Lunar Base Construction

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The possibility of establishing a permanently manned lunar base was considered seriously as soon as early studies indicated that it was technically feasible to put men on the Moon and return them to Earth. Such studies were conducted by industry, the Air Force, and the Army. The greatest difficulty in giving credence to results from lunar base studies lies in the fact that very little is known about the physical and chemical properties of the surface. Of course, this situation is expected to change when television pictures taken from an impacting *Ranger* spacecraft are transmitted back to Earth. Additional information will be obtained within the subsequent two years from the *Surveyor* program, which is designed to soft-land a spacecraft containing instruments to measure and photograph the physical features of the lunar surface at the landing site.

Notwithstanding the present dearth of information, it has been possible to make meaningful studies of lunar bases. This was accomplished by making a wide range of assumptions regarding the nature of the lunar surface. Then, by designing a base that is insensitive to surface features over the range of assumed conditions, feasible base designs could be obtained.

An important factor influencing the base design is the sequence of events and equipment available before man can have extended stay times on the Moon. It is, therefore, necessary to review briefly the planned approach to these problems. The first two men to land on the Moon in a lunar excursion module will have an intended stay time of only 6 hr but life-support provisions for approximately 48 hr. Subsequent flights may provide a stay time of several days for the two men landed but will be limited by two factors: (1) the length of time the third man can stay in lunar orbit waiting for the landed crew to return and (2) the amount of life-support provisions that can be carried in the landed spacecraft. This second limitation can be overcome if a one-way (Earth-to-Moon) lunar-logistics supply vehicle can be landed shortly before or soon after the men land and provided the supply vehicle can be landed in close proximity to the manned landing.

Since the foregoing supply vehicle can be of substantial size, it can be designed as a shelter for the men. It would undoubtedly be more adequate than the lunar excursion module, which the men must use otherwise. Subsequent supply vehicles would possibly contain a manned surface vehicle, landing aids, power supplies, surface measurement equipment, or base building equipment. Such items will probably be combined in any one supply vehicle payload.

It must be assumed that for stay times on the order of weeks, the man left in lunar orbit will return to Earth after the lunar excursion module has landed. A separate one-man flight to the Moon at a later date will be required to pick up the two men remaining there. By proper scheduling of the foregoing events, it is possible to have several men on the Moon at all times. (The numbers being discussed vary between six and twenty.) An example of proper scheduling would be to rotate two-man crews by using the lunar orbiting spacecraft that had just brought two men to the Moon to return two men that had been placed on the Moon in an earlier mission.

From the foregoing, it should be obvious that the supply vehicle will be required before a permanent base can be constructed. The supply vehicle will provide shelter for the men while they construct a more permanent base. The number of men available for construction work will depend upon the size of the supply-vehicle shelter and the number of shelters landed. However, a

safe assumption at this time is that at least one shelter will be available and that this should house four men.

All studies to date indicate that a permanent base should be underground or consist of surface modules covered with lunar soil. Using surface soil for cover, if possible, would be an economical means of providing protection from solar and cosmic radiation, decreasing the thermal control problem, and providing protection from meteorites.

It is during this phase of the lunar base development that possible use can begin to be made of indigenous materials. It is not considered necessary at this point to prove mathematically that it is more economical to use natural resources found on the lunar surface than to transport them from the Earth. If, for example, water could be found or obtained by processing lunar soils, a heavy transportation burden from the Earth to the Moon would be obviated. The water could be separated by electrolysis into H_2 and O_2, a rocket fuel. Another example would be a means of processing lunar soils to obtain building blocks, or the use of lunar soil as an ingredient in a slurry that would "set up" in a vacuum.

If fairly simple means can be found to utilize lunar materials for shelter construction, a series of such bases can be visualized. These would have similarities to oases in the desert; i.e., surface parties traveling in a lunar surface vehicle would proceed from one shelter to another and remain at a shelter while operating in the local area.

The foregoing concept appears to be a logical sequence of events based on present plans. It means that permanently manned lunar bases are possible within this decade.