Paper Abstract submitted to RAMS

Requirements Based System Level Risk Modeling

I. Problem Addressed

Assessment of the ability of a system (mission) to perform its required functions in a given time frame can be accomplished using appropriate modeling techniques. One such technique is a quantitative representation of the dependencies between the system (mission) requirements and their respective risk elements. The success criteria for the system are identified by the set of requirements that it is intended to achieve. Requirements have different weights from a systems perspective; some may be more important than others. The degree of system success is expressed as a weighted sum of the requirements attainment. Any event that prevents one or more requirements from being satisfied is a risk element. Risk elements appear in various forms. In some cases, they are decomposed into more atomic events. In other cases, they are combined to yield further risk elements. Both the combined and the decomposed elements may in turn effect one or more of the requirements specified in the system or mission success criteria. Moreover, requirements could be subject to the same process. They could be decomposed into more atomic elements, or combined to yield higher level requirements.

The problem that we address in this paper is assessing the expected degree of success of the system or mission based on the degree to which each requirement is satisfied and the relative weight of the requirements. We assume a complete list of the requirements, the relevant risk elements and their probability of occurrence and the quantified effect of the risk elements on the requirements. The challenge that we encounter is carefully defining the relationships between the elements within each category (intra-category) and the elements between the two different categories of risk and requirements (inter-category). In addition, appropriately quantifying and modeling inter and intra category dependencies is crucial in estimating the exact measures of system success.

II. Work Performed

We consider the degree to which each requirement is satisfied to be a function of the risk elements that affect it. The relationships between the elements within each category of requirements and risk elements are

classified into independent, child-parent, or overlapping classes. Events that are not subsets or supersets of each other, but aren't independent either are analyzed for their degree of overlap which is determined by decomposing them into their common and separate sub-events. Further, we define algorithms and heuristics as appropriate to correspond the inter category elements and assess their dependencies. The probability of occurence of higher level risk elements are assessed from their basic events using fault tree analysis techniques.

III. Expected Results

The results of this work are twofold. First it provides a clearer understanding of the relationship between the two categories of requirements and risks and clarifies the type and nature of the dependencies. Second, it establishes protocols for computing the exact requirement attainment measures based on the probability of occurrence of the basic risk elements.

IV. Applicable Category

Effective Risk Assessment/Analysis
Modeling and Simulation
Risk and Safety Management
R&M Requirements
R&M Cost versus Benefit Tradeoffs

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Steven Cornford *is a Senior Engineer in the Strategic Systems Technology Program Office at NASA's Jet Propulsion Laboratory. He graduated from UC Berkeley with undergraduate degrees in Mathematics and Physics and received his doctorate in Physics from Texas A&M University in 1992. Since coming to JPL he focused his early efforts at JPL on establishing a quantitative basis for environmental test program selection and implementation. As Payload Reliability Assurance Program Element Manager, this evolved into establishing a quantitative basis for evaluating the effectiveness of overall reliability and test programs as well as performing residual risk assessments of new technologies. This has resulted in the Defect Detection and Prevention (DDP) process is the motivation for this paper. He received the NASA Exceptional Service Medal in 1997 for his efforts to date. He has been an instrument system engineer, a test-bed Cognizant Engineer and is currently involved with improving JPL's technology infusion processes as well as the Principal Investigator for the development and implementation of the DDP software tool. Steve is the one in the middle of the picture.*

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