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How the Space Elevator Grew into a Galactic Harbour

Peter Swan* & Michael Fitzgerald**

^a International Space Elevator Consortium, Paradise Valley, Az, USA dr-swan@cox.net. **Technology, Architectures, and Integration; LLC, Rancho Palos Verdes, Calif. USA.

Abstract

One of the principle elements of the International Space Elevator Consortium’s (ISEC) action plan towards an operational space elevator is to understand its customer utilization. To fully understand the potential application for commercial ventures on the space elevator, the concept of a Galactic Harbour surfaced. Galactic Harbour represents continuous operations moving customer payloads on multiple space elevators from entry ports to exit ports. These locations would most logically be an Earth Port where customers have their payloads loaded onto space elevators and their release points at multiple altitudes per the desires of the customers. The Galactic Harbour would then be the volume incorporating multiple Earth Ports [on the ocean, with incoming and outgoing ships/helicopters and airplanes] and then stretch up in a cylindrical shape to include tethers and other aspects out to the Apex Anchors. Products and payloads [satellites, people, resources, etc.] would enter the Galactic Harbour around the Earth Ports and exit at some point along the tether [to LEO, to GEO region, to Mars, Moon, asteroids, intergalactic, towards the sun] dependent upon where it is released.

1. Introduction: The International Space Elevator Consortium’s concept of a Galactic Harbour will enhance understanding of space elevator operations.

Concept: “Galactic Harbour” is a new term representing multiple independent space elevator segments [Earth Port, Tether, Tether Climbers, GEO Node and Apex Anchor] which make up the concept.

Definition: “The continuous operations of the space elevator as the Galactic Harbour moves customer payloads on multiple space elevators from the entry ports to exit ports. These locations would most logically be the Earth Port where the customers have their payloads loaded on space elevators and then the release points are at multiple altitudes as per the desires of the customer.”

2. Definition: The “Galactic Harbour” is identified to be the transportation “port” for the total transition from the ocean to release towards space. The port would be three dimensional, not surface only. The concept is the payload come into the Galactic Harbour. It is then processed inside and released at some location. Thus, payloads come

in, are processed, and then released on their way. The intra-transportation is very similar to a train operation, movement on rails from one pier to another pier. The difference is the Galactic Harbour will be up to 100,000 km high for payloads to be released at Apex Anchors.

Visualize:

- An Earth Ports with a complex of platforms performing different functions
- Two tether going up from each Earth Port tether terminus
- An Apex Anchor at the far end [100,000 km altitude] of each tether
- Up to seven tether climbers on each tether below GEO [with three climbers beyond GEO going to Apex Anchor or release point for Mars or the Moon]
- GEO Node region centers - read that as free floating multi purpose spaceports with multiple functions [such as refueling/servicing/ construction, tug boats, power generation, communications, etc]

The Galactic Harbour would then be the area encompassing the Earth Port [covering the ocean where incoming and outgoing ships/helicopters and airplanes operate] and stretches up in a cylindrical shape to include tethers and other aspects out towards Apex Anchors. Customer

* This paper reflects results from one-year studies by ISEC on SE topics. Much of the content is paraphrased from the study activities. [1, 2, 3]

product/payloads [satellites, people, resources, etc] will enter the Galactic Harbour around the Earth Port and exit someplace up the tether [to LEO, to GEO region, to Mars, Moon, asteroids,

intergalactic, towards the sun, dependent upon where it is released]. The current vision of a Galactic Harbour is as follows:

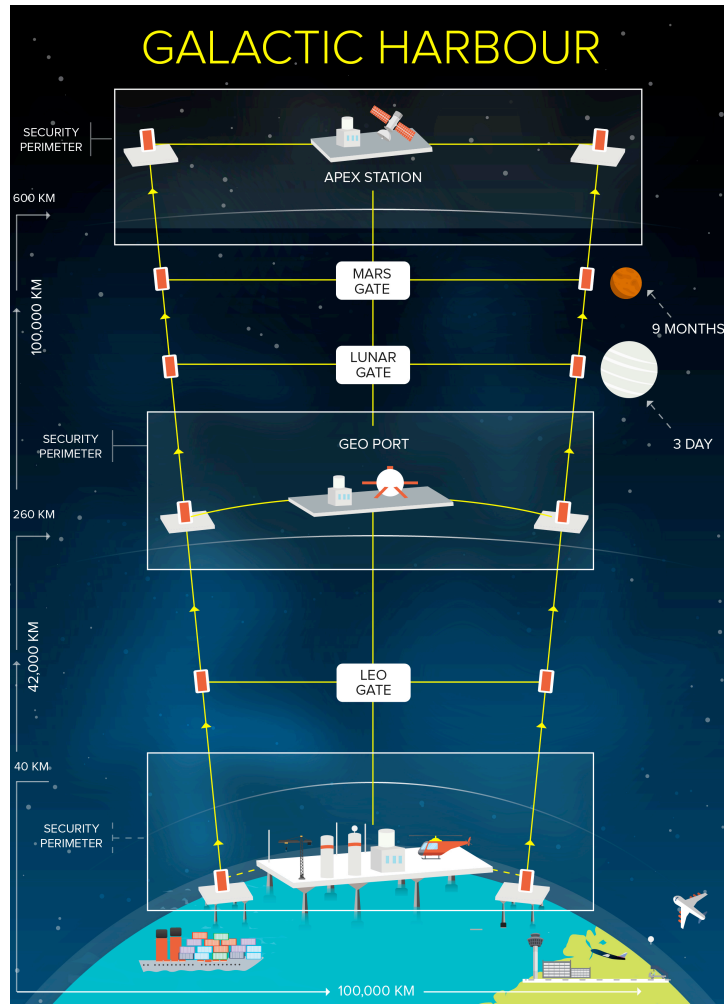


Figure 1, Galactic Harbour

3. Major Segment: A complete breakout of major segments can be accomplished when one looks at the recently completed studies by ISEC covering tether climbers [1], Earth Port [2], Apex Anchors [3] and GEO Nodes [3]. [each can be downloaded at the ISEC site as a pdf]. However, the first step is to understand the terminology inside the Galactic Harbour. The following definitions will be presented to assist in understanding the next few images:

- Space Elevator Column: The volume swept out during normal operations starting at the Earth Port [a circular area within which it operates]

and extending through the GEO Region up to the Apex Region. This column of space will be monitored, restricted, and coordinated with all who wish to transverse the volume. The current concept is similar to the FAA’s Automatic Dependent Surveillance – Broadcast approach. Satellites, aircraft and ships will announce where they are and coordinate motion through the space elevator column. Each space elevator has a column of allocated volume.

- Earth Port Region: The volumetric region around each Earth Port to include a space elevator column for each tether and the space between multiple tethers when they operate together. The Earth Port Region will include the vertical volume through the atmosphere up to where space elevator tether climbers start operations in the vacuum and down to the ocean floor.
- Earth Port: A complex located at the Earth terminus of the tether and has the requirements to support its functions. These mission elements are spread out within the Earth Port Region. When there are two or more termini of tethers, the Earth Port reaches across the region and is considered one Earth Port. [For full definition and explanation of Earth Ports, see both ISEC reports on Architectures and Earth Ports.]

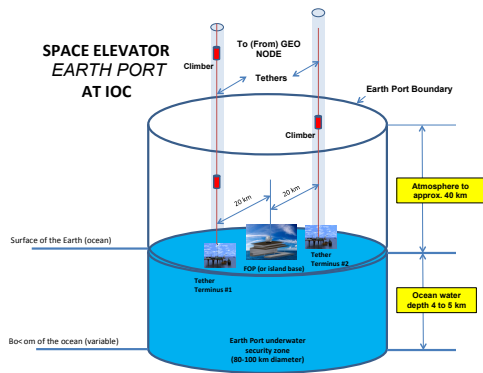


Figure 2, Earth Port with Two Space Elevators

- GEO Region: This Region encompasses all volume swept out by the tether around the Geosynchronous altitude, as well as the orbits of the various support and service spacecraft assigned to the GEO Region. When two or more space elevators are operating together, the region includes each and the volume between elevators.
- GEO Node: A complex of Space Elevator activities positioned in the Space Elevator GEO Region of the Geosynchronous belt directly above the Earth Port. There will be several sub nodes: one for each tether, one for a central main operating platform, one for each “parking lot,” and others. [note: at the GEO

altitude, the GEO Node complexes can maintain their locations naturally within the GEO Region].

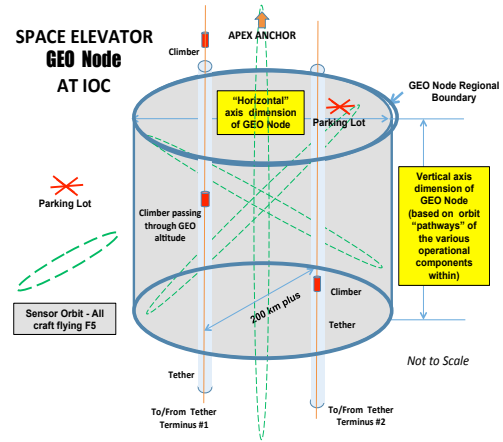


Figure 3, GEO Node Region with Two Space Elevators

- Apex Region: The region around the Apex Anchor is defined by the amount of motion expected at the full extension of the tether. The region is the volume swept out by the end of the tether during normal operations. When two or more space elevators are operating together, the region spreads to the volume between them.
- Apex Anchor: A complex of activity located at the end of the Space Elevator providing counterweight stability for the space elevator as a large end mass. Attached at the end of the tether will be a complex of Apex Anchor elements such as: reel-in/reel-out capability, thrusters to maintain stability, command and control elements, etc. [Note: nothing stays at that altitude unless attached to a tether].

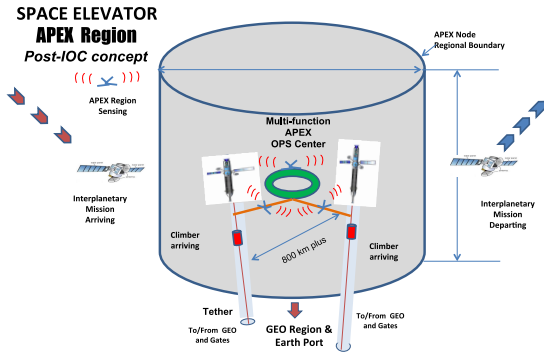


Figure 4, Apex Anchor Region with Two Space Elevators

Conclusions and Recommendations: As the system matures, a clear distinction between the transportation revolution and the visionary entrepreneurial enterprises will emerge into the Galactic Harbour vision. The concepts of a Space Elevator Transportation System and Space Elevator Enterprise must be distinguished. The strategy is to link the Space Elevator Transportation System to the Space Elevator Enterprise within a Unifying Vision: the Galactic Harbour. A Space Elevator Transportation System will be the core priority construction activity; and, its success will be the foundation of the Space Elevator Enterprise. The concept is simple with the realization that the term Galactic Harbour is new. – There will be multiple dependent space

elevator segments tied into a tremendous infrastructure for movement upward and downward, in three dimensions. The Galactic Harbour is the unification of Transportation and Enterprise.

Galactic Harbour as the Unification of Transportation and Enterprise

Space Elevator Transportation is the “main channel” in the Galactic Harbour	Businesses flourish as a part of the Space Elevator Enterprise System
GEO Node	Business support to Operational Satellites
Earth Port	Power and products delivered to Earth
Apex Region	Interplanetary Efforts within reach
Tether Climbers	Research
Tether System	
HQ/POC	

5. Vision: The following vision is a series of individual images stacked along side a visualization of the space elevator regions, leading to the concept of a Galactic Harbour.

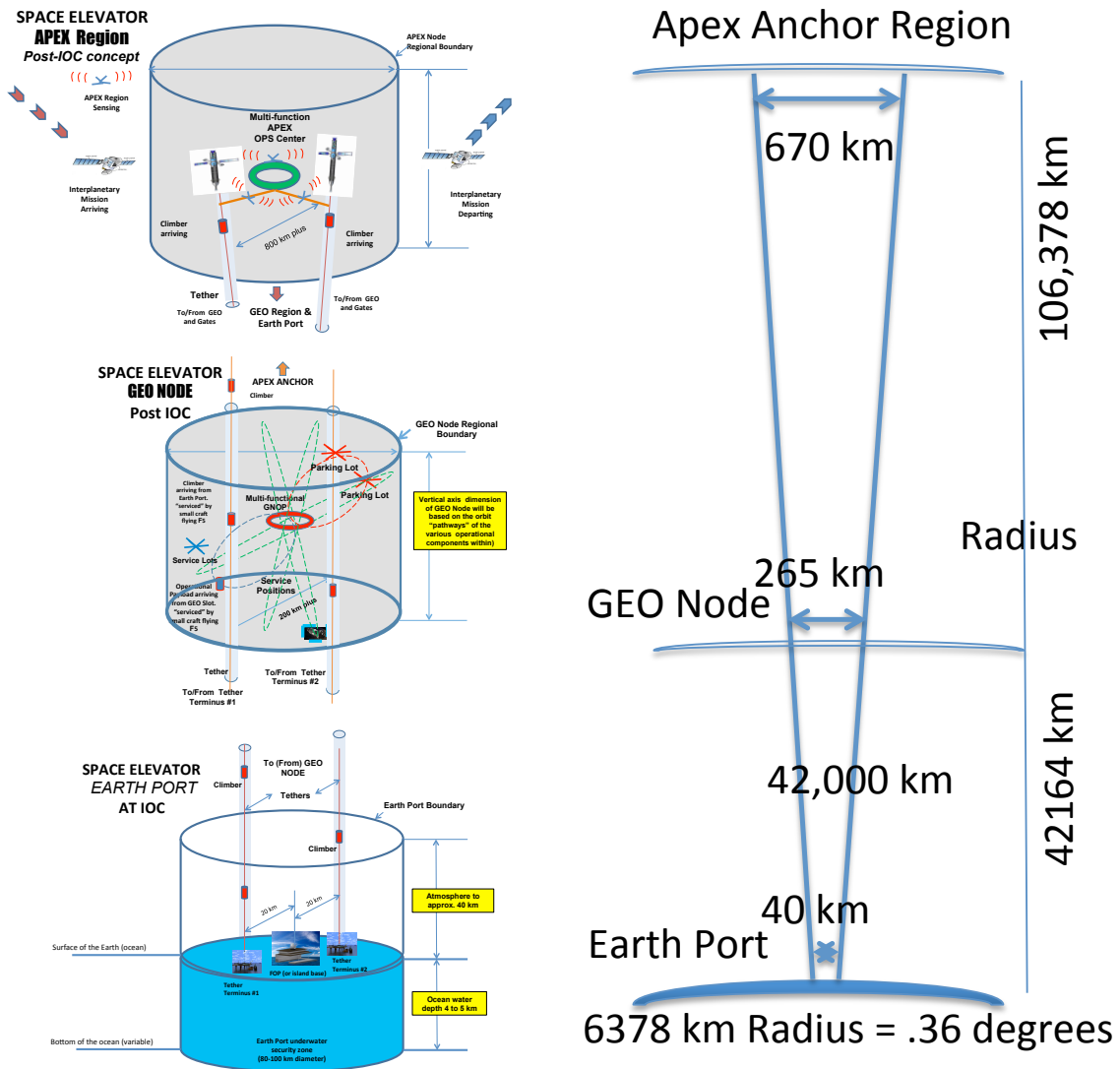


Figure 5, Space Elevator Regions within Galactic Harbour

References

- [1] Penny, Robert, Cathy Swan and Peter Swan, Design Considerations for Space Elevator Tether Climbers, International Space Elevator Consortium Study Report, 2014
- [2] Hall, Vern, Michael Fitzgerald, Robert Penny, and Peter Swan, Design Considerations for Space Elevator Earth Port, International Space Elevator Consortium Study Report, 2016
- [3] Fitzgerald, Michael and Peter Swan, Design Considerations for Space Elevator Apex Anchor and GEO Node, International Space Elevator Consortium Study Report, 2017