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DESIGN OF A FLIGHT LOAD MEASUREMENT SYSTEM FOR SOUNDING ROCKETS

Abstract

Currently, only estimates of the aerodynamic flight loads acting on sounding rocket vehicles from the German Aerospace Center's Mobile Rocket Base (DLR MORABA) are known. These estimates are based on experience and analytical modelling using data derived from semi-empirical methods. As these predictions are used to inform the launch vehicle design, significant safety margins are employed, resulting in a degradation of performance. An accurate knowledge of the loading during flight will aid in the validation of these techniques and ultimately improve the design of the vehicles.

This investigation conducted the design, manufacturing and calibration testing of a Flight Load Measurement System (FLMS) for sounding rockets. A system was designed that measures the structural strain and correlates this response to the applied axial, transverse and bending moment loading. This system can operate under the temperature and mechanical shock conditions of flight and both store generated data locally and transmit a low bit-rate signal via the telemetry system.

This was achieved using three sub-systems packaged within a structural module: strain and temperature gauge data is processed by measurement amplifiers and then stored and transmitted by a processor card. Tee strain rosettes were selected to measure the structural strains in a $90/0$ configuration for the longitudinal and circumferential strain due to axial and bending loads and in a $+45/-45$ configuration for the shear strain due to transverse loads. Temperature gauges were installed near each strain gauge to quantify the response from thermal expansion.

During flight, complex transient forces exist, arising from aerodynamic, thrust and rotational loads that vary over the flight regime. Using flight load and vehicle roll predictions, the transient strain distribution was analytically determined. This concluded that the strain follows a sinusoidal distribution over time due to the oscillating loading arising from the vehicle roll.

The Skopinski Load Calibration method was used to relate the measured strain gauge response to the applied loading. This is the first known published application of the Skopinski method to sounding rockets, with modifications being made to account for the axial, transverse and bending loading. The calibration testing produced promising results, with the loadings being predicted to within a low error margin for the first application of this method.

The next step is to fly the FLMS on a sounding rocket and measure flight load data. The first flight is planned for a student rocket, REXUS, with subsequent flights on other vehicles.