SPACE TRANSPORTATION FOR A LUNAR RESOURCES BASE (LRB)

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This is a report of a work in progress. So far as the author is presently aware, this topic has not been previously addressed. Proprietary work by NASA or others may, however, exist that address similar topics.

This work assumes that a base near the South Pole of our Moon will be established for the purpose of exploiting the resources of the Moon; principally the water ice that many believe was discovered by the *Clementine* and *Lunar Prospector* satellites. The ice is of particular value as, with the aid of the ample solar resource available nearby, it may become an essentially limitless source of oxygen / hydrogen propellants for continued visitation to and expansion of the base and for the support of additional space exploration missions, including human exploration of Mars.

This work placed a total 129 tons initial base for both the in-crater and crater rim installations, as well as a 90 tons "marshalling yard" at the Earth-Moon L-1 libration point. For launch services, the results of an in-house *Shuttle-Derived Heavy Lift Launch Vehicle* study were used. It is called *Aquila*. This vehicle can deliver over 50 tons to low Earth orbit from the Kennedy Space Center, using a combination of *Space Shuttle* and *Delta IV-Heavy* components.

A second stage of the *Delta IV-Heavy* vehicle was used to deliver 15 tons payloads from Earth orbit to docking at L-1. By so doing, no "new start" systems are needed beyond those of the L-1 station and the LRB itself, provided the *Aquila* and *Crew Exploration Vehicle* have been previously developed. At L-1, three of these once-used stages are fitted with landing gear and other elements needed to produce a highly capable *Lunar Vehicle* and it is refueled from propellants delivered from Earth to place the base and to provide a single visit of a six person crew to aid the robotic operations necessary to produce a fully functional base.

If the ground rule is established that "dry" cargo and propellant must be launched separately, 34 launches were required. This will permit over 50% of the launches to launch only propellants.

Later missions, using propellants produced by the *LRB,* show a large net gain in propellants available at L-1. For example, a round trip mission with the *CEV* results in a net gain of over six tons of propellant at L-1; a cargo delivery nets over 69 tons.

Work continues on the "pay-off" phase; that is, further missions making use of the propellants obtained from the shallow "gravity well" of the Moon. Propellants produced on the Moon will only be used from the lunar surface or from L-1; no attempt will be made to deliver them to other locations. That will come, but is "out-of-scope" for the present work.

A Mars mission departing from L-1 with mass of 686 tons can be placed on the trans-Mars trajectory expending lunar-origin propellants and just one of the *Lunar Vehicle*s, requiring an additional 13 *Aquila* launches. This will permit dual Mars spacecraft to be used for each mission with a 28% mass margin over a single, similar mass vehicle departing from low Earth orbit.