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GEOSTATIONARY STATION KEEPING CONTROL OF A SPACE ELEVATOR DURING INITIAL CABLE DEPLOYMENT

Abstract

The space elevator construction begins with the initial orbital cable deployment. After the anchoring the initial cable to the ground, more cables are added by the crawling robots to enhance the elevator's strength and survivability [1]. However, the difficulty in the initial cable deployment has rarely been focused, and just a few researches have been carried out [2] [3]. Both papers have shown that the initial orbital cable crushes to the ground without any orbital control. An orbit control simulation is also presented in [3], where the full deployment is performed. However, the detail discussions are not provided, and the presented result implies that the control strategy requires unrealistic thrust force and propellant. In this paper, we show a feasible control strategy to have the space elevator stay on the geostationary position during the initial cable deployment.

The mass center of a large spacecraft no longer flies on Keplerian orbit [4], and it must fly higher than the GEO altitude so that its orbital period is equal to the GEO period. Therefore, the mass center of the cable deploying space elevator should be controlled to climb up vertically. By focusing on the angular momentum, a control algorithm is obtained. In this control, only the tangential thrust force is given so that the angular momentum of the space elevator has the same value as its reference one. In addition, a simple feedback control is also necessary to stabilize and have the orbital motion follow the reference trajectory. Exact nonlinear numerical simulation has shown that the presented control strategy facilitates the full deployment of the initial space elevator with a small thrust force. For example, the maximum thrust force is 3N to fully deploy the total 20t space elevator, which is in the feasible range of the electric propulsion.

Some simulations using more complicated model and more sophisticated discussions on the mechanical energy, controlled dynamics, etc. will be presented at the IAC.

References [1] Edwards, B.C., "Design and Development of a Space Elevator," Acta Astronautica, Vol. 47, No. 10, pp. 735-744, 2000. [2] Mantri, P., "Deployment Dynamics of Space Tether Systems," Doctoral Degree Dissertation, Graduate Faculty of North Carolina State University, 2007. [3] Lang, D.D., "Space Elevator Initial Construction Mission Overview," available online: http://home.comcast.net/ GTOSS/ [4] Beletskii, V. V., "Motion of an Artificial Satellite about Its Center of Mass," NASA TT F-429, 1966.