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A Cruiser-Feeder Concept for a Space Transportation System

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Abstract: This paper presents a conceptual framework for a next-generation space transportation system designed to support human expansion to the Moon, Mars, and beyond. Centered on a modular Cruiser-Feeder architecture, the system aims to make space access reliable, reusable, and economically viable, targeting delivery costs under $20 per kilogram to Low Earth Orbit. The Cruiser, operating on permanent cycling orbits, connects celestial bodies and hosts modular life support and docking systems with expansion capabilities. The Feeder, exemplified by the reusable Ring lander, facilitates efficient cargo and crew transfer between planetary surfaces and orbital cruisers as well as between ground locations. Integral to the system is a standardized space container vehicle, enabling scalable logistics and industrial operations across the solar system. This approach promotes commercial opportunities, fosters global technological advancement, and lays the foundation for long-term space settlement and the creation of a space economy.

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1. Introduction

The planned return of humans to the Moon and the vision of establishing permanent bases, eventually extending to Mars, may mark the beginning of a new era in space development. Space is rapidly becoming an operational domain for our economy and society. To realize this ambitious vision, advanced technologies must be developed to support the utilization of space. One of the most urgent challenges is improving space accessibility. Up to now, space travel has been prohibitively expensive. However, as with the evolution of air travel, from an elite privilege to an accessible mode of transportation for the general public, space transportation must also become reliable and affordable. Achieving this shift will enable the commercialization of space and open the door to a new age of prosperity, innovation, and resource availability. To support this transformation, new concepts must be explored, technological breakthroughs encouraged, and sustainable business models promoted. One promising idea is the Cruiser-Feeder concept, which proposes a cost-effective and scalable approach to space travel and transportation for a variety of missions and applications. Future developments on the Moon and Mars have the potential to significantly expand the global economy, creating new jobs, opportunities, and challenges. These advances will not be limited to space; they will also drive progress across many Earth-based industries, such as food production, healthcare, governance, robotics, artificial intelligence, education, and the circular economy, as previously happened with the Apollo program.

2. Goals

The main design goals for the proposed space transportation system are: fully reusable components to allow affordable costs, with all system components reutilized with fast turnaround from conventional airports; minimal maintenance between flights, based on proven and reliable technologies, with parts reduced to a minimum number and easily substituted when necessary; low-cost delivery to Low Earth Orbit (LEO), targeting under $20 per kilogram as the final goal of the system; a space-based cruiser component requiring only fuel resupply, staying in

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space with support from the space station for refueling, overhaul, and parts substitution when necessary; an inexpensive and simple ground-based feeder component, with a ground facility base for overhaul and refueling, using simplified protocols to minimize downtime between utilization; high flexibility and modularity, allowing various uses from ground to LEO or between ground bases, with modularity for specific missions or expansion; a scalable and expandable design, permitting expansion by adding specialized modules in accordance with mission requirements; and artificial gravity (1G) for the cruiser, achieved by rotation around a central hub for long-duration interplanetary missions, such as to Mars.

3. Space Transportation System Overview

The envisioned space transportation system is centered on a Cruiser-Feeder architecture, where feeder spacecraft transport passengers and cargo between planetary surfaces and orbital transfer points, connecting with cruiser spacecraft that follow permanent, cycling orbits between celestial bodies.

Cruiser Spacecraft

The cruiser is a modular, reusable, expandable, and space-based spacecraft initially composed of:

- **Service Module**: Equipped with propulsion systems, fuel tanks, navigation, and communication infrastructure to support orbit entry, exit, and maintenance of cycling trajectories.
- **Node Module**: Provides docking and transfer interfaces with feeders and other future components. For more advanced missions, it can become crew-rated with the addition of a:
- **Habitat Module**: Accommodates up to four crew members for specific missions, with life-support systems and expansion capabilities.

Other specific modules can be added depending on mission requirements. The cruiser will operate on a cycling trajectory between Earth and the Moon or Mars, depending on mission needs. It can also be expanded into a traveling space station to accommodate hundreds of settlers, particularly for long-duration Mars missions.

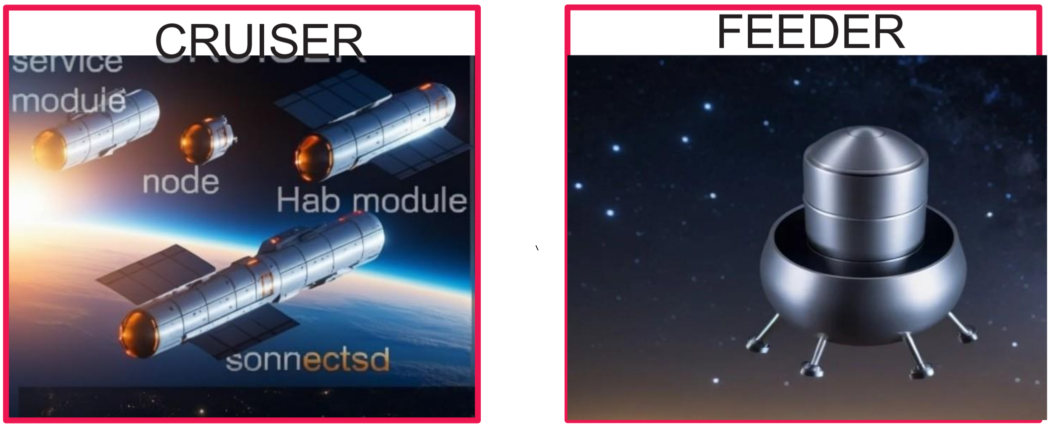

Fig.1-Cruiser-feder system

Feeder Spacecraft – The Ring

The Ring is a reusable feeder spacecraft specifically designed for efficient container transfer between the surface and orbital cruisers or surface-to-surface locations.

Key Features:

- **Ring-Shaped Design**: Optimized for container handling and surface mobility, eliminating the need for ladders or elevators for surface access.
- **Compact Engineering**: Integrates rocket engines, fuel tanks, folding landing gear, landing pad, and avionics into a 160 cm-thick frame.
- **Sector Division**: Divided into four equal modular sections to facilitate takeoff, landing, and docking operations.
- **Scalability**: The baseline model features a 10-meter external diameter and a 6-meter height (excluding landing gear), with potential for larger configurations.

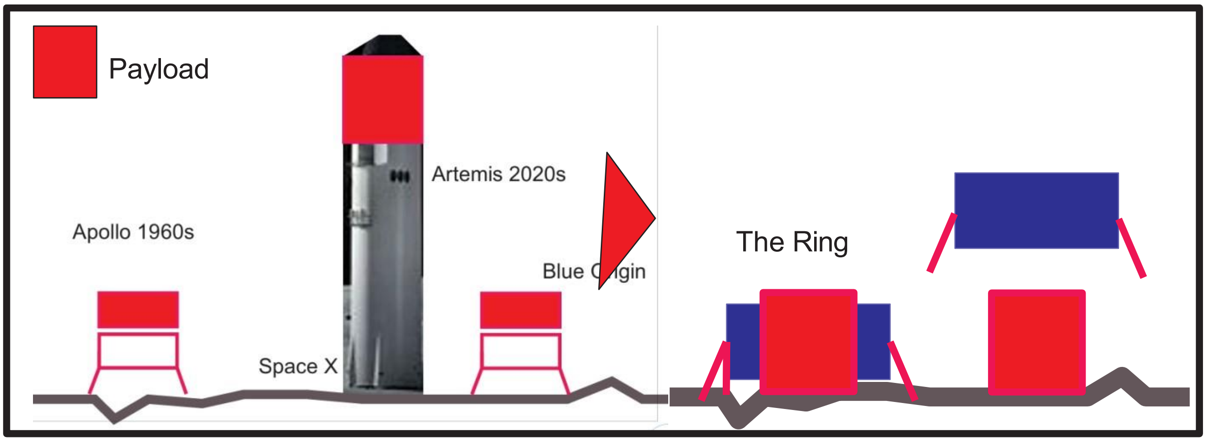

Fig.2-Accessibility by systems

The Ring is capable of operating independently, without dependence on traditional rocket launch infrastructure, making it ideal for repeated lunar, Martian, and asteroid surface missions. The main advantage of the Ring system compared to conventional launchers is its shape, which allows containers and payloads to be loaded or unloaded without ladders or elevators. This simplifies operations since the container rests at ground level rather than elevated (Fig. 2).

4. The Space Container System

The second component of the Ring system is a modular container designed to fit within the transporter ring's diameter. This cylinder-shaped vessel is dimensioned to fit concentrically inside the booster, sharing a similar diameter but offering variable height options to accommodate different payloads, including habitats with crews. Such modularity ensures support for missions with varying payload dimensions. When on the ground, the container, supported by its landing pad legs, is positioned approximately 2.4 m above the ground, allowing easy access to the payload and facilitating crew movements. The containers have a standard diameter of 7.6 m and variable heights ranging from a minimum of 2.50 m to a maximum of approximately 15 m. Internally, they are divided into platforms with a height distance of about 2.5 m between them, enabling accommodation of payloads at different levels. A mechanical system facilitates movement up and down the platforms for accessibility to payloads. Each container is equipped with an external door measuring approximately 1.6 m wide and 2.2 m high at the lower level, streamlining loading and unloading operations for efficiency and convenience. For space-only operations, the container can be totally transferred to a space station or settlement properly equipped.

Fig.3 Space containers system

System Configurations

Single-Container System - "The Ring"

Designed to transport a single container between ground bases and orbiting cruisers. Optimized for simplicity, flexibility, and frequent use. Can connect with cruisers, space stations or ground spaceports for payload transfer (Fig.3).

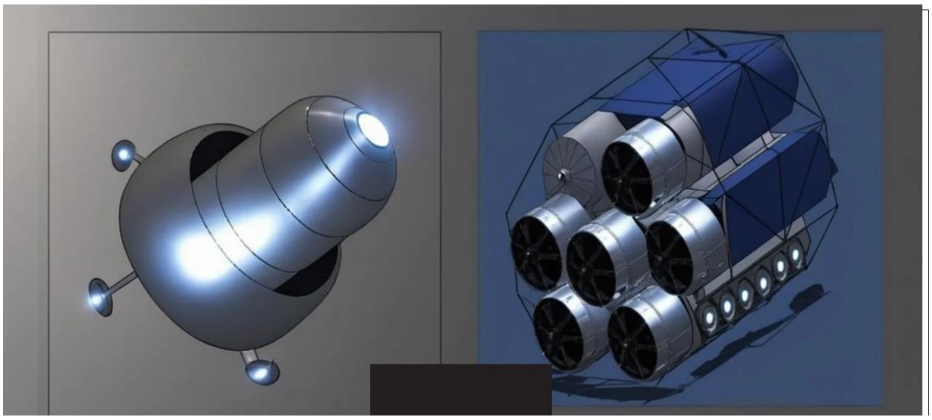

Fig.4-Single ring and Constellation

Multi-Container System - "The Constellation"

Modular system with a central propulsion, fuel, and navigation core, entirely space-based. Capable of transporting multiple containers simultaneously. Forms a scalable network between the orbital terminals network and traveling cruisers, enhancing transportation efficiency and adaptability.

Fig.5-Connected cruiser and feeder

The Multibody Spaceplane

Another major advance forecasted for the near future is the spaceplane that can land and take off like a regular airplane from existing airports. Such a plane could have been the more obvious follow-up to the Space Shuttle.

Several programs have been built around it, with the Lockheed-led X-33 as one example of SSTO (single stage to orbit) spacecraft. Studies indicate that the more convenient configuration would be TSTO (two stages to orbit) since over 90% of the load is due to the propulsion system and its fuel. In this case, the booster component would be discarded at adequate altitude (around 100 km) and speed (over Mach 6), where a much lighter, manned orbiter vehicle would complete the mission.

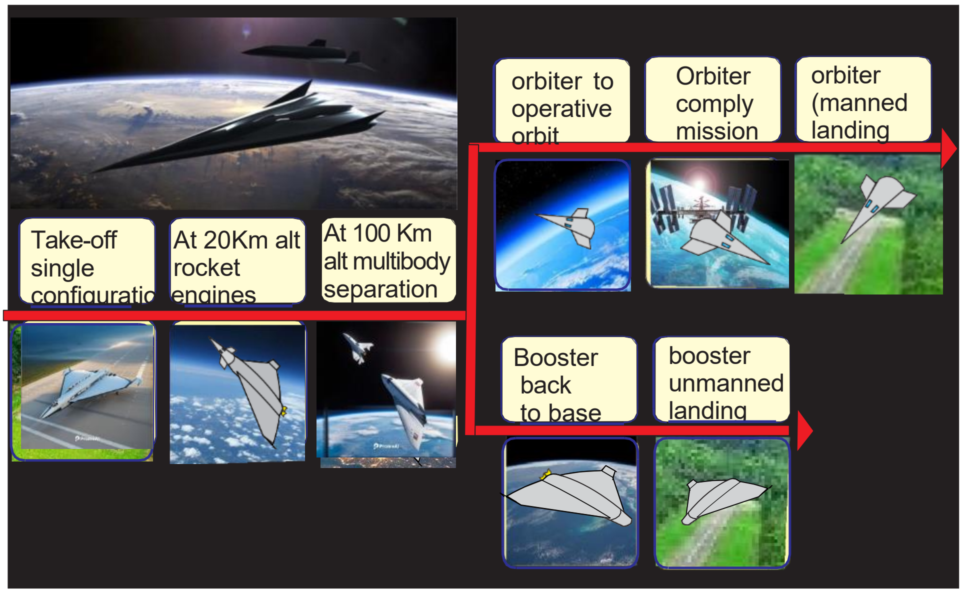

Fig.6-Multibody spaceplane

The multibody spaceplane proposed here could be a possible solution as it combines the best of both technologies. The hybrid system, composed of a booster and an orbiter, maintains a single shape during horizontal takeoff from an airport. The scramjet-powered booster would reach Mach 6+ before the orbiter (front section) detaches to complete the orbital mission, while the unmanned booster returns autonomously to the departure airport.

This spaceplane could serve as a feeder for passenger transportation only, as it lacks sufficient cargo capability.

5. Space Elevator

Another system to deliver payloads in space, without the aid of vehicles, is the space elevator, in case serious technological barriers to its implementation could be broken by breakthroughs in technology. In fact, the cable connecting the elevator to the ground and allowing the passage of cabins to a geostationary base at 35K altitude must still be invented since today's technology cannot propose the required material able to support the enormous loads that are required. Such an infrastructure, when built, not only on our planet but also other celestial bodies, would allow extremely low cost space accessibility to all, would be totally green and non-polluting. The system would represent an ideal feeder without the need of moving space vehicles.

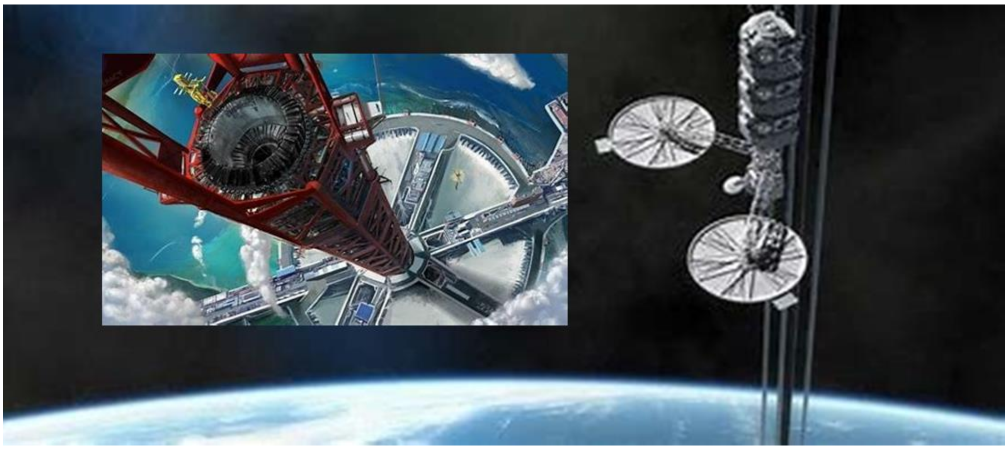

Fig.7-Space elevator

Space infrastructural system - Second generation space station

A space station is a manmade facility to allow humans to live in space. Is different from other transportation vehicles for its lack of propulsion systems, the impossibility of landing and the need to be assembled in space with different components due to its dimensions. The second generation station is different for its predecessors due to its ring shape being dictated by the need of generating artificial gravity for its human occupants by rotating around a central hub and creating centrifugal force that would allow artificial gravity at the edges. At the ring modular facilities with various functions to be performed inside the station will be attached. In the figures are visualized several space station module possibilities. They range from laboratories for scientific research, habitat for the human crew, food production module, debris processing, spaceport terminal and more. In this proposal we are showing a station composed of spokes and rings assembled in orbit and delivered by existing chemical rockets. The assembly and the components are shown in the figure.

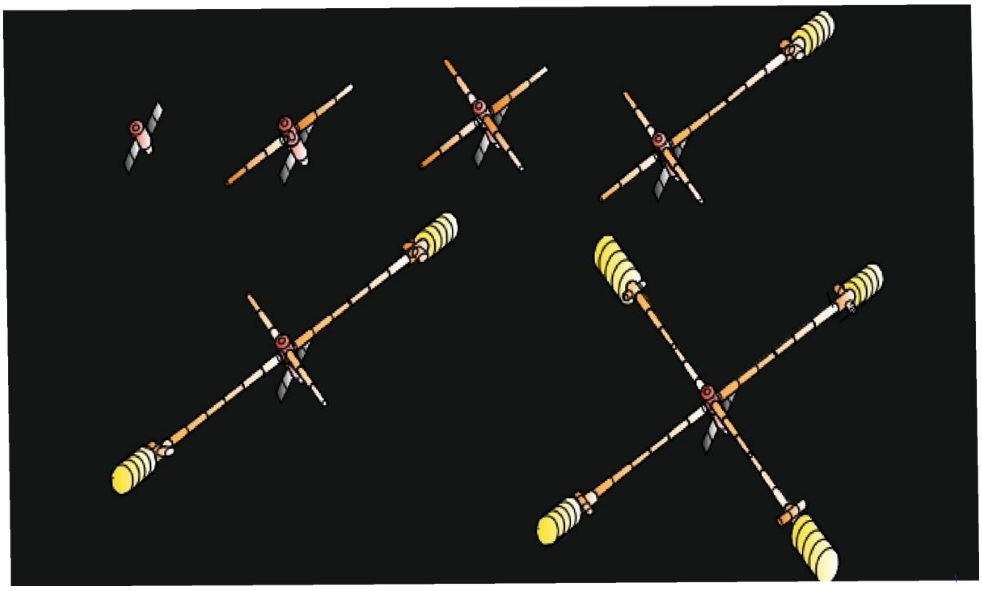

Fig.8-Station modular assembly

A service module, with a propulsion system, fuel tanks, navigation and communication equipment, with a node module, with four connections in the sides for the spikes and one in the front for incoming and outgoing spacecraft attached, would be inserted in orbit. They will be followed by the telescopic spikes modules to allow rotation to the system. At the end of the spikes will be connected to the functional modules and the ring connector, also telescoping modules to fit the launcher dimensions.

Fig.9-Space stations as cruiser spacecrafts

The second generation space station is designed to utilize several concepts and modules that could be utilized also on the cruiser for long range travels. In effect, for such scope we need more a traveling space settlement than a transportation system. A travel to Mars would take approximately nine months. In such times the passengers need to eat, health care, life support systems, work and, when possible, lead a normal life. Our society had similar activities and needs when emigration to America was a must for most European countries and big transatlantic ships took care of passengers. Big ships were the same as future cruiser spaceships that would carry hundreds, even thousands of migrants to Mars if we ever approach Terraforming as a planned and feasible event. For that purpose, cruisers are shown as traveling settlements for future utilization on a big scale. Like future space settlements they would have all the facilities needed, like a terrestrial resort, plus the production of food, health care facilities, residences, robotic and human help to run the entire organization. Cruisers in their cycling orbit would contain all such facilities.

Phase 2 - Return to the Moon

This activity should be performed as part of a Master Plan and not as a dead end mission like the proposed Artemis with an exorbitant cost of 4B$ per launch. Once the transportation system, the feeder and an embryonic cruiser could be ready, the first activity should be to send robotic rovers and AI to prepare the site for the outpost construction. If urgency is the issue it could be possible to send the containers by Falcon 9 launchers fully available directly to the Moon selected site as follows:

Container 1

With the necessary equipment to start preparing the future outpost including:

- Solar panel array
- Communication system
- 100Km range microwave power system
- Two crew vehicles trailers
- Teleoperated robotic rovers
- Two high AI humanoid robots

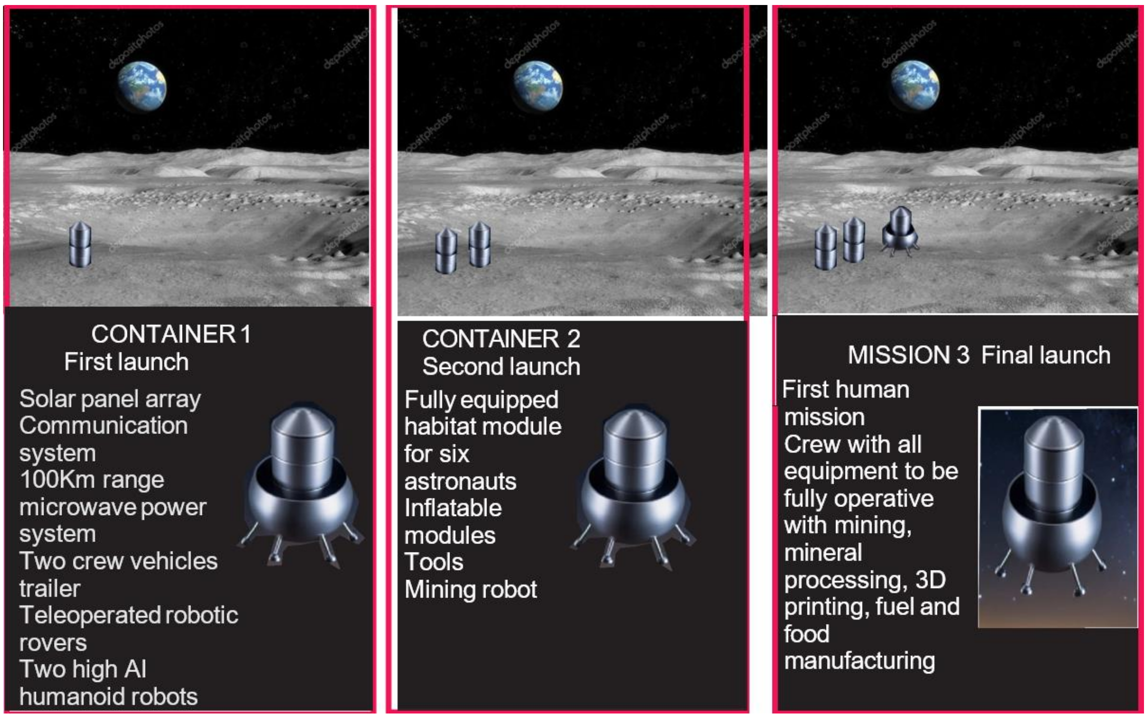

Fig.10-Moon direct

The first mission will be to set up the communications and power system for future utilization and to explore the territory for future missions.

Container 2

With the remaining equipment to render the base operative for a human crew:

- Fully equipped habitat module for six astronauts
- Inflatable modules
- Tools
- Mining robot
- Water extraction equipment
- Life support systems

During this mission inflatable areas will be operative for food production and mineral processing.

Mission 3 crew arrival

Only after completion of all tasks and rendering operatives all life support systems do the first human crew arrive. Their main task is assessing the situation, complete all needed to be fully operative, start mining, mineral processing and manufacturing activities. Experiment local technology to produce concrete for construction activities from local materials and continue research for minerals and resources in the site area. Use manned rovers to explore and prospecting the area. Only after the outpost is ready to receive a human crew should the first manned mission depart our planet and return to the Moon. There is no sense in sending humans to the Moon, already done, if they must only walk and look for curiosity as happened with Apollo. The reason for human return to the Moon will be to create a permanent base and to start doing business. In this case, prepare the life support system from local resources, perform mining, explore the site region for resources, mainly water and start excavating for resources. The entire operation must be part of a carefully prepared Master Plan for lunar development that must include business plans and business models. When operational the system may look as if it was on Fig.12.

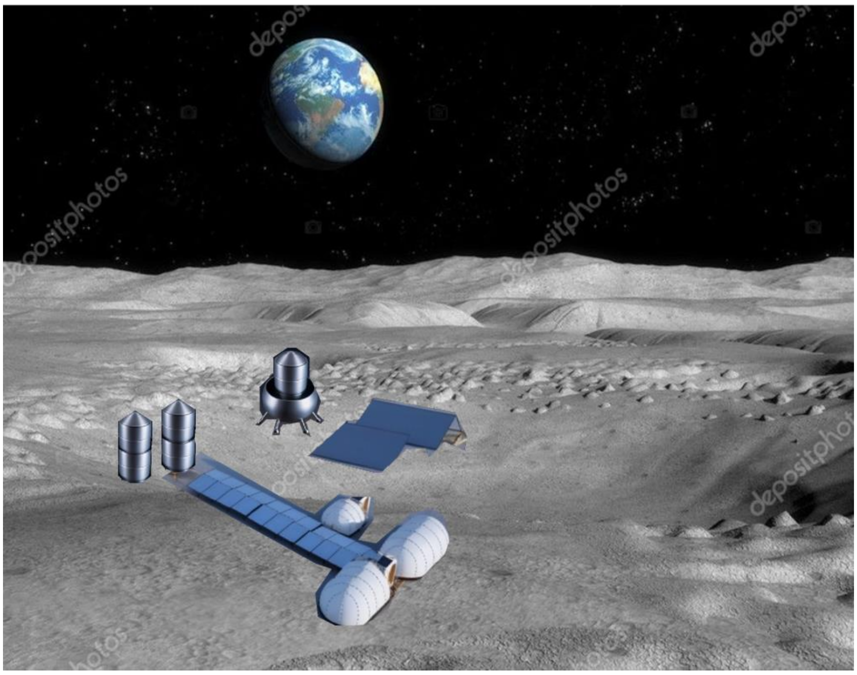

Fig.11-Moon outpost

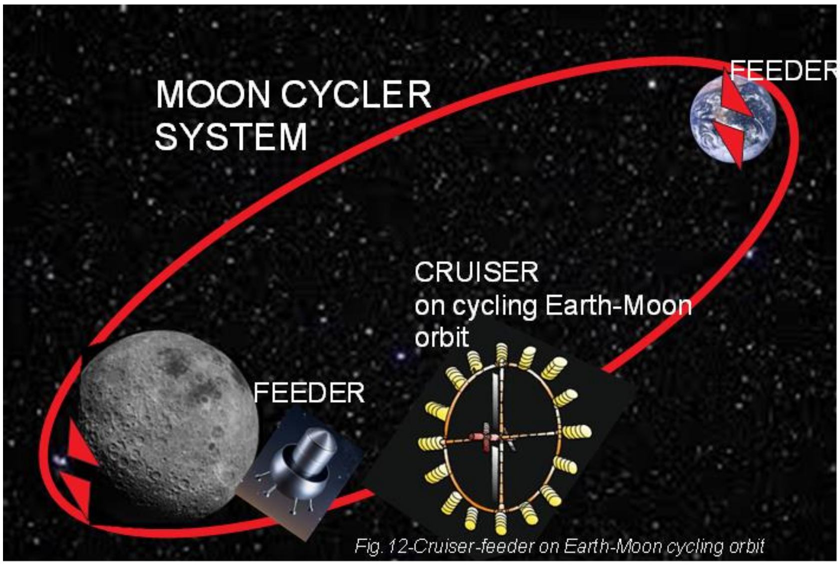

Fig.12-Cruiser-feeder on Earth-Moon cycling orbit

6. Mission to Mars

Unlike the Moon where a full two way mission can be performed in a single week, seven days, a two way mission to the red planet would have a minimum of three years, half of them for travel time, nine months each for going and returning. While we would still utilize the cruiser feeder concept as the most suitable, long time exposure to zero gravity by a human crew has shown the enormous limitations due to such condition. Astronauts return to our planet weak, falling to the ground and unable to perform essential functions. Such conditions would be unacceptable for a Mars mission since the crew must arrive to the red planet in optimal physical condition to perform the designated activities and to survive a year and a half on the planet surface. The cruiser that would transport the crew to Mars must create an artificial 1G gravity, by rotating around a center of gravity during the trip. The starship proposed by space X would be unable to create such gravity requirements and would render unfeasible any Martian mission. Furthermore, to survive one and a half year on the surface of Mars, without counting on any terrestrial support the selected site of arrival, must be prepared for a fully self-sufficient capability to produce food, health care, fuel, water and all other life support systems needed as well as the facilities and equipment to explore and prospect the planets resources and create a local technology as a logical goal for a first mission with a permanence of a year and a half.

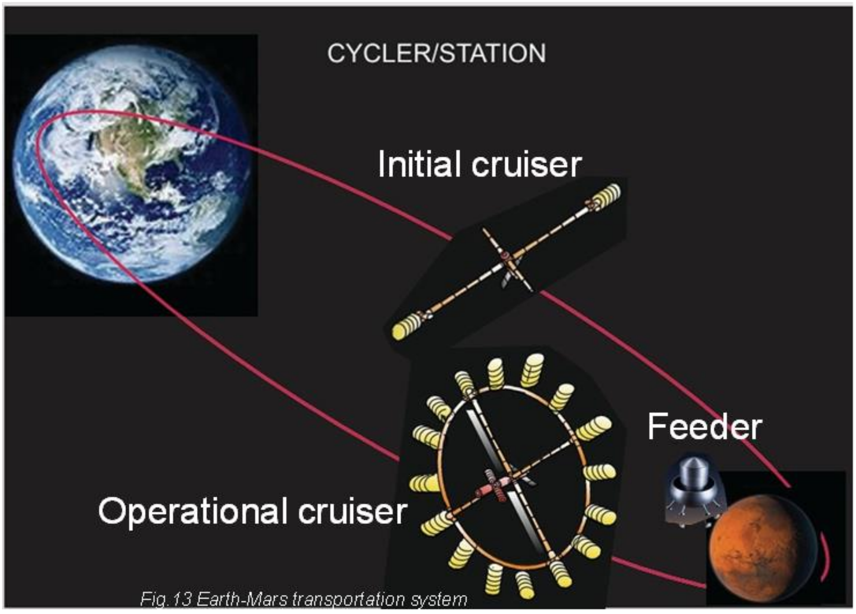

Fig.13 Earth-Mars transportation system

7. Earth-Mars Space Transportation System

A future Martian population of thousands will require an entirely new, efficient, low cost, and high capacity transportation system between Earth and Mars. Given the two year launch window between the planets, a robust interplanetary transportation network must be established. Similar to the transatlantic ships that carried thousands of migrants between Europe and America in the 19th and 20th centuries, Mars bound vessels must be capable of transporting thousands of passengers on a nine month journey. This spacecraft must feature artificial gravity (1G), be self-sufficient in food and life support, and have independent power and fuel systems. The best solution would be a cycling spacecraft system operating between Earth and Mars, supported by cruisers and feeder vessels to transfer passengers and cargo. The cruiser with a few hundred passenger capacity, similar to a space settlement, in a beaded torus shape, to generate artificial gravity by rotation around a central hub. Such vehicles would be composed of modules attached to a torus ring with the several functions needed for transportation (habitat, food production, feeder port, health care, maintenance, life support system etc.). It will be assisted by a feeder system to carry back and forth passengers between the surface of the two planets and the modules with passengers, cargo, agricultural and manufacturing levels to support the crew and passengers.

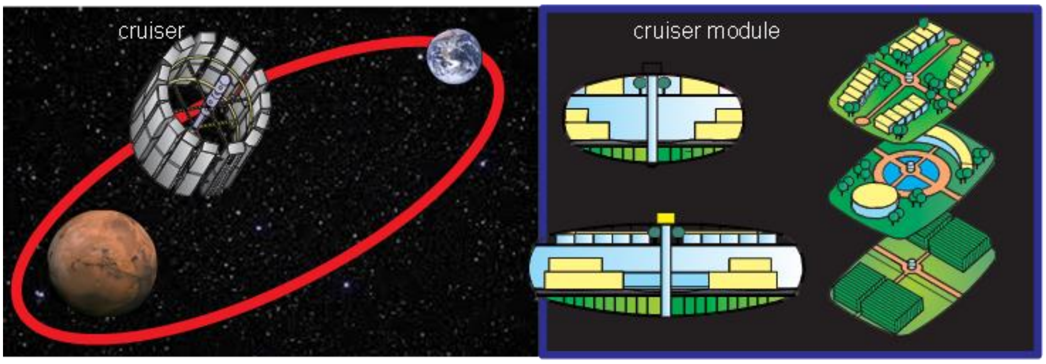

Fig.15-Advanced Earth--Mars cruiser

8. Conclusion

This integrated space transportation system, built on both current and emerging technologies, envisions a resilient infrastructure for moving cargo and people throughout the solar system. By enabling frequent, cost effective, and scalable access to space, it establishes the foundation for future economic growth, scientific progress, and sustainable human presence beyond Earth. To achieve this vision, future missions must be guided by a comprehensive Master Plan for space development—one that addresses individual celestial bodies of interest in a coordinated and strategic manner. The pioneering phase of space exploration is behind us; we are now entering a transformative era where space becomes a vital economic domain, generating new territories, industries, jobs, and opportunities for people across the globe. Affordability and practical implementation will drive the next wave of space related ventures, directly or indirectly involving millions of citizens in the global space economy. We must look to the future with optimism and carefully crafted plans, ensuring that extraterrestrial territories become integral to our expanding economic landscape.

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10. Conflict of Interest

The author declares no competing conflict of interest.

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