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Electrostatic Accelerometer for the Gravity Recovery and Climate Experiment Follow-On Mission (GRACE FO)

Eddy Perrot, Bruno Christophe, Bernard Foulon, Damien Boulanger, Françoise Liorzou, and Vincent Lebat
ONERA (The French Aerospace Lab)

The GRACE FO mission, led by the JPL (Jet Propulsion Laboratory), is an Earth-orbiting gravity mission, continuation of the GRACE mission, that will produce an accurate model of the Earth's gravity field variation providing global climatic data during five year at least. The mission involves two satellites in a loosely controlled tandem formation, with a micro-wave link measuring the inter-satellites distance variation. Non-uniformities in the distribution of the Earth's mass cause the distance between the two satellites to vary. This variation is measured to recover gravity, after substracting the non-gravitational contributors, as the residual drag. ONERA (the French Aerospace Lab) is developing and manufacturing electrostatic accelerometers measuring this residual drag applied on the satellites.

The accelerometer is composed of two main parts: the Sensor Unit (including the Sensor Unit Mechanics and the Front-End Electronic Unit) and the Interface Control Unit. In the Accelerometer Core, located in the Sensor Unit Mechanics, the proof mass is levitated and maintained in a center of an electrode cage by electrostatic forces. Thus, any drag acceleration applied on the satellite involves a variation on the servo-controlled electrostatic suspension of the mass. The voltage on the electrodes providing this electrostatic force is the measurement output of the accelerometer.

The impact of the accelerometer defaults (geometry, electronic and parasitic forces) leads to bias, misalignment and scale factor error, non-linearity and noise. Some of these accelerometer defaults are characterized by tests with micro-gravity pendulum bench and with drops in ZARM catapult. Besides, a thermal stability is needed for the accelerometer core and front-end electronics to avoid bias and scale factor variation. To reach this stability, the sensor unit is enclosed in a thermal box designed by Astrium, spacecraft manufacturer.

The accelerometers are designed to endure mechanical excitation especially due to launching vibrations. As the measure must be accurate, no displacements or sliding must appear during excitations. The electrode cage is made of glass material (ULE), which is very critical, in particular due to the free motion of the proof-mass during the launch. Specific analysis on this part is realized to ensure mechanical behavior.

The design of electrostatic accelerometer of the GRACE Follow-On mission benefits of the GRACE heritage, GOCE launched in 2009 and MICROSCOPE which will be launched in 2016, including some improvement to win in performance, in particular the thermal sensitivity of the measurements.