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LATEST RESEARCH ON DYNAMIC ENVIRONMENTAL TESTING FOR SPACE HARDWARE

Abstract

Dynamic environmental testing is required to ensure the survivability of space hardware, from component level to full assembly. A variety of mechanical tests are performed throughout the spacecraft program to expose the structure to the same vibration and acoustic environments as it will experience during operation. Current standard approaches to perform these tests are predominately based on Single Input Single Output (SISO) control strategies to simulate the operational environments in the laboratory, for instance to impose a single-axis acceleration on a shaker table. However, it is well known that in many cases SISO-based tests show inconsistencies when compared to the actual response of the structure in operation, which is usually excited in all directions simultaneously. In this context, recent advancements in control strategies based on Multiple Input Multiple Output (MIMO) control enable to simulate more accurately such loading conditions in a controlled environment. This paper presents the advantages of MIMO testing for mechanical verification and qualification of space hardware. In vibration testing, multi-shaker methods are employed to reproduce 3D responses covering a wide range of environments, from low-frequency transients to random and shock events. In acoustics, traditional tests performed in reverberant chambers are nowadays being substituted by a novel method named Direct Field Acoustic Noise (DFAN) testing, which relies on the use of many loudspeaker devices driven by an advanced MIMO controller. Furthermore, the role of simulations to support the adoption of these new testing platforms is discussed. Digital twins of the test rigs are developed to optimize and de-risk the test campaign, whereas high-fidelity simulations of the operational environments, for example CFD analyses of the flight conditions, can be used to synthesize more accurate targets for the laboratory tests.