# Attitude Stability of a Spinning Spacecraft During Appendage Deployment/Retraction

Norman Fitz-Coy* and Wayne Fullerton**
AeMES Department
University of Florida

The work presented in this paper is motivated by the need for a national satellite rescue policy, not the ad hoc policy now in place. In studying different approaches for a national policy, the issue of capture and stabilization of a tumbling spacecraft must be addressed. For a rescue mission involving a tumbling spacecraft, it may be advantageous to have a rescue vehicle which is compact and "rigid" during the rendezvous/capture phase [1]. After capture, passive stabilization techniques could be utilized as an efficient means of detumbling the resulting system (i.e., both the rescue vehicle and captured spacecraft). Since the rescue vehicle is initially compact and "rigid", significant passive stabilization through energy dissipation can only be achieved through the deployment of flexible appendages. Once stabilization is accomplished, retraction of the appendages before maneuvering the system to its final destination may also prove advantageous. It is therefore of paramount interest that we study the effect of appendage deployment/retraction on the attitude stability of a spacecraft. Particular interest should be paid to appendage retraction, since if this process is destabilizing, passive stabilization as proposed may not be useful.

Over the past three decades, it has been an "on-again-off-again affair" with the problem of spacecraft appendage deployment [2-7]. In most instances, these studies have been numerical simulations of specific spacecraft configurations for which there were specific concerns. The primary focus of these studies was the behavior of the appendage during deployment; the effects of appendage retraction was considered only in one of these studies. What is missing in the literature is a thorough study of the effects of appendage deployment/retraction on the attitude stability of a spacecraft.

This paper presents a rigorous analysis of the stability of a spinning spacecraft during the deployment or the retraction of an appendage. The analysis is simplified such that meaningful insights into the problem can be inferred--it is not overly simplified such that critical dynamical behavior is neglected.

The system is analyzed assuming that the spacecraft hub is rigid. The appendage deployment mechanism is modelled as a point mass on a massless rod whose length undergoes prescribed changes. Simplified flexibility effects of the appendage are included. The system is examined for stability by linearizing the equations in terms of small deviations from steady, non-interfering coning motion. Routh's procedure [8] for analyzing small deviations from steady motion in dynamical systems is utilized in the analysis. The system of equations are nondimensionalized to facilitate parametric studies. The results are presented in terms of a reduced number of nondimensional parameters so that some general conclusions may be drawn. Verification of the linear analysis is presented through numerical simulations of the complete nonlinear, nonautonomous, coupled equations.

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\*     Assistant Professor

\*\*   Graduate Research Assistant

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SESSION 6