The Benefits of Space Colonization

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On my honor as a University 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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STS Research Paper

Introduction

As technological innovation continues to progress, ideas once constrained to the world of science fiction are entering the realm of reality. A single person has already spent over 350 continuous days on the International Space Station (ISS), with a cumulative individual record of 665 days (Garcia, 2016b). After 23 years of continuous habitation on the ISS (Garcia, 2016a), the National Aeronautics and Space Administration's (NASA's) next goal is the Moon through the Artemis programs, which are intended as a stepping stone to Mars (*NASA*, n.d.). The plan of the Artemis program shows that the ability to colonize the Moon and Mars is no longer just a technical problem, but rather one of choice and determination. On the other hand, some such as Yvon Chouinard, the founder of the clothing and gear company Patagonia, view space exploration as a waste of resources better spent on Earth going so far as to create the slogan "Fuck Mars" (Rinella & Chouinard, 2019, 1:38). The varying opinions on the efficacy of space travel and colonization call into question whether or not it is worth it in the end. With an expansion into space, there comes technological development and improvement in the systems and technology available on Earth. The original space race in the 1960's and later space programs are the reason for many technological innovations used in modern society (https://www.jpl.nasa.gov, n.d.). Using the Wicked Problem framework within this report, the research question "How can humans colonize other celestial bodies while leading to improvements in the conditions on Earth?" will be addressed.

Methods of Research

The method of gathering data is primarily through the sources of journals and public reports to determine the technologies and future beneficial products necessary for space travel. While the contrasting public opinion is gathered from opinion pieces and public articles. The documents under analysis relate to the history of the space industry, where it is advancing towards in the planned future in regards to long term goals and technology needed, and the public opinion on the current long-term goals of colonization. This topic is analyzed through documentary research methods, case studies, and discourse analysis. The collected data functions as a basis for potential results from the expanding space industry and provides areas of analysis to focus on.

The Past and Present in Space

The colonization of celestial bodies has been considered for many centuries, with the first novel being written about it in the 19th century (Hale, 1869). Space travel itself dates back to the 1950's with the launch of the first satellite, Sputnik, by the USSR. Through the Space Race between the US and USSR, space travel was accelerated and culminated with the US being the first and only country to land and put human beings on the Moon. Since the Space Race, no countries have landed humans on the Moon. Governmental support has since been focused closer to the Earth, with a current total of 5,465 satellites orbiting the Earth as this paper was written (*Union of Concerned Scientists*, 2022). Additionally, there have been 12 space stations in orbit, with the ISS being the longest station in service since 1998 (*Britannica*, n.d.).

Announced in 2019, NASA is working on the Artemis programs, which will restart human missions to the Moon. Through a series of launches, NASA will incrementally establish a

foothold on the Moon using a planned “Gateway” space station that orbits the Moon. This space station will serve as a transfer station from the Earth to the Moon. With the experience of long-term habitation and logistical supply near the Moon, the Artemis program serves as a test bed for technology that will be used for Mars. This activity in space will allow studying how the human body responds to a deep-space environment for extended periods of time. Depending on the success of the Artemis programs, there are plans for long term habitation on the Moon, and most notably in the public eye, Mars. Some private corporations such as SpaceX are even planning Martian colonization, and designing a large-scale rocket for mass colonization (*SpaceX*, n.d.).

With the high cost of individual space missions, the public view of space travel is not always viewed as a wise use of funding. However, the current NASA budget is proportionally small compared to during the Space Race. The 2022 NASA budget was 0.3% of the total US federal budget (*USAspending*, n.d.). The historical record for highest budget as part of the federal budget is 4.4% in 1966 (Rogers, 2010). The other viewpoint is that the goal of colonizing other celestial bodies is not just a misallocation of funds, but a waste of human resources that could be better spent solving the climate crisis. As previously stated, Yvon Chouinard, the founder of the company Patagonia, has publicly gone out and said how he views the goal of colonizing Mars to be wasteful and has “Fuck Mars” items at public relations events (Rinella & Chouinard, 2019, 1:38). This general anti-Martian colonization opinion views the planets as an ultimatum, where only one planet is chosen. Since the resources that would be spent on Mars, would be unavailable on Earth. However, devoting some resources will not harm life on Earth, but in fact will aid the conditions of life on Earth.

The Wicked Problem in Relation to Colonizing Space

As technology progresses, new abilities become possible under human imagination. However, there is always a cost to action in the world, and a choice must be made where to invest the resources available to mankind. This is how the choice of space colonization is not just a technical matter, but one that is a part of society. The STS framework that is used in the analysis of this research paper is the Wicked Problem Framework (WPF). The WPF was created by urban planners, Horst Rittel and Melvlin M. Webber in 1973, and is being used since it is suited to analyze large problems without a clear solution that is not universally agreeable (Rittel & Webber, 1973). This framework is suited for the research question since it involves analyzing the problem of quality of life on Earth and the potential avenues of space colonization; both of which have no clear nor direct solutions.

It is worth discussing that some critiques of WPF state that "The wicked problems idea is flawed because it is poorly conceived and disconnected from its historical context, and thus stretched beyond conceptual coherence" (Turnbull & Hoppe, 2019). Therefore, the authors claim, using this framework is misguided and any policy research that is based upon WPF is "ill-equipped to support [the policy]" (Turnbull & Hoppe, 2019). The authors argue to reject WPF and transition back to a general framework for any problem, rather than one that implies the issue is unsolvable. With these critiques in consideration, the WPF can still be used in a successful, and beneficial analysis. The WPF has been used to analyze the space industry previously, but in the context of public perception of governmental space programs, given the rise of private companies active in the space industry (Blalock, 2020). While this article did not discuss colonization, it did examine the space industry and how its resources and technology produced have influenced life on Earth.

Results and Discussion

Colonies on the Moon and Mars were originally thought to be contained exclusively in the world of imagination, but now the real-world impacts of these journeys must be analyzed. A multi-point analysis about influences on society must be considered to answer "How can humans colonize other celestial bodies while leading to improvements in the conditions on Earth?" Using the wicked problem framework, the research question will be examined in regards to its positive influence on technological innovations, advancements in science, reducing the draw on natural resources on Earth, and the promotion of global interaction in regards to a common challenge. Additionally, space colonization acts as a wicked problem since the resources produced and its influence on general quality of life is not able to be empirically measured, but it can be examined if it is being used on projects where the aim is to improve an aspect of life on Earth.

Technological Innovations

One of the most striking and prevalent results from advancing into space is the increase in technological innovations. While all innovations resulting from space colonization cannot be predicted, there are some that must be first achieved in order to make space colonization feasible. One of the most pressing issues are efficient and reliable power generation. In space, the challenge of power generation has primarily appeared as solar arrays for space stations using photovoltaic power. The solar panels for use in NASA's Gateway space station already have been constructed and are significantly more efficient than solar panels used on Earth (*Rocket Lab*, n.d.). The Rocket Lab solar panels have a minimum 30% average efficiency, while solar panels commercially available to consumers have an efficiency from 15-20% (*Rocket Lab*, n.d.;

Aggarwal, 2022). The most cutting-edge solar panels that are necessary for space, are not commercially available to average consumers. But with increased usage, the technology to produce more efficient solar panels will become widespread, and it will allow the cost to decrease with scale and regularity of production.

While surface operations on the Moon and Mars will make use of solar energy as well, dust conditions and higher energy processes necessitate higher yield and more consistent power generation for long term missions. The current plan for NASA's long term base on the Moon is to use advanced solar cells in combination with fission power systems for longer duration missions (*A Sustained Lunar Presence NSPC Report*, n.d.). While both of these technologies are currently used on Earth, higher efficiency, low mass, and more durable nuclear systems are necessary to be developed for use in space (Mason, 2019). While fission power sources have a historical precedence in space, fusion is still at the forefront of development, where it has not been used in power systems. NASA has conducted research into fusion energy methods, that could prove viable for deep space and terrestrial uses alike (*Lattice Confinement Fusion*, n.d.). While there is research on Earth for nuclear fusion energy, fusion, when viable, would serve as an exceptional power source for space colonization, and has already been identified as an ideal source when in a low mass system designed for space (Miley & Shaban, 2003). By supporting research into fusion, it increases the likelihood of a viable method being developed and implemented. Once this technology is implemented in a scientific or space setting it will later be refined into a commercially available method of energy production which will greatly reduce the need of fossil fuels (*Advantages of Fusion*, n.d.). This reduction in the need of fossil fuels will greatly eliminate carbon emissions associated with power production, and significantly help in reducing both the cost and environmental impact of the main sources of steady energy

production. By bringing down the cost and environmental impact of electricity, fusion will have a net positive impact among all of its users and globally from the reduction in harm to the environment.

Branching away from power generation, colonizing other celestial bodies will require self-sustaining, renewable habitats for people to live in. The constraints of a space habitat has already produced new water purification systems that have seen implementation on Earth (Guzman, 2020). Water purification of brackish or salinated waters would allow more people on the Earth a healthy and consistent supply of clean water. While water purification methods already exist, new and more efficient methods would allow more people in impoverished communities access to water as the technology is refined. Space colonization additionally provides a financial motivation to develop the more efficient technologies that can then be implemented in communities that cannot afford the research and development alone. The technology developed and used will have significant impacts on many groups of people with different values and backgrounds. Since the implementation of technology is controlled by many uncontrolled factors such as cost, availability, and feasibility of implementation it is not possible to define an impact. But determining the potential of the technology and finding that cleaner, more efficient, and renewable resources are likely to have a net positive impact on the lives and environment of those on Earth.

Advances In Science

Aside from the solely technological advancements for use in space, there has already been large amounts of research into biology, genetics and astronomy from the current presence

in space. From disease research, drug development, to pulsar and black hole research, the unique environment in low gravity and outside the atmosphere provides a testing ground for new experiments that are not able to be done on Earth (Guzman, 2020). With an increased human presence in space, it opens the door to conduct more specialized research and look for new medical breakthroughs unavailable on Earth. Parkinson's and cancer research have been conducted in space, with the research providing information useful in treating both conditions (Guzman, 2020). With an established precedence of conducting beneficial research that has gone back to Earth, it is likely that this trend will continue and more lifesaving research will be conducted and implemented on Earth.

The long-term periods astronauts spend in space will provide a useful study of how low gravity and reduced gravity influence the human body. This time in space allows for research into the effects on astronauts that can then be applied to people with muscle atrophy and bone loss on Earth. The special conditions in micro and reduced gravity make isolating specific cells and how they are influenced by local conditions and responses to treatments (Johnson, 2019). Similarly, it is possible that other medical conditions may be amplified in space, in which the studying and analysis for prevention thereof will be applied to those who suffer on Earth. Quantifying and determining the causes of human health conditions is in itself a wicked problem. However, any treatment that can aid the wellbeing of the general population will in turn lead to an overall benefit to quality of life.

Reducing Resource Requirements

With life on Earth having finite resources, outsourcing the collection of materials to the Moon or Mars could provide valuable resources such as Helium-3, used in fusion reactors, or rare Earth metals, which are key components of modern technology (*L5 News*, 2017). While large scale space mining operations are further off than colonization, the beginning of mining scarce resources is within reach at the same time. Additionally, as the human presence increases in space, use of local resources will become more common. For example, lunar regolith has been analyzed as a potential building material to create lunar habitats and other structures (*Lunar Resources*, 2017). The use of local resources for colonies on the Moon and Mars will aid in self-sustainability of colonies, and limit the fiscal and physical resources needed from Earth. Since the fewer resupply missions that are necessary, the less the missions will cost overall. Through this reduction in Earth-side natural resources and labor, there will be more resources given back to Earth. This advancement will result in a shrinking cost to activities in space. While not directly benefiting life on Earth, the advancements of using local resources will decrease the negative impact to conditions on Earth.

Global Interaction

While the space race started in the heights of political tension and competition between nations, expanding into space has since fostered unity and advanced foreign policy. With the Global Positioning System (GPS) being used across the world and in several participating nations for civil use in personal and trade purposes, it exemplifies how establishment in space can bring many nations into partnership. Several nations, primarily in Europe use the US's GPS in addition to each respective countries own satellite systems, while even Russia and China have had agreements regarding civil cooperation of both systems being in use. (*GPS.Gov:*

International Cooperation, n.d.). The greatest example is the ISS, with the first letter standing for international, having 15 nations signed the original intergovernmental agreement. Since the ISS's start, 68 nations have contributed in ISS activities. Juxtaposing with the start of the space race, the US and Russia have had large partnerships which are necessary to progress in space, along with the European Space Agency having 22 member states. Due to the challenging environment, advanced technology, and high costs of space activities, it fosters increased international relations that would otherwise not exist. As efforts are moved to colonizing the Moon and Mars, other nations will have an impact on the progress and the challenge cannot be overcome by the US alone. This implicitly forced cooperation stands to benefit global prosperity as a whole. Since as nations work together for a unified goal, trade and public relations will increase. Increased trade between counties and additional reasons not to go to war, stand only to benefit humanity as a whole.

Further Research

While this research paper focuses on analyzing the benefits of space colonization, where and how it will impact the Earth, it is limited in scope for a full analysis on the worthiness of space colonization. Primarily this paper is limited by only analyzing the benefits without the costs, and potential negative impacts from space colonization. In order to determine the worthiness of colonies on the Moon and Mars, both the benefits and costs must be evaluated and reconciled to find a net positive or negative value to the undertaking. As to further research on the subject of this paper, additional fields of improvements in other technologies or sectors should be evaluated. Most importantly, as NASA progresses with the Artemis program, the realized impacts and benefits should be analyzed to determine the validity and areas of

improvement produced from space colonization. Since the actions theorized in this paper are nearing fruition, it presents a unique opportunity to examine the predicted outcome against the actual outcomes.

Conclusion

In conclusion, extrapolating from released goals and historical precedence, space exploration and further colonization is set to provide many advancements in a variety of fields that will result in tangible benefits to life on Earth. Rather than just benefiting the those going into space, or invested in the enterprise, the breakthroughs developed will go on the benefit all life on Earth. These benefits will present in a variety of areas, from technology and scientific research, to international relations. The most significant of which can lead to cleaner energy production and resource recycling of water and raw materials. Lunar and Martian colonies have been planned, and are in the starting phases of execution with NASA's Artemis program. Analyzing the future technology that will be developed and its impacts should be planned and expected so as to best utilize the advancements in all ways possible.

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