National Aeronautics and Space Administration

# Gateway Science Summary

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# Agenda

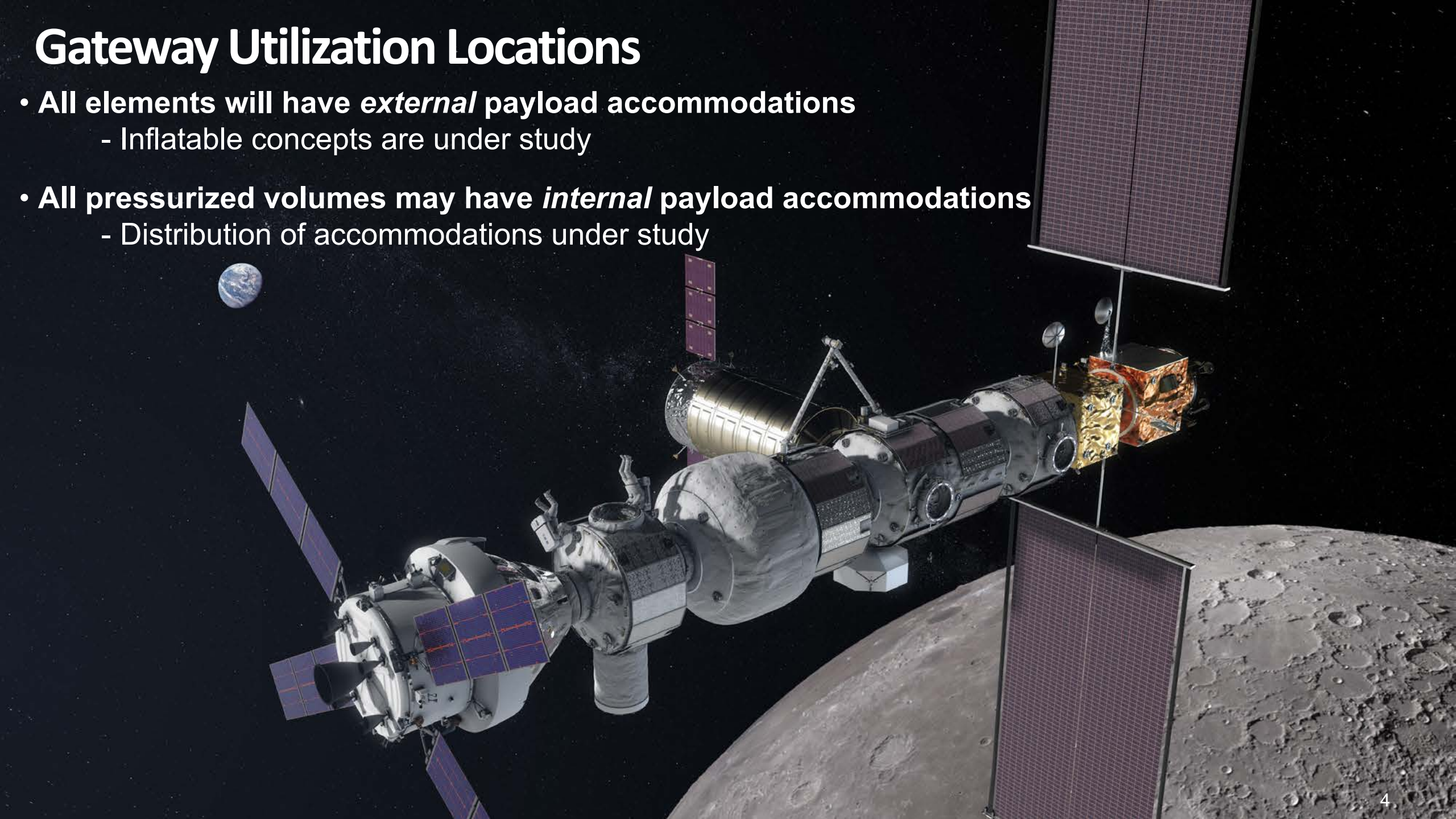
- **Focus areas for Gateway utilization**
- **External/internal Gateway payload capabilities**
- **Science workshop**
  - Top science/engineering outcomes
  - Gateway resources
  - Payload/resources comparison
- **Other workshops**
- **ISS Lessons Learned**
- **Targeted science-related Gateway studies**

# Gateway Utilization – Four Focus Areas

1. **Technology: Identifying high-priority technologies for Gateway demonstration:**
   - Evolve its initial capabilities or enable new capabilities for human exploration.
   - Stimulate the development of commercial technologies for operations in cislunar space
   - Request For Information (RFI) released May - numerous responses received
2. **Commercial: Developing overall commercialization strategy for gateway:**
   - Identifying commercial uses of a Gateway beyond NASA plans
   - Released RFI on Gateway commercial in June – responses received 4 August
3. **International: Enabling collaboration between interested parties:**
   - International Space Station partner discussions ongoing, working on strategy to involve international, non-ISS partners (ongoing)
4. **Science and Research: Identifying potential science opportunities, and how gateway infrastructure can support various investigations:**
   - Identifying science events and forums to raise awareness and obtain requirements insight
   - Targeted Gateway studies increasing science potential
   - SMD/HEOMD-hosted Denver Gateway science workshop (February)
     - Revising current Gateway utilization ground rules & assumptions

# Gateway Utilization Locations

- **All elements will have *external* payload accommodations**
  - Inflatable concepts are under study
- **All pressurized volumes may have *internal* payload accommodations**
  - Distribution of accommodations under study




# Gateway Workshop Summary


**Workshop sponsored by NASA HQ (HEOMD & SMD), JSC, MSFC & GSFC**

***Three driving rationale for the workshop:***

- **Engage the science community with respect to the scientific potential of a lunar Gateway**
- **Discuss potential scientific investigations leveraging the Gateway**
  - Including the scope of possible instruments
  - Using the Gateway infrastructure
- **Discuss what resources the Gateway would have to provide to facilitate different types of scientific investigations**

# Science Workshop Format

- **Introductory briefings on NASA plans, ISS lessons learned, Gateway orbit options**
- **~180 Talks, ~300 Attendees**
    - Government, academia, industry, international
- **One day of discipline-focused sessions in five venues – 5-20 minutes per abstract**
    - Heliophysics
    - Earth Science
    - Astrophysics & Fundamental Physics
    - Lunar & Planetary
    - Life Sciences and Space Biology
- **Cross-cutting discussions**
    - Orbits, Human exploration, Potential future capabilities, Space Weather
    - External Instruments
    - Samples
    - Telerobotics & Leveraging Infrastructure
    - Internal Instruments

# Science Workshop Analysis

- **~180 abstracts proposed 220 investigations**
  - Each proposed instrument included parameter and usage information:

**Instrument Parameter:**
- Mass
- Volume
- Power
- Thermal requirements
- Daily data volume
- Current TRL
- WAG cost & basis
- Duration of experiment
- Other parameters

**Instrument Usage:**
- Orbit Considerations
- Field of View (FOV) requirements
- Requires use of airlock
- Crew interaction required?
- Will astronaut presence be disruptive?
- Does the instrument present a risk to the crew?
- Other consumables or gateway requirements?
- Special sample handling requirements
- Need for telerobotics?

  - *~7,200 data items returned*

- **Top Science and Resource takeaways**
- **Detailed Gateway resources**
- **Selected comparisons to existing Gateway Groundrules and Assumptions**
  - Mass, power, volume, communication data rates

# Workshop Top Science 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
- 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
- Need to coordinate with international partners on sharing/allocation of science resources - avoiding duplication, maximizing science

# Workshop Top Engineering/Resource Takeaways

- External payloads with a variety of desired look directions, and many benefit from precise pointing and/or long duration stare capability
- Ability for external (i.e. in vacuum) delivery of science elements
- Contamination concerns (gateway exosphere & optical payloads passing through the hab)
- Interest in internal analysis equipment (multi-use, flexible and configurable)
- Automation of internal payload interactions (automated systems and robotics)
- Science can generate large amounts of data
- Farside of the Moon is a unique radio science location, need to consider Gateway RF noise
- Enhancement of generic gateway capabilities can facilitate science (GPS – nav & timing)
- Lunar science needs significant transportation infrastructure investment

# External Payloads – Gateway Resources

- **Assume a central data recorder for payloads**
  - Instruments send to central SSDR, Gateway handles downlink
- **Onboard data computing capability**
- **Large amounts of data**
  - Potential for terabytes daily feasible required depending on science payloads
  - Need for laser com or send hard drives back to Earth
- **Need to determine the gateway's vibrational environment (crewed and uncrewed)**
  - Vibration isolation potentially required for majority of optical payloads
- **Potentially consider generic telescope facility**
  - Photons sent to multiple sensors
  - Sensors possibly inside gateway (easier to swap with improved/different sensors)
  - Might require optically pure window

# Gateway Internal Payloads

- **Significant amount of volume could be utilized for internal experiments**
  - Neutron/radiation detection, neurocognitive function, radiation and microgravity effects, behavioral health, gardening and food evaluation, waste reclamation
  - Need / opportunity for a separate science module?

- **Interest in multi-use analytical equipment**
  - Multi-use glove box, configurable
  - Partly a result of assumed limited downmass capability?

- **On-board storage and distribution of space radiation environmental data (external/internal) from payloads as available meta-data for other payloads, especially Space Biology or HRP.**

# Gateway Infrastructure Capabilities

- **Capability to deploy CubeSats/SmallSats from the Gateway**
  - Interior payload source via a science airlock
  - Externally using the robotic arm to remove a satellite/pre-packaged deployer from an unpressurized logistics module.
  - Deployment capability of up to 12U identified as likely candidates

- **Provide communication relay or navigation aid for other orbiting/lunar surface assets**
  - Small spacecraft/cubesats, farside locations, polar regions, and steep terrain

- **Teleops of space/surface assets conducted by Gateway crew or by Earth payload operators**
  - Installation, assembly, and deployment of external instruments
  - Management of samples collected from free flyers and robotic landed missions
  - Extend lifetime of internal Gateway experiments into uncrewed Gateway modes
    - autosampling, programmed fluid delivery or fluid/water delivery, programmed or human-in-the-loop measurements
  - General maintenance.

# Samples – Specific Gateway Resources

- **Ability to install, and retrieve dust collectors on the gateway in different look directions, avoiding contamination from the gateway.**

- **Ability to dock, or berth, a sample return vehicle with or without crew present**
  - Need for a science airlock

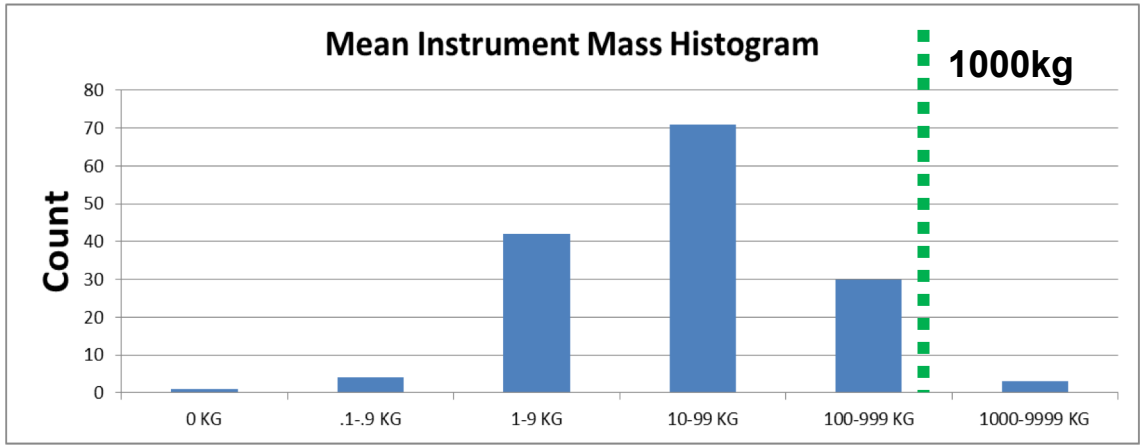
- **Some internal volume needed of science support equipment, in addition to experiments**
  - Glove box (multi use) and analytical equipment
  - Emphasis on in-situ analysis (assumption of limited downmass to Earth)

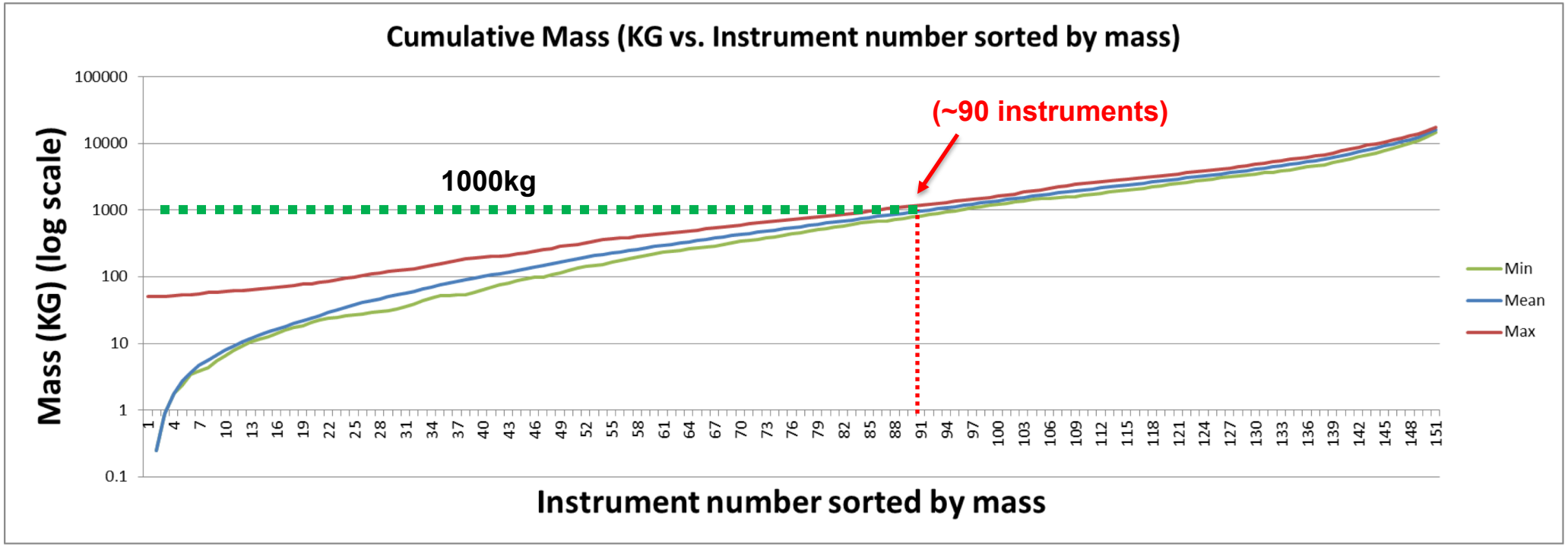
- **Many Space Biology and HRP return samples will require on-board and return cold stowage capability**

- **External analytical equipment possible**
  - Decrease need to open “dirty” lunar samples inside the gateway

# Science Workshop: Upmass Analysis

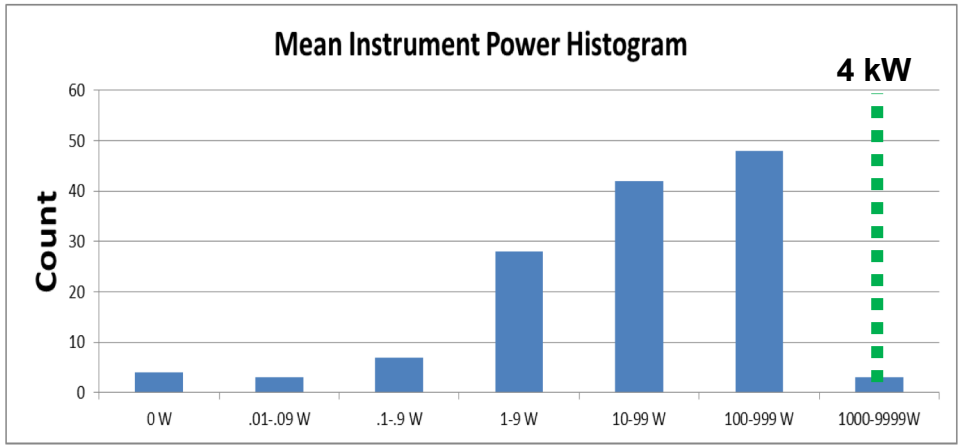
- ***Current Groundrule: For each crewed Gateway mission starting with Gateway Mission (GM)-2, a minimum of 1,000 kg shall be available for utilization.***
- If instruments were equal priority and without considering other parameters, ~90 accommodated by a 1000 kg allocation
- Only 2 instruments are >1000 kg

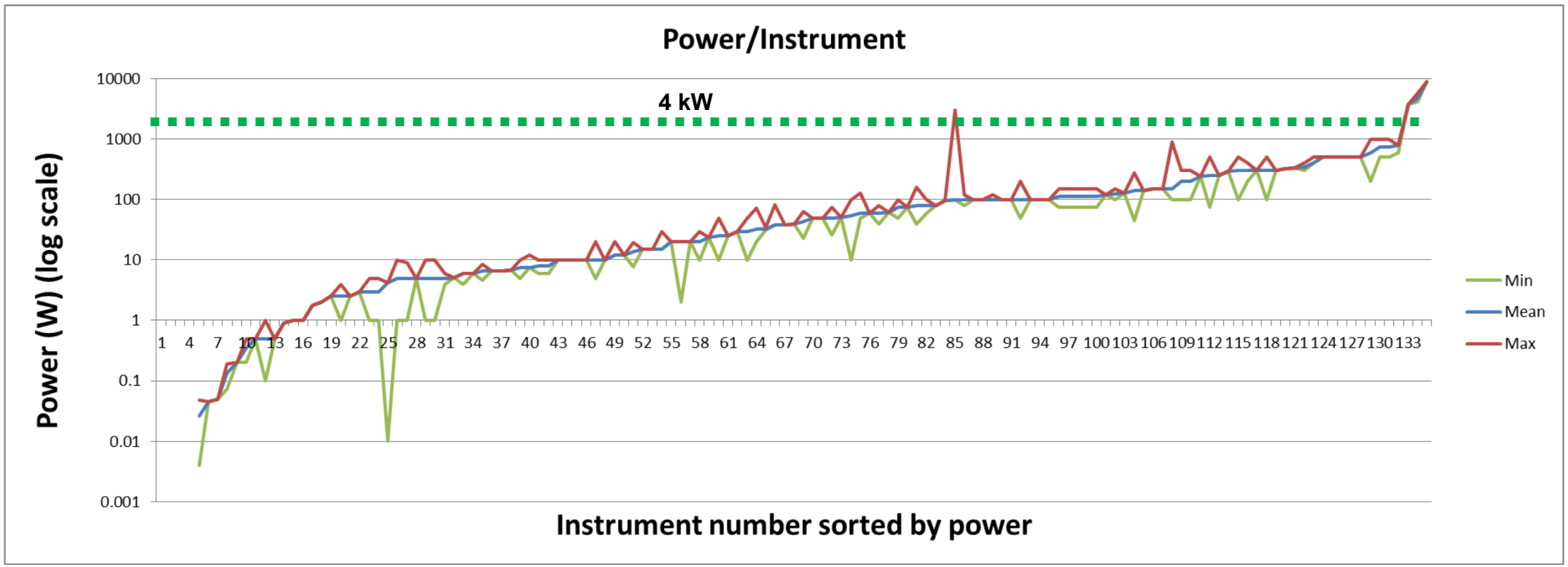


# Science Workshop: Electrical Power Analysis

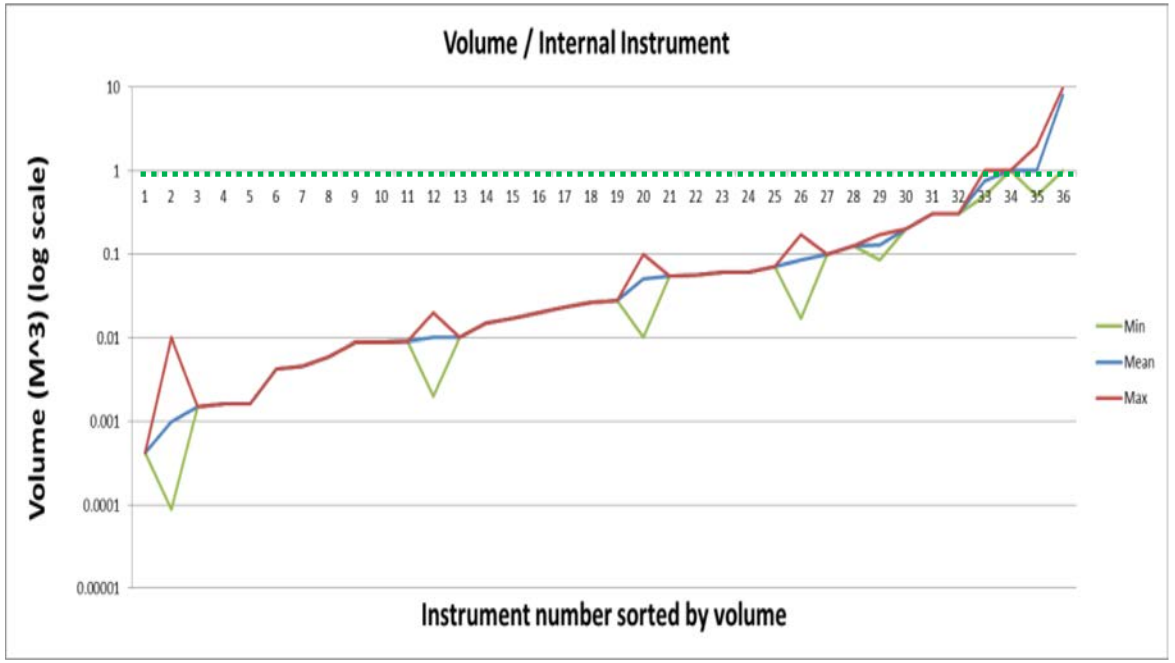
- ***Current Groundrule: Gateway shall provide a minimum of 4kW power during SEP operations and crewed operations for Utilization. Gateway shall provide a minimum of (TBD)kW power during non-SEP operations for Utilization.***
- 50 concepts in the 100s W range, almost all concepts <500 W, 3 concepts in 4-9 kW power range

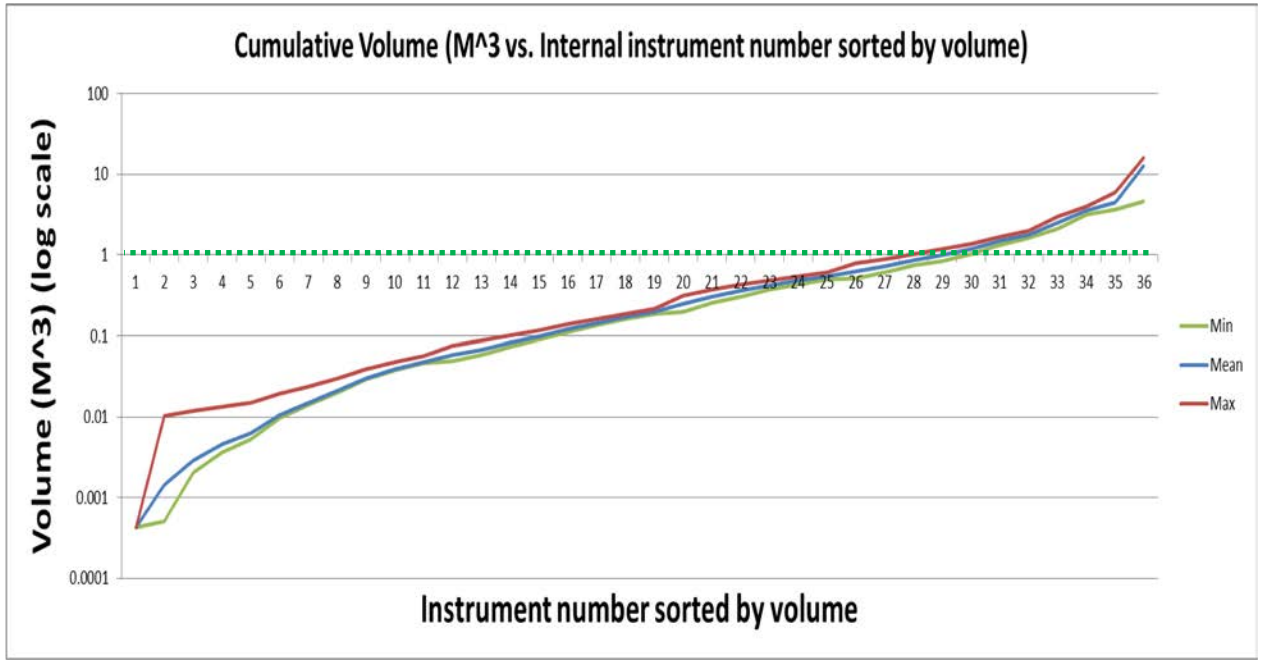


# Science Workshop: Internal Volume Analysis

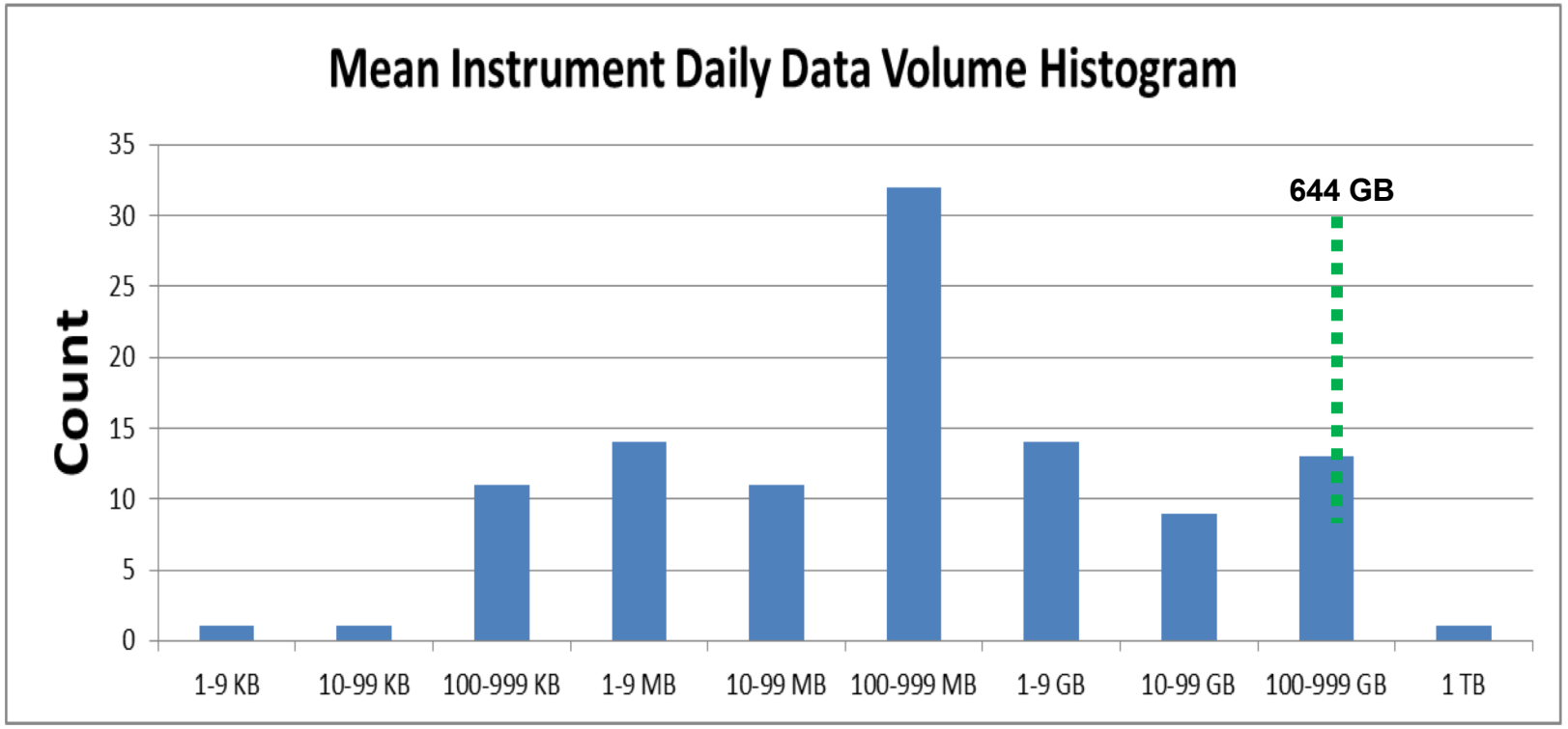
- ***Current Groundrule: The Gateway shall provide at least 1 (TBD) $m^3$ within each of the Habitation Elements, for powered payloads.***
- 1 $m^3$ could support 29 smallest of 36 payload proposals providing volume data
- Currently assuming all SLPSRA payloads are internal and all others are external
- Total sum of internal payloads: 12.5 $m^3$ (single largest 8 $m^3$, sum of all other concepts is 4.5 $m^3$)
- Assumption of 100% efficient packing in these values - need to factor in additional volume margin due to varying payload geometries and packing configurations

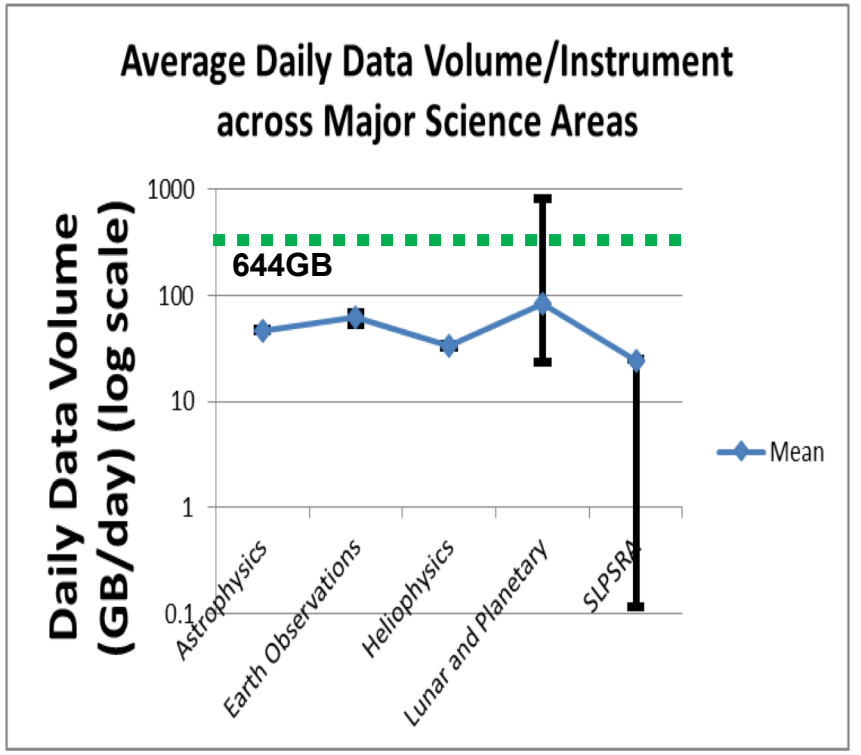


# Science Workshop: Daily Data Volume

- ***Current Groundrule: The Gateway shall provide 5.15 Tbits/day (644GB) allocation for utilization downlink.***
- Factoring in the possibility of high drivers being selected and considering the need for additional margin (e.g. hi definition video), 644GB/day appears to be a reasonable baseline assumption for daily data downlink needs from onboard experiments and Gateway systems.



# International Gateway Science-Focused Events

1. **ESA Science Workshop**
   - European science community
   - NASA workshop outcomes provided to ESA
   - Using results to advise ESA industry studies on Gateway elements

2. **CSA Science Meeting**
   - Invited Canadian scientists
   - NASA workshop outcomes provided to CSA

3. **JAXA Gateway Science Workshop**
   - Provided NASA workshop data templates & outcomes
   - Informing JAXA contributions

- **All agencies are participating in the Gateway design and development process**

# Key ISS Lessons Learned for Gateway

1. **Target obtaining science support from key science stakeholder communities**
   - Engage SMD and science communities early
   - Build stakeholder support to aid funding and long term sustainability
   - Align Gateway capabilities with key stakeholder needs (e.g. sample/sample return, astrophysics, heliophysics, human research, Earth/Moon observations)

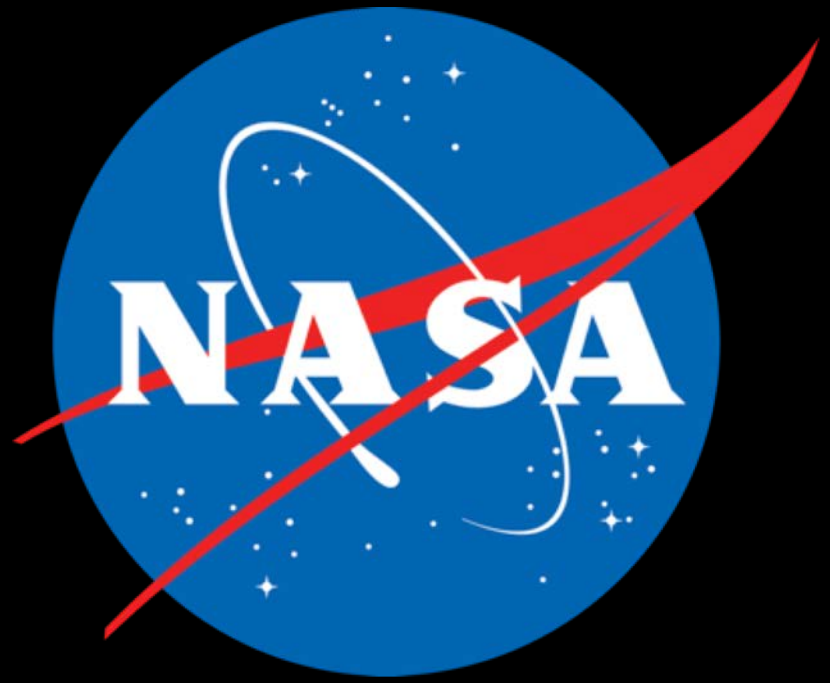
2. **Consider Utilization location within Program Office**
   - Goal of Gateway operations - touches all systems and needs all systems
   - Systems view of Utilization sets up competition with other Gateway systems resources rather than *supported by* other resources

3. **Consider new accommodation of internal experiments (i.e. different than Express Racks)**
   - Incorporate modern improvements – software upgrades, plug and play, standard interfaces, automation, structural improvements
   - Legacy experiment considerations
   - Balance between crew and automation/robotics

4. **Prioritizing science among Gateway users and partners**
   - ISS evolved to current prioritization processes
   - Start defining processes now

# Near Term Science Utilization Activities

- **Providing GPS/Navigation on the Gateway**
  - Precision timing/location for physics experiments, facility capability for instruments or cislunar/surface assets
- **Utilization during uncrewed periods**
  - Defining Gateway internal environmental conditions for experiments - requirements
  - Developing ConOps to optimize automation planning, robotic system potential designs
    - Established Software/Autonomy working group
- **External location of experiments**
  - Field of View studies, vent location designs, shadowing, exosphere analysis (includes NRHO)
- **Logistics**
  - Advocating for dual use logistics vehicles (supply, secondary missions/tugs, experiments)
- **External arm delivery**
  - Protecting earlier delivery in Gateway assembly sequence
- **SLPSRA**
  - Detailed studies on potential internal science experiments and identifying common facility lab systems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