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# Architecture Note

## #7

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

*Michael A. Fitzgerald*

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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 is the second of three notes discussing “Sequences”; 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 repeated until we “get it right”; the essential definition of our perseverance.

Let's talk about the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> steps in the Sequences.

## **Sequences #3 – Single String Testing**

As the development of the Space Elevator begins reaching early stages of design & development, investigative tests, simulations, and demonstrations are needed to ascertain whether the system is “coming together” as envisioned. We call these single string tests. Single string tests are conducted to a selected set of functions of the Space Elevator which are aligned and operating; strung together if you will.

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In early forms, single string testing could “simply” be an end-to-end simulation of a portion of an SE segment. Later, all the functions of entire segment could be examined. In some cases, important functions across the entire system could be tested; think here of a software test or a communications test. The essential purpose is determining whether the several functions operate cooperatively and effectively. Single strings tests across interfaces are essential for design integration.

Single string testing is largely investigative; aiding the engineering progress and evaluating the design maturation. Single string tests could examine the work flow within the Earth Port or the GEO Node. Single string testing of safety functions across several segments seems likely. ISEC envisions a recurring set of single string tests of the transactional communications between the Architecture’s robotic operations.

As things mature, engineering models will be inserted into the simulation of the single string to evaluate design details. Later, hardware in the loop (HWIL) tests are conducted, and “launch” versions of hardware are functionally validated before being sent to aloft. Think here of thermal testing and stress testing.

The primary purpose of single string testing is to get evidence that collaborative functions collaborate! In that sense, design changes will not be allowed after accommodating the results of single string testing; the design configuration is set. Single string testing is also an important part of maintenance and logistics. After IOC and through to FOC, repair and replacement of components will be robotically executed with “line replaceable units” (LRU’s). Single string testing will certify the efficacy of LRU’s.

Space Elevator performance improvements will be attained via modular units. All modules will be installed after single string tests. The performance validity of each module will be single string tested. Compatibility will be verified by single string tests. The Single String tests will never be construed to be an operational test; but, it is clearly a necessary step.

The Sequences approach, especially single string testing, is the basis of a constant & recurring attitude of “show me” → a taxonomy of tests, demonstrations, simulations, inspection, analysis, and experiments that reward success with admission to the next set of tests, demonstrations,

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simulations and experiments; iterative risk removal. Our single string testing phase initiates a constant awareness of the technical veracity of the Space Elevator development. Sequence #3 and follow on Sequences represent a confidence building process for our march into the unknown.

### **Sequences #4 – Operational Testing**

Operational testing is that set of test events intended to validate that a system or segment performs as designed in an operational context.

The operational tests are an amalgam of development specifications, environment specifications, the system engineering approach, and an overall test program, and other such documents. These documents do not exist now but are going to be produced in the coming few years.

The operational testing of the Tether Segment will require a ribbon deployed at full length. The operational testing of the Climber Segment will require a Tether Segment and a wide-reaching set of on-orbit observational and test data collection systems. It must be noted that some operational tests will be conducted 100,000 kilometers above the earth. We will need to see and record what is going on; for proper post-test analysis. Many of the operational testing topics was discussed in the Architectures & Roadmap Report.

### **Sequences #5 – Limited Operational Capability**

LOC is like the baseball concept of spring training. All aspects of the Architecture are included & the hardware has been operationally deployed.

This phase is good for assessing whether the operator personnel are knowledgeable and trained, that payload customers are aware & understand how this Space Elevator works for them, and operational instruction documents (nee checklists) are finalized and vetted with “real” operations and operators. It is quite likely that Sequence #5 could have a Pre-IOC sub-phase; as Dr. Skip Penny has suggested. Pre-IOC activities would include clients and their product payloads; an important step as we seek common technical veracity and risk removal.

This limited operational capability will be concurrent with the tether buildup activities – adding tether mass from tether buildup climbers.

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### **Repetition is not a bad thing - Repetition is not a bad thing**

The early Space Elevator component and segment designs will likely go through Sequence #3 and #4 a few times; first focusing on capturing the technical performance and how it varies in detail; later measuring the performance as designs improve; and finally testing components and segments with other component and segments.

### **In closing**

I started Note #6, last month, stating that no one has ever built a Space Elevator before; and that is our lot in life. We will overcome with persistence. We will find the technologies and evaluate them in Sequences 1 & 2. In Sequence 3, 4, and 5 we will raise our technology foundation to a solid engineering foundation and prepare for operations. Next month I will discuss the last three steps in our “Sequences”; achieving Initial Operational Capability and expanding it to full operation.

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