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MODEL-BASED SOFTWARE ENGINEERING FOR ROBUST FLIGHT SOFTWARE DESIGN AND IMPLEMENTATION: THE ROLE OF NASA FPRIME AND CUBESATS

Abstract

Flight software is a critical component of aerospace systems that demands high reliability, safety, and performance. Traditional approaches to developing flight software involve manual coding, testing, and verification, which can be time-consuming, costly, and error-prone. An alternative approach is model-based software engineering (MBSE), which uses graphical models to capture system requirements, design, analysis, and validation in a formalized way. MBSE improves the quality, efficiency, and traceability of flight software development by enabling early validation, automatic code generation, back-to-back testing, and end-to-end coverage analysis. However, MBSE presents challenges such as model complexity, tool integration, verification and validation of models and generated code, certification standards compliance, and human factors.

NASA FPrime is an open-source software framework developed by NASA for the development of flight software. FPrime is based on the MBSE approach and is designed to support the development of reliable and robust flight software. The use of FPrime has been demonstrated in several NASA missions, including the Mars Reconnaissance Orbiter and the James Webb Space Telescope. In this paper, we will discuss the use of FPrime as a development tool for a CubeSat flight software, focusing on applying software architecture and systems engineering principles.

The MBSE approach, exemplified by FPrime, offers significant advantages, including early detection of design flaws, consistency between the model and code, efficient verification and validation, consideration of various factors such as system complexity, reliability, performance, and safety, and the use of formal methods. The use of the MBSE approach is particularly important for CubeSats, which have limited resources and require reliable and robust flight software to ensure mission success. By leveraging the benefits of MBSE and FPrime, we aim to achieve a robust and efficient design and implementation of CubeSat flight software.