Large Space Observatory for Planetary Science (LSOPS)

Overview:

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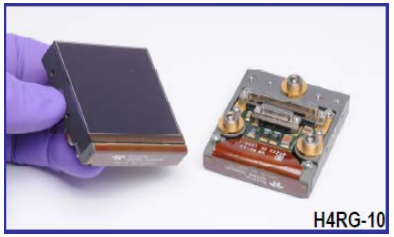
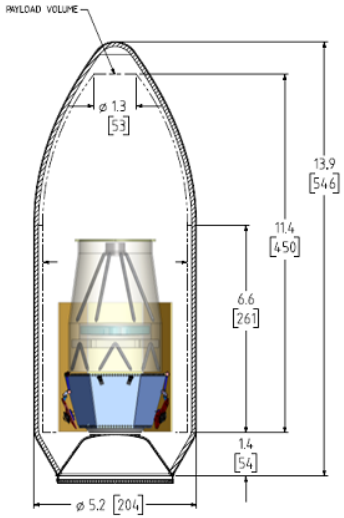
Key collaborators: Jim Bell, ASU; Amanda Hendrix, PSI

Goals: LSOPS is a Hubble Space Telescope-class observatory dedicated to observations of planetary bodies in the solar system. The primary emphasis will be on observing time-variable phenomena that would benefit from a dedicated space-based platform, revealing detailed processes over diurnal and orbital time scales. Observations of many targets are also synergistic with human spaceflight to better characterize potential destinations and monitor potential hazards.

Graphic:





Candidate detector and notional LSOPS Observatory shown stowed in a Falcon 9 5-m fairing

Description:

Concept overview: Two cameras for high spatial resolution imaging (<0.025" IFOV) of planetary surfaces and atmospheres, one optimized for UV-VIS and the other for VIS-NIR observations, and a NIR spectrometer for more detailed compositional investigations. All passively cooled. Can be placed in terminator, sun-synch LEO orbit to minimize LV and operational costs and enhance serviceability.

Candidate observations: Cometary volatile composition, surface compositions of icy satellites, asteroids and minor bodies, dynamics of giant planet atmospheres, changes in the climate and weather on Mars, volcanic and plume activity, deep searches for new objects or companions to known objects

Readiness level of key technologies: All elements of this proposed system are technically mature

Collaboration opportunities: Competed instruments and science teams enable international participation

Synergies with human exploration: Characterization and identification of potential HSF destinations; full value of system is enhanced with human servicing

Value to NASA:

Benefits: Provides a dedicated facility for planetary observations, currently limited by observing time allocation, and by temporal gaps in monitoring of events that persist and change over a range of time scales. Enables rapid science return.

Advancing Agency Objectives:

- A dedicated facility would directly address multiple major questions in the current Planetary Science Decadal Survey, "*Visions and Voyages for Planetary Science, 2013-2022*"
- Opportunities for engagement of robotic and human capabilities for maintenance and upgrades, via HST-like servicing.
- Support for future in-situ robotic and human exploration, with supporting measurements and monitoring for potential hazards

Concept name: Large Space Observatory for Planetary Science (LSOPS)

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Collaborators: Jim Bell, ASU; Amanda Hendrix, PSI

Primary concept goal category: Planetary Science

Qualification Statement: Dr. Richard Dissly is currently a Sr. Manager for business development in Civil Space and Technologies at Ball Aerospace. He holds a doctorate in Planetary Sciences from Caltech and has 20 years of experience in the development of mission concepts and flight instrumentation in the fields of planetary science, astrophysics, and earth science.

Concept Summary: The Large Space Observatory for Planetary Science (LSOPS) is a Hubble Space Telescope-class observatory dedicated to observations of planetary bodies in the solar system. The instrument suite nominally includes two cameras for high spatial resolution imaging of planetary surfaces and atmospheres, one optimized for UV-VIS and the other for VIS-NIR observations, and a NIR spectrometer for more detailed compositional investigations. The primary emphasis will be on observing time-variable phenomena that would benefit from a dedicated space-based platform, revealing detailed processes over diurnal and orbital time scales. Candidate observations include compositional assessment of cometary volatiles, compositional measurements of icy satellite, asteroid and minor body surfaces, monitoring the atmospheric dynamics of giant planet atmospheres, observing changes in the climate and weather on Mars, UV imaging of aurorae and magnetospheres of giant planet systems, monitoring volcanic and plume activity, deep searches for KBOs, Trojans, TNOs, and MBAs, and searches for satellites or companions to known objects. Observations of many targets are also synergistic with human spaceflight to better characterize potential destinations, from observing dust storm activity on Mars to defining the rotation state of possible NEAs. Instrumentation is modular to enable future servicing and upgrades, either robotic or human-assisted. LSOPS is a powerful and versatile observatory that continues the legacy of space-based planetary astronomy enabled by Hubble, and as a dedicated facility will greatly enhance observations by both JWST and ground based facilities.

Goal of the Proposed Application: LSOPS is envisioned as a dedicated observatory for planetary applications. The primary emphasis is on imaging and compositional measurement of time-variable phenomena that would benefit from a dedicated space-based platform.

Benefits of the Proposed Application: HST and ground based observations have well-demonstrated the scientific merit of remote planetary observations. But the advancement of our understanding of many fundamental planetary processes is currently limited by minimal observing time allocation to planetary applications, and by temporal gaps in monitoring events that persist and change over a range of time scales. A dedicated facility for planetary science will help alleviate this bottleneck, and address multiple questions listed in the latest Planetary Decadal Survey.

Design and operation of the proposed system: LSOPS as envisioned will resemble the Hubble Space Telescope both physically and programmatically. A Low Earth Orbit (LEO) operational location, ideally polar and sun-synchronous, can be reached with low-cost commercial launch vehicles to minimize mission cost. LEO and GEO are both compatible with the thermal design of the telescope, allowing efficient communications and operations, and enabling potential future servicing using autonomous or telerobotic agents or human astronauts.

The existing Telescope Subsystem (TSS) can be used as-is with relatively minor refurbishments. The primary and secondary mirror coatings will likely need to be replaced with improved coatings suitable to span UV to near IR wavelengths. Although the spatial resolution from the existing 2-mirror TSS is insufficient to meet many high resolution imaging objectives, additional powered optical elements can be added to the back-end to produce images of HST quality or better, without modifying the existing TSS prescription.

The notional instruments for LSOPS are described in **Table 1**. All baseline components are technically mature, although increasing the TRL of 4kx4k HgCdTe arrays (such as the H4RG)

Instrument	**Spectral Range**	**IFOV**	**FOV**	**Spectral res**	**FPA**	**Comments**
UVIS Imager	200-1000 nm	0.025”	100”	N/A	4k x 4k CMOS	Includes filter wheel, potential dispersing element for mid-res spectroscopy
VNIR Imager	600-2500 nm	0.025”	100”	N/A	4k x 4k (H4RG)or 4x (2kx2k) HgCdTe H2RG	Includes filter wheel, potential dispersing element for mid-res spectroscopy
NIR Spectrometer	1000-2500 nm	0.1”	100”	R~1000	2k x 2k HgCdTe (H2RG)	Thermal constraints likely preclude longer wavelength cutoff.

Table 1: Notional instrument specifications for LSOPS

would be desirable. Serviceable interfaces for the science instruments will be incorporated into the Aft Metering Structure. The instruments and telescope are passively cooled to be operated near room temperature, so the Outer Barrel Assembly may be used as-is, although additional baffling may be required to minimize stray light.

The new observatory can make extensive use of the infrastructure for science and mission operations that exist for HST and JWST. Observing time allocation would ideally be assigned on a competitive basis. This asset would be truly international, with opportunities for participation via instruments, operations, launch services and scientific research.

Anticipated Results: LSOPS will provide observations over a range of important planetary processes, many listed in the Decadal Survey. Some key candidate observations include:

- ***Mars climate, weather, and water cycle*** – Observations of the growth and decay of both regional and global dust storms, water ice clouds, and polar cap interannular variability. Spectral/spatial observations of atmospheric H2O over seasons to better understand the active water cycle on Mars. Trace gas observations (e.g, O3, hydrocarbons).
- ***Comet activity and composition*** – Dedicated monitoring of the evolution of outgassing products vs heliocentric distance, and distance from the nucleus, to understand what drives comet activity, and quantify the input of volatiles to the inner solar system.
- ***Giant planet atmospheric dynamics*** – Routine monitoring of belt and storm evolution to define what dynamical processes are driven internally vs radiatively.
- ***Physical properties of NEAs and other small bodies*** – Size and albedo determination, color and surface composition, spin state, and time variability to quantify and refine dynamical processes, e.g. YORP.
- ***NEA surveys, follow-up observations*** – Surveys for near earth asteroids, particularly those that might be accessible for human exploration. Follow-up to refine trajectories.
- ***Spectral assessment of small bodies*** – Taxonomic identification and observations of potential volatile components on primitive objects (KBOs, TNOs, Trojans, MBAs) to refine our understanding of the distribution and evolution of volatiles in the solar system.
- ***Volcanism/plume/tenuous atmosphere monitoring*** – Routine monitoring of satellites (e.g, Io, Enceladus) and other bodies (Triton, Pluto) for changes in activity/atmospheric state to better understand driving forces.
- ***Deep surveys for new objects and companions to known objects*** – Surveys to better understand the population of MBAs and outer solar system small bodies. Dedicated observations of objects like Pluto for satellites; survey of Trojans or MBAs to build statistics on the prevalence of multiple systems.

These and many other examples directly address major unanswered questions in planetary science, and have direct, cross-cutting benefits that support both future robotic probes and human exploration of other worlds in our solar system.