The Continuing Impact of the Space Industry

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On my honor as a University of Virginia Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Abstract

This paper looks into societies continuing need for space exploration and how NASA and other space companies or organizations have made positive impacts on technology in the past 60 plus years. Since the Apollo missions, NASA has continued to do a lot of research and scientific development on a limited budget. This paper looks at the issue of space exploration by using the Social Construction of Technology (SCOT) framework. This framework states that society shaped technology and this is very evident in the history of space exploration. The human population decided that they were going to land a person on the Moon and then they created the technology capable of doing that feat. Throughout human history, people have faced impossibly difficult tasks and found ways to overcome them. The SCOT framework ties into this in that people have to make the technology to reach their goals, such as going to the Moon or Mars. The SCOT framework is used in this paper to show that society needs goals in order to develop technologies and continue to advance. Technologies are not going to be created without people working hard to make them. NASA has created numerous technologies that everyone uses every day and has been at the forefront of research since they have been in existence. All of the new technologies have greatly benefited countries other than the United States, especially developing countries that cannot afford to do research themselves. The new privatization of the space industry has allowed for new technologies to be developed at a greater rate. With so much money going to the space industries it was important to first look at how this money was being used and what results have been made in recent years. This paper investigates what private companies are doing within the aerospace industry and how these companies are making an impact in society. Private companies are more concerned with generating profits than government agencies are and therefore should lead to quicker results. Getting to these results may be very costly, however.

NASA and other space organizations provide jobs and economic benefits that would not exist without them. While the private space industry is likely to lead to some problems, the economic and technological benefits will be of great benefit of society.

This study argues that NASA and other space science organizations still have a very relevant place in this society and should receive more funding. The increase in funding would lead to even more technological advances and increase excitement in science and technology in the society. This thesis tells people why so much time and money is spent toward space exploration and how it is helping them in ways they do not now. The continued spending in this area of science is only helping society and giving society tangible goals that should be celebrated. Studying this topic is important because people spend a lot of time and money in this area of study, and this should not be done without first making sure it is necessary and good.

For the technical design project, the team I was a part of designed and built an Electrical Discharge Machining device. This device was designed to be able to drill a hole through a piece of metal using sparking. A voltage difference will be applied between the piece of metal being machined and another piece of metal, called the tool piece, and a spark will occur causing part of the metal to chip away. The two pieces of metal are sitting in a tub of water so that the electrons can flow from one piece of metal to the other through the water. For this project, the team had to design the device, present the idea, order the materials, build the device, test the device, and present the final project. The project team encountered many challenges throughout the project and learned many lessons. Such lessons include the limit of a budget and the value of a good design.

Introduction

Over the past sixty plus years, NASA has been a crucial component of the American economy and has influenced society in ways that had never happened before. According to NASA, in 2022, the government agency generated almost $7.7 billion in federal, state, and local taxes throughout the United States and supported more than 339,600 jobs. NASA and other aerospace companies are spending a lot of money and resources to continue exploring the great unknown that space is. Ultimately, it needs to be determined if the continued spending in the space industry is advantageous for our current society. This needs to be answered because a large portion of U.S. tax dollars are used to fund NASA. This topic will be discussed using the Social Construction of Technology (SCOT) framework. SCOT is a theory that states that society shapes technology. This paper will look at how society has influenced the development of the space industry and how this industry can continue to benefit society.

In this thesis, it is my goal to highlight different ways in which the space industry has benefited society in the past as well as to look at ways the space industry is aiming to benefit society in the future. The technologies, revenue, and enthusiasm to society that is generated by NASA and private space companies will be looked at in this paper to determine if the need for these entities is still significant.

Technical Topic: Electrical Discharge Machining (EDM)

Electrical discharge machining is the process in which a metal tool piece is brought within microns of another piece of metal that is intended to be machined, called the work piece. A large voltage is induced between the two pieces of metal which causes a spark to be generated that erodes the work piece very slightly. The spark is repeated several times a second and allows for the tool piece to cut away parts of the metal work piece. The EDM process is not extremely well practiced and has the potential to be developed further.

Rocket Engines use regenerative cooling to keep the engine from overheating. This process works by flowing liquid fuel through channels inside of the rocket engine bell nozzle to keep the metal from melting. This allows for an opportunity to use EDM. Currently these channels inside the rocket engine are made from multiple pieces of metal that are welded together. EDM would allow for these rocket nozzles to be produced with one piece of metal. EDM is known to be better than typical machining processes when the metal being machined is very hard. Rocket engine nozzles need to withstand extremely high temperatures and therefore EDM is a clear candidate for making rocket engine nozzles that can withstand high temperatures without having to attach more than one piece of metal together. The goal of the project is to create an EDM device that is capable of drilling holes into pieces of metal that can be used as cooling channels for regenerative cooling.

The EDM device needs to be able to make relatively precise cuts in a relatively short amount of time. Typical EDM takes a lot of time, and if this process could be shortened, then this would be exceedingly beneficial to the manufacturing industry. To research this topic further, the articles Electrical Discharge Machining: Principle and Manufacturing Applications and Electrical Discharge Machining: Construction, Application, Pros and Cons will be very useful. These two articles discuss how EDM works, different types of EDM, and when it is best to use EDM. This project will take a lot of testing because there is still limited amount of information on the EDM process as it is not an extremely common practice. This also means that even deeper research of the practice needs to be conducted. Finding out precise values for voltages and currents in certain situations will help the group come up with a better design.

Throughout this project, several challenges came up to hinder the progress and make it difficult to complete. In the end, the device was able to create a single spark and detect that the

tool piece was touching the work piece and then shut off. It is suspected that the voltage being used was not high enough to create a spark through the water dielectric and that if we had been able to use this device at a higher voltage then the device would have worked appropriately. This project demonstrates that it is possible to create a small scale EDM device that is capable of cutting through aluminum.

STS Framework: Social Construction of Technology

Social construction of technology (SCOT) states that human actions shape technologies instead of technology determining human action (Klett, 2018). People who believe in SCOT, or social constructivists, also believe that the way in which a technology is embedded in its social context must be understood first before being able to understand the ways a technology is used (Klett, 2018). Since society is working so hard to reach goals in the space industry, this allows a way to study social construction of technology. The actions of people wanting to go to the Moon in the 1960's developed new technologies that were used to get humans to the Moon. Technologies did not just appear and then humans thought to go to the Moon, the people apart of the Apollo missions had to work very hard to develop the technologies that enabled the first man to walk on the Moon. The men and women who worked on the Apollo missions had to decide that they wanted to go to the Moon and develop the technology that would make it possible for that to happen. The opposite view would state that technology came to be and that influenced humans to go to the Moon. This is simply not true because the technology that could get humans to the Moon did not exist at the time. Humans need to have goals and ambitions that force these technologies to be developed. According to SCOT, people need to act so that society does not remain idle. If people do not work toward a specific goal, such as getting humans to Mars, then technology will not advance. NASA is aiming to put people on Mars by 2039, the technology to

do that does not fully exist currently, but the engineers and scientists at NASA will develop the technologies necessary to do so. Society has always been the driving factor in the advancement of technology. People are faced with a problem and then find a way to solve that problem. This has been the case since the beginning of time, and this will always be true. Mankind has a remarkable way of problem solving in challenging situations and this is confined in the SCOT framework.

According to Bijker et al., "Technological systems solve problems or fulfill goals using whatever means are available and appropriate; the problems have to do mostly with reordering the physical world in ways considered useful or desirable, at least by those designing or employing a technological system" (Bijker et al, 1987, pg. 47). Based on this quote, a technological system, such as a rocket or space station, will be created to fulfill goals and will be useful for the people of Earth. The argument of whether or not building a rocket or a space station is useful will be discussed later in the article. Regardless, these technologies will be built because people will have a goal or reason to build them and use whatever is available to them to make it happen. This returns to the idea that people are going to achieve their goals any way possible, even if that means creating new technologies. From Bijker et al., "Technology, like science, involves process as well as product. In short, both scientific facts and technological artifacts are to be understood as social constructs" (Bijker et al, 1987, pg. 47). From this, it is important to think about space exploration as a social construct. When space exploration is thought of as a social construct, it makes a lot more sense to work toward the goal of exploring space. Because everyone will collectively be working toward the goal set by society, for example landing a person on Mars, it will be in societies best interest to attain this goal. This goal is set because of the technological, economic, and overall societal potential that this goal has.

One issue with SCOT, is what happens when new technologies are invented. Communities working on projects must adapt to new technologies to make their design as efficient and productive as possible and this can often be difficult. “In general, the notion of radical change or of technological revolution in a tradition of practice is relative, and probably no issue has caused as much disharmony among students of science and technology as the problem of revolutionary versus incremental change” (Bijker et al, 1987, pg. 221). The idea of revolutionary versus incremental change, as brought up here, is very interesting because all change could be useful toward a design, but the amount of time in which it needs to be implemented should ideally be much shorter for revolutionary change and the amount of focus on this change should be much higher. For example, if a new technology is created that can safely get humans to Mars much quicker than any technology could now, this should be researched, developed, and put into practice as fast as possible because it greatly contributes to the goal of getting humans to Mars. Also, if a technology is discovered that would give astronauts more oxygen and allow them to spend more time on the surface of Mars, this should also be developed, but with not quite as much importance as the previous example, because the goal can still be accomplished without this design.

STS Topic: The Continuing Impact of the Space Industry

Since NASA was established in 1958, numerous technologies have been developed to get humans to space and to understand more about the universe. These technologies would not have been developed if not for the goals discussed in the previous section. According to the Jet Propulsion Laboratory, numerous items of technology would not have been invented if it was not for space travel (Jet Propulsion Laboratory, n.d.). This includes the cell phone camera, LEDs, athletic shoes, wireless headphones, the portable computer, and many other things that we use

every day (Jet Propulsion Laboratory, n.d.). All of the items listed above are practically an essential aspect of modern society, and these devices quite possibly would not exist without the space industry. In particular, LEDs are specific types of lights and are extremely common in lighting systems across the globe. In 2023, sixty nine percent of adults aged 30 to 49 own a laptop ("Share of Americans…", 2023). Clearly, these are important technologies to our modern society and have benefitted a countless number of people since their conception.

The argument could be made that the money used to fund the space industry could be better used for other purposes, such as feeding impoverished people or helping third world countries. However, the indirect benefits of the space industry ultimately aid those third world countries far more than what they could do with the money that is being used to advance space exploration. The technology that has been developed by NASA, including what was highlighted in the above paragraph, has led to improvements in areas including health and medicine, transportation, public safety, consumer goods, energy and environment, information technology, and industrial productivity ("Benefits Stemming from Space Exploration", 2013). All these areas benefit developing countries in ways that they do not have the technology to do themselves. NASA and the U.S. Agency for International Development have a program that provides developing countries in Central America, East Africa, and the Himalayas with Earth observation data from satellites to assist with their environmental decision making, especially with regards to natural disasters (George C. Marshall Space Flight Center, n.d.). This is one specific example where NASA is using its technology to help benefit third world countries.

The science and technology that has been developed from traveling to space has been used to propel the world into a fourth industrial revolution (Dooley & Signé, 2023). For example, lower launch costs have made it possible to put more satellites into space that make it

possible to optimize broadband infrastructure, enhance earth observation capabilities, and increase national security (Dooley & Signé, 2023). In fact, there were twice as many active satellites orbiting the Earth in 2023 as there were in 2020 (Munoz, 2023). Some companies are even considering implementing operations in low-orbit space to take advantage of the physical properties low gravity offers (Dooley & Signé, 2023). For instance, pharmaceutical companies are considering growing organs for transplant patients and producing drugs that target cancer cells in low orbit (Dooley & Signé, 2023).

With all the positive benefits that the space industry offers, more private companies are now looking to expand their presence into the space industry. Private space companies have been growing rapidly with goals of building reusable rockets, commercial space stations, hotels in space, and even visits to the Moon and Mars (Ludwig, 2023). According to Weinzierl and Sarang, in 2020, a private company transported people into space for the first time. This is important because it allows for opportunities to build an economy that is in space and made for space (Weinzierl & Sarang, 2021). According to the European Space Policy Institute, traditionally, global space activity has been driven by governments, but now private actors are playing an important role in a market of space-based products. New projects of commercial industry have affirmed the intention of private companies to implement new methods to develop and produce space systems aimed at cutting down costs and disrupting existing markets (European Space Policy Institute, 2017). All this information points to the change from the traditional way of governments running the space industry, to the new way in which so many private companies are beginning to make their own rules. This means that even more advancements, lessons, and motivation will happen because of the competition between companies.

The new privatization of the space industry will provide the world with new opportunities and great benefits in the near future. For example, NASA and other governmental space agencies are focused on missions that benefit national security, basic science, and national pride (Miller, 2022). However, private space companies do not have to worry about pleasing the common citizen, their main goal is to make a profit and they are going to do whatever it takes to do that (Miller, 2022). Because of this, speed, efficiency, and cost are extremely important for private companies and will generate better and quicker results that way (Miller, 2022). The new privatization creates competition and jobs that will promote economic growth.

The space industry has provided people with jobs ever since it became relevant in the Apollo era and continues to do so today. NASA alone sustains approximately 339,645 jobs across the country in 2022 (Zelalem, 2022). “At the national level, NASA supports labor income of $25.7 billion per year and an estimated economic output of $71.2 billion annually” (Zelalem, 2022). With such a large budget and an economic output of about 2.77 times that, it seems obvious that the space industry is producing more than it is spending. NASA’s budget encompasses 0.3% of the United States Government budget (Shibu, 2023). This is a tiny fraction of the budget and is being used to create incredible scientific discoveries and advances. Also, NASA invests $280 million in small businesses in order to help fund research that will help promote the future of space exploration (Shibu, 2023). One of the goals of NASA’s program that donates money to small businesses is to “Increase private sector commercialization of innovations developed through federal R&D funding” (Markowitz, n.d.). This is good for small businesses and the space industry because it gives more people the opportunity to develop technologies. With more people and different organizations working toward the advancement of space technologies, the likelihood of new and better technologies is much greater.

Conclusion

This thesis explores the reasons as to why the continued advancement into the space industry is important. The research into the space industry will provide the public with an explanation as to why so much time and money is spent toward something that feels far away to some people. This is specifically relevant for my technical project. With more funding being put into aerospace sciences, it should make it more possible to continue researching applications for EDM to produce regenerative cooling channels. This specific technical project does not affect the everyday person, but many aerospace projects produce technologies that will benefit far more people than those directly involved in the space sciences.

In conclusion, NASA has provided the modern society with technology that has made significant impacts for mankind in the past 60 years. There are no indications that NASA or the private aerospace companies will slow down their development of technology, if anything, technology development will only increase based on the current relevance of the private space science companies. The private sector will offer more jobs in the space industry and is a new economic market. As talked about in the discussion of SCOT, NASA is working to go to Mars in the 2030s and a lot of technology still needs to be developed for that to happen. This will lead to technological benefits for all of society. SCOT also shows that technology does not drive human actions, and therefore, people cannot wait around for the technology to appear. People must strive for a goal in order to continue to advance.

From this paper, it has been determined that the continued spending in the space industry is in fact advantageous for our current society. The space industry has proved time and again that it has the capabilities to produce the technologies that will be used for the betterment of society.

The need for NASA and private space companies is still great because of the technologies, revenue, and enthusiasm to society that is generated by these organizations.

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