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TOLOSAT : STUDENT CUBESAT FOR GRAVIMETRY APPLICATION

Abstract

Earth Observation is a major space application for nanosatellites. From weather science, geology, archeology to security and disaster monitoring, many fields can benefit from remote sensing of our planet. More specifically, Gravimetry enables an overall view of the Earth's mass transport with geoids, that are graphic representations of the gravitational field. CubeSats are cost-effective small standardized satellites that can perform such scientific missions through ambitious student projects.

TOLOSAT project is one of them. More than 65 students across all major universities and engineering schools in Toulouse joined forces through two associations *ASTRE* and *SUPAERO Cubesat Club*. This partnership has taken the shape of the three unit nanosatellite TOLOSAT which across its four years has been helping hundreds learn all the different aspects of a space mission through different phases of development. The team was split into subsystems in accordance with the concurrent engineering principles. The work performed followed recommendations from experts from the *French National Center for Space Studies (CNES)* as well as academia and the industry.

TOLOSAT students selected a low-cost and efficient GNSS Gravimetry solution. Instead of expensive on-board gravimeters, off-the-shelf components are implemented on a 3-Unit CubeSat to compute the gravitational field with an acceleration method. As an equipotential, a geoid verifies a Laplace equation : One can demonstrate that a development in spherical harmonics is a solution of this equation :

$$V(\theta,\lambda,r) = \sum_{n,m}[C_{nm}V^{(c)}(\theta,\lambda,r) + S_{nm}V^{(s)}(\theta,\lambda,r)]$$

Relying on the four main GNSS constellations (GPS, GLONASS, GALILEO and BEIDOU) the latitude θ, longitude λ and altitude r of the satellite are known. Then, the acceleration can be computed through numerical derivation methods, and linked to the gradient of the potential. A least square method finally gives the two Stokes coefficients S_{nm} and C_{nm}, giving access to the gravitational field.

The CubeSat preliminary design was completed. **TOLOSAT** was designed to operate on a $97.4°$ inclined, $500km$ high orbit. A second payload has been implemented in order to communicate with the Iridium Constellation, and then improve the short communication windows. Besides this technological demonstration, margins were ensured to enable a possible third payload.

Detailed designs are still underway, but **TOLOSAT** achieved its educational purposes, in terms of discovery of the development of space missions as well as in the team work culture.