A Framework to Model Reliability and Failures in Complex Systems During the Early Engineering Design Process

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Abstract

An open area of research in complex systems is to move reliability and failure assessments earlier in the engineering design process. Standard methods are limited by the availability of data and often rely on detailed representations of the system. The research presented within this dissertation is focused on this need by developing an early design reliability and failure modeling framework. This framework presents a suite of engineering design methods that are used to assess reliability and failure modes during the early design process. Several instances are provided to show how specialized data sets can be developed that are specific to early design applications. These data sets use specific tools and data sources to generate example data used in case studies; however, they are presented in such a way that they can be regenerated using new sources. A specific importance in this dissertation is placed on design theory and methodology to support decision making. In some cases these results are an early design equivalent to traditional methods, while in others cases they present fundamentally novel ideas. Overall these methods address important early design considerations including the automated identification and mitigation of high-occurrence failure modes, the abstraction level of failure modes and mechanisms, quantifying uncertainty and functional reliability, a customer’s risk of losing functionality, a system’s risk to a set of failure modes, and the behavior modeling of important failure modes.

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