Five Phases of Technical and Financial Lunar Development. D. S. Plata[1], [1]The Space Development Network, 29120 San Timoteo Canyon Rd, Redlands, CA 92373; developspace1@gmail.com.

Abstract:

Overview: Sustainable lunar development will likely follow a path of increasing complexity. It is proposed that this development could occur in five successive phases and that methods of funding each of these phases can be readily envisioned.

Lunar Resources: In the 2009 LCROSS mission confirmed the long-suspected presence of water ice on the Moon. Some of the locations suspected to have water ice are conveniently near local peaks with sunlight for a large percentage of the lunar year. It is generally thought that the next, initial steps of lunar development will involve telerobotic prospecting at the lunar poles to characterize the distribution of those resources. The LCROSS results indicate that, in Cabeus Crater, the estimated amount of water ice in the excavated impact crater was about 5.6% +/- 2.9%. This comes to one part in 18 which is very high concentration in terms of ore. Several peaks with sunlight for a large percent of the year have been identified using LRO data. Several local, smaller (e.g. 1-2 km diameter) craters can be identified as targets of high interest for the Resource Prospector mission.

Resource Prospector: NASA is developing a small telerobotic mission to scout areas on interest on the Moon with a particular emphasis on polar areas suspected to contain high quantities of ice. This mission(s) would provide the necessary data about the distribution of the ice within the regolith and whether extracting it at sufficient levels for propellant and crew is cost-effective. A set of small craters near one of the peaks with high quantities of sunlight is identified as a potentially interesting target.

Telerobotic Phase: Prior to crew arrival, and while the lander is not yet human-rated, a full-scale, telerobotic ice-harvesting phase could be attempted. If successful, this would significantly reduce the cost of later transportation. A notional concept for ice harvesting is briefly presented including a video animation. The concept minimizes the number and mass of hardware necessary to go from icy regolith to propellant. The telerobotic phase could also include the delivery of an initial, large, flat-roofed habitat with the telerobotic covering with regolith for shielding.

Initial Crew Phase: For infrastructure and historic reasons, it is recommended that the initial crew be a small, commercial team composed of men and women able to remain on the lunar surface for an indefinite period of time. Their primary roles would include the maintenance and expansion of the telerobotic, ice-harvesting workforce and the establishment of additional habitats in prepration for the next phase.

International Exploration Phase: The fourth phase could involve a large number of nations sending their national astronauts to the surface for scientific exploration on behalf of their citizens. This could involve the teams being transported in refueled landers on a series of suborbital hops before returning to the polar base to refuel.

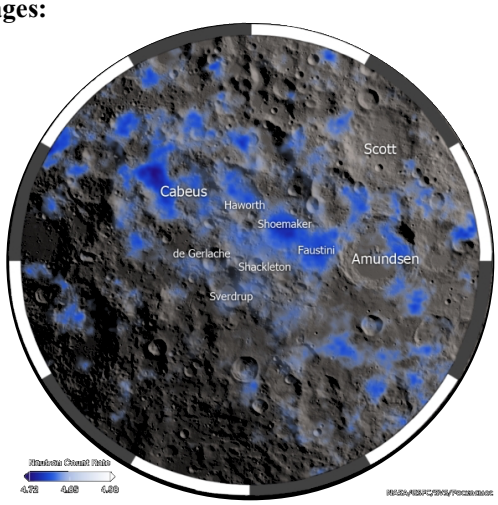
Private Settlement Phase: With the increased flight rate and in situ propellant production, the final phase of private settlement might be possible. Based upon the age distribution of wealthy individuals, it is suggested that retirees will be over-represented among this population.

Financing: It is proposed that the prospecting phase be funded as a regular NASA program and that the relerobotic and initial crew phases be funded via a set of public-private programs. Evidence suggests that a large number of countries would like to see astronauts exploring the Moon on behalf of their citizens and so the international exploration phase would be funded via national budgets. Finally, private settlement of the Moon would be primarily funded via the savings of the individuals.

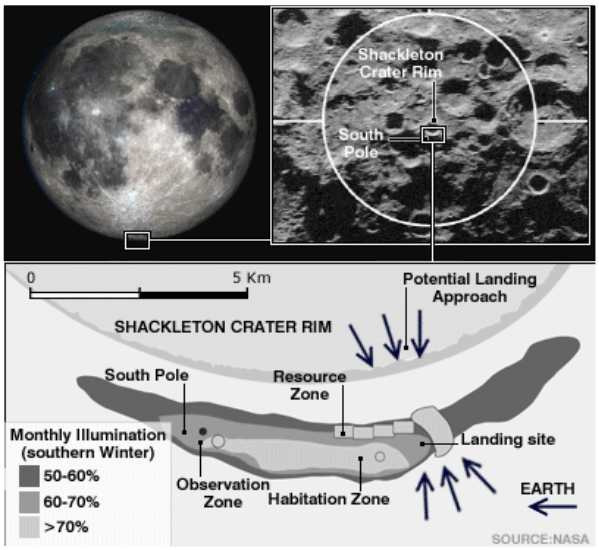
References:

[1] A. Colaprete, et al. "Detection of Water in the LCROSS Ejecta Plume", Science 22 Oct 2010: Vol. 330, Issue 6003, pp. 463-468. [2] A. F. Zuniga, et al. "Kickstarting a New Era of Lunar Industrialization via Campaigns of Lunar COTS Missions", AIAA SPACE 2016, AIAA SPACE Forum, (AIAA 2016-5220). [3] D. R. Andrews, et al. "Introducing the Resource Prospector (RP) Mission", AIAA SPACE 2014 Conference and Exposition, AIAA SPACE Forum, (AIAA 2014-4378). [4] M. Duke, et al. "Mining of Lunar polar ice", 36th AIAA Aerospace Sciences Meeting and Exhibit, Aerospace Sciences Meetings, https://doi.org/10.2514/6.1998-1069. [5] L. Purves. "Use of Lunar Outpost for Developing Space Settlement Technologies", AIAA SPACE 2008 Conference & Exposition, AIAA SPACE Forum, https://doi.org/10.2514/6.2008-7680

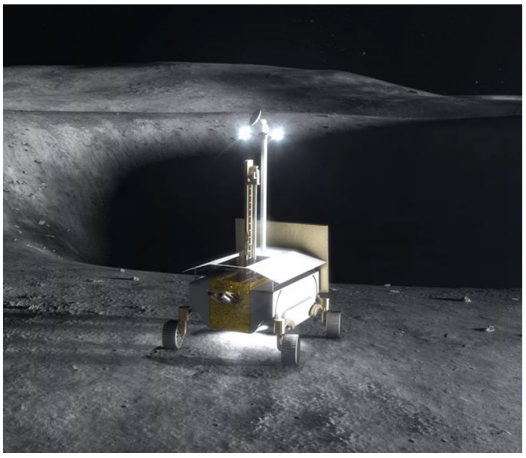
Images:



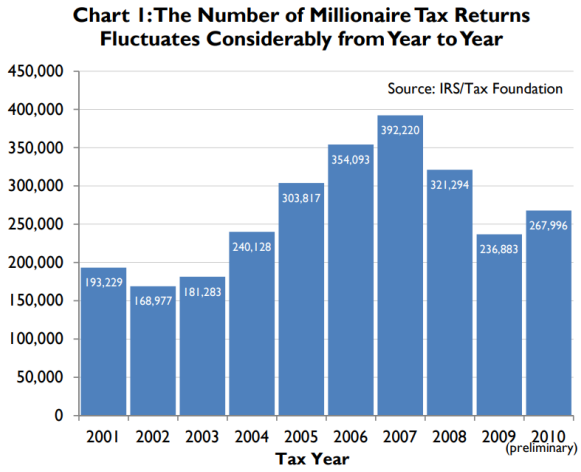
Hydrogen distribution by the south lunar pole (NASA).



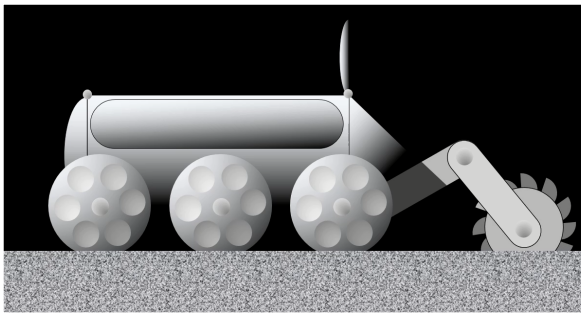
Lunar base concept - Shackleton Crater (NASA)



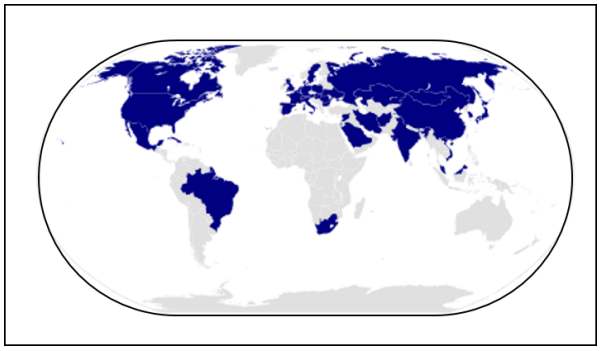
Resource prospector mission (NASA).



(IRS – Tax Foundation)



Notional concept for an ice harvester.



Countries of astronauts (Wikipedia - AstroFreak29)