

## **The Hubble Space Telescope and the Future of Space-Based Astronomy in Light of a Return to the Moon**

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The Hubble Space Telescope remains one of the most popular successes of the Space Program. The glimpses it continues to give us into the surrounding universe amaze us, expand our conceptions, and sometimes shatter them.

To maintain the HST in orbit and ever improve on its capabilities has required periodic visits by Space Shuttle crews. Now the Space Shuttle is to be phased out before the replacement Crew Exploration Vehicle is operational. Meanwhile, new operations guidelines prohibit sending any of the three remaining Shuttles to orbits out of reach of safe abort to the Space Station. This places the Hubble's future in jeopardy.

NASA has proposed to deorbit the Hubble, its charred remains sinking to the bottom of the ocean. While the HST has been scheduled to be replaced by the James Webb Telescope, a larger telescope with greater power and capacity, the Webb will not be ready by the proposed deorbit time. As the Webb will be stationed not in easily accessible low Earth orbit, but a million miles out into space in the Earth-Sun L2 Lagrange point, it seems foolish to junk the Hubble before the Webb is successfully in position, and operating properly.

The scheduled servicing mission to Hubble should be restored, and safe service mission profiles identified, in the hope that the telescope will continue to function until the Webb becomes operational, and possibly until a heavy lift vehicle can deorbit the Hubble intact for display at the Smithsonian, which is certainly what the public expects as a fitting retirement.

Meanwhile, with NASA embarking on a new destination-driven, open-ended mission to the Moon and Mars, we now have the opportunity to explore designs for future space telescopes stationed on the Moon itself. The Moon offers a much cleaner environment than low Earth orbit, gravity purging the boundary space of debris and dust. Its surface is seismically quiet, making feasible very large array optical interferometers thousands of kilometers across. The resolving power of such an array would give us detailed views of distant objects well beyond the capacity of the Hubble, the twin Kecks, and even the James Webb. Further, the Moon's deep farside, shielded from the intense radio noise emanating from Earth, is the best site in the solar system for radio astronomy.

NASA should take advantage of the coming return to accessibility of the lunar surface to identify, list, and prioritize possible astronomical observatory projects according to the logistic demands of maintenance from Earth and/or future lunar outposts. Robotic and teleoperated optical instruments could be placed on the Moon in advance of human outpost deployment to test and prove out systems and components. Once we have crews on the Moon, more ambitious and advanced instruments requiring periodic visits for maintenance and instrument changeouts could

be deployed. If and when outlying outposts are built, companion telescopes could be built to work in tandem with the first, creating an interferometer.

On the farside, if a radiometric probe indicates that there is useful radio silence there, a demonstration radio telescope could be placed at the Earth Moon L2 Lagrange point, and maintained there for a period with a station-keeping fuel reserve, communicating with Earth via a simple relay placed at either Earth-Moon L4 or L5. Such an instrument would be in the Earth's radio noise shadow.

The opportunity to place future space telescopes in superior environments where they can be easily visited by Moon-based crews is promising enough that NASA should now begin brainstorming the options and opportunities. Telescopes on the Moon, especially instruments capable of feats well beyond the Hubble and Webb, would garner significant public support for continued human presence on the Moon. Thus placing telescopes within the service range of lunar outposts will have the effect of firming up the future for those outposts, and of the funding necessary to keep them operational and growing.

The future of astronomy and the future of outposts on Moon would seem to be inextricably intertwined.

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