Acceleron Aerospace Journal || AAJ.11.2106-2518
Volume 4, Issue 3, pp (1020-1034)
Review Paper
E-ISSN- 2583-9942 || DOI: 10.61359/11.2106-2518

Beyond Earth: Space Elevators as Catalysts for a Sustainable Multiplanetary Economy

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Abstract: This proposal explores the potential of space elevators to revolutionize space development and establish a multiplanetary economy. It envisions a future where space elevators enable cost-effective access to space and the transportation of heavy payloads, transforming the way we utilize space. The proposal outlines a plan for constructing space infrastructure, including transportation systems, space settlements, and space factories, all facilitated by space elevators. It also addresses the importance of utilizing space resources to restore Earth's environment and create a sustainable future. Furthermore, the proposal discusses the potential applications of space elevators in various fields, including power generation, tourism, defense, and even the preservation of human civilization.

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1. Introduction

Our planet and society are currently grappling with a myriad of global challenges, ranging from social and environmental issues to potential catastrophes and beyond. Some of these challenges have evolved due to the exponential growth across all fields in the past century and have been further intensified by the increasing social and environmental demands of the new century. We firmly believe that innovative tools emerging from technological progress should play a pivotal role in addressing these challenges and improving our overall situation. The primary objective should be to leverage these advancements not only to confront challenges but also to revolutionize entire economies, fostering significant progress in our journey toward a better world. To illustrate, poverty, one of the most pressing global social challenges, can be overcome by generating wealth, translating into job creation at all levels. Achieving such results requires expanding the existing economy on an unprecedented scale. Space development and the establishment of a multiplanetary economy and society emerge as key drivers for this expansion, offering the potential for an order of magnitude growth in our current economic conditions. Simultaneously, the space elevator, as a fundamental player in this scenario, could represent one of the most effective instruments for achieving such a purpose. It is crucial to remember that seemingly straightforward inventions, such as the 19th -century elevator, have had the power to transform our cities. The

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** Received: 12-March-2025 || Revised: 30-March-2025 || Accepted: 30-March-2025 || Published Online: 30-March-2025.

introduction of the third dimension through elevators enabled the construction of skyscrapers, high rises, and various building types, forever altering our cityscapes and the way a city functions. Similarly, the space elevator has the potential to create a transportation infrastructure that would provide cost -effective access to space while accommodating heavy payloads, changing the rules of the game. In fact, since the creation of an expanded multiplanetary economy is the primary goal as an efficient way to address the global challenges threatening our society, we aim to explore the various possibilities and benefits that an instrument like the space elevator could generate for this purpose. Let us delve into a scenario where the space elevator could make a difference in an unexpected utilization, opening doors to a multiplanetary society and economy starting in the 21st century.

Figure-1 Space Elevator Geo-terminal

2. The Mission

Our primary mission is to confront global challenges, both social and environmental, by harnessing the capabilities of the space elevator. On the environmental front, we aim to create a planet free from pollution and carbon emissions, restoring the natural ecosystem and phasing out the use of non-renewable materials. Simultaneously, from a social perspective, our vision is to foster an exponentially expanded economy capable of eradicating poverty, addressing global challenges, and enhancing overall human well-being, providing opportunities for a wealthier and healthier life. Our mission is to accelerate the establishment of a multiplanetary society through the development of efficient and affordable equipment and infrastructures for transportation and settlement. The proposed space elevator, serving as a game changer, stands as one of the fundamental instruments to achieve these missions and goals. With this proposal, we aim to paint a scenario where space elevators become commonplace, facilitating seamless access to and from celestial bodies and enabling a space economy to encompass our entire solar planetary system.

3. Summary Proposal

This proposal aims to explore the myriad possibilities and analyze specific fields transformed by the introduction of space elevators in a future multiplanetary society. The key focus is on developing a space economy that leverages space infrastructure on selected celestial bodies, including the utilization of spaceships equipped with space elevators to spread these infrastructures throughout the solar system. A critical aspect is defining the role of our planet in a future planetary economy, along with other celestial bodies and space-based settlements. Recognizing the uniqueness of Earth, the proposal emphasizes the importance of preserving, restoring, and enhancing our planet to return it to pristine conditions, adapting to future conditions, population growth, wealth distribution, and various activities. This entails eliminating or reducing activities that have contributed to the current poor environmental conditions. While Earth undergoes restoration, Mars is proposed to be terraformed to adapt to terrestrial conditions, and other celestial bodies would be made habitable through underground terraforming. The creation of an economy based on their exclusive resources is envisioned. The human presence is identified as the primary driver for the expansion of the space economy, with all life support requirements and human needs acting as catalysts for multiplanetary economic activities. Future multiplanetary society presents numerous scenarios influenced by different parameters that require in-depth analysis. The proposal aims to identify and prioritize the most significant parameters, showcasing the substantial impact of the space elevator's contribution to the envisioned multiplanetary future.

4. Space Infrastructures

To allow an efficient space economy space infrastructures must be built that would support all activities.

Such infrastructures would be of two types: The transportation system, based on space elevators and the space settlement system in ground bases at selected bodies as well as space-based ones; To further understand material behavior, microstructural analysis was conducted to examine phase formation, grain structure, and carbide precipitation. Inconel 718 relies on γ' and γ'' strengthening phases, while Inconel 625 exhibits solid solution strengthening with carbide formation. These structural differences play a key role in their high-temperature performance and durability in rocket nozzle applications.

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Space elevator

Space elevators, functioning as a low -cost transportation system for space access, are envisioned as essential infrastructures on major celestial bodies. The fundamental components of these space elevators include the ground terminal, cables and cabin equipment, and a geolocation terminal. Analyzing each component from a space development perspective is crucial for understanding their roles and potential adaptations.

Ground Terminal

The primary function of the ground terminal is to serve as the base station for the space elevator. However, depending on its location and purpose, it can assume various roles. In non-terrestrial applications, the space elevator ground terminal could evolve into a local ground base that expands alongside the development of local activities

Cables and Cabin Equipment

The cables and cabins play a pivotal role in the space elevator's functionality. Different functions may require varying specifications; for instance, space factories might demand a larger cabin capability.

Geolocation Terminal

The geolocation terminal serves as a designated point equipped to construct settlement-type facilities through an assembly facility. Beyond its primary function, it becomes a central hub for a range of activities, including serving as a spaceport for solar system transportation, maintenance facility, space hotel for tourists and workers, healthcare center, food production site, power generation station, and more. The geolocation terminal emerges as a multifunctional facility integral to the overall success of space elevator operations. In the subsequent sections, a detailed analysis will explore how these components can be modified to fulfill specific requirements, showcasing the adaptability and transformative potential of space elevators in addressing the diverse needs of celestial bodies within our solar system.

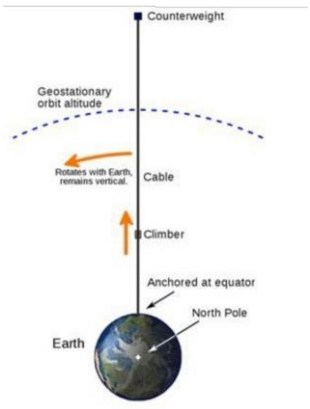

Figure-2 Space Elevator Components

5. Space Transportation System

The envisioned space transportation system is designed around a cruiser-feeder combination, where feeder spacecraft transport cargo and passengers between ground bases on Earth and other celestial bodies, connecting with cruiser spacecraft following permanent cycling trajectories between these bodies. Currently proposed with single spacecraft, the future vision involves integrating the space elevator infrastructure into this system, utilizing it for the feeder function. The space elevator would efficiently transport payloads between ground bases and geo-terminals. In this scenario, geo-terminals would be equipped with spaceports, warehouses, and maintenance facilities for cruisers, along with specific functions tailored to their unique requirements. The further incorporation of space elevators into traveling settlements could transform ground terminals into local bases, supporting further developments.

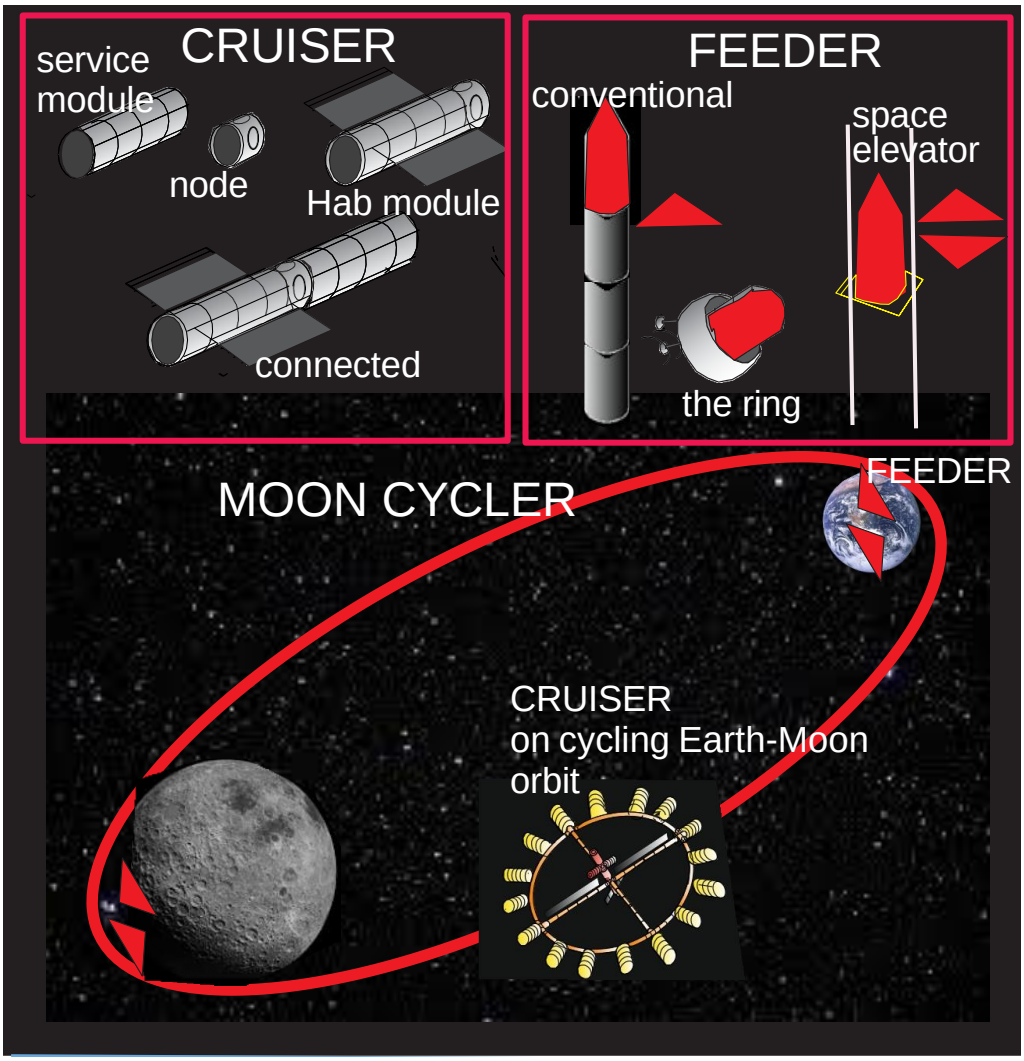

Figure-3 Cruiser-Feeder System

6. Space Container System

Integral to the transportation system is the space container system, responsible for transporting cargo and passengers between terminals, space settlements, and ground bases. Space elevators play a crucial role in facilitating the transfer of containers between the surface and geo-terminals, forming the foundation for various human activities, including mining, metal processing, manufacturing, and efficient transportation systems. A solar system network of geo-terminals on different celestial bodies, connected to the ground level through space elevators, complements the space transportation system. Space tugs, designed for single or multiple containers, move goods and passengers between bodies, including space stations and settlements. Space containers serve as

the fundamental cargo components, facilitating their transfer between ground and space bases in varying quantities.

System Overview

Single System - "The Ring"

- Feeder or cruiser spacecraft designed to transport a single container.

Multiple System - "The Constellation"

- Modular system containing a central propulsion, fuel, and navigation systems to transport several containers.
- Structured as a network between terminals, forming an efficient and flexible transportation system.

This integrated space transportation and container system, with the support of space elevators and geo-terminals, envisions a comprehensive network facilitating the movement of cargo and passengers within our solar system.

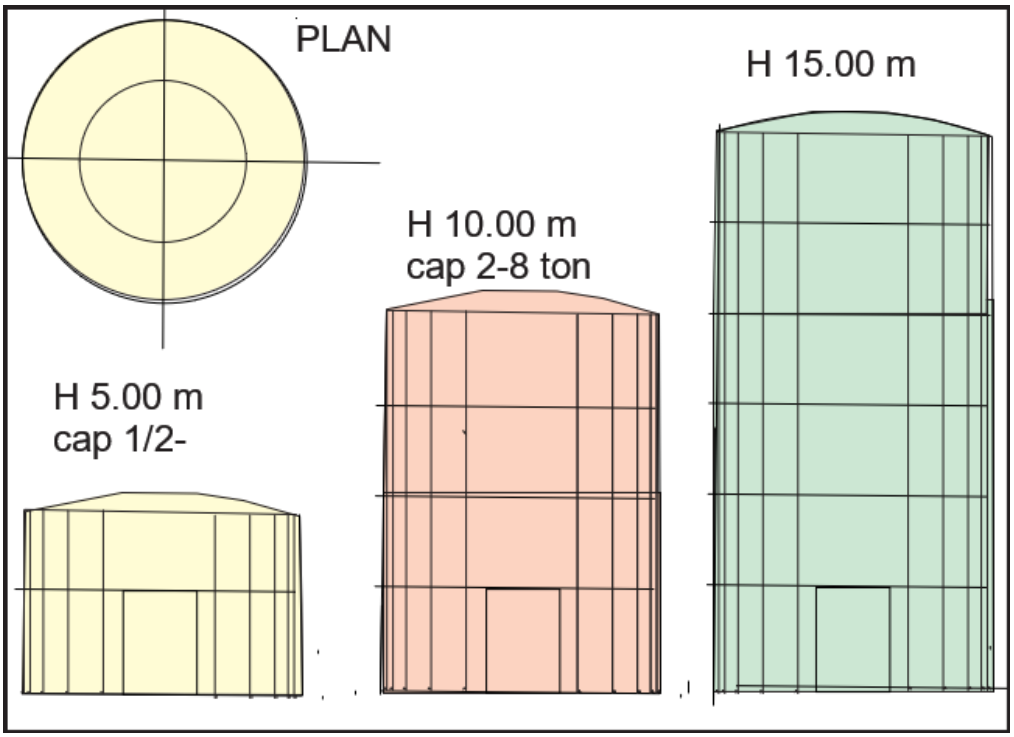

Figure-4 Modular Containers

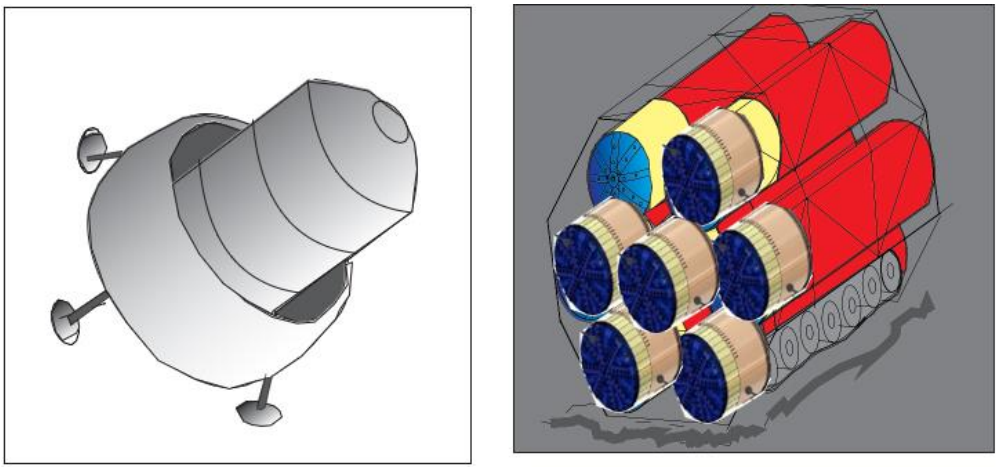

Figure-5 The Ring and Constellation

7. Space Settlements

The feasibility of establishing human settlements in space and on chosen celestial bodies represents a groundbreaking frontier in space development. Proposing a paradigm shift, these settlements could be manufactured on Earth and efficiently assembled in geostationary orbit, facilitated by space elevators and creating an entirely new industry. This approach positions space settlements as pivotal instruments for space development, capable of supporting human life with advanced terrestrial life support systems and facilitating sophisticated manufacturing activities for celestial body exploitation. The integration of space elevators in the construction process enables the creation of modular space settlements on our planet at a low cost, utilizing advanced technology akin to existing shipbuilding operations.

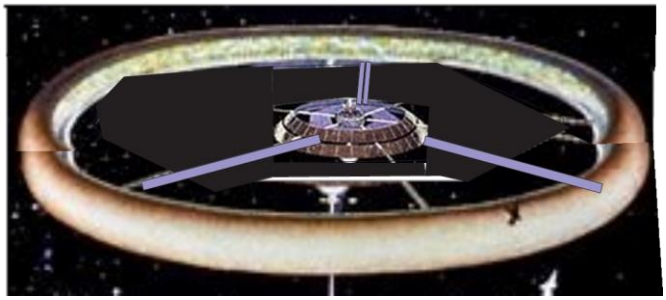

Figure-6 Geoterminal with Space Settlement

These modules can then be transported by space elevators and assembled in geo-terminal stations or in settlements connected with the space elevator, since the connected settlement would represent the optimal solution for terrestrial space settlements allowing low-cost transportation for all space activities performed in space. From these stations, space settlements can be dispatched to their designated destinations, fully equipped to initiate the exploitation of a new celestial body or follow a predetermined trajectory in any solar system location.

8. Traveling Space Settlements Equipped with Space Elevators

Some space settlements may be equipped with space elevator facilities, further facilitating the development of selected celestial bodies. Together with the settlements, the space elevator facilities would be built on our planet and delivered by space elevator to the geo-terminal where they would be assembled in a proper facility. Such a settlement, once arrived at their destination, would deploy the space elevator, use its ground terminal as local base and be immediately operational. Such settlements will be donut shaped rotating around a ring while the space elevator geo-terminal and other facilities would be non-rotating. The construction of space settlements is envisioned to evolve into a major industry, starting on Earth and expanding to future space facilities that utilize non-terrestrial materials. This transformative approach not only opens the door to unprecedented human presence beyond Earth but also establishes a foundation for sustained space exploration.

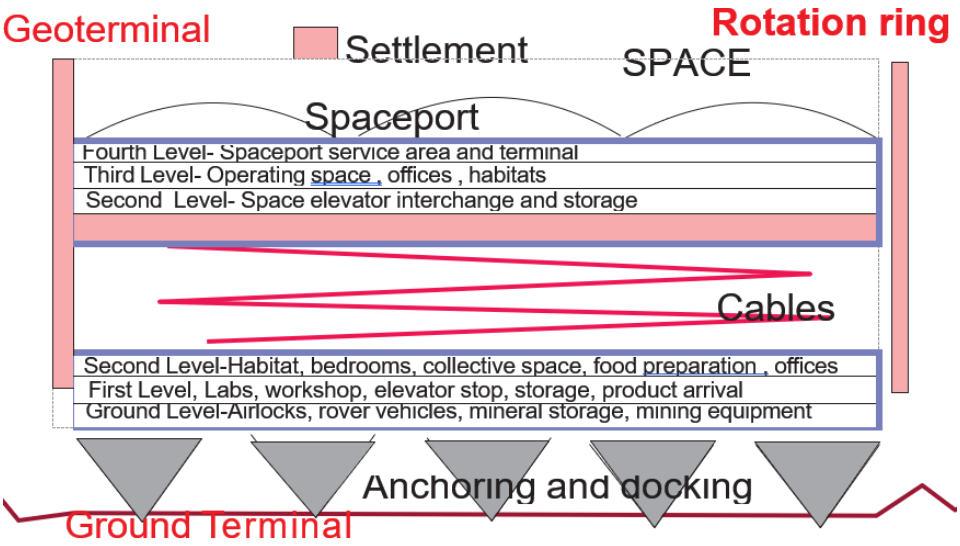

Figure-7 Space Elevator Terminals

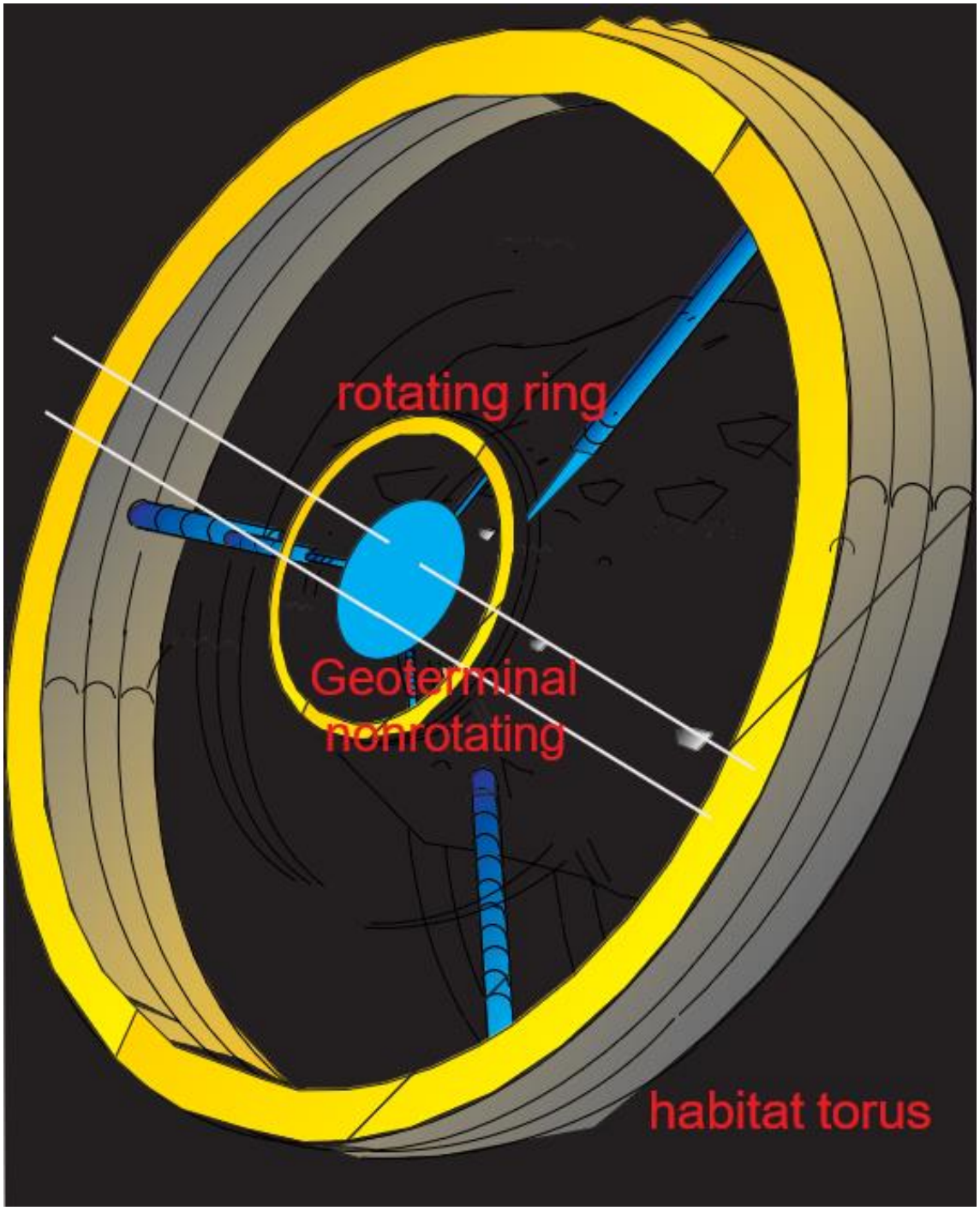

Figure-6 Settlement at Geo-terminal

9. Space Factories

In the broader context of addressing global challenges, our mission is to curb, if not eliminate, the use of non -renewable resources on Earth by importing essential materials from space. This approach aims to restore our planet to pristine conditions, mitigating pollution, and reducing the carbon footprint. Simultaneously, it paves the way for the creation of a new multiplanetary society, offering numerous benefits for humanity. At the heart of this transformative mission stands the proposed space elevator, serving as the primary instrument to achieve these ambitious goals. This innovative solution addresses the urgent challenges our planet faces and provides a pathway to sustainable resource utilization.

10. The Concept

Millions of asteroids and comets are available in the solar system and could satisfy future requirements for centuries to come, even in an expanded multiplanetary society. Utilize small, deflected NEO asteroids as raw material resources to be delivered to a geo orbital mineral processing and manufacturing plant, attached to a multiple cabin space elevator that would initially support the space manufacturing assembly in geo orbital position and further on transport all finished manufactured products to our planet.

Utilization Resources

The relentless and escalating consumption of non-renewable minerals to fuel economic growth poses a threat to our planet's resources. With the current trajectory, Earth's finite resources could be depleted within a few decades. In an expanded multiplanetary e economy with exponentially growing mineral demands, a strategic solution is imperative.

Procuring Minerals from Asteroids and Comets:

The proposed solution involves tapping into the vast reserve of small asteroids and comets scattered throughout the solar system. These celestial bodies hold immense wealth in the form of minerals needed to sustain and fuel our economy. This approach not only addresses resource scarcity on Earth but also offers the opportunity to restore our planet to pre-industrial Revolution conditions, preserving the natural ecosystem and mitigating the adverse effects of pollution.

The Enormous Potential:

Millions of small asteroids and comets, readily available in the solar system, represent a colossal reservoir of essential minerals. By harnessing the potential of these celestial bodies, we can secure a sustainable supply of resources, simultaneously deviating the strain on Earth's limited reserves and promoting responsible resource management for future generations. In summary, the concept of space factories, coupled with the utilization of resources from asteroids and comets, presents a groundbreaking solution to the challenges posed by the depletion of non -renewable resources on Earth. The proposed space elevator serves as the linchpin in this ambitious endeavor, offering a transformative and sustainable path toward a new era of resource utilization and planetary stewardship.

Space Property Law Requirements

Recognizing the vast economic potential of minerals in space, particularly within asteroids, it is imperative to establish comprehensive legal frameworks before initiating any asteroid deflection and mining activities. The complexities of space property law.

11. The Space Factory

This facility will be constructed following the design principles of space settlements, aiming to recreate all terrestrial conditions, including atmosphere, temperature, and gravity. It will take the form of a double donut, featuring several functional levels inside while rotating around a central hub. This rotation will ensure centrifugal force at the perimeter walls, creating gravity close to 1 to support human habitat.

12. The Proposal

To obtain the planned goals as described above lets analyze the general activities needed and their sequence

Phase one

Build a space elevator facility in a convenient location for future operations. Based on the type of product, the terrestrial final assembly facilities and the markets' location select the most appropriate location, with good ground access, truck or rail, to the transportation network to install the space elevator ground terminal. The main components of the space elevator must be specifically designed for their tasks, receive raw materials, transform them in space and deliver finished products to our planet and in particular.

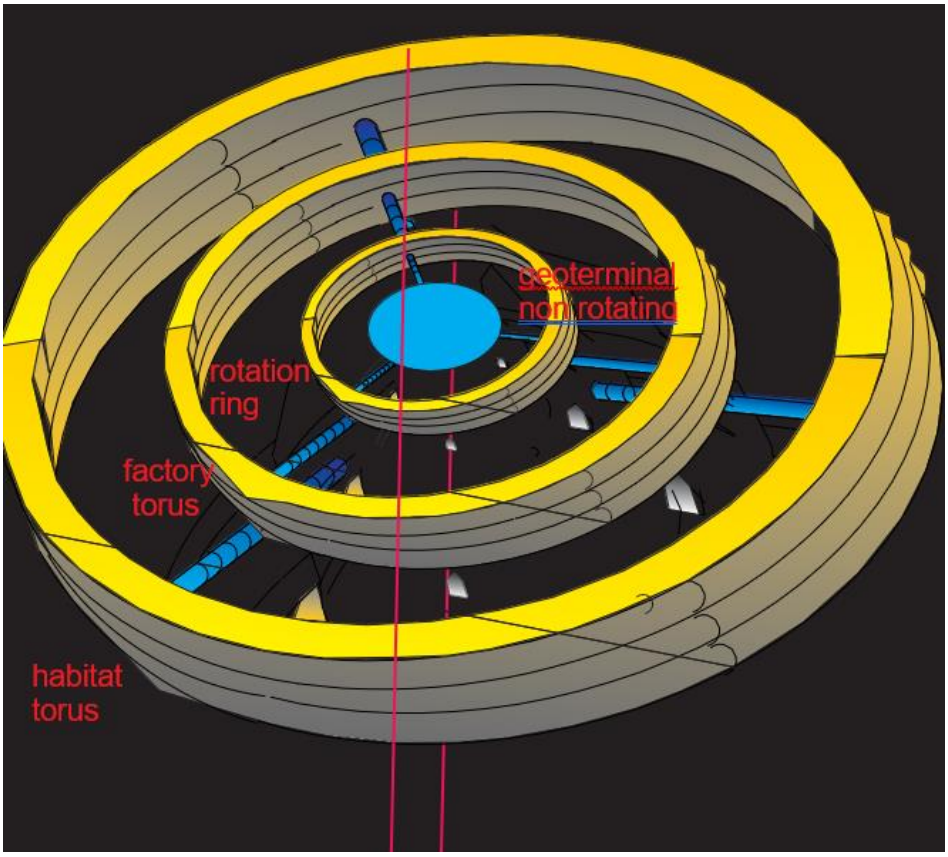

Figure-8 Geoterminal with Space Factory

Ground Station

The ground station terminal must contain all mechanisms and equipment related to the space elevator. A large warehouse and storage area to receive the pods from the geolocation, disassemble, prepare the packaging and ship them by utilizing automate d high AI robots. Due to the high requirements the cabin capacity of 170K per year is not sufficient, in case of no improvements from the space elevator designers, a multi-cabin solution will be needed. Ten cabins would allow 1700K tons, that would make more reasonable the presence of the space factory. The geo-terminal must contain its basic functions such as the connections needed with the space factory, storage areas for receiving the finished products for delivery to the ground station, including spaceports for space transportation system as well as facilities for human personnel. Depending on the business plans, other functions may be operative in the terminal.

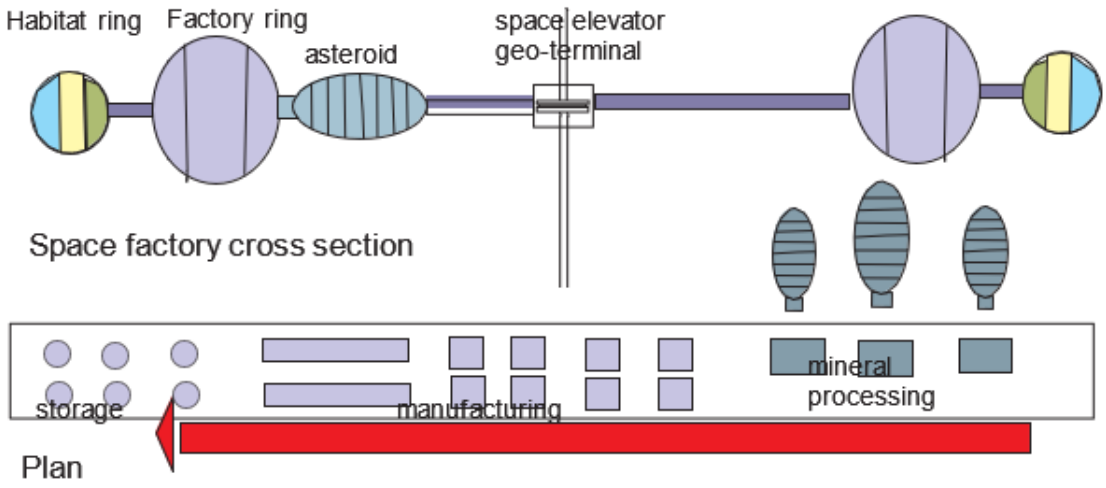

Figure-9 Geoterminal with space factory

Operational Activities

Once the factory is operational the activities could be classified as follows Phase1-Retrieve a small, selected asteroid for raw materials. Small asteroids initially (up to 50 m diameter) will be captured by the retriever vehicles of the space factory, deflected and delivered to the storage and processing facility of the manufacturing torus. To allow such activity asteroid deflection technology will be a fully developed business activity, automatically performed by manufacturing retriever vehicles that can rendezvous with the asteroids, meet their speed, direction and rotation, if existing, dock and capture them. Once they are secured the retriever would change their direction to the desired one. During the return trip to their base robotic systems will start mining, processing the ores and manufacturing needed products so much manufacturing will be ready at arrival where they will be stored in the construction facilities.

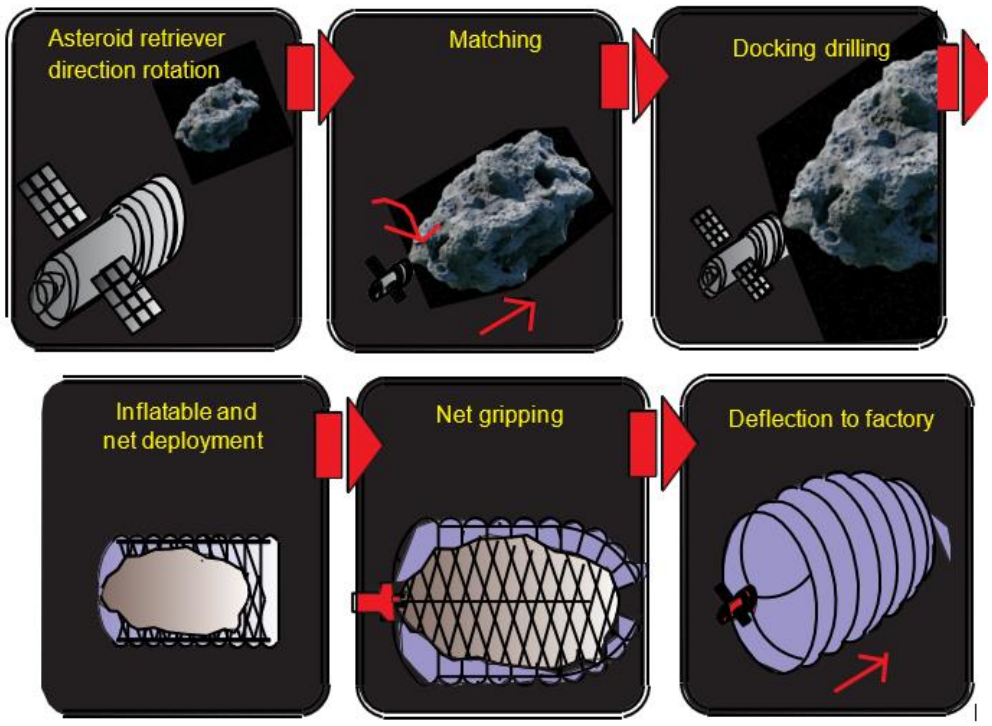

Figure-10 Asteroid deflection Flow Diagram

Phase 2-Arrival and Further Processing activities in Space Factory

In accordance with the origin of the materials different processing facilities and methodology will be necessary. As soon as the raw materials arrive at the storage facility they will be separated by mineral type and being processed at nano dimensions to be atomically reassembled for needed materials and alloys, and later to manufacture needed products. Mineral processing follows mining and prepares the ore for extraction of valuable metals in the case of metallic ores and produces a commercial end product such as iron ore and others The mineral transformation equipment will consist of mini steel foundries that will initially separate the single materials in accordance with their quality and further on utilize those needed to manufacture the sheet coils, pipes and beams. The sheet metal will be further molded in accordance with product requirements.

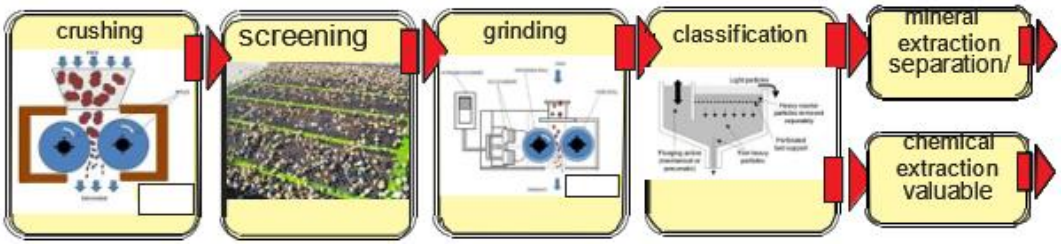

Figure-11 Mineral Processing Flow

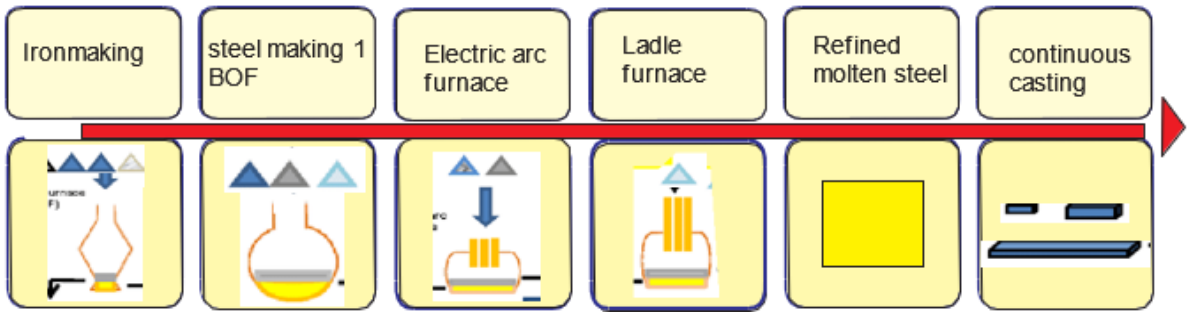

Figure-12 Steel Manufacturing Flow

13. Power Generation

Goals: Create a space power generating system for affordable and universal utilization and develop a safe method for delivering such power to our planet.

Concept: Develop a solar space power generating system featuring photovoltaic fields located in space's geosynchronous orbit. Utilize the space elevator for both its construction and its technology to facilitate delivery.

Our mission with this proposal is to outline a scenario where space elevators support the generation of space solar power. This involves delivering and assembling solar satellites in space and subsequently transmitting the generated power to ground stations through added power cables integrated into the space elevator infrastructure. This approach aims to eliminate unsafe and heavy polluting ground facilities (rectennas) and alleviate our planet from the environmental impact of heavily polluting power generation activities. Our goal is to enable the affordable, non -polluting, abundant, and safe utilization of space-generated energy to address current and future energy requirements on Earth. Simultaneously, by providing inexpensive power to all, we aim to enhance societal conditions in the face of global challenges such as poverty, contamination, resource depletion, and economic hardships. The proposed space elevator and its technology serve as the primary instruments to accomplish these missions and their associated goals.

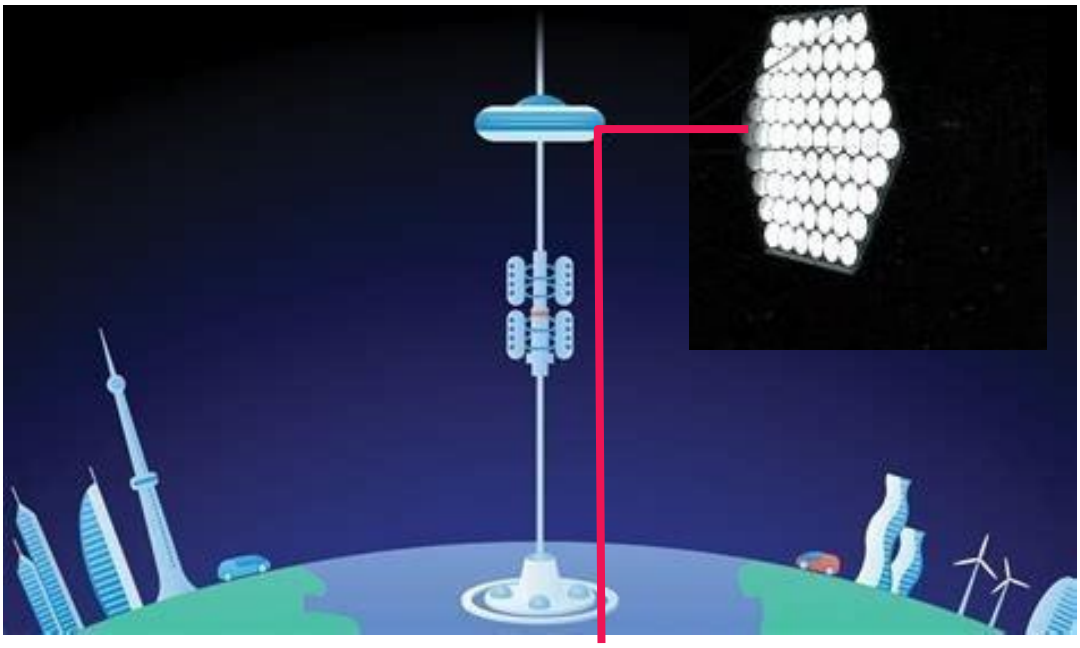

Figure-13 Solar Power Connected

14. Space Tourism

In light of the recent developments in space tourism, exemplified by Virgin Galactic and Blue Origin, which have successfully carried a few passengers to suborbital altitudes for short durations, the space elevator presents an opportunity to transport dozens of passengers in a low-risk environment through specifically designed cabins. This opens up an entirely new market, potentially supported by a hotel resort connected to the geo-terminal station

and the potential settlement. This resort could offer food and lodging for tourists for several days, with the exciting possibility of excursions.

15. The Ark

The possibility of having space elevator capabilities in the near future may allow us to perform several unique missions that may be necessary to face global challenges. At present the human species is living on a single planet. This allows several possibilities of extinction such as:

Asteroid impacts, world deadly pandemics, earthquake and tsunamis of global reach, abc and civil wars, air, water and soil contamination to render our planet unlivable, climate change, space disease, hostile alien invasion, Artificial Intelligence takeover and more. For this reason, we believe that by utilizing the space elevator capabilities, high volumes to space at low costs, we could propose a potential system to allow the preservation of human society in case of emergencies that could produce an extinction: The ark will be an independent traveling space settlement, built in geo-orbit thanks to the space elevator, with terrestrial life support conditions, including 1 G gravity, to store most terrestrial plants seeds and animal embryos, (insects, reptiles, mammals , birds, marine) including human for future bringing to life event in case of need represent the scope of this proposal. Such mini world is designed to preserve and recreate terrestrial life, human culture, history and technological data, for the possibility of the loss of the entire body of information due to catastrophes.

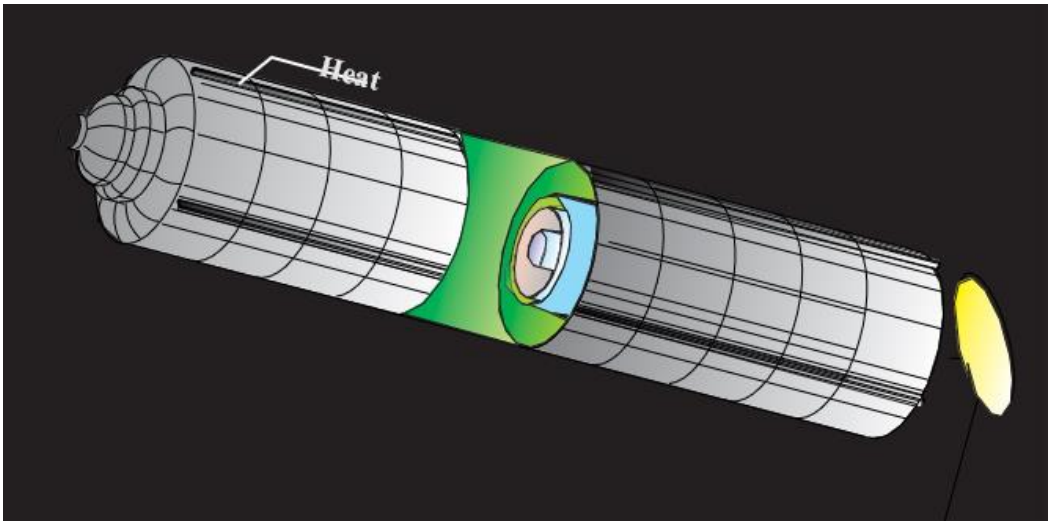

Figure-14 The Ark Traveling Settlement

16. The Impactor

An asteroid impact with our planet is a permanent threat. Scientists have established that large near-Earth asteroids (bigger than 1 km diameter) have the potential to cause geologic and climate effects on a global scale, disrupting human civilization, and perhaps even resulting in extinction of the species. Smaller Near-Earth Objects in the 140 meters to 1 km size range could cause regional up to continental devastation, potentially killing hundreds of millions. Impactors in the 50 to 140 -meter diameter range are a local threat if they hit in a populated region and have the potential to destroy city -sized areas. Only recently has our society found out the risks that our civilization may run unless, with new technology, we act to eliminate such challenges. For this purpose, the defense of our planet against asteroids or comets impacts, we believe that the features of the space elevator, could change the rules of the game and allow to position in Earth orbit a large body, composed of hundreds of heavy steel modules to form a bullet shaped mass over 120 m long, equipped with propulsion system, navigation and communications, rocket engines and fuel tanks to be directed toward incoming asteroids to impact and deflect their trajectory if and when needed. It could also be equipped with nuclear weapons that in contact would shatter the asteroids to smaller pieces, rendering them not dangerous anymore. Such an impactor could be assembled in space, at the geolocation of the space elevator, that would deliver heavy metal modules, to be assembled in orbit, to form the bullet shaped body.

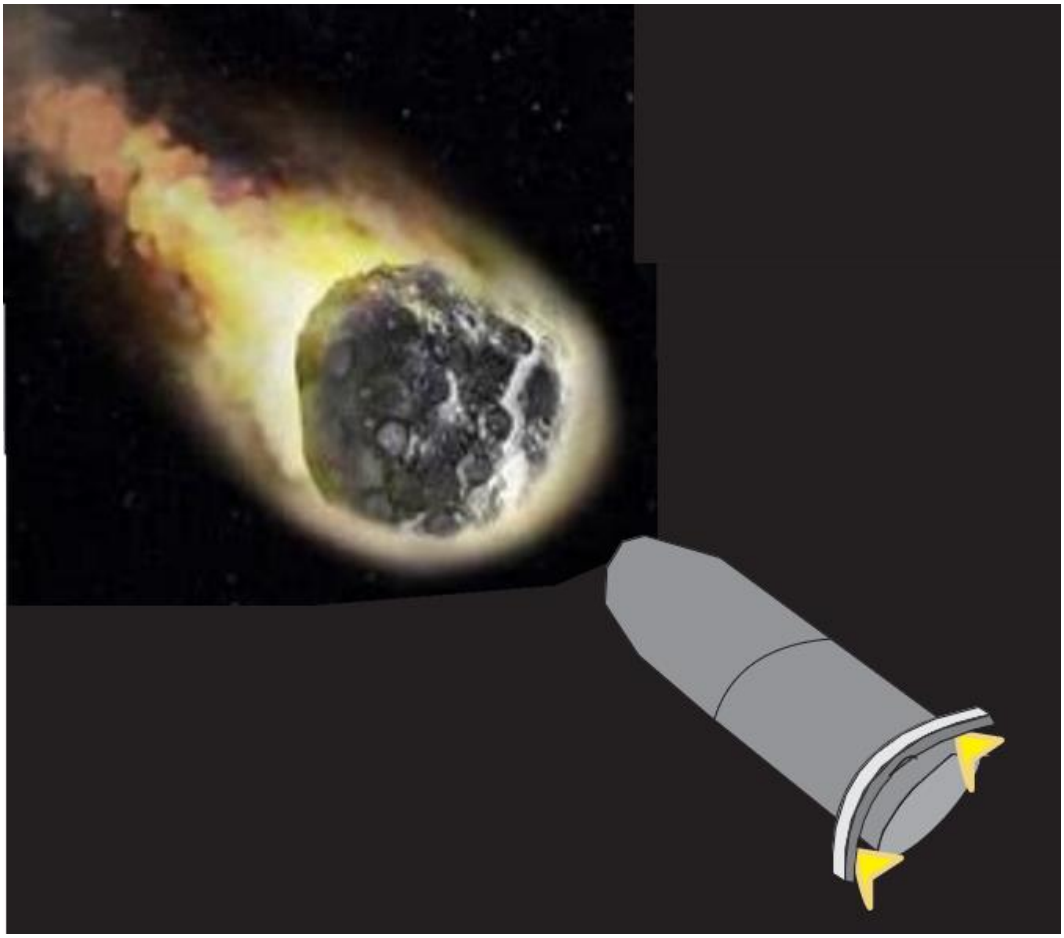

Figure-15 Impactor to Defect Asteroids

17. Defense

The militarization of space is an inevitable consequence of the expansion of space activities. Although not politically correct, we must confront the reality that such developments will revolutionize defense forces globally. Traditional army, navy, and air force structures may be rendered obsolete by the potential of space-based weapons, leveraging the capabilities of the space elevator.

Figure-16 Drone Swarm from Space Battle Station

The space elevator could facilitate rapid and efficient deployment of space-based weapons, enabling the elimination of entire naval fleets or tank columns in a matter of minutes through the use of space-based weapons, drone swarms, or accurate cruise missiles. The devastating impact of space-based nuclear weapons could pose a significant threat to humanity. To prevent such scenarios, international treaties should be urgently considered, banning the deployment of nuclear weapons in space, with stringent controls to enforce compliance. Orbital battle stations represent another component of a space defense system. Constructed on advanced Earth facilities, delivered by the space elevator, assembled at the Geoterminal location, and later distributed in appropriate operational Low Earth Orbit (LEO) or Geo-synchronous Earth Orbit (GEO) positions, these stations will likely become crucial elements of future defense infrastructure. Taking proactive measures now through diplomatic efforts and international agreements can help mitigate the threats.

18. The Future

A multiplanetary society with a network of settlements in the entire solar system would create a quadrillion economy, since humans will be involved with their requirements like life support systems, food production, health care, residence, transportation and more. Through underground terraforming many worlds will be developed and human expansion in the solar system will be assured thanks to the many new opportunities offered to mankind. The expanded economy will bring wealth to everybody and will solve most global challenges actually threatening our planet. At the same time many other advances will be possible such as health care, governance, education, manufacturing, and many more, since space expansion and its technological requirements will push forward most sectors of our society in continuous progress. The final goal, once the solar system is developed, will be the more ambitious of them all, interstellar travel.

19. Conclusion

The envisioned future involves the establishment of a sustainable and prosperous multiplanetary society, with space elevators serving as a crucial element in fostering a space economy that addresses global challenges and transforms our approach to space development. Detailed exploration of these concepts is provided in our comprehensive proposal. In the prospective quadrillion -dollar space economy briefly outlined here, our society is poised for a complete revolution driven by technological advancements and innovative products. These include automatic flying cars, sustainable construction, self-sufficient green power generation systems, domestic hydroponics cultivation, brain-computer interfaces, personal assistance bots, increased lifespan, and more. The introduction of the space elevator and its associated consequences represents yet another trans formative opportunity with some possibilities previously discussed. The expanded space economy will not only offer unexpected opportunities but also generate wealth for the entire global population, fostering a new social system based on collaboration between AI advanced bots and humans. This symbiotic relationship, where AI bots and humans cooperate for common interests, holds the promise of reshaping societal dynamics. Given its game-changing potential, the introduction of the space elevator can be viewed, at this stage, as a potential Singularity. This technological shift has the capacity to disrupt our society in unforeseeable ways, opening up new horizons and possibilities that demand careful consideration and ethical contemplation as we navigate the path toward a future shaped by space exploration and innovation. A multiplanetary society will represent the end result of this phase of human civilization preparing the stage for a further and practically endless step interstellar travel to allow an interstellar society.

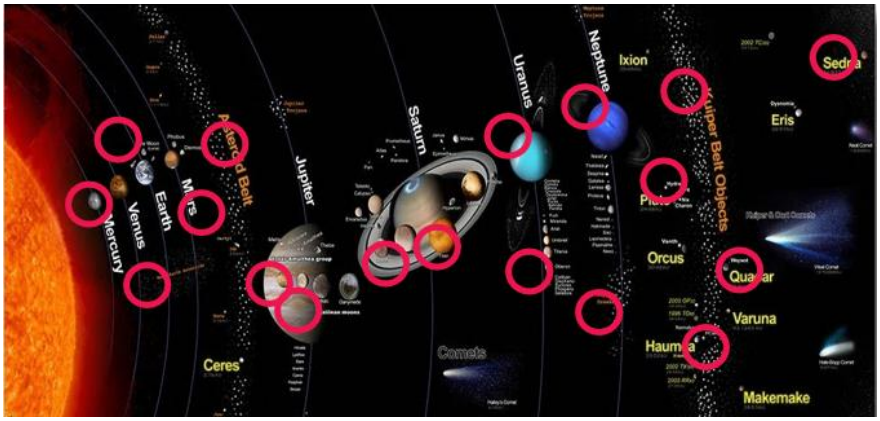

Figure-18 Solar System Space Settlements

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21. Conflict of Interest

The author declares no competing conflict of interest.

22. Funding

No funding was issued for this research.