

Final

Architecture Note

#6

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**Taking the Space Elevator from NOW,
to THEN, and BEYOND.
We need “Sequences”.**

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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.

Michael A. Fitzgerald

From NOW, to THEN, and BEYOND.

We envision moving from NOW – holding a vision of the Space Elevator; to THEN – a marvelously engineered space transportation system; and BEYOND – to a gloriously robust enterprise in a Galactic Harbour

Introduction

This Architecture note will be the first of two or three notes that will discuss what “Sequences” is about and how it is at the heart of our Technology Maturation and Engineering Validation process. This process is the source of our technical and intellectual fuel. Many of the early steps will be repeated until we “get it” and until we “get it right”; the essential definition of perseverance. By “get it”, I mean engineering validation. By “getting it right”, I mean a Space Elevator transportation system design. Let's talk about the first few steps in the Sequences.

“Sequences” - You need to know what it is and why.

I figure that most of you know that no one has ever built a Space Elevator before. Yet as one part of us talks to another part of us; we aren't daunted by that at all. Let me explain. You build something that has never been built before by persevering; relentlessly. We must prevail. We must not fail our vision. But, we need a playbook! This Architecture Note is about that perseverance playbook. We call that playbook “Sequences”.

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The idea of Sequences is simple. Take a technology that is needed in the Space Elevator. Then work with it until it matures to become a valid engineering approach. Then take the engineering approach and build it into something that operates. Then take that thing that operates and make it operate good enough to be part of the Space Elevator transportation system. Those of us who have built these “first ever” sorts of things, figure it’ll take 8 steps → 8 steps in Sequence.

The next few Architecture notes will discuss the 8 Steps. I want all to know how we will persevere; together. The official published paper can be downloaded. It was presented as a paper at International Astronautics Congress 2016; September 29 2016; *IAC-16-D4.3.8*.

Space Elevator “Sequences” – Here are the 8 steps.

1. Pathfinder
2. Seed Tether
3. Single String Testing
4. Operational Testing,
5. Limited Operational Capability (LOC),
6. Initial Operational Capability (IOC),
7. Capability On Ramps leading to FOC
8. Full Operational Capability (FOC)

“Sequences” – First, start the design process for the Space Elevator Transportation system

This is really Step Zero. The early design activity of the Space Elevator development will take a few years; reaching a system design that we are confident can be achieved. Part of that design process will require that relevant technologies be identified within the design. As discussed in ISEC report #2014 -1; a large number of tests, analyses, inspections, simulations, and experiments are needed to generate the technical information necessary for the development process. In addition to the planning approach and because of the breadth of the test taxonomy portrayed in 2014 -1; a common, orderly, stepped process is required; the “Sequences”. For that, ISEC’s Technology Maturation programs will call for

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any number of specific “Pathfinder” efforts to examine the validity of the various technologies. That is where we enter the Sequences; moving from Step Zero to Step #1.

Sequences #1 – Pathfinder

The technologies identified in the early design process will be examined in variety of engineering tests, experiments, or modeling & simulation forms in order to validate that the technology can be molded into something that works. As a particular technology completes its transit of Sequence #1, we envision an on-orbit flight demonstration; a Pathfinder flight. The Pathfinder flight may have several objectives for the topic at hand but the primary one is to assess the technology in the space environment and some other stress environments. It is already clear that a Tether Pathfinder flight is needed; but we expect on-orbit Pathfinder flights of other parts of the Space Elevator. One could envision Pathfinding an approach on which the Japanese Space Elevator team seeks collaboration. Successful Pathfinder flights make investors interested.

Sequences #2 – Seed Tether / Seed Events

This is an important step in the Sequences. It represents the transition from technology to a valid, workable engineering manifestation of our vision; or some important portion of our vision. This Seed phase of the Space Elevator development will not be a one and done demonstration but rather a substantive and thorough technology readiness assessment and engineering technique validation. Much of what we currently envision as parts of the Space Elevator has never been built before. As a consequence, many of the future seed events have not yet been defined.

We see, but are not intimidated by, our modular view of things; as discussed in Architecture Note #1. That vision of the Space Elevator being assembled using unmanned, robotic operations will be achieved only with practice. These repetitive robotic assembly practices will be birthed in Sequence #2. The Seed activities will be the basis for safe and efficient operating procedures. The assembly of key portions of the Space Elevator transportation system will be initially portrayed in Sequence #2. Successful Seed events make investors more interested.

Sequences have sequences

At this point I must emphasize that most everything to be accomplished in each Sequence step will be done a few times. Tests will be repeated until we get it right; and repeated again to be sure. In my many years of chasing unique system solutions, I feared “random success” more than a failure. In many instances we will repeat success to show it was not a random success.

Each Sequence phase will have its own sequence. Each effort to add functions to the Space Elevator will levy specific testing; in order to ensure that operational validity is retained when the capability is added. Generally, each Sequence will have a sub-sequence like this:

1. Entrance criteria review
2. Simulation of the tests to be conducted
3. Validation of risk reduction and test data collection
4. Execution of the sequence phase tests
5. Assessment of the performance data collected
6. Repeat as necessary
7. Exit criteria review; proceed to the next Sequence phase

In closing – Sequences have consequences

This is a huge topic and will have great impact on our efforts. It is our long term perseverance playbook. It will take us to our Space Elevator vision. We will learn that Sequences has consequences; good ones. In the March newsletter, I will discuss the next steps of Sequences.

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