Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

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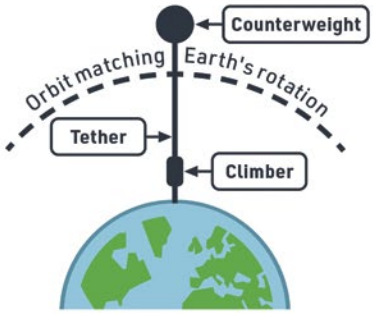
The science of space elevators

PERIODIC GRAPHICS

Space elevators are a hypothetical way of getting cargo and materials into space without rockets. Here we look at the challenges in constructing them and which materials could be up to the task.

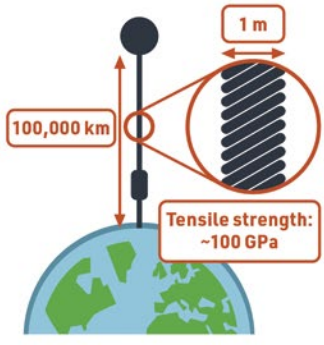
What are space elevators?

Space elevators have long been a hallmark of science fiction, but scientists have considered how to make them a reality. Theoretically, a space elevator would consist of a cable (tether) attached to Earth's surface and extending into space. Elevator cars (climbers) would travel along the tether.



Material requirements

The crucial element of the space elevator is the cable, which would require a material of low density and high tensile strength. The competing forces of gravity and centripetal force would hold the cable upright and under tension.



The tether material would need to be made of a continuous molecule, or single crystal, for maximum strength. And the 100,000 km cable would need to be manufactured quickly—ideally much faster than 1 m/s.

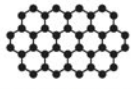
Manufacture speed	Manufacture time
1 m/s	3.17 years

The tether material would also need to withstand impacts from small meteorites and space debris.

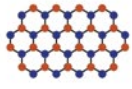
Possible materials

Three materials are strong enough for a space elevator tether: carbon nanotubes, graphene, and boron nitride.

Carbon nanotubes
Tensile strength: 77 GPa
Longest single-crystal length made: 500 mm



Graphene
Tensile strength: 130 GPa
Longest single-crystal length made: 500 mm



Hexagonal boron nitride
Tensile strength: 100 GPa
Longest single-crystal length made: 200 mm

So far, the candidate materials' maximum single-crystal lengths are well below the length needed. Polycrystalline graphene can be manufactured at lengths up to 1 km and, while not as strong as single-crystal graphene, may still be strong enough for tether material.

Polycrystalline graphene
Tensile strength: Up to 99 GPa
Longest length made: 1 km
Manufacture speed: 2 m/min