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N85-26568

TELESCOPE IN LUNAR ORBIT

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NASA JSC Code SN (483-3728)

In order to support the establishment of a lunar base around AD 2000, this paper proposes the use of a large telescope in high lunar orbit 4000 km (2500 mi) above the Moon's equator. After this idea was first proposed at the National Academy of Science Symposium on Lunar Bases last Oct in Washington, DC, it was recognized that NASA's Hubble Space Telescope (ST), scheduled to be launched into low Earth orbit by Shuttle in 1986, will provide the necessary capabilities if it can be transferred to lunar orbit. The Orbital Transfer Vehicle (OTV), expected to be in service by the mid-1990s, will be able to make such a transfer. With a few modifications, ST will then be able to scan the lunar surface, locate small outcrops of minerals important to base development, and support early base operations. It can then undertake detailed geophysical exploration of the whole lunar surface more expeditiously than geologists making long traverses on Lunar Rovers.

Space Telescope was designed for astrophysical observations from low Earth orbit (LEO), but it is shown that high lunar orbit offers several major advantages for this purpose as well as for the proposed unconventional use to survey the lunar surface. It is noted that these advantages can be thoroughly checked during 10 years' use of ST in LEO before transfer to lunar orbit. They are:

1) Absence (in lunar orbit) of red "Shuttle Glow" and the foreground ultraviolet light of the geocorona, both of which will tend to obscure faint astronomical sources to be detected and analysed by ST,

2) Lower orbital velocity (1 km/sec in lunar orbit vs 8 km/sec in LEO) which affects spectra by the Doppler shift, and greater sky coverage (the Earth blocks almost half the sky from LEO), and

3) The ability to observe close to the Sun for several minutes just before sunrise and just after sunset in lunar orbit. Preliminary operating rules forbid pointing ST closer than 45° from the Sun, which rules out observations of Venus, Mercury, the solar corona, comets, asteroids, and other celestial objects that happen to be close to the Sun. (In LEO, the intervals before sunrise and after sunset are much shorter, and the Earth's atmosphere intervenes.)

Although many astronomers oppose changes in plans for ST, which was designed for 15 years' use in LEO, it is emphasized that this proposal leaves 10 or more years in LEO and will extend ST's later usefulness in lunar orbit. Modifications to the six initial ST instruments -- cameras, spectrometers, polarimeters, photometer, and measurer of very accurate star positions -- will undoubtedly be undertaken in LEO during the first 10 years, and some upkeep (replacement of batteries and solar cells) will probably be necessary, all accomplished by Shuttle astronauts on EVA, or by returning ST to Earth. The modifications necessary for use in lunar orbit involve extending instrument sensitivity from deep red to infrared wavelengths (from 700 nm to 3000 nm). For pointing at targets on the Moon rather than at stars and galaxies in the sky, new computer programs must be written for ground-based computers at the ST Control Center at Goddard Space Flight Center in Greenbelt, MD.

With these modifications, ST will be able to measure near-infrared colors and the spectrum of sunlight reflected from rocks and soil on the lunar surface at selected locations such as the Apollo landing sites, where 12 astronauts spent a total of 81 hours collecting samples and doing experiments on EVA. Because of these past explorations, these six Apollo landing sites will certainly be considered as potential locations for a permanent Lunar Base. Other locations will probably be proposed. One important requirement will be easy access to minerals such as ilmenite (titanium-iron oxides) from which oxygen can easily be obtained by heating in a solar furnace. Scans by ST will show the location of ilmenite outcrops as small as three to five meters (10 to 16 ft) in extent, and give the distance and direction from the Base. After assembly and construction at Space Station, metal habitats, radioactive electric generators, and supplies of oxygen, water, food, etc. will be transferred to lunar orbit and landed at the selected Base site along with three or four astronauts and equipment to dig in the habitats and cover them with three to five meters of soil.

If all goes well in the first year at Lunar Base (with crews rotated every three months), the production of oxygen and iron should be underway, and geophysical research starting. ST in lunar orbit will help the research effort by scanning for mineral content of soil and rocks along designated west-east traverses and across the layers exposed in crater walls, detecting layers as thin as three meters. The results should provide planetary scientists with data to improve their theories of the history of the lunar surface, including the back side, which even lunar-based geologists cannot easily reach. All the data gathered by ST are radioed back to Earth by the TDRSS satellites, and also to Lunar Base, In between these geophysical observations, ST will continue astrophysical observations of galaxies, stars, planets, and objects close to the Sun -- he[illegible] its proposed name, Geophysical-Astrophysical Lunar Telescope (GALT).

As a final service to planetary scientists, GALT/ST can monitor gases released from Lunar Base that might contaminate the pristine lunar surface which the geologists hope to sample and study for evidence of events during the Moon's 4.5-billion-year history. This can easily be done by recording the spectra of early-type (hot) stars along the line of sight from ST just above Lunar Base from lunar dusk to dawn. (In lunar daytime, the gases would undoubtedly escape to space, but during the night they can be blown across the surface by the solar wind.) If the stellar spectra show increasing amounts of gases like CO, CO_2, H_2O, CH_4, O_2, metals, and metal oxides, the Lunar Base crew must take steps to prevent the release.

Much of this may sound like science fiction, and it was, about 20 years ago, when Robert A. Heinlein's book "The Moon is a Harsh Mistress" was published by G. B. Putnam, NY, 1966. Heinlein portrays lunar cities in the year 2075, and has most of his facts straight except for the prevalence of water ice on the Moon. (There is no evidence of water on the Moon, but speculation that there may be some ice in craters near the poles never reached by sunlight.)

As the abstract indicates, ideas for this paper were contributed by planetologist Michael B. Duke of NASA JSC (not by Heinlein). The use of reflected sunlight to detect minerals on the lunar surface was developed by several geophysicists including Carle M. Pieters, now at Brown University in Providence, RI, who reviewed the MS. The use (or misuse) of ST as GALT was reviewed by C. R. O'Dell, ST Principal Scientist, now at Rice University in Houston.