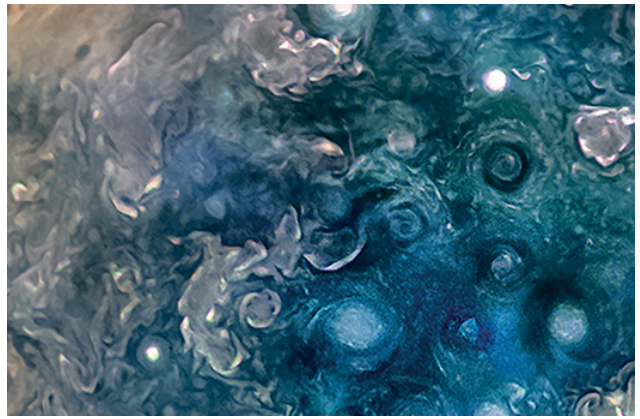
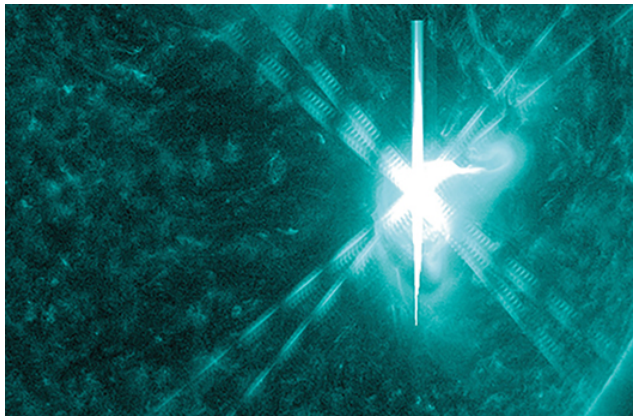
SCIENCE

National Aeronautics and Space Administration



SPACE STUDIES BOARD

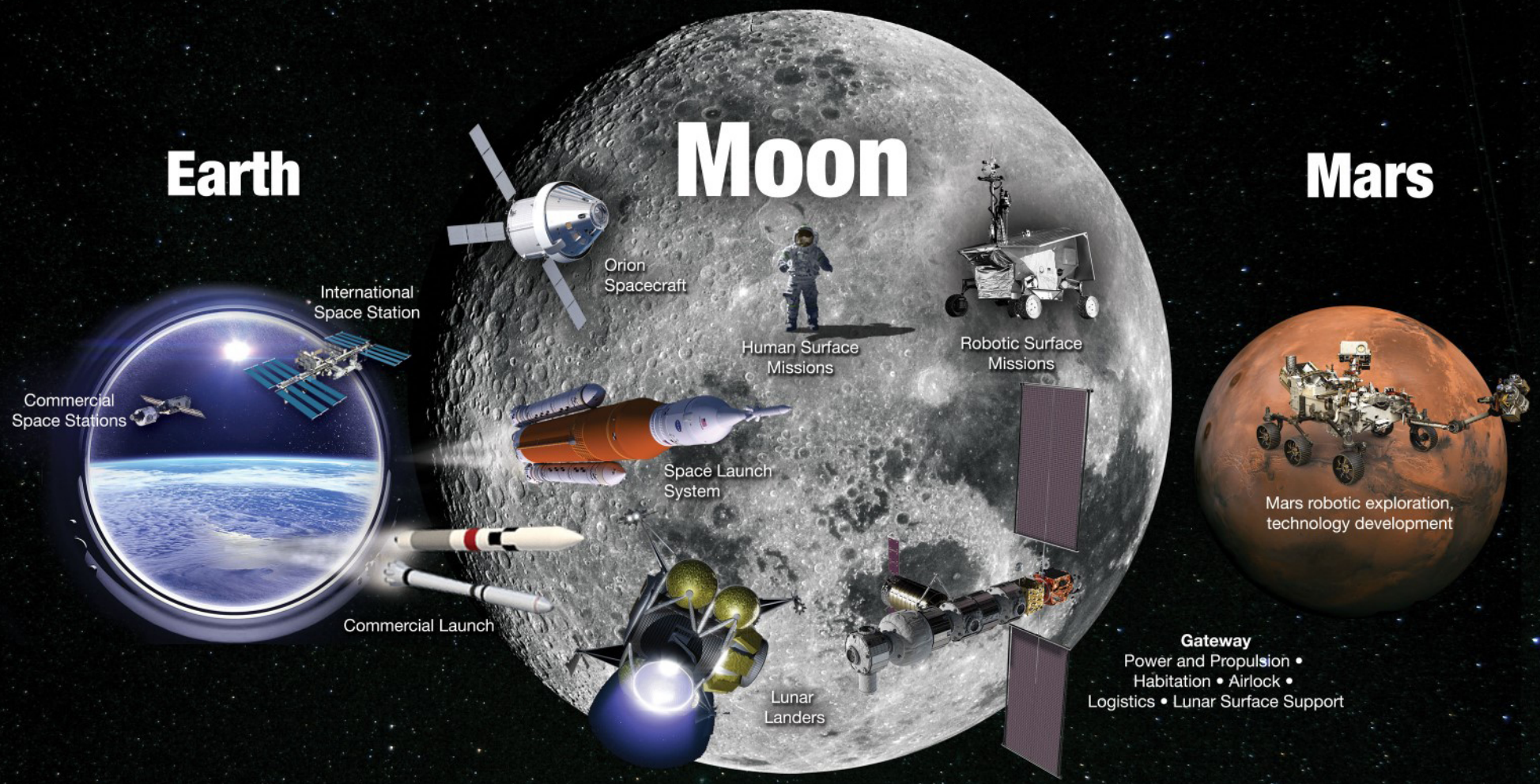
Science Enabled by the Lunar Gateway

Steve Clarke
Deputy Associate Administrator for Exploration
Science Mission Directorate, NASA

November 8, 2018

EXPLORE

DEVELOP

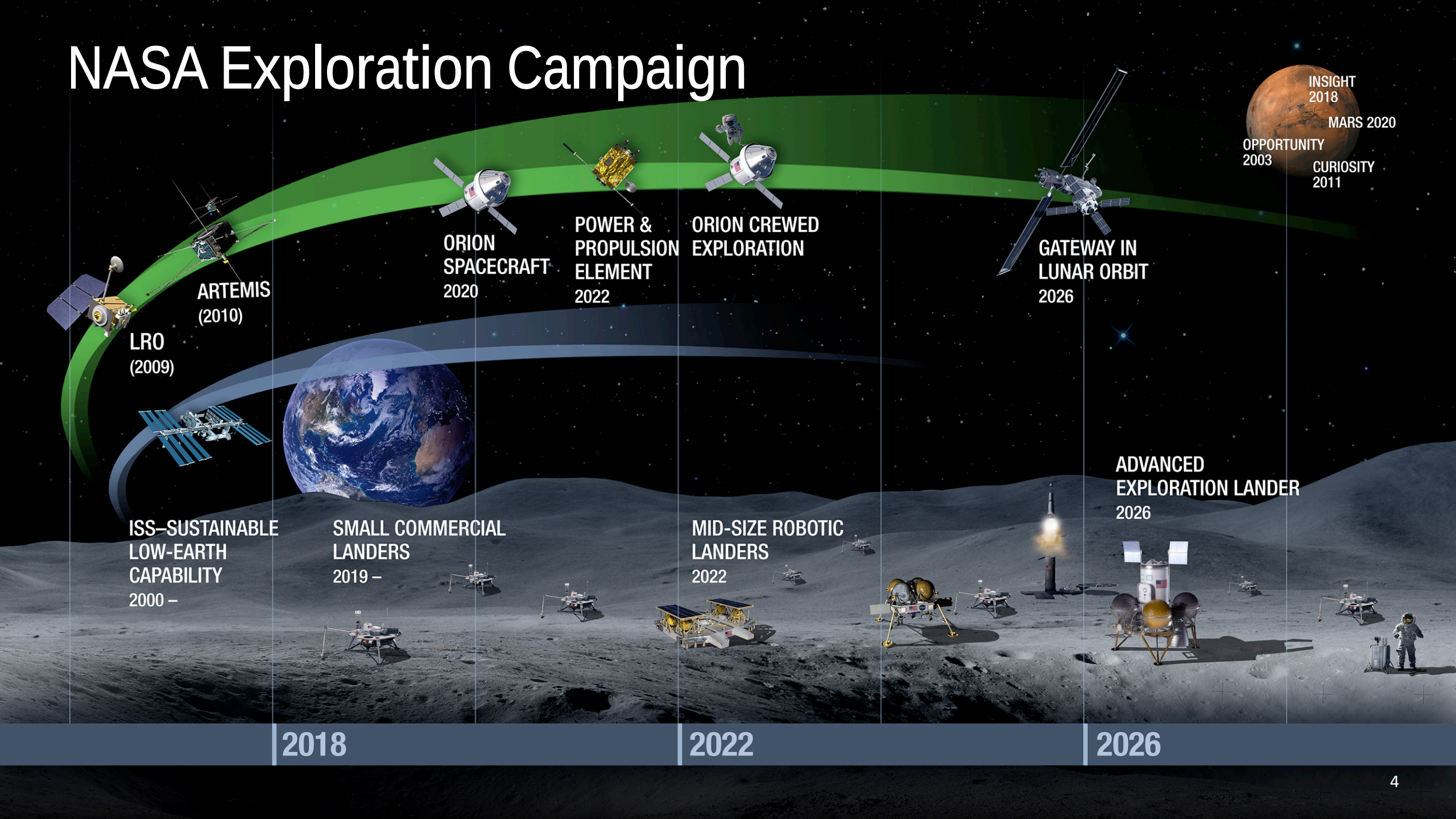


America Will Lead
Fly Astronauts on American Spacecraft
Develop New Commercial Space Stations

America Will Lead
Fly Astronauts Around the Moon
Establish the First Human Outpost Around the Moon
Develop American Landers to Return Humans to the Moon

America Will Lead
Return the First Scientific Collection from Mars
Practice a Round-trip Leading to Humans to Mars

NASA Exploration Campaign



GATEWAY

A spaceport for human and robotic exploration of the Moon and beyond

HUMAN ACCESS TO & FROM LUNAR SURFACE

Astronaut support and teleoperations of surface assets.

U.S. AND INTERNATIONAL CARGO RESUPPLY

Expanding the space economy with supplies delivered aboard partner ships that also provide interim spacecraft volume for additional utilization.

INTERNATIONAL CREW

International crew expeditions for up to 30 days as early as 2024. Longer expeditions as new elements are delivered to the Gateway.

SAMPLE RETURN

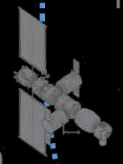
Pristine samples robotically delivered to the Gateway for safe processing and return to Earth.

SCIENCE AND TECH DEMOS

Support payloads inside, affixed outside, free-flying nearby, or on the lunar surface. Experiments and investigations continue operating autonomously when crew is not present.

COMMUNICATIONS RELAY

Data transfer for surface and orbital robotic missions and high-rate communications to and from Earth.



SIX DAYS TO ORBIT THE MOON

The orbit keeps the crew in constant communication with Earth and out of the Moon's shadow.

A HUB FOR FARTHER DESTINATIONS

From this orbit, vehicles can embark to multiple destinations: The Moon, Mars and beyond.

GATEWAY SPECS

- 50 kW Solar Electric Propulsion
- 4 Crew Members
- 30-90 Day Crew Missions
- 125 m^3 Pressurized Volume
- Up to 75 mt with Orion docked

ACCESS

384,000 km from Earth

Accessible via NASA's SLS as well as international and commercial ships.

20180905

Lunar Science and Technology Integration

Gateway Workshop Takeaways

- Gateway, in a NRHO, offers unique opportunities for some Earth, Heliophysics, Astrophysics and fundamental physics investigations
- With the addition of additional transportation infrastructure (LLO tug/pallet, surface access, sample return capability) gateway can enable additional important lunar science
  - Concepts for free flying platform now under review at NASA
- Externally mounted sample collection with controlled pointing can collect samples and provide important science about cometary material, solar composition, interstellar particles, and near Earth objects
- Radiation environment of the Gateway can provide important tests of the effects of radiation on biological organisms
- Science utilization extremely constrained until the presence of an external robotic arm
  - Arm is the de facto external experiment installer
  - Some small-scale initial science might be possible with instruments on PPE

Heliophysics and Gateway

Compelling Heliophysics investigations can be conducted from the Gateway Platform

- Unique perspectives of Geospace to study the coupling between the magnetosphere, ionosphere, upper atmosphere
- Development of space weather observatories needed for deep space exploration that do not rely on Earth connection
- Staging and deployment for prototype telescopes and multi-spacecraft missions

Astrophysics and Gateway

- Experiments that use the Gateway to conduct compelling Astrophysics investigations will be solicited through the Astrophysics Explorers Missions of Opportunity AOs
- First opportunity will be the 2019 Astrophysics Explorers Mission of Opportunity AO
  - Draft AO in Fall 2018, Final AO in Spring 2019, Proposals due 90 days later
  - Investigations may be proposed as either a Small Complete Mission ($75M PI cost cap) or as a SmallSat ($35M PI cost cap)
  - NASA provided transportation to the Gateway is outside the PI cost cap
  - Proposals must include Gateway accommodation information such as payload mass/volume envelopes, fields-of view, contamination environment including both particulates and EMI, opportunities for free-flyer deployments from the Gateway, and schedules for payload delivery to Gateway, in situ servicing, and return to Earth
- Constraints on Gateway utilization still under development
  - First Gateway utilization opportunities are NET 2024
  - Additional Gateway payload utilization definition expected at Gateway external payload workshop planned for early 2019

Planetary Science and Gateway

- Communications relay for the lunar farside
  - The lunar farside has never been explored by landers or rovers
  - Significant new science can be conducted on the far side (e.g., sampling, seismology)
- Low-latency telerobotics, enabling real-time exploration of complex and difficult terrains
  - Many terrains on the moon are currently inaccessible to humans
  - Forerunner for the telerobotic exploration of Mars
- Continuous impact flash monitoring of the lunar surface to constrain impact flux
  - Details of the Earth-moon meteorite impact flux still not known well
  - Flash monitoring could contribute to understanding an important parameter for both science and exploration
- Platform for deploying cubesats
  - Cubsats are poised to revolutionize planetary science instrument deployment
- Platform for a reusable lander that can explore and/or collect samples at multiple locations on the surface
  - Sample collection from the moon (e.g., Lunar South Poll Aitken Basine) is a high priority of all recent science community documents involving the moon (e.g., NRC The Scientific Context for Exploration of the Moon 2007, Planetary Decadal 2012)

Earth Science and Gateway

- The Earth Science Decadal Survey programmatic activities would have priority for the foreseeable future; however an EVI solicitation could be targeted
  - The earliest EVI solicitation that would be suitably timed would be in the 2021 timeframe
  - There is some potential for contribution to Earth System Science as reflected in the 15 abstracts submitted associated with the presentations made in the Gateway workshop; however, these abstracts were notable by not being well-aligned with decadal priorities
  - There is some potential benefit associated with being in an orbit significantly closer to Earth compared to that of DSCOVR, but further than geostationary, and it does mean that observations at high latitudes that are NOT possible from geostationary can be done


EXPLORE AS
ONE
EXPLORER 1
INSIGHT
PARKER
ICESAT-2
WEBB