João de Teixeira da Encarnação

SUMMARY

In my research, I look for ways to measure Earth's gravity changes with satellites. With a background in Aerospace Engineering, I focus on Space Accelerometry, Estimation Theory and satellite data processing. I have worked for the TU Delft in the Netherlands and for the University of Texas in the United States. My main research objective is to devise data processing and modelling strategies that maximize the temporal resolution of the gravimetric data collected by LEO satellites.

As assistant professor at the Delft University of Technology, I study ways of exploiting the maximum resolution and accuracy of the measurements collected by the Gravity Recovery And Climate Experiment (GRACE) satellites, as well as exploiting small satellites for gravimetric and thermospherometric purposes.

I manage a research project that exploits the Global Positioning System (GPS) data from the Swarm satellites to describe the temporal variations of Earth's gravity, describing the hydrological cycle and climatological trends over river basins and Polar Regions. I took the lead in coordinating with several European and US institutes (Institute of Geodesy of the Graz University of Technology – Austria, Astronomical Institute of the Academy of Sciences of the Czech Republic, Astronomical Institute of the University of Bern – Switzerland, Faculty of Aerospace Engineering of the Delft University of Technology – the Netherlands – and School of Earth Sciences of the Ohio State University – USA) the cooperation initiative for the research and promotion of Swarm's gravity field models, which eventually lead to being funded by the Swarm Data, Innovation and Science Cluster (DISC) consortium and will continue in the coming years. This project has moved from a development phase, where we tested the added value of inter-satellite baselines estimated from GPS data and different options for the modelling or observation of the non-gravitational accelerations, into an operational stage, where the Swarm gravity fields will be distributed quarterly to the scientific community.

In cooperation with Center for Space Research (CSR), I manage the uPGRADE project, where we aim at measuring the movement of water in the Earth's near surface, at regional scale, by sensing the minute changes in our planet's gravity from its 500km orbit. The uPGRADE satellite will contribute to the monitoring of surface mass transport processes along with other gravimetric satellite missions such as GRACE-FO and Swarm. It will also be able to measure the neutral density and cross-track winds in the thermosphere, contributing to the study of the effect of solar activity on that environment and perfecting the drag models necessary to accurately predict the consequences of the sharp increase of space debris. Although most systems in uPGRADE are Commercial Off-The-Shelf (COTS), such as the dual-bad GNSS-receiver, communications, magneto-torquers and propulsion, we are developing the star-tracker and the space accelerometer based on Micro Electro-Mechanical System (MEMS). The latter is being designed specifically for the gravimetric application; by taking advantage of the micro-scale physics in MEMS devices and carefully designed low-noise electronics, it may be able to measure non-gravitational accelerations down to a few mHz, far below what traditional electrostatic accelerometers are able to measure.

As a Scientist Associate at CSR of the University of Texas at Austin (UTexas), my work focusesed on:

- the calibration of the accelerometers, particular relevant after 2011, when the thermal control on the satellites was switched off;
- testing large number of unconventional parametrization schemes;
- processing the Gravity field and steady-state Ocean Circulation Explorer (GOCE) data in preparation for the GGM07 static gravity field mode.

As a Post-doctoral Fellow at Delft University of Technology (TU Delft), I dedicated my efforts to implement the Level 2 data processing facility of the Swarm satellite mission, concerning the Precise Orbit Determination and Thermospheric Neutral Density processing streams. I have acquired expertise in Digital Signal Processing (DSP) techniques and contributed to the processing of Swarm accelerometer data, by combining non-gravitational accelerations derived from GPS data and the accelerometer measurements. In doing so, I have greatly removed the long-term bias in the accelerometer data. During this time, I also matured my skills in data management and automated processing.

During my PhD, I have worked with different types of satellite gravimetric data, namely High-low Satellite-to-Satellite tracking (Kinematic Orbits), low-low Satellite-to-Satellite Tracking (Inter-Satellite Ranges), and Satellite Gravity Gradient (differential accelerometer measurements). My PhD research focused on:

- modelling the data errors accurately and how its amplitude and spectra influences the quality of the resulting gravity field models;
- quantifying the error budget of future gravimetric satellite missions, to an unprecedented level of detail;
- analysing several mission concepts and modelled their error budget in terms of the observations and gravity field parameters;

- demonstrating that some mission concepts (those with large radial distances, e.g. the cartwheel formation) are very sensitive to particular types of errors (specifically errors connected with GPS observations);
- proved that alternative mission concepts (the cross-track pendulum formation) are much better suited to complement planned future gravimetric missions.

This has allowed me to study future gravimetric missions in detail, even unconventional ones such as augmenting dedicated gravimetric missions with a large constellation of non-dedicated satellites. My expertise on this topic has been noted by peers, who have invited me to participate in numerous research projects involving international teams.

I have studied and worked in numerous areas, including Structural Mechanics, Aerodynamics, Preliminary Vehicle Design, Single Stage to Orbit and Laser Propulsion, which have given me the opportunity to broaden my understanding of Physics. I am an avid programmer, actively learning new languages and techniques in order to better implement the algorithms and procedures required to develop my research. I openly share the code I develop in GitHub.