

A Viable and Sustainable Economic Plan for Building and Maintaining an International Lunar Station

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ABSTRACT

There have been several architectural and design studies conducted over the past several decades to develop and build a permanent lunar base or station on the Moon. Beginning with the Apollo Program in the 1960's, there were several studies and proposals for building a lunar base following the first few manned landings on the Moonⁱ. However, the Apollo program was cancelled in 1972 due to shortage of funding, loss of public support and changes in political priorities.ⁱⁱ Since then, there have been several other NASA studies to build a lunar base culminating with the recent Constellation program initiated in 2006. The goal of Constellation program was to build a heavy-lift launch vehicle to transport astronauts to the surface of the Moon and begin development of a permanent lunar base. However, this program was also halted in 2010 after a review by the Augustine Committeeⁱⁱⁱ found the program's budget plans to be "unsustainable". Therefore, we conclude from history that in order to be successful in designing and building a Lunar Station, we must first implement a viable and sustainable economic plan that not only justifies the initial investment needed but also demonstrates a high likelihood for a positive return on investment to all stakeholders involved.

In addition to the economic plan, this paper will also include updated analysis and results of an ongoing architecture study previously published in IAC Paper^{iv} entitled, "Lunar Station: The Next Logical Step in Space Development" by mostly the same authors. This paper reviewed the many

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benefits and justification for building a Lunar Station, describing it as a very useful development step between our current capabilities in LEO, to the capabilities needed to transport humans to Mars. The paper also noted that Lunar Station would establish important infrastructure in transportation, high value extraterrestrial resources, power and communications, crew habitats and facilities that would significantly lower technical and financial risks for missions beyond the Moon. The paper also outlined architecture for Lunar Station including robotic precursor missions, launch vehicles, power and communications, landing site preparation, lunar habitats and crew transportation. Finally, the study concluded how it would be feasible for a station to be built in approximately 5 years and \$2 billion/year by leveraging ISS best practices and lessons learned, combined with current and emerging capabilities from the traditional and emerging aerospace industry.

The current paper will provide an update to Lunar Base architecture study by providing more detail on hardware elements including lunar landers, propellant depots, solar power stations, high-bandwidth communication stations, lunar rovers and ISRU and additive manufacturing methods. Also the latest capabilities and technologies being developed by traditional and emerging space companies will also be examined, such as, SpaceX's reusability of first stage for Falcon-9 and Falcon-Heavy and Made-In-Space 3D printing capabilities. Additionally, an informed cost estimate and schedule will be provided as a result of this study.

In addition to the architecture updates, an economic study will be conducted to estimate potential growth to markets and industry as well as potential impacts to US economy as a result of Lunar Station. To develop a successful economic plan, the study will closely examine different strategies to distribute the investments needed for building a Lunar Station including:

- Public/Private Partnerships
- International Partnerships
- Technology Investments
- Angel Investors
- Prizes/Challenges
- Anchor Customers

Other factors will also be considered, such as, assessments of emerging markets, new industries and new policies as well as review of best practices and lessons learned from development of a similar space infrastructure, the International Space Station. In the end, a viable and sustainable economic

plan will be presented for government and industry to adopt and implement together to successfully achieve the next milestone in human space exploration, an International Lunar Station.

References

ⁱ <http://www.astronautix.com/craft/alsrbase.htm#more>

ⁱⁱ Alan W. Wilhite and Patrick R. Chai, “Plan B for US Space Exploration Program,” AIAA Space 2014 Conference & Exposition, AIAA 2014-4237, August 2014.

ⁱⁱⁱ Review of US Human Spaceflight Plans Committee, Augustine, N., et al., “Seeking a Human Spaceflight Program Worthy of a Great Nation,” National Aeronautics and Space Administration, October 22, 2009, Office of Science and Technology Policy

^{iv} Robert Bruce Pittman, Daniel J. Rasky, Lynn Harper and Mark Newfield, “Lunar Station: The Next Logical Step in Space Development,” 65th International Astronautical Congress, Sep-Oct 2014.