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

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HOW DO INTENSE MAGNETIC STORMS AFFECT A SPACE ELEVATOR?

Abstract

In this paper we examine the dynamic susceptibility of a space elevator (Edwards 2000) to changes in the geospace environment precipitated by magnetic storms. The elevator consists of a thin carbon nanotube ribbon extending to approximately 15 Earth radii in the equatorial plane where it is terminated by a massive counterweight. The elevator is so long that it extends through the inner magnetosphere and radiation belts past geostationary orbit and, at times, into interplanetary space. As a result, different segments of the space elevator encounter different regions of magnetic and electric fields. As the elevator rotates with the earth, it experiences diurnal variations in the fields and these variations are compounded by changes associated with magnetic storm events. Electric fields will induce currents in the ribbon which interact with magnetic fields to apply forces to the ribbon. Magnetic storms are already known to present hazards to spacecrafts and suspected cases of damage have been documented. Larger magnetic storms produce larger electric fields. Since the beginning of the space age, there have been no direct measurements of field changes resulting from so-called superstorms, but historical evidence points to storms far larger than any seen in recent decades. The question of what effect a superstorm could have on a space elevator is thus not merely academic, but reflects foreseeable circumstances. Accordingly, we have devised a spectrum of possibilities and applied them to a well understood model of a space elevator. We utilize numerical simulation which incorporates symplectic integration to examine storm and cargo scenarios to portray realistic dynamic responses. We will show that strongly perturbed electric and magnetic fields can seriously interfere with the ability to implement elevator position control for space debris avoidance purposes. As a byproduct of these cases studies, we also quantify the changes in internal stress which the elevator must be able to withstand to avoid being damaged.