Progression of Society Through an Established Presence in Space

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Introduction

The American and Russian space race of the 1960s brought about social change and introduced grand scientific achievements to mankind. Political strife and competitiveness between the superpowers increased support for technological advancements. Computers, jet propulsion, GPS, etc. were utilized more and saw constant improvement. Technology was advancing to help the competing nations dominate the space race, and, as a side effect, helped improve society. The collapse of the USSR left the United States with no competitor, thus ending the need to compete. Technology has continued to advance overtime and at a lower rate due to the lack of political motivation. Society is on the verge of greatly improving with the concepts of self driving vehicles, abundant energy sources, and genetic modification awaiting support from governments and world leaders. These opportunities can and will improve humankind as a species, but their progress is slow and deterred by political ambitions.

The following research document, through the utilization of meta-analysis research, proposes the best method of expanding mankind's dominion in space to advance societal progress. Multiple documents and concepts proposed by innovators and scientist were accumulated to recognize solutions for man's current challenges in space exploration. The gathered research consists of solutions and obstacles that prevent a concept from becoming realized. This paper uses the collected concepts to resolve challenges that currently restrict their feasibility. Thus, an overall solution is created through the utilization of ideas proposed by credible sources which have been held back by challenges.

This universal solution proposes an answer to the deadlock in societal progress by solving the setbacks of human space travel; therefore, introducing new technologies and boosting society's advancements. Ideas of efficient earth-to-low orbit travel, interplanetary colonies, and an extraterrestrial economy are mentioned as necessities to humanity's expansion throughout the solar system. Current technologies, like the Hyperloop, and concepts, such as SpaceTram, can be married into new proposals that will make space travel technologically advanced, efficient, and safe. To boost societal progress through efficient and safe space travel, governments and companies will need to implement advanced, reusable spacecraft technology, an independent fuel / supply economy in space, and habitable environments.

Literature Review

In order to conceptualize an optimal solution for efficient manned space exploration, feasible and reviewed proposals fabricated for advancing man's dominion in space must be adjusted and affixed to other existing concepts. Throughout its existence, the National Aeronautics and Space Administration, NASA, has visualized multiple concepts that have been dismissed due to absent government approbation, monetary restrictions, or lack of resources. The High Altitude Venus Operational Concept, HAVOC, is a proposition for colonizing the Venusian atmosphere conceived by NASA's Dr. Dale Arney and Chris Jones, and it is one of many projects that have not been able to receive approval from NASA and the U.S government. HAVOC is an example of the projects that will be referenced or used as supportive evidence to propose a solution for improving space travel and safety. All have been created and presented by scientists and engineers that have experience in the fields associated with their projects, and their ideas have been reviewed by peers to assure the plausibility of the project being implemented in the physical world. Other sources, for example, *Popular Mechanic's* "Why Hacking DNA Is the Secret of Deep-Space Travel" suggests that gene editing, utilizing the Crispr-Cas9 enzyme, and cybernetic enhancements will allow humans to venture farther into space with a reduced amount of risk. Genetic and cybernetic enhancements have proven to be possible not only in the field of space exploration but also in medicine. Similar to the engineering proposals held in limbo, most propositions dabbling in gene manipulation or cybernetic enhancements are restricted as a result of absent government support and moral ambiguity. The documents being assembled, to propose a solution for improved space exploration and, ultimately, a successful method for stimulating societal advancements, are individual propositions for specific problems. Throughout this report, each individual source will be reviewed for its feasibility and an explanation on how it will contribute to the advancement of space exploration and society. Any other source will serve as a basis for asserting the information presented within the individual propositions. Thus, the paper will accomplish gathering rejected ideas to assure the feasibility and necessity for the final, unique resolution.

Problems

The Inefficient State of Launch Vehicles

The first obstruction that must be confronted, before initiating any extensive ventures into space, is the state of current launch vehicles. As stated in “Space Elevators: A History” by the International Space Elevator Consortium History Committee, if ambitious space projects and missions are to be tackled in the near future, then the cost of getting into orbit must become a small fee when compared to the total price of the expenditure.[4] Large scale projects will never see completion if the task of getting supplies, people, or structures into space is unreliable and expensive. This is the current state of launch vehicles used around the world to transport people and items into earth’s orbit. Richard Hollingham, a science journalist and writer for BBC Future, outlines the primitive state of today's rockets through cost and technology.[15] He discloses that it cost around $16,700 per kilogram to transport objects into space and describes that some rockets are simply retrofitted missiles with the ability to reach space.[15] Along with the monetary restrictions, solid-fueled rockets largely restrict the amount of objects and passengers that can be transported into space per launch due to the majority of the payload consisting of fuel. For example, a fully loaded (sum of propellant mass, structural mass, and max payload mass) SpaceX's Falcon 9 rocket, a frequently used launch vehicle, has a mass of 549,054 kilograms and is able to transport 22,800 kilograms to LEO (low earth orbit), 8,300 kilograms to GTO (geostationary transfer orbit), and 4,020 kilograms to Mars. [9,10] Utilizing the formula for a rocket's payload ratio, provided by NASA,

(1) $$\textit{payload mass} \,/\, (\textit{propellant mass} + \textit{structural mass})$$

estimates can be provided by comparing the amount of payload mass with the mass of the fully fueled rocket (3,800 kg per 87,709 kg to LEO, 4,150 kg to 270,377 kg to GTO, 670 kg per 90,839 kg to Mars).[23] By only looking at the largest payload, the payload ratio reveals that for every kilogram added to the payload mass the propellant mass increases around 23 fold. This ratio only widens as the distance from Earth increases, such that, when traveling to Mars, a kilogram added to the payload mass results in about a 136 fold increase in the propellant mass. These ratios, calculated from the most efficient rocket currently in use, display the antiquated technology that is solid-fuel propulsion. Current propulsion technology will not allow for manned-interplanetary missions, the construction of large orbital structures, or inception of extraterrestrial colonies. The price and reliability of reaching space must improve significantly in order to persuade governments and companies to discern that ventures into space are profitable and reliable.

Underutilization of an Orbital and Lunar Presence

Current rocket design and technology also hinder the implementation of advanced design and technological concepts for deep space transports. Extensive weight limits on solid-fueled rockets restrict the amount of passengers and supplies needed to embark on voyages beyond the Earth and Moon. It is unlikely that large, deep space transports will replace solid-fueled launch vehicles due to the vast amounts of energy that would be needed to propel a craft of that magnitude. Conversely, the method of embarking on deep space excursions will reasonably change into a more systematic operation. Rockets, in the past and present, have been utilized as the launch vehicle and deep space transports by employing multiple booster stages. This forces engineers to reduce the amount of the payload to compensate for the structural and propellant mass needed to escape Earth's atmosphere and travel to its destination in the solar system. An ideal method of space travel would require two separate vehicles, a launch vehicle and a deep space transport, and the utilization of orbital stations or moon bases. NASA has stated, in their proposal for the Deep Space Gateway, that orbital stations and moon bases can serve as transition points from GTO to the rest of the solar system.[12] For context, large boats, such as aircraft carriers and cruise ships, are typically not constructed on land to later be transported to the ocean; instead, they are constructed in the ocean while docked at a shipyard. Similarly, the construction of vehicles on Earth meant for deep space travel is ineffective when compared to deep space vehicles constructed in space.

Isolation due to the Expanse of Space

Sharing a similar cause, the complication of traveling expansive distances throughout the solar system is a consequence of rudimentary propulsion technology on modern rockets. In solid-fueled rockets, the mass of the rocket increases exponentially as the strength of the engines is increased due to high rate in which the fuel is consumed. Even large solid-fueled rockets constructed in space, would not be capable of traveling throughout the solar system because combustion engines are not capable of reaching high speeds efficiently. Using today's methods and technologies, it would take a manned, round trip to Mars two or three years to complete.[10] This travel time is inefficient as a result of more supplies being needed to supplement astronauts during the journey, and the inclusion of prolonged exposure to cosmic radiation.[30] John Slough, professor of the Plasma Dynamics Laboratory, calculated that propulsion methods utilizing fusion could reduce the travel time to Mars to around 30 days.[26] Slough's calculations show that advanced propulsion methods have the capability travel 1 AU (average distance between the Earth and Sun) in 60 days. This allows for realistic travel times during expeditions throughout the solar system. Therefore, deep space transports need to be propelled by systems that produce large amounts of energy and occupy less than half the vehicle's mass.

The Expensive Endeavour of Space Exploration

Technology results in the majority of obstacles restricting the expansion of space exploration, but funding and government approval also pose as major obstructions to the advancement of space exploration. Similar to a business, space exploration will not begin yielding profit until large amounts of money are invested into initial missions and projects. The construction of geostationary, centrifugal stations and a proficient launch system will cost billions of dollars. These initial investments will not total more than the annual US military budget ($598.5 billion); however, large scale projects will require support from governments around the world.[18] The lack of support from countries will increase the time it would take to fund and construct a project. An established mining economy in space is capable of addressing other issues concerning fuel and safety.

Obstructions Induced by the Human Body

Manned space exploration prompts more obstacles than robotic missions due to the vulnerability of the human body when exposed to extreme environments. Presently, few infallible solutions exist for major hazards such as launch failures, cosmic radiation, and the absence of Earth's gravity. Modern rockets, with the purpose of transporting humans, are equipped with escape towers that are capable of detecting engine failures or explosions and can automatically boost the command module away from the booster stages.[16] Even with the existence of this technology, some manned spacecraft, most notably NASA's space shuttles, have been flown without any emergency escape features as a result of structural and monetary constraints. Once astronauts escape Earth's orbit, their problems switchover to physical and mental health complications that may occur during long journeys. Due to structural constraints, spacecraft cannot be equipped with heavy radiation shielding for prevention of long exposure to cosmic radiation. The problem of minimal radiation protection will become more problematic if nuclear engines and reactors are utilized within the spacecraft. Solutions for other obstacles facing space exploration could increase the dangers that astronauts would face if used in tangent with today's safety methods, thus the implementation of new safety methods is needed to resolve current and future safety hazards.

Solution

Rail Launch System

Presently, the system of transporting humans and supplies to space requires the attachment of a small payload capsule to a large booster filled with flammable chemicals that are ejected in large amounts and ignited to provide thrust. Aside from being inefficient, this system requires astronauts to put their lives at risk especially if their craft does not have an emergency escape feature. Hence, the crucial issues that need to be addressed in future launch systems are reliability, cost, and, ultimately, efficiency. To resolve these issues, the method of propulsion must change from mainly using solid-fuel propulsion. Dr. George Maise and Dr. James Powell, inventor of superconducting maglev, invented a concept for an orbital launch system labeled Startram.[5] The system utilized magnetic levitation to reduce friction and to acquire a velocity 9 km/sec (above the required orbital velocity).[5] Consequently, the track would have to span 1,609 km for long periods of acceleration to avoid exceeding safe g-forces during ascent.[5] After being reviewed by Sandia National Laboratories, the Startram concept was found to have no profound flaws and was estimated to cost $60 billion ($85.5 billion accounting for inflation).[5] This cost is miniscule when compared to the amount of money spent on military endeavours in the U.S ($598.5 billion), but the magnitude of the structure restricted its feasibility.[18] The Startram concept failed because it was ambitious on the engineering side; however, it succeeded by showing the feasibility of a launch system that was not dependent on large, solid-fueled boosters. Since Startram's conception, few similar launch systems have been proposed, whereas the technology utilized in the concept has continued to evolve through research by organizations and companies. NASA engineers at the Kennedy Space Center, proposed a concept that allowed hypersonic craft to reach space through a combination of maglev and solid-fuel propulsion.[6] Similar to Startram, the NASA concept never saw fruition; meanwhile, the scramjet technology continues to be developed and has working prototypes. While NASA conceptualized the launch vehicle, Hyperloop One, a company in the process of establishing maglev (magnetic levitation) vacuum-sealed transportation, has significantly advanced the maglev technology that Powell originally invented. The hyperloop technology uses vacuum chambers and electromagnetic propulsion to reach speeds around 1080 km/hr by avoiding friction from the air and ground.[8] The Startram's technology has continued to progress exponentially over the past decade, thus permitting the revitalization of a similar and more feasible concept. NASA's rail launch system demonstrated that an immense track was not needed to put a craft into space. It also introduces the idea of using small amounts of solid-fuel on the spacecraft to assist with exiting Earth's atmosphere. The hyperloop technology proves that maglev propulsion now has the ability of propelling vehicles almost three times faster than past maglev technology.[8] Using NASA's concept and Hyperloop One's technology, a modern rail launch system can be realized to reduce the cost of getting into space and increase the efficiency of traveling to space. This rail launch system would utilize a vacuumed, maglev track that would accelerate a launch vehicle equipped with scramjet and ion engines. Once the craft escapes the track, its high velocity will allow the scramjet engines to deliver the final amount of force needed to reach space. In orbit, the craft will utilize ion engines to maneuver in the zero-g environment without the need of solid fuels or large engines. These launch vehicles will be restricted to traveling near the Earth and will not be capable of reaching other planets due to its miniscule thrust. The purpose of these vehicles is to perform the tasks that the space shuttle was intended to do: transporting humans, supplies, and equipment between Earth and nearby space. Lacking rocket engines and boosters, the envisioned launch vehicle will significantly reduce the cost of transporting objects into space (from $10,000 per kg to $50 per kg), and it greatly increases the reliability of traveling into space.[5] To guarantee the system's efficiency, the size of the spacecraft would need to remain small, but the increased payload mass available, as a result from a reduction in propellant mass, enables for larger payloads to be sent into space. This new payload limit will not be significant when compared to today's rockets, but the system's effectiveness permits for constant departures to space. The proposed rail launch system treats the task of traveling from Earth to space differently from the journey that takes place in space. Modern rockets serve as both the launch vehicle and spacecraft, thus causing the problems that are seen in the current launch system. A reliable, reusable, and cheap launch system will make many other space expenditures highly feasible and increase the utilization of space as a means of transportation.

Permanent Orbital Installations & Sophisticated Propulsion Systems

The implementation of the envisioned rail launch system requires the construction of a spaceport and deep space vehicles. Ion engines, like the ones on the launch vehicles, cannot generate enough thrust to travel long distances, therefore separate vehicles intended for long distance travel must be constructed in space. Space stations must serve as space ports to ease the transition between launch vehicle to deep space vehicle. In 2017, NASA proposed the construction of a Deep Space Gateway in a cislunar orbit (between the Earth and its moon) with the intention of serving as a spaceport mitigating manned missions to the lunar surface.[12] The agency ultimately plans on utilizing the station as practice for deep space travel and a gateway for embarking on long distance journeys.[12] The Deep Space Gateway would assist with the establishment of deep space transportation and mining operations, but a larger space station is required to fully visualize an efficient system of traveling between Earth and other celestial bodies. In order to shorten travel times and increase the dependability of interplanetary missions, solid-fuel propulsion must be replaced by a more advanced propulsion technique. Fortunately, the technology for cutting-edge thrusters has been developed and was once approved for use in space. Known as NERVA, this method of propulsion harnessed the concept of a nuclear reactor for thrust, and it was able to reach specific impulses (mass of propellant consumed per second) of around 925 seconds. [22,10] Currently, the most powerful rocket engine in use, the Raptor engine, is capable of producing specific impulses of 304 seconds which is only about a third of the thrust generated by the NERVA engines.[10] Two containable complications that result from the use of nuclear engines are the inability to generate enough force to escape Earth's atmosphere and the excessive amounts of energy required for fuel. The power produced by small nuclear reactors and potentially fusion reactors is sufficient for fueling a nuclear engine at its peak (4,000 MW).[22] Furthermore, these engines do not need to overcome the Earth's atmosphere if they are constructed and launched from orbital stations, thus emphasizing the need for a more permanent establishment unlike the DSG. At the current pace of technological advancements, deep space vehicles will be propelled and powered by nuclear power, and cislunar spaceports will serve as shipyards that assemble and dispatch vehicles throughout the solar system. Hence, after the technology has been mastered, the introduction of fusion drives, like the VASIMR engine, would provide a higher level of efficiency due to their low fuel consumption and ability to reach linear speeds of 180,000 km/hr.[17] These thrusters are the updated versions of nuclear engines as a result from the use of fusion energy instead of fission energy in order to produce less radiation and only consume about a gram of fuel for long journeys.[26] Nuclear reactors will remain standard in deep space vehicles whether fusion or nuclear rockets are employed. The implementation of these advanced propulsion drives and permanent orbital installations coincide, and each must come to fruition in order for the distances between celestial bodies to become less substantial.

Establishment of an Extraterrestrial Mining Economy

The construction of orbital stations, spacecraft, launch systems, and nuclear devices will require large amounts of financial and political support. All of the proposed projects and concepts are technologically and monetarily feasible; nevertheless, political support has been what decides whether a project comes to be or not. Politics determined the fate of the NERVA project and the early Moon missions; the absence of political interest freezes advancements in the technology and launch systems being currently used for space exploration. This political disinterest is due to the deficiency of monetary motivation. In the United States, the relationship between the government, military, and space agency distinctly demonstrates the detachment politicians have with their space agencies. Most recently, about 54% of all federal discretionary spending was assigned to the Department of Defense; meanwhile, the entirety of scientific government organizations received only 3%.[18] As deduced by Vox's multimedia producer, Sam Ellis, the U.S. government's strong inclination to support military expenditures results from politicians wanting to secure jobs from private defense companies in order to stimulate the economy and maintain public support.[7] Consequently, the mutual relationship between the federal government and private defense companies results in funding being constantly leached from scientific organizations such as NASA. A practical answer to the situation would be the substitution of military expenditures with astronomical endeavours. This is possible due to the fact that defense companies, namely Boeing and Lockheed Martin, are also aerospace companies that work on spacecraft and satellite technology. The only change required is for the government to order more aerospace technology instead of weapons and militarized vehicles. Whereas vehicles like the F-35 Lightning Ⅱ fighter plane will provide little military advantage or financial gain, advanced spacecraft and aerospace technology have the potential to yield excessive profits.[7] By investing on cost-effective launch systems and permanent orbital spaceports, governments and/or businesses would have access to unlimited resources rarely found on Earth. Asteroids and other celestial bodies, including the Moon, contain large amounts of expensive and rare earth materials (platinum, scandium, yttrium, helium-3, etc.) that are rarely found on Earth or are projected to become scarce in 20 years.[29] Small probes and spacecraft, similar to the sample collection probe OSIRIS-REx, would either capture or drill out material from asteroids and have it sent back to Earth or a spaceport.[23,27] The utilization of small, autonomous craft will result in low-cost mining operations considering that powerful propulsion systems and human accommodations will not be needed. An established mining economy in space has the capability to not only produce an influx of money but also expand space exploration and technology in general. The large abundance of helium-3 on the Moon and other celestial bodies are going to provide an indefinite fuel source for fusion reactors, thus allowing for cheap fuel cost when conducting deep space missions.[19] Technology on Earth will have less restrictions impeding its progress due to the unlimited supply of rare materials that a space mining industry would yield. The initiation of an industry based on the collection of extraterrestrial material would stimulate the global economy, create and sustain employment, and progress technology while simultaneously deterring the world's focus on militaristic ventures to the acquisition of resources in space.

Utilization of Genetics & Advanced Habitats for Safe Space Travel

The greatest inhibitor to the development of man's presence in the solar system and beyond is the frailness of the human body. Improved launch and propulsion systems can only reduce the number of threats that humans face when confronting the final frontier. Structural shielding and shorter trips only limit the amount of cosmic radiation that astronauts would be exposed to, and they would do little if a coronal mass ejection or gamma ray burst crossed paths with a spacecraft.[11] A cislunar orbital station, unlike the currently in service International Space Station, would also be exposed to substantial amounts of cosmic radiation. Additionally, the lack of Earth's gravity on both space stations and spacecraft will result in increasing health issues as humans remain in microgravity environments for extended durations.[28] These two factors along with the constant risks any explorer faces (i.e food and water shortage, mechanical failure, unknown predicaments, etc.) establishes manned-space exploration as exceptionally burdening and dangerous undertaking. The human body's vulnerabilities are difficult to overcome since it is not a predicament that can be remedied with mechanical feats. Nevertheless, a combination of technology and medical advancements could provide the answers of ensuring safe and reliable space flight. To start, the absence of substantial gravitational forces can be addressed through the conventional concept of habitat wheels. Circular orbital stations configured with a diameter of 30 meters and a spin of 8 seconds per rotation would exert a centrifugal force equivalent to Earth's gravitational force.[28] The concept has never been expanded upon due to insufficient funding and health complications that arise from having a person's body experience different forces in different places as a result from the increase in force when approaching the centerpoint of the station. The differentiating force issue can be resolved by exponentially increasing the diameter of the habitat to make the change in force negligible, but this would require more resources to construct a habitat. These habitats would see use in both microgravity environments, foreign celestial bodies, and spacecraft in order to create Earth-like environments that will help astronauts prevent bone atrophy and maintain muscle strength. On the matter of cosmic radiation, mechanical structures can only provide limited protection through the use of hydrogenated boron nitride nanotubes (BNNT) and dense radiation shelters.[11] To achieve full insurance against radiation, genetics, specifically genetic manipulation, will need to be employed to create immunities against harmful environments in the solar system. The key to this proposal is the CRISPR gene editing tool, which is capable of reprogramming cells in order to give them manual commands or tasks.[34] Currently, doctors in the United States, China, and throughout Europe are ready to begin reprogramming immune cells, a procedure that has been successful in mice, in cancer patients to target tumors directly. [2,21] The CRISPR tool allows for a wide range of ways that cells can be manipulated, thus permitting the seemingly endless editing and copying of any genome.[34] The proposed solution does not ask for the use of CRISPR as a method of creating an immunization for radiation within humans; instead, it is seen as a device that can be used to retrofit the natural defenses against radiation that already exists in nature.[1] Tardigrades and other extremophile microorganisms have displayed their resistance to radiation when the ESA conducted an experiment that exposed a variety of organisms to the vacuum of space.[13] More than half of the tardigrades survived the procedure by entering a dehydrated state and repairing their DNA as quickly as it was destroyed.[13] The increased DNA repair rate found within tardigrades exhibits the reality of a natural defense against radiation. With full political approval, doctors and scientist would be capable of conducting more research in exploring how to convey the tardigrade radiation immunity within human cells.[1] The concept of organic protection against radiation for humans is feasible and is only restricted by governmental consent and limited experience in the use of CRISPR for human genome editing. By mastering the CRISPR gene editing tool, humans would be able to rid spacecraft of heavy radiation shielding and, ultimately, the need for extensive, physical radiation protection. This combination of radiation immunization, artificial gravity, and quick spacecraft will result in the establishment of reliable and safe space habitats that serve to promote the expansion of Earth's organisms throughout the solar system.

Conclusion

Critics of space exploration and expenditures usually raise the notion that the funding of space programs would provide insignificant benefit to society on Earth. They reason that space stations, rockets, and moon bases will do nothing to solve current societal problems such as hunger, global warming, war, etc. Contrary to this belief, advancements in space exploration will not only assist with humanities' current problems but also become the catalyst for monumental societal change. The discovery and exploration of the north and south american continents during the 1400s and 1500s, was fueled by the desire for territory and resources and resulted in the population growth of Europe due to the discovery of new foods originating from the new world. Similarly, the availability of expensive REMs throughout the solar system must play the role that gold once played when convincing nations to invest in the exploration of new worlds. The introduction of technologies like fusion reactors, along with the unlimited provisions of helium-3, would be capable of powering entire cities on Earth while also propelling spacecraft into the unknown.[32] A deeper understanding on the topic of genetic manipulation could bring about new and reliable methods for combating cancers, while the same techniques could allow astronauts to expose themselves to cosmic radiation without being harmed.[2] Advancing space exploration is, admitibly, an overwhelming task that requires the confrontation of governmental red tape, financial issues, and technological challenges. Although feasible, these challenges are bound to be time and resource consuming. Nonetheless, by conquering space flight and exploration, a new age of exploration would be initiated which will result in societal advancements that fundamentally expands and ensures humanities' survival throughout the solar system.

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