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# Quality Function Deployment for Designing the Virtual Enterprise

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## Abstract

*The design of distributed or virtual enterprise organizations is a complex activity requiring the evaluation of process competencies of multiple potential participants. This analysis must also incorporate the functional requirements for the desired product or service as specified by the intended customer. Experience in non-distributed business environments show that failure to meet customer needs can lead to a worsening competitive position. This paper presents a methodology based on quality function deployment design methods for delineating responsibility for process components in a virtual enterprise. A brief description of the design requirements for the virtual enterprise is presented. The methodology defined in this paper provides the link between customer needs and the process competencies provided by participants in the venture.*

## Introduction

Businesses around the world are attempting to position themselves to operate in a highly competitive global economy. To compete, corporations must be able to meet rapidly changing customer demands and competitive circumstances. These business opportunities or threats are often short term and arise suddenly in the competitive environment. A single organization is often not able to develop sufficient internal design or production capabilities to respond effectively within a short period of time. Beyond the need to respond to rapidly arising opportunities, business organizations have also begun off-load activities not deemed critical to their primary mission to strategic partners (Hope and Hope, 1997).

The Agility Forum Virtual Enterprise Reference Model (Goranson, 1995) defines four types of organizations that employ collections of business partners that function as a single business entity. Type 1 refers to the distributed or *virtual enterprise* is a temporary alliance of partner enterprises that each contributes core competencies to take advantage of a specific business opportunity or fend off a market threat. Type 2 also represents a collective business entity, but established on a more permanent basis (Goranson, 1995; Hope and Hope, 1997). These two categories comprise the types of organizations referred to in the literature as virtual enterprise or organization. The remaining two types of virtual organization refer to supplier chains and industry groups, and are outside the scope of the current discussion.

The business processes of the virtual enterprise are formed by incorporating the distinct competencies of each member organization (Barnett and Meade, 1994; Barnett, Presely, Johnson, and Liles, 1994). This configuration effort must identify essential customer requirements and then align the abilities of participant organizations to meet those requirements. This flow of translating customer requirements into component specifications and then evaluating comparable components is reminiscent of manufacturing design. Designers must identify customer requirements for the product, these requirements are translated into part specifications, and finally alternative parts are evaluated for their ability to satisfy customer requirements. In manufacturing, the Quality Function Deployment (QFD) method is used to provide this link between customer requirements and design (Hauser and Clausing, 1988; Sullivan, 1986a).

This paper will explore the application of QFD to the specification and design of a virtual enterprise. This scheme will modify the software QFD method developed by Barnett and Raja (Barnett and Raja, 1995) that emphasizes the identification and evaluation of business process.

## Design Issues in the Virtual Enterprise

The need for a virtual enterprise is derived from special functional requirements that a single enterprise is unable or unwilling to accommodate due to prohibitive costs or time constraints. Successful attainment of the original business goals of the virtual enterprise depends on its ability to align the business processes and practices of partner organization with the functional requirements of the particular opportunity.

By definition, virtual or distributed enterprises are temporary entities of cooperating organizations. Such organizations are assembled from a series of individual business processes contributed by partners in the venture. Each functional aspect involved

in the accomplishment of design, production, distribution and marketing a product may be performed by many different organizations (Barnett and Meade, 1994; Henderson, 1990; Johnston and Lawrence, 1988).

Identification of functional requirements and an evaluation of organizational capabilities are necessary first steps in the formation of a virtual enterprise (Goranson, 1995; Tuttle and Kanter, 1995). Process capabilities must be identified within the pool of potential virtual enterprise participants. The nature of these functional requirements should then become the driving force behind the selection of participant organizations and their degree of involvement.

Organizing around the process capabilities of a number of participant organizations requires the development of specifications that provide for the:
1. Identification of essential functionality required to address the target opportunity
2. Identification of criteria for selecting the component activities that will be used to meet a particular requirement
3. Assigning responsibility for providing required functionality based on capabilities in meeting functional requirements
4. Development of performance metrics to guide operations

Activity-Based Costing (ABC) (Tuttle and Kanter, 1995) and simulation modeling (Mahajan, 1995) have been proposed as methods for establishing virtual enterprise specifications. Although these approaches provide a more formal set of methods for defining the virtual enterprise, they fall short in two major areas. First, neither *ABC* nor *simulation modeling* provides formal methods to evaluate customer requirements. The ability to identify and prioritize requirements is critical to the delivery of products and services that completely satisfy customers (Hope and Hope, 1997). These methods also lack a side-by-side comparison of the ability of potential partners to satisfy customer requirements. The QFD design method employed in manufacturing and software engineering provides the quantitative evaluation capabilities provided by an ABC approach along with direct linkage to customer requirements.

## Applying QFD to Virtual Enterprise Design

The QFD method of design supports the translation of functional requirements into component specifications and subsequent evaluation of process capabilities. In QFD, a series of matrices are used to translate customer requirements into specifications that support manufacturing and quality control. Figure 1 shows the general layout of a QFD matrix. On each matrix, the requirement or attributes to be developed are placed on the vertical axis. Each attribute is then prioritized. Along the horizontal axis, mechanisms for enabling the requirements are listed. The contribution of each mechanism to each requirement is then specified in the matrix area. An assessment of each mechanism is developed along the bottom of the matrix. This assessment provides information on the required capability of the mechanism, and this information is used to produce performance metrics. Finally, competing sources of the attribute and their capability information are shown along the right margin of the matrix (Hauser and Clausing, 1988; Sullivan, 1986a).
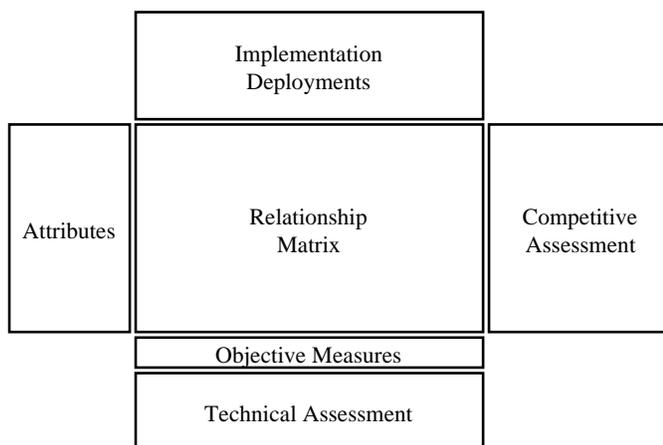


**Figure 1.  QFD Matrix**

Barnett and Raja (1995) have described an extension of the traditional manufacturing QFD approach for use in software engineering. This modified approach directly links customer or stakeholder requirements to supporting business processes, supporting software components necessary to support business processes are then defined. The linkage between customer requirements and business processes established by this method provides the type of formal specification needed to meet the design requirements for the virtual enterprise. This paper proposes to apply the "Customer Deployment" and "Business Process Deployment" (page 34) matrices to the design of a virtual organization. These two matrices provide a formal specification approach that addresses each of the virtual enterprise design requirements. The essential functional attributes are identified in a manner that links customer priorities to the supporting business processes. This type of analysis directly supports the evaluation of organizational capabilities in terms of customer requirements. The identification of required competencies that an organization does not possess or that are not best in class, is the primary justification for forming a virtual organization (Goranson, 1995; Hope and Hope, 1997; Tuttle and Kanter, 1995). The technical assessment area of the QFD matrix provides guidelines to evaluate potential partners and performance metrics to control the operation of the virtual organization.

### *Customer Deployment Matrix*

The *Customer Deployment* matrix focuses on specifying and prioritizing customer requirements. QFD methods found in the literature traditionally begin with the identification of specific stakeholders and their requirements for a product or service (Bossert, 1991; Hauser and Clausing, 1988; Sullivan, 1986a). Stakeholders (emphasizing potential customer groups) form the

vertical (*ATTRIBUTE*) axis of the *Customer Deployment* matrix. The importance of each of these stakeholders is evaluated through the assignment of priority ratings. Across the horizontal (*REQUIREMENTS*) axis of the matrix, product characteristics are listed. The analysis conducted in the central portion of the matrix attempts to match product requirements to stakeholders. The outcome of this analysis will be the identification of product requirement important to the most critical stakeholders. The *COMPETITIVE ASSESSMENT* portion of the matrix examines the way that stakeholders are supported (or not supported) by competitors. *TECHNICAL ASSESSMENT* in this matrix provides a description of the success criteria for each of the product characteristics.

### Business Process Deployment Matrix

*Business Process Deployment* uses the requirement specifications developed in the *CUSTOMER DEPLOYMENT* matrix to evaluate the potential sources of business functionality. The primary outcome of the analysis performed in this matrix will be the delineation of responsibilities for process components to virtual enterprise participants. The prioritized customer requirements are listed along the vertical (ATTRIBUTE) axis of the matrix. The horizontal (*REQUIREMENTS*) axis is populated with the activities that will serve as mechanisms to fulfill customer requirements. These are the business processes that will fulfill the product requirements specified by the customer. In the *COMPETITIVE ASSESSMENT* portion of the matrix potential sources (candidate partners) of required functionality are evaluated in terms of their ability to satisfy stated customer requirements. This analysis permits the organizing firm to evaluate it's process capabilities in terms of customer requirements and to identify requirements for outside partners. The *TECHNICAL ASSESSMENT* area in this matrix is used to define activity performance metrics necessary to control and evaluate the ongoing operations of the virtual enterprise.

## Conclusions and Future Directions

In this paper, we have examined the specification requirements used to design a virtual enterprise. Design methods such as ABC or simulation modeling provide an analytical means to examine these requirements. However, there is a lack of formality in the linkage between customer requirements and business process specifications that comprise the virtual enterprise. A QFD-based method was proposed to address these shortcomings. This method provides venture organizers with a means of performing a formal analysis of product requirements and process capabilities. The QFD method provides a flexible tool for performing this type of design analysis.

Future work with this method should focus on validating the method through field-testing. General QFD analysis has been employed by researchers at the University of Texas at Arlington's Automation & Robotics Research Institute in connection with organizing joint ventures. Comparisons between those efforts and the proposed method may prove insightful. Future efforts should also focus on extending the proposed method to the design of supporting technologies.

### *References*

References available upon request from first author (bbarnett@alpha.nsula.edu).