SEISMIC DETECTOR FOR MICROMETEOROIDS AND SPACE DEBRIS

P. M. Genequand and F. Droz
CSEM, Swiss Centre for Electronics and Microtechnology
Maladière 71, CH-2007 Neuchâtel, Switzerland

ABSTRACT

A new satellite-borne active detector is proposed, for particles in the mass range 0.001 to 100 µg corresponding to a size range of 0.01 to 0.5 mm at an average specific mass of 1 g/cm^3 and an impact velocity of 10 km/s. In the considered concept momentum and angular parameters of a captured particle are calculated from microaccelerometer measurements. Location of the impact position in the excited panel can also be deduced from the measurements. A preliminary design has been evaluated, based on modular independent units.

1. INTRODUCTION

Observation of orbital debris objects of all sizes is a necessary task in the assessment of the risks to space activities (Ref. 1). Objects larger than 1 cm are the most dangerous, as this size corresponds to the practical limit of shielding possibilities. However smaller debris are not to be neglected, especially with respects to external work by station crew, or to erosion of delicate unshieldable structures. They can supply worthy evidence to the evolution models.

Ground-based radars and space-based optical or infrared sensors are the known measurement means for the mid to large size range of objects (Ref. 2).

In the present study, the direct measurement of the velocity change induced in seismic elements by particle impacts has been evaluated in the frame of the Technology Research Programme of ESA.

2. DETECTOR PRINCIPLES

The panel design is based on a 1 m2 array of 16 modular seismic plates which are spring mounted in a rigid commom honeycomb frame.

Each panel has its own electronic control and constitutes an independent unit.

The panel electronics detects which plate is excited by an impact, then reads the transient signals from the sensors and store the peak value for further transmission to the on-board computer or telemetry module of the satellite.

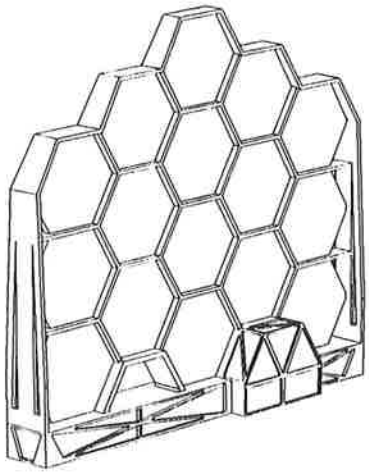

Figure 1. 16-plate seismic detection panel module

The seismic plate is a lightweight (300 g) sandwich structure. A double wall ensures both high stiffness and efficient stopping power at hypervelocities.Six solid-state microaccelerometer packages are fixed between the walls, in the peripheral region of the plate.

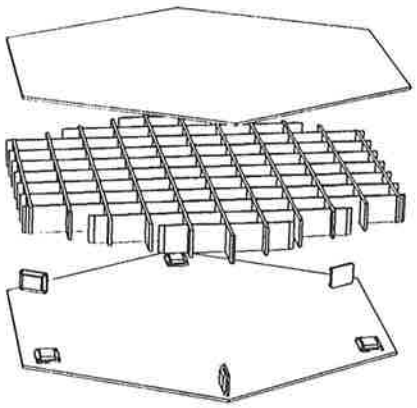

Figure 2. Spread-apart view of a seismic plate

In a simplified 1-D description, the measurement is based on the velocity change induced by a given impact in the corresponding plate. This change is equal to the time integral of the absolute acceleration. Solid-state miniature microaccelerometers developed at CSEM under ESA contract have been found of adequate size, mass and sensitivity (Refs. 3 and 4).

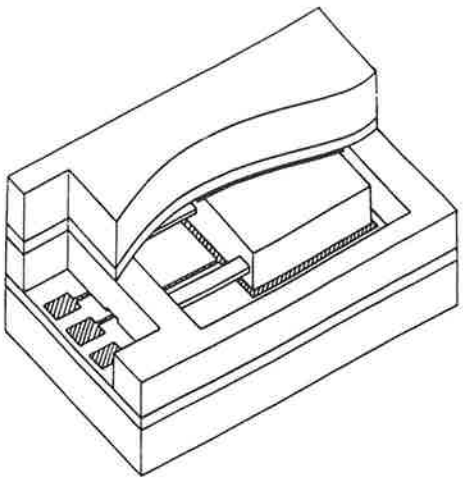

Figure 3. CSEM solid-state microaccelerometer sensor

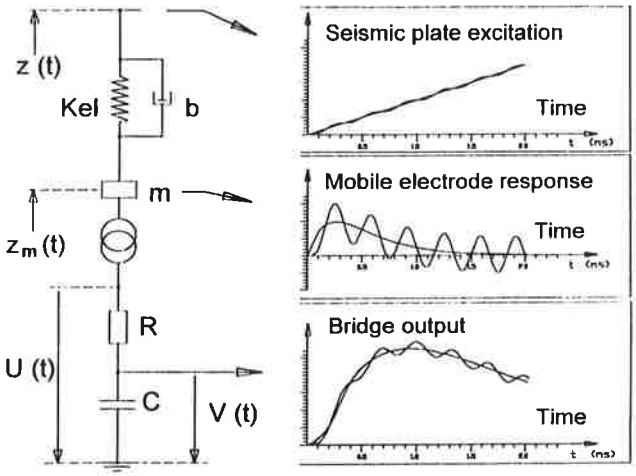

Figure 4 Detector model and response to impact transient

Discrimination between meteoroids and debris is possible to a large extent by measurements of the angular momentum parameters. Knowing its absolute velocity, of the order of 8 to 9 km/s, the mass of an impacting debris in low Earth orbit can be approximately determined from the measured mv value. Determination of particle size needs independent optical measurement performed by onboard or ground equipment after retrieval. It is proposed to use thin metal coated plastic blankets both for thermal protection of the panels and for evaluation of the particle size.

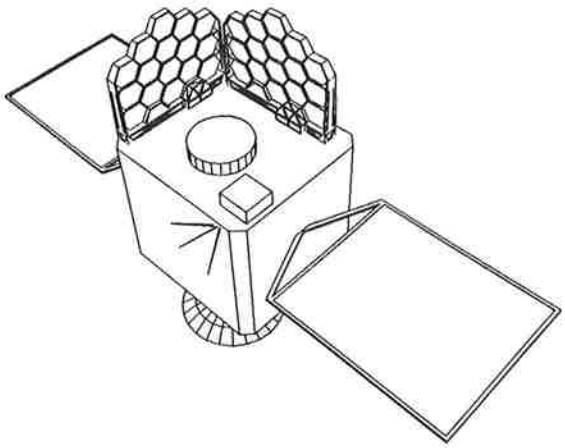

Figure 5. Tentative detector implementation on a satellite

3. REFERENCES

1. Flury, W., Overview on European Activities on Space Debris, *Proc. 4th European Aerospatial Congress*, 427-432, 1991.

2. Eichler, P.,et al., J., Closing the Data of Space Debris: Ground-based or Space-based Sensors ?, *Proc. 4th European Aerospace Conference*, 433-438, 1991.

3. Rudolf, F., et al., Precision Accelerometers with Micro-G Resolution, *Sensors and Actuators*, A21-23, 297-302, 1990.

4. Leuthold, H. and Rudolf, F., An ASIC for High-resolution Capacitive Microaccelerometers, *Sensors and Actuators*, A21-23, 278-281, 1990.