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Investment in new product reliability

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ABSTRACT

Product reliability is of great importance to both manufacturers and customers. Building reliability into a new product is costly, but the consequences of inadequate product reliability can be costlier. This implies that manufacturers need to decide on the optimal investment in new product reliability by achieving a suitable trade-off between the two costs. This paper develops a framework and proposes an approach to help manufacturers decide on the investment in new product reliability.

1. Introduction

Modern industrial societies are characterised by new products appearing on the market at an ever increasing pace. Some of the reasons for this are (i) rapid advances in technology, (ii) increasing consumer expectations and, (iii) global competition. As a result, the complexity of products and the cost of product development are increasing and the product life cycle is getting shorter with each new generation. Consumers are getting more concerned with the performance of the product over its useful life, and increasing power of consumer groups has resulted in stronger legislation to protect consumer interests. All of these have implications for manufacturers of all kinds (consumer, commercial and industrial) of products.

A product is designated by its characteristics and attributes. The distinction between these two is best explained by the statement "product characteristics physically define the product and influence the formation of product attributes; product attributes define consumer perceptions and are more abstract than characteristics" from Tarasewich and Nair [1]. Consumers view products in terms of attributes.

The reliability of a product is a characteristic, which conveys the notion of dependence or absence of failure. Unreliability is the opposite. According to IEC 60050-191 [2], the reliability of a product (system) is the probability that the product (system) will perform its intended function for a specified time period when operating under normal (or stated) environmental conditions.

One way for manufacturers to assure consumers about product performance is through warranty. A warranty is a contractual obligation, which requires the manufacturer to rectify, replace or provide compensation, should the product not perform satisfactorily over the warranty period. It can be viewed as a product characteristic that serves two important roles for a manufacturer—(i) to signal product reliability (as better warranty terms indicate a more reliable product) and, (ii) to differentiate the product from competitors as warranty is bundled with the product and sold as a an element of product support.

Product reliability depends on the decisions made during the design and production of the product. Building-in product reliability is costly as it involves considerable expenditure during the design, development and production phases of the product life cycle. Not having adequate reliability is costlier as failures result not only in higher warranty costs but also reduced sales and revenue due to the negative impact of customer dissatisfaction resulting from product failures. As reported in Warranty Week [3] the warranty costs vary from 1% to 4% of sale price depending on the product and the manufacturer. Viewed as a fraction of profits, this figure jumps by an order of magnitude. In the long run it affects the reputation of the manufacturer, impacts on the bottom line of the balance sheet and the survival of the manufacturer. From the customer's point of view, unreliability reduces availability and increases maintenance costs over the useful life of the product. This implies that manufacturers need to decide on the investment in product reliability from an overall business viewpoint. This topic has received some limited

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attention, but has not been addressed properly in the reliability literature.

There is a need for an effective approach for manufacturers to decide on the level of investment in product reliability as part of the new product development process. In this paper, we propose such an approach that takes into account the technical implications of building-in reliability and the commercial consequences of unreliability from an overall business viewpoint. The outline of the paper is as follows. We start with a brief review of the literature in Section 2. Section 3 deals with the reliability investment issue and this involves two tasks. The execution of these tasks requires a proper framework and an effective approach. Section 4 deals with the framework that involves several elements. Section 5 looks at the approach involving a product life perspective and the use of mathematical models. We conclude with a brief discussion of the execution of the two tasks in Section 6.

2. Literature review

- British Standards BS 5760 [18,19].

Although the literature on product reliability is vast, the literature on reliability design is rather limited. It can be grouped into two categories based on the focus—(i) management and (ii) engineering. In this section, we review briefly the literature dealing with both these categories as well as reliability-related standards.

2.1. Management focus

Kohoutek [4] discusses product reliability in the context of new product development, in terms of desired reliability performance. According to Kohoutek, mature companies establish goals (objectives) on three different levels—(a) company, (b) product family and (c) individual product level. The goals can be (i) arbitrary goals, (ii) goals based on market sensitivity assessment, (iii) end product and company requirements, (iv) goals based on past performance and, (v) goals based on reliability cost optimisation. The approach proposed is informative in a general sense, but does not provide any guidance on how to actually arrive at these goals, and in turn how to handle the reliability goals as the new product development project progresses. Priest [5] and O'Connor [6] briefly discuss reliability goal setting in a very qualitative sense.

2.2. Engineering focus

Over the last 30 years, several books dealing with engineering design for reliability have appeared and [5–11] is a small sample. Many books contain chapters that deal with reliability design, for example, [12] contains the chapters by Liebesman [13] and Moss [14]. The books cover a range of topics. These include stress–strength interference models, reliability allocation, reliability testing during development, reliability prediction, reliability growth, stress–strength models, etc. There are books that focus on reliability design in a specific discipline—for example, [15] deals with mechanical component design, and [16,17] deal with electronic component and system design. The focus is on technical aspects—tools and techniques for design. The commercial implications and the impact on the overall business performance are by and large either ignored or discussed in a cursory manner.

2.3. Reliability-related standards

There are several reliability-related standards and some of the more well-known ones (for consumer, commercial and industrial products) are the following:

- IEC Standards IEC 60300-series [20–27]
- IEEE Reliability Program Standards-IEEE-STD-1413 [28,29]

There are many other standards (relating to custom-built defence products) and a more comprehensive list can be found in Ref. [30].

The IEC 60300-series is an extensive collection of standards that provide detailed and useful guidance to management of dependability (see [31] for more on dependability) from a life cycle perspective as well as application guidelines to specific issues such reliability analysis techniques, data collection, life cycle costing, specification of dependability requirements, reliability testing and reliability stress screening of electronic hardware.

Ref. [25] describes the process of specifying dependability requirements, and the process of verifying them, in a qualitative sense.

The focus of most standards is, to a large extent, on the engineering process subsequent to system definition. They provide tools and techniques for design, but do not effectively address the challenging issue of linking reliability requirements to business objectives (and/or customer needs) and the decision-making process regarding the requirements. This also applies to [28] and its guideline [29].

Other standards, developed by different organisations for their specific needs give the reader a good insight into reliability management and engineering in the same sense as the IEC 60300-series. However, they do not address the issues raised in this paper. The NASA-STD-8729.1 [32] has a programme management focus. The reliability programs define the list of activities that are considered to be essential to the success of the product and a description of each task and an assignment of responsibility and accountability.

3. Reliability decision-making

A product is best described through a multilevel characterisation with the product viewed as a system at the top level, components at the bottom level and with one or more intermediate levels (corresponding to sub-systems, assembly, sub-assembly, and so on). Reliability decision-making involves the following two tasks.

- **Task 1:** Defining reliability requirements at the system level.
- **Task 2:** Deriving the reliability specification at the component level.

Fig. 1 shows the link between these two and the implications for investment in reliability. The reliability requirements at the system level are obtained through an optimal trade-off between the investment in reliability and the benefits derived from an overall business perspective of the manufacturer. This task is executed in the Front-end phase and the early stages of the Design phase. It needs to take into account the implications of reliability for the post-production phases. Deriving the specifications at the component level is carried out during the Design and Development phases of the product life cycle.