TRANSFER AND PARSE ORBIT MOMENTUM MANAGEMENT SYSTEM ARCHITECTURE.

T. H. S. Harris, Dynamicist, Orbit Analyst, Lockheed Martin retired (THSHarris@mindspring.com)

Introduction: The campaign to revisit the Moon has become exactly that, a far reaching, multi-functional enterprise. As various entities take interest in any one of many stages and settings of the overall paradigm, the cost of safe, reliable transport to the moon is purvasive above all other factors. As mission demand increases and the list of points of interest on the lunar surface become diverse and potentially dynamic, many trajectory architectures will be considered. Ultimately a semi-consolidated transport architecture to service many different mission types and payload mass requirements may reduce the overall cost of bulk transport for lunar missions. Architectural elements of Earth-Moon system mass transport "structure" are developed for lunar orbital residence.

A system of one or more orbital tethers is suggested to capture generic payload containers out of transfer orbit from Earth and divert them to their reqiured parking or pre-landing trajectories. The perferred system is one that absorbs a portion of the transfer orbit energy for maintenance of its own orbit and orbit parsing delta V requirements (solar electric powered for guidance and actuation). Benefits and drawbacks or risks are considered in the context of Human Exploration and Operations in the Earth-Moon System (EMS), while the conceptual framework is applicable for destinations beyond the Moon, with hardware & control commonality as potential benefits for such additional uses.

Context: A coordinated approach to mass transport in the EMS for both transfer orbit to the Moon and then parsing orbits at the moon has the potential to optimize both specific angular momentum and total mechanical energy. Reduced specific delivery cost vs. chemical rockets for soft landing would have to exceed the system cost of viable solutions within the EMS mass transport system architecture.

When not ferrying human payload, mass transport costs may be reduced via any EMS mass transport system that is more conservative and reusable than the large "human-rated" chemical boosters. Humans are a very small fraction of all of the infrastructure and robotoc mass we would like to provide at the lunar surface. What is needed is some sort of "on-station conveyor" around the Moon that can be adapted, controlled and/or configured to accept incoming mass from transfer orbit and parse it to a pre-landing orbit.

Top Level Requirements: We assume soft landing capability on the lunar surface is a requirement for payload survivability. We know that areas of interest on the Moon could be anywhere from equatorial to polar, so we would like access to all latitudes. We would also like the ability to place mass on the lunar surface without need of expendable propellant or thrster to do so. Using a rotating tether to place a payload on the surface during flyby, delta V is conserved during the delivery, and the tether delivery vehicle extracts payload energy by accelerating itself in a controlled fashion for orbit upkeep. The challenge is mainly divided into control/actuation and orbit determination for the tether vehicle/system. Tight constraints on transfer orbit definition are also required, offset by improved tether control performance.

Recievers and Workers: A larger, higher orbiting tether may be used to match or "receive" higher incoming velocity transfer orbit requirements [1]. The reciever tether then parses the payload to a smaller "worker" or "delivery" tether (fleet), at a lower, near surface orbit [2]. This two tier system can theoretically reach stated requirements. Choice of delivery tether would depend somewhat but not completely on target latitude. Ultimately the entire tether system can derive its required delta V by strategic choice of transfer delivery condition depending on current vs. desired tether states, before payload launch from Earth [3].

Discussion & Conslusion: Proposed EMS mass transport architecture allows for a resident delivery conveyor within the EMS environment, alleviating delta V requirements during science and coeval support infrastructure build-up to human arrival.

Single point failure sensitivity of this EMS mass transport system architecture may be reduced by multiple active orbital tether units in each of an upper or "reciever" tier, and a lower or "delivery" tier.

The preferred workup to this architecture starts with smaller scale tethers to handle low mass science payloads such as "CubeSat" scale, for survivable placement on the lunar surface at various latitudes. Larger scale tether devices for larger mass payloads may then be successively deployed to expand the mass/time capacity of the overall system. A varsatile and delta V conservative mass transport system should be delivered early in the modern lunar campaign to aid in the entire exploration process. This system has the added advantage of possible fast resupply after human occupation.

References: [1] R.R. Bate, D.D. Muller, J.E. White, 1971, Dover Publications. [2] M. P. Cartmell & D. J. McKenzie, 2007 *Progress in Aerospace Sciences* V44 I1 P1-21 [3] T.H.S. Harris, 2015 *Bridging the Gap III* 1042.