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Mass variation observing system by high-low inter-satellite links (MOBILE) – a mission proposal for ESA Earth Explorer 10

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As changes in gravity are directly related to mass variability, satellite missions observing the Earth's time varying gravity field are a unique tool for observing mass transport processes in the Earth system, such as the water cycle, rapid changes in the cryosphere, oceans, and solid Earth processes, on a global scale. A proposal for a next-generation gravity field mission has been submitted in response to the ESA call for a Core Mission in the frame of Earth Explorer 10 (EE10). This proposal directly addresses the resolution adopted by the Council of the International Union of Geodesy and Geophysics in 2015, supporting the need for sustained observation of mass transport processes from space.

The observation of Earth's gravity field was successfully done by the GRACE and GOCE missions, and will be continued by the GRACE Follow-On mission. However, we propose an innovative new observational concept, complemented by new instrument concepts, based on a high-low tracking formation with micrometer ranging accuracy. Since a high-low tracking mission primarily observes the radial component of gravity-induced orbit perturbations, the error structure will be close to isotropic. This will significantly reduce artefacts of previous along-track ranging low-low formations (GRACE, GRACE-Follow-On) such as the typical striping patterns. For the EE10 proposed mission, we target for an initial minimum configuration, which shall consist of at least one medium-Earth orbiter (MEO; e.g. 8000 km altitude or higher) and two low-Earth orbiters (LEOs; around 400 km) in the same orbital plane, separated by 180-degree mean anomaly. All three satellites shall fly in a polar orbit in order to maintain a long-term stable formation (no relative drifts of the orbit planes). The main observable consists in range measurements from the MEO to the LEOs, where the two LEOs are alternating targets. The main instrument shall be a laser based distance or distance change measurement system, which will be placed at the MEO. The LEOs will be equipped either with passive reflectors or transponders. The target ranging accuracy shall be on the micrometer level, which turns out to be technically feasible as demonstrated in preliminary studies performed by industry. Non-gravitational forces will be observed by electrostatic accelerometers, with additional options to consider a hybrid instrument (including cold-atom interferometry) on the LEO satellites in order to enhance the accelerometer performance in the long wavelength range, or to apply innovative technologies such as opto-mechanical inertial sensors.

As an add-on to the proposed configuration one could consider including elements of the European Reference Station in Space (E-GRASP) concept as a technology demonstrator on the MEO, by hosting additional instruments such as a VLBI transmitter and a time synchronizer by laser link.

The proposed explorer configuration provides immense future perspectives by linking to existing space infrastructure such as Galileo next-generation, and holds the potential of miniaturization even up to swarm configurations. As such it can be considered as a precursor and role model for a sustained mass transport observing system at reasonable cost level.