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ON THE IMPACT OF GRAVITY DURING THE MICRO-VIBRATION CHARACTERIZATION OF REACTION-WHEELS: AN EXPERIMENTAL ASSESSMENT

Abstract

Spacecraft operating in orbit rely on a disturbance-free environment to achieve the designated mission goals spanning between remote systems for observation and communication purposes or special microgravity missions. They require pointing mechanisms to target, for example, a star or a patch of land on Earth or to maintain operation without unnecessarily changing the attitude, a representative example being reorienting solar panels according to an orbit. An accurate pointing generally requires components like motors or rotating masses for attitude control systems: they generate disturbances, also called micro-vibrations, alongside the whole vehicle, often resulting in jitter if not mitigated. As such, it is crucial to characterize the disturbance source to study the mitigation possibilities and reduce their impact in later operations.

A common practice to characterize reaction-wheels is to mount them on dynamometers to measure the forces and torques generated over a wide bandwidth, with the rotation axis aligned with the gravity vector. In contrast, another possibility is to perform tests using reaction-wheels on an integrated or semi-integrated spacecraft in a flight-comparable configuration. However, combining and applying both methods during spacecraft or mechanism development may leave some dynamics unmodeled and uncertainties omitted. These uncertainties result from the many different system mechanical configurations available in the spacecraft development cycle and the impact of gravity on the structures and actuators under test.

In this study, we focus on the impact of changing the gravity-vector direction during the characterization of reaction wheels in a laboratory by comparing the results under varying conditions. Specifically, the method measures the generated micro-vibrations against the gravity vector with a rotating measurement setup, including a dynamometer and the reaction-wheel under test. The feasibility of this method for characterizing small- and medium-sized reaction wheels is explored, including a range of possible configurations. Additionally, we discuss tools and methods used to compare test cases and recorded vibration data. Consequently, this method allows the validation and verification of further simulations, numerical models, or tests during a spacecraft's design lifecycle up to assembly and integration. In a broader context, this investigation shows the test possibilities to be considered while developing new space systems and actuators, especially as the latter get more complex in geometry or design of the components assembly.