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COMPARISON AMONG PROPELLANT MASS ESTIMATION METHODS FOR A GEOSTATIONARY SATELLITE

Abstract

The Aerospace Operations Command (COMAE) operates the Brazilian Geostationary Satellite for Defense and Strategic Communications (SGDC). Given the impossibility of in orbit refueling, the operational lifetime of this satellite is directly dependent on the amount of available propellant in its tanks.

When the available propellant is about to be depleted, the operator typically performs a last maneuver to reposition the satellite to a few hundred kilometers above the geostationary belt altitude, called the graveyard orbit.

Therefore, it is crucial for operators to have the most accurate available propellant mass estimation in order to determine the correct moment for this last maneuver. The greater the uncertainty of these estimations, the greater the safety margin necessary to ensure enough propellant will be available for the maneuver and, consequently, the shorter the operational time.

In this work, three methods for estimating propellant mass were compared using SGDC telemetry data to identify the parameters that best model the behavior of the satellite in orbit.

The first is the Pulse Counting Method (PCM), which is based on the thrusters firing count. Considered the most accurate during the satellite Begin-of-Life, it is used as a reference for the evaluation of the other two methods.

The second is the Pressure-Volume-Temperature method (PVT), which is based on the ideal gas law, relating pressure and temperature measurements to estimate residual volume in the tanks and, as a result, the propellant mass. Thus, its reliability mainly depends on the accuracy of the sensors used.

The third is the Thermal Capacity Method (TCM), which is based on estimating the propellant thermal capacity when switching the tank heaters on or off. Knowing the specific heat of the analyzed propellant, it is possible to estimate its mass.

The preliminary results showed that the PCM has a tendency to quickly accumulate errors due to its summation characteristic. The PVT has a high but constant uncertainty, being better than PCM at the satellite End-of-Life. Finally, the TCM proved to be the most accurate of the three methods, but it only allows point estimates, as it actively requires a significant change in temperature, which may not be possible at any time.

Making use of this three-method toolkit, the operator will more reliably estimate the propellant mass at the satellite End-of-Life, allowing to safely operate with smaller safety margins, postponing the last repositioning maneuver and, finally, extracting the maximum value from the satellite operation.