“Reaching for the Stars: The Importance of NASA Administered Rocket Research and Development Alongside SpaceX”

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In response to the launch of the first satellite by the Soviet Union, the United States Congress established the National Aeronautics and Space Administration (NASA) in the late 1950's as a civilian government agency, funded solely by the government, responsible for space exploration. After a decade of conducting rocket research and development (R&D), NASA reached the pinnacle of its accomplishments with the production of the Saturn V rocket system, which brought the first men to the Moon and safely back to Earth. NASA continued rocket R&D until the turn of the century, when it shifted to contracting out this work to United Launch Alliance (ULA), a joint venture between the defense arms of two publicly-traded aerospace companies, Lockheed Martin and Boeing. This joint venture—which is an agreement between companies to work together on certain projects, sharing project expenses and profits, while keeping the rest of their businesses separate—allowed Lockheed Martin and Boeing to work on rocket R&D for NASA without having to compete with each other. Because both Lockheed Martin and Boeing are public companies, ULA is required by law to disclose operational and financial information to the public, which keeps the public informed of its progress in rocket development. As administrator of ULA, NASA funds the work, directs how money is spent, sets progress milestones and determines engineering and time constraints.

Elon Musk founded SpaceX as a privately-held company "in 2002 to revolutionize space technology, with the ultimate goal of enabling people to live on other planets" (Muegge, Reid

20). In less than two decades, the company went on to become the industry leader of commercial rocket production. Recently, SpaceX became the first company to compete with ULA for NASA contracts, underbidding ULA with reusable rockets that cost considerably less. In contracting SpaceX, NASA would be buying technology without input into its development, from a private company that is not required to publicly disclose operational information. Given Musk's ability to outperform and undercut the cost of ULA's rockets, considerable debate exists whether NASA should continue to administer rocket research and development or purchase commercially available technology from private launch service providers. Because there are no other providers that can currently compete with SpaceX, abandoning NASA management of rocket R&D would put NASA at the mercy of SpaceX in determining the pace and cost of rocket development. Moreover, while the public is supportive of funding space exploration, it is skeptical of private space explorers. Continuing to manage the work of ULA, while inefficient, provides a backup that ensures the work can progress if SpaceX decides to no longer sell rockets to NASA. Furthermore, it ensures investment in research without foreseeable applications, which is necessary for great strides in the advancement of science. Given concerns about relying on a private company and public support for government managed research, despite the cost savings from purchasing commercially available rockets and the redundancy of supporting two parallel sources of rocket technology, NASA must continue to manage rocket research and development while also purchasing SpaceX's commercially available low-cost technology to ensure the continued success of the space exploration program.

Comparing NASA-Administered Rocket Research and Development to Commercial Product Development

Abandoning NASA-administered rocket R&D to purchase rockets from SpaceX equates to relying on a single source of technology from a company that will prioritize corporate gain over advancing space exploration and following the will of society. Studies have shown that bias in favor of profits exists in privately funded scientific research. For example, there is evidence that "Drug research sponsored by the pharmaceutical industry is more likely to end up favoring the drug under consideration than studies sponsored by government grants or charitable organizations" ("Who Pays for Science?"). The aftermath of corporate greed goes beyond approving a drug that may not be as effective as advertised. Meghan O'Gieblyn warns of greater dangers in her piece *Objects of Despair: Mars*. Private space explorers, with Elon Musk as the lead example, are too focused on the science that won them funding to consider the needs and wants of the people. Their corporate goal is to alter the political landscape in a way that better benefits their bottom line. Corporations and their Chief Executive Officers (CEOs) end up encouraging the system that keeps them on top: "The billionaires are not becoming multiplanetary to experiment with different political and economic philosophies but rather to clone the one that … put them in charge in the first place" (O'Gieblyn). Rather than exploring space to realize the dream of improving society, they look to expand beyond our planet while maintaining the current power structure. Even if it is not explicitly stated, this misuse of power has consequences for the general public, as it "will result in a culture warped by its founders" (O'Gieblyn). With the use of "warped", the author describes the extent to which the private explorers' goals differ from those of the taxpayers, and the potential damage that results from allowing them the power to dictate social, political and economic structures in space settlements.

This is why Mars is an "Object of Despair," as it will bring nothing but despair and hopelessness for the American public; private space explorers will continue to grow in power, and the public will never realize the space utopia it yearns for, instead enabling the development of a 'corporate dystopia.' O'Gieblyn's omen for the future presents a valid argument for fearing privatization of space exploration.

While fears of a corporate dystopia may seem far-fetched, the dramatic pace of the growth of SpaceX's global internet access project provides an example of a project with the potential to realize these fears. As of early November, Elon Musk has been launching constellations of satellites into space in support of developing space-based global internet access. Once completed, his Starlink project is expected to "contain more than eight times as many satellites as the total number currently in orbit" (Hall). While this would revolutionize the broadband service industry, astronomers are concerned by the light pollution caused by these satellites, since SpaceX has been approved to launch 12,000 satellites and "If thousands more of these satellites are launched… 'it will look as if the whole sky is crawling with [false] stars…'" (Hall). The seemingly fantastical future presented by "Objects of Despair" where corporations take advantage of their power without regard for the will of the people is already becoming a reality. As astronomers clamor over the swath of consequences of launching so many satellites, enough that they could ruin a whopping 20% of all images of the night sky, Elon Musk broadcasts his accomplishments tweeting "Sending this tweet through space via Starlink satellite 🛰…Whoa, it worked!!" (Hall). SpaceX is truly running full steam ahead with Starlink, without regard to the worries of astronomers. Elon Musk's breathy excitement regarding his achievements shows his obliviousness to the potential negative impact of his project and the foreboding concern for the damage to efficiency of billion-dollar telescopes and the potential

drastic reduction to the effectiveness of ground-based astronomy. As “Objects of Despair” reads, corporations do not have an answer for the issues that affect society, but instead focus on their latest developments, perhaps happily droning on about reusable heat shields (O’Gieblyn). Discontinuing government funded administration of rocket R&D and purchasing commercially available rockets from a single source is concerning, since it is impossible to assess the extent a corporation would “care about the opinion of people who care about science and astronomy” (Hall) over making decisions that improve its profit margins. The public is justified in fearing that SpaceX will favor its own success over societal wants and needs.

While the public is skeptical of private space endeavors, it is generally supportive of funding government administered space exploration to advance scientific discovery. As evidenced by Massimo Florio’s study, “there is a positive social attitude, proxied by the WTP [Willingness to Pay] for basic research” (Florio et al. 14). In his analysis, Florio goes to great lengths to detail the importance of maintaining government-funded research, describing the construction of large-scale research infrastructures as “the contemporary cultural equivalent of building pyramids or cathedrals because of its highly symbolic value” (Florio et al. 13-14). This symbolic value is tied to government-funded agencies because only they are positioned to conduct “curiosity-driven” (Florio et al. 2) research independent of the profit demands placed by corporate investors. Government-funded research is elevated to a high standard, with the potential to yield marvels such “pyramids or cathedrals.” The choice to compare the output of research infrastructures to such important cultural cornerstones suggests a moral obligation to support them. While these marvels will not directly benefit the average citizen, they demand support, since “the existence value of RIs [research infrastructures] should arise from the pleasure (or utility) of knowing that something may be discovered, hence its existence is

revealed, even if there is no predictable use of it" (Florio et al. 2). Therefore, supporting publicly funded research itself is as important as are the potential research outcomes. This creates a dichotomy between the privately funded research of SpaceX and the government-funded work of NASA. Government funded agencies like NASA are not constrained by pressures to make profits, and with virtually unlimited funds and time, have the ability to conduct research for the sake of research, producing long-lasting scientific monuments: "History... will find in the monuments of Big Science – the huge rockets, the high-energy accelerators, the high-flux research reactors – symbols of our time just as surely as she [History] finds in Notre Dame a symbol of the Middle Ages" (Florio et al. 13-14). Because SpaceX's goal is to improve its profit margin, it cannot afford to take the time required to build "Big Science monuments." While government funded R&D is expensive, it has the potential to yield invaluable rewards for society that are worth investing in.

The Importance of Redundancy in Rocket Development

Solely supporting government-funded research in lieu of purchasing commercially available products is not the most efficient method of supporting rocket development. The fact that SpaceX has been able to develop rockets without government funding, and more effectively than NASA has, calls into question if government funded research is the optimal path to support this research field. Unfortunately, NASA's shortcomings go beyond over-spending. In the case of NASA's aptly named Space Launch System (SLS), the super heavy-lift launch vehicle, the program "certainly…is behind schedule and over cost" (Koren "Reality Check"). NASA project delays are a regular occurrence. When petitioning Congress regarding the SLS system, NASA "seemed to be setting up another disappointing delay, ready to reassure lawmakers with a new date for the inaugural flight of the record-breaking rocket" (Koren "To the Moon"). Launch

delays became an expectation, with continued "reassurance" that there would eventually be a date for the rocket's launch. Eventually, the delays became severe enough that NASA determined that they would "consider using a rocket from a commercial U.S. company," (Koren, "To the Moon") and give up on plans for a NASA rocket. SpaceX already has the technology that NASA has yet to achieve, so it is fiscally irresponsible to pay for development when the end-product is commercially available. NASA itself admits it would be more economical to use SpaceX rockets.

While NASA's management of rocket research and development is costly, abandoning it to purchase rockets from SpaceX equates to allowing SpaceX to dictate the progress of the space exploration program, since there would be no other technology source to meet the space program's needs. Combining NASA's administration of rocket R&D with parallel use of SpaceX's rocket technology can safeguard against the limitations of solely relying on either option. As previously stated, in other industries, most scientific research comes from privately funded organizations ("Who Pays for Science?"), so in order to have significant progress in a field, privately funded research is critical. Beyond the simple aspect of increasing research output, this duality of approach brings a variety of benefits. For example, having a single source of rocket production to take people into space and back is dangerous: "we are violating this principle of dissimilar redundancy by having only one way to launch crews into space" (Gerstenmaier). Should the single source operations cease, NASA would need to restart its own rocket R&D administration to sustain the space program, let alone make progress in space exploration. The synergy of both approaches is exemplified by the success of the Center for the Advancement of Science in Space, which is a non-profit that manages the operations of the International Space Station. This collaboration is designed to show "typically nonspace [sic]

commercial companies the advantages of using the space station as a research environment" (Gerstenmaier). These results have been excellent for NASA: "Here are results we can use to improve life on Earth that were developed using the unique laboratory of micro gravity" (Gerstenmaier). From new vaccines, to more durable and versatile materials, the advancements made by these commercial companies are extremely impressive. This is where commercially funded corporations can shine the most: advancing research in concert with NASA, making use of the resources available on the International Space Station, and accomplishing drastically more than they could have working independently. Collaboration across institutional types is important because the disadvantages that plague them in isolation disappear, and together they create something truly superior that advances scientific knowledge and allows for corporate profit.

Even though NASA's rocket R&D administration may be expensive, preserving its existence in parallel to the work of SpaceX ensures the continued evolution of space exploration. Scientific milestones are usually reached when investing in research pursuits that may not initially appear to have foreseeable applications. As a private company, SpaceX will not pursue work that will not yield profits. Conversely, NASA's government support enables it to take on costly pursuits which have the potential to greatly advance space exploration. The Lewis and Clark Expedition and the US Exploring Expedition (US Ex-Ex) were both examples of expensive investments that yielded invaluable profits (Gerstenmaier). These expeditions, which cost a significant portion of the federal budget, were critical to the US for drastically increasing the available knowledge regarding the Earth's geography and enabling the development of maps that would eventually be used a hundred years later during World War II. These research projects netted immeasurable returns, which were unpredicted when the decision to invest in them was made by the government. The decision to invest in these expeditions parallels investment in

rocket research and development: “it is also important for us to remember that we are the latest in a long line of explorers, scientists, engineers, and entrepreneurs that stretch back hundreds of years. We are not different; we are merely continuing the work they began.” (Gerstenmaier) This inspirational message explains how these seemingly absurd and over-budget projects are a continuation of the government’s support of bold and expensive programs to gain knowledge and reach heights that were once thought insurmountable. “When the crew of some future starship *Enterprise* looks back at the history… they will see our work today in the same way we see Lindbergh, Lewis, Clark, and even Columbus - as foolhardy, fragile, brave, audacious, and utterly necessary” (Gerstenmaier). Even as NASA drives past their budget, and consistently attempts to complete projects beyond their ability, conducting research that is “foolhardy, fragile…audacious,” it is still advancing the scientific field, and providing the work to hopefully bring about a day when we can fly about in a “starship Enterprise.” Funding NASA-administered rocket R&D, in parallel to buying commercially available rockets, is not an option, but a necessity to ensure continuous progress in space exploration.

Conclusion

Continual funding of NASA is critical for the advancement of rocket research and development, because even though self-funded companies like SpaceX have commercially available technology, their development is always fiscally influenced, while NASA can pursue research independent of cost that can advance science. Parallel rocket development between SpaceX and NASA administering ULA offers the safety net of redundancy to ensure continuous progress in space exploration. Given the public support for investing in scientific research, it is imperative that NASA continues to administer rocket research and development while taking advantage of low-cost rockets supplied by private launch service providers such as SpaceX.

To further explore this issue, the role of other emerging launch service providers, such as Blue Origin, should be explored. Emerging competitors will eventually drive down SpaceX pricing and eliminate single source product development concerns. While SpaceX is very open with the public regarding its rocketry achievements (Elon Musk regularly tweets at @elonmusk and @spacex), there is not much publicly available information on emerging competitors. Another possible option would be to broaden the scope of this paper and analyze the implications and importance of other aspects of space research. Beyond the advancement of scientific research, the long-term survival of the human species may depend on the advancement of space travel, as "the inevitable changes in the environment, independent of asteroid impacts, will make the Earth uninhabitable in a few hundreds of millions and [sic] years" (Munévar 1). This dilemma is one of wider importance, as its likely inevitability makes it more impactful to the average citizen; however, such a problem would not affect society for millions of years. The choices society makes about rocket research and development will have implications in the far future. Since "our choice is the universe or nothing" (Munévar 1), society must decide when it is ready to look beyond, regardless of the cost or however foolhardy it may be, for something that will not affect humanity for over a million years.

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