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A DISTRIBUTED NANO-SATELLITE CONSTELLATION FOR GRAVITY FIELD RECOVERY AND ATMOSPHERIC NEUTRAL DENSITY ESTIMATION

Abstract

Observing Earth's gravitational field variations from low orbit using a combination of ranging measurements, GPS and onboard high-accuracy accelerometers has become the most accurate way to monitor surface mass transport processes in the wake of missions such as GRACE (NASA/DLR), Swarm (ESA) and GRACE-FO (NASA/DLR). The GRACE missions, in particular, have been successfully used to monitor the movement of large bodies of water and ice on the Earth's surface, providing clues to some of the most essential climate change phenomena - the accelerating loss of ice in the Arctic region (especially in Greenland) and in certain regions of Antarctica, and the seasonal water storage changes associated with the world's largest regional drainage systems. The availability of on-board accelerometer also presents the opportunity to measure and study the non-gravitational accelerations acting on the spacecraft, down to estimating the neutral thermospheric density with the help of radiation pressure models. In the past decade, the key technologies required to gather gravimetric and thermospheric data have undergone significant improvements - suggesting that the next-generation gravity recovery and thermospheric missions could potentially take advantage of low-cost, miniaturized, standardized and distributed nano-satellite platforms each carrying its' own suite of sensors, at a total cost of one (perhaps even two) order of magnitude less than in the past. In a collaboration with the Center for Space Research at the University of Texas at Austin and three other Portugal-based institutions (University of Minho, nanotechnology laboratory INL and the institute for quality monitoring ISQ), Spin.Works is currently leading the first effort to apply the same techniques and concepts to space gravimetry and the study of the neutral thermosphere. We will integrate three state-of-the-art sensors into a compact (6U) nano-satellite platform capable of performing these types of measurements from orbit, specifically now focusing on high-low satellite-to-satellite tracking. We describe the spacecraft concept, its systems architecture, the mission-specific challenges and each of the key sensors under development within the consortium. i.e., the star tracker and the high accuracy MEMS-based accelerometer, which we believe have a promising market of their own. Finally, the project will also serve as an in-orbit technology demonstrator and a precursor to a future constellation of small satellites, with missions with similarly demanding scientific applications. With that in mind, we also explore in this paper a number of ways in which we could maximize the scientific return of such

small satellite constellation. We will look into aspects such as different satellite orbit configurations or additional sensor types, for example inter-satellite metrology to provide highly accurate gravimetric data or mass spectrometers to aid in the estimation of neutral thermospheric densities.