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GENERIC SPACECRAFT DESIGN PREDICTION AND MODELING

Abstract

Designing an optimal spacecraft is a challenging and arduous task. The set of initial unknowns is large, while system inter-dependencies are complex. Thus, either multiple design iterations by a human are required or a well proven design with flight heritage is selected. Neither approach is certain to yield an optimal solution, while the former requires significant development time. A free and open-source tool is being developed to allow for automated spacecraft design in the form of the Evolutionary System Design Converger. It consists of a three stacked solvers: A presolver to estimate spacecraft system parameters from incomplete data, (sub-)system solvers to define and refine the system parameters and a part selector for real hardware fitting. The presolver is able to give system predictions on mass and power budget of each implemented systems. These are payload, propulsion, structure, power supply; TC, TTC, OBC and ADC. One or more mass/power of a subsystem or a total system mass/power has to be user defined to allow to derive predictions for all other systems. These predictions are based on mass/power system parameters of a database of spacecraft with flight heritage. Respective scaling laws are derived via least-square fitting of n-polynomials. This solver additionally applies an additional margin on mass and power to allow for flexibility in the subsequent steps. The (sub-)system solvers have to be individually implemented for each subsystem and will require automatic iterations, as total mass, power, heat and data budgets are continuously updated. Optimization in a first stage is realized by maximizing the available margins, while in a second stage these margins are traded for reducing the total system mass, which is a main cost driver. A (sub-)system solver is required to solve the highly non-linear and non-continuous available parameter space. Various technologies are individually available, which discretize the solution space. e.g. arcjets are significantly different from hall-effect thrusters and additionally vary in applicable propellants. This problem is solved by an evolutionary algorithm to find optimal system parameters. Scaling laws are derived from a hardware database similar to the full system heritage data. Here a TRL dependency is being implemented to allow a user to preset the to be considered data base on technology readiness. The part selector then picks specific hardware once system parameters are known. This tool is part of the DLR project IRAS, which aims for significant satellite development cost reduction and is part of its digitization efforts.