Response to comments on ‘First In Situ Measurements of the Prototype Tesseract Fluxgate Magnetometer on the ACES-II Low Sounding Rocket’ by reviewer #1 on February 5th, 2024

We thank the referee for the constructive comments which we have incorporated into the manuscript. The reviewer raised an important issue about the temperature dependance of the instrumental sensitivity as well as other corrections, which we address below. Referee comments are in plain text our responses in *italics* and any content added to or changed in the manuscript are in “*quoted italics*”

Temperature stability is an important factor of magnetometer operation, especially in the case of spacecraft on-board installation. Declared sensitivity temperature dependence of 13-17 ppm/deg is exactly a thermal expansion coefficient of feedback coils. Is it wholly satisfactory for this mission? There is no description of how this figure was measured. Moreover, temperature behavior of polynomial coefficients for non-linearity correction (which seem to be not dependent on feedback coils), has not been addressed at all. Your consideration on the subject would be relevant and instructive.

The reviewer highlights the importance of the dependance of sensitivity on temperature for fluxgate measurements and raises important questions about the characterization of Tesseract’s sensitivity over temperature. The reviewer points out that temperature dependance of Tesseract’s sensitivity is shown as 13-17 ppm/deg in Table 1. This figure was measured in testing detailed in a previous study (Greene et al., 2022) which found the temperature stability of the Tesseract’s base and feedback coil without any dependence on cores and electronics. This was accomplished by temporarily configuring the sensor’s feedback windings as an air-core search coil magnetometer. The sensor was placed in a thermally insulated box made from 10 cm-thick polystyrene to create a controlled temperature environment for the sensor. The polystyrene box is then placed within the Merritt coil system and the coil system is used to generate a known 60,000 nT AC field in each axis. Dry ice is placed inside the box to chill the sensor, and measurements are taken after the dry ice has sublimated and the sensor is slowly warming. A platinum RTD temperature sensor is attached to the sensor and records the change in temperature as the sensor returns to room temperature (Fig. 10). As the Tesseract sensor temperature slowly increased, the voltage induced in the Tesseract prototype sensor's feedback windings and the RTD were measured. The details of the test and measurements are described in depth in Greene et al., 2022.

We have added the following text in section 3 to clarify the origin of these measured values:

A sentence has been added to Line 160: “Table 1 shows the characteristics of the Tesseract Sensor which flew and ACES-II. The temperature stability of the Tesseract sensor’s base and *feedback coils, without any dependence on cores and electronics, were characterized in a previous study (Greene et al., 2022).”*

Line 158 now reads “The temperature stability of the Tesseract sensor’s base’s sensitivity and orthogonality was characterized in a previous study and is described in detail in Greene et al., 2022.”

The also reviewer points out the importance of temperature dependence of a fluxgates characteristics such as sensitivity and nonlinearity when feedback electronics are used to null the field around the fluxgate cores. This characterization test was not performed on Tesseract flight model before the ACES-II rocket flight. The expected change in temperature over the course of the 10-minute rocket flight was expected to be minimal. The measured sensor temperature ended up changing by only about 4 degrees °C. This small change in sensor temperature, we expect, will have a very small effect on calibration and nonlinearity and that other sources of error in the calibration such as uncertainties in rotation angles and the offset due to the stray field of the rocket payload will dominate. An in-depth characterization of the temperature dependence of the Tesseract instrument’s calibration is being carried out in preparation future missions, such as the upcoming TRACERS satellite mission where temperature changes as large as 70 °C will have a more significant impact on calibration.

We have added this context in line 164: “A full thermal calibration of entire Tesseract instrument is not explored in this paper. The sensor temperature changed by only 4 °C over the course of the flight aboard ACES-II, so the errors in calibration introduced from changes in temperature are expected to be minimal. An complete temperature calibration of the Tesseract instrument which includes the cores and electronics will be performed in preparation for the upcoming TRACERS SMEX satellite mission.”

Line 245: Sensitivity figure for Z direction seems to be erroneous.

We thank the reviewer for their careful eye in catching this error. The Z direction has an erroneously added zero. We have corrected this mistake in Table 2.

Please find that the following changes have been made as suggested:

Line 35: “20 pT/Hz” should be 20 pT/sqrtHz

Line 211: “inside a single-axis four-layer mumetal magnetic shield (Figure 5a)” According to Fig.5 and its legend, it is “a three-layer mumetal magnetic shield”.

Line 223: “Robust linear regression was used to fit a linear trend to the noise floor from 0.05 to 1.0 Hz, and this trend was evaluated at 1 Hz” Consider “Robust linear regression was used to fit a linear trend from 0.05 to 1.0 Hz, and the noise floor was evaluated at 1 Hz”.

Line 302: “computationally highpass filtered below 1 Hz”. Should it be “over 1 Hz”?