Are space elevators possible? Physicist says they could transform humanity into a 'spacefaring civilization'

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Humanity's quest to explore—and, perhaps eventually, colonize—outer space has prompted a great many ideas about how precisely to go about it.

While conventional wisdom suggests that space launch via rockets is the best way to send human beings into orbit, other "non-rocket" methods have been proposed, including a futuristic "space elevator."

The concept of a space elevator—essentially a sky-high cable that would let humans climb into space—has been championed by some industry experts as a way to overcome the astronomical costs associated with sending people and cargo into space by rocket, says Alberto de la Torre, assistant professor of physics at Northeastern.

"Current launch systems are predominantly single-use and typically exceed $10,000 per kilogram of payload, totaling around $60 million per launch," de la Torre says. "Here's where space elevators are appealing."

First imagined by Russian rocket scientist Konstantin Tsiolkovsky in the late 19th century, the space elevator would extend from the ground through the atmosphere, then past "geostationary orbit," an altitude where objects in space—pulled in by the Earth's gravity—orbit more or less in tandem with its rotation. Geostationary orbit is roughly 22,236 miles above the Earth's surface.

Effectively, a cable would descend from a satellite structure anchored in geostationary orbit that would act as a "counterweight" down to Earth.

Theoretically, a satellite positioned beyond geostationary orbit would act to stabilize the cable through a combination of forces: the Earth's gravitational pull, which would exert a downward force on it from the ground, and the centrifugal force of its rotation, which would exert an upward force on the cable from space. The interaction of forces would

create an ideal tension—a tautness—necessary to sustain a cable of such length, de la Torre says.

"The key element of a space elevator is its cable, positioned at the Earth's equator and synchronized with the Earth's rotation," de la Torre says.

No proof of concept exists for a space elevator. While there have been several attempts at architectural designs, including an award-winning design by a British architect that recently bore a six-figure prize, numerous technical obstacles have kept the space elevator decades out of reach.

"A cable of such length [more than 22,236 miles above the Earth] isn't feasible with standard materials," de la Torre says. "If made of steel, the maximal tension it faces at geostationary orbit exceeds its tensile strength rating by over 60 times."

For an Earth-based space elevator, strategies to reduce tensile forces, or the ability of a material to withstand tension, are crucial, he says.

But there are some materials that carry promise. Boron nitride nanotubes, diamond nano threads and graphene—all materials with "low density and high tensile strengths"—could fit the bill, de la Torre says.

"Carbon nanotubes are proposed as an ideal material due to their high tensile strength," he says. "Recent research has raised concerns about the feasibility of translating their nano-scale properties to megastructures."

In the long-run, the space elevator's promise lies in its potential to make trips to outer space significantly more economical. "The cost of putting a payload beyond a geostationary orbit can be cut to just a few hundred dollars per kilogram," de la Torre says.

"While the initial investment in a space elevator might be substantial—akin to the expense of developing and launching the James Webb Space Telescope into orbit, the costs could be recouped after successfully launching a mere few tons of payload," he says.

"With the continuous evolution of materials sciences, space technology and engineering, the concept of space elevators shouldn't be ruled out in the not-so-distant future," de la Torre says.

Until those breakthroughs in materials science arrive, the space elevator may only continue to serve as fodder for science fiction enthusiasts.

"Space elevators, in essence, hold the promise of transforming humanity into a spacefaring civilization," de la Torre says. "They could present a safe, cost-efficient avenue to bring into orbit the heavy payloads needed for hypothetical space stations, asteroid mining or developing extraterrestrial habitats."

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