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Title

Classification of Flight Control Law Requirements in the Context of Model-Based Software Development and Verification

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Abstract

Flight control systems (FCS) are developed from **system requirements**, from which **system requirements allocated to software** (SRATS) are derived for Flight Control Law (FCL) software design and verification. As an FCS is complex and safety-critical, its development process must adhere to strict guidelines [1] in a certification context. The software development aspects are covered by [2] and its supplements. The processes for FCL development that the aircraft industry has to follow are costly as they require significant resources of highly-trained engineers.

Model-based controller design is common industry practice today. In the MODULAR project, sponsored by the German Federal Ministry for Economic Affairs and Climate Action, one of TU Berlin's tasks addresses efficiency improvements in the model-based development process of flight control software. Software code generation from FCL design models can be automated with qualified code generators like SCADE Suite KCG. A process for model-based FCL software development was defined according to [3] for Level A software. This paper focusses on the verification process and its optimisation.

The first step towards more automation is to examine methods for requirement-based verification. The FCL requirements are divided into seven **requirement classes** based on suitable verification means: requirements on control law structure, criteria for control law design, input filtering and command shaping, open-loop behaviour, logic circuits, output shaping, and filter design.

The classification scheme was applied to the primary flight control laws of a generic medium range aircraft that are representative for state-of-the-art commercial flight control laws. The FCL functions provide vertical, lateral load-factor and roll rate demand laws with decoupling of roll, pitch, and yaw motion, automatic pitch trim, envelope protections (load factor, stall, overspeed, low-energy, pitch angle, bank angle, tail strike protection, asymmetric engine thrust, rudder deflection), gust load alleviation, degraded operation in case of non-critical sensor failures and the synchronisation between three redundant flight control computers.

The proposed requirement classification can improve the quality of requirement writing by assigning adequate verification methods when a requirement is written. Furthermore, it provides a foundation to plan verification activities, to assign responsibilities and to identify verification activities that are suitable for automation. Figure 1 shows the basic structure of a test generation model, which is used to automatically generate test stimuli with Simulink Design Verifier (SLDV).

In this paper, the characteristics of all requirement classes are described and methods are selected that are suited for verification. The use of the classification scheme is demonstrated by examples from a typical industrial application. The results and the benefits of the method are discussed. The paper ends with an outlook on automated model-based test generation.

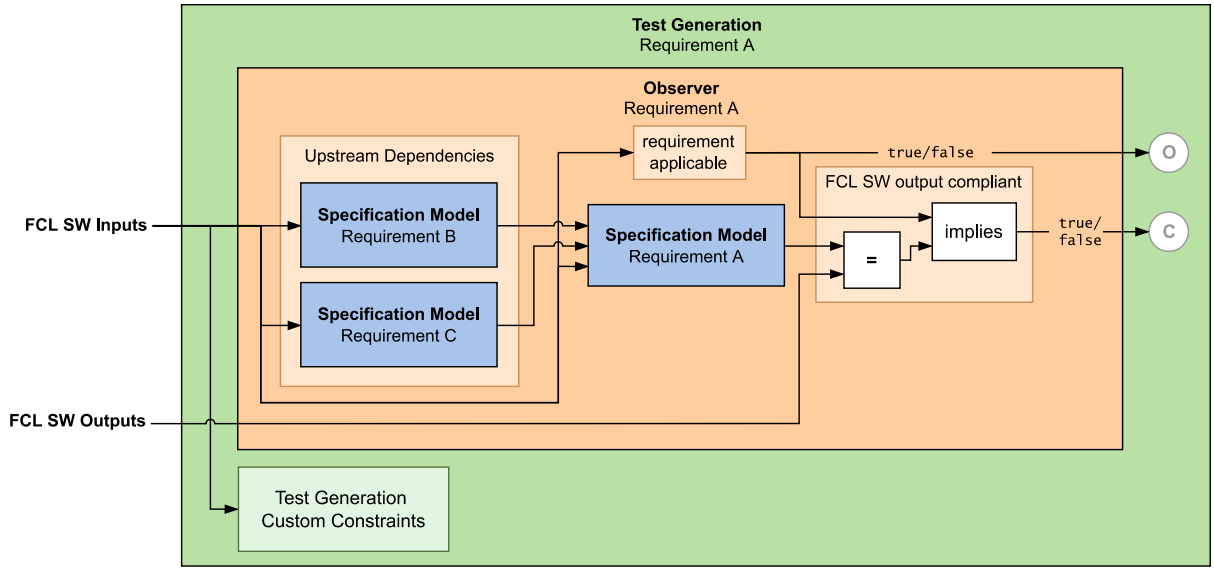

Figure 1: Test generation model with specification models in Simulink

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