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EXPLOITATION OF A LUNAR-BASED NUCLEAR ECONOMY: IMPLICATIONS FOR SOLAR SYSTEM COMMERCE; Gary C. Hudson, The Foundation Institute, Suite 704, 810 Thornton St., SE, Minneapolis, Minn. 55414 (612) 332-6621.

Technological civilizations are built on the foundations of power, resources, transportation and communication. This paper addresses the three former topics, and discusses ways in which a nuclear economy based on the moon can lay the foundation for future exploration and exploitation of the solar system as well as provide the underpinnings of solar system commerce.

At this time, the fundamental ways of obtaining thermal or electric power are from the sun (fossil fuels, solar photovoltaic conversion, etc.) or from nuclear reactions (fusion, light or heavy metal fission). While solar sources have their utility, mostly for small scale heating and electric power generation on earth, space vehicles and communities will be forced to depend upon nuclear energy sources almost exclusively. The exceptions may be in certain moderately sized space colonies of the type suggested by O'Neill[1] and others[2], or at lunar factories mass "refining" the regolith in preparation for selected materials extraction and gas processing.

Nuclear reactions will be necessary to provide compact, lightweight, easily transportable power sources. These will be used, first and foremost, for life support and propulsion. The energy required for life support systems will always be small compared with propulsion requirements and can probably be accommodated by nuclear thermionic batteries or Rankine/Brayton cycle generators[3,4]. Fuel requirements for these systems can economically be met from earth-based fission stockpiles, but the fuel needs of propulsion systems are a different matter altogether.

Several types of nuclear propulsion schemes may find niches where they have unique attributes or economic utility. These systems include gaseous (plasma) core nuclear engines,[5,6,7,8,9]. Orion fission bomblet pulse motors[10], and pure fusion pulse engines [11,12,13]. It should be noted that all the mentioned propulsion schemes have the attributes of both high specific impulse as well as high thrust-to-weight. The advantages of such a combination are of overwhelming economic importance in the commercialization and utilization of the solar system, and this has been convincingly, indeed eloquently, pointed out by Hunter [14,15,16].

However, to produce the low costs necessary (ranging from a few cents per pound to a maximum of a few dollars per pound, depending on total ΔV required), large scale nuclear operations will be necessary on the lunar surface. A number of potential activities of a nuclear nature are possible on the moon which would be excluded from practical utilization in the biosphere of earth for environmental reasons. These include manufacturing large scale lots of fissile materials through the use of simple breeder reactors, hybrid reactors (fusion breeders employing a fertile thorium blanket to produce U-233), or "bomb" breeder systems. The latter system uses the cheap neutrons produced during the detonation of thermonuclear devices as a neutron source for an "open-air" breeder; the bombs are simply detonated a few thousand meters above a distributed mass of depleted uranium[17]. Certain problems exist with this method, not the least of which is the low binding energy of high-Z materials, such as uranium contrasted with the high energy of neutrons and gamma rays deposited in the material. In any case, by using the inherent advantages of the moon, including its location, free vacuum, and population sparsity, the manufacture of nuclear materials should be unencumbered by many of the constraints present on earth which drive the costs of nuclear facilities up.

The existence of significant amounts (thousands of metric tons) of weapons-grade materials will make very large engineering projects possible, including nuclear excavation on the moon and planets, movement of asteroids and similar small bodies within the solar system, and will allow reconsideration of the Orion concept launch vehicle as a device for the transport of lunar materials to Lagrangian points or to geosynchronous orbits for solar or nuclear power satellite stations. Masses in excess of 300,000 metric tons could be moved from the surface of the moon with no substantial advance in the state-of-the-art over work done originally by General (then Gulf) Atomic Corporation in the early 1960's.

Certain potential hazards exist in the concept of a lunar-based nuclear economy, not the least of which is the safe-guarding of ton lots of fissionable materials, and the prevention of the diversion of many thousands of very small fission bomblets used in the Orion ships. However, the moon is far more difficult for potential thieves to reach than earth-based power plants and reprocessing facilities and design precautions can be taken which would prevent the unauthorized use of the Orion bomblets outside of the Orion vehicle. Ultimately, the use of pure fusion detonations would obviate the problem completely, while also permitting very high speed transit among the bodies of the solar system.

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17. Credit for the concept of the manufacture of plutonium from depleted uranium must be given to T. Taylor, who first proposed the concept in 1956 at the Los Alamos Scientific Laboratory of the University of California.