Verification and Validation of Control Laws for Future Re-Entry Vehicles: the state-of-the-art, future needs and future challenges

Dr. Declan Bates, Control and Instrumentation Research Group, University of Leicester

Verification and validation techniques for complex safety-critical control systems aim to provide guarantees about the ability of these systems to maintain required levels of stability and performance in the face of uncertainty, environmental disturbances and fault/failure scenarios. In addition, worst-case performance characteristics of the closed-loop system must be computed, in order that reliable estimates of the expected deviations from "nominal" system performance can be generated.

The current state-of-the-art in verification and validation technologies for atmospheric re-entry vehicles (and many other space applications) involves a combination of simple robustness measures from classical control theory (gain/phase margins, etc) and computationally intensive simulation-based analysis using Monte Carlo techniques. In this talk, I will highlight the main limitations of this approach, and argue that, for future Atmospheric Re-Entry Vehicles with complex dynamics and control laws, there is a serious risk that these limitations could result in both (a) failure to uncover mission critical problems in the vehicle's control law and (b) extremely expensive bottlenecks in the V&V process.

In order to avoid these risks, I will argue that a sustained research effort is required on the part of the European space research community, similar to that which has been undertaken by the European aeronautical research community over the past 10 years, [1],[2],[3]. The aim of this effort must be two-fold. First, further stimulation must be given to researchers working in the general area of systems analysis to address the specific needs and problems associated with V&V of future Re-Entry vehicles, [4]. Second, ways must be found to transform the many powerful analytical and computational techniques for worst-case analysis which have recently been developed by theoretical researchers into useable, portable and flexible engineering tools, which may be applied to complex problems with manageable computational and manpower overheads.

References:

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