Abstract: The Intraplanetary Superhighway and the Development of the Moon

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The development of the Moon is a critical step for extending permanent human presence in space beyond low Earth orbit. A critical part of the development process is a thorough understanding of the low energy orbits in the Earth-Moon environment. Like the explorers in the Age of Discovery prior to the Industrial Revolution, we need to find our equivalent of the Northwest Passage in space travel until someone makes that major breakthrough for cheap and fast space travel. The "Interplanetary Superhighway" provides some of the cheapest orbits throughout the Solar System. This is a network of connecting orbits generated by unstable orbits around the Lagrange points and unstable resonant orbits between planets. In this paper, we restrict our examination of the Interplanetary Superhighway to around the Earth's Neighborhood, a spherical region in space centered on the Earth with a diameter of around 3 to 4 million km. We call this the "*INTRA*-planetary Superhighway".

Many of the orbits within this so-called "Intraplanetary Superhighway" are well known to us. After all, the "Three Body Problem" has been studied since the time of Newton. Nevertheless, the orbits in the Earth's Neighborhood are complex indeed, as they are generated by the Sun-Earth-Moon system which is actually a Four Body System (the spacecraft is the implicit fourth body). As such, there is no complete classification of all of the orbital families to date. Of the families of orbits that have been identified, little engineering and mission analysis has been performed on them to realize their potential for application to the develop of the Moon and of the entire Earth's Neighborhood. We will describe some of these orbital families and discuss some of their potential applications to the development of the Moon.

Recently, the NASA Exploration Team proposed providing human servicing of spacecraft beyond low Earth orbit. One potential class of candidate missions for such servicing are future telescopes in orbit around the Earth's L_2 (EL_2) Lagrange point. However, sending humans to EL_2 is nearly as challenging as sending humans to Mars because of the 3 months transit time required. To speed up the transfer sufficiently would be extremely costly. A solution proposed by the author is to locate the humans at a Lunar Gateway Module in halo orbit about lunar L_1. The spacecraft can be moved between EL_2 and the Gateway Module via the low energy pathways of the Intraplanetary Superhighway. This is but an example of the large number of possibilities these new orbital concepts can bring into the architecture for the development of the Moon some of which will be described in this paper.

We conclude by providing a road map for the development of the orbital technologies needed to support the development of the Moon.