A Comparison of Fuel Gauging Methods Utilising the Experience of S/C De-orbiting Operations

Lutz Massonne[1]
[1]*Telespazio VEGA Deutschland GmbH, Darmstadt, Germany*
lutz.massonne@telespazio-vega.de

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The fuel budget evaluation is an important part of the ESOC Flight Dynamics support to the ESA Earth Observation missions.
There are two basic methods – the actuators consumption integration method and the PVT method. The latter based upon the gas equation of state and measured tank parameters. Operationally, on ESOC Flight Dynamics side the actuators consumption integration method is used throughout the missions and the PVT method is used as a secondary check.
A large variety of missions with different propulsion systems have been supported in the past, the monopropellant Hydrazine RCS systems of ERS, Envisat and the Sentinel missions, the cold-gas RCS system of Cryosat and the electric propulsion system of GOCE.
For all these systems the adequate ground modelling had been developed and a substantial amount of data has been collected during the mission's lifetimes.
These data can be used to demonstrate the inherent inaccuracies of the methods and the relative evolution of the respective spacecraft fuel budget estimation.

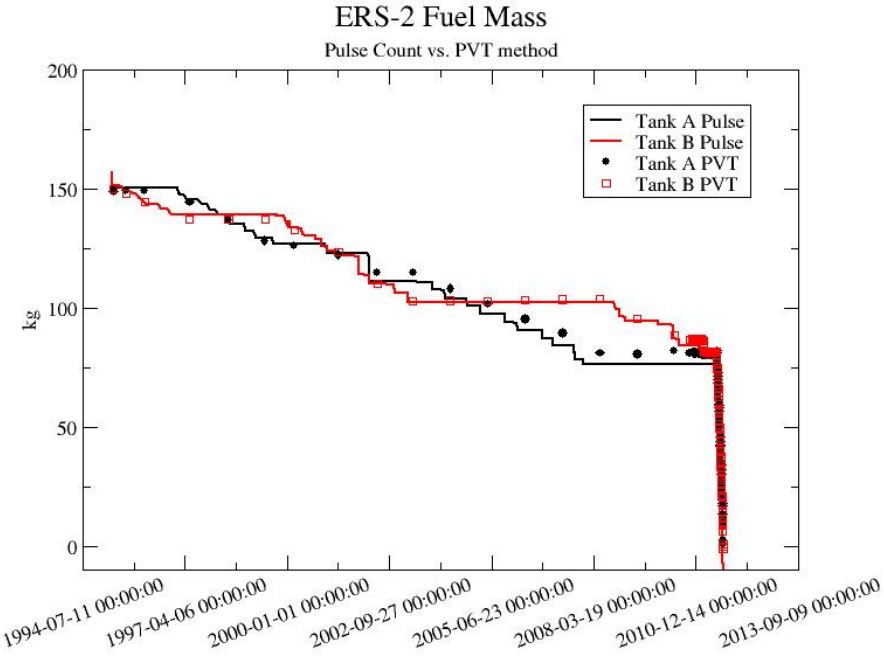

Fig. 1. ERS-2 Fuel Budget

On two missions (ERS-2 and GOCE) telemetry was available until the depletion of the propellant tanks – here the achieved conformance of the two methods can be calibrated at EOL.
The paper shall give a short overview about the propellant budgeting methods, demonstrate the operational experience and try to evaluate the theoretical error margins on the results of the EOL data.
As future Earth observation missions will have to foresee de-orbiting operations to reduce the amount of space debris, an accurate forecast of the propellant supply on-board is essential for the planning of the final mission phases. The experience from the past might help to improve the quality of this task.