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Evaluation of Pendulum NGGM Scenarios by Full Closed-Loop Simulation

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The GRACE mission (2002-2017) delivered temporal gravity field solutions of the Earth for 15 years. It's successor, GRACE follow-on (GRACE-FO) is continuing it's legacy since May 2018. The time series of monthly gravity fields revealed global mass redistribution in in the near surface layer of the Earth with unprecedented accuracy. This assessed a completely new observable in geoscience disciplines and has become a crucial data product for climate research.
Despite the groundbreaking success and relevance of the GRACE mission(s) for Earth observation and climate science, no further successor gravity mission is planned, yet. Summarized by the name Next Generation Gravity Mission (NGGM) concepts for future gravimetry missions have been proposed and analyzed for a while. As an outcome of these studies the so called Bender-configuration (two GRACE-like satellite pairs, one in a polar orbit and a second in an inclined orbit around 60° to 70°) is the concept currently favored by the scientific community for a candidate of the next gravity mission to be realized.

However, an other concept still remains interesting due to specific advantages that might contribute to future improvements of gravity missions. In order to emphasize this, we present results of a full closed loop-simulation for a different ll-SST approach, the so called pendulum. It offers a quite similar overall performance with just two satellites. For this configuration the satellites are following each other in orbits with slightly different longitudes of the ascending nodes, thus the inter-satellite measurement direction is varying between along-track and cross-track. This configuration makes an interferometric laser ranging (LRI) quite challenging on the technical level. Nevertheless, the LRI accuracy is not necessarily needed. The relevance of the pendulum configuration has also been shifted into the focus of the French MARVEL mission proposal.

In this contribution we analyze in detail the performance of the pendulum formation with the main parameters being the angle between along-track and cross-track component of the ranging direction at the equator, and the mean distance between the satellites. We conduct the angle variation for different mean ranges and assumed ranging accuracies. As reference, the GRACE and Bender concepts are simulated, as well. The orbit simulations are performed using a derivative of the ZARM/DLR XHPS mission simulator including high precision implementations of non-gravitational accelerations.
The different concepts and configurations include complete GRACE-FO like attitude control and

realistic environment models. State-of-the-art instrument noise models based on GRACE/-FO are used to generate observation data for accelerometer (ACC), range dependent inter satellite ranging (KBR/LRI), kinematic orbit solution (KOS) and star camera (SCA). For the gravity recovery process we use the classical variational equation approach. As for real GRACE processing, ACC calibration parameter are estimated and KOS and KBR range-rate observations are weighted by VCE.