



Graphene Super Laminate is the Leading Tether Material of Choice!

[Peter Swan, Ph.D](#) April 8, 2024

Welcome to an update on the Space Elevator tether material that needs to be “long, strong and light enough.”

Abstract

"The manufacture of tether-quality material for a space elevator still needs more development, but the trajectory to a high-quality industrial product is clear. It is not unreasonable to think that.... space elevator tether production could begin in five to ten years using Graphene as its material." That is from "The Right Stuff," an article in the British Interplanetary Society's Spaceflight (June 2023) by Adrian Nixon, John Knapman and Dennis Wright. This lack of awareness of our (ISEC's) findings on two-dimensional materials is of concern, it is almost a denial of the physics and development that many have achieved.

Introduction

The magic number is 88 GigaPascals (GPa) of strength to enable a robust tether sufficiently strong to hold its own weight [with all stresses] and seven tether climbers that are ascending or descending.

In this article we will not address the details of that number but the type of material needed to reach that level of strength. Initially, carbon nanotubes were projected to be able to handle the tasking.

Breakthroughs ...Finally

In today's world, the two-dimensional materials [graphene, hexagonal boron nitride, and others] are leading the pack with two significant characteristics. Graphene has extreme strength and is being produced at roughly 120 meters per hour. "The manufacture of tether-quality material for a space elevator still needs more development, but the trajectory to a high-quality industrial product is clear. It is not unreasonable to think that, as this graphene process continues apace, space elevator tether production could begin in five to 10 years using graphene as its material." [1]

Recently, there have been several articles discussing the new materials and assessing their ability to meet the criteria of the tether operations. The following three quotations explain the current situation. They can be accessed, along with so much more on the tether material, at the body of knowledge location for the Modern-Day space elevator at www.isec.org – both in the recent articles shown and the materials research section.

- "A suitable material for the construction of the space elevator tether appears to be near at hand. There are three materials to choose from, each of which has seen rapid development since their discoveries. It is essential that the sample size of these materials be increased so that detailed mechanical, electrical and thermal testing can be done. Given what is known now, graphene super-laminate seems the best choice, with hexagonal boron nitride as an alternative." [2]
- "The manufacture of tether-quality material for a space elevator still needs more development, but the trajectory to a high-quality industrial product is clear. It is not unreasonable to think that, as this graphene process continues apace, space elevator tether production could begin in five to 10 years using graphene as its material." [1]
- "Industrial scale manufacturing methods are likely to produce polycrystalline rather than perfect single crystal graphene at the scales and speeds needed to manufacture space elevator tether. This work shows that provided the material has crystal grain boundaries that are well-stitched and have few defects, the current manufacturing methods can make graphene that is strong enough to make a space elevator tether." [3]

The Future

To help us with the challenge of developing and testing materials that will support space elevator needs, ISEC has excellent resources. Each of the following has been reviewed and presents the latest research on the Space Elevator Tether and its material of choice.

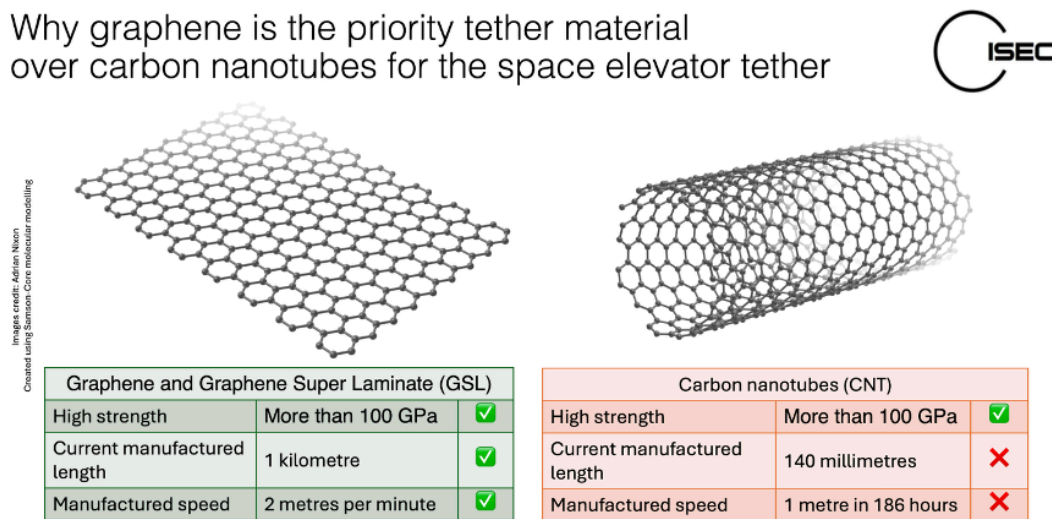
1. The first is the phenomenal support given to the Space Elevator community by Adrian Nixon and his working relationship with so many of the 2-D research centers. His ability

to analyze the results and present them in a manner that leads to the concepts of “how to” – “with what” – “when” – “real samples” and lastly, projections into the near and mid-term future. His work is displayed in the ISEC monthly newsletter – see current issue and archived ones.

2. The second is our excellent team of resources that are working within ISEC to understand these materials and then how they will be integrated into a 100,000 km tether, work with the tether climbers, be deployed, withstand the environment, and provide that permanent space access transportation infrastructure. Recently, many papers have been published/presented and made available to the community assessing and projecting into the future the health, new capabilities, and a path towards the future that will result in robust tethers for Space Elevators. Here are a few of them:

- Dennis Wright : "[Building the Space Elevator Tether](#)", Special Issue: Future Directions for Space Elevators", Journal of the British Interplanetary Society Volume 76 No.7 July 2023.
- Adrian Nixon, John Knapman and Dennis Wright "[THE RIGHT STUFF](#)" SpaceFlight Vol 65 No 06 June 2023.
- Adrian Nixon , John Knapman and [Dennis Wright](#) , "[Space Elevator Tether Materials: An Overview of the Current Candidates](#)", Paper at the 2022 International Astronautical Congress, Paris (also published by *Acta Astronautica*).

One recent article by Nixon, Knapman and Wright assessed the current candidate materials. Their analysis lead to the following chart with illustrates why graphene is the priority tether material at this time.



Nixon, A., Knapman, J. and Wright, D.H. (2023). Space elevator tether materials: An overview of the current candidates. *Acta Astronautica*, [online] 210, pp.483–487. doi:<https://doi.org/10.1016/j.actaastro.2023.04.008> ISSN 0094-5765.

Conclusions

The conclusions from the recent investigations, and resulting articles, mean that graphene and other 2D materials are leading the challenge to provide a tether that is long, strong and light enough. This leads to the following conclusions:

- Graphene Super Laminate is leading the tether material field of choices.
- Hexagonal Boron Nitride [and other 2D materials] are not far behind with many supplemental benefits.
- Polycrystalline Graphene has all of a sudden shown up as being a front runner as it is further into development and has sufficient strength [$> 80\text{GPa}$].
- CNT's are not living up to their "hype" from the early 2000's [as to length and strength combined].

[1] [Adrian Nixon](#) , [John Knapman](#) and [Dennis Wright](#), "**THE RIGHT STUFF**," *Space Flight* Vol 65, No 06, June, 2023

[2] [Dennis Wright](#) "**Building the Space Elevator Tether**," Special Issue: Future Directions for Space Elevators, *Journal of the British Interplanetary Society*, Volume 76, No.7, July, 2023

[3] Adrian Nixon [Graphene update in ISEC Newsletter, March 2024](#).

[Also see the historical development of graphene ([here](#)).]