REVIEW OF FORCE LIMITED VIBRATION TESTING EXPERIENCE AT JPL

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A new vibration testing technique, which imits the force applied to the test item by the shaker, has been used successfully in ten JPL flight hardware tests during the past three years. For lightweight aerospace structures, the mechanical impedance of the test item and the flight mounting structure are typically comparable so that the combined motion involves modlest interface forces and little amplification. Thus the high" amplification resonances and associated failures which often occur in conventional vibration tests, with essentially unlimited force, are test artifacts which can be eliminated by limiting the force in the test to that predicted for flight. **The most recent** of the ten JPL applications of force limiting was the Wide Field Planetary Camera II for the Hubble Space Telescope servicing mission scheduled for December 1993; the first was **the radiative cooler for the Pressure Modulator Infrared Radiometer on the** Mars Observer spacecraft which will begin orbiting Mars in August 1993.

The paper contains a review of the theory and the implementation methodology of force limited vibration testing. The theory for the dual control of both acceleration and force is based on Norton and Thevenin's equivalent circuit theorems. T he three aspects of implementation are: 1) deriving the force specification, 2) instrumenting the test with force transducers, and 3) controlling to multiple specifications. Two different methods, source impedance and two-degree-of-freedom, of deriving the force specification will be discussed and compared. Both analytical and experimental methods of obtaining the source and load effective weight will be described, and the importance of using asymptotic values of effective weight will be emphasized and justified, The degree of conservatism associated with several aspects of deriving the force specification will be addressed. Various approaches to incorporating the force transducers into the test fixturing will be discussed by way of example. A method of implementing force limiting with older controllers which do not allow multiple reference specifications will be described.

Three of the ten applications of force limiting to JPL flight hardware projects will be described in some detail: 1) the Wide Field Planetary Camera for the Hubble Space Telescope servicing mission, 2) the Visual and Infrared Mapping Spectrometer for the Cassini spacecraft which will be launched to Saturn in 1997, and 3) the Shuttle Imaging Radar electronic boxes scheduled for launch in September 1993. In addition, validation data from three other flight projects, where both component and system test data are available, will be presented to provide confidence in force limiting.

Finally, problem areas and topics requiring additional research will be identified and discussed. Some of these are: accelerance vs. effective 'weight measurements, reconciliation of measured and analytical effective weights, combining multiple mounting point effective weights, moment specifications, cross-axis specifications, and analysis of conservatism.

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