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ON THE DEPLOYMENT OF A SUBSATELLITE IN A SPACE ELEVATOR SYSTEM

Abstract

It has been shown (Takeichi, 2010) that a low cost and not fully controlled constant rate deployment of a sub-satellite leads to a fall-down trajectory, while a fully controlled constant rate deployment results in a long time and cost intensive deployment. Considering these two somehow extreme cases, it is clear that one has to find a cost effective strategy for the deployment of the space elevator system.

To start with, the paper considers deployment of the space elevator neglecting the librations of the ribbon. The results obtained by Takeichi (2010) are reviewed.

In practice, ribbon librations will be experienced during deployment. The paper analyzes near-optimal solution for deployment of the ribbon and sub-satellite in a space elevator system and examines effects of the librational motion of the system on the optimal solution. Dynamics of the system in the orbital plane is described by four generalized coordinates:r,θ,l,and α where r and α describe the main-satellite motion with respect to the central mass, let us say the Earth, l denotes deployed length of the space elevator, and α corresponds to the librational motion of the whole system. It is clear that any constraint on the system like moving in a specific orbit, or any specific type of deployment, reduces the number of degrees of freedom of the system.

Considering the applied radial and tangential external forces on the main-satellite and sub-satellite, equations of motion are derived through the Lagrange's method. A near optimum solution is then determined for an optimization problem which formulates an optimum fuel consumption deployment problem in different deployment strategies such as

- Case 1: The system is continuously kept in its circular orbital motion while the sub-satellite is deployed.
- Case 2: The space elevator system is orbiting around the central mass with constant angular velocity and the deployment starts from and ends in its original orbital motion.
- Case 3: The system has no constraint in the deployment phase except it starts its deployment from a circular orbital motion and returns to this orbital motion at the final stage of the deployment.

The study is initially conducted for the system with no librational motion and the near optimal solution is obtained through the comparison of the results of different deployment strategies. Then effect of librational motion on the optimal solution is analyzed by including the librational motion in the analysis.