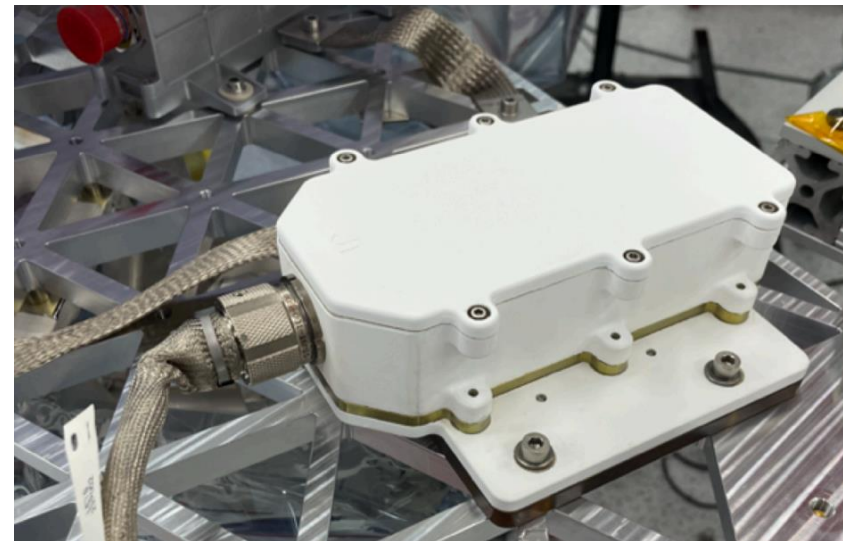
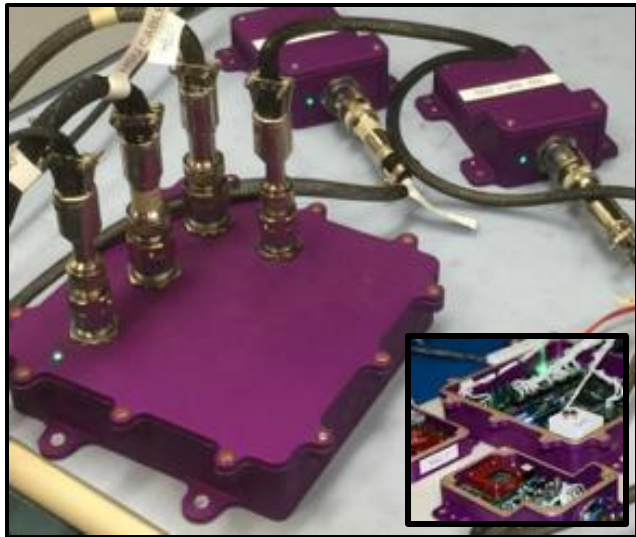


Challenges

- Development had challenges from the start.
 - Define ARES interface and payload requirements for vehicles that did not have defined payload or environmental requirements defined.
 - Envelope expected requirements across the vehicles.
 - Reduced to a 2 year development to qualify the flight design
support deliveries for the revised (March 2019)
2024 Boots on the Moon.
- The accelerated schedule refocused the development to meet the near-term needs of the Artemis.

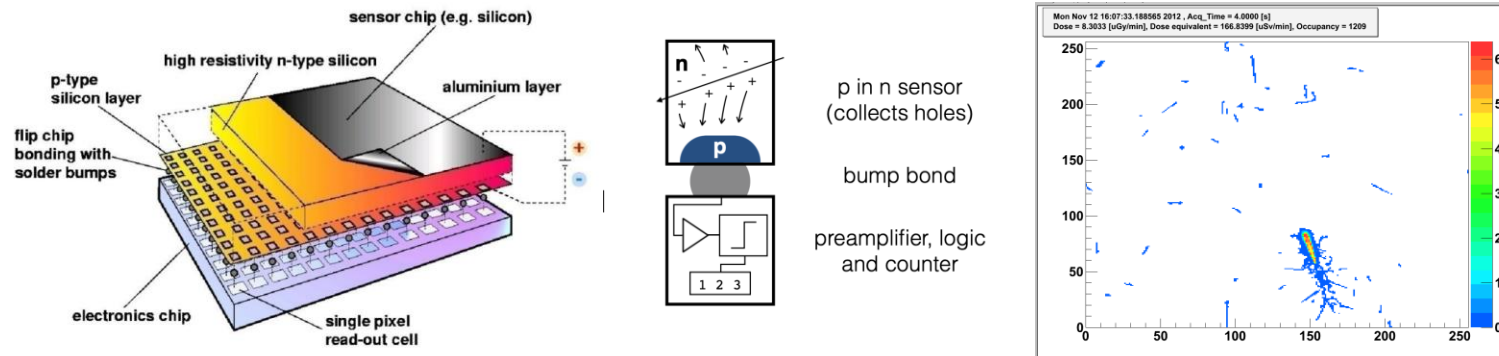
ARES Heritage

- Leverage knowledge gained with previous Si Timepix sensors.
 - REM on ISS
 - HERA –ISS missions and Artemis 1
 - LETS Biosentinel and CLPS missions



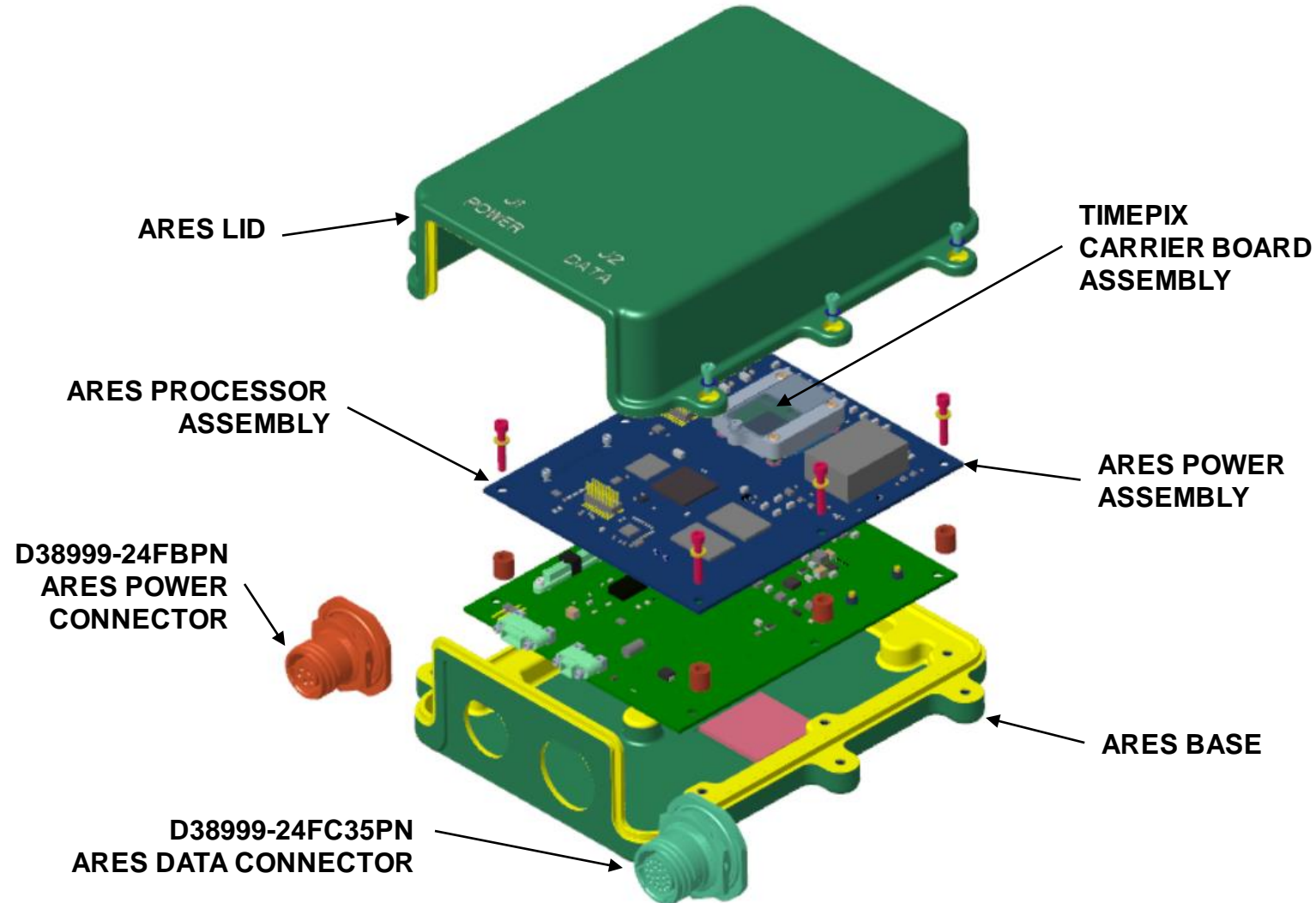
Radiation Sensor

- Timepix meets the sensor requirements for ARES on Artemis
- Timepix quantities were available even though production of wafer had stopped
- MCO procured enough Timepix mounted on NASA provided carrier boards in advance full system design

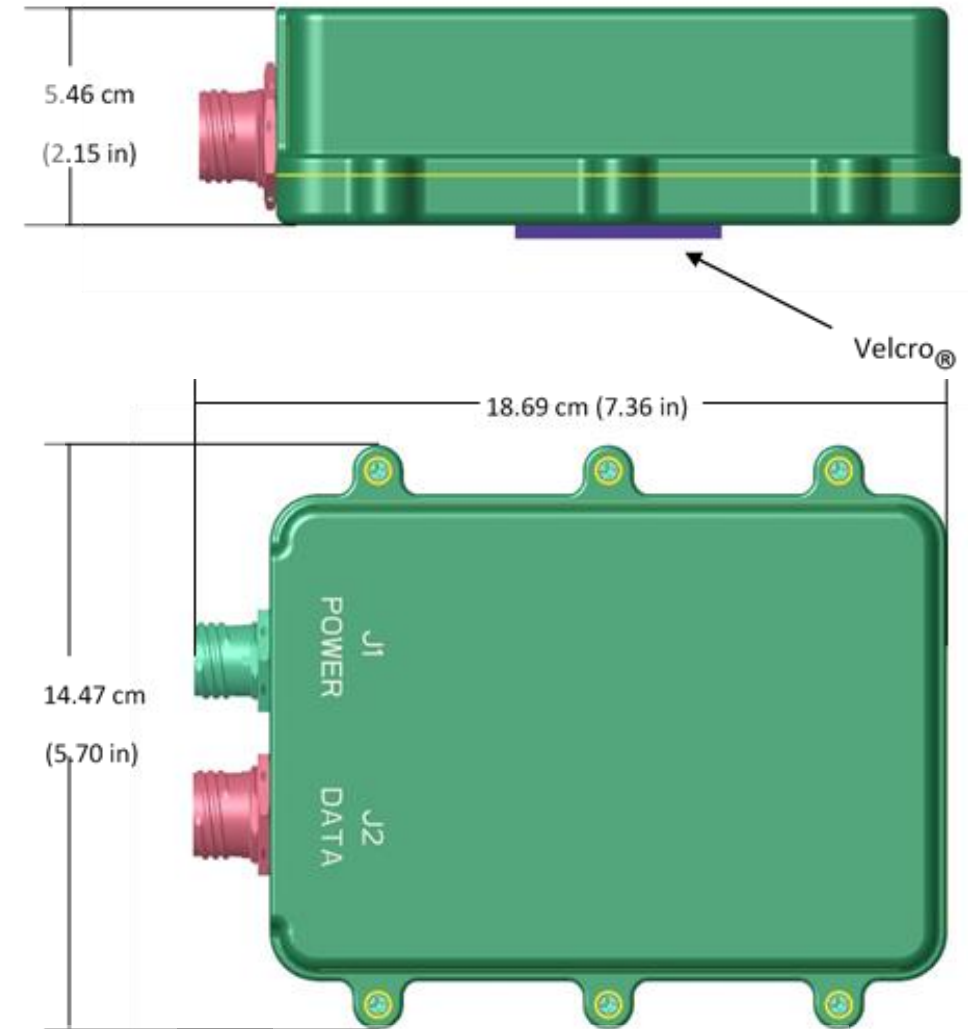
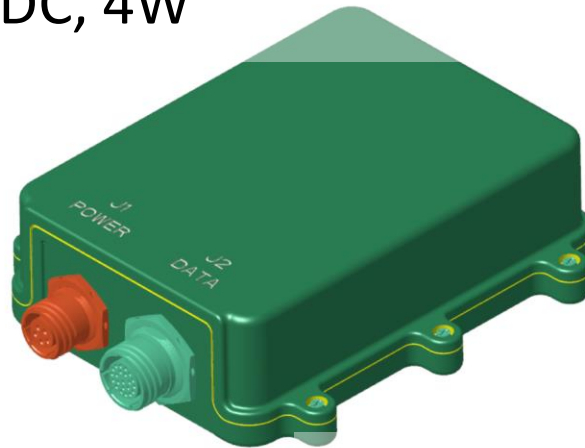


Design Goals

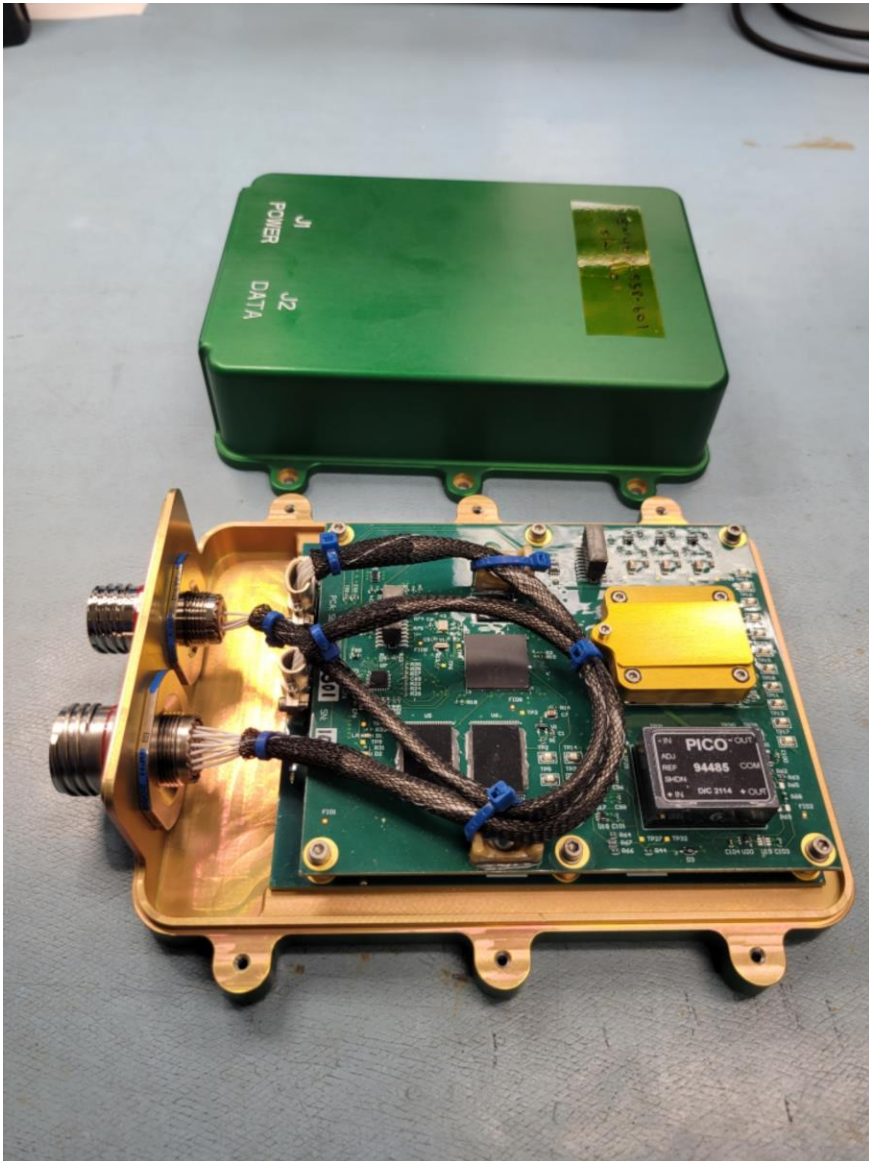
- EEE part upgrades were selected to increase reliability of heritage hardware
- New processor and memory
- New PCB designs to meet physical constraints
- Separation of power board to support active heating if required
- Better thermal management for Timepix heat transfer
- Housing design for soft stowed payload (no hard mount option)



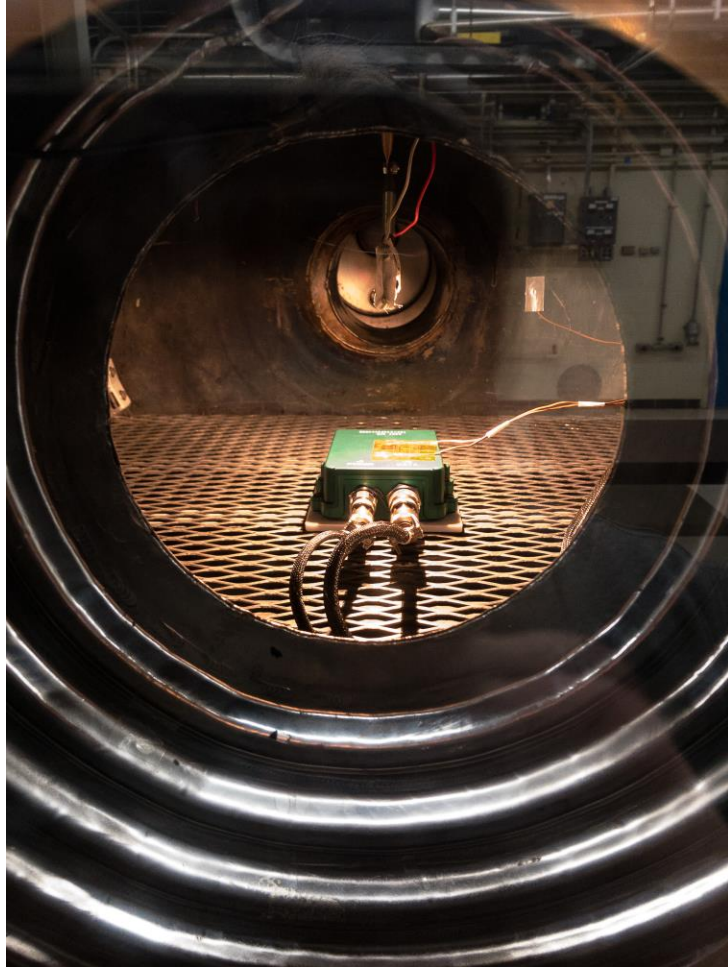
- **Mass:** 0.8 kg
- **Volume:** 1054 cm³
- **Housing:** Anodize/Alodine AL6061
- **Mounting:** Velcro
- **Power and Data Connectors:** D38999
- **Communication:** Ethernet command and data, 1/min cadence
- **Power:** 28 VDC, 4W



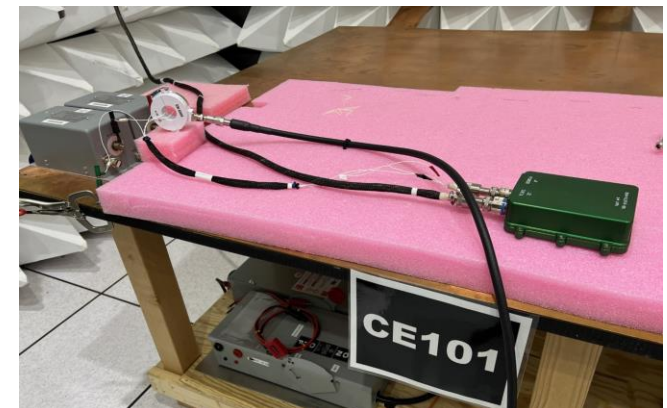
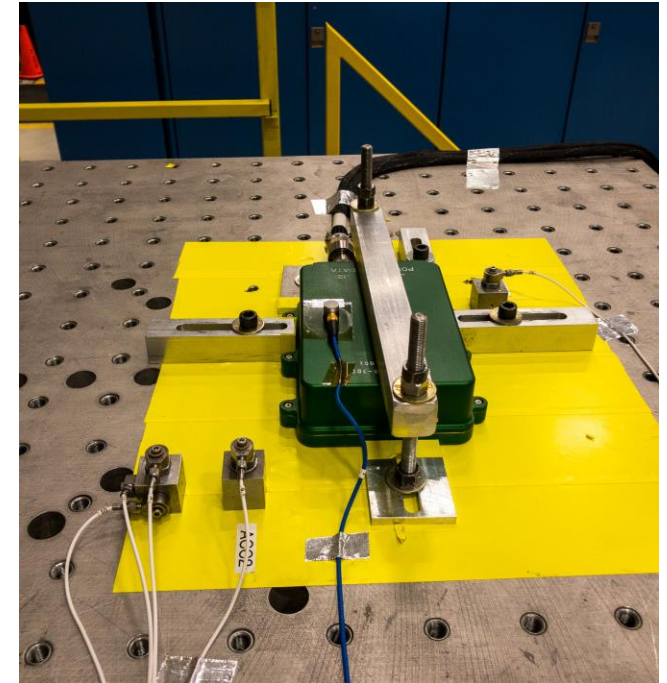
ARES Assembly



Test Environments



Test Event	ARES Testing (as performed)
Random Vibration	
Level	21.3 Grms / 10.2 Grms
Duration	3 minute per axis
Thermal Vacuum/Thermal Cycle	
Pressure	1X10 ⁻⁵ Torr
Temperature	-34 C to 71 C
Cycles	20 Thermal/Vacuum
EMI/EMC	SMC-S-016
Power Quality	Per ISPSIS
Burn-in	200 Hours Duration. Temperature: +142°F (61.1°C)





ARES Assemblies



- Current Flight builds for Artemis
 - HLS (2 units for each)
 - Artemis III
 - Artemis IV
 - Artemis V
 - Gateway (3 units)
 - HALO Module
 - IHAB Modules
 - ISS Tech Demo
- Remaining assets do not have vehicles assigned at this time



ARES ConOps



The ARES primary function is to **monitor the radiation environment** in the habitable volume **during crewed mission phases**. Two units delivered per vehicle (prime and spare flight units)

- **Launch, Stowage and Logistics**

- ARES is soft-stow for launch.

- **Installation and Checkout**

- Crew will retrieve the ARES from stowage for installation and checkout.
- Installation is a shirt-sleeve operation, max
 - two cable install (one 28VDC for power, one Ethernet for data),
 - vehicle mount via Velcro.
- Upon installation, vehicle provided power will initiate autonomous start and operation.



ConOps

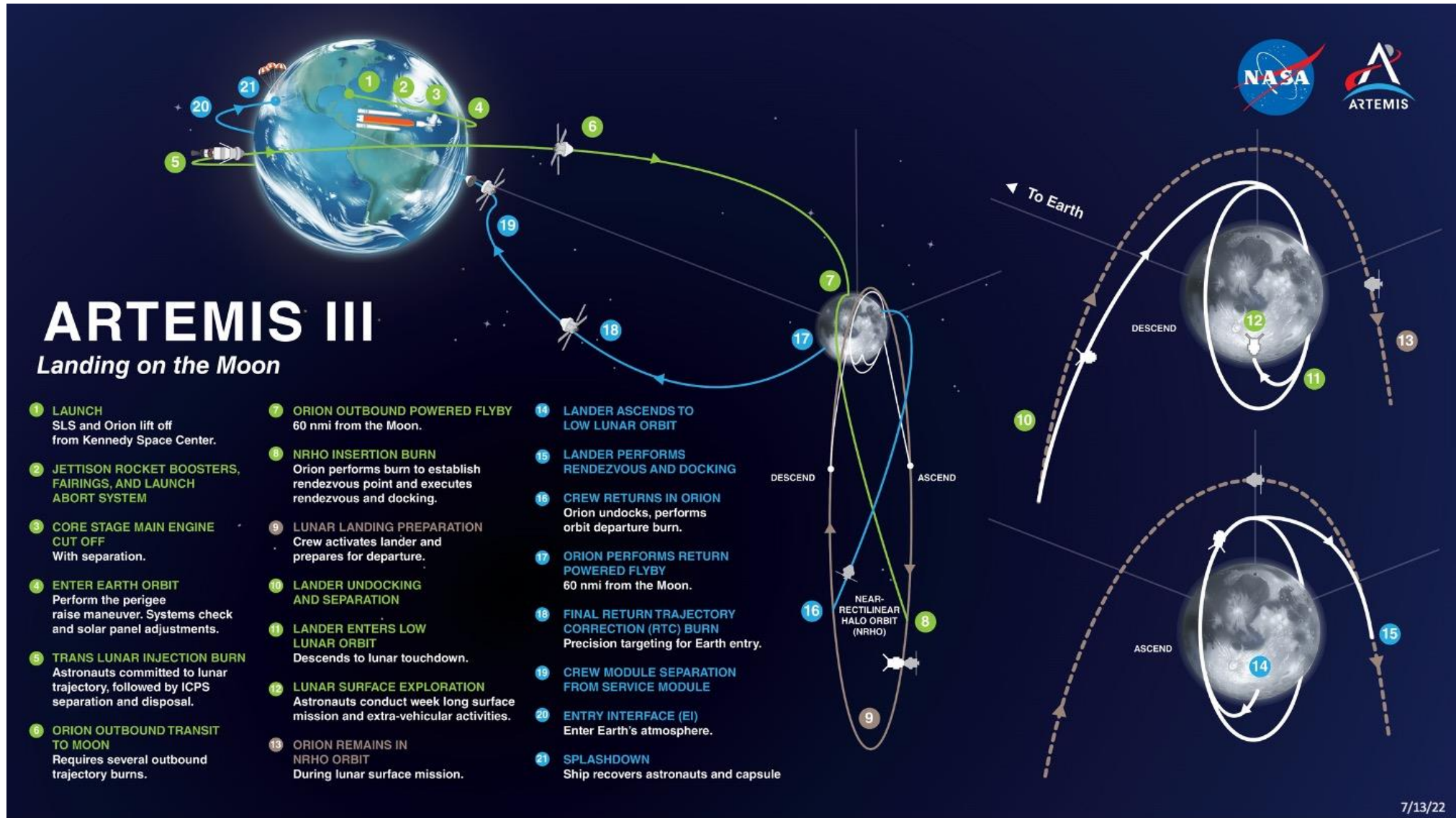


- **Nominal In-Flight Operations**

- ARES is activated for 24/7 radiation monitoring when crew is in the vehicle
- Hands free startup and operation after installation
- The cumulative dose rate and absorbed dose is transmitted to the vehicle for communication to the crew and ground.
- ARES will send an *alarm flag* to vehicle for high dose rate detection
- The vehicle will downlink ARES data to the ground for analysis.

- **Quiescent Phases**

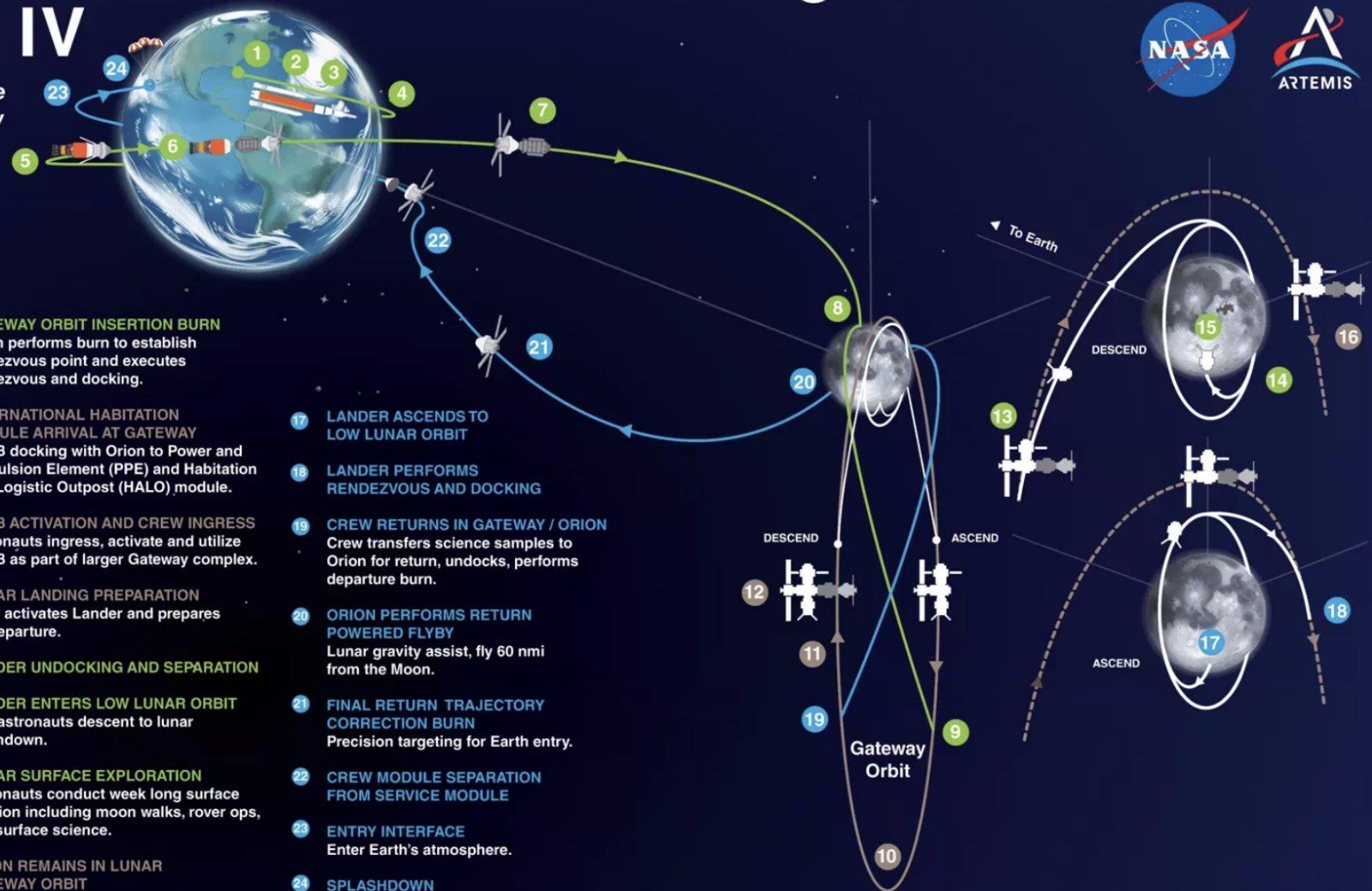
- Powered off



ARTEMIS IV

International Habitation Module delivery to Gateway followed by Crewed Lunar Landing

- 1 LAUNCH**
SLS with I-HAB co-manifested payload and Orion with 4 crew members 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 (EUS) performs circularization of Low Earth Orbit. Systems check and solar panel adjustments.
- 5 TRANS LUNAR INJECTION BURN**
EUS commits astronauts in Orion and I-HAB to lunar trajectory.
- 6 ORION TUGS I-HAB TO MOON**
Orion separation from Universal Stage Adapter (USA), ejection of USA, Orion docking with I-HAB for extraction from EUS/ Payload Adapter Fitting (PAF) followed by Orion tug of I-HAB to Gateway Orbit and EUS disposal.
- 7 ORION OUTBOUND TRANSIT TO MOON**
Requires several outbound trajectory burns.
- 8 ORION OUTBOUND POWERED FLYBY**
60 nmi from the Moon.
- 9 GATEWAY ORBIT INSERTION BURN**
Orion performs burn to establish rendezvous point and executes rendezvous and docking.
- 10 INTERNATIONAL HABITATION MODULE ARRIVAL AT GATEWAY**
I-HAB docking with Orion to Power and Propulsion Element (PPE) and Habitation and Logistic Outpost (HALO) module.
- 11 I-HAB ACTIVATION AND CREW INGRESS**
Astronauts ingress, activate and utilize I-HAB 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 GATEWAY / 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.





What's Next....

- For ARES, Deliver the units to the vehicle providers and support integration
- Console product development
- Wait for the flight and data
- For the project team, already working on the next generation of low power, low mass radiation detectors for MCO.
 - ARES2 will have 10 years operation life for cis lunar and beyond
 - CEPS Space Weather Radiation sensor