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SYSTEMS ENGINEERING STUDIES OF LUNAR BASE CONSTRUCTION

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Many ingenious concepts have been proposed for lunar base construction, but few systematic studies exist which relate time-consistent lunar base construction technologies and the choice of lunar base approach with the long-term SEI objectives—i.e., lunar indigenous base construction and Mars Exploration equipment development.

To fill this gap, CSC has taken a two-pronged approach. First, the Center undertook basic geotechnical investigations of lunar soil, fabrication of a scale prototype of a lunar construction crane, a multi-robot construction team laboratory experiment, and a preliminary design of lunar base structures. Second, during June and July, 1991 two lunar base construction systems engineering studies were accomplished—a “near-term lunar base” study, and a “far-term lunar base” study. The goals of these studies were to define the major lunar base construction research problems in consistent technology/construction frameworks, and to define design requirements for construction equipment such as a lunar crane and a regolith mover.

The “near-term lunar base” study examined three different construction concepts for a lunar base comprised of pre-fabricated, pre-tested, Space Station Freedom-type modules, which would be covered with regolith shielding. Concept A used a lunar crane for unloading and transportation; concept B, a winch and cart; and concept C, a walker to move the modules from the landing site to the base site and assemble

them. To evaluate the merits of each approach, calculations were made of mass efficiency measure, source mass, reliability, far-term base mass, Mars base mass, and base assembly time. The model thus established has also been used to define the requirements for crane speed and regolith mover $m^3/sec.$ rates. A major problem addressed by this study is how to “mine” the regolith and stack it over the habitats as shielding.

To identify when the cost of using indigenous lunar materials to construct the base exceeds the cost of development and delivery of the equipment for processing lunar materials, a study of construction of a candidate sintered regolith “far-term lunar base” was undertaken. A technique was devised for casting slabs of sintered (basaltic) regolith and assembling these into a hemispherical (or geodesic) dome. The major problem occurs with the inner liner. At 14.7 psi and 20% oxygen internal atmosphere, the entire structure is in tension, even with the regolith load. Also, another study has indicated that at 14.7 psi major resupply of air will be needed because of leakage, and astronauts may have to engage in extensive pre-breathing and post-breathing for EVA tasks, thus detracting from useful mission work time. An alternative is to operate part of the base at, say, 5 psi and 70% oxygen, or to equip the astronauts with hard suits at 8.3 psi or greater. All of these choices directly influence base design and construction techniques.