The Mutuality Between Science and Commercial Exploration of the Moon

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Summary Introduction

The growth of the commercial space industry offers the potential for a new paradigm in space science and exploration. A clear understanding of the relationship between NASA and commercial space exploration, and what this means for the future of scientific exploration is needed. It is important for the commercial sector, science community, and the general public to appreciate that commercial space exploration facilitates science and that science can prosper as a result of commercial space exploration.

1. Topic

1.1. Historical analogs for commercial space exploration and development, and the role of government

1.1.1. Railroad Industry

Some may argue that the railroad industry is the type example of privately-funded American industrialization. However, indirect federal subsidies were provided by the federal government in the form of route surveys made by army engineers. In 1850 the federal government provided assistance to railroad companies by giving them millions of acres of public land. The railroad companies sold the land to make money, which they used to build their railroads [1].

1.1.2. Mining industry

The hope of finding wealth in mineral treasure was one of the incentives that led the early colonists to America. As the population expanded into the West, the discovery of large deposits of both precious and base metals, as well as other valuable minerals, was an attraction to both workers and investors. Mining has the possibility of making a great deal of money in a short time, so, despite several speculations turning unprofitable, private funding was sufficient to drive the industry without the need for government backing [2].

Unfortunately, since there is no profit in worker safety or environmental protection, oversight is left to the federal government. In 1910, the U.S. Bureau of Mines (USBM) was established with the mission to “provide the mining industry with information on blasting materials and techniques that could be used safely in the presence of flammable mine gases and dust”. USBM work resulted in an important body of information with much wider applications. For example, USBM’s work on explosive and flammable materials was of interest to other industries and government agencies, including the Department of Defense, Air Force, Department of Transportation, Coast Guard, and NASA [2].

1.2. Innovative technologies from businesses funded by government

Over the last 130 years, the U.S. economy has grown exponentially, and this growth can largely be traced back to technological advancement. The U.S. military was the first example of government-funded innovation, beginning with the production of arms and

the seminal industrial technology of interchangeable machine-made parts. This technological advance ultimately paved the way for mass production, typified by the Ford Model T [3]. Military support is also responsible for early development of the computing industry, beginning as the sole market, and eventually subsidizing private industry toward commercialization (Fig. 1) [4].

Innovation relies on supporting research and development, and innovations are critical for the success and safety of advancing space exploration, especially human exploration. Most commercial companies, especially start-ups, are not financially capable of funding basic research; they focus their money on the development stage.

Commercial technology development has driven down costs for software and hardware components, and paved the way for the inception of CubeSats, and more recently ChipSats [5], which use commercial off-the-shelf components instead of space-qualified components. These types of innovations are expected to be the fruit of commercial space exploration.

Without federal involvement, extensive and potentially prohibitive delays in the development and commercialization of space exploration will occur. Compared to the early days of industrial technology advancements (Section 1.1), the U.S. government is in a much more stable position and a world leader in technology innovation. There is, however, a need to expand the synergy between science and exploration for building

Figure 1: IT Sectors with Large Economic Impact. Source: NRC report, "Continuing Innovation in Information Technology".

new opportunities through which both the science community and the private sector can mutually benefit. It would be a disappointment if our country slipped behind, particularly in space exploration - which is an inspiration to so many people world-wide - through indecisiveness, mismanagement, or miscommunication in how NASA-commercial space partnerships will develop.

2. Significance

As private companies venture into space, NASA is the lighthouse, Science is the ship. NASA illuminates the way, and Science is crucial for companies to safely navigate these waters. It is in these companies' best interests to maintain and invest in improvements to their vessel as we boldly go into the vast beyond.

2.1. The mutuality between science and commercial space exploration

The synergy between science and commercial space exploration is not unlike the type of prospecting done for oil or precious metals. Private companies rely on science to understand what is needed to successfully meet their commercial objectives. Science enables commercial space exploration by identifying the best locations for different resources, determining the accessibility of different resources, assessing the feasibility of landing sites, and determining strategies for hazard mitigation.

The growth of the commercial space industry is a boon for science, as these companies become innovators in providing access to space at reduced cost, develop new methods of exploration, and through this, advance scientific knowledge. The commercial sector enables science by building equipment, providing platforms to space, carrying, deploying, and returning data from our instruments, utilizing our instruments for their prospecting endeavours, and ultimately providing an alternative source of funding to conduct our science. As these companies grow and push the boundaries of what is known, it is in their interest to invest in scientific research, for their own profit and security, in order to better understand new terrains, new ways of accessing resources, discovery of other potential resources, and other things that are outside the scope of prediction. In this way, space exploration, as a business, will advance science.

2.2. The Moon is the logical first step

At this point in our effort to build a sustained space economy, the Moon is the best place to begin. It will be much easier for commercial programs to develop on the Moon than on Mars or asteroids, so we stress the importance of maintaining focus on the Moon over the coming decade; that is the only way for commercial space beyond LEO to become sustainable.

The Moon is close to home. This means travel times from Earth and LEO are relatively quick; much quicker than to Mars or an asteroid. Astronauts can see home (provided they are on the nearside). We have not yet begun to explore the psychological effects of being very far from the safety and security of home Earth. If studies on the effects of isolation give us any indication, it could be devastating. Being

able to see home, or, if on the farside, at least know home is less than three days away, will be a small comfort that astronauts will not have at Mars or an asteroid.

We have a future goal of going onward to Mars. The Moon is a better place to develop and prepare for Mars because the gravity environment is closer to Mars compared to an asteroid. Grappling, landing, manipulating, developing, and extracting resources on an asteroid is going to be very complicated, and the kinds of technologies and methods that will need to be developed for that specific gravity regime will not work on Mars. Likely there will be a need for working with an asteroid in the far future, however, if our vision, our ultimate objective, is to prepare for human travel to Mars, the Moon is the logical first step.

In 10 years, hopefully, regular, low-cost lunar delivery missions will be common, with NASA as a marginal buyer within an ecosystem of other clients from around the world. Additionally, the first wave of successful resource prospecting activities will have occurred, yielding private investment in ISRU demonstrations, along with infrastructure on the lunar surface for large power system generation, material extraction and sampling, habitat build-up, and other elements needed for permanent, sustained presence for crewed and uncrewed activities.

2.3. Commercial Lunar Payload Services (CLPS)

The CLPS initiative was designed to leverage the expertise and innovation of private industry to get to the Moon quickly. As we build a steady cadence of deliveries, we'll expand our ability to do new science on the lunar surface, develop new technologies, and support human exploration objectives.

- Thomas Zurbuchen, Associate Administrator of NASA's Science Mission Directorate

"NASA's Commercial Lunar Payload Services (CLPS) initiative allows rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration or commercial development of the Moon. Investigations and demonstrations launched on commercial Moon flights will help the agency study Earth's nearest neighbor under the Artemis program." [6]

The expectation is that through competition to win NASA contracts, the CLPS program will reduce the cost of future lunar missions, facilitate technological innovation, and usher in a new age of commercial space exploration. The CLPS program serves as a bridge to foster the commercialization of lunar exploration for establishing a sustainable lunar exploration program. The investments in commercialization further enable a next big step to building a space economy beyond low-Earth orbit.

NASA and other government agencies may be the initial customers, but after CLPS companies demonstrate their capabilities and success, other clients will surface, such as university investigators and private companies that wish to do experiments in cislunar space. Eventually, as a cislunar economy develops, an ecosystem of commercial enterprises will emerge; directly as customers of the CLPS companies and indirectly as technologies developed by CLPS companies are desired by missions to

other Solar System destinations, other businesses around the world, and even different industry sectors.

NASA is acting as a “lighthouse customer” by providing technical expertise and guidance to these private companies as the “lunar delivery services,” market emerges. NASA is in a unique and valuable position to help create an international standard for future lunar exploration that can protect the scientific integrity and natural heritage of the Moon.

2.3.1. What’s working

The speed at which CLPS has moved to get missions on contract and payloads developed matches commercial timescales and helps show the space community the seriousness and depth of the U.S. return to the lunar surface. It motivates the private sector to get engaged with the research and development of lunar payload delivery technologies. With time, the demand for CLPS flights will hopefully increase, thereby encouraging competition and a new pool of companies interested in joining space exploration.

This rapid pace of the CLPS missions is also appealing to PIs who, for the first time, have the opportunity to do repeated or iterated investigations to the same planetary destination, and could conceivably have numerous such opportunities in their career. That is a new paradigm for doing science investigations in space. In addition, CLPS has begun engaging with NASA mission directorates outside of SMD. These factors will contribute significantly to the program’s progress and sustainability.

NASA has decided that sophisticated and nationally important missions, like VIPER, which are so critical to our future on the Moon, can and should be delivered via CLPS. This is an immensely positive development because it shows that NASA is serious about the utility of the CLPS program to achieve important agency goals, and shows great confidence on the part of the US government in the providers. This is definitely being noticed by the non-NASA commercial market.

2.3.2. What could be improved

At least for the primary rounds of task orders, NASA restricted communication between the CLPS proposers and members of the instruments’ science teams. NASA’s stated intention was to ensure that no proposing team (science or commercial) could gain advantage over another through that communication. It may have made for a level playing field for the proposing teams (instrument and commercial), but it created considerable confusion and lingering uncertainty as to whether the selected teams will ultimately be compatible. Hopefully, this policy restricting communication will not be necessary in future competitions.

NASA could help facilitate and encourage a better interface between the CLPS payload developers and commercial partners to inform the types of payload accommodations needed, platform capabilities, selection of landing sites, analytical procedures and necessities, and a myriad of nuanced information about a mission. It is not efficient for NASA to work as an indirect middle man in these types of communications (which was how communication worked during preparation of CLPS

proposals). The CLPS providers do not know what is needed until they are able to talk directly with scientists. If instrument developers need to consider alternative platforms and interfaces, they need to know this early in development. Involving industry early in preparing an instrument RFP can help clarify requirements and expectations, resulting in fewer amendments and questions.

Start-ups are struggling to make a credible business case to potential customers and investors in an emerging market that may take decades to get anywhere near self-sustaining. If the intention of the CLPS program is to help smaller, or less resourced companies become sufficiently competitive in order to foster the growth of the commercial space sector and thereby drive down costs and get to the Moon faster, then there must be a system for ensuring the competition is fair to all competitors, big and small. For example, there could be "tiers" of CLPS-like programs - seed money for start-ups who have little development, more money for companies who are close to finishing, etc.

3. Recommendations

We request that the Decadal Survey address the future of commercial partnerships. If it is within the Committee's scope, we ask that the Survey recommend that NASA continue support to develop commercial space programs.

This is important because commercial space companies could enable many - perhaps all - of the goals described in the Decadal Survey by making missions less costly, more feasible, in reasonable time frames, and without the kinds of funding and directive ebbs and flows that come from government entities. It will be much cheaper for NASA to buy rides to other planetary bodies to conduct science investigations and test new technology systems, instead of owning the delivery systems. The science community can explore more places and do more science, faster and for less cost, as one of multiple customers on a commercial company's vehicle.

We urge the Committee to include in the Decadal Survey a recommendation that NASA develop a 10-year plan for the NASA-commercial partnership for the Moon and Gateway that is goal-oriented¹. We find these enumerated topics of particular importance to be addressed in this 10-year plan:

1. In this plan, NASA should specify the role that CLPS and any similar commercial partnership programs will play in relation to Artemis.
2. The plan should include whether NASA will continue to dictate the goals and locations of every CLPS mission, or whether mission objectives will become part of the competition in future CLPS mission task orders.

It is important for the science community to know NASA's plan and intended pace so that the community can plan the direction of research projects and instrument developments. It is important for the community to know NASA's vision for how those goals will evolve from science, exploration, and tech demonstrations to preparation for

¹ Some of the things requested here have already been specified by NASA, but are included here to describe a cohesive plan.

human missions and ISRU. It is important for private space companies, in the developing phase, to know the specific path for government funding.

3. We request that the plan address whether and how similar investments are planned for Mars science and exploration [7].
4. Lastly, we request that this 10-year plan address how the partnership is expected to develop beyond 10 years, including, if possible, how NASA's role with the currently supported space companies will transition from supported to customer.

Perhaps, NASA might consider taking on some responsibilities as a safety and oversight agency, working in conjunction with other national space agencies. There will be issues that require government oversight, such as international law with respect to property rights and space mining rights. NASA would continue to fund scientific research, and like USBM (Section [1.1.2](#)), start a research program focused on regulating the environmental impacts of commercial space and the safety of workers (in space/on Moon/Mars/ asteroids).

We ask the Survey to recommend that NASA consider including, in their 10-year plan, NASA's longer-term vision (up to 100 years), and how the next 10 years prepares for that future. Although the Decadal Survey is limited to 10 years, it should not be short-sighted. The planetary community would like reassurance, or a clearer understanding, of NASA's vision for future generations.

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