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A Comparative Study on Human Space Flights over Robotic Space Missions and Habitation involved in the Human Space Mission

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Abstract: This research paper delves into the history of human space flights alongside the advancements and new inventions in space technology over the years. We also observe that just as humans have evolved over time, so have the environment, other living beings, the land, and the sky. This paper explores early space exploration, emphasizing technological advancements, psychological challenges, and the profound impact of sending humans to outer space. It begins by providing a glimpse into how humans first ventured into space, followed by additional information on robotic space missions, including rovers, landers, satellites, and space observatories like the Hubble Space Telescope. Space probes are programmed to perform specific tasks. A glimpse of NASA's Apollo mission, the first-ever human space mission, is considered while discussing the risks faced during this pioneering flight. The paper also explains proposed solutions, detailing their physical aspects and assessing whether these solutions may or may not work.

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1. Introduction

Human interest in exploring the unknown and seeking answers is a universal phenomenon. Since the evolution of mankind, humans have questioned the unknown and sought to understand it. This curiosity led to the formation of natural philosophies, which later evolved into various scientific fields, including space exploration. Humans have long been fascinated by climate change, the repetition of day and night, eclipses, and other natural phenomena. In their quest to understand these events, they began observing the movements of celestial bodies using small-scale instruments and mathematical calculations. The invention of telescopes significantly enhanced our understanding of the movement of stars and celestial bodies in space, leading to the discovery of the mechanisms governing the planets in our Solar System. The rapid advancement of technologies such as rockets and satellites in the 20th century propelled space research forward. During the first half of the 21st century, space exploration was primarily conducted using telescopes and ground-based observatories. However, in the second half of the century, the space race between the USSR and the USA began, marked by the USSR's launch of Sputnik 1 and the USA's launch of Explorer the following year. This space race paved the way for Yuri Gagarin to become the first cosmonaut to travel to space. Although space exploration and human space missions initially emerged

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from the space race, they have since evolved into missions focused on studying outer space, searching for habitable planets, and exploring habitation possibilities on nearby planets. The main objective of this paper is to study human space missions and robotic space missions, analyze the advantages of human space exploration over robotic missions, examine the risks involved, assess the demand for sending humans to outer space, and explore proposed solutions for habitation on exoplanets **[1-3]**.

2. Evolution of Human Space Missions

Beyond numerous reasons such as scientific, practical, and non-scientific benefits, the scientific benefits have been a primary driving force behind sending humans into space. Over the years, space probes like COBE (Cosmic Background Explorer), the Planck observatory, and WMAP (Wilkinson Microwave Anisotropy Probe) have been sent into space and have played a vital role in exploring Cosmic Microwave Background Radiation. Voyager 1 and Voyager 2 have been traveling through and exploring deep space. The launch of the Hubble Space Telescope revolutionized space research by capturing photographs of various celestial bodies. While these robotic spacecrafts are essential, human involvement becomes inevitable when it comes to the maintenance and repair of these probes. For example, probes like Voyager 1 are located in regions inaccessible to humans for maintenance. However, the lifespan of the ISS and the Hubble Space Telescope has been sustained through continuous maintenance by astronauts. An astronaut who serviced the Hubble Space Telescope once stated, "I can say without hesitation that traveling to space to upgrade the instruments and ensure the future of the Hubble Space Telescope was worth the potential risk to my life." This statement underscores the indispensable role of humans in space exploration, despite the importance of robotic missions **[4-6]**.

3. Robotic and Human Space Missions

Robotic space missions involve autonomous space probes sent to outer space for exploration. These may include rovers, landers, satellites, or space observatories like the Hubble Space Telescope. While these probes are programmed for autonomous functions, their capabilities are limited. Human space missions, however, offer more advantages over robotic spacecraft. Humans can understand space and its activities in a broader and more comprehensive way because the scope of human research is larger. For example, the Apollo missions, which sent humans to the Moon, allowed astronauts to conduct more research, solve problems on the spot, and repair equipment on the lunar surface. They were able to dig lunar soil and collect samples, tasks that would be difficult or impossible for robotic spacecraft. The same advantages apply to potential missions to Mars. This example highlights the human ability to conduct research in outer space, as astronauts are not limited by pre-programmed instructions like robots. While robotic missions would require many spacecrafts to explore the Moon, from 1969 to 1972, just twelve people walked on the Moon's surface and explored aspects such as gravity, temperature conditions, suitability for human habitation, and the availability of minerals. Human missions offer the flexibility to explore as needed, thanks to their greater capacity for adapting to new conditions **[7-9]**.

3. Risk Involved in Human Space Missions

Human spaceflight missions are both expensive and risky. Astronauts are exposed to extreme temperatures, harmful radiation, high vacuum, space debris, circadian desynchrony (caused by the light-dark transitions that occur every 45 minutes, leading to sleep pattern disruptions), microgravity, and more. These missions cause both structural and functional changes in astronauts' bodies. Functional changes affect brain function, while structural changes manifest physically. For example, astronauts returning from space often experience balance issues due to microgravity, which leads to bone and muscle loss. The International Space Station (ISS) experiences nearly 90% of Earth's gravity, but due to its continuous freefall, astronauts inside feel weightless and don't need to exert much effort, leading to bone and muscle loss. This makes it difficult for them to regain balance upon returning to Earth. Microgravity also affects cardiac function; the heart doesn't need to pump as vigorously as it does on Earth, leading to a reduction in cardiac muscle size. These are just some of the natural challenges astronauts face. Technically, human spaceflight also presents challenges. From the crash landing of the first crewed Soviet Union's Soyuz spacecraft in 1967 to the breakup of the Columbia shuttle in 2003, 18 people have died during manned spaceflights. Supporting astronauts in orbit significantly increases costs, as ensuring the safety of launch, re-entry, and landing requires expensive equipment. This makes human space missions costly. Since the start of human spaceflight programs, there has been debate about whether the benefits of these missions justify the costs and risks. Some argue that robotic space missions can accomplish the same exploration at a lower cost without the need to send humans into space. However, the benefits of human spaceflight are vast, both scientifically and non-scientifically. Scientifically, humans can cope with different conditions and perform tasks that robotic probes cannot. Unlike robots, humans do not need programming and can adapt to various situations. Human spaceflights help us understand the extreme conditions, as well as the physiological and psychological impacts, that outer space has on humans, which can lead to the discovery of new technologies to help humans survive in space. Non-scientifically, human spaceflight missions spark curiosity and inspiration among students and the younger generation, turning their interest toward science and technology, particularly in space research, and fostering a desire to explore space. These missions also enhance a country's reputation by showcasing technological strength, which can increase the country's economic status as other countries seek to collaborate on space exploration. NASA's Apollo missions are an example of this. The Apollo program was part of the Cold War competition between the Soviet Union and the USA. Although the Soviet Union was ahead of the USA in sending satellites, humans into space, and probes to the Moon, the USA's decision to send humans to the Moon demonstrated its technical strength. Human space exploration also lays the foundation for a passion for inquiry that can drive humanity forward. Thus, the benefits of human spaceflight far exceed those of robotic missions, enhancing a nation's scientific, political, economic, educational, and technological standing. The development of space tourism also highlights the growing interest in spreading human presence in space **[10-14]**.

4. Proposed Solution for Human Habitation

Habitation in space is a complex challenge, involving various aspects necessary for survival and comfortable living. As Michio Kaku said, "Living in outer space is only an engineering problem now." Many theories have been proposed on how humans can survive in outer space. But first, why would humans want to move to space? Earth is not a permanent space for our race to continue its existence, so it is crucial to expand our species beyond Earth and ensure its survival for future generations. When we talk about outer space habitation, it's not just one aspect we should consider; we must address sustainability, food, shelter, clothing, and creating a safe society. The idea of inhabiting Mars is feasible, but humans would have to adapt to Mars's existing ecosystem and develop many new technologies, which could be challenging. An O'Neill cylinder (also called an O'Neill colony) is a space settlement concept proposed by American physicist Gerard K. O'Neill in 1976. It involves using materials extracted from the Moon and later from asteroids. An O'Neill cylinder would consist of two counter-rotating cylinders, which would cancel out any gyroscopic effects and help maintain stability while keeping the cylinders aimed toward the Sun. Mars's gravity isn't sufficient to keep humans healthy, so these rotating cylinders would be a great idea. The main advantage of the O'Neill cylinder is its ability to maintain constant gravity. However, while this concept solves some problems related to creating a sustainable place to live, it doesn't address all the challenges humans might face. Moreover, this concept is still theoretical, and no practical implementation has been demonstrated. Gravity is one of the biggest challenges for human habitation in space. Gravity plays a crucial role in human physiology. Zero gravity leads to weightlessness, increased height due to spinal lengthening, changes in chest, waist, and limb circumference due to fluid shifting, and loss of weight and bone density. These factors could pose hazards as astronauts adjust to new circumstances. Basic needs for interplanetary or space habitation include life support systems, water recycling, air purification, sufficient resources, and meeting daily nutritional requirements. All these requisites must be met to ensure a sustainable and habitable environment in space. Tardigrades, or water bears, are ancient animals that can survive extreme environments by entering a "tun" state for extended periods. They can survive being dried out, frozen to just above absolute zero, heated past the boiling point of water, exposed to extreme radiation, and even deprived of oxygen. These tardigrades weren't born with these abilities; they adapted and evolved over time. This demonstrates that habitation should involve not just creating an initial habitat but also providing a well-built structure that mimics Earth's gravity. Essentially, creating another Earth would be a feasible solution **[15-18]**.

5. Conclusion

Though human space missions are associated with risks and high financial costs, they offer significant advantages over robotic exploration. Astronauts can adapt to and be flexible in any situation that may arise, allowing them to conduct a wider range of research than would be possible with pre-programmed robots. Human spaceflight does more than satisfy scientific curiosity; it also generates public interest in STEM fields, fuels technological innovation, and symbolizes national progress. We must look to the future of space exploration to develop sustainable solutions for human habitation on exoplanets, such as the O'Neill cylinder. By addressing challenges like gravity, resource management, and life support systems, we can open the door to a future where humanity has expanded beyond Earth. Space exploration is a fundamental pursuit that expands humanity's presence beyond Earth, driven by both curiosity and necessity. The comparison between human and robotic space missions shows that despite the significant contributions of robotic probes like Voyager and Hubble in our understanding of the universe, human space missions are more beneficial because they allow for flexibility, on-the-spot problem-solving, and extensive research. Human spaceflight brings elaborate challenges and high costs due to the need for continuous innovation to manage risks such as microgravity effects and radiation exposure. However, these investments are well justified by the significant scientific, educational, and inspirational benefits. The challenge now is to continue exploring the possibilities for continuous habitation in space, whether through advanced concepts like O'Neill cylinders or the more realistic approach of colonizing places like Mars. Pursuing these ambitious goals will not only preserve humanity's future but also fundamentally advance technological progress and deepen our understanding of life and survival in extraterrestrial environments. Indeed, as we move toward these new horizons in space, the potential for expanding human knowledge and ensuring the future survival of our race is immense.

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