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Minimizing life cycle cost by managing product reliability via validation plan and warranty return cost

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Abstract

This paper presents a quantitative solution that minimizes the life cycle cost of a product by developing an optimal product validation plan. Dependability constitutes an integral view of a product's reliability, availability, maintainability, quality, and safety. The methodology developed in this paper incorporates several dependability-related activities into a comprehensive probabilistic cost model that enables minimization of the product's life cycle cost. The model utilizes the inverse relationship between the cost of product validation activities and the expected cost of repair and warranty returns. The model emphasizes the test duration and sample size for the environmental qualification tests performed in a product validation program. The overall stochastic cost model and its minimization are done with Monte Carlo simulation in order to account for uncertainties in model parameters. The model is demonstrated on an automotive electronics application. The results of this work provide application-specific optimal product validation plans and evaluate the efficiency of a product validation program from a life cycle cost point of view with an emphasis on the cost of validation and product warranties.

Keywords: Warranty; Reliability; Life cycle cost; Validation; Automotive

1. Introduction

Life cycle cost (LCC) analysis is a tool that produces important metrics for choosing the most cost-effective approach from a series of alternatives. LCC generally refers all the costs associated with a product throughout the product's life. The exact content of LCC varies depending on the horizon of the interested party; however, generally LCC includes conceptual/preliminary design costs, detailed design and development costs, production and/or construction costs, and product use/support/phase-out/disposal costs (Fabrycky and Blanchard, 1991). In this paper, LCC is used to refer to the combination of design, validation, manufacturing, and warranty costs. One important contributor to LCC for many types of products is the cost of product failure. The product characteristics associated with a product's potential failures or malfunctions are often summarized by the term Dependability, which constitutes an integral view of product's reliability, availability, maintainability,

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quality, and safety (Fernández, 2001). This paper focuses on two major quantifiable dependability contributions: reliability and quality.

To assure uninterrupted performance during a system's mission life, product testing and validation is conducted as an important part of the development cycle. Product validation activities normally include reliability analysis and testing (both functional and environmental), which are intended to prove that the design satisfies specified quality and reliability requirements. From a supplier's viewpoint, the cost of product validation activities is a significant variable in the overall cost model. Product development activities associated with dependability are presented in Fig. 1.

Clearly product validation activities have a direct impact on the expected warranty cost, although in many industries the issue of product validation cost and its impact on the development program are not given sufficient attention especially in the early stages of product planning.

Traditionally, in the initial phase of the business cycle during product quoting, the costs of product development and validation are treated as a one-time expense, and usually not treated in conjunction with the rest of the product's non-recurring costs. This often leads to a customer's insistence on the highest possible reliability without proper consideration for the costs involved in the process. As an example, in the mid-1990s, one of the major automotive manufacturers was on a quest to improve quality and reduce warranty claims. They decided to approach the problem exclusively from the product validation process. The product validation organization calculated the number of test samples and finds that for a required reliability of 0.90 with a confidence level of 90%, the number of test samples required is 22 (see Appendix A for a discussion of sample size calculations). If the reliability requirement is raised to 0.99, the number of required test samples becomes 229. As the reliability approaches 1.0 (100%), the number of test samples required approaches infinity. Obviously, the suppliers want to minimize validation testing in order to save money, while the customer often assumes that more testing by the supplier will solve all warranty problems—in this case the customer desired increasing reliability targets without an accurate understanding of the economic benefits (or lack thereof).

Product warranty is a significant contributor to the post-manufacturing portion of the LCC. For example, according to Nasser et al. (2002), on average General Motors spends approximately $3.5 billion per year (roughly 22.5 million warranty claims) paying dealerships to repair failed parts under warranty. Original Equipment Manufacturers (OEMs), the brand name of the product, often penalize their suppliers based on their cost of warranty by passing to the suppliers all or part of their warranty cost (Balachandran and Radhakrishnan, 2005). Based on these considerations, suppliers must make decisions at the beginning of a product development cycle regarding how much should be spent on product validation and estimate the effect of that spending on the expected warranty cost. Project managers often need to focus their activities on the dependability-related variables of LCC analysis, since these are the inputs that can be affected during the development process.

Fig. 2 shows a qualitative diagram of the relationship between the pursued reliability and the total cost. The higher the pursued reliability of the product, the higher the product development cost (the ascending curve). At the same time the higher the achieved dependability of the product, the lower the cost of the associated warranty and service (the descending curve). Relationships similar to Fig. 2 have been referred to as 'contractor's cost vs. reliability' (Blischke and Murthy, 1994) and 'dependability vs. non-dependability cost' (Fernández, 2001).

The sum of those two costs in Fig. 2 resembles a U-shaped curve with a minimum at the lowest sum of product validation and warranty cost, thus minimizing the contribution to total LCC. Unlike

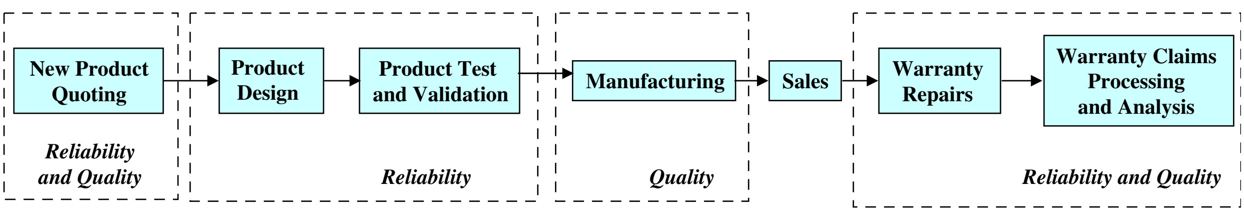

Fig. 1. A product development process involving dependability-related activities.