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MODELING MICROVIBRATIONS TRANSMISSION IN SPACECRAFT STRUCTURES

Abstract

Micro-vibrations on board spacecraft are an issue of growing importance, as some modern payloads, and in particular the new generations of optical instruments require extreme platform stability. These low level mechanical disturbances are usually created by the functioning of mechanical equipment (sources) such as reaction wheels, antenna pointing mechanisms cryo-coolers etc., and cover a wide frequency range. Because of the low level of the vibrations and their wide frequency range, the modeling and analysis of microvibrations poses a challenge as the typical structural modeling techniques used in this sector (Finite Element Method (FEM) and Statistical Energy Analysis (SEA)) are reliable only in some areas of the frequency spectrum. The FEM is well suited for low level frequencies; whereas energy methods (e.g. SEA or Energy Finite Element Method EFEA) are suited for high-frequency problems; in the mid-frequency range, finally, other methods (e.g. Hybrid FEA-SEA) tend to be used, even if they're still not well-established such as the ones named before. However the issue is that there is no single method that can address microvibrations in the whole frequency range. In this paper, the methods cited above will be very briefly reviewed and their use in specific micro-vibration prediction problems will be investigated in detail and compared with experimental results. In practice the work presented here uses the Finite Element Method as base-line method to investigate the whole frequency range (say up to 1000 Hz). The FEM predictions are then compared with the experimental results, showing that at medium and high frequencies the response start to deviate significantly from the FEA predictions. The structure has then been analyzed with SEA and the results show that at high frequencies they start to become reliable. The mid-frequency range, finally, has been tackled from both directions. Hybrid FEM-SEA involves that the structure has to be divided into subsystems: some of them need to be studied with the FEM and the others with the SEA. The core activity here is the "subsystem recognition", which obviously will be frequency dependent. Also a possible mode hybridization technique has been investigated. The tests are carried out using the structural qualification model of an SSTL satellite bus that has been used to support a high resolution camera. The computational transfer functions and those from the experimental activity will be finally compared using various correlation techniques (e.g. Frequency Response Assurance Criteria FRAC etc.).