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Space Elevator Critical Technology Verification and Validation Testing (3)

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SPACE ELEVATOR DYNAMIC RESPONSE TO PAYLOAD RELEASE

Abstract

Continued development of advanced materials has led to increased levels of research about space elevators, including their dynamics. This paper presents a fundamental study associated with space elevator dynamics; it assesses the effect of releasing a climber's payload on the motion of the entire space elevator structure. As payload release must be an instantaneous event, it abruptly disturbs the system's equilibrium, which leads to excitation. The dynamic model is limited to the equatorial plane. The initial state of the system is assumed to be in static equilibrium just prior to payload release. The system's governing dynamical equations are then developed using a Lagrangian formulation. The tether's structural dynamics are handled using the assumed modes method.

Numerical simulations are obtained by solving a system of discretized ordinary differential equations. The excitation of each mode is examined for payload release at various altitudes along the tether. Since all of the structural oscillatory modes will eventually dissipate, the paper focuses on the fundamental pendulum mode. Payload release from geosynchronous altitude has no dynamical effect. Release from below GEO causes the entire system to stretch upward, which imparts a westward rotation due to a westward Coriolis force. Conversely, release from above GEO leads to eastward rotation. Knowledge of the anticipated dynamics brought upon by payload release allows for countermeasures to be coordinated with it, with the intent of minimizing any unwanted dynamical behaviour.