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SYMPOSIUM ON VISIONS AND STRATEGIES FOR THE FAR FUTURE (D4)
Space Elevator Design and Impact (3)

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ENERGY CONSIDERATIONS IN THE PARTIAL SPACE ELEVATOR

Abstract

The space elevator has been proposed as an alternate method for space transportation. A full elevator consists of a very long tether or ribbon, of hundreds of thousands of kilometres in length, attached to the surface of the Earth, with a counterweight at the top. However, very high tensile stresses will be developed in the space elevator, too great for currently existing materials to withstand. Therefore, a partial elevator is proposed. It is composed of a shorter tether held vertically in tension between two end masses,with its centre of orbit placed at the geosynchronous orbit. A spacecraft can dock at the lower end, and then use the climber on the elevator to ascend to higher altitudes. In this paper, energy calculations are performed, to determine whether a partial elevator can provide sufficient savings in operational costs, compared to the traditional rocket-powered launch.

In the first part of this study, the stress distribution along the tether is presented and the maximum stress is found. Knowing the tensile strengths of some candidate materials, an upper limit for the tether length is calculated. Then, in the main part of this paper, the energy required to launch a spacecraft from a Low Earth Orbit (LEO) to the geosynchronous orbit (GEO) is calculated for two trajectories. In the first trajectory, the spacecraft travels from LEO to GEO via a Hohmann transfer. In the second trajectory, the spacrecraft travels from LEO to the lower end of the partial space elevator with a Hohmann transfer, then uses the elevator to climb to GEO. The total energy required is then compared between the two trajectories.

In the second trajectory, the length of the tether is a key parameter that affects the total energy required to place the spacecraft at the desired altitude. Another parameter to consider is the mass of the spacecraft, relative to the mass of the climber. If the spacecraft and the climber are of comparable mass, then a longer tether provides more energy savings. On the other hand, if the spacecraft is much less massive than the climber, then the longest elevator is not the most efficient.

Numerical values for different elevator lengths and various climber-to-spacecraft mass ratios are presented. In some example cases, it is found that energy savings of over 25% can be obtained. Thus, the partial space elevator provides an attractive alternative for launching cargo into space.