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MODEL BASED SYSTEMS ENGINEERING APPROACH TO SUPPORT SAFETY ASSESSMENT OF SUBORBITAL VEHICLES

Abstract

Investigating the possibility to operate suborbital vehicles on the Italian territory and within the national airspace requires preliminary safety assessments to identify, among others, contingencies and emergency conditions. The existing literature about safety and reliability assessment in the early design stages proposes document-based and statistical approaches which are usually not applicable to highly innovative products, where a significant statistical population is not existing, for example, in the case of suborbital vehicles' operations. This paper overcomes this problem by adopting an innovative integrated methodology implemented following a Model Based Systems Engineering approach. It exploits safety and reliability assessment analyses already developed in both aeronautical and space engineering domains, but it combines them in an innovative way to overcome the lack of statistics at vehicle level. The methodology consists of two different steps: (i) a qualitative analysis where, starting from the top-level design activities, a safety assessment is performed following a top-down approach, from the mission level to the equipment level. This process does not imply any quantitative evaluations; (ii) a quantitative analysis where, starting from the results of the qualitative analysis and following a bottom-up approach, it is possible to retrace the way to derive the probability of the top-event related to the mission or to the system. This set of analyses leads to the identification of the most critical subsystem in each mission phase, thus guiding to the identification contingency and emergency scenarios. In this paper, the methodology is implemented in Capella, an open access tool conceived to implement the Arcadia methodology, which aims at defining and verifying the architecture of complex systems following a function-driven approach. This rationale, differently from the requirements-driven strategy exploited, for example, by SysML, allows for a better integration of systems engineering and safety assessment tasks in a model-based environment. The study is applied to a vehicles' system representative of the Virgin Galactic's WhiteKnight Two (WK2) / SpaceShipTwo (SS2) system, hypothetically operating from/to Grottaglie airport, in southern Italy.