

Establishing a Logistics Architecture for Expanding Civilization into Outer Space

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ABSTRACT

The need for routine, daily, safe, and inexpensive operations on a Green Road to Space is necessary to improve the quality of life on and beyond Earth. As humanity moves off planet, there is a tremendous need for a revolution in the approach, one which goes from 1% of launch pad mass arriving in Lunar or Martian orbits [defined by the rocket equation] to a robust 70% of the pad mass delivered. The permanent infrastructure established within the Modern-Day Space Elevator Architecture enables estimates of 170,000 tonnes per year released towards locations to and beyond Geosynchronous orbit. This paper will explain the inherent benefits of a permanent architecture and discuss the recent progress accomplished in materials and tether climber designs. If you think of railroad operations with truck stops along the way for repair, refueling, storage and assembly of very large space systems – the concept is transformational.

1 Introduction

The priorities of the SRI2026 IV World Congress covers four missions, objectives, or goals: 1) Raise awareness of risks, 2) Promote accelerated civilian space development, 3) Debate priorities, and 4) Build coalitions to advance industrialization and settlement beyond Earth. These will, hopefully, lead towards the title of the Congress: “Quality of Life, on Earth and Beyond.” The authors of this paper believe the development of a permanent space access transportation infrastructure will lead to those objectives, missions, and goals. One concept, being developed by Aolani Gonzalez and her team at Yale centered around a series of Space Elevator Accords, will leverage global teams of government and corporate sponsors moving the concept forward.

Similar to the transition from small boats crossing a huge river to the installation of a permanent infrastructure (called a bridge), the installation of a “bridge to space” will transform access to geosynchronous orbit (GSL), the Moon and Mars. The installation of Modern-Day Space Elevators around the equator (Figure 1), becomes the Green Road to Space. The operational tempo does not burn rocket fuel along its path; nor, leave debris along the way. It will enable: (a) Low cost, reusable, safe, daily, and reliable releases towards GEO, Lunar and Mars orbits; (b) Remarkable delivery of logistics to those destinations (170,000 tonnes per year); (c) Unmatched delivery efficiency of 70% of the pad liftoff mass to destination vs. rocket equation numbers of 2% to LEO, 1% to lunar orbit and 0.5% of pad mass to the surface of the Moon or Mars. When humanity builds a CISLunar economy and supports settlers off planet, there MUST be an infrastructure capable of inexpensive, daily and on-time logistics support. Those characteristics are inherent in Modern-Day Space Elevators’ concepts and architectures. Can you image, in the near future, 79 tonnes being released towards customer destinations every day time six Modern-Day Space Elevators? They would be positioned around the equator lifting payloads towards mission locations such as GEO, Lunar or Martian customer destinations.

2 Modern-Day Space Elevator Architecture

The Modern-Day Space Elevator architecture has developed through eight concepts,¹ all of which led to the concept of Galactic Harbours. Each Galactic Harbour has two tethers at each Earth Spaceport radiating outward towards the 100,000 kilometers Apex Anchor Spaceport with an intermediate location at the GEO Spaceport. The concept is one operation leveraging two tether “bridges” towards space with one uplifting tether climbers while the other one brings down payloads inside tether climbers – or, early on, there will be two up and no downs while the logistics operations grow. The concept would then grow toward three Galactic Harbours spread around the equator with several corporations or countries operating them.

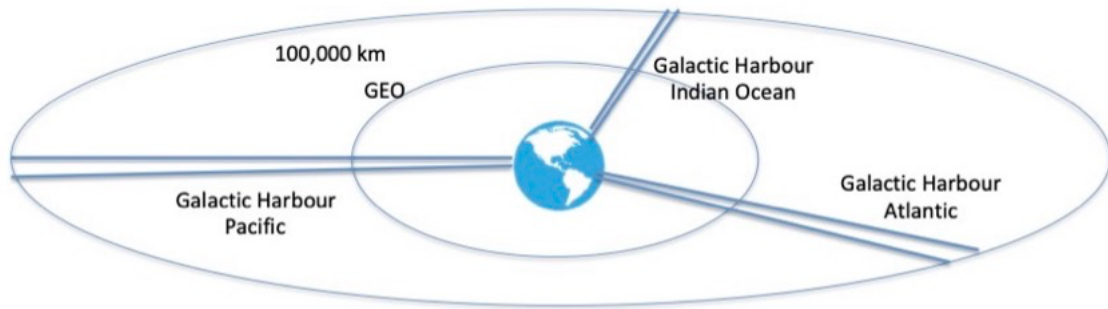


Figure 1. Global Layout of Galactic Harbours

3 Spaceports

The major strength of Modern-Day Space Elevators is the daily, routine, safe and inexpensive lift of massive payloads at 70% delivery efficiency of the pad mass to GEO and beyond. Multiple customer destinations will range across our solar system as well as in Earth orbit. Along the tether there would be multiple locations that the customers will be leveraging to include²:

- **Earth Spaceport:** This location is the starting point [or end location] for space systems using this permanent space access infrastructure.
- **GEO Spaceport:** The GEO Spaceport will be focused upon receiving payloads from tether climbers to conduct missions in the GEO Region
- **Apex Anchor Spaceport:** The top of the tether has the fastest moving spaceport with exciting missions such as planetary defense, astronaut rescue, communications and navigation support for Cis Lunar region as well as the routine missions of acceptance (capture) and release of mission space systems.

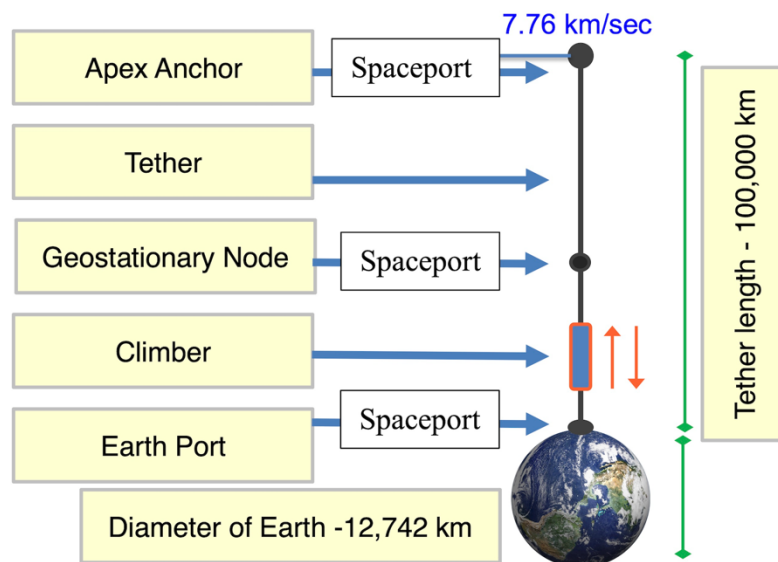


Figure 2. Spaceport Locations

The dominate strength of each of these spaceports is the ability to release mission space systems towards their customer destinations with tremendous energy – daily, routinely, safely, and inexpensively while being environmentally friendly. Another point, not recognized during the first 15 years of space elevator development, is its ability to store segments of space systems along the tether and then assemble the multiple segments into MUCH larger space systems for release towards its mission destinations. The remarkable characteristics of each of these spaceports is that they become “truck stops” in space for the customers’ missions. In addition, each of these spaceports will have the ability to release towards mission destinations, capture incoming space systems, refuel, repair, store or develop operations “centered” at those locations.

4 Modern-Day Space Elevator Strengths

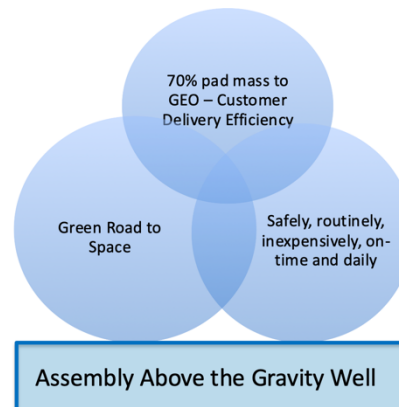
Modern-Day Space Elevators will provide a revolutionary set of characteristics and transformational aspects providing capabilities well beyond the rocket equation. These strengths are a result of adding energy raising the climbers daily along the tether. This results in tremendous energy for each spacecraft released. Some examples are 14 hours to lunar orbit and daily releases towards Mars with sufficient energy to reach Mars without rocket thrust [of course need trajectory adjustments and retro-thrusters at Mars].

The revolutionary aspects of six Modern-Day Space Elevators include;

- Massive Movement of Logistics (30,000 tonnes per year at initial operations and 170,000 tonnes per year at full operations).
- Remarkable delivery statistics of 70% of the mass at the pad when released (the other 30% is reusable climbers).
- Daily, routine, efficient, inexpensive operations.
- Massive energy upon release from altitude with rotational energies.

Figure 3. Strengths

Modern-Day Space Elevator Transformational Strengths



The transformational strengths in parallel are:

- Green Road to Space
- Daily releases to Mars with tremendous velocity (7.76 km/sec) from above the gravity well (no 26 month wait for planetary alignment). Recent studies conducted at Arizona State University, with Professor Peet as the lead, resulted in transit time as low as 61 days with an average around 140 days.³
- Assembly of larger space systems at spaceports enabling huge spacecraft released for future missions. This includes storage and assembly.

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<i>Customer Benefits of Modern-Day Space Elevators</i>	
Benefits	Space Elevator at Full Operational Capacity (FOC)
Daily & Routine	Similar to Bridge operations
Massive Logistics Delivered	30660 MTs to GEO and beyond - Initial Operational Capacity (2037) -- with 170,000 MTs per year - Full Operations Capacity (2041)
Environmental Impact	Neutral [Green Road to Space]
Delivery Efficiency	70% of liftoff mass to customer with the other 30% reusable climber [vs. rocket equation delivering 2% to GEO, 1% to Moon & Mars]
Reusable Mass	100% (70% payload 30% reusable climber)
Extreme velocity at release	Matches GEO velocity at height - 7.76 km/sec at 100,000 km altitude [free release has energy to go beyond Mars with only fuel for corrections and landing]
Assembly at GEO and Apex Anchor	Full-Service Transportation Node: Enables huge space systems assembly while providing refuel, repair and storage.
Days to Mars	As fast as 61 days with average around 110 days
Launch Window to Mars	Every day [no 26 month wait for launch window]
Safety	Permanent Infrastructure - similar to bridges
Lowest Cost	Studies show cost comparison relates to the impact of placing a bridge across a river. The permanent infrastructure costs less per MT than single event approaches, especially when they consume 80% of their mass to deliver less than 2% of initial mass to their destination.

Table 1: Customer Benefits of Modern-Day Space Elevators

5 Conclusions

When the reader looks at the tremendous strengths of Modern-Day Space Elevators, the revolutionary and transformational benefits ensure that the concept should be initiated soonest. Table 1, Customer Benefits, illustrates the customers' view.⁴ This should initiate development of the program.

Within the previous description, Galactic Harbours will help fulfill the reach out goals of SRI 2026 IV World Congress. This implementation of the global architecture would:

- Raise awareness of risks,
- Promote accelerated civilian space development,
- Debate priorities, and
- Build coalitions to advance industrialization and settlement beyond Earth.

Indeed, the establishment of the Galactic Harbour architecture should greatly improve the "Quality of Life – On Earth and Beyond!"

REFERENCES

¹ Raitt, D. "Space Elevator Architectures," Quest, Vol. 28, #1, 2021 pg 17-26.

² Swan, P. Architectural Note #74, Space Elevator Spaceports, <https://www.isec.org/architects-notes>

³ Swan, Peter, Fitzgerald, M, Swan, C, Peet, M., "Fast Transit to Interplanetary Destinations," 2020 International Astronautical Congress - CyberSpace Edition

⁴ Body of Knowledge of Modern-Day Space Elevators at www.isec.org