LUNAR DEVELOPMENT: THE WAY IT MAY HAVE TO BE

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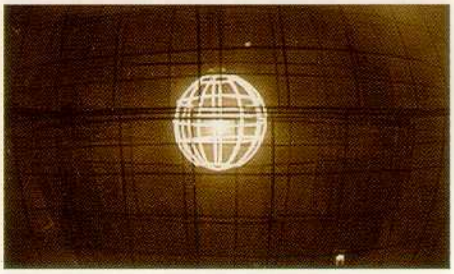
Few indications exist that governments will initiate or finance a return of humans to the Moon or a human expedition to Mars. The private sector, however, may find a business rationale for a return to the Moon, based on the economic return from the extraction of lunar helium-3 and its use as a fusion fuel on Earth as a future alternative to fossil fuels. By-products of helium-3 extraction from the lunar regolith will include hydrogen, oxygen, and water - valuable consumables needed elsewhere in space. A business enterprise based on lunar resources will be driven by cost considerations to minimize the number of humans required for the extraction of each unit of resource. Humans will be required, on the other hand, to prevent costly breakdowns of semi-robotic mining, processing, and delivery systems, to provide manual back-up to robotic or tele-robotic operation, and to support human activities in general. Humans will provide instantaneous observation, interpretation, and assimilation of the environment in which they work and in the creative reaction to that environment. Human eyes, experience, judgement, ingenuity, and manipulative capabilities are unique in and of themselves and highly additive in synergistic and spontaneous interaction with instruments and robotic systems. During the early years of operations the number of personnel will be about six per mining/processing unit plus four support personnel per three mining/processing units. Cost considerations also will drive business to encourage or require personnel to settle, provide all medical care and recreation, and conduct most or all operations control on the Moon. Technology and facilities required for success of a lunar commercial enterprise will enable the conduct and reduce the cost of continued scientific investigations on and from the Moon, exploration and settlement of Mars, asteroid interception and diversion, and many other space activities.

A commercial enterprise to develop Helium-3 fusion power, fueled by lunar Helium-3, has been proposed (1) as an early 21st Century alternative to fossil fuel and fission power plants. Although supplies of both fossil and fission fuels would be adequate to support a projected factor of eight growth in forecasted terrestrial energy demand by 2050, the indefinite use of such fuels does not appear to be a good environmental or economic choice. Within the proposed lunar Helium-3/fusion power initiative, major objectives are to provide investors with a competitive rate of return; protect the Earth's environment by using clean energy from space; develop other resources from space that will support future near-Earth and deep-space activities and human settlement; and develop reliable and robust capabilities to launch payloads from Earth to deep space at a cost of $1,000/kg or less. Past technical activities related to access to and operations in deep space and to terrestrial mining and processing provide a strong base for initiating this enterprise. Recent progress in the development of inertial electrostatic confinement (IEC) fusion at the University of Wisconsin indicates that this approach to fusion has significantly



Photograph of a D-3He plasma in the center of the Wisconsin IEC device. Currently fusion rates of nearly 3 x 106 per second at 55 kV and a current of 60 mA have been achieved.

more commercial viability than other technologies pursued by the fusion community in the past. International law relative to outer space (Outer space treaty of 1967) is permissive relative to properly licensed and regulated commercial endeavors, i.e., lunar resources can be extracted and owned but national sovereignty cannot be asserted over the mining area. Attaining a level of sustaining operations for a core business in fusion power and lunar resources requires about 10-15 years and $10-15 billion of private investment capital as well as the successful marketing and profitable sales of a variety of applied fusion technologies. Success also depends to some degree on the U.S. Government being actively supportive in matters involving tax, regulatory, and international law but no more so than is expected for other commercial endeavors.

Global demand for energy, the likely initial economic driver for lunar development, will likely increase by a factor of eight or more by the mid-point of the 21st Century due to a combination of population increase, new energy intensive technologies, and aspirations for improved standards of living in the less-developed world (1). Lunar helium-3 (3He), with a resource base in the Tranquillitatis titanium-rich lunar maria (2,3) of at least 10,000 tonnes (4), represents one potential energy source to meet this rapidly escalating demand. The energy equivalent value of 3He delivered to operating fusion power plants on Earth would be about $3 billion per tonne relative to today's coal which supplies most of the approximately $90 billion domestic electrical power market (5). These numbers illustrate the magnitude of the business opportunity. The results from the Lunar Prospector neutron spectrometer (6) suggest that 3He also may be concentrated at the lunar poles along with solar wind hydrogen (7). Mining, extraction, processing, and transportation of helium to Earth requires new innovations in engineering but no known new engineering concepts (1). By-products of lunar 3He extraction, largely hydrogen, oxygen, and water, have large potential markets in space and ultimately will add to the economic attractiveness of this business opportunity (5). Inertial electrostatic confinement (IEC) fusion technology appears to be the most attractive and least capital intensive approach to terrestrial fusion power plants (8). Heavy lift launch costs comprise the largest cost uncertainty facing initial business planning, however, many factors, particularly long term production contracts, promise to lower these costs into the range of $1-2000 per kilogram versus about $70,000 per kilogram fully burdened for the Apollo Saturn V rocket (1). A private enterprise approach to developing lunar 3He and terrestrial IEC fusion power would be the most expeditious means of realizing this unique opportunity (9). In spite of the large, long-term potential return on investment, access to capital markets for a lunar 3He and terrestrial fusion power business will require a near-term return on investment, based on early applications of IEC fusion technology (10).

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Selected for the Scientist-Astronaut program in 1965, Schmitt organized the lunar science training for the Apollo Astronauts, represented the crews during the development of hardware and procedures for lunar surface exploration, and oversaw the final preparation of the Apollo Lunar Module Descent Stage.

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