Science in the Lunar Architecture: Summary of LAT Science Activities

Laurie Leshin

Director of Sciences and Exploration, NASA GSFC

Co-Lead, Science Capability Focus Element, Lunar Architecture Team

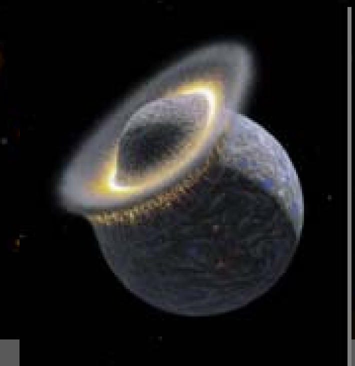
Presentation to NAC Workshop on Science Associated with the Lunar Exploration Architecture

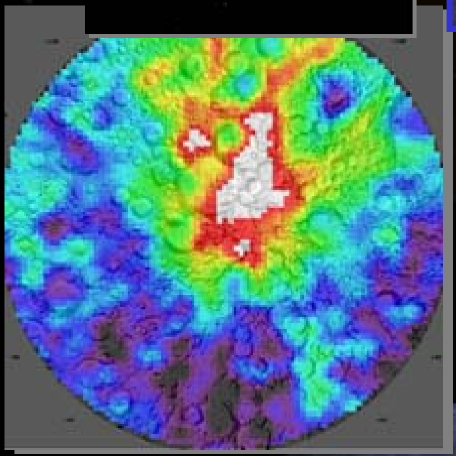
February 28, 2007

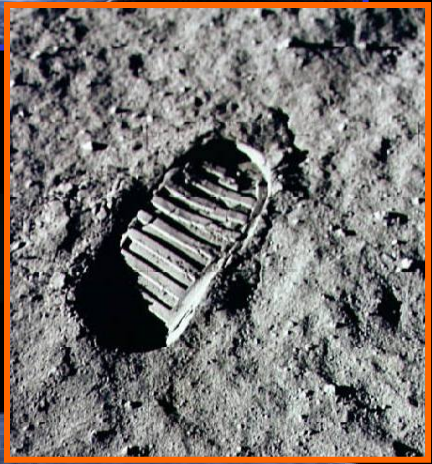
Implementing the Vision

The Moon Presents Compelling Science Opportunities

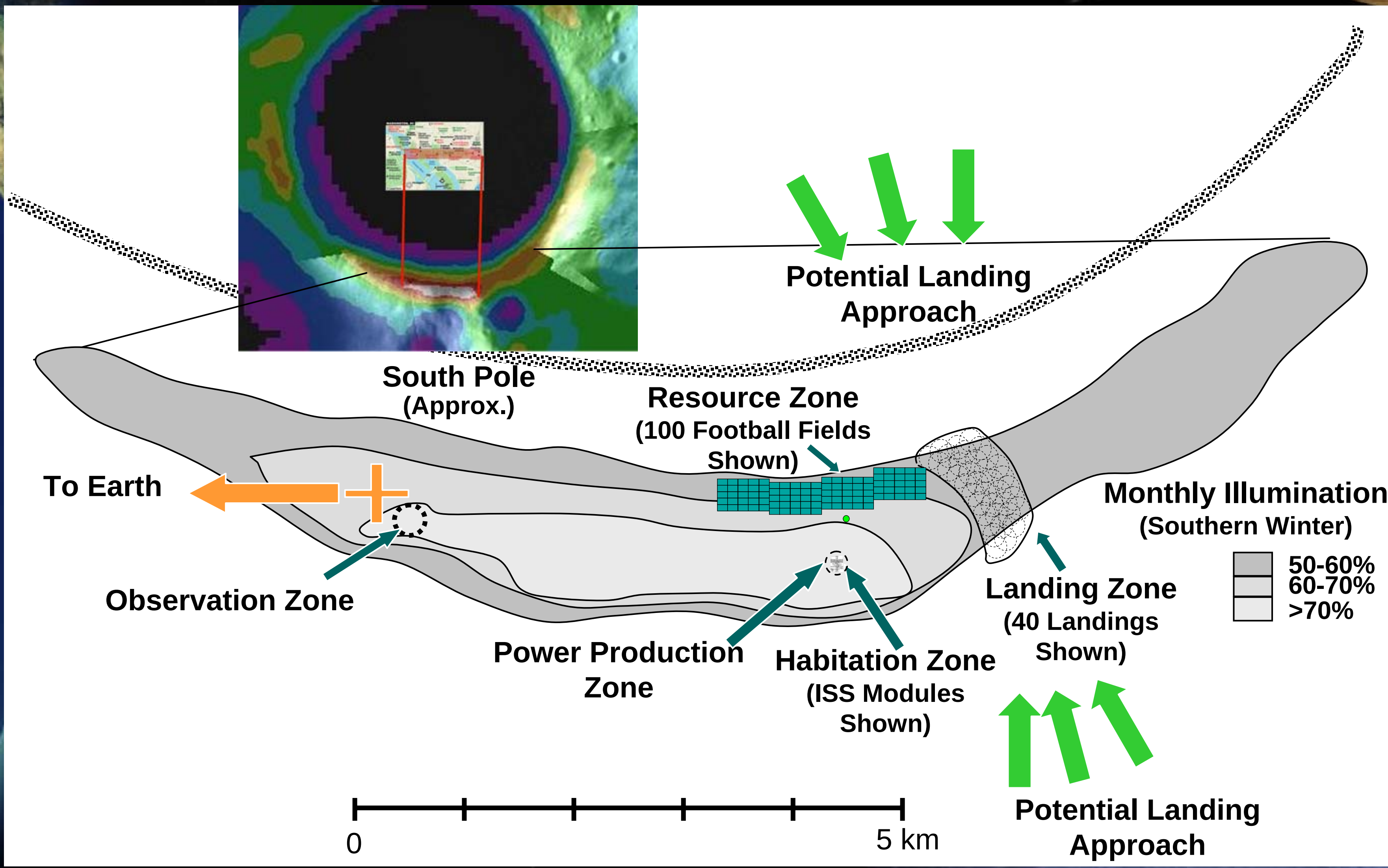
- Bombardment of the Earth-Moon system: Consequences for the emergence of life
- Lunar surface and interior processes and history
- Scientific treasure in the permanently shadowed polar environment
- Regolith as a recorder of the Sun's history
- The Moon as a Science Platform: Astronomy, Earth and Solar Activity Observations
- Testing Planetary Protection protocols





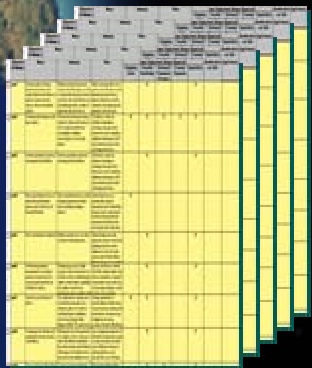


Notional Activity Zones at a Shackleton Crater Rim Outpost Site



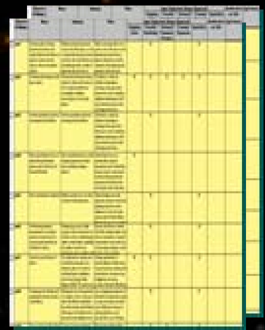
Lunar Architecture Team Science Capability Focus Element Activities

181 Objectives from Global Strategy Team



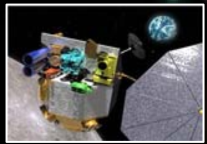
ALL Science Objectives

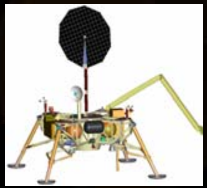
(45 “SMD” Science objectives + some others…)



Each Objective Deconstructed to Define Needed Capabilities*

***Capabilities such as human or robotic mission, location, surface mobility, payload mass, sample return, data rates, power, subsurface access, etc.**





Each Objective Mapped to Architecture for “Goodness of Fit”

This work is intended to show what science can be relatively easily accommodated and what changes would need to be incorporated to accomplish additional science goals

LAT Phase 1 Science Activity Participants

- Laurie Leshin, GSFC and Tom Morgan, HQ (Co-Chairs)
- Pam Clark, GSFC
- Dean Eppler, JSC
- Jay Herman, GSFC
- Chris McKay, ARC
- Wendell Mendell, JSC
- Bill Oegerle, GSFC
- Yvonne Pendleton, ARC
- Marianne Rudisill, LaRC
- Jim Spann, MSFC
- Paul Spudis, APL
- Rich Vondrak, GSFC

Capability Assumptions in Ratings

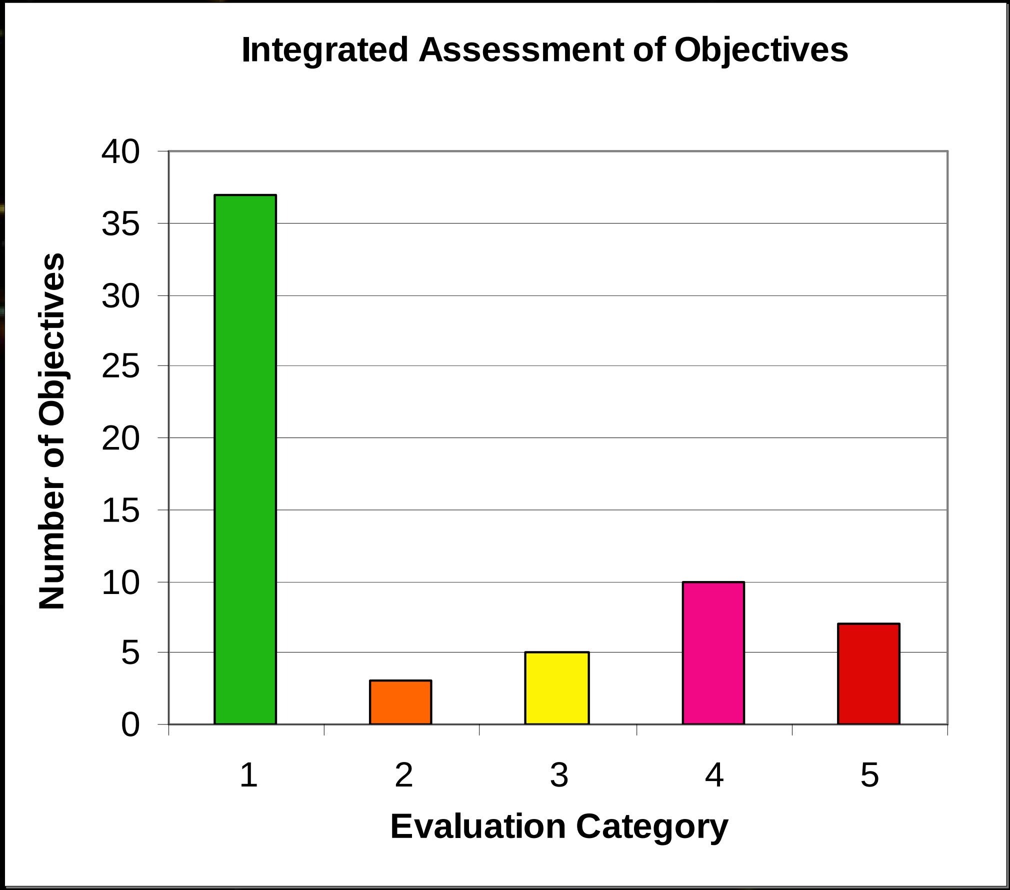
- Polar outpost-based architecture – All missions in this phase go to (or near) the outpost site (except for any orbital capability)
- 4 crew, 7-14 day stay mission initially, followed by longer missions
- Some capability to fly robotic missions, especially before the humans arrive
- Some moderate mobility for the crew from the outpost site during the short stay missions -- ~10-20 km away from site
- ~500 kg of payload downmass for science experiments/tools on crewed missions
- ~100 kg sample return capability on crewed missions

Science Objectives – to – Architecture Rating Scheme

1	*Green* – objective can be substantially accomplished by 2025 within the current architecture assuming the priority and funding are allocated
2	*Orange* – objective will very likely take longer than the 2025 time horizon to accomplish, but could be accomplished in an outpost-based architecture
3	*Yellow* – some part of the objective can be accomplished within the current architecture by 2025
4	*Pink* – the objective can be accomplished with a combination of outpost-based science and robotic sorties
5	*Red* – the objective can really only be accomplished through addition of human sorties, or some other additional capability, to the current architecture

Overall Assessment

- **37 out of 62 rated objectives are GREEN (59%)**
- **The NASA Architecture provides many opportunities for science!**
- **Priorities must now be considered -- we probably cannot accommodate all GREEN objectives, and some YELLOW and PINK objectives are likely to be of high science priority *(note: this is why we're all here!)***

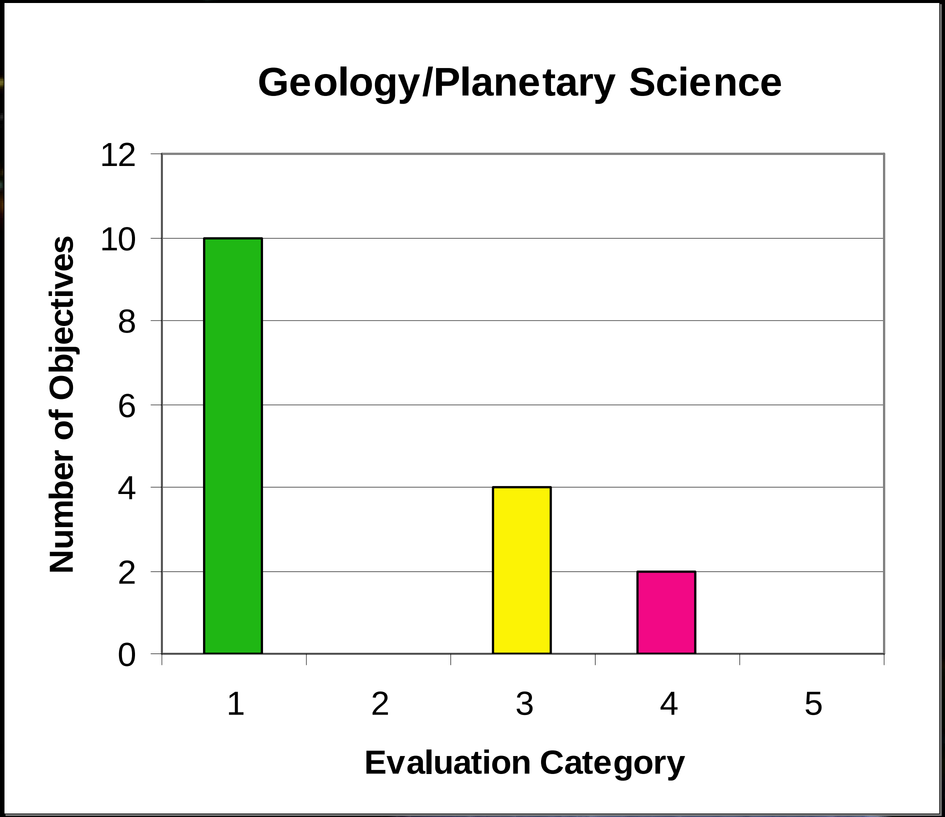


Geology ("Planetary Science") Objectives

- Most Geology objectives are GREEN (58%), requiring field work that is either non-site specific (geologic *process* studies) or polar-focused (volatiles) and that could be accomplished robotically and by humans

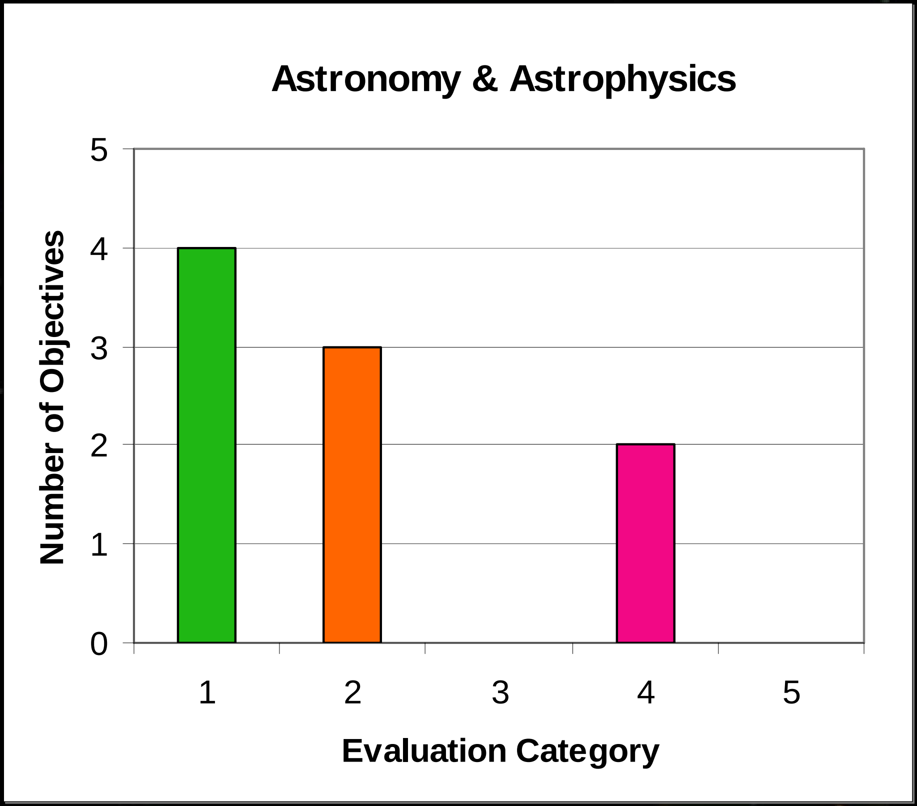
- YELLOW objectives are largely field mapping and sampling objectives, where much progress can be made at the outpost site, but that will ***absolutely require*** human visits to non-outpost locations to fully achieve the objective

- PINK objectives require deployment of sensors (seismometers, heat flow, etc.) at non-outpost sites – could probably be done robotically, at least for initial instruments



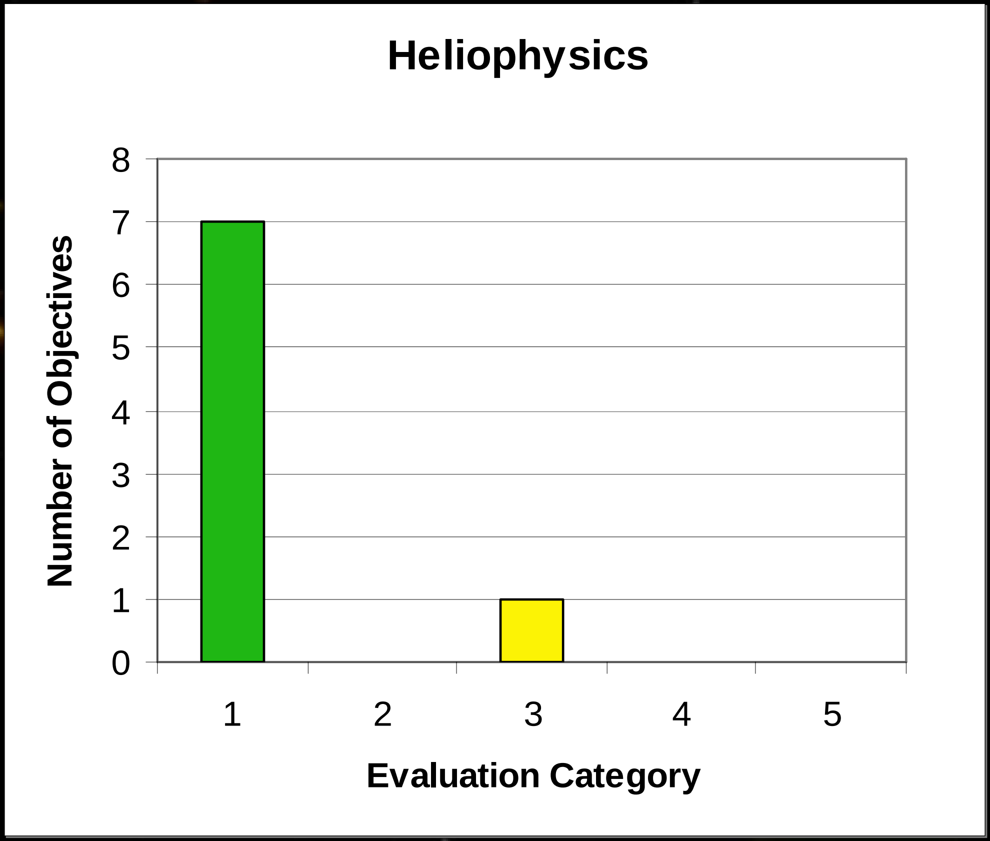
Astronomy & Astrophysics Objectives

- A & A has a relatively large fraction of “non-GREEN” objectives (44% are GREEN) due to the complexity of emplacing large telescopes
- GREEN objectives are those requiring small telescopes or other limited sensors that could be deployed near the outpost site
- ORANGE objectives would require more complex deployments, possibly further from the outpost site
- 2 PINK objectives require deployment of simple sensors at non-outpost sites – could be done robotically



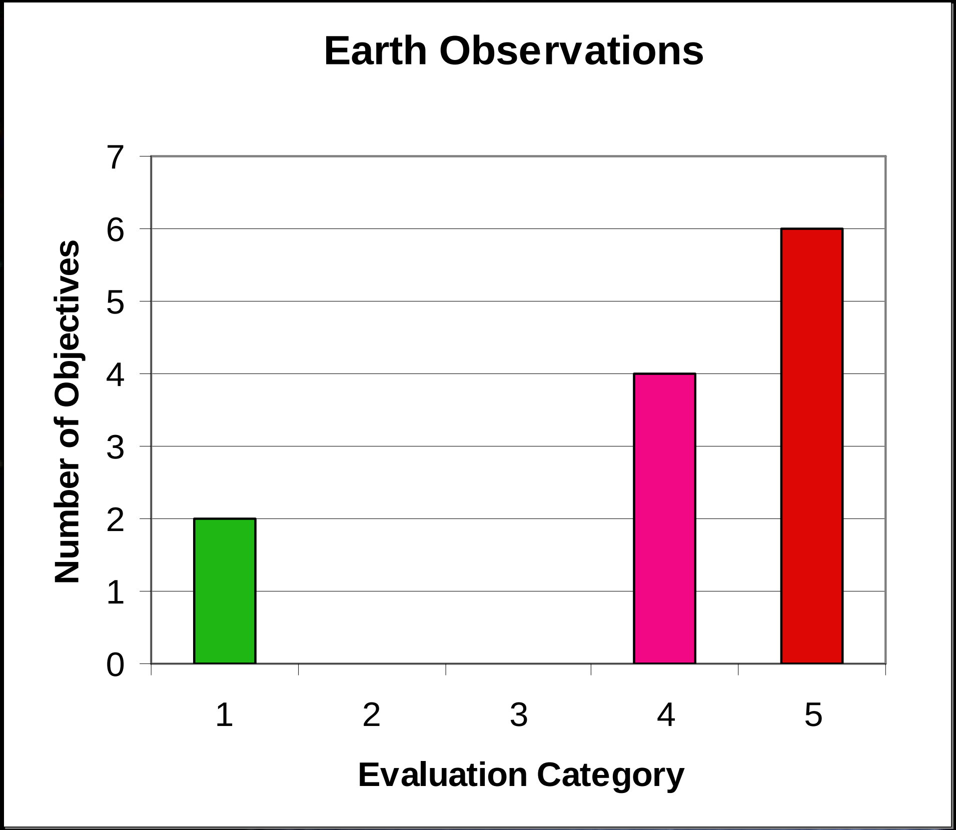
Heliophysics Objectives

- Most Heliophysics objectives are GREEN (67%), requiring relatively small sensors that could be deployed either robotically (some in orbit) or by humans
- YELLOW objective is for radio observations of the Sun – a small array could likely be emplaced early in the program, but a larger array is likely desirable



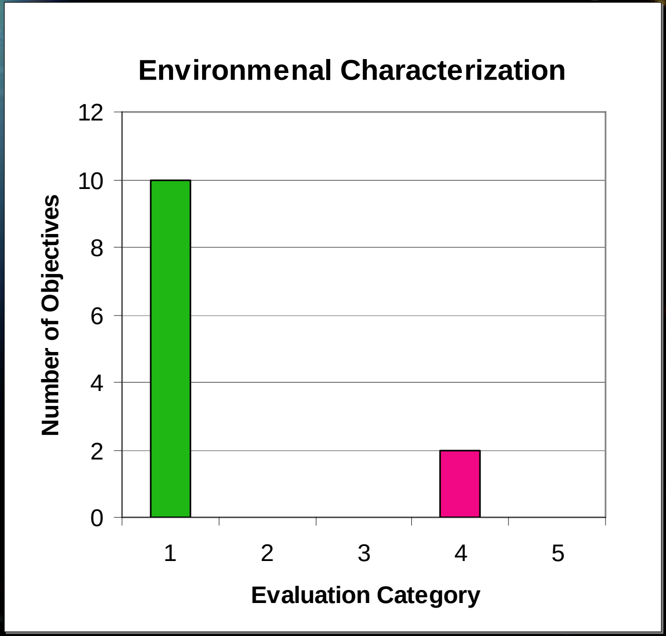
Earth Observation Objectives

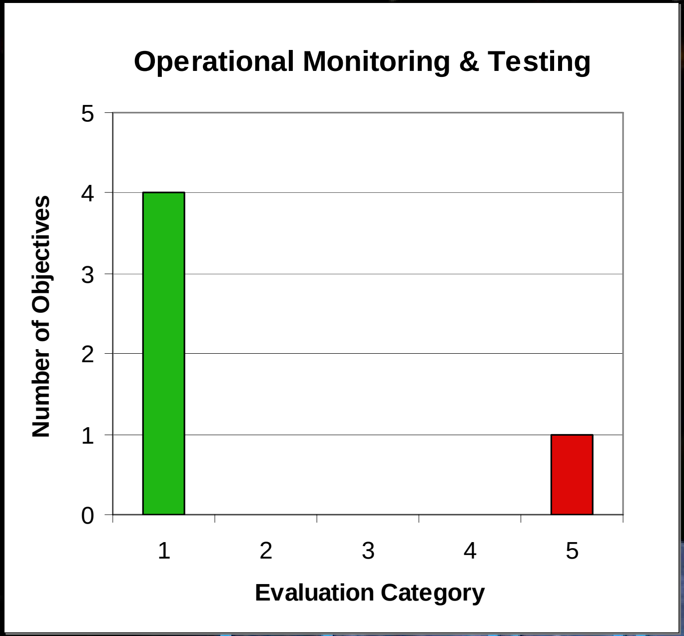
- **Many Earth Observation objectives require continuous view of Earth – therefore most are NOT achievable at a polar outpost location where Earth is in view only about 50% of the time**
- **PINK objectives require deployment of modest Earth observing telescopes/sensors at an Earth-facing, non-outpost site – could be done robotically**
- **RED objectives require very ambitious telescopes and sensors that would likely require humans to deploy -- this would necessitate sending humans to a non-outpost location**



Environmental Characterization and Operational Monitoring Objectives

- Most objectives are GREEN and can be accomplished through robotic missions and/or with small robotic packages deployed at the outpost site
- For environmental characterization, two objectives (seismic characterization and magnetic field characterization) require robotic sensors at non-outpost sites
- Operational objective to "monitor space weather" is best done away from the Moon and is thus RED as written





Science Opportunities Beyond the Current Architecture

- ***Yellow*** **objectives** ***typically*** **require** **<u>geological field work and sampling</u>** **at the outpost location, PLUS other locations. However, progress can be made at a single location.**

- ***Pink*** **objectives** ***typically*** **require <u>deployment of instrument packages at sites around the Moon</u>, creating a "<u>network</u>" of sensors**

Suggestions: How You Can Help

- Comment on any high priority missing or erroneous objectives
- Comment on LAT science-to-architecture ratings if you disagree (Note that Objectives Spreadsheets are on the wall of each breakout room)
- PRIORITIZE as much as possible at this meeting – decisions on which science objectives we will accomplish will likely be made through competition, but an understanding of which objectives are HIGH priority will significantly help LAT in scoping resource needs for science
- Detailed comments on “con ops” (concept of operations) for high priority objectives would be very useful – How is this objective most reasonably accomplished?
- Consider naming a couple of “community experts” for each objective (especially high priority ones…) – these contacts would be useful to us moving out on planning

Forward Work

Using priorities and knowledge derived from this meeting, and interfacing with evolving architecture options, we will:

- Develop “design reference science payloads” and their corresponding resource requirements as inputs into the lunar surface architecture for LAT Phase 2
- Define representative concept for a science workstation inside habitation module, with associated mass, power, volume requirements (working with CAPTEM on this)
- Identify potential lunar sortie sites of high science interest and help define representative crew tasks at each site
- Continue to engage this community in our efforts!