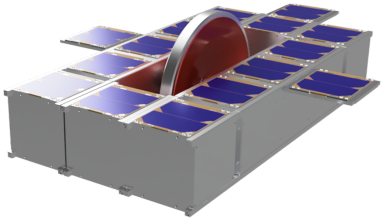
Group 09 - The MAGEOS mission

Design Synthesis Exercise, Spring 2022

236 million euros, 350 million euros, 430 million euros. These are costs for magnetic and gravitational field measurement missions from the past, and missions that will be flown in the near future. But what if the same mission can be performed, using equipment that has a similar accuracy, with a total mission cost of fewer than 5 million euros? The MAGEOS mission, Magnetic And Gravitational Earth Observation Spacecraft, seeks to fulfill this purpose. The mission is comprised of two CubeSats equipped with magnetometers and gravimeters that will orbit at an extremely low Earth orbit. To remain stable, they are equipped with a newly developed ADCS system, known as SHAPE, that makes use of a momentum wheel with magnetic biased bearings and magnetorquers, and to maintain their orbit they use ion propulsion.



The mission objective for the MAGEOS mission is the following:

Measure the Earth's magnetic and gravitational fields in very low Earth orbit, providing cheap and high-quality science data to the scientific community.

The MAGEOS mission consists of a constellation containing two spacecraft, each with a size of 30 x 50 cm, orbiting at an altitude of 230 kilometres above Earth's surface, following a path with an inclination of 96°. The main advantage of this low altitude is that the magnitude of the Earth's magnetic and gravitational field is larger compared to higher altitudes. Therefore accuracy similar to more expensive missions can be achieved by using less expensive components. The mission duration is 2 years and will be launched in 2028, at the expected solar cycle minimum. To perform magnetometry, an AMR and Fluxgate are brought on board, allowing cross-calibration to be performed for even higher accuracy. For gravimetry, GPS sensor data will be calibrated by making use of the GRACE mission, after which it will be sent to a ground station. At the ground station, the data will be processed by an artificial neural network that has learned to remove noise and outliers. In doing so, the MAGEOS spacecraft can compensate for the fact that they cannot bring aboard large instruments. The gravimetry mission also functions as a technology demonstration, to show what kind of accuracy can be achieved by a CubeSat.

The MAGEOS mission will contribute to climate change monitoring, as the gravitational field measurements can be used to assess polar ice loss, the amount of terrestrial water storage, sea-level changes and ocean dynamics. As the magnetic field protects life on Earth from the harsh space environment, it is also important to know if and where the magnetic field changes, which the MAGEOS mission can contribute to as well. Since the MAGEOS spacecraft are comparatively small, a ride-share launch can be used to bring the two spacecraft into orbit. This leads to a decrease in environmental impact compared to other missions, which use a launcher for themselves to reach orbit.

At this point, the final design, as well as the mission architecture, have been developed, and important characteristics such as the final configuration, aerodynamic coefficients and Delta-V budget are known. The spacecraft's definitive internal configuration, final mission cost and manufacturing plan will be considered and developed in the upcoming weeks.