The Lunar Direct Polar Moon Base Concept

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WOW – I can put three hundred foot tall lunar bases onto the poles of the moon before the year 2020.

HOW – By treating cryogenic fuels as payload, redirecting the SLS core stage design requirements to uncrewed lunar lander specific missions, using multiples of efficient cross fed liquid reusable boosters, Al-Li alloys, aerodynamically shaped fuel tanks, and upper stage engines integrated into the core stage.

WHY – To establish power, navigation and communications for all future lunar polar landing missions, and to deliver potable water and usable living space for any future astronaut crews visiting these bases.

WHO – Stennis Space Center for testing of the advanced cryogenic propulsion systems of the future. Marshall Space Flight Center for the design of the new all liquid powered cryogenic core stage landers. Michoud Assembly Facility for the large scale production of the lightweight, aerodynamic core stages. Kennedy Space Center for the assembly and integration of the engines and the mission mechanicals and electronics into these core stages for their subsequent launch on these initial lunar base missions. Johnson Space Center for the continuous long term operation of these autonomous lunar outposts.

WHAT – Liquid reusable boosters with clustered engines and fuel cross feeding capabilities allow for their immediate landed recovery downrange of the launch site, and provide for higher performance and better control authority and acceleration management of the core vehicle stack through the atmosphere. Ground started SSMEs burning continuously through trans-lunar-injection at maximum acceleration, with sequential engine shutdown, is a remarkably efficient manner of reaching the moon with reserves. Five (5) restartable RL-10 engines provide a stable and robust landing system, transitioning seamlessly from lunar orbit insertion to parabolic landing using outer engine shutdown to inner engine touchdown.

WHERE – Launch Complex 39A/B at KSC are immediately available, and can be custom designed for the rapid turnaround railroads and erector systems needed to streamline launch operations. The Vehicle Assembly Building allows for vertical integration of systems into the large core stages before launch. Reusable boosters may be recovered near or in the Bahamas, without flying back to the launch site. Boosters may also be recovered on landing barges sitting in the middle of the Atlantic, or in the state of Florida or any other stationary floating platforms in the Gulf of Mexico if launching from Brownsville.

WHEN – We can start now and fly before the congressionally mandated date of December 31, 2016, and certainly before the end of the decade. By that time it is anticipated that commercial methane and hydrogen boosters and engines will be available, such as a restartable and deep throttleable 100k lbf offering from Blue Origin, and a 150k lbf methane version of the Merlin 1D engine from SpaceX. Much larger and more powerful engines using cryogenic fuels will then greatly simplify operations.

WORK – In the past year since I submitted my two page 2012 NIAC white paper entitled - *Resource Exploration and Exploitation in Near Earth Space – Satellite Salvage, Reservoir Crater Exploration and Asteroid Capture and Derotation* (link), I have since extended this primary space development architecture to incorporate direct lunar landings of large hydrogen powered core stages on the moon. I have produced a workable design for adapting the Space Launch System to lunar landing missions, investigated alternative circumnavigational, flyby and gravity assist trajectories to all near Earth orbital phase space, and offered compelling justifications for immediate implementation of this architecture.

This NIAC research proposal is a continuation of my development of the concept of incorporation and reuse of efficient and expensive hydrogen fueled core and upper stage launch vehicle elements into a general space development architecture, in order to greatly increase the useable mass and hardware value of any launch vehicle immediately after it has delivered any payload to the desired trajectory.

Payloads and their propulsion stages are delivered to identical orbital trajectories, and since space exploration and development payloads are unfunded, an obvious cost effective method to proceed is to use the propulsion stage itself as the payload. Propulsion stages, whether they are orbital capable core stages, or the upper stages of conventional launch vehicles, contain most of the elements of any viable space development architecture, including fuel and oxidizer tanks, cryogenic engines and attitude control systems.

The Space Launch System (SLS) as designed presents a multitude of engineering and policy problems - weight issues related to the need to carry large and heavy unfunded payloads requiring huge payload fairings, high development costs, high operational costs due to its expendable nature, a perceived lack of goals, missions or destinations, infrequent test flights in the far distant future with no discernible usefulness, and inability to meet congressionally mandated deadlines.

I propose that the Space Launch System could be redesigned for unmanned near term lunar polar landings, with the goal of establishing large lunar bases for robotic and eventually human operations. In this scenario the solid rocket boosters would be enhanced or replaced by liquid reusable boosters, the SSMEs would be pressed into service as direct ascent trans-lunar-injection engines, and the upper stage engines, most likely RL-10 and/or J-2X derivatives, would be integrated into the base of the core stage to serve as both lunar orbit injection and landing engines, yielding direct flights to the lunar poles.

I also propose methods by which basic human habitation with adequate radiation protection would be integrated into the vehicles for future lunar and asteroid industrial operations, and methods by which these industrial operations can yield the desired result of beyond earth orbit human space exploration. Additionally I have developed a set of lunar trajectories that permit the delivery of SLS cores stages of this type to lunar and solar Lagrange points, as well as asteroid and Mars transfers orbits, for future applications of this innovative space exploration and development technique – stated goals of NASA.

The goal of this effort is the timely establishment of large operational lunar polar bases for future power, navigation, communications and observation of the lunar polar environment by future telerobotically operated landers and rovers, for any government or organization that may wish to participate in this endeavor. This includes elementary, middle and high schools, and university level educational institutions. Methods I intend to utilize to develop and publish any results derived from this proposed NIAC research effort include the Orbiter Space Flight Simulator, an extensible program eminently suitable for interactive international, public and student participation in this effort.

The goal of this NIAC research proposal is to publish and promote, via peer review, the efficient and cost effective space development architecture I have developed over the last year as a direct result of work performed since my previous NIAC white paper submission.

A secondary objective is to obtain the relatively modest funding required to further extend, refine, develop and advocate this unique lunar base concept and space development architecture, in ways that I cannot predict, dependent upon fiscal and policy issues which are sure to evolve over the coming year of this proposed research effort.

Building Space Colonies on the Poles of the Moon and in Deep Space

In a series of white paper briefs over the last year, I have created a new space development architecture using an efficient and resuable dual fuel cryogenic launch vehicle design - developed for that purpose. A vital element of this architecture is the repurposing and refurbishment of the launch vehicle tankage into usable radiation protected water storage facilities, plant growing spaces and human rated habitats. Recent information on the severity of high energy particle damage to DNA, cells and organisms brings the poles of the moon back to the forefront of human destinations in deep space, due to its proximity to Earth, large mass and modest surface gravity, axial tilt nearly perpendicular to the plane of the ecliptic, the availability of raw materials, and the optical and thermal gradients necessary for their processing.

Problems of delivering infrastructure resources to the surface of the poles of the moon in a reasonably expedient manner have been addressed. Cryogenic fuel tank insulation must be upgraded to space rated materials that eliminate well known polyurethane foam shedding behaviors and still permit low boil off rates of the cryogenic fuels for the multi-day flights to the moon. A minimal attitude control system for the vehicle must be installed and large stowable lightweight rectangular thin film sunshade reflectors must be deployed to shadow the tanks and minimize cryogenic fuel boil off - oriented towards the sun. Cryogenic fuels must be settled to the bottom of the tanks to minimize surface area, and thus boil off, and then securely settled to permit the starting of the landing engines upon reaching a lunar flyby orbit. Variable tank pressures must be maintained to allow for the higher accelerations of the lunar injection burns incorporated into longer launch flight profiles with rapidly dimishing fuel loads and sequential engine shutdowns, and to secure the remaining fuel for orbital injections and landings onto the surface. Pressurization of the tanks must be maintained in lunar cruise and after landing, to permit the boil off gases of the settled fuels to either be used directly in fuel settling microthrusting, or to be recovered and converted into potable water by fuel cells - for use by future astronauts visiting the landed lunar bases. These are the well known engineering problems of cryogenic space flight that must be solved anyways, for any long duration human space flight programs that intend to be both cost effective and sustainable.

Now that reasonable chemically abundant space architectures and launch vehicle designs are available, we can extrapolate from the vertically landed lunar bases, to the habitation schemes contained therein.

Vast reusable spaces for materials storage and human habitation will clearly be available in the empty hydrogen and oxygen fuel tanks after they have been landed upon the surface of the poles of the moon. Utilization of these spaces for storage and habitation requires that access hatches and refurbishment be preenginnered for a minimum amount of suited astronaut interaction in the harsh vacuum environment. This requirement in turn demands that inflatable tank inner liners be integrated into the top of the tanks, where they can be deployed in a series of rings down the full length of the space, seperated by airlocks. In this manner during stowage and while flying, the inflatable spheres may be protected from cryogenic fuels, and after landing, deployed sequentially down into the tank in the much lighter lunar gravity. The storage ring collars and hatches between the spherical inflatable modules can also provide a measure of isolation between the individual segments of the habitation stack. Thus the entire habitation and storage stack can be deployed internally, without interfering with the fuel tank pressurization integrity, or the external airlock and docking port that is integrated into the top of the upper fuel tank (fuel or oxidizer). The entire tank habitation system is self contained, from the exterior docking port and airlock, to the sequential module stowage rings (doubling as cryogenic isolation and containment), to the individual module isolation hatches. This internally deployable system can be suspended from cables interior to each of the modules to eliminate the hanging stresses due to the relatively light lunar gravity. Once this technique is demonstrated, small capsules can be integrated into the nose of the vehicle for a crew and pressurized spaces interior to the fuel tanks may be used for water storage and large scale plant growth.

Solar Energetic Particle (SEP) and Galactic Cosmic Ray (GCR) Radiation Protection

Once a basic habitation scheme has been established for empty fuel tanks sitting vertically on the moon then the problem of SEP and GCR radiation protection can be addressed. In deep space the problem of radiation protection is greatly simplified by the absence of strong gravity fields, allowing any shielding materials to be stored between the walls of the internal inflatable habitats and their containing tankage. The closest guaranteed availability of shielding materials is the moon. The moon itself already protects residents from half of the universe, and mounded concentric rings of regolith or exhaust blast ejecta deflection walls can be erected in concentric rings with offset entrances to protect from any horizontal particle streams originating from the sun. The bottom portion of the lower tank can be filled with water or regolith to provide protection from above for any mobile habitats that may be parked underneath. Interior water or regolith protected spaces in the large diameter tanks can also provide up to eight feet of cosmic ray portection in nearly every direction. Future innovations could include seperations of the engine modules from the tank after lunar orbit insertion and a portion of the landing burn with seperate horizontal landings of the tanks and vertical landings of the engine modules, using multiple hypergolic attitude control thrusters for the tankage, and hypergolic fuel settling thrusters for the engine modules. This would provide empty horizontal surface tankage for large scale habitation and regolith protection, and properly oriented propulsion units with lighter landing gear available for almost immediate reuse. Alternatively, the entire vehicle could be landed horizontally with appropriate use of hypergolic thrust.

The primary purpose of tall vertically landed cylindrical launch vehicle cores on the poles of the moon remains the establishment of radial solar energy conversion surfaces for reliable energy production and to provide communications and navigation services for an extensive fleet of teleoperated robotic craft. The fact that the moon provides rich resources for radiation protection of the electronics and visitors is secondary to the primary goal of the exploration of the surface for carbon, volatiles and water deposits, and exploiting optical and thermal gradients for oxygen production and carbon dioxide sequestration, enabling infrastructure for future long term visits by astronauts in even the most rudimentary fashion. Large cable and tubing spools can simply be rolled across the surface to establish industrial capabilites between warmer sunlit areas of the site, down to the dark cold thermal reservoir craters located nearby. Deployable cables and jack systems integrated into the tanks and landing gear can stabilize the stacks against the high center of gravity and heavy storage loads anticipated with major industrial operations. Cryogenic storage tanks may be delivered in situ to any selected site after its observation and mapping. Specialized materials handling and processing equipment can be incorporated directly into the lower portions of these vehicles such that resource production can begin immediately after their delivery.

I have developed a cryogenic launch vehicle design and space development architecture that permits the repurposing and reuse of launch vehicle components as fundamental deep space infrastructure, and provided ample justification for its necessity. Over the next year I intend to sell this innovative concept to the public, private investors, NASA, Congress, the President, his advisors, and the OSTP and OMB.

References

Resource Exploration and Exploitation in Near Earth Space, Satellite Salvage, Reservoir Crater Exploration and Asteroid Capture and Derotation, NASA Innovative Advanced Concepts Solicitation Number NNH12ZUA002N.

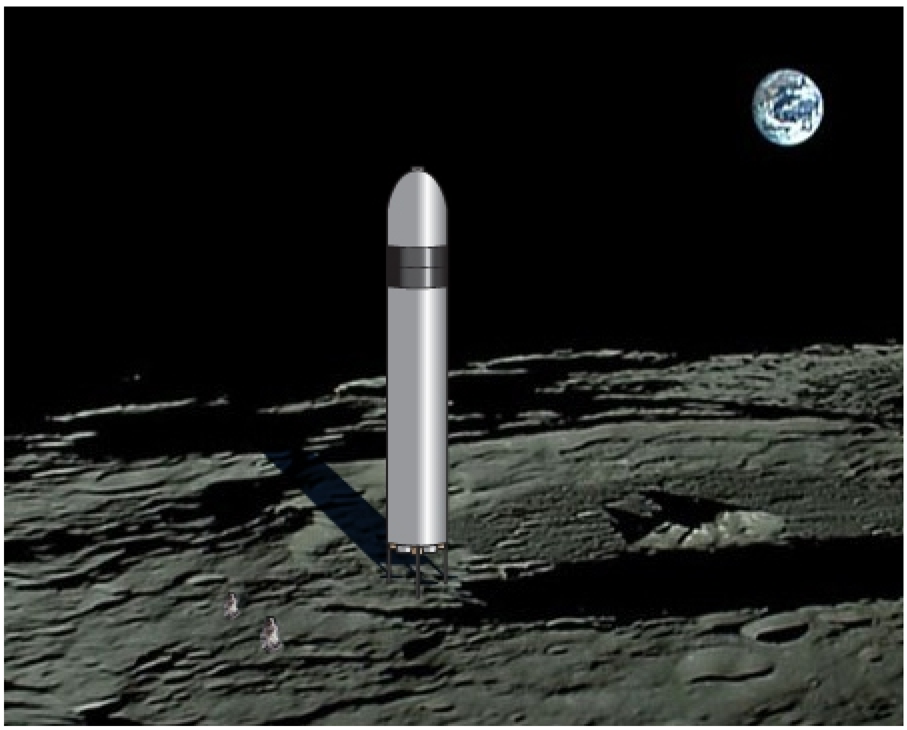
Lunar Direct – Landing on the Moon in a Single Launch.
Space Exploration and Development Architectures (For SpaceX Falcon Launch Vehicles).
Liquid Reusable Boosters for Lunar Direct Polar Moon Base Development (Using SLS Core Stages).
Lunar Injection, Circumnavigation, Flyby and Gravity Assist Trajectories (For SLS Core Stage Recovery).
Terraforming Planet Earth

Concept

Lunar Direct Polar Moon Base Development
Direct Lunar Flights to the Poles of the Moon
Reusable Deep Space Transportation Architecture
Reusable Launch Vehicle Design and Engineering
Integrated Radial Solar Power Generation Array
Wide Area Instrument Observation Platform
Power, Navigation and Communications Nodes
Scalable to Industrial Cryogenic Operations
Integrated Water Storage and Plant Habitats
Geometric Mass Radiation Protection Schemes

Study Approach

2013 NASA Innovative Advanced Concepts
Orbiter Space Flight Simulator Trajectories
Orbiter Space Flight Simulator Scenarios
Orbiter Space Flight Simulator Modules
Crowd Sourcing to International Partners
Crowd Sourcing to Government Partners
Crowd Sourcing to University Partners
Crowd Sourcing to Industrial Partners
Crowd Sourcing to Public Education
Personal Innovation and Publications



Benefits

Proximity, Location, Gravity and Resources
Reduces Costs and Risks of SLS Development
Provides Policy, Missions and Goals for the SLS
Definitive Demonstration of US Space Dominance
Uses Existing Legacy Assets to the Fullest Potential
Drives Public Private NASA Industry Partnerships
Future Lander Navigation and Communications
Future Rover Power, Command and Control
Future Industrial Cryogenic Storage Facilities
Future Human Rated Life Support Habitats
Future Lunar Resource Utilization (ISRU)
Future Orbital Resource Transportation

Evaluation Notes