THE LUNAR EXPLOITATION INDUSTRY COULD TAKE OFF WITH SOME MORE GOVERNMENT SUPPORT

by Giulio Prisco

In my last *SpaceNews* Op-Ed I argued that we should build a sustainable presence on the Moon before moving on to Mars and beyond.

I stated that promising business cases for returning to and start exploiting the Moon, with reasonable funding and reasonable expectations of return, are beginning to appear. Some readers criticized me for stating this without supporting evidence (I just linked to Paul Spudis' 2016 book). They also noted that, were this the case, space companies should be rushing to the Moon with their own money, without government support.

There is, however, a big difference between the "promising business cases are beginning to appear" and "solid business cases exist" phases. In the first phase, a few venture capitalists start investing, but most large investors stay behind to see what happens. The exploitation of lunar resources is still in the first phase, and I think public funding is still needed to bootstrap the industry.

Therefore, I think governments (and in particular the U.S. government) should continue to lead the way, in partnership with private industry, and encourage commercial partners to assume leadership when the time is right.

For the sake of clarity and intellectual honesty, I should state where I'm coming from. As a follower of Konstantin Tsiolkovsky and other visionary space pioneers, I think becoming an interplanetary and then interstellar species is our cosmic destiny and existential imperative. Therefore, I firmly support humanity's expansion into space as a primary goal. However, I realize that many don't share my philosophical convictions, and that I can only persuade them with arguments based on practical utility and returns.

Having said this, I'll now outline some promising business cases that could (and should), in my opinion, motivate commercial interest in lunar resource exploitation and a following wave of human expansion into the solar system.

The Moon can be mined for water, rare earth elements, and helium-3.

Lunar water and the oxygen that can be extracted from it would be used by astronauts in lunar outposts and colonies. Furthermore, lunar water can be processed into rocket propellant for future crewed missions to Mars and other planets. Of course, arguments based on lunar water are somewhat circular, since they assume the need for astronauts on the Moon and the planets in the first place.

However, a comprehensive open study of a commercial lunar propellant architecture demonstrates, according to its authors, "both the technical and economic feasibility of establishing a commercial lunar propellant production capability," with the assumption that the U.S. government will purchase the propellant to "fuel a new age of economic expansion, sustained space exploration, settlement, and American leadership in space." The proposed production facility would be, at least initially, purely robotic with no human presence required.

Mining the Moon for resources that can be sent back to Earth and sold at a profit is easier to justify without circular arguments.

There is a high demand for rare earth elements in the defense and high technology industries. At this moment, China controls more than 80 percent of the global rare earth elements supply, which could lead to dangerous geopolitical developments and the need to pursue lunar supplies independent of China.

In "*Return to the Moon*" (2006), Harrison Schmitt developed a comprehensive end-to-end plan for mining helium-3 on the Moon and shipping it back to Earth to power next-generation nuclear fusion reactors. A large supply of helium-3, which is only present in trace amounts on Earth but is much more abundant on the Moon, could open the door to environmentally safe nuclear fusion, which might be the solution to future energy needs.

Schmitt briefly covers other lunar exploitation schemes as well, including lunar surface solar power systems. David Criswell and others proposed to build large solar collectors on the lunar surface, using local lunar materials, and beam power to Earth via microwaves. However Schmitt thinks lunar helium-3 mining is a more realistic business model that could be pursued by commercial companies with no or limited government support.

Helium-3 "is an ideal fuel for fusion power, produces no radioactive residuals of any kind, but produces electrical power at very high efficiency when fused with itself, or with the heavy isotope of hydrogen called deuterium," confirms Schmitt in a recent NASA podcast.

In his foreword to Schmitt's book, Neil Armstrong noted that the viability of the plan depends on three substantial and important developments: a commercial fusion reactor, an efficient mining operation on the Moon, and a reliable cargo transportation system. Schmitt's plan covers all three, with plenty of detail.

Schmitt's plan has been criticized, mainly because the first of these elements, a commercial fusion reactor powered by helium-3, doesn't exist yet and doesn't seem very close since there are many technical challenges to overcome. However, there are promising indications that using helium-3 in fusion reactors could be the way to achieve practical nuclear fusion. Further developments have been funded by large energy companies and could create a huge market for lunar helium-3.

Lunar helium-3 could "solve human beings' energy demand for around 10,000 years at least," said Ouyang Ziyuan, chief scientist of the Chinese lunar exploration program, as reported by *BBC News*. The idea comes to mind that China could try and become the leading supplier of lunar helium-3.

"The cost of placing large payloads on the Moon will constitute the single greatest component of the total cost of obtaining lunar helium-3 fuel," notes Schmitt. According to his detailed analysis, this cost must be reduced to $3.000 per kilogram (a 20-fold reduction of the Saturn V cost) to make lunar helium-3 mining commercially viable.

“We should be looking for technologies that will radically transform the economics of going into space,” said the late lamented Freeman Dyson. “We need to reduce the costs of space operations, not just by factors of five or ten but by factors of a hundred or a thousand, before the large-scale expansion of mankind into the solar system will be possible.”

The reusable launch systems developed by SpaceX and Blue Origin are making significant and steady progress toward meeting Schmitt’s target cost of $3,000 per kilogram on the Moon, which now seems achievable. The more spectacular cost reductions envisioned by Dyson could be offered by future technologies, but what we have now is beginning to look good enough for lunar resource exploitation.

I think the best way for the U.S. government to create cheaper space transportation options suitable for lunar exploitation is to support commercial operators. Instead of developing new government-owned space transportation systems, which are too vulnerable to cost overruns, the government should buy launch and lunar cargo services from SpaceX, Blue Origin, and other commercial operators. Therefore, I think the recent NASA authorization bill, which would reject NASA’s plans to use public-private partnerships in favor of government-owned launchers and landers, is a big step in the wrong direction.

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