ASTRONOMICAL OBSERVATORIES ON THE MOON; F. Vilas, NASA Johnson Space Center/SN3, Houston, Texas 77058.

The Moon offers an ideal location for astronomical observations and a unique location for some specific astronomical experiments. The lack of a substantive lunar atmosphere permits complete transmission of radiation covering all spectral regions from an astronomical object to a telescope . No scattered light will affect the observations, allowing diffraction-limited performance for any observing facility. Although smaller than the Earth, the Moon is massive, providing gravity 1/6 the strength of the Earth's gravity. Thus, the Moon would serve as a stable platform on which to mount large telescopes, eliminating the long time intervals required to point the space-based telescopes lacking a stable anchor. The lighter gravity also allows very massive telescopes to operate easily on the Moon's surface. Maintenance and construction by astronauts would be easier to conduct under the reduced gravity. With the elimination of the atmosphere and conscious minimization of dust and particulates near facilities, thermal infrared observations would be limited only by the zodiacal background signal. Telescope cooling is facilitated in the already-cool environment, and shielding from sunlight and earthlight to prevent interference with observations would be much easier.

Depending upon a facility's location on the lunar surface, anywhere from 50 - 100 % of the celestial sky is available to observers. (A telescope located at or near to the lunar equator will see ~100% of the sky throughout one month's time, however, only 50% of the sky is visible at any given moment. Located near one of the poles, a telescope would be limited to ~50% of the sky but be able to observe anywhere within that hemisphere at any given time.) Locating an observatory near the lunar limb reduces the area for which shielding would need to operate to protect the facility from exposure to earthlight. Maintaining the facility on the near side, however, allows line-of-sight communications between the observatory and the Earth. Observing programs could be conducted remotely from the Earth. Astronauts on the Moon would be available for facility installation and maintenance as necessary.

Under the philosophy that lunar outpost astronomy should concentrate on those astronomical observations which can only be accomplished from the Moon, the NASA Astrophysics program chose to emphasize seven primary astronomical facilities which would be unique to a lunar setting (1): The Lunar Transit Telescope, the Small Lunar Automated Telescope, the Lunar Optical Interferometer, the Lunar Nearside Very Low Frequency Imaging Array, the Sub-Millimeter Interferometer, the Lunar Farside Very-Low Frequency Interferometer, and the Large Lunar Optical Telescope. Each of these facilities was designed under the philosophy that lunar outpost astronomy should - from the outset - take the next step beyond the space-based Great Observatories. The Lunar Transit Telescope takes advantage of the slow rotational rate of the Moon to use a CCD in a time delay integration (TDI) mode to obtain astronomical integrations on objects lasting many hours. The Small Lunar Automated Telescope would be deployed early on the Moon's surface with the intention of getting an immediate, low-cost scientific return from the lunar outpost, and gaining experience in the operation of a telescope on the lunar surface. The Large Lunar Optical Telescope will ultimately be a 16-m diameter high-sensitivity UV-optical-IR telescope.

A number of the astronomical observatories proposed for the lunar surface take full advantage of our capability to create long base line arrays of telescopes on a stable, atmosphereless platform. The Lunar Optical Interferometer will start with 3 telescopes and build up to 12 telescopes in order to do ultra-high-resolution optical astronomy. Images will have 100,000 times the resolution of the best Earth-based (including orbiting) telescopes. Nineteen stations of two 10-m dipoles each comprise the Lunar Nearside Very Low Frequency Imaging Array. These stations will be spread over a T-shaped formation, each branch being 36 km long. Ultimately, the Lunar Farside Very Low Frequency Interferometer would take advantage of the radio-quiet lunar far side to emplace multiple dipole antennas and receivers across a baseline of hundreds of km. The Sub-Millimeter Interferometer will consist of twelve 5-m diameter sub-millimeter antennas set upon a 1-km baseline.

An alternate philosophy concerning the emplacement of lunar astronomical facilities has also been discussed by astronomers (2,3). This initial placement of small, robotic telescopes on the Moon, each perhaps dedicated to an initial observing purpose (e.g. photometry, ultraviolet astronomy) would provide both a rapid scientific return at a smaller cost, while also providing the small telescopes necessary to do a "site survey" of the lunar surface. Astronomers would learn what technical problems the Moon presents for astronomical observatories prior to deployment of the larger, more ambitious lunar facilities.

(1)FY 90 Final SEI Science Payloads: Descriptions and Delivery Requirements. JPL D-7955 (1990). (2)Talent, D. L., Smith, H. J., and Vilas, F. (1990) LPSC XXI, 1235-1236. (3) Sykes, M. V., et al. In Astrophysics from the Moon, M. J. Mumma, Ed., in press.