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Spacecraft vibration testing: Benefits and potential issues

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Abstract. Jet Propulsion Laboratory has traditionally performed system level vibration testing of flight spacecraft. There have been many discussions in the aerospace community for more than a decade about spacecraft vibration testing benefits or lack thereof. The benefits and potential issues of fully assembled flight spacecraft vibration testing are discussed herein. The following specific topics are discussed: spacecraft screening test to uncover workmanship problems for launch dynamics environments, force- and moment-limited vibration testing, potential issues with structural frequency identification using base shake test data, and failures related to vibration shaker testing and ways to prevent them.

Keywords: random vibration and sine test; acoustic; shaker vibration; virtual shaker; force limited RV test

1. Introduction

Spacecraft vibration testing involves the use of two types of vibration testing equipment: stinger- and base-drive shakers. Base-drive vibration tests are conducted with test articles mounted to a moving platform that is driven by an electro-dynamic shaker. For base-drive shaker tests, three types of excitation are used in spacecraft vibration tests: sine, random, and transient. The base-drive shakers are used to qualify flight hardware to launch dynamics environments and workmanship screening before it is transported to the launch site. Stinger vibration tests, on the other hand, are conducted with the test article in either a free-free or a fixed-interface configuration. Stinger vibration tests are commonly used for modal testing where the objective of the test is to generate data for verifying and potentially updating a mathematical model. Fixed-interface testing is the most commonly employed technique for spacecraft. Shaker testing to recover modes and modes shapes have also been used by other organizations. The pitfalls of shaker dynamics coupling with the spacecraft are discussed in this paper.

The primary objectives of a spacecraft dynamic test are to qualify it in a fully assembled flight configuration, to increase the probability of mission success by detecting possible workmanship issues and to validate that the system will survive the mission dynamics and loads environments. Spacecraft vibration tests also help verify assembly-level test requirements and spacecraft analytical models. In the past couple of years, the benefits of shaker vibration tests have been

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