

THEMIS: Spin Axis Magnetic Field Reconstruction

by

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The study presents a method for reconstructing the missing component of the measured magnetic field on one of the space probes within the THEMIS mission. Its absence is a consequence of the failure of the instrument, the sensor of which is oriented along the spin axis of the probe. The reconstruction of the magnetic field component is possible thanks to the relatively favourable geometric configuration of the measuring device, which provides two additional components measured in a plane slightly deviated from the spin plane, and also thanks to the knowledge of the probe's spin.

The manuscript is organized as follows: The introductory part describes the conditions and motivation of the measurements performed, the problem that is the subject of the solution and the circumstances of its emergence, and the proposal of the solution itself. The second part presents the mathematical approach to the solution. In the third part, the solution is implemented on measured data, the fourth part presents the results and their comparisons, the fifth part is devoted to the discussion, and the sixth part formulates the conclusions. The study is supplemented with an appendix.

The presented results indicate that, with the availability of 2 additional components, the presented approach can obtain a relatively accurate image of the 3-dimensional magnetic field even if one of the sensors fails. The significance of the study lies mainly in two respects:

1. It proposes an emergency solution for maintaining the continuity of measured data in a situation where, due to the impossibility of intervention in the form of repair/replacement/ adjustment of the instrument, it is inevitable to face a measurement failure. This solution therefore largely saves the success of the mission and brings significant scientific and economic value.
2. It may lead to a more general proposal for a more advantageous geometric arrangement of the instruments, so that the eventual failure of any component does not cause significant loss of data or their accuracy.

However, the manuscript has serious shortcomings that will need to be addressed before it can be published. In particular, the presentation of the problem and the approach to its solution gives the impression that the authors of the text were not sufficiently familiar with the methodology and the authors of the computational part were not fully familiar with the interpretation. I therefore call on all authors to approach the revision of the manuscript responsibly, to participate in it in an appropriate manner, and to each of them to identify with the final form of the manuscript. When revising, remember that your work should be presented in a way that allows for its reproducibility.

In summary: the manuscript requires extensive revision.

My reservations about the current form of the manuscript and suggestions for improvement consist of the following points:

1. Introduction

1. Please do not use the term "offset" in connection with the measured magnetic field value, p. 2, line 46. It is very confusing considering that this term is reserved for quantifying the systematic error of the sensor. Replace it with, for example, the term "contribution" or similar. Likewise, the term "despun coordinate" is inappropriate and very confusing.

2. If I understand it correctly, the projections of the B_{SA} field component measured along the spin axis onto the axes of the other sensors represent that permanent, non-removable contribution. However, this does not exhibit sinusoidal behavior with the ω_{spin} frequency, as stated on p.2, line 47. This is also evidenced by relation (2), where the only time dependence of this contribution is related to the time variability $B_{SA} = B_{SA}(t)$. Please clarify this part of the text.

2. Mathematical Background

1. For the sensor configuration as described in Abstract and Introduction, the second step in the coordinate transformation is redundant because the probe spin axis coincides with the P_z -axis, as it is depicted in Figure 1(a). The presentation of Figure 1(b) and the matrix Σ (which actually should be an identity) is very confusing for the reader. Please remove this contribution to the explanation, or present it as a general case of rotating the sensor design with appropriate commentary for the current case.
2. Please justify the use of the transformation Φ , apparently $\phi_a = \phi_a(t)$.
3. It is appropriate to present the conversion by the \mathbf{G} matrix first, since this is applied to the data that has not yet been transformed.
4. The origin of relation (8) is unclear, the angles α_{S_i} apparently $\alpha_{S1} = 90^\circ - \theta_{S1}$, $\alpha_{S2} = 90^\circ - \theta_{S2}$ (what is α_{S3} ?). Please provide the derivation and explain also with regard to the reservation in point 1.
5. Please specify that formula (11) is applied to (9) and (10) individually. From the fitting procedure, I assume, the unknown values A_1 , $B_1(t)$, C_1 , $D_1(t)$, φ_1 and A_2 , $B_2(t)$, C_2 , $D_2(t)$, φ_2 arise and the value $B_{ST}(t)$ is common to both expressions. Please demonstrate in detail how this is achieved. In relation (11) also correct for the linear increase in amplitude with time.

3. Implementation

1. p. 5, line 111: You now have recalculated the components B_{raw1} and B_{raw2} (and not $(B_{S1}$ and $B_{S2})$), according to relations (9) and (10). Please consider the designation for raw data and treated data and be consistent in their use in the following text.
2. p.5, line 115: An average reader is not familiar with the devices you mention. This requires a more thorough description of the functionality of the device whose data you use, and possibly also a picture with a description.
3. p.5, line 120: Please provide an example of this procedure using relations (12) and (13) with specific values and a specific result and with an appropriate comment.
4. What is the origin of the amplitude $A(t)$ in the weight function $w(t)$, p. 6, line 126? What are the criteria for its magnitude? Please, provide details.
5. The angle α (α_{S1} , α_{S2}) does not come from measurements or from the derivation of the matrix \mathbf{C} - on the contrary, it must enter the calculations as a data known from the technical settings of the device. Please clarify this fact on p. 6, 7. If this is not the case, I consider it impossible to solve the considered problem - then the equation (2) has all input quantities unknown.

3. Comparison of Results

1. Please increase the size of the images.
2. Please add information regarding the data's affiliation to the period and probe in the description of Figures 5 and 6 (as well as to the other figures).

5. Conclusions

Please, design the optimal geometric arrangement of the sensor axes and justify it.

Minor corrections:

p.1, l.3: ...including a set of fluxgate magnetometers that measure...

p.1, l.21: ...predefined rate denoted as T_{spin} ... please correct. Provide the value.

p.2, l.36: ...six orientation angles... please, explain or correct.

Scientific significance: Does the manuscript represent a substantial contribution to scientific progress within the scope of Geoscientific Instrumentation, Methods and Data Systems (substantial new concepts, ideas, methods, or data)?	Yes (1)
Scientific quality: Are the scientific approach and applied methods valid? Are the results discussed in an appropriate and balanced way (consideration of related work, including appropriate references)?	Partially (3)
Presentation quality: Are the scientific results and conclusions presented in a clear, concise, and well-structured way (number and quality of figures/tables, appropriate use of English language)?	Yes (2)