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Space Elevator

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Abstract

Scientists have been involved in the discovery of space for many years. However, the process of moving to space from the earth is expensive and time-consuming. Therefore, they have developed several concepts concerning the cargo movement and people from earth to space in an easier, cheap and safe way. Konstantin Tsiolkovsky developed space elevators idea in 189. Since then, more concepts were developed by different researchers and scientists. Technology advancement has also enhanced the knowledge of space elevator; however, space elevator will need to ride from the earth to the moon via a cable. This will need a strong and light material to protect it from breaking and other external stress such as earthquakes and wind. Although different pieces of literature have suggested various materials, spaceline technology seems to change the game. This project report aims to survey several pieces of literature to identify the concepts, technology use, financial viability and safety issues of space elevator.

Space Elevator

The world is explored for a very long time and this has resulted in scientists discovering space. Space is a very critical component and it has always been unidentified to the world. Therefore, scientist is mindful in understanding the experiences of the space because of its unknown features. Although several theories have been from science fiction and scientist across the globe concerning traveling to space, the only thing that was challenging to this achievement was technology. Ahmed et al. (2019) stated that the space elevator was designed many decades ago and thus, probable theories and experiments were also executed. Nevertheless, it is always viewed as an unusual and almost unreasonable concept to develop a space elevator to space. However, scientist argues that this can become a reality shortly.

The project on space elevator is facilitated by the advancement in technology, which aims to be the most significant breakthrough in space exploration. This technology comes with both benefits and disadvantages, but more advantages are available in the development of the elevators than disadvantages. For instance, one of the primary disadvantages is the infrequent technologies and the cost of building the elevators. However, there are many chances for resources to build a space elevator despite the reduced technology available. Ahmed et al. (2019) claimed that scientists have presented that carbon Nanotubes are among the best, strong and effective ideal elements for developing the space elevator. Moreover, the technology continues to be erudite based on the way the world advances, this results in significant effects, but the cost of implementing the technology is becoming a problem. Therefore, this paper will focus on researching the previous concepts of space elevator developed by past researchers and scientists as well as explaining the best technology to be used, the financial viability of safety issue of the space elevator project.

Project Aims and Objectives

Space elevator is a form of space carriage system with the main elements to be a cable, also referred to as tether, which is attached to earth's surface and spreads to space, despite many scientists and researchers exploring the concepts of space elevator much needs to be considered before the project is implemented. Therefore, this report aims to explore the previous literature and identify the gap as well as their concepts. These concepts when combined will result in the development of a viable and most efficient space elevator. Furthermore, the report also explores the technologies stated with other scientist and compare with current technologies.

The objectives of the report will comprise of:

1. To combine the concepts developed by different scientists and researchers concerning the development of space elevators.
2. To identify the possible technologies to be used in the development of space elevators.
3. To recognize financial viability in the construction of space elevator
4. To explore the safety issues of using the space elevator as a mode of transport to space

Methodology

There is an increase in research concerning the development of the space elevator. Therefore, different scientists and researchers have come up with varying concepts concerning the space elevator development. Nevertheless, proper research is needed to combine different pieces of literature in coming up with the efficient concepts, technology to be used, and financial viability and safety issues that need to be considered for an effective space elevator. This qualitative study will provide appropriate knowledge concerning the space elevator by exploring several literature pieces to incorporate different scientific concepts. The methodology is less

controlled and more interpretive because it deals with concepts from existing knowledge. The literature materials are obtained from peer-reviewed scholarly articles and the articles collected are up to date because they were less than two years ago. Survey of literature is selected because the proposal on developing a space elevator already has substantial information. Therefore, this method will yield efficient concepts and in-depth understanding of the space elevator design and implementation.

Survey of Literature

Space elevator is a form of space transportation system. Therefore, the space elevator's primary component is a tether extended from the earth to space. Different designs are developed; however, they all aim to allow the cars to travel across the tether from the earth to space. This has both advantages and disadvantages. The main benefit of the tether is to allow heavy elements and objects to be taken to space at lower cost than using rockets. Zhu & Li (2020) researched a partial space elevator concept and anticipated a new thought of tether transportation structure with high-efficiency payload.

Nevertheless, Ahmed et al. (2019) argued that Konstantin Tsiolkovsky first wrote the tower concept going to the geosynchronous orbit in 1895. Tsiolkovsky suggested that the free-standing tether should move from the earth to the geostationary orbit. Thus, the tether will be considered as the building and thus, the space elevator will be under density by sustaining its weight from below. Furthermore, Ahmed et al. (2019) added that by 1959 many concepts for space elevator were developed and concentrated mostly on virtuously tensile structures where centrifugal forces will apprehend the weight of the scheme. Through this, the cable can take a heavy mass outside the geostationary orbit to the ground.

Harris et al. (2019) concentrated on the life cycle evaluation of suggested space elevator designs. The authors argued that the initial life cycle evaluation of suggested orbital transportation scheme design was already accomplished. The space elevator plans were considered ecologically and financially justifiable. The three initial suggested space elevator system designs comprised the one-tether elevator, two-tether elevator, and another one-tether. Since the compassion examination to relate the effects of decreased usage size was done, it was found that the added one-tether elevator system had the last ecological effects.

On the other hand, the tow-cabled space elevator had the least production cost in one unit of mass taken to orbit. Nevertheless, the use phase effects needed to be decreased by enhancing the terrestrial carriage to space. Harris et al. (2019) recommended that scientists do more supportable research for all orbital transportation systems.

Another research by Пристромова (2020), explained the use of carbon as the best material to build the space elevator. The authors explained that carbon materials had become a critical element of a space rocket. Moreover, the discovery of the nanoparticles, including nanotubes, has increasingly helped find the strongest materials. Space elevator requires strong materials and light (Ahmed et al., 2019). Therefore, Пристромова (2020), claimed that the carbon has materials that are strong as well as have an operating temperature of four thousand degree Celsius and a density of less than $2g/cm^3$. The concept of the best materials to fit the development of the space elevator is critical; carbon nanotubes were identified as the appropriate material. The nanotubes are prolonged tubular edifices with a diameter of one and a dimension of some centimeters comprising at least one hexagonal graphite plane trolled in a tube.

Knapman (2019) discussed the design considerations for space elevators and stated that the building materials are vital in the successful development of the elevator. Therefore, creating

new materials that can attain the strength specifications will help advance the designs and fasten the implementation process. Knapman (2019) explained the primary challenge in developing the space elevator was getting robust materials that are light for the tether that can emerge to the earth's equator from an altitude of one hundred thousand kilometers. Nevertheless, the same source added that the problems are already addressed because the concept of carbon nanotubes has indicated significant strength and needs for the space elevator.

Moreover, other materials found to meet the space elevator requirements comprise boron nitride nanotubes and diamond nano threads. Knapman (2019) stated that many funds are used in research to identify the best materials; although there are more challenges, the benefits are many. Also, despite the construction of long buildings reducing interest in the past few years, more work is already done in the development of the space fountain as well as the launch loop, which is also referred to as the High Stage One. The loop will help the space elevator when winds and ice occur. Similarly, efficient design materials are essential as they can be used with other structures, including the planes.

Gravity plays a crucial role on earth; however, it also causes immense challenges in scientists expanding to space. Gravitational pull makes many objects use a lot of energy to get to space. However, scientists believe that through the advancement in technology, space elevation can work efficiently. This will make going to the moon easy, safe and efficient because cities can also be developed on the moon. Huang et al. (2021) researched Spaceline technology which can make the space elevator work efficiently. Although space elevator helps in evading the problem of gravity because it permits payloads in traversing along a tether adjusting from earth all the way to orbit, no robust materials currently enough in building a cable with the capacity to sustain its weight.

Penoyre & Sandford (2019) demonstrated another way of reaching the space apart from the normal space elevator using present technology, the spaceline. Therefore, by adjusting the line attached to the moon to unfathomable in the earth's gravity, scientists can build a steady, crossable tether that will permit free undertaking from locality of the earth to moon. Furthermore, with the present materials, it is possible to develop a tether adjusting near height of geostationary orbit, permitting calm traversal as well as building between earth and space.

The Spaceline technology will look like a skyhook. Therefore, it will be different from the tower because it will be a thin and robust piece of material that adjusts thousands of kilometers from space to a secure place on the earth that will not affect the satellites. Similarly, Penoyre & Sandford (2019) stated that everybody who needs to go to the moon could easily launch to the right orbit height move using the spaceline. The technology is also vital in saving costs because it will utilize solar-powered propulsion to move; hence no fuel is needed. Besides, upon reaching the other side, they will reduce the speed and safely land on the lunar orbit. The spaceline will also pass through the earth and moon Lagrange point because there is no gravity and other physical intrusions in this region, hence making building and storage easy. Furthermore, the base will have several engineers to make and maintain other new space trials tested to move across other solar systems.

YAZICI (2020) explained the economic feasibility of Space Elevator and thus stated that since it's a new concept that has gained immense interest among scientists and researchers. The interest is based on the economic advantages of transporting objects and individuals from the earth's surface to the moon. Currently, taking cargo from the earth to space will consume many resources because it is expensive. Similarly, it is also complex to take cargo to space because it will take a lot of time. Therefore, building the space elevator will help individuals to travel to

space easily and less expensively. As stated by YAZICI (2020), the economic feasibility of space elevator argues that taking cargo to space will be cheap and offer more accessible access to space. Moreover, tourism always plays an essential role in individuals' adventure and visiting new places. Therefore, through space elevator tourism sector will be enhanced because it is the future of tourism.

Another research by Harris & Landis (2020) added that the space elevator feasibility situation is adequate. However, it is not an essential condition for the practicality of being a transport system. The space elevator is also financially viable based on Harris & Landis (2020) because, in most cases, it is always depicted as a free mode of transport. After all, the cable is invariant and the walkers are reusable. Also, the cost of power is insignificant because it uses solar power.

Nonetheless, for a comprehensive financial archetypal, it is essential to consider the cost of cable replacement as well as to conduct monetary trade-offs, including selecting between decreasing throughput, utilizing more cable materials or disposing of the walkers. Based on the choices, space elevator is regarded to be financially viable situation because it will execute a snugger bound on its actual possibility. Although the price of technology constraints is not yet realized, the scientific prototype can be developed.

Otsuka et al. (2020) researched how space elevator tether's oscillation produced in space thermal ecosystem and found that the space elevator cable behavior with its smaller modulus's temperature reliance because the cable vibration is thrilled in east-west route only. Therefore, since the authors were testing the smaller modulus reliant on the temperature, they examined the behavior of space elevator cable by considering cable temperature. The results indicated that the cable did not have vibration in the north-south path. Since the vibration has an amplitude of

about forty kilometers in half a day oscillation, the temperature varies in many parts of the cable in a half-day sequence.

Moreover, the vibration occurs due to temperature variations during the expansion and contraction of the cable. Otsuka et al. (2020) state that Coriolis force is obtained by increasing and reducing the cable vibration by substituting it as an inflammation force. Therefore, this indicates safety issues because of the dangers of resonance caused by the vibration. Notably, it is critical that variation in the standards of two constructs can result in the formation of the ordinary incidence of the space elevator and the inside pressure developed in the cable. However, by enhancing the cable length or reducing the inside pressure, the normal frequency can be changed to the lesser side.

On the other side, by reducing the cable length or enhancing the interior strain, the usual occurrence can be adjusted to a higher level. Also, for the real process of the space elevator, it is recommended that the changing of the greater incidence side is better. Similarly, when the space station is at risk of being attacked by the satellite in orbit, it can release its thrusters to remove them out of the way. Therefore, whether the space elevator is anchored on the moon or the earth's surface, it will always be stationary and fixed. This makes it to be at the broad clemency of any object that can appear on its way. The safety issue will arise because the object can be the satellite that can be moved from the way; however, it can also be another broken or another thing beyond the individual's control.

The concepts developed concerning the space elevator are immense and can result in significant benefits in supporting the project. Although different scientists had varying viewpoints, they can be combined and integrated to achieve one common concept. Technology advancement is critical in developing the space elevator; however, spacelines are the best

technology to use because of the safety issues. Space elevators do not have the best material that is strong and light to support their weight; hence through spaceline technology, the journey to space and back is almost impossible.

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3	Koushik Ahmed, Shuva Dasgupta Avi, Md Shahnewaz Tanvir, Md. Mominur Rahman et al. "Transportation in Between the Earth and Space by Using Carbon Nanotubes as the Elevator Cable", 2019 5th International Conference on Advances in Electrical Engineering (ICAEE), 2019 Publication	<1%

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