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Design constraints affecting magnetometers for Jupiter and Saturn missions

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The magnetic field is a fundamental physical parameter, vital for the study of processes in interplanetary space and at giant magnetospheres such as those found at Jupiter and Saturn. It can provide information on induced or internal magnetic signatures at planetary bodies; resolve the planetary rotation rate, plasma transport etc., and thus its accurate measurement at multiple points in space and time is crucial in space missions.

Proposals currently being considered to the Jupiter and Saturn systems offer the opportunity of taking multi-point magnetic field measurements with sensors located on orbiters as well as landers and balloon platforms. These missions pose considerable engineering challenges for payload developers. In addition to contending with extremely low mass and power constraints as well as the expected intense radiation fluence, exposed instrumentation (such as magnetometer sensors) must be capable of successful operation at low temperatures, estimated at below 110K in the case of a Titan or Europa descent. Whilst orbiter and balloon based instruments may be able to use heaters to maintain operating temperatures of boom mounted sensors, power is unlikely to be available to heat lander based instruments.

For the DC vector magnetic field measurement the traditional space magnetometer sensor of choice, the fluxgate, is mass limited according to its noise performance (typical mass of the order 200g) and generally operates at working temperatures of much higher than 110K employing a heater element where necessary. It is therefore worthwhile to ask at the mission concept stage if there are other technologies for DC field measurement that can mitigate either the low mass constraints or permit heater free operation while delivering science grade capability on the timescales of future Jupiter and Saturn missions.

We describe two technology regimes capable of delivering low resource magnetometers and how they may be targeted to orbiter, balloon and lander applications on the required timescales. The first is based on a traditional fluxgate sensor but optimised for low temperature operation and the second is a novel design based on a magneto-resistive sensing element.

Note: if a decision has been made at the ESA level between the mission proposals targeted at Saturn or Jupiter, then this submission will concentrate on the chosen mission.