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INTEGRATED SPACECRAFT DESIGN: DEMONSTRATION OF A PROTOTYPE PROCESS AND PLATFORM FOR SATELLITE DESIGN APPLICATION

Abstract

Conceptual Design (CD) is one of the most critical life-cycle phases where crucial design decisions are taken and a baseline design is frozen. Almost 80% of the system configuration, technology, and mission tandem is decided at this stage. A traditional CD approach applies a design process that analyses and integrates various subsystems into a system-solution to satisfy the mission objectives. This approach implements a design convergence check and provides the capability to automate trade studies through an iterative execution of the process. On the other hand, a more modern approach is to apply model-based systems engineering (MBSE) frequently through a concurrent design platform where the design is driven by a system-model that integrates subsystems analysis towards top-level mission requirements. Both approaches have their advantages and drawbacks. However, no process or platform exists that combines and takes advantage of both approaches.

In this paper, we present a prototype design process and platform that combine and extend both, the parametric design framework and concurrent design application. This approach aims to support and automate the engineer's design activities. We have implemented this modular framework by a tool-chain composed of the concurrent engineering tool COMMET, a component configurator relying on constraint programming and a modular library of subsystems analysis methods solved using python scripts. The framework allows concurrent design and assesses the selected system architectures concerning the top-level design drivers and requirements and includes python modules for sizing of major subsystems of a satellite (i.e. Power, Communication et al) based on physical equations. With this modular platform, we provide a framework to integrate the subsystems modules in a valid spacecraft configuration following a proof of design convergence. Each module of the simulation can be used independently as a stand-alone platform and in parallel with other subsystems as in concurrent methodology.

A validation case study is presented addressing a satellite design application to demonstrate the capability and features of the framework. The validation case study demonstrates the application of the framework in both design approaches (parametric process and model-driven concurrent approach). The case study further demonstrates the automation of system-level trade studies and develops a solution space of alternative system designs for the same mission objective. Together with our case study, this framework can act as a benchmark for future research on systems design modeling and analysis for space systems.