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TOWARDS MODEL-DRIVEN DEVELOPMENT OF AOCS/GNC FOR SMALL SATELLITE MISSIONS

Abstract

Due to the rapid evolution of small satellite missions, the Attitude and Orbit Control System (AOCS)/ Guidance, Navigation and Control (GNC) system becomes increasingly complex. Especially, there is a strong motivation for small satellite formation flying missions recently. For example, European Space Agency (ESA) will fly the Proba-3 mission around 2017 and Delft University of Technology (TU Delft) plans to launch the DelFFi formation flying satellites in 2016. In this case, since the states of more than two satellites are coupled through control law, it is a big challenge to develop the onboard AOCS/GNC functionality for such a complex system. As a consequence, using traditional design strategy is no longer feasible: it takes a too long development process and is difficult for engineers to build a prototype. In contrast, Model-Driven Engineering (MDE) can efficiently solve this problem since it enables the development directly from models and provides model reuse capability.

Actually, the Swedish Space Corporation (SSC) has adopted the model based design method for the SMART-1 moon probe and the PRISMA space mission. Although the considerations of strategies have been outlined, there is no detailed MDE experience focusing on the integration of GNC functionality into traditional AOCS. This paper aims at filling this gap by presenting our design process and experience in utilizing MDE for AOCS/GNC of complex small satellite missions, taking DelFFi formation flying mission as a case study. Firstly, according to a provided initial design, AOCS/GNC architecture is built up in Simulink with detailed design of models, including dynamics and algorithms. The main points of realizing workable Simulink models and interfaces are demonstrated. Secondly, the AOCS/GNC models are automatically generated into C code and integrated into a full MDE approach. Although the system is already intensively tested during simulation and provides a clear separation among models, its integration into an implementation can also lead to errors. Actual traps and pitfalls during this procedure are specified, followed by the analysis of the test results. Finally, a comparison is carried out to illustrate the advantages of DelFFi's MDE based software development over handwritten Matlab/C++ software development in the Delfi-n3Xt mission.

This advanced Model-Driven Development of AOCS/GNC and autocoding procedure help save design efforts and avoid human errors for safety-critical systems. In particular, the new methodology enables a seamless transition to real-time software simulations as well as hardware-in-the-loop simulations. These results and experiences provide guidelines and preparation for further applications.