Impact of accelerometer modelling and parameterization on the BepiColombo orbit determination and gravimetry experiment

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**Introduction**

**Mission:**
BepiColombo mission  
Launch: October 2018  
Arrival to Mercury: Dec. 2025  
**MPO:** Mercury planetary orbiter

**Relevant on-board instruments:**
ISA: Italian Spring Accelerometer  
MORE: Mercury Orbiter Radio-science Experiment

**Goal of the study:**
Impact of accelerometer noise modelling and its parameterization on the MPO orbit determination and gravimetry experiment

**Tool:**
Planetary extension of **Bernese GNSS software**  
Developed at the Astronomical institute of the University of Bern  
Also used for planetary POD for GRAIL and for mission concepts at Europa
Model description

Force model:
- Mercury gravity field HGM050 d/o 50
- Sun and planets third body gravitational perturbation
- Tidal perturbations (Sun)
- Solar and planetary radiation pressure

Simulation of Doppler observations:
- 2-way X-band and K-band
- White noise on the observations
- Station and planetary eclipses

Simulation of accelerometer measurements:
- White and colored noise based on ISA team publications
- Random biases are added to the accelerometer measurements (constant for every two weeks)

Parameter estimation

Assumptions:
- Error on the initial state vector of each arc
- NO knowledge of non-gravitational forces

We solve for:
- Initial state vector of the arcs
- Coefficients of the gravity field
- Accelerometer parameters

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Model description

\[ A_{\text{meas}} \approx B + S_f A_{\text{true}} + A_{\text{noise}} \]

Alessi et al (2012)
Model description

Accelerometer model

Alessi et al (2012)
Zero test: A test for model verification

- No Doppler noise, No initial condition error
- We use the same force model in simulation and parameter estimation
- Doppler residuals are in the order of 1E-5 Hz
Results

Sensitivity analysis
Recovery of the accelerometer parameters to the arc length

Recovery error of ACC biases as a function of arc length

Along-track direction of the ACC bias can be determined with one day arc

Factor 10 improvement with 5 days arc

Factor 50 improvement with 10 days arc

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Recovery of ACC bias
Using 1 day of observation

Recovery of ACC bias
Using 15 days of observation

Recovery of ACC bias
Using 1 day of observation

Recovery of ACC bias
Using 15 days of observation

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Sensitivity analysis
Recovery of the accelerometer parameters to the Doppler and accelerometer noise

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Results

- Recovery of the gravity field, spacecraft orbit and accelerometer parameters
- At least 5 days of observation for the recovery of the ACC parameters
- Different assumptions on the accelerometer noise and bias lead different results for the recovery of the orbit and the gravity field

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• If the a priori field is similar/close to the real field the process is
• If a degraded field is used, accelerometer parameters must be dealt with very carefully.
• If not constrained, the ACC parameters can absorb the unmodelled dynamics and ruin the solution
• Stochastic pulses / empirical accelerations are needed to absorb the unmodelled dynamics and avoid them from going to the ACC parameters.
• One solution is to first solve for the orbit/gravity by ignoring the ACC parameters and solve for them using the recovered field
• Testing different orbit determination strategies
• Full results, including the final accuracy of the gravity/orbit recovery in different cases will be presented in the paper to be submitted