WHY WE WANT/NEED TO GO TO THE MOON WITH HUMANS. C. R. Neal[1], [1]Dept. of Civil & Env. Eng. & Earth Sciences, University of Notre Dame, Notree Dame, IN 46556, USA. (neal.1@nd.edu)

Introduction: Since the return of the last human mission to the Moon, Apollo 17 in December of 1972, human spaceflight has been restricted to Earth orbit. With a stated, but as yet unfunded, mandate by the US government to get the US human spaceflight program beyond Earth's orbit, it requires a destination to aim for. To date, the Moon, a near Earth asteroid, and Mars have been seopculated as destinations, although current US Space Policy only includes an asteroid rendezvous and Mars orbit as destinations for human spaceflight [1]. While a lot of capability has been lost since the end of the Apollo program, technological advances and strengthening of the private space industry could facilitate the development of commercial human space flight to the Moon.

Sample Return: Samples from the Moon continue to yield imposrtant insights about our nearest celestial-neighbour. Lunar samples can be categorized on the way they were collected: 1) Lunar meteorites collected on Earth, with no idea of source location on the Moon; 2) Robotically collected regolith samples (the Soviet Luna sample returns), with little geologic context and, until recently, the exact location of one sample return was not known; 3) Human collected samples that have geologic context. While any lunar sample is important, having samples that fall within Category 3 are the most valuable, not least of which is their ability to ground-truth orbital observation. While geologic context can be evaluated in a rudimentary fashion via robotic sample return, having the trained human mind present on the surface not only allows for more efficient sample collection, but also enables the ability to react to non-optimal mission scenarios and serendipitous science discoveries (e.g., discovery of the orange soil by Apollo 17 astronaut, Harrison Schmitt). Apollo samples are still yielding exciting results 40+ years since their collection (e.g., existence of volatiles in the interior of the Moon [2]; a long-lived magma ocean [3]).

Surface Experiments: Like the Apollo samples, data from the Apollo Lunar Surface Experiment Packages (ALSEP) are also a "gift that keeps on giving". For example, using modern computing power, the existence of a lunar core with solid inner and liquid outer portions [5] has been discovered. In addition, there is still one active ALSEP experiment – laser ranging – that utilizes instruments placed by the Apollo astronauts on the lunar surface (e.g., [6,7]).

Exploration: With the current long-term goal of NASA being to send humans to Mars, the logical testbed is the Moon. However, the current administration appears reticent to include the Moon in its long term human space exploration plans [8]. This does enable the US private sector to facilitate human lunar science and exploration. The Lunar Exploration Analysis Group (LEAG) has developed the Lunar Exploration Roadmap after much input from the broader lunar community [9]. This roadmap and other LEAG documents (e.g., [10]) concludes that the only way to sustain human space exploration is through the development of lunar in situ rources and involvement of the private sector (through commercial on-ramps) early in the next stage of human Solar System exploration.

Why Human Exploration? One can argue that the main reason for human space exploration is for national pride. However, with a non-governmental approach, this main reason could be cynically viewed as making a profit. I view the main reason as one of opportunity. The detailed exploration over 3 Earth days on the lunar surface that could be conducted by humans would take months or even years with robotic landers. Both sample return and deployment of surface experiments (returning data long after the astronauts have left) could be achieved. Given the complexity of sample collection and return plus that of surface experiment deployment, at least two robotic missions would be required to achieve the outcomes of one human mission. However, note that the quantity of robotically returned sample would be lower. Finally, with the trained human eye on the lunar surface, serenditpitous science discoveries can occur (e.g., return of 15415 Gensis Rock by Apollo 15).

Conclusions: The development of the commercial human spaceflight industry is critical for a sustainable exploration beyond Earth's orbit. With the relative closeness of the Moon, developing human lunar surface exploration via the private sector will bring the Moon into Earth's sphere of economic influence and will generate highly skilled jobs. It will also rekindle the dream human Solar System exploration that has been lost since the cancellation of the Apollo program.

References. [1] National Space Policy of the United States (2010) http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf. [3] Saal A.E. et al. (2008) *Nature 454*, 192-195. [4] Borg L.E. et al. (2011) *Nature 477*, 70-72. [5] Weber R.C. et al. (2011) *Science 331*, 309-312. [6] Williams J.G. (2006) *Adv. Space Res. 37*, 67-71. [7] Murphy T.W., Jr. (2009) *Space Sci. Rev. 148*, 217-223. [8] Obama B. (2010) *http://www.nasa.gov/news/media/trans/obama_ksc_trans.html* [9] LEAG (2013) *http://www.lpi.usra.edu/leag* **[**10**]** LEAG (2011) *http://www.lpi.usra.edu/leag/reports.shtml*.