

## A LARGE TELESCOPE CAN BE ENABLED BY NASA'S LUNAR EXPLORATION ARCHITECTURE.

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**Introduction:** The architecture being developed for the Vision for Space Exploration's return to the moon will enable the construction of large telescopes in space that could serve the astronomical or Earth sciences communities. The Ares V launch vehicle with a large diameter fairing, autonomous or telerobotic assembly and servicing capabilities, and a versatile spacecraft based on the Orion service module allow us to envision a UV-optical space telescope with a 10m aperture and collecting area of 50m<sup>2</sup>.

**Science opportunities:** Such a telescope will have an angular resolution of 10 mas in visible light, sufficient to resolve stars in nearby galaxies for stellar population studies, to measure proper motions in globular clusters in five years, and to detect structures with scales of 1 AU in circumstellar disks to a distance of 100 pc. Sensitivity will be sufficient to measure  $V = 29$  stars in one hour and to obtain  $R = 20000$  UV spectra of 21<sup>st</sup> mag quasars. This telescope could detect the atmospheres of transiting terrestrial planets spectroscopically, probe the inter-galactic medium in absorption lines, study the production sites and dispersal mechanisms of heavy elements, and observe the evolution of galaxies in the modern universe.

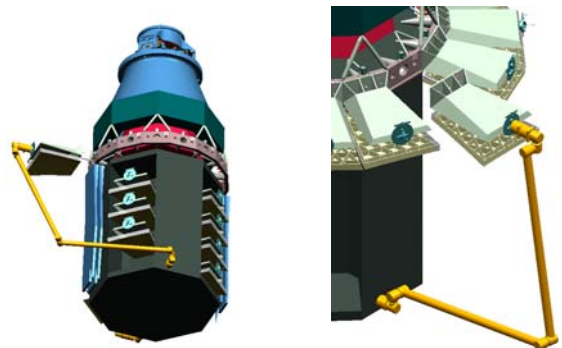
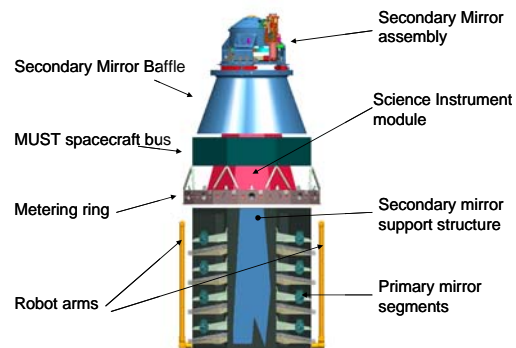
**Assembly in space:** A telescope that is larger than the fairing must be launched in a stowed configuration and either deployed or assembled in space. NASA has developed robotic technologies for use on the Shuttle, the ISS and planetary surface rovers. Serious consideration was given to robotic servicing of HST. In fact, a robotic arm and a variety of end-effectors were built. Many future Exploration projects envision robotic activities, either autonomous or "telerobotic", with human mediation. Our 10m telescope is launched with critical components, such as primary mirror segments, stowed in a service module that is designed to be a "storage rack" that absorbs launch loads, maintains a safe thermal environment and protects against contamination. The placement of the components in the rack aims for mass and volume efficiency, and has no relationship to their geometrical arrangements in the finished observatory. Assembly in space using robotic assets is a pathway to achieving a very large telescope.

The Service Module will provide the robotic capabilities. They may be shuttle-like arms attached to the SM or a separate agent, such as a telerobotic Ranger.

In either case precision mechanisms are concentrated in the robotic devices, not distributed to multiple subsystems with hinges, actuators, sensors, latches etc.

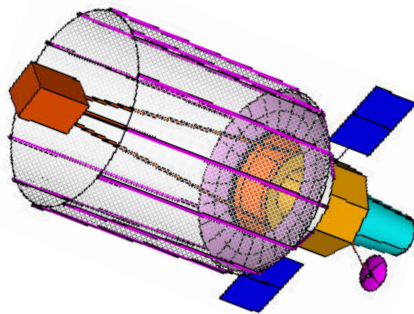
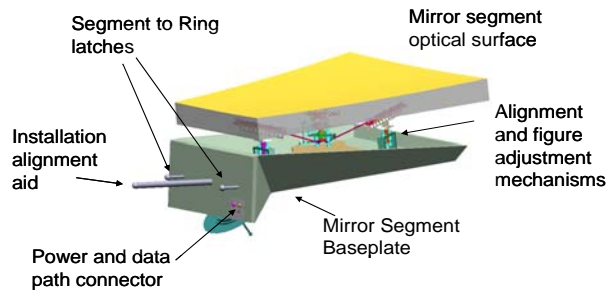
An optical design that allows identical segments simplifies design, manufacturing and testing. For a 10m telescope sixteen segments, each approximately 2 meters on a side are required. Each segment is a reasonable size for manufacture and testing.

A metering ring is the structural keel to which other components are attached. It is a single element, which is assembled, aligned and tested before launch. It does not require deployment or assembly itself. The ring contains docking stations for 16 primary mirror segments, and attachment fittings for the secondary mirror support structure and the outer sunshield/baffle. It has connectors for power and data paths for the primary mirror segments, the secondary mirror and the spacecraft bus.



**Scalability:** The metering ring for our 10m design is 6m in diameter, which should be accommodated by the Ares V. The 5m fairings of current launch vehicles would allow a 4.4m ring and an 8m diameter

primary mirror with a collecting area of at least  $35\text{m}^2$ . This would be an extremely powerful instrument, and would be achievable without waiting for (or paying for) a larger fairing. Scaling to larger apertures also appears to be feasible. A 6m hub, but with segments one meter larger in the radial direction would allow a primary mirror with  $D = 12\text{m}$  and  $A = 100\text{m}^2$ . Such a size would be of interest for the “Life Finder” component of the TPF long-range plan.



**The Vision:** Exploration of the universe using advanced telescopes to understand its origin, contents and structure remains an important strategic objective of NASA. A large ultraviolet-optical telescope with the resolution and sensitivity envisioned here will be a tool of unprecedented power. A critical element of our concept is the Robotic Service Module. While such a vehicle could be designed from scratch to meet the specific requirements of this mission, a more generic facility could be developed using the core design of the Orion CEV and its Service Module. Such an approach could motivate the definition of standardized modularity and interfaces that could be applied to many future space assets. Although we describe an astronomical telescope assembled and used in free space, similar techniques could be used on the lunar surface, either by robots or astronauts to construct tele-

scopes for earth or space science, or for deep-space optical communications.

**Acknowledgement:** The ideas suggested in this paper were developed during a NASA-funded Visions Mission study led by James Green of the University of Colorado, NASA contract NNG04GJ2G. Since then the development of this idea has benefited from numerous helpful discussions with members of the Future In-Space Operations Working Group (FISO WG), led by Dr. Harley Thronson of NASA Goddard Space Flight Center. The application of capabilities developed for exploration to the construction and servicing of scientific observatories is a prime interest of the group.

### References:

- (1) The Modern Universe Space Telescope: A Visions Mission Study for a Large UV-Optical Space Telescope. Final report to NASA HQ.
- (2) Ebbets, D.C., DeCino, J., and Green, J.C., 2006, Architecture concept for a 10m UV-optical space telescope, Proceedings SPIE, Vol. 6265.