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A Successful Space Elevator  
Conference is Highlighted by Progress

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## Personal Prolog

This is an Architecture Note. It is the opinion of ISEC's Chief Architect. It represents an effort to document ISEC's ongoing science and engineering discussions, and is one of many to be published over time. Most importantly, it is a sincere effort to be the diary, or the chronicle, of the multitude of our technical considerations as we progress; along the pathway developing the Space Elevator.

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# A Successful Space Elevator Conference is Highlighted by Progress

## Introduction

The International Space Elevator Consortium met in Seattle at Boeing's Museum of Flight for its 2017 Conference. It was a nice time of the year, and the then recent solar eclipse had a strong effect on our conference; if only to increase motel room prices to new highs. Be that as it may, the conference was fun and fantastic. The Museum of Flight sets the right tone for our musings; and, we all had a great time.

This year, the ISEC Board and Conference attendees openly embraced the changes dictated by the maturing thoughts about a Space Elevator; as a transportation force in the future, as an enabler of robust space-based enterprise, and as the initial infrastructure of the 3<sup>rd</sup> dimension of Earth's transportation and logistics system. This triad of featured attributes is captured by ISEC's portrayal of the Space Elevator Architecture as the Galactic Harbour. ISEC sees a classic harbor ... where transportation and business meet. To that end, the ISEC Board accepted the 2017 position paper; "*Design Considerations for the Space Elevator Apex Anchor and GEO Node*".

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## **Unifying Vision officially introduced – the Galactic Harbour.**

The key word is officially; some of us have talked about this for almost three years. The notion was “initially” introduced in one of my Architecture Note #5 in January 2017, Pete Swan started a trade mark sweep just after the 2016 conference, and I chatted about the notion with Vern Hall, our Earth Port Harbor Master, in 2015 when he was composing his Earth Port study.

Now, officially, the Galactic Harbour is a part of our Strategic Approach. Our “strategy” is to link the Space Elevator Transportation System to the Space Elevator Enterprise System; within a Unifying Vision ... the Galactic Harbour. It is best to read such things very slowly and to interpret them for insight and clarity. The strategy cites a transportation system **AND** an enterprise. It also calls for unification (a unifying vision). The core thought is that we are to build two things and then unify them. Another version of the thought is that we build one which enables the second; or we are to build the first so that we may have the second. Guess what ... they are all correct. Keep the elements and activities of a harbor in mind: main channel, entry, departure, port services, security, and so on.

## **Transportation and Enterprise**

Talk about a symbiotic relationship! Transportation and Enterprise!! The connection is historic. Cities are established at transportation hubs ... always have been; always will be. It happens because that is where enterprise flourishes; always has, always will. If one looks closely at history, one sees a special cycle; ... the enterprise activity shapes the transportation capability after the transportation has enabled the enterprise. The same will be true for us and our elevator. A relationship our Architecture engineering team must embrace.

At this point, separate systems have been identified – the Space Elevator Transportation System and the Space Elevator Enterprise System. The transportation system is straight forward. Transportation is delivered by the six segments of the Elevator - moving cargo from earth to space:

- Earth Port
- GEO Node
- APEX Anchor
- Tether Segment
- Tether Climber
- HQ / POC

Each of the six segments has transportation functions, and later each will acquire functions that are part of the enterprise system. Consequently, the engineering development of the transportation system must be aware of the coming new functions; post-IOC (Initial Operations Capability). The development must be conducted in a way not blind to the post-IOC acquisition of enterprise functions. To that end, a “Separate but not segregated” engineering paradigm is to be enforced. It includes an emphasis on cross system development awareness and collaborative involvement with a variety of Space Industries (our enterprise partners).

## Design Considerations for Space Elevator - overall

Three Space Elevator segments were identified as regional in their construct. The Earth Port was already seen as an open water region more than 50 kilometers across. The GEO Node is now seen as a region hundreds of kilometers across and the APEX region is even larger. Perhaps the most telling design consideration was that extensive amounts of test activity will be required; and conducted on orbit. This activity is detailed in “Sequences”; starting with initial pathfinder deployment demonstrations. The Initial Operations Capability (IOC) was defined as:

- One Headquarters & Primary Operations Center
- 2 tethers
- 14 Climbers
- One GEO Node
- One Earth Port – with 2 Tethers Termini
- One Apex Anchors Node– with 2 anchors

GEO Node role at IOC was also clarified. Its role in testing and deployment is extensive and will be ongoing for years. With that, the GEO Node region will be a busy place!

- Parking orbits for service craft and test support craft; supporting test execution and test data collection
- A collection of Situation Awareness sensor craft; keeping a watchful eye and assuring safety.

## Design Considerations for the Apex Anchor – It must work right way!!

The personality of the Apex Anchor is much like that big guy at the back end of the Tug of War contest at each year's family picnic. There is no way one has a winning team if that position is less than completely successful ... all through the event. From the beginning moments of the Tether's initial deployment (departing GEO), the Apex Anchor deployment satellite must service the balancing of tether mass above versus below geosynchronous. Too little and the deploying system tumbles to Earth --- too much and it wanders off to Mars or somewhere.

The deployment satellite is the initial counter weight; the initial Apex Anchor. That satellite is the manifestation of nucleation, leadership, and stability. When it reaches the Apex altitude there is a Space Elevator. Immediately, mass buildup begins and tether stability is maintained; and the early Climbers get onboard.

### Apex Functions

- Initial Apex functions
  - Tether Stability
  - Mass collection operations
  - Mass Buildup (to 6300 (tbr) Metric Tons)
  - Mass management operations
- Mature Functions
  - Tether Reel / In Reel Out (RIRO) Operations
  - RIRO testing with first w Earth Port only
  - Early operations ... as new Climbers board @ the Earth Port
  - Tests Galore ... research / on ramp results
  - Operations Models validation
- Apex Region encompasses
  - 2 Tether counterweights' i. e. anchors
  - Lunar Gate and Mars Gate Operations
  - Spacecraft operations / construction / services

For now, Apex Anchor's FOC (Full Operations Capability) is only loosely defined. All activities related to interplanetary missions.

## Design Considerations for the GEO Node - impressive and daunting

The personality of the GEO Node is much like the Godfather. It will help things get started, even assist the early deployment, and ensure all is safe and well; for everyone. It doesn't get directly involved - until operations start. After that, it controls all; directly and indirectly. Everything goes through the GEO Node, and then it manages all for the good of all. The Godfather, er, the GEO Node, offers services, repairs, safety, and keeps an eye on all things. Many of these services are delivered by new members to the Enterprise; deemed worthy by the GEO Node because the new members became part of the Space Elevator via "Sequences" and, especially, via its Limited Operations Phase.

### GEO Node Functions

- Some Functional involvement through Transportation IOC
- Essential deployment support
  - Parking Lots (orbits) within the GEO Region
  - Surveillance Systems
    - Test Data Collection and Test event documentation
    - OPS Support w Sequences and Clients
  - Safety
  - Initial activities – after Transportation
    - RIRO
    - Tether Stability
    - Execute the Limited Operations phase
    - Early operations with Climbers
    - Operations Models validation
  - Mature activities – Transportation and Enterprise.
    - RIRO
    - Operations Rhythm → mass balance // speed // repair
    - ...
    - Refuel, upgrade software, generate power, special comms, transfer payloads, maintain positions of all space craft,
    - Interface Operations with multiple Climbers and multiple Clients
- FOC → Magnitude of IOC to FOC functional transformation is daunting

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## **In closing**

As you can see great progress was made in the Architecture development of our vision. In the coming year, we must do more collaborating; more discussing, more investigation of newer answers and newer technologies. An unrelenting push is required to achieve the future.

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