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# Fuzzy QFD for supply chain management with reliability consideration

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**Abstract**

Although many products are made through several tiers of supply chains, a systematic way of handling reliability issues in a various product planning stage has drawn attention, only recently, in the context of supply chain management (SCM). The main objective of this paper is to develop a fuzzy quality function deployment (QFD) model in order to convey fuzzy relationship between customers needs and design specification for reliability in the context of SCM. A fuzzy multi criteria decision-making procedure is proposed and is applied to find a set of optimal solution with respect to the performance of the reliability test needed in CRT design. It is expected that the proposed approach can make significant contributions on the following areas: effectively communicating with technical personnel and users; developing relatively error-free reliability review system; and creating consistent and complete documentation for design for reliability. 

*Keywords*: Fuzzy QFD; Reliability; Customer satisfaction; Supply chain management

## 1. Introduction

Although many products are made through several tiers of supply chains, a systematic way of handling reliability in product planning stage has drawn attention, only recently, in the context of supply chain management (SCM) (Garg [1]).

Consider a monitor production schematic as displayed in Fig. 1. One of the major components of PC monitor is cathode ray tube (CRT), which requires numerous processing as well as a series of assembly operation with various subcomponents such as an electron gun, shadow mask, and glass panels provided by vendors. This kind of an assembled CRT is then used as part of a PC set.

In order to maximize end users' satisfaction, PC set makers must understand what needs to be done in order to attract customers of PC. Once customers' needs are identified, they, in turn, have to be properly propagated to design specifications of the subsystem such as CRT. Accordingly, needs of CRT makers should be known to vendors of CRT component or raw material, In order to maximize the system effectiveness, one would expect that vendors of the component of CRT (e.g. electron gun, shadow mask, and glass panel) need to comply the requirements of CRT makers in relation to those of PC monitor makers in the context of SCM.

End users' needs for a monitor typically consist of reliability, cost and aesthetic attributes for the finished product. Among them, we focus our attention on reliability. When managing CRT vendors, set makers should be able to properly translate end users' needs for PC monitor in terms of necessary reliability attributes of a CRT. This transition however, is not trivial.

For instance, customers of a PC monitor may require the brightness of monitor should not fall down to a certain level in the lifetime of a monitor. What kind of reliability test has to be required for CRT to keep this level of brightness? Since the brightness can only be observed in the form of a monitor, reliability assurance test for the brightness cannot be directly performed on the CRT itself. Therefore, when CRT is made, instead of directly conducting the degradation test in terms of brightness, voltage test is done on CRT samples by taking the average maximum cathode induction (MIK) of red, green and blue beams of electron gun of a CRT over various times of age. Although we use the MIK level changes as the proxy for the brightness level change, the relationship between the MIK level and the brightness is not clear yet (Sohn [2]).

In addition, the critical level of brightness which would annoy monitor users are often represented in fuzzy verbal expression. Therefore, one can easily imagine that the

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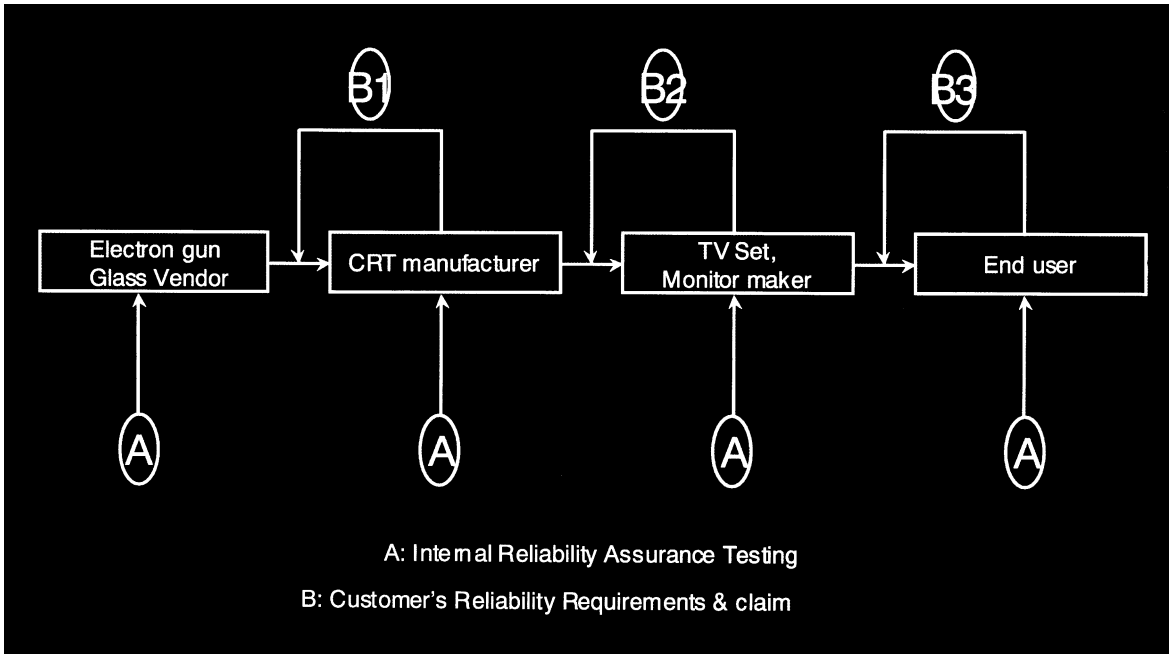


Fig. 1. Design for reliability in a supply chain management.

required relationship for the reliability attributes between the CRT and the components of CRT would be fuzzy in many places. This is just a simple example where many relationships in SCM could be fuzzy. Therefore, in SCM, it is important to define customers and their fuzzy needs properly at every chain. Consequently, customers' fuzzy needs have to be identified in relation to design specification as well.

Quality function deployment (QFD) is often used to understand customers' needs on the product and to relate them with design specifications through several hierarchies of house of quality (HOQ). Defining customers and their needs at each stage is not relatively difficult compared to reflecting recursively both fuzzy needs and relationship in several HOQs. Fuzzy QFD has been developed mainly in view of fuzzy relationship between the customers' needs and design specifications (Khoo and Ho [3]). However, not much research has been done to deal with fuzzy customers' needs for reliability tests in the context of the SCM.

The main objective of this paper is to develop a fuzzy QFD model in order to convey fuzzy relationship between supply chains in terms of multi-attribute reliability requirements. A fuzzy multi criteria decision making procedure is proposed and is expected to make significant contributions on the following areas: effectively communicating with technical personnel and users; developing relatively error-free reliability review system; and creating consistent and complete documentation for design for reliability.

Organization of this paper is as follows. In Section 2, QFD studies are reviewed. In Section 3, a fuzzy multi criteria decision making procedure is illustrated. We then, in Section 4, apply fuzzy QFD to finding design specifications for reliability in the context of SCM. In Section 5, study results are summarized.

## 2. QFD studies

QFD consists hierarchically of several HOQ. Typically the first HOQ represents the relationship between the end users' needs and product design variables as displayed in Fig. 2. In the second HOQ, design variables of a product are related to those of components. In the third HOQ, design variables of components are related to job attributes. Finally, in the last HOQ, job attributes are related to personnel job assignment.

Much variation of QFD has been extensively studied recently. We review it in terms of application areas and methodological issues. Main application areas of QFD are the new product design (Halbleib et al. [4], Belhe and Kuisak [5]). Examples of other application areas include service improvement (Trappey et al. [6]), software development (Haag et al. [7]), business planning (Crowe and Cheng [8]), rehabilitation engineering (Logan and Radcliff [9]), education process (Pitman et al. [10]), construction management (Mallon and Muligan [11]), and road traffic accident control (Sohn [12]) as well.

Some methodological problems of QFD are associated with dimension problem of the relational matrix, comparison method of customer requirements and assessment of relational matrix.

In terms of methodology, first, the dimension problem (Kim and Shin [13]) has been indicated. That is the size