Method of Obtaining High Resolution Intrinsic Wire Boom Damping Parameters for Multi-body Dynamics Simulations

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The goal of NASA's Magnetospheric MultiScale (MMS) mission is to understand magnetic reconnection with sensor measurements from four spinning satellites flown in a tight tetrahedron formation. Four of the six electric field sensors on each satellite are located at the end of 60-meter wire booms to increase measurement sensitivity in the spin plane and to minimize motion coupling from perturbations on the main body. A propulsion burn however, might induce boom oscillations that could impact science measurements if oscillations do not damp to values on the order of 0.1 degree in a timely fashion. Large damping time constants could also adversely affect flight dynamics and attitude control performance.

In this paper, we will discuss the implementation of a high resolution method for calculating the boom's intrinsic damping, which was used in multi-body dynamics simulations. In summary, experimental data was obtained with a scaled-down boom, which was suspended as a pendulum in vacuum. Optical techniques were designed to accurately measure the natural decay of angular position and subsequently, data processing algorithms resulted in excellent spatial and temporal resolutions. This method was repeated in a parametric study for various lengths, root tensions and vacuum levels. For all data sets, regression models for damping were applied, including: nonlinear viscous, frequency-independent hysteretic, coulomb and some combination of them. Our data analysis and dynamics models have shown that the intrinsic damping for the baseline boom is insufficient, thereby forcing project management to explore mitigation strategies.