

THERE'S NO THERE, THERE -- AT THE CG

Terry Scharton
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Dr., MS 157-410
Pasadena, CA 91109

Dynamics analysts typically specify the design loads for aerospace vehicles and payloads in terms of the "quasi-static" acceleration of the center-of-gravity (CG) of the structure. This practice has long been a source of confusion, particularly as regards the vibration testing of aerospace equipment. Often the quasi-static acceleration level is misinterpreted as the vibration input to the equipment, rather than the CG response, which leads to a gross vibration overtest. Further, it is very difficult to measure the acceleration of the CG of a flexible body with an accelerometer. First, the CG of the undeformed structure (the static CG) may be located at a position where it is impossible to place an accelerometer, e.g. out in space, or at an inaccessible location. A more fundamental difficulty is that for a vibrating, flexible structure, the CG is a virtual point which moves relative to the structure and is at a different position for each vibration mode and associated resonance frequency. Clearly, one could not locate an accelerometer there -- at the CG.

The paper defines the CG as the instantaneous centroid of the mass, and discusses the relationship between the CG acceleration and the total external force, i.e. Newton's 2nd law. Then the following questions are discussed. Why do dynamics analysts like the CG? Where is the CG of a flexible body? What's the problem with accelerometer data taken at the static CG? How can I measure the CG acceleration in a vibration test? The non-physical location of the CG of a flexible body is illustrated with simple lumped mass and cantilever beam examples. The problem with accelerometer measurements at the static CG is illustrated with data taken on a structural model of the Cassini spacecraft. The use of force gages to measure the CG acceleration is illustrated with data from the Cassini and QuikSCAT spacecraft vibration tests. In the QuikSCAT vibration test, the forces and moments measured at the shaker/spacecraft interface were taken to the corresponding limit loads, predicted from the coupled loads analysis, plus a 10% margin in order to provide the structural qualification of the spacecraft.

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