



Space Elevators

Concept Overview

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<http://flightprojects.msfc.nasa.gov/fd02.html>



Early Concepts



Artsutanov (1959)
Isaac, et al (1966)⁸¹⁹⁴⁻⁸³
Pearson (1975)

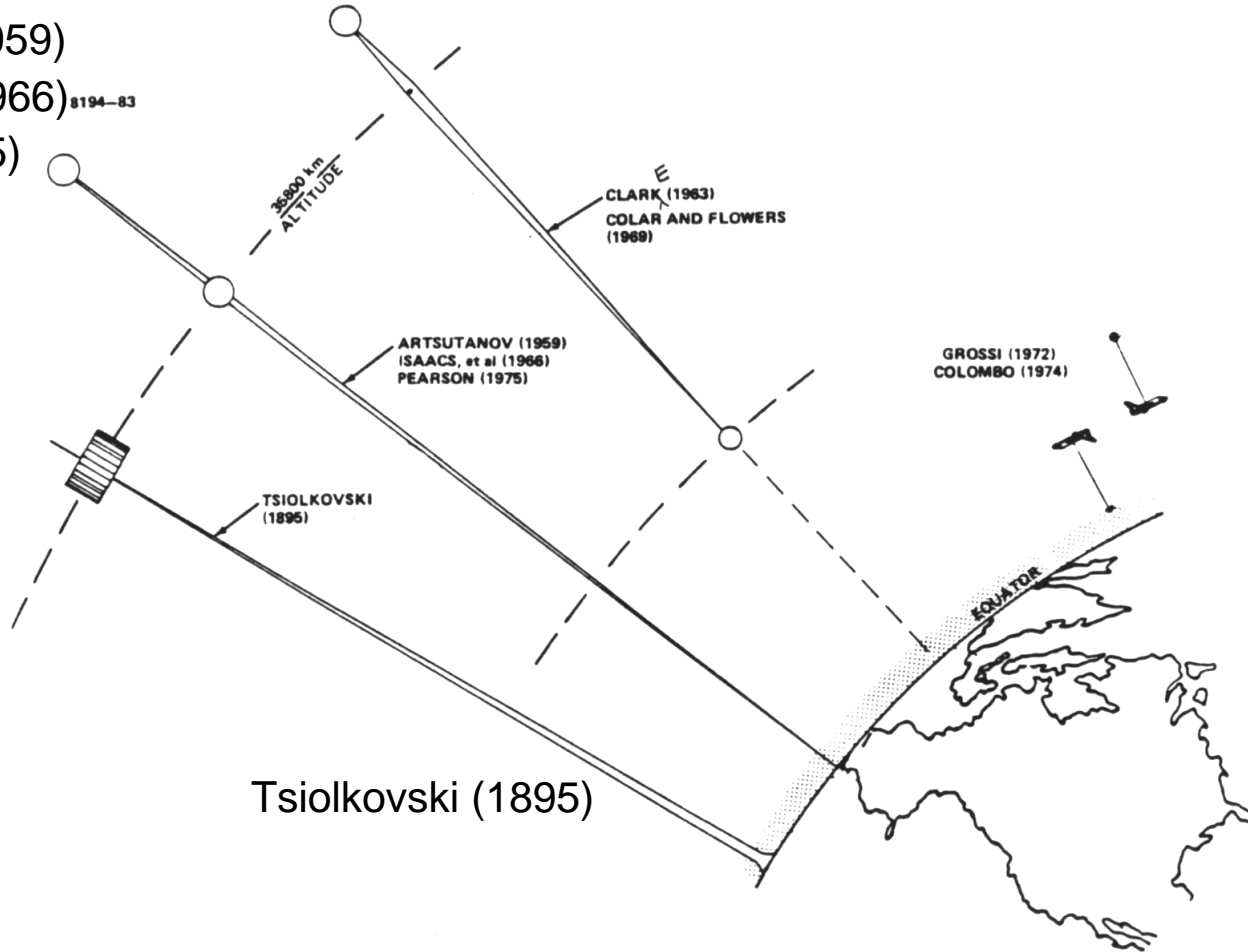
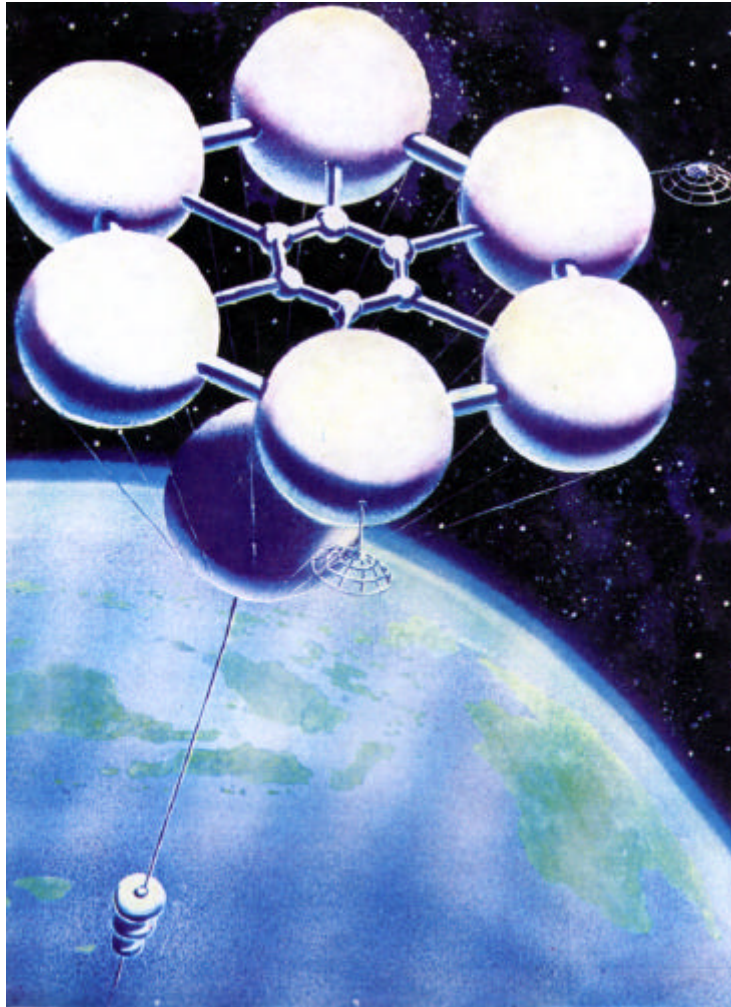


Figure 1. Early orbital tower and skyhook concepts.



Early Artwork



1967: Leonov, A., Sokolov, A., *The Stars are Awaiting Us*, Mol. Gvardiia, Moskva, USSR, p. 25

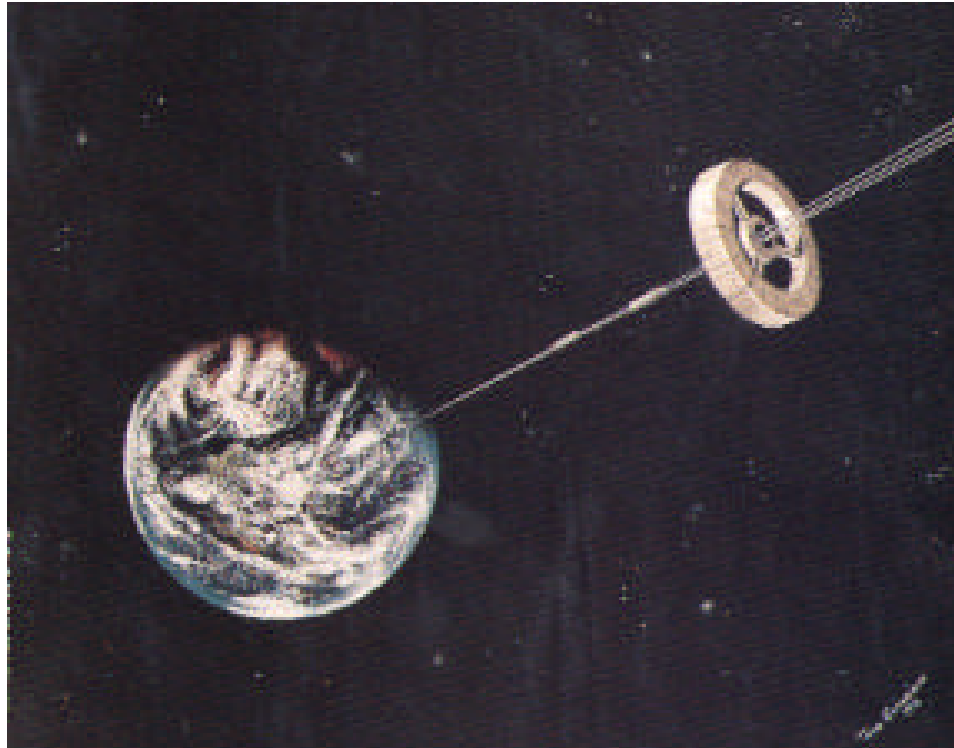
(Text and captions in Russian and English)

SPACE ELEVATOR

Among the multitude of possible near-earth orbits one is a very special one - the orbit of the so-called 36,000 kilometers satellite. If a satellite is launched to this altitude above the Equator it will orbit the planet every 24 hours, i.e. its period of revolution will coincide with the Earth's rotation around its axis. And this means that the satellite will, so to say, stay fixed in a certain point in the sky. If a cable is lowered from the satellite to the earth you will have a ready cable-road. An "Earth-Sputnik-Earth" elevator for freight and passengers can then be built, and it will operate without any rocket propulsion.



Technical Papers



1975: Material strengths not sufficient to construct an Earth space elevator.

1979: Materials are available to build a lunar space elevator

1975: Pearson, J., “The Orbital Tower: a Spacecraft Launcher Using the Earth’s Rotational Energy.” Acta Astronautica, Vol. 2, 785-799, 1975.

1979: Pearson, J., “Anchored Lunar Satellites for Cislunar Transportation and Communication.” J. Astro. Sciences, Vol. 26, No. 1, 39-62, 1979.





References



Towers

1450 BC: Moses, *Book of Genesis*, Chapters 11 & 28

- Tower of Babel, Construction in ~ 2100 BC
- Jacob's Ladder, Vision in ~ 1900 BC

1895 AD: Tsiolkovski, K.E., "Speculations about Earth and Sky and on Vesta." Moscow, Izd-vo AN SSSR, 1959 (first published in 1895).

Synchronous Space Elevators on Earth

1960: Artsutanov, Y., "Into the cosmos with an electric locomotive.", Komsomolskaya Pravda, July 1, 1960.

1966: Isaacs, J.D. et al., "Satellite Elongation into a True Skyhook." Science, Vol. 151, 682-683, 1966.

1967: Lvov, V., "Skyhook: old idea." Science, Vol. 158, 946-947, 1967.

1969: Collar, A.R. and Flower, J.W., "A (Relatively) Low-altitude 24-Hour Satellite." J. of the British Interplanet. Society, Vol. 22, 442-457, 1969.

1975: Pearson, J., "The Orbital Tower: a Spacecraft Launcher Using the Earth's Rotational Energy." Acta Astronautica, Vol. 2, 785-799, 1975.

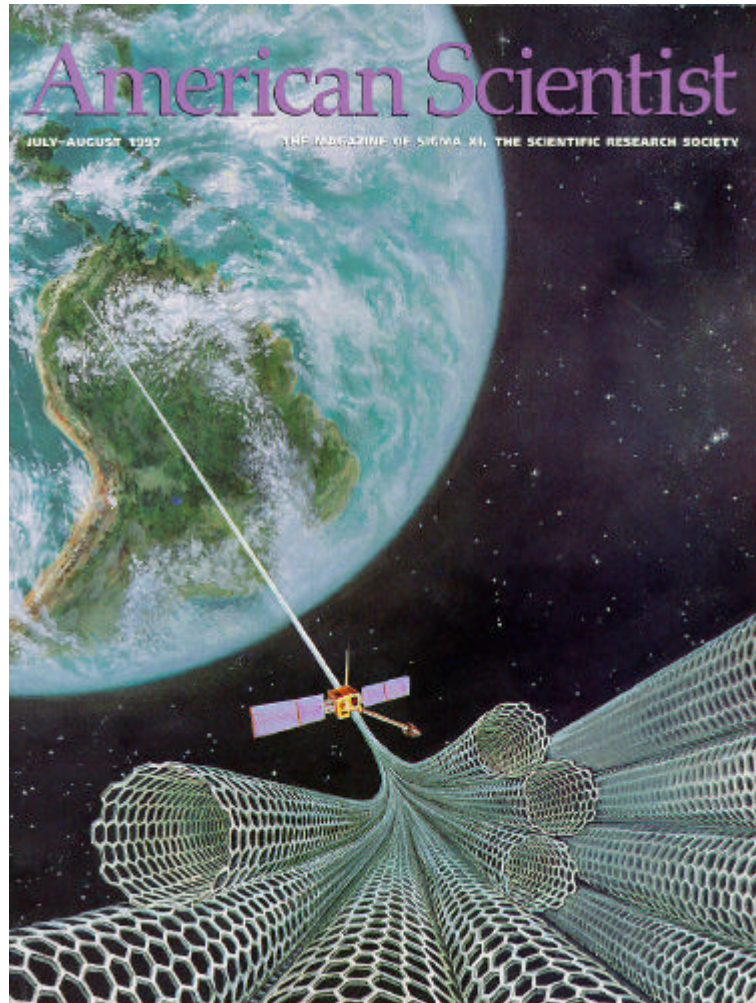
1981: Clarke, A.C., "The Space Elevator: Thought Experiment or Key to the Universe?" Adv. in Earth Oriented Appl. Of Space Tech., Vol. 1, No.1, 1981.



Fullerene Nanotubes



“The stuff space elevators are made of.”



1997: Yakobson, B. I., Smalley, R. E., “Fullerene Nanotubes: $C_{1,000,000}$ and Beyond,” *American Scientist*, 85, pp. 324-337, July-August 1997

Carbon Nanotubes (CNT)

Single-Wall Nanotubes (SWNT)

- Strength (~ 100 x steel, 10 x kevlar)
- Electrical conductivity (~ copper)
- Thermal conductivity (~ diamond)
- Manufacturing is difficult (now)

Its future in manufactured products...

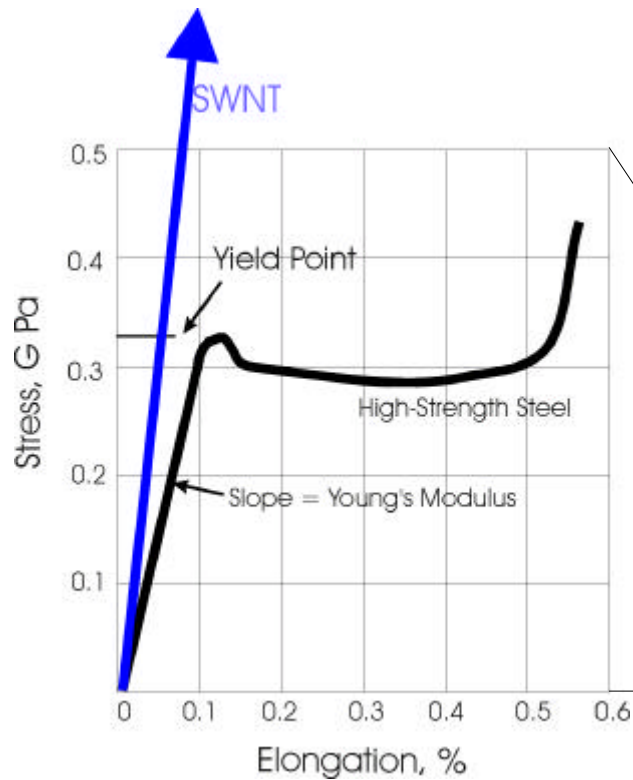
- High tensile strength
- Ultimate laminate
- Low mass
- Forms strong fibers
- Good electrical conductor
- Excellent thermal conductor



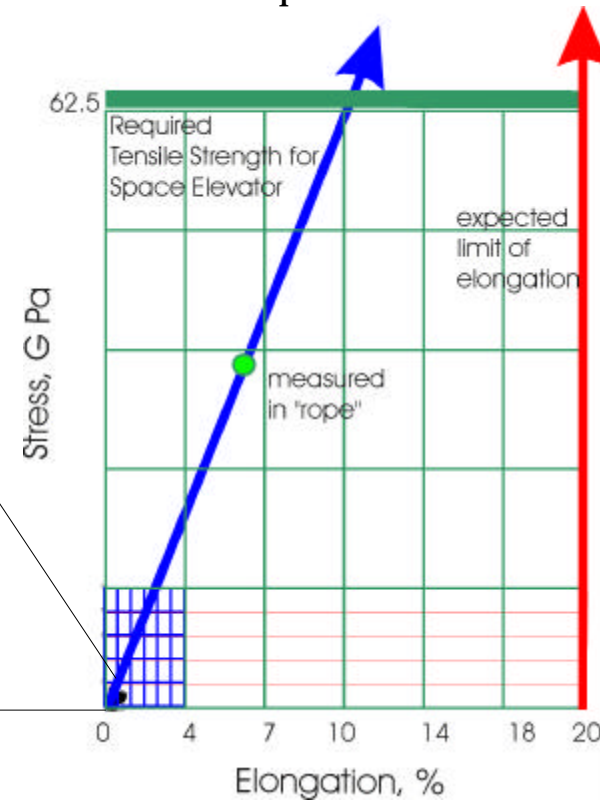
Single-Wall NanoTubes



Steel vs. Carbon Nanotubes (SWNT)



Space Elevator Requirements





NASA Space Elevator Study



Smitherman, Jr., D. V., *Space Elevators: An Advanced Earth-Space Infrastructure for the New Millennium*, NASA/CP—2000–210429, NASA Marshall Space Flight Center, Huntsville, Alabama, 2000.

- Technology Development Needed
 - CNT Materials Development for Structural Applications
 - Tether Demonstration Missions
 - Tall Tower Development
 - Electromagnetic Propulsion
 - Space Infrastructure
- About 50 Years Away



Available from FD02, or
http://flightprojects.msfc.nasa.gov/fd02_elev.html

Participants included:
Robert Cassanova, Director, NASA Institute for Advanced Concepts
Ken Smith (representing Dr. Richard Smalley) Rice University
Jerome Pearson - AFRL, ret.

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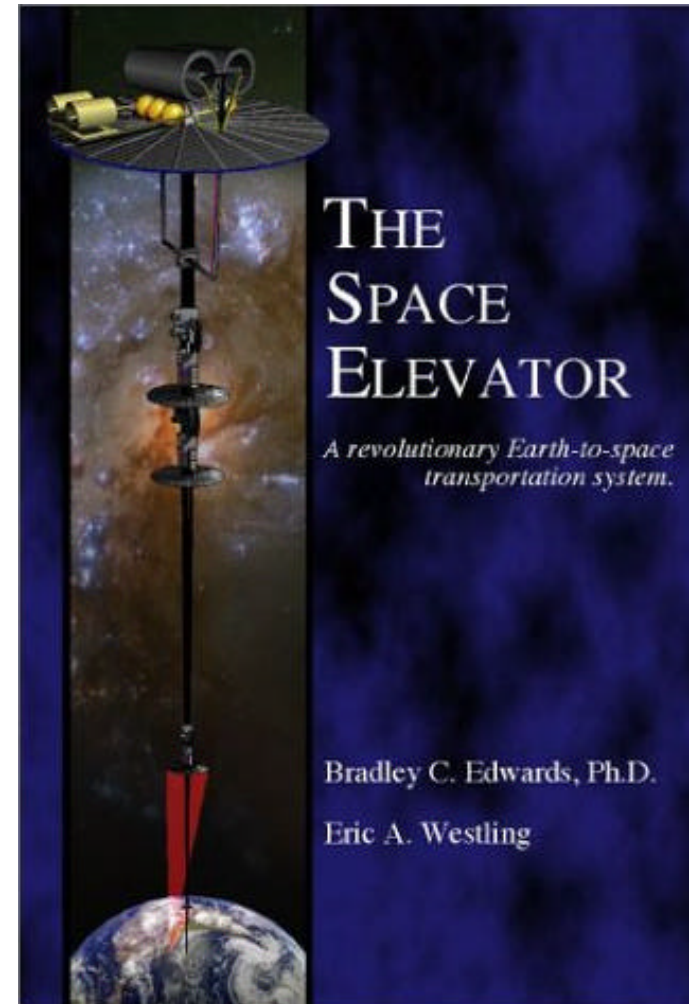
NIAC Space Elevator Study



Edwards, B.C., Westling, E.A., *The Space Elevator*, Spageo Inc., San Francisco, CA, 2002

Funding provided through a grant from the NASA Institute for Advanced Concepts

- Technology Developments Needed:
 - CNT composites
 - Electric Propulsion
 - Laser Power Transmission
 - Robotics
- About 15 years away



Spageo Inc. - <http://www.spageo.com>

Institute for Scientific Research - <http://www.isr.us>

NASA Institute for Advance Concepts - <http://www.niac.usra.edu/>.

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NIAC Space Elevator Study - (2001)

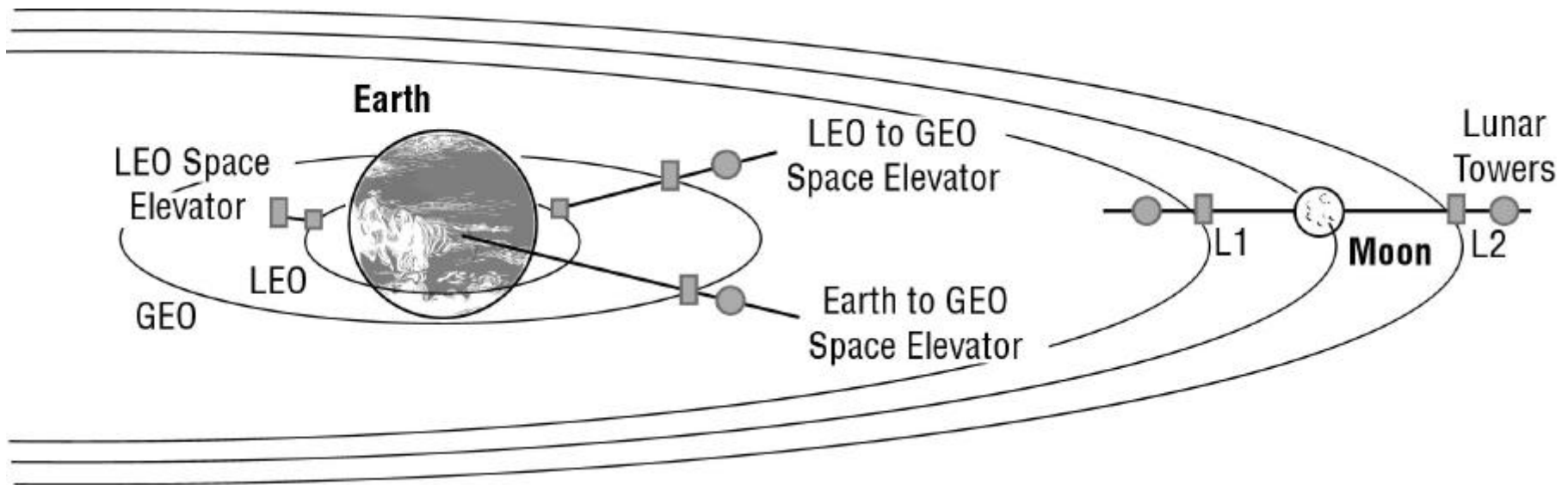


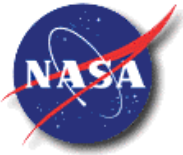
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Space Elevator Animation (Near-term Vision)

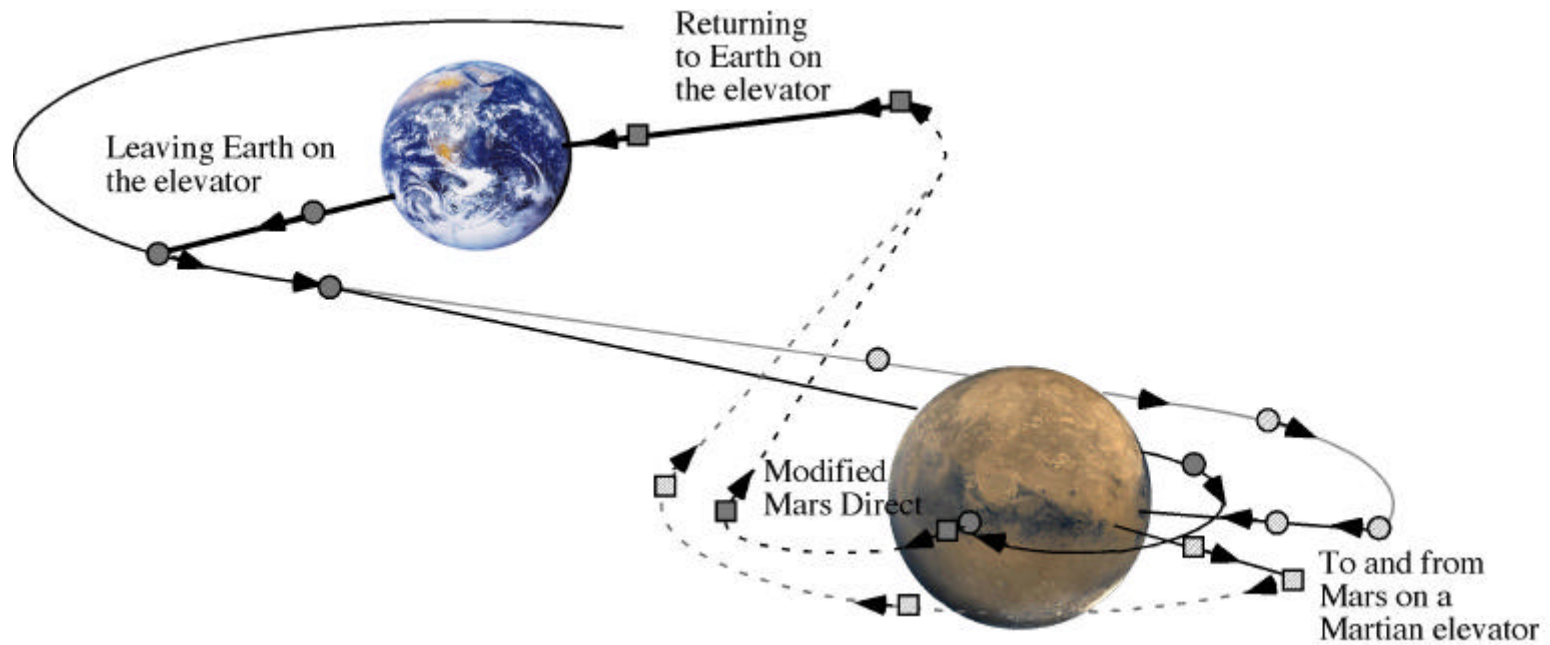


Space Elevator Concepts & Demonstrations





Mars Elevators





Tether Impact Research

NASA Marshall Space Flight Center