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Space Elevator Transportation System

Architecture Note #24
The Path to Tech Readiness!

Michael A. Fitzgerald
Senior Exec VP and Co-Founder
Galactic Harbour Associates, Inc
Space Elevator Transportation & Enterprise Systems

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Personal Prolog

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This is an Architecture Note. It is the opinion of the Chief Architect. It represents an effort to document ongoing science and engineering discussions. It 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.

Michael A. Fitzgerald

Preface

This note addresses a milestone for all of us in ISEC. It documents, in summary form, how we have entered the Space Elevator Era. The discussion explains how we moved from a roadmap study in 2014 to today; ready to declare "Tech Ready". All readers should at least examine the graphics and understand them. Industry must now get involved, and we should help them.

Background

In the last 6 years, ISEC's Technology Maturation approach has melded with a better definition of the Space Elevator engineering solution. The 2014 publication of ISEC's "Architecture and Roadmap" Report removed the shroud of mystery and myth from the Elevator's scope and complexity. The elevator was no longer a mystery. "Design Consideration" documents published between 2013 and 2017 delineated the engineering approach for the Tether Climber, the Earth Port, the GEO Region, and the Apex Anchor. An Architecture simulation tool was selected. The last technology hurdle - strong material for the tether – was conquered. Based on this technology maturity, and its engineering momentum, we expect that by the middle of this century an operational Space Elevator Transportation System will be built and operating.

Further, the engineering substance of the Space Elevator has solidified and become organized; most notably as the Galactic Harbour. The Galactic Harbour will support enterprise activities along the GEO belt, factories and solar power generation near GEO, efficient interplanetary departures from the Apex and arrivals at GEO. Ultimately, products and materials will be delivered from space to the Earth Port. All this, closer than you think!

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The Technology Momentum of the Galactic Harbour is real; and it underwrites the interplanetary vision of transportation, enterprise, and exploration

In the last year, the International Space Elevator Consortium advocated that the basic technologies needs were available, and each segment of the Space Elevator Transportation System was ready for engineering validation. The ISEC position:

1. The Galactic Harbour Earth Port ➔ ready for an engineering validation program
2. Space Elevator Headquarters / Primary Operations Center ➔ ready to start an engineering validation program
3. Tether Climber ➔ Engineering model assemblies needed; then start an engineering validation program
4. GEO Node ➔Engineering discussions and demonstrations with key members of Industry needed; and collaboration / outreach with certain government offices.
5. Apex Anchor ➔ Engineering discussions and various simulations needed. Near term collaboration with engineering organizations and academia should be started. Then outreach to key members of Industry and government offices. Engineering validation follows.
6. Tether material ➔ Prime material candidate identified. Production demonstrations needed.
7. Collision avoidance ➔ Architecture engineering definition being finalized. Candidate concepts are identified. On orbit performance demonstrations are need.

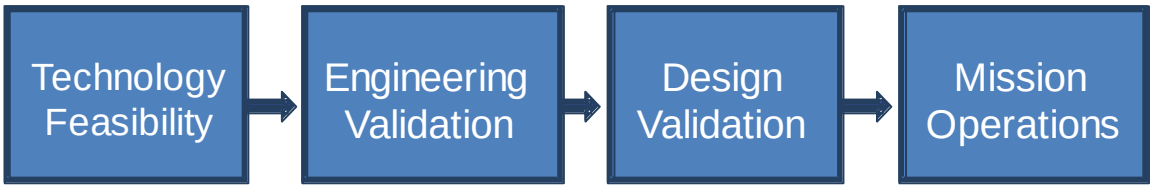
Q: Where are we, exactly?
A: We are nearing the end of the Technology Development Phase

During our 2014 roadmapping effort, it seemed evident that within the envisioned Space Elevator Architecture, new entities and technologies would be required; engineering approaches needed refinement, and new materials need to be found. In street talk, we need new stuff, new ways to make it, and new ways to operate such things.

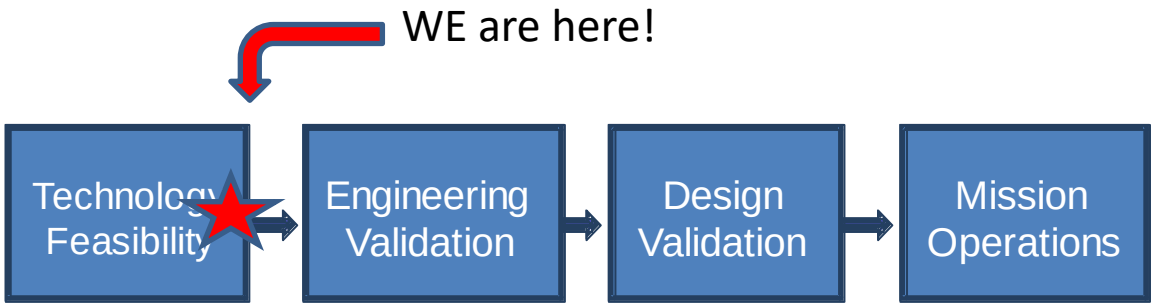
A technology development approach was built; based upon a development approach of "Show Me." The "Show Me's" were essentially a set of well-constructed demonstrations, inspections, tests, simulations, experiments and analyses - best conducted by industry (since industry would be building the elevator).

ISEC also noted that each segment of the elevator had its own challenges and would likely need to resolve those challenges in segment unique manner. The technology and engineering issues facing something at the equator and in the middle of the Pacific Ocean are not directly relatable to something at the APEX Anchor at 100,000 kilometers above the equator; and indeed, in the middle of "Outer Space". As much as the issues are dissimilar, they are the same. Define them, mature the solutions, and determine if we can build something from them. Our work retains that theme.

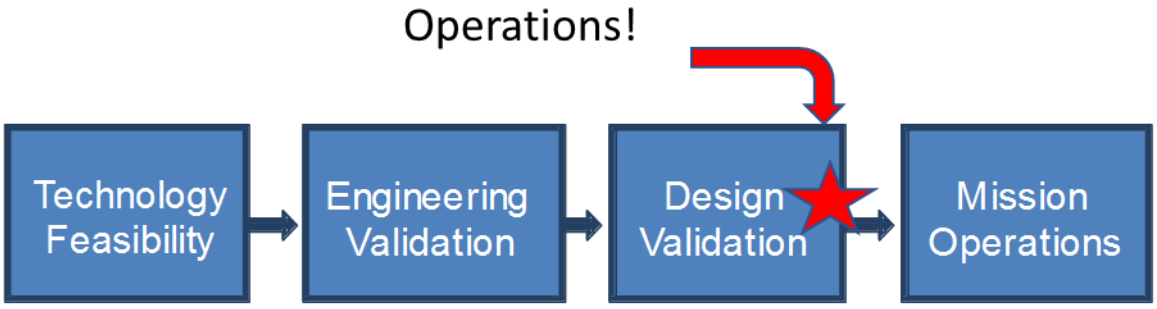
ISEC's technology development follows a tried and true sequence. Our approach extends the thinking of industry / commercial Technology Plans.



The progress within the plan continues to be based upon an iterative approach to risk mitigation; recurring Technology Readiness Assessments, culminating in operations demonstrations & prototypes, …



All this ensuring mission success at Initial Operational Capability.



The ISEC team has been assessing the technology feasibility situation since 2008. In recent times, the team has begun an open dialog with those members of industry, academia, and others; who could be the deliverers of ISEC solutions. Industry (especially) will show how the needed technologies are being matured and when they could be dependably available. These readiness assessments are the Phase one exit criteria:

- **Document technology readiness state.** Determine if the technologies are State of Art (SOA) or State of the industry (SOI) or State of the Market (SOM
- **Establish readiness level rationale for all portions of the Program.** Given that the technology availability has been demonstrated the level of readiness can be established for each program segment

- **Set Success Criteria regarding Engineering Validation – the second phase.** Prudent acquisition planning calls for an early design reviews. “Show me” means a lot at this point.

Q: Then what?
A: Phase two: Validate engineering approaches

Phase two will begin soon after phase one completion. Industry involvement is an imperative. Phase two activities are driven by six major activities:

- **Examine Industry’s production foundation**
- **Determine if the segments can be built**
- **Assess schedule & technical risk:**
- **Delineate design criteria**
- **Set criteria and standards to enter the Design Validation Phase**
- **Baseline operations performance:**

In closing

We need to spread the word. Outreach to Industry, academia, and government has become an imperative. China and Japan have each determined that the space elevator can be built.

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