ABSTRACT

Cost Deployment Based on
Quality Function Deployment

by

John Goceljak

A methodology for Cost Deployment based on Quality Function Deployment (QFD) architecture is developed and explained. Following a comprehensive review of Quality Function Deployment terminology and composition, a house-of-quality is developed, and matrix correlation methodologies are discussed. Current applications are presented to illustrate the scope and adaptability of this quality assurance tool. In addition, an exercise in product design and review is conducted to illustrate a unique approach to cost deployment. Quality Function Deployment issues, including software, consulting, and preferred practices are also presented.

COST DEPLOYMENT BASED ON QUALITY FUNCTION DEPLOYMENT

by

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CHAPTER 1
INTRODUCTION

A disparity has been evident between Japanese companies and their counterparts in the United States, both in the areas of time to market and intrinsic product quality. This has been noted by Womack [1], Nishiguchi [2], and others.

The Japanese emphasis on quality assurance methods, such as Quality Function Deployment, has significantly contributed to this condition. What differentiates true quality assurance from quality control is the focus on design for quality up-front, as opposed to post-production inspection and problem analysis - and accordingly this is the strength of Quality Function Deployment [3].
Figures 1.1 and 1.2 illustrate this, by noting the concentration of resources during the product lifecycle, by both Japanese companies and U.S. companies.

Similarly, the Cranfield Institute in England has found that 66% of Japanese design effort is expended in early conceptual design. This is in direct opposition to the American practice of using 50% of the total effort in redesign, at the end of the process [4].

In keeping with this theme, this thesis will focus on Quality Function Deployment architecture, and the process of

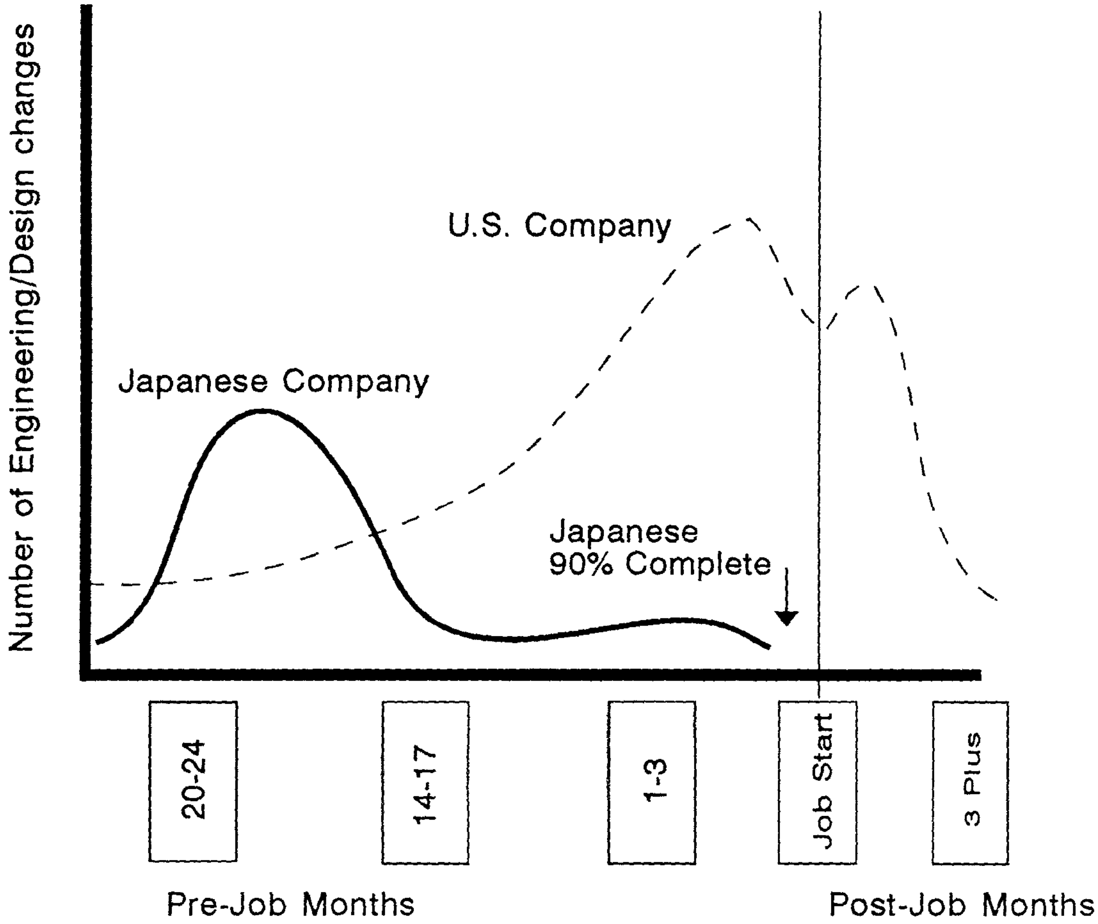

Figure 1.1 Frequency and distribution of redesign (QFD utilized by Japan).
Source: Adapted from Automotive Engineering, Feb. 1988, 124.

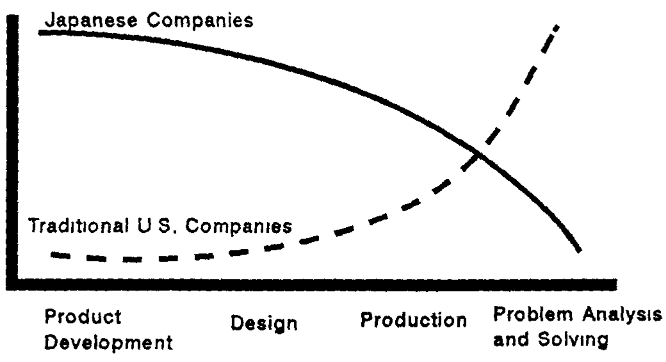

Figure 1.2 Addressing quality early in the product lifecycle.
Source: Adapted from Automotive Engineering, Feb. 1988, 126.

utilizing the tool in conjunction with a design target cost parameter. This technique is known as cost deployment based on Quality Function Deployment.

1.1 Defining Quality Function Deployment and Cost Deployment

Quality Function Deployment is defined by Akao [5] in both narrow and broad based terms. Narrowly defined, it is the business or task functions responsible for quality, such as design, manufacturing, and production. Broadly defined, it is a combination of these business or task functions responsible for quality, and the charts and descriptive matrices used to design the quality needed in a product or service.

Cost deployment is a systematic way of decreasing the cost of a product or service, while simultaneously maintaining the balance with quality as defined by the customer. Specifically, the product or service is designed to a designated cost, or target cost, based on the price the market is most likely to accept [6]. Cost deployment based on Quality Function Deployment involves dispersing the target cost among the product features which evolve within the quality charts.

Quality Function Deployment serves well within an integrated quality system [7], and compliments other techniques, such as design for assembly (DFA). This is done by placing attention on product features which contribute little to overall customer requirements, or which exceed targeted costs. Thus, the focus of methods such as DFA may be concentrated on areas of optimum opportunity. Not surprisingly, the leading DFA rankings for Japanese and U.S. automakers belong to the two companies most ingrained with the Quality Function Deployment approach - Toyota and Ford Motor Company [8].

1.2 Problem Statement

Designing for performance, reliability, functionality, and other parameters should be done with a concurrent objective of minimizing cost. Currently, two approaches exist for achieving this balance, Value Engineering (VE) and Design to Cost (DTC).

VE evaluates the design of a product to assure that essential functions are provided at a minimum overall cost, while DTC starts with a specified target cost and a statement of overall function desired, but no design approach [9]. However, a void exists in the field of designing to a target cost while simultaneously addressing the voice of the customer.

This is the obstacle to be confronted by this thesis, through both the presentation and application of cost deployment based on Quality Function Deployment methodology.

1.3 Research Objective

This research carries two objectives of equal standing. The first objective is to present Quality Function Deployment methodology and pertinent supplemental information in a concise manner. The second objective is to resolve the problem stated in the preceding section with regard to cost deployment.

1.4 Organization of the Thesis

To fulfill the first objective of this research, Chapter 2 addresses Quality Function Deployment in detail. Included is an overview of the system, a complete description of all applicable terms and components, and a step-by-step development of a house-of-quality, including matrix correlation. Chapter 3 explores numerous current applications of Quality Function Deployment to illustrate the adaptability of the process.

Chapter 4 presents cost deployment methodology, and an application of cost deployment based on Quality Function Deployment. For the exercise, a real product has been deployed based on the technique. Chapter 5 outlines preferred practices with regard to Quality Function Deployment, and provides a listing of software and consulting. This chapter also provides an overall conclusion to the thesis.

CHAPTER 2
QUALITY FUNCTION DEPLOYMENT

2.1 Introduction

As stated earlier, Quality Function Deployment is a quality assurance system which translates customer requirements into the product development process. Quality Function Deployment, commonly denoted by the acronym **QFD**, facilitates the design and development of quality products and services by defining product attributes according to the voice of the customer. The measurement of quality in companies embracing a customer driven philosophy and total quality control is conformance to customer requirements, and QFD systematically integrates these requirements [10]. Through matrix linkage, customer needs or desires are carried from the marketing level through the production stage, with the focus maintained on customer requirements throughout.

The concept of Quality Function Deployment originated in Japan during the late 1960's and early 1970's, and the quality chart was first implemented at Mitsubishi Heavy Industry's Kobe Shipyard in 1972. The Bridgestone Tire Corporation also developed the quality chart concept during this same period, and both breakthroughs were based on the concept outlined by Dr. Yoji Akao in 1966 [11]. QFD was further formalized into an integrated system through the work of Dr. Akao and Sihgeru Mizuno. Their 1978 text Quality Function Deployment named the system, and moved QFD into the mainstream as a tool for Japanese Total Quality.

In 1983, Quality Function Deployment was formally introduced to the United States by Dr. Akao in the magazine Quality Progress. Other early introductions of QFD to U.S. industry were done by Don Clausing of Massachusetts Institute of Technology, and by the American Supplier Institute in Dearborn, Michigan. Today, approximately 200 American companies utilize Quality Function Deployment in some capacity [12]. However, even though QFD is becoming more prevalent in the United States, Japanese utilization is still much greater, and there, the system is an integral part of product development.

In Japan, QFD has been developed and applied in numerous ways, and by a wide gamut of industries. Automobile manufacturers are significant users, but the system is also used to design software, construction equipment, consumer electronics, and a plethora of other products and services. Among the companies most ingrained with the QFD approach is the Toyota Motor Company, which has utilized the system since 1977. Using that year as a baseline, in 1984 Toyota reported a cumulative 61% reduction for a vehicle launch start-up cost. During the seven year period beginning in

1977, the product development cycle at Toyota was reduced by one third while quality rose in direct relation [13]. Accordingly, the entire Toyota supplier network uses QFD.

While it has been noted that QFD is gaining increased acceptance in the United States, and is used substantially by companies such as Ford Motor Company, DEC, and Hewlett Packard, Japanese companies are still significantly ahead in both practice and erudition. Over the past 20 years in Japan, Quality Function Deployment has become so imbedded in certain companies - such as Toyota - that it is no longer thought of as a unique tool, nor is it referred to by name [14]. There, QFD is a standard business practice that is utilized company-wide. Usage may evolve to this level in the United States, but the process will be (and should be) slow, because QFD is best learned through experience and should be tailored to specific company needs [15].

2.2 The System Approach

There are several fundamental concepts which make a properly devised Quality Function Deployment scheme a competitive advantage. Each concept should be properly developed or the system will satisfy neither customer requirements nor management directives. The integration of these fundamentals is critical to enable the measurable substitute characteristics that evolve (from the true quality characteristics demanded by the customer) to become the focus of various checkpoints in the manufacturing and inspection process [16].

The first basal concept of QFD is the preservation and continuation of customer requirements - the voice of the customer [17]. Initially, customer requirements should be inputted to the matrix in untranslated form from customer verbatims or unmanipulated observations. From this point, customer needs are maintained in undissociated form throughout the product development process via matrix linkage.

The graphical matrix is the component which gives QFD a distinctive look and facilitates all product development realization. The highest level matrix, sometimes called the product planning matrix, is universally known as the House-of-Quality [18]. In this matrix, customer requirements are related to design requirements, and the design requirements carry the customers needs into part development and beyond through subsequent matrices.

The Quality Function Deployment team, or core team, is a group of selected individuals from throughout the product development organization. This cross functional group typically contains members from marketing, engineering, production, and other pertinent groups (figure 2.1). Teams should always be kept under ten members, and should be directed by a facilitator with strong interpersonal

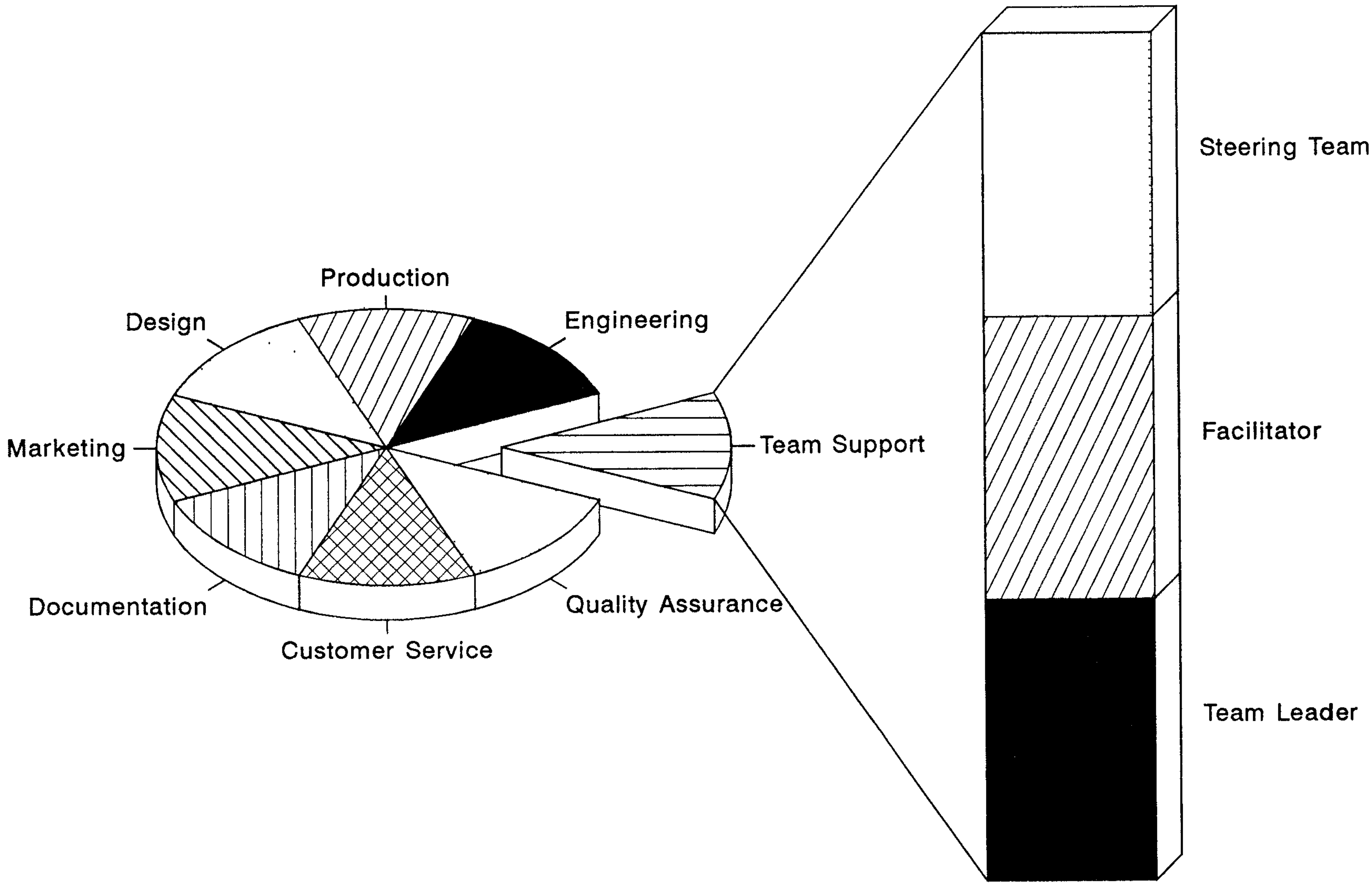

Figure 2.1 A typical QFD core team.

skills [19]. The function of the QFD core team is to provide input and expertise from the entire organization responsible for product realization. This ensures that the process is developed properly, and that all concerns and needs are addressed before product development proceeds too far.

The final key to Quality Function Deployment is simultaneous engineering. Here design, engineering and production participate in the product realization phase in a concurrent and unbiased environment. This is in direct contrast to the traditional engineering approach, which employs a linear development hierarchy. Typically this means that a design is "thrown over the wall" from the design department to the engineering group, and on to manufacturing [20]. Quality Function Deployment systematically eliminates this form of product development by drawing all related functional groups into the process.

2.3 QFD Terms and Components

There are numerous terms associated with QFD methodology, many of which pertain to matrix composition. In order to properly create and implement the QFD system, these terms must be understood. A listing of this terminology follows, and succinct definitions are included.

2.3.1 The House of Quality

The first level QFD matrix, sometimes called the product planning matrix. It is here that customer requirements are displayed against design requirements, and are where the relationships are weighted. Customer Competitive Assessment and Engineering Benchmarking are facilitated by the House of Quality (HOQ).

2.3.2 Customer Requirements

A stated or observed customer need or want. The verbatim statement or observation of a particular need should not be translated or distorted from the original content. Figure 2.2 illustrates the proper method of extracting and developing customer requirements.

PRIMARY (LEVEL 1)	SECONDARY (LEVEL 2)	TERTIARY (LEVEL 3)
PRODUCT IS DEPENDABLE	RELIABLE TROUBLE-FREE	*ALWAYS STARTS *DOESN'T STALL
	LONG LASTING	*PARTS DON'T WEAR OUT *NO PART DETERIORATION
	SERVICED FAST AND EASY	*PARTS ARE AVAILABLE *SERVICE IS FAST *SERVICE IS COMPETENT

Figure 2.2 Clarifying and deploying customer requirements. Source: Adapted from Sullivan,"Quality Function Deployment." Quality Progress, June 1986, 40.

2.3.3 Design Requirements

These are mechanisms or functions that initially meet customer requirements in the HOQ. Design requirements should have measurable standards for target objectives, such as weight, force, decibels, and so on [21].

2.3.4 The Relationship Matrix

The body of the QFD graphical display where customer requirements or any other stated need (what) is correlated with the mechanism of fulfillment. In the HOQ, this matrix relates customer requirements to corresponding design requirements. In all level QFD matrices, the strengths of relationship are depicted as either strong, medium, weak, or none. Typically, a strong relationship is accorded a "9", a weak relationship a "3", and a weak relationship a "1" [22].

2.3.5 The Correlation Matrix

A matrix which depicts the interaction between mechanisms of fulfillment, or "hows" [23]. In the House-of-Quality, this matrix plots design requirements against one another. Positive relationships are depicted as such, and functions which are in conflict are depicted as having negative correlations. The correlation matrix gives the HOQ and other QFD matrixes a distinctive triangular-shaped roof.

2.3.6 Customer Importance Rating

Priority level given to customer requirements by the respondents themselves. In the matrices deployed subsequent to the House of Quality, these ratings are assigned to needs (whats) based on previous technical importance ratings.

2.3.7 Customer Competitive Assessment (Benchmarking)

This function enables direct comparison between a company and its competitors based on customer perception.
A graphical comparison is made for each explicit customer requirement in the HOQ.

2.3.8 Quality Plan

Relative strategy for meeting each expressed customer assessment. This target is usually based on a scale of 1 to 5, as are the customer competitive assessments [24]. The current assessment for each customer requirement row is divided by the corresponding quality plan to express the desired rate of improvement.

2.3.9 Sales Points

As defined by Sullivan [25], sales points are "advertisable characteristics to be emphasized in a particular market segment". Based on this theme, product strategies are numerically represented. Typically, a 1.2 - corresponding to 120% - indicates a sales point, and these are listed in the HOQ matrix.

2.3.10 Demanded Quality Weight

The demanded weight is a relative display of the total importance a particular customer requirement carries. Both customer considerations and company policy are merged to provide this weighting. The equation for determining the demanded weight for each customer requirement is:

$$\frac{\text{Customer Importance Rating* Rate of Improvement* Sales Point}}{\text{Summation of Absolute Demanded Weights}}$$

2.3.11 Objective Target Values

The measurable terms to which the design requirements are compared and regulated. For example, if low weight were a specified design requirement, a corresponding target value would be stated in pounds, ounces, or other unit. Objective targets quantify the utility of meeting customerrequirements at the product planning stage.

2.3.12 Engineering Benchmarking

Competitive evaluations which compare a company and its competition on the grounds of conformity to design requirements. This type of competitive benchmarking is somewhat analogous to customer assessment tabulation, except that the data is obtained from in-house engineering tests and evaluations - not from customer opinion. In addition, Engineering Benchmarking compares performance with regard to design requirements, whereas customer assessments focus on customer needs. Particular attention should be given to areas where a negative relationship exists between customer perception and engineering review.

2.3.13 Technical Importance Rating

Sometimes noted as imputed importance, this capacity quantifies the contribution of each design requirement towards the satisfaction of stated customer requirements [26]. The importance rating is a critical element because it clarifies the actual accession associated with each design requirement - consequently overall development is directed by the demands of the customer instead of by the aspirations of the design and engineering groups.

2.3.14 Part Deployment Matrix

Restates the output of the House-of-Quality into parameters for critical part characteristics. This matrix is the second level in the hierarchy of linked houses [27]. Effectively, parts deployment moves customer requirements deeper into the development process.

2.3.15 Process Planning

The third level in QFD matrix development, the planning matrix registers significant process parameters and control points. A graphical display of the quality control plan is often included in this matrix, along with a process map depicting flow, and pertinent sampling methodology.

2.3.16 Production Planning

The final level in QFD is the production planning matrix, or operating instructions [28]. As alluded to by the latter, this document directs the production operators based on the parameters set forth in process planning. Of particular concern are critical process parameters and quality checks. Instructions must be included in the production plan which clearly define how a parameter is to be validated, and when this test is to occur.

2.4 Developing the House-of-Quality

The first step in the development of the product planning matrix is the gathering and organizing of customer requirements (i.e., needs and expectations) by the QFD core team. The statements and observations collected should not be translated into technical jargon, but should instead represent customer terms in rudimentary form [29].

From this point, the core team sorts and combines the customer requirements database to eliminate replicated terms, and to group them in terms of relation. Customer importance rating are then assigned to each remaining third level customer requirement based on information extracted from the respondents themselves.

The second step in this developmental process is the establishment of specific design requirements and the corresponding objective target values. These mechanisms of fulfillment should be developed with customer needs in mind, and the specified values should be measurable. If a design requirement does not satisfy any explicit customer need, the core team should consider either removing the mechanism or searching for unstated or deleted customer requirements.

Subsequent to the evolution of customer and design requirements, the relationship matrix is established. The graphical display of this function with customer and design requirements is depicted in figure 2.3. The correlation between need and fulfillment may be illustrated in either symbolic or numeric terms. From the relationship matrix, it becomes quickly apparent which design requirements are contributing towards the quality of the product, as determined by conformance to customer requirements [30].

The fourth step involves the construction of the customer competitive assessment, or competitive evaluation [31]. This utility enables a company to determine where it

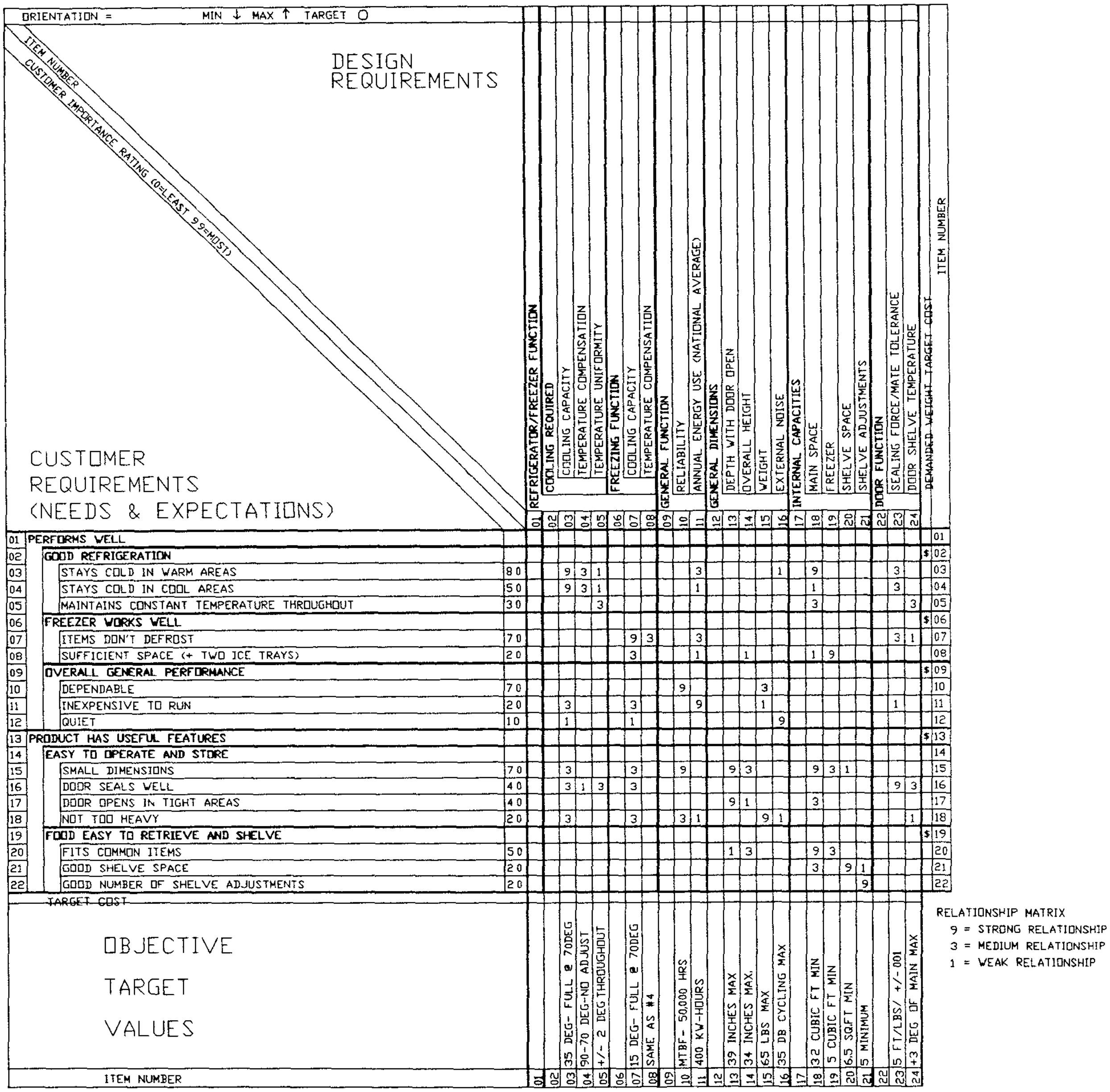

Figure 2.3 Developing the relationship matrix.

stands in terms of satisfying the individual customer requirements. A company's competition may also be evaluated on the same terms, with the results being displayed on the right side of the House-of-Quality, as shown in figure 2.4.

The marketing plan for each explicit customer requirement is added between the customer competitive assessment and the relationship matrix, and this comprises step five (see figure 2.5). Included in this section is the company rating now per the customer assessment, the quality plan or goal, the calculated rate of improvement, and the sales point. Additionally, the absolute and demanded weight for each customer requirement is calculated and displayed during this step. This step may be done manually, but it is often accelerated through the use of QFD software packages [32].

The sixth step in creating a HOQ is developing the correlation matrix, or the graphical roof of the house. As stated earlier in this chapter, the correlation matrix displays the negative or positive interaction between design requirements (columns). If a design function reacts positively or negatively with another design function, a symbol depicting the correlation and the level of intensity is placed in the matrix. This correlation may also be assigned a numeric weight to enable design optimization

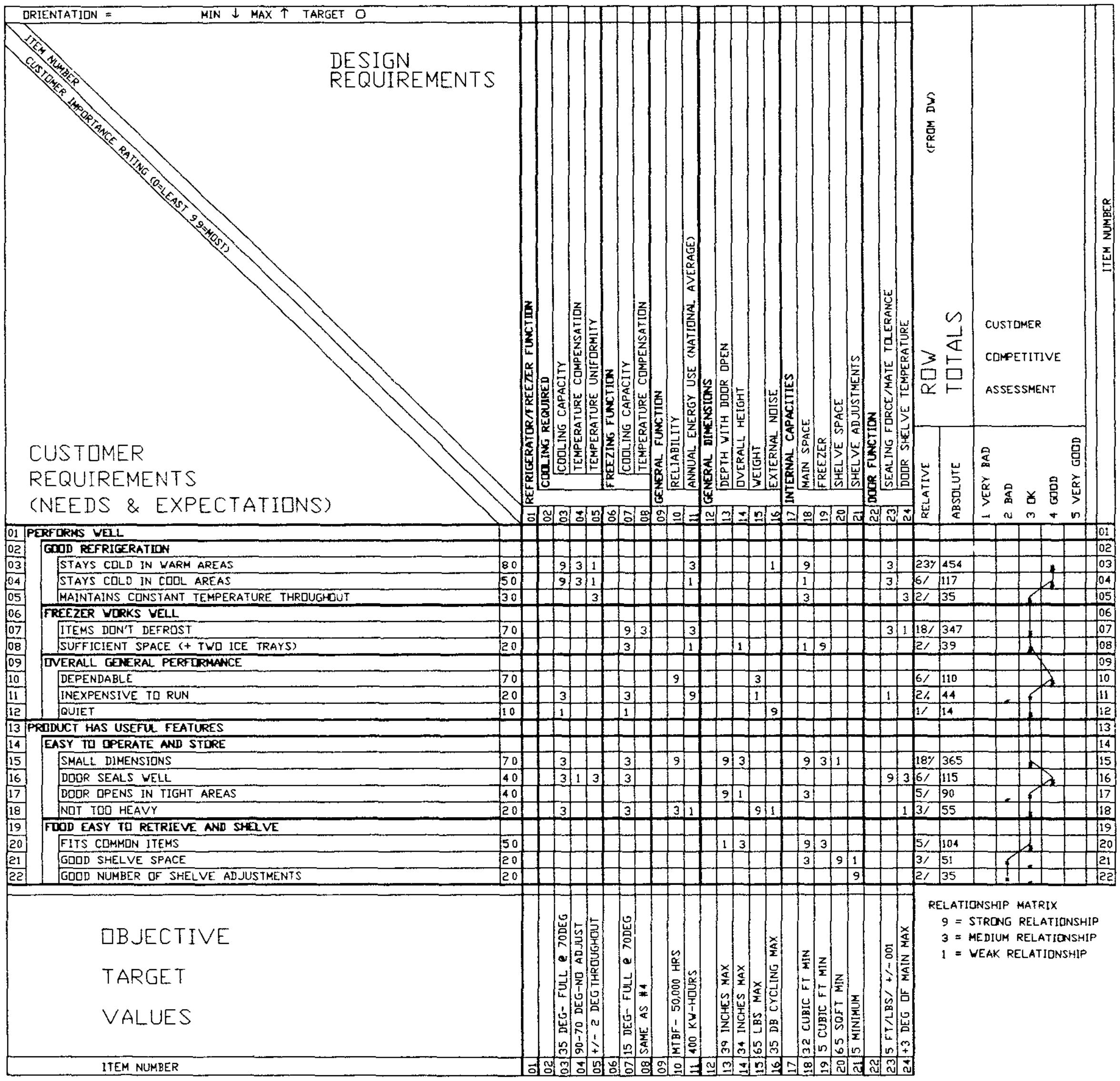

Figure 2.4 Developing the customer competitive assessment.

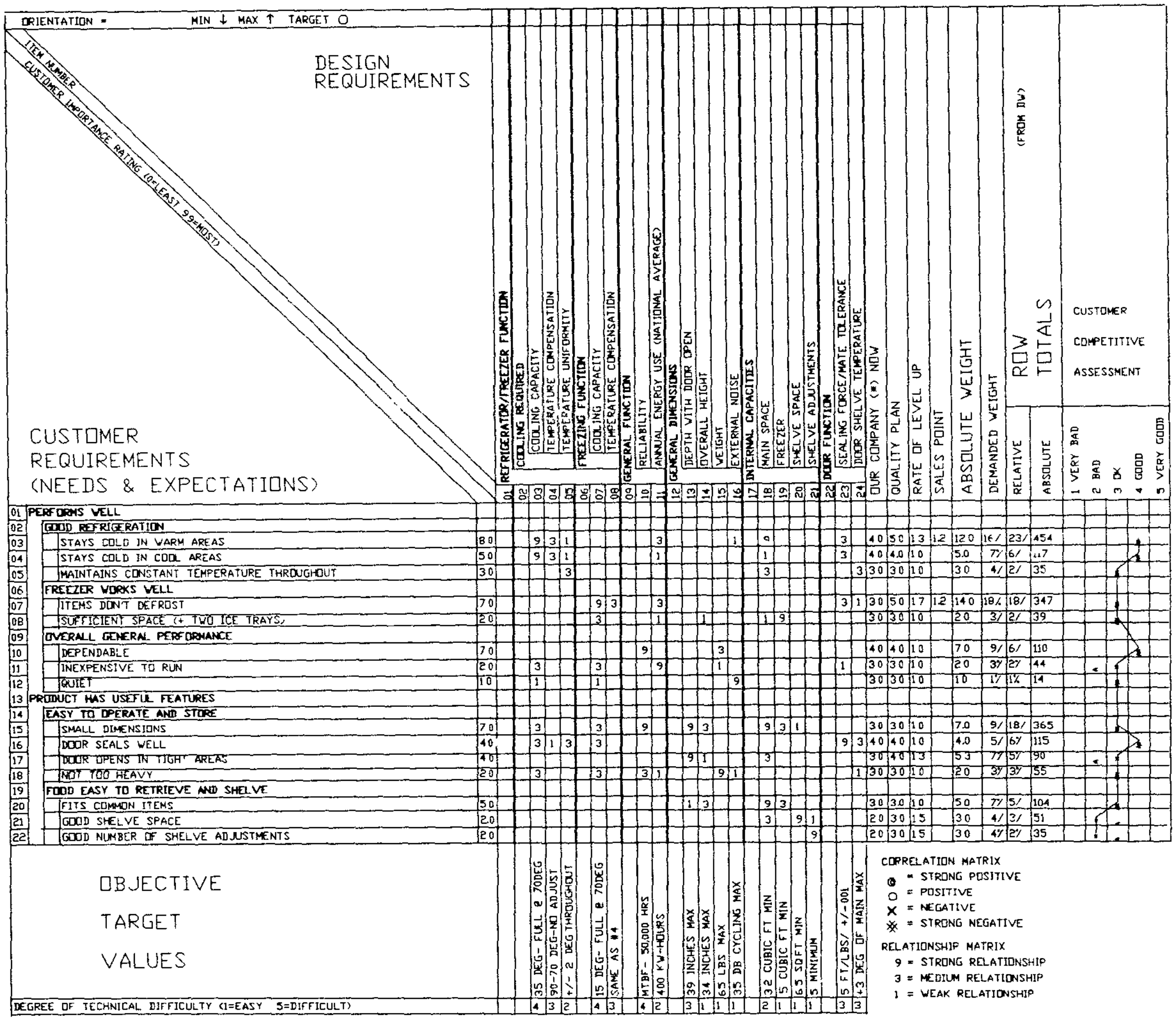

Figure 2.5 Addition of the marketing plan.

through design of experiments (Taguchi Methods) [33]. Figure 2.6 illustrates the addition of the correlation matrix to the HOQ.

Step seven, also shown in figure 2.6, is the creation of the Engineering Benchmark. Here, the engineering department analyzes each design requirement based on data realized from testing and tear-down analysis of both its in-house and competitors' products. The graphical display produced allows the individuals involved in the process to visualize potential design strengths and weaknesses. Also, any discrepancies between what the customer perceives to be strength or weakness, and what engineering develops are more evident when benchmarking is applied.

The Technical Importance rating at the base of figure 2.6 is a critical phase in the planning matrix. Often this data is generated by software packages, because manual development is laborious and prone to errors of ommision/addition [34]. In simple terms, the technical importance rating clues the core team and others to design requirements which are not contributing to customer needs. If a characteristic mechanism has a very low technical importance rating, it is either unneeded, or it is filling a customer need which has been missed in the developmental stage. In any case, this item requires further attention.

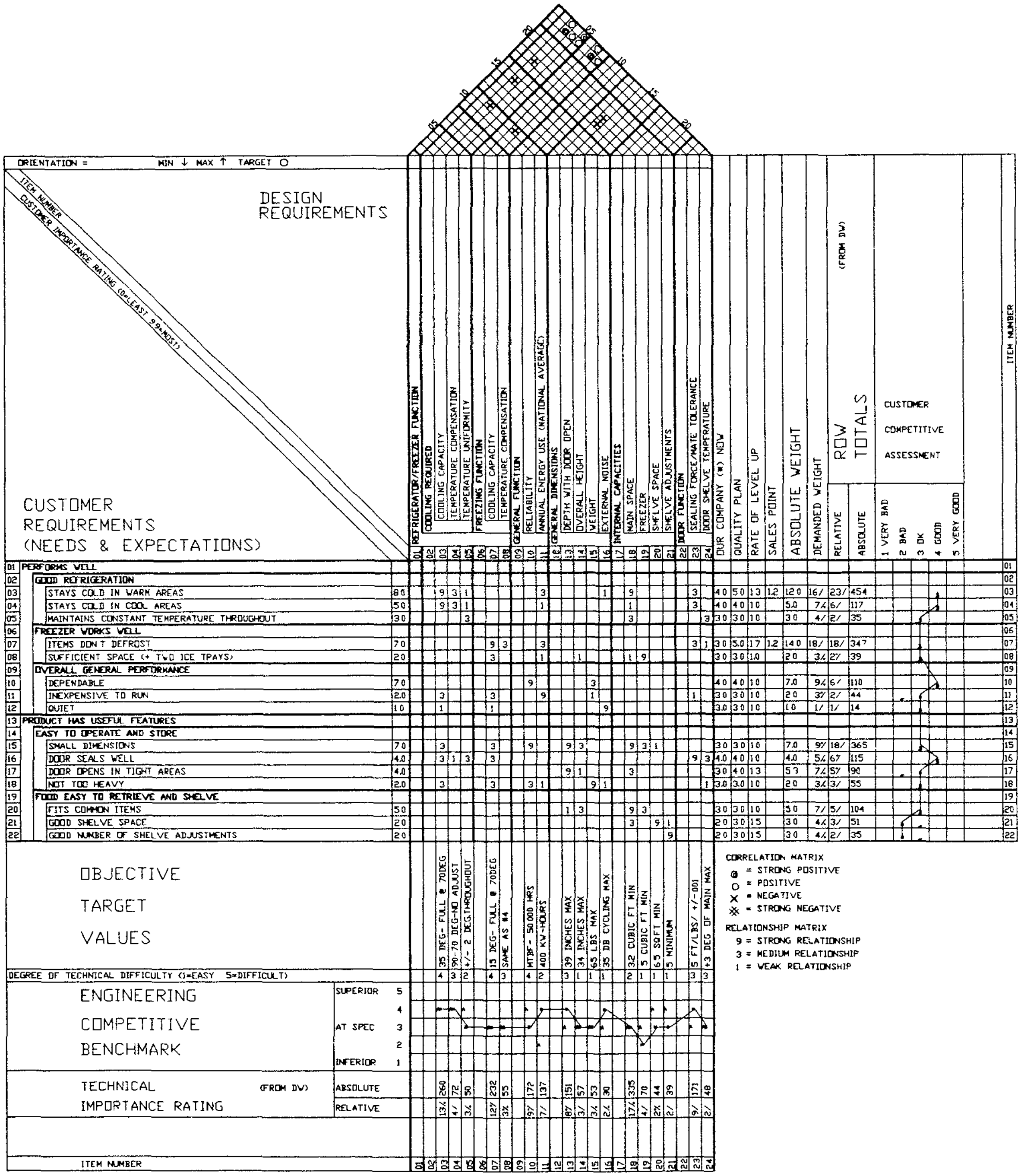

Figure 2.6 The completed house-of-quality.

Likewise, if a design requirement has a high importance rating, it may be considered especial and warrant additional regard in later stages of development [35].

The final step in this process is the selection of design requirements to be retained and subsequently deployed through the remainder of the QFD proceeding. The decision should be a based on a consensus taken from the core team membership, and should take into account the technical importance, benchmarking, and technical difficulty of the candidate mechanism [36]. The technical importance rating is most valid when the demanded weight is the subject of correlation, because the demanded weight accounts for both customer and strategic needs - the customer importance rating by itself fails to take into account strategic goals, such as sales points.

2.5 Matrix Correlation and Refinement Techniques

There are two primary QFD methodologies engaged to deploy customer requirements throughout the product development organization. Both utilize coupled matrices, but format and complexity differ substantially.

The four phased system illustrated in figure 2.7a is offered by the American Supplier Institute of Dearborn, Michigan. Following these guidelines, each decending matrix

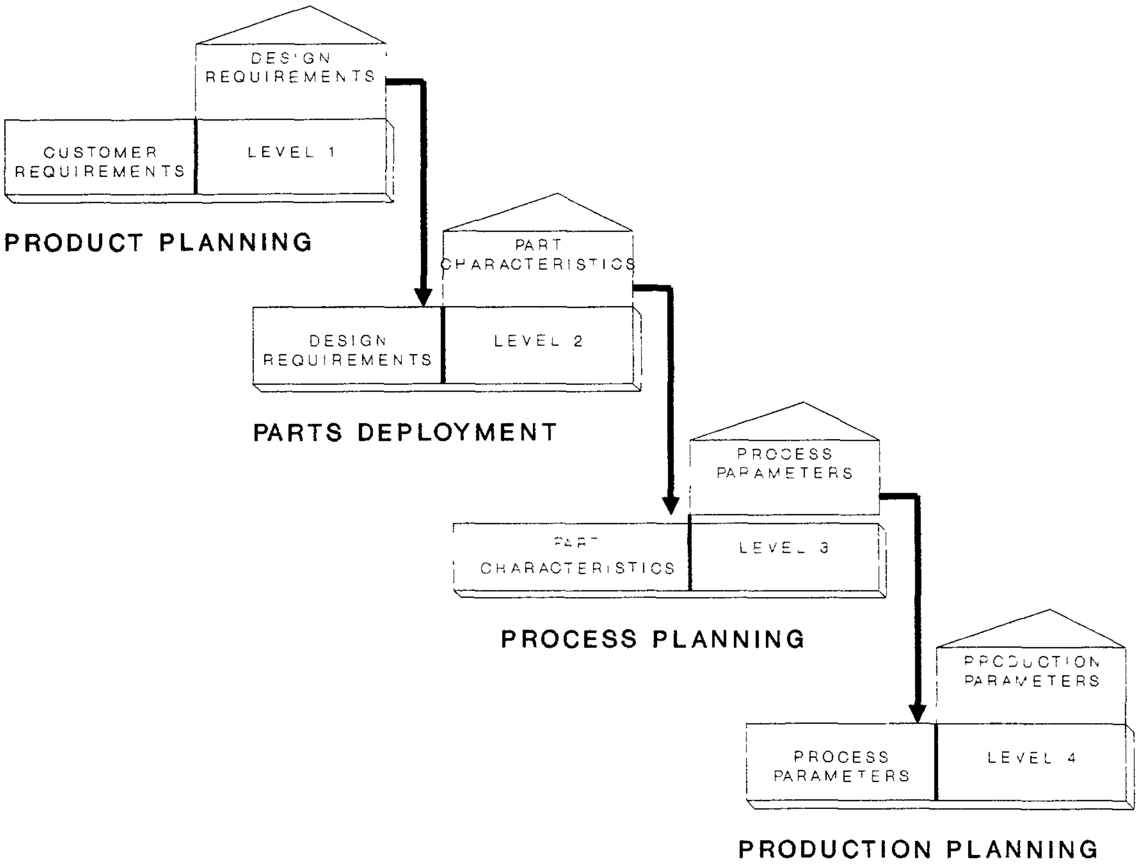

Figure 2.7(a) The four-phased ASI methodology.

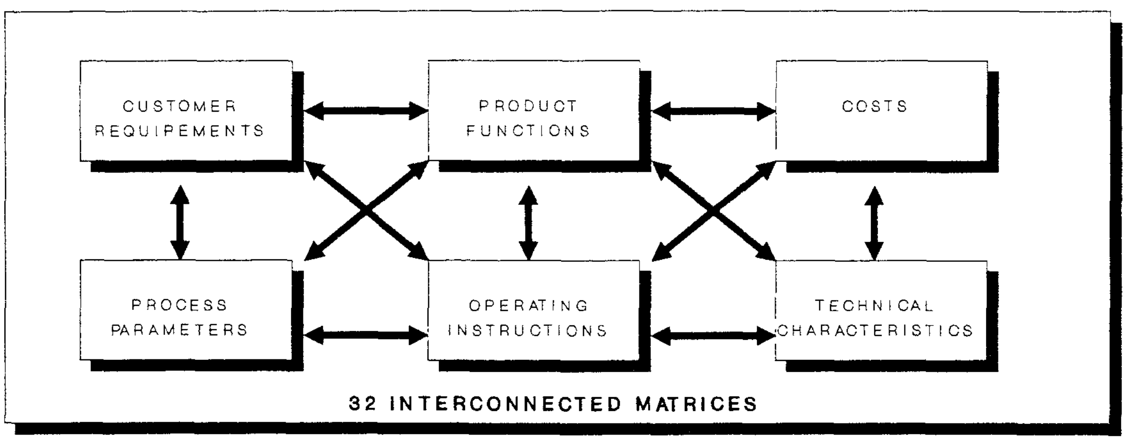

Figure 2.7(b) Goal/QPC matrix of matrices.

level draws mechanisms of fulfillment from the previous matrix, and deploys these terms within as needs to be met [37].

The first defined level in this methodology is the planning matrix, more widely known as the House-of-Quality. Design requirements developed within this matrix are analyzed for feasibility, and are retained subsequent to a favorable judgment.

The second level, the parts deployment matrix, retains the design requirements as needs or wants, and identifies the significant part characteristics necessary for satisfaction of these requirements [38]. The term "component" may be substituted for "part" for the design of a service or strategic plan.

Process planning is the third descending level of matrix development, and is where significant process parameters are identified. Part characteristics from the second level are deployed as requirements to be met in the process plan, and explicit process parameters serve as the "hows" to achieve this end. Figure 2.8 exhibits the elements of a conceptual process plan matrix.

In the fourth and final level, production mandates are advanced to satisfy the process parameters set forth in the process plan. Using the House-of-Quality for an analogy, process parameters must be addressed by production requirements in the production plan in the same manner

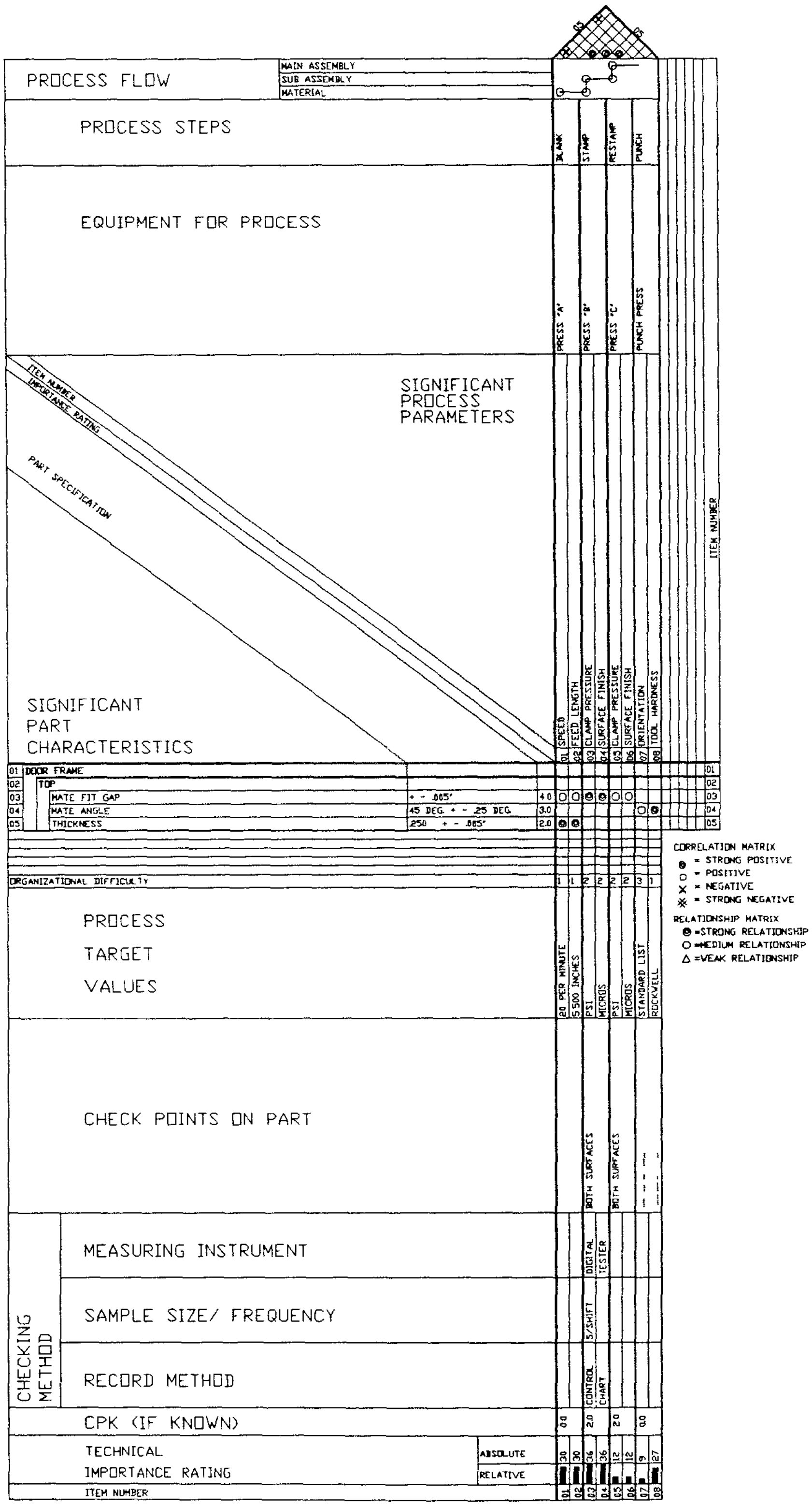

Figure 2.8 A conceptual process plan matrix.

customer requirements are satisfied by design requirements in the HOQ. The production planning matrix should express operator instructions in a concise but comprehensive format, and quality points and checks are inclusive.

An approach to QFD favored by the consulting firm GOAL/QPC interweaves 32 matrices into a single comprehensive matrix [39]. Utilizing this rationale (fig. 2.7b), the core team may analyze a plethora of scenarios, including function versus cost, customer requirements versus cost, and so on. This system not only continues focus on the voice of the customer, but also enables implementation of QFD for strategic planning issues [40].

For projects already under development, there are options which focus on a simplified approach to QFD. One such method, known as S-QFD is marketed by the consulting firm PRTM. The former acronym stands for simplified QFD, and the focal point is centered on the fine-tuning of developmental projects [41]. PUGH charts also offer another option - a quantitative method for selecting the best design from a collection of options.

CHAPTER 3
CURRENT APPLICATIONS OF QUALITY FUNCTION DEPLOYMENT

3.1 An Overview

The QFD approach is a flexible tool which can be suited for a plethora of design realization schemes. This includes both new designs, and the upgrade and redesign of existing products. Currently, the bulk of existing applications center on the development of "hard" products, as opposed to services, processes, or policies. However, there are numerous practices in these latter areas, for items ranging from documentation to strategic planning.

Almost every conceivable industry has applied QFD to some degree, and these include the automotive, electronic, communications and construction industries. The basic House-of-Quality (HOQ) has been used successfully by Japanese manufacturers of home appliances, clothing, integrated circuits, synthetic rubber, agricultural engines, construction equipment, and consumer electronics. Japanese companies also utilize QFD for services from swimming schools to designing apartment layouts [42].

This chapter will examine pertinent QFD applications from numerous industries to provide a flavor for the capabilities and adaptability of the approach.

3.2 Product Development Using QFD

3.2.1 The Automotive Industry

The most significant activity to date in the application of QFD has occurred in the automobile industry, especially in Japan. Also, many domestic assemblers currently utilize QFD, and one - Ford Motor Company - is a noted innovator in the field, through the spin-off American Supplier Institute [43]. The Toyota Motor Company originated automotive use in 1977, and its entire supplier network is engaged in QFD, with impressive results.

Toyota improved its rust prevention record from one of the worst to one of the best after having initiated the HOQ. Body durability was sectioned into 53 customer demands, and decisions on sheet metal, coating, and baking parameters were made based on the aspects most important to the customers needs [44].

The supplier of 98% of Toyota transmissions, Aisin Warner, reported that the overall effect of QFD on transmission development and start-up cycles was a 50% reduction [45]. For a particular product, customer demands focused on performance, reliability, fuel consumption, drivability, noise, and the vehicle production schedule. Smaller size and higher rotational speeds for a damper disk were the critical design requirements isolated for satisfaction of these requirements [46].

In the U.S., the Budd Company has utilized quality deployment for the design of wheel and brake assemblies, with the initial case study having started in 1986 [47]. Ford Motor developed the first domestic automobile with the benefit of formalized QFD - the 1988 Lincoln Continental, but isolated work had proceeded this launch [48].

An example of an automotive redesign facilitated by QFD is the Ford Taurus of the 1980's. While initial market research had indicated that consumers wanted fuel injected engines, QFD studies subsequent to the launch verified that drivers were really looking for more powerful engines [49].

3.2.2 The Electronics Industry

According to Electronic Business, Digital Equipment Corp., Hewlett-Packard, IBM, Intel Corp., and Texas Instruments have all developed or have announced plans to develop products using QFD [50]. In Japan, the usage of the approach for product design is widespread in consumer electronics and the computer industry, led by the Matsushita Electric Company.

NEC began designing a 32-bit microprocessor in 1987 using matrix deployment, and the results were significant. Whereas the 16-bit chip designed without QFD had four specifications wrong, rendering it dysfunctional, the 32-bit chip had no missed specifications and far fewer complaints [51].

The new palmtop computer offered by Hewlett-Packard has been defined and developed by a QFD team, and the final package is interesting. Whereas some HP executives wanted a gold colored palmtop, customer demands dictated black. In addition, extra weight was added to the unit per the team's request, so as to avoid the "plastic feel" many customers disliked [52].

Matsushita Electric, long a practitioner of QFD, developed a line of home products in the mid-1980's which targeted the general improvement of the standard of living. Since these products were not necessities, planning and development had to focus intently on the consensus of customer desires, and QFD enabled this. Among the products developed during this period was a revolutionary air purifier, which was the recipient of new customer driven technology [53]. Certain companies within Matsushita have relied on different components of QFD - especially process charts - for nearly two decades [54].

Smaller domestic firms within the electronics industry are following the lead set by the industry's innovators. BBN Communications in Cambridge, Massachusetts has designed input-output devices and other communications equipment using QFD. Among the customer demands extracted beyond what engineering had envisioned were redundant ports - on both the front and back of the units [55].

3.2.3 Miscellaneous Applications

Initial images of QFD are usually drawn from automotive applications, because of the depth of case studies and successful implementations in the industry. However, there have been positive results in numerous other sectors with regard to product development, ranging from expensive equipment to seemingly mundane low cost products.

In the communications industry, AT&T has applied QFD to a variety of projects, including lead-acid batteries, a digital telephone-transmission system, and new products in the Network Systems Division [56]. AT&T has also used the process for a host of applications not related to product development, and some of these are discussed later in this chapter.

Machining centers, injection molders and heavy construction equipment have all been developed in Japan under the umbrella of QFD. In the latter case, Komatsu Manufacturing developed 11 new models of wheel loaders on a tight schedule, after a venture agreement was terminated in 1982 [57]. These products were more representative of product redesign than new product design, because the line was an extension of existing products. Nonetheless, the marketplace judged the resulting products favorably in relation to the past performance of the company [58].

The same positive results garnered by Komastu and AT&T have been achieved by companies producing products such as air conditioners, painting equipment, and control devices for automation systems. Quality Deployment in the Construction Industry has also been cited by Akao [59] as a area of significant growth in Japan. Products include factory manufactured multiple-family housing, underground storage tanks [60], and improved floorplans.

Deployment of construction projects differs in content, and to some extent, in matrix form from that which has been outlined in Chapter 2. In the place of parts characteristics in phase two, materials properties, or simply materials, are instituted. The construction plan replaces the standard process plan in the third phase of customary QFD, and if so desired, inspection points and procedures may be implemented in lieu of production planning.

3.3 Developing Services with QFD

Quantifying the characteristics of a service is often more difficult than measuring the same for a tangible product, such as a computer or automobile. Nonetheless, there are still customer demands and corresponding design requirements to fulfill them. Again, QFD becomes a tool to formalize the design approach, with the planning matrix often serving as sufficient in itself for many cases.

While an abundance of working examples exist in Japan, maturation within the service industry is in the fledgling stage in the United States. AT&T is a current leader in this arena, and the company currently has plans to undertake several service-related projects. As forwarded by Brown [61] these include efforts to define computing service offerings and enhancements, improve internal and external documentation services, align work plans with customer values, and redesign the Network Systems order-fulfillment process.

Within the banking industry, Riffelmacher [62] has presented the concept of designing automatic teller machines (ATMs) based on QFD methodology. Also, Weyerhaeuser Mortgage has used a simplified approach to improve the dialogue between customers and lending officers.

3.4 Application in a Process Industry

This area is exclusively a Japanese realm of expertise, as is such with many of the current leading-edge applications. Koyatzu [63] has found that the best structure for deploying demanded quality in a process industry is a matrix arrangement of demanded quality and production engineering factors. Since raw materials in a process do not function independently of the other additives, materials are deployed as mechanisms, as opposed to delineated parts. Also, the quality of the overall product depends heavily on how the raw materials are individually formulated, because the final product, such as plastic, is itself a constituent of a later product, such as a pipe [64].

Koyatzu [65] has participated in the design of vinyl plastic under this approach, and has stated that the deployment led to an efficient product development cycle.

3.5 Strategic Planning and Policy Management with QFD

3.5.1 Strategic Planning

Within the U.S. Army Missile Command, Maddux, Amos and Wyskida [66] have outlined a procedure for using QFD as a strategic planning tool. The goal of this procedure was to develop a coherent strategy for the implementation of a Production Engineering Tools program. Through the evaluation of internal and external customer demands within the QFD process, primary wants and hows were developed and analyzed to determine how strategic changes might affect each [67]. Through this evaluation, an overall strategy was formulated for the initiation and management of the program.

Similarly, Kymal and Ryan [68] have outlined a modified house-of-quality that incorporates both the voice of the customer as well as company strategy, thus integrating QFD with corporate strategic directives.

Closely related to strategic planning is the use of QFD for organizational planning. As related by Cohen [69], an organizations customers are those internal groups and employees served, and the product is the range of services provided. The "voice of the customer" is easily obtained through the companies internal networking system or through simple inter-department contact. This procedure has been in place at the DEC corporation since as early as 1988 [70].

3.5.2 QFD for Policy Management

Sullivan [71] has found policy management to be a very creative soft application of QFD. Defined, policy management is the structured method to achieve a companies business or policy goals, with the work being done by top management. The matrix charts are used to illustrate and organize policy objectives, and the corresponding activities, inspection points, and adjustments. The benefit of this procedure is that it focuses management on the company business plan, in the same way engineering and design focus on the customer during product development [72]. Similar work has been achieved in Italy, and has been reported by Galgano [73].

3.6 Software Development

Actual applications of QFD for software development have been evident in Japan since 1982, and more recently, applications have been reported by several companies, including IBM, NEC, Nippon Systems, and by several trade associations [74].

In the United States, AT&T has used QFD for defining software tools and for planning software development environments. As reported by Brown [75], the customer demands are concerns relative to the purpose the software would fulfill. These might include the number of tasks reported, availability, documentation, and so on. The subsequent phases of the process would then specify items such as the support hierarchy and the specific programming language needed.

CHAPTER 4
COST DEPLOYMENT BASED ON QFD

4.1 Introduction

The function of cost deployment is to build into the design and development process a systematic method of reducing product cost, while simultaneously addressing quality [76]. In theory, the cost of a product or service should be directly related to the inherent quality of the said product, as defined by the customer. Likewise, Taguchi has devised a similar concept - Quality Loss Function - which states that the quality of a product is determined by the overall cost transmitted to society during the product life-cycle [77].

The product attributes which together constitute quality as a characteristic are generically denoted by the initial letters FURPSAP, and are listed as follows:

- Functionality
- Usability
- Reliability
- Performance
- Supportability
- Availability
- Price

These characteristics of quality collectively form the demanded quality for a product, when explicitly sought after by the customer [78]. A detailed definition of each attribute follows in this chapter.

Specific measures and targets for the attributes of quality are to be established at the onset of product development, and cost deployment based on Quality Function Deployment is an effective procedure for doing this. To advance the procedure, specific demanded quality features are divided into 2 subgroups: Target Cost and Target Quality.

The target cost replaces the ambiguous attribute "price" by setting a measurable objective to which the final product cost before profit must conform. The remaining attributes are represented in the product as targeted qualities or features - those customer demands selected for implementation. By assigning the product target cost systematically to the targeted qualities based on proportional importance, a dollar value is equated with each customer requirement [79]. Quality Function Deployment provides the formalized structure for dispersing the target cost among customer and design targets, and further on to part characteristics.

4.2 Target Quality Development

During the early stages of product planning, market research provides the basis for establishing the major product specifications or characteristics. This step correlates to the concept and feasibility phase in the seven phase concept of product development (Juran) [80]. Here, the known or anticipated need for a product or service is studied in enough detail to determine whether a market exists, and if it is feasible or worthwhile to capture.

After a particular market has been targeted, marketing research works in conjunction with the QFD core team to configure a list of desired or demanded features. This list can be developed through a number of mediums, but the questionnaire is among the most effective, because customer verbatims are captured in the rough [81]. Each of these customer demanded features fall into one of the first six attributes of FURPSAP - or demanded quality - and are further delineated based on degree of importance into target qualities.

A complex product or service has a set of measures that relate to customer satisfaction: FURPSAP elements [82]. The overall quality of a product is determined by how effectively the product meets these elements, which are defined as follows:

Functionality: The group of features and functions fulfilled by a given product or service. The more demanded functions a product performs, the greater the implied functionality.

Usability: Measures how easy a product is to use, relative to the number of functions. The term "user friendly" would suggest a high usability standard.

Reliability: Reliability measures both the ability of a product to perform over time (mean time between failure), and how closely a product equates to design specifications.

Performance: The level at which a product performs the design functions. Performance is usually expressed in terms of accuracy, efficiency, and response time, and is easily quantified [83].

Supportability: As defined by Shores [84], serviceability is the measure of the customers cost to maintain the services of a given product. The following formula 4.1 (Shores et al) provides an index of serviceability (supportability):

(4.1)

Serviceability Index = [Cost of Service Documentation + Average Annual Cost of Repair + Average Annual Cost of Calibration or Preventive Maintenance + Annual Cost of Downtime] / Selling Price

Availability: Availability is both the time it takes to introduce a new product to market, and the lag time between order procurement and delivery. QFD facilitates availability in the context of reducing development times.

From a collection of numerous customer desires, a selected group of targeted qualities is extracted. This is done because representation of all possible respondent demands is an admirable yet unconscionable objective. The designated target quality for a product is then either injected into the QFD planning matrix (as customer requirements), or is classified by the measurable quality attribute it correlates to. For example, target qualities relating to supportability would be catalogued under this attribute.

The purpose of this additional procedure is to reduce the number of elements to be entered in the QFD planning matrix, by enabling the creation of a second related planning matrix. Past experience in QFD exercises has shown that matrixes larger than 60 by 60 (3600 possible relationships) become counterproductive [85]. By dividing the demanded qualities into marketing and sales classification and engineering/design/manufacturing classification, deployment of target qualities becomes feasible for complex undertakings. The single multi-functional core team simply develops both a service matrix and a product matrix.

4.3 Target Cost Evolution

Quality based cost deployment borrows a couple of key points from the design-to-cost (DTC) approach. In the DTC method, the starting point is a life-cycle target cost and a statement of the overall function desired [86]. Thus, cost deployment is a variation of the DTC technique which establishes cost as a parameter scaled to quality added.

Cost deployment (CD) or a standard DTC approach, such as MIL-STD-449A, should not be confused with value engineering. Value engineering is a technique which evaluates designs to assure that necessary functions are provided at a minimum cost [87]. This is in contrast to the CD/DTC approaches, which establish target costs before any design takes place.

The practice of designing a product to a specified target cost is in direct contrast to the conventional design approach. Traditionally, a design is first created, and then the cost is estimated and evaluated for practicability by accounting (see fig.4.1) [88]. This conventional approach has been cited as a shortcoming of U.S. industry when compared to the cost-driven development process used by the Japanese [89]. Where-as products designed with little regard for a cost objective are subject to sophisticated post-design cost accounting and subsequent redesign, products developed to a targeted cost require less of both. Costs are

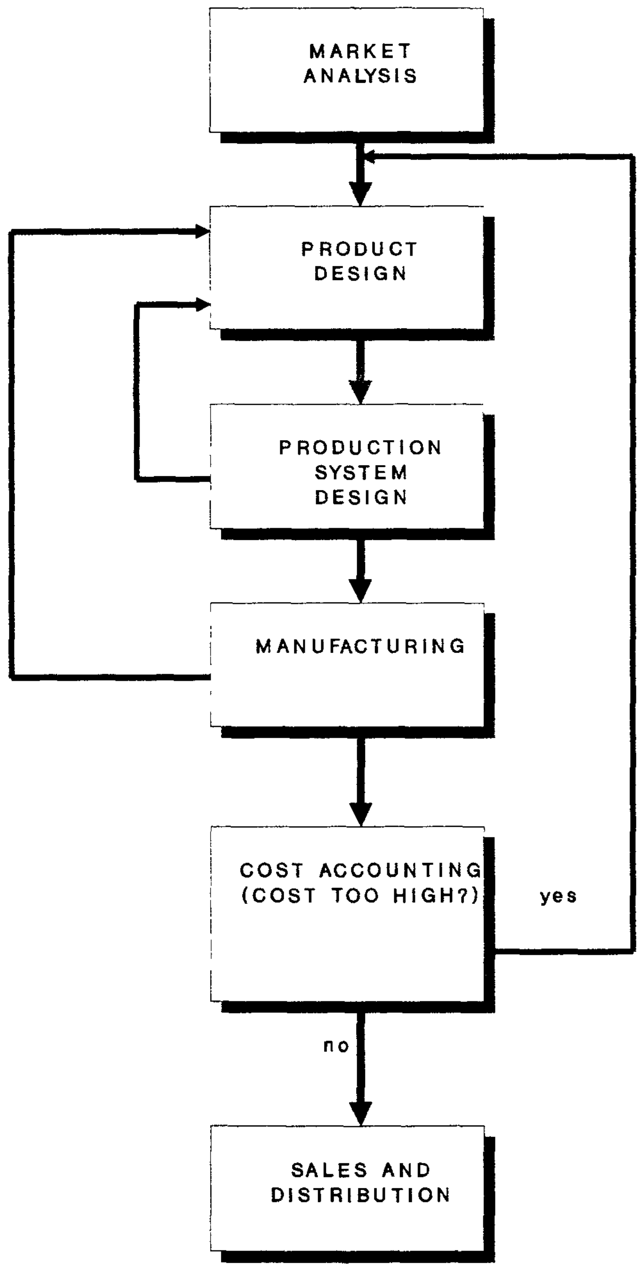

Figure 4.1 Traditional product development.

driven out between functional groups through simultaneous engineering and other routines, to the point where sophisticated accounting methods and redesign are dispensable [90].

A product target cost is developed is usually the net difference between the targeted selling price and the targeted profit [91]. A system for further dispersement of target costs is the subject of the next section - Cost Deployment based on QFD.

4.4 Cost Deployment Based on QFD: Methodology

Figure 4.2 shows the process outline for development activity using cost deployment. At the conceptualization stage, marketing research provides the basis for general product or service characteristics. From this level, marketing research works in conjunction with the QFD core team to extract more specific customer requirements for the product in question (i.e. verbatims) [92]. These customer expressions may run a wide gamut, but each nonetheless falls into at least one quality attribute category.

The products overall target cost is formed by marketing research before any design takes place. Initial product demand qualities with the highest imputed importance are designated as target qualities, and are subsequently entered into the QFD planning matrix as customer requirements (see fig. 4.3) [93].

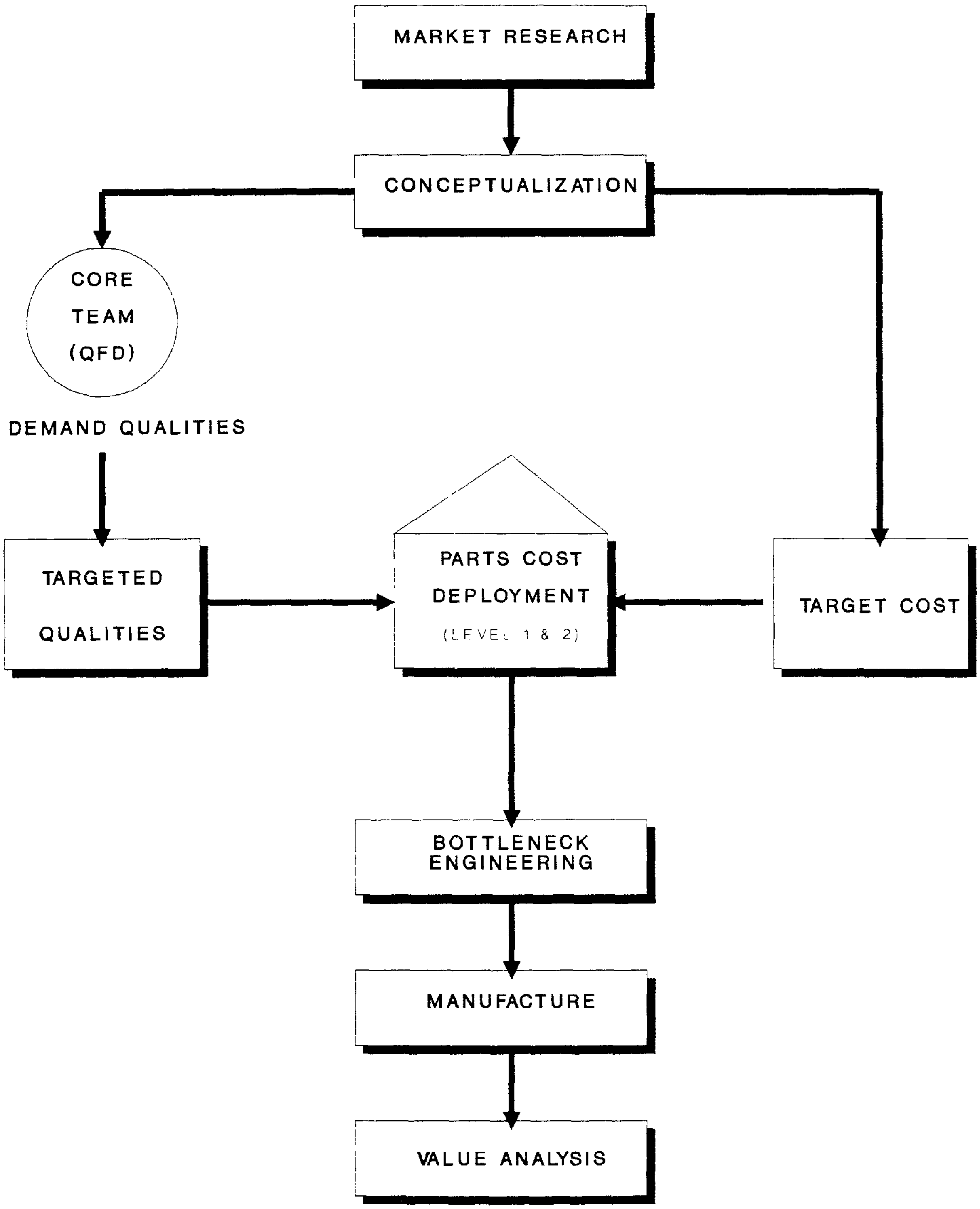

Figure 4.2 Cost deployment in product development.

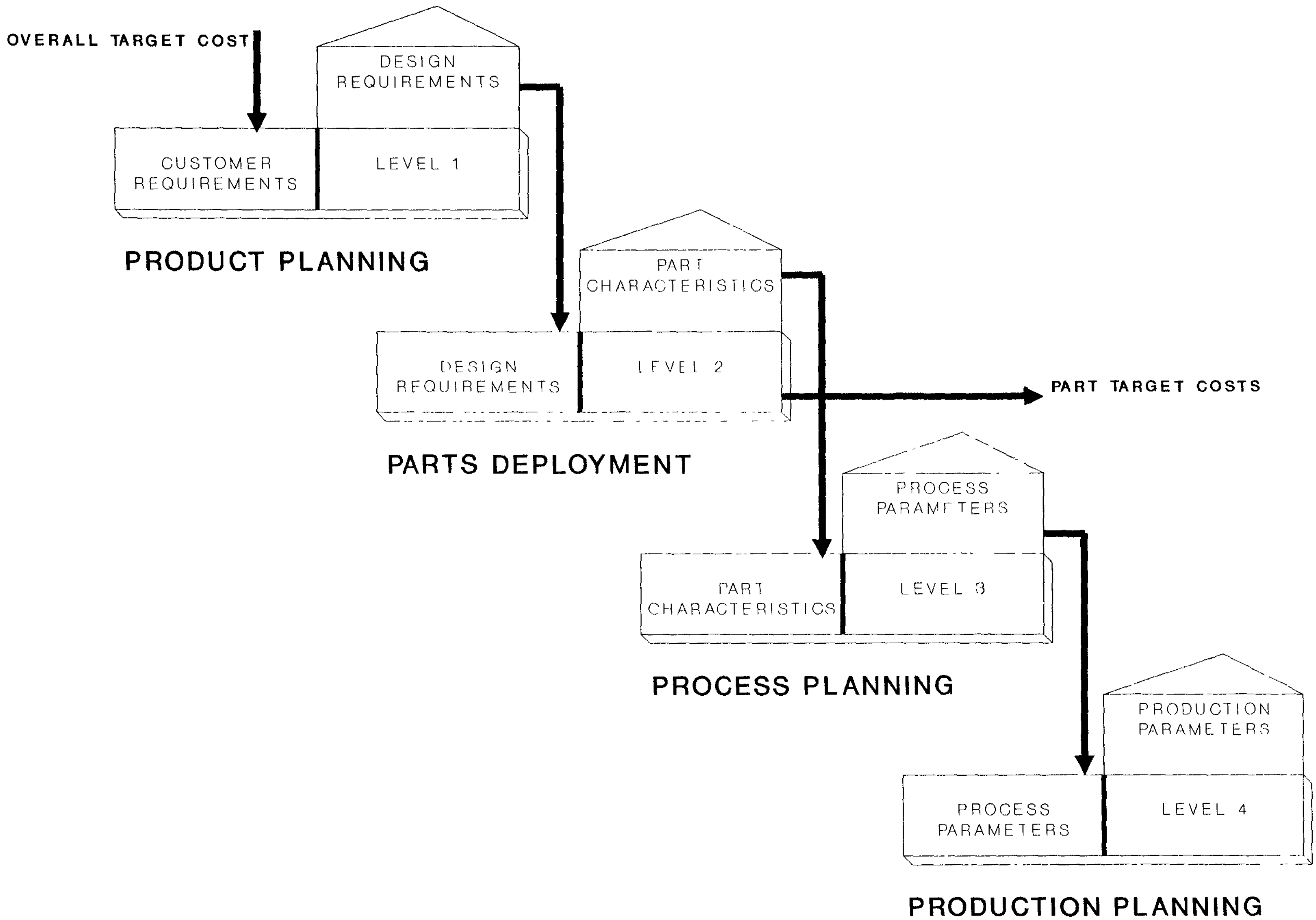

Figure 4.3 Parts cost deployment.

In the ensuing phase, cost deployment based on quality deployment is a five step process, as follows:

1. Determine the demanded weight for the individual customer requirements.

A demanded weight for each customer requirement is calculated using the technique outlined in Chapter 2 (pp.16). The demanded weight considers both customer needs and company objectives, so it is a more representative index of value added than the customer importance rating (CIR) alone. Most QFD software packages will calculate this weight upon request [94]. Relative weights for each customer requirement are calculated by simply dividing the absolute weight by the sum of the whole column.

2. Determine demanded weight cost.

The product target cost is dispersed among the design requirements according to the relative demanded weights. Table 4.1 demonstrates this technique.

Table 4.1 Developing element target costs - $120 base.

Target Cost	Relative Demanded Weight	Element Target Cost
$120.00	6.5 % 1.2 % 2.0 %	$7.80 $1.44 $2.40

3. Design requirement cost.

When a demanded weight is divided into the design functions, the resulting element is the technical importance rating (TIR) - the contribution of each design element to quality. The design requirement cost is extracted in the same manner as the demanded weight cost, using the TIR as a meter.

4. Part cost deployment.

The target cost for each product part element is obtained by deploying the design requirement cost among the parts characteristics in the parts deployment matrix. This is based on the relative technical importance rating for each item. A high technical importance rating implies a substantial contribution to quality, and the part cost target signifies this accordingly.

5. Review parts which exceed allocated target costs.

When a part target cost is exceeded by the actual quoted cost, simultaneous design review is necessary. This includes both study of the design, and of the proposed production methods. For either exploration , bottleneck engineering (BNE) generally solves the problem [95]. Quality control tools such as paretto diagrams and cause and effect analysis may be applied while performing BNE.

If too many demanded qualities are extracted for a product, it is may not be reasonable to develop a single planning matrix. Instead, the initial product target cost may be allocated to different functional groups based on product attribute responsibility. This may be done by using a product attribute matrix (fig.4.4) [96]. This dispersion is preferable to activity based allocation, because activity does not always equate to quality or value added [97]. For example, the marketing and sales organization might be allocated 40% of the overall product target cost, with the remaining element earmarked for design , engineering, and manufacturing. From this allotment, two separate matrices would evolve, one directed to service and support, another towards the product itself.

Attribute	R&D	Marketing	Manufacturing	Quality Assurance
Functionality	d	d	i	n
Usability	d	d	i	n
Reliability	d	d	d	i
Performance	d	d	d	i
Serviceability	d	d	i	n
Availability	d	d	d	n
Price	d	d	d	n

d = direct influence i = indirect n = no influence

Figure 4.4 Product Responsibility Matrix.
Source: A. Richard Shores, Survival of the Fittest (ASQC Quality Press, 1988), 126.

4.5 An Application of Cost Deployment

4.5.1 Introduction

An experimental application of cost deployment based on QFD has been undertaken within the scope of this chapter to illustrate the concepts and contentions previously forwarded. Cost deployment as a process has been used utilized in Japan by the Nippon Steel Works and Toyada Machine, but few if any applications have been attempted in the United States [98]. This is most likely a consequence of the 10 year lead the Japanese have with regard to QFD. Nonetheless, full-scale integration of QFD with cost reduction and other strategic concerns will occur in the U.S., though when and to what extent are unknown.

4.5.2 Preliminary Assumptions

To both examine cost deployment and conduct a viable exercise, a real product was chosen for this application - an intermediate refrigerator. Intermediate refrigerators are defined by internal capacity, which is between 2 and 4 cubic feet, and the units universally contain a small freezer area [99].

These refrigerators contain a many of the same rudimentary components as the larger units, but do not contain the abundance of accessories common to the same [100]. These characteristics make the intermediate a good candidate for trial cost deployment, because the design contains enough parts to exemplify the process, yet not so many to make the matrices burdensome.

The refrigerator has five primary parts - the body, the compressor, the evaporator, the condenser, and refrigerant-filled tubing (fig. 4.5).

The compressor squeezes and pumps the refrigerant through the sealed tubing leading to the evaporator and condenser. The refrigerant compressed is usually Freon type R-22, although a new breed of refrigerants are being developed for CFC elimination [101]. The cycling of the compressor is controlled automatically by a thermostat.

The evaporator enables the Freon to expand and vaporize, thereby causing a cooling action. In other words, the evaporator is a low pressure area. Smaller refrigerators have the evaporators located in the freezer section to enable the heavier cool air to descend into the main compartment [102]. No evaporator fan is employed.

Condenser function is self-descriptive, and within this part, the refrigerant is placed under high pressure from the compressor. While the pressure is increasing, the vaporized Freon liquefies and loses previously retained heat. The transfer of heat from the Freon is facilitated by cooling fins and a fan, which increase air volume and cross sectional cooling area. The condenser is pressure-isolated from the evaporator by a capillary tube.

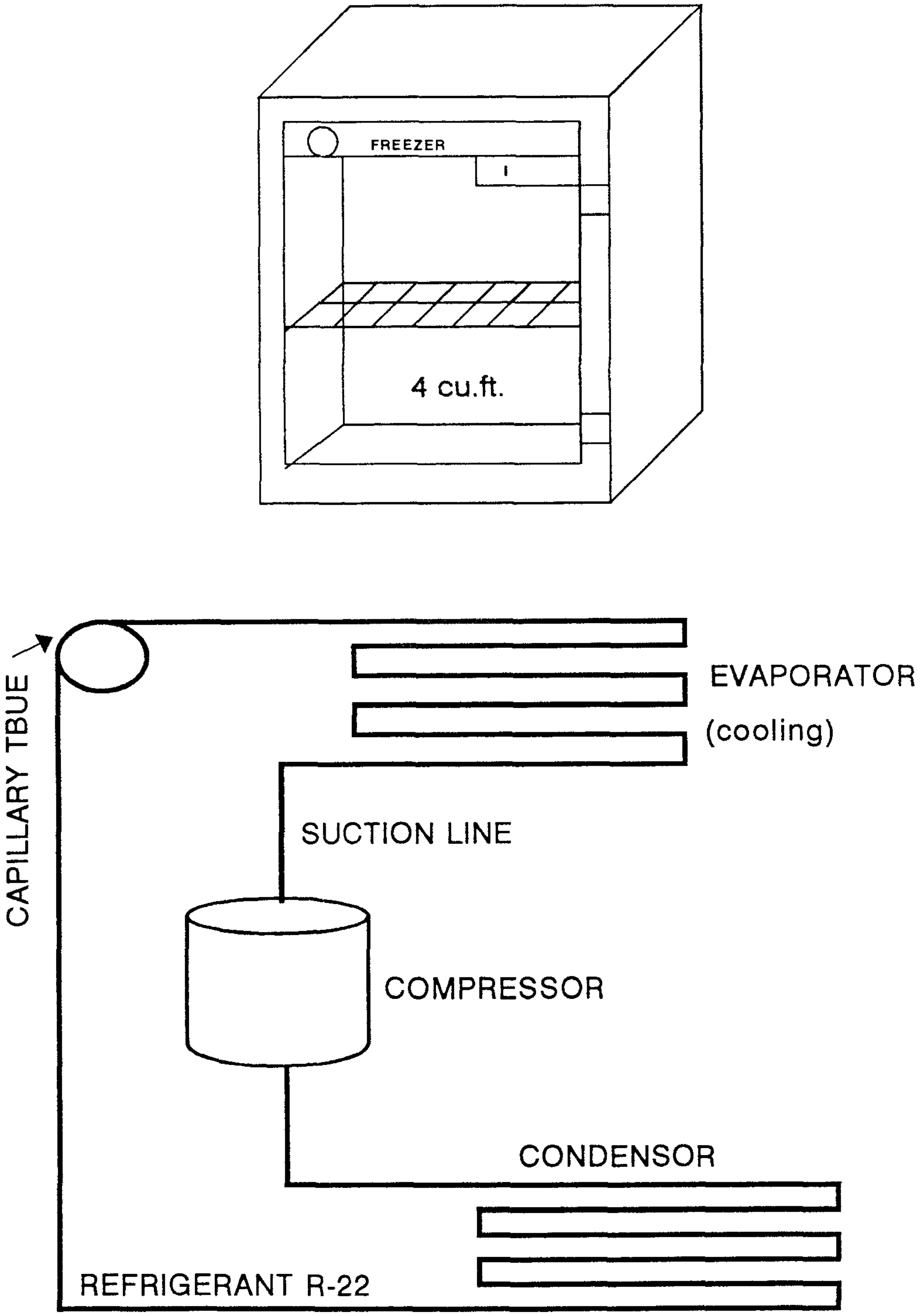

Figure 4.5 Intermediate refrigerator design w. door-off.

Within the refrigerator body, there is a plastic/metal liner and inter-wall insulation. The insulation is a critical component in small refrigerators, because it directly effects the physical size of the unit, efficiency, compressor cycling, and temperature uniformity. In addition, CFC regulations and 1993 energy standards place additional constraints on the use of foam insulation, many of which are not sufficiently met by current technology [103].

The focus of this deployment will be on the functional aspects of refrigerator design, and not on the service and documentation demands. While these concerns are equal in importance to physical product features, it is beyond the scope of this exercise to amortize the total product cost to all functional areas. Instead, approximately half of the average pre-profit cost of an intermediate refrigerator ($100) will be allocated to the QFD development. This number also simplifies the allocation calculations and clarifies the process for the reader.

4.5.3 Data Collection

The primary sources of demanded qualities for a product are developed through marketing research in coordination with the core team. Most often, special customer surveys, focus groups and specialty periodicals are used to gather this critical initial information. For this reason, Consumer

Reports magazine was chosen for the acquisition of customer requirements and many target objectives for this example. The magazine is not only a form of the "consummate consumer", but the evaluations included are subjective, and influential with regard to potential customers [104]. This is not to say that there are no deficiencies with this method, but lacking other data, it is the best alternative.

The primary demands extracted from Consumer Reports evaluations were the ability to cool the refrigerator area effectively to 35 degrees, and the ability to maintain a 15 degree freezer temperature [105]. Since no product tested cooled either compartment to these objectives under any test condition, these items have been targeted as sales points for this exercise, because they would differentiate the product from any other on the market. Other functions which carry explicit demands which are addressed in the deployment matrix are:

- Cooling and freezer space
- Dimensions
- Door size
- Energy usage
- Overall convenience

4.5.4 Developing the matrix and part target costs.

The targeted customer requirements selected are shown in figure 4.6 under the needs and expectations heading, with features and performance being the first level concerns.

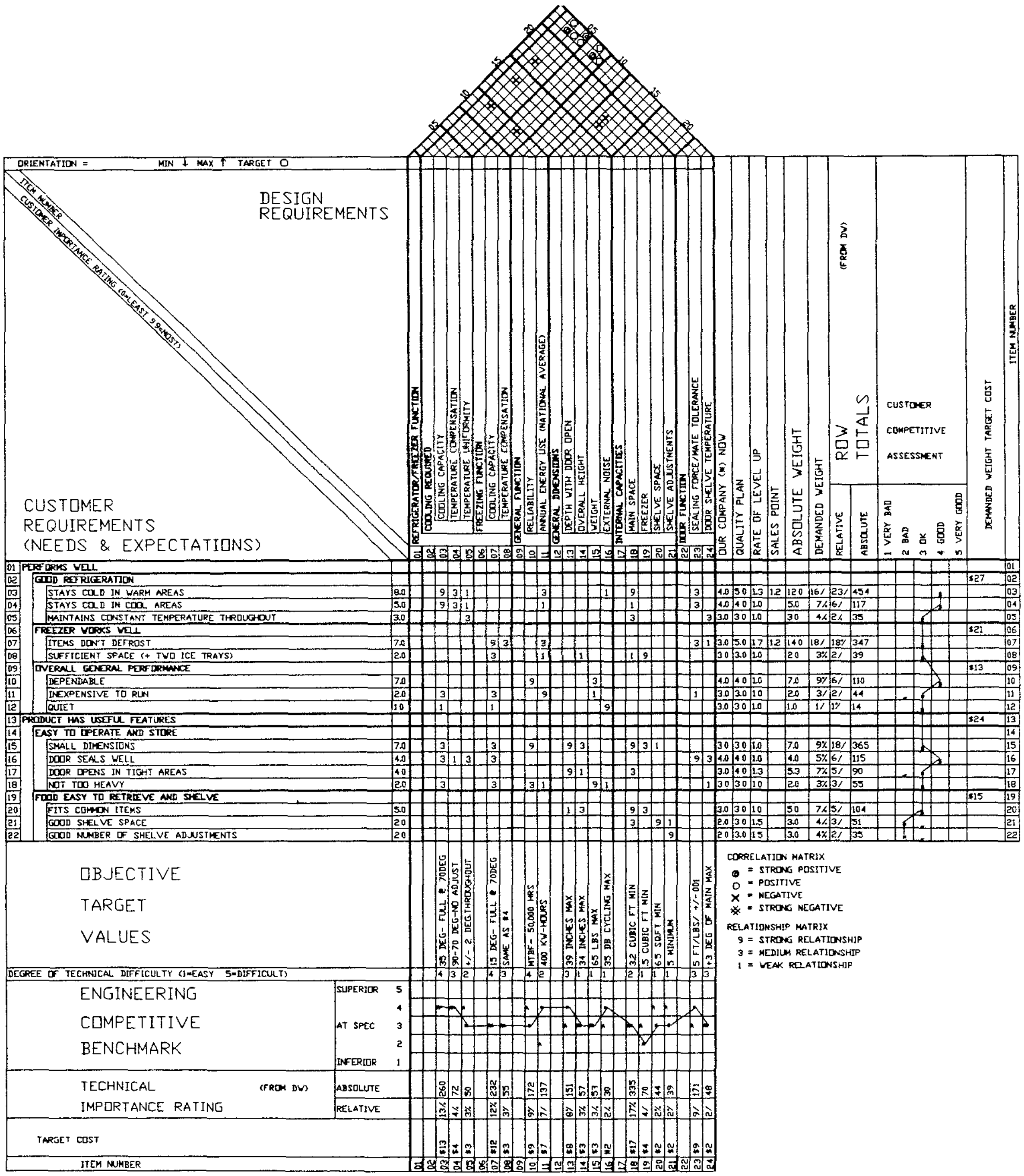

Figure 4.6 Developing design requirements target costs.

Through affinity combination, the secondary needs have been assigned to either performance or functional hierarchy. Customer importance ratings are assigned relative to explicit statements or inferences from the Consumer Reports evaluation [106].

The quality plan and benchmarking were derived from the point of a hypothetical manufacturer desiring to build an intermediate refrigerator unsurpassed in the class. Sales points indicate areas where a refrigerator design could equate into an advertisable feature, because no existing product completely fulfills the need. The products benchmarked against were the two leading intermediates, as determined by the forementioned periodical, namely the Euro-Cold and the Goldstar models [107].

Beginning with the allotted $100 overall target cost, demanded weight target costs were allocated based on the individual relative demanded weights. As shown in figure 4.6 in the far right hand column, the largest targeted cost was for "good refrigeration" due to the 27% load assumed by the customer requirements under this item.

The design requirements were developed using comparisons against the refrigerators with the best current individual functions. For example, the design requirement "main space" (under internal capacities, fig. 4.6) has an objective target value of 3.2 cubic feet. This is equivalent to the best in class value for space measured in the Euro-Cold intermediate [108].

The target costs for each design requirement are administered according to the technical importance ratings for each design function, and are detailed at the base of fig. 4.6. These numbers were generated by the QFD-PLUS software based on correlations between design functions and demanded weight. The function "main space" received the highest allocation due to the satisfaction of 17% of the total demanded weight column.

The parts deployment matrix shown in figure 4.7 was generated from phase one design requirements and corresponding part mechanisms. Parts were selected based on information provided by various refrigeration technical manuals [109]. Design requirement target costs were carried over from the planning matrix, and were regarded in the same fashion that the customer importance rating (CIR) would normally be. This is where in fact the method carried forth in this example varies from other cost deployment procedures. Often, CIR's are developed for the phase two matrix in addition to the ones formulated and implemented in the House-of-Quality [110]. This can work if care is taken to eliminate potential incongruity between ratings, but it is still dangerous because the contradictions can often be subtle.

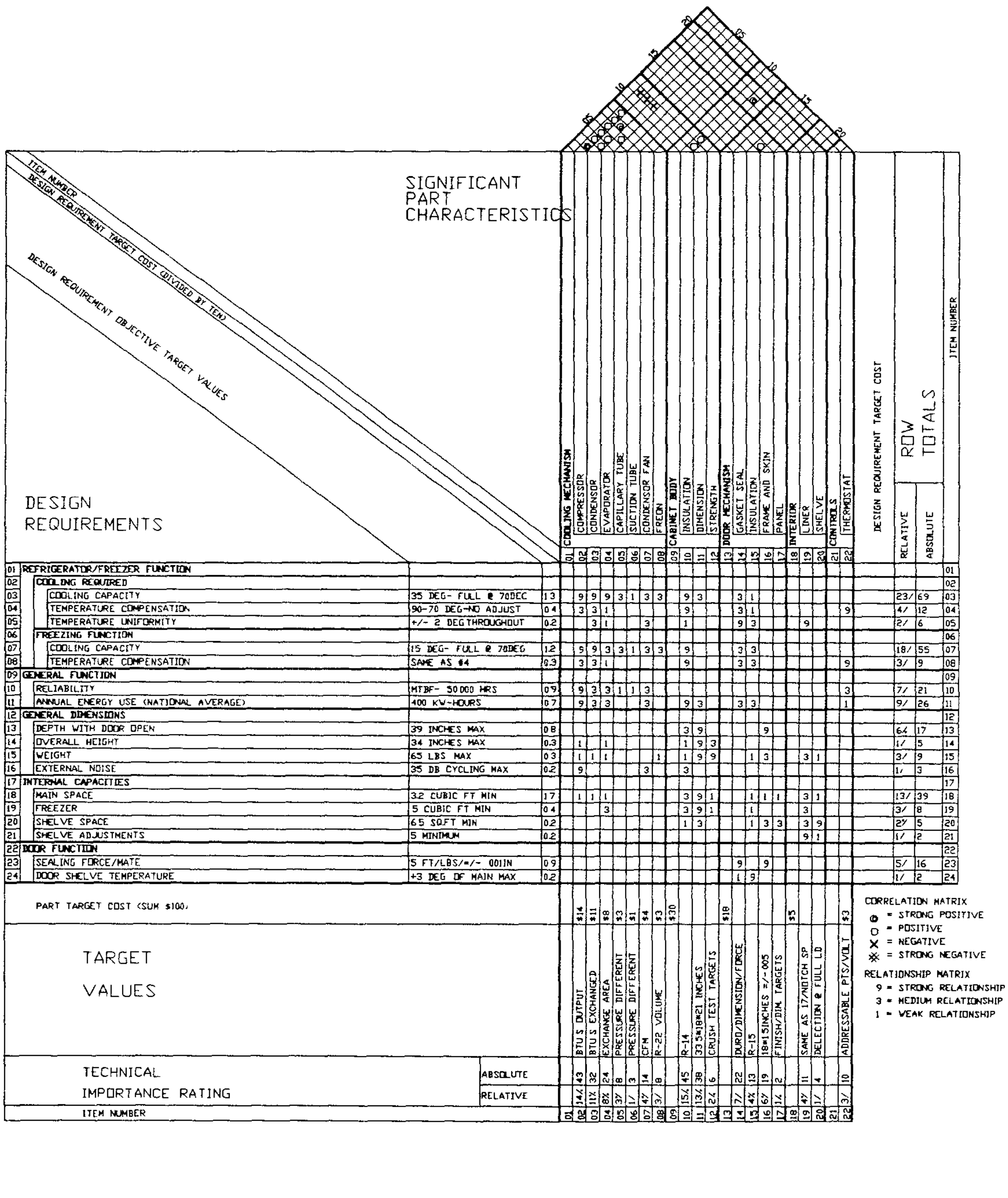

Figure 4.7 Developing part characteristics target costs.

The final parts target costs are developed as in the planning matrix, only that the technical importance rating is calculated from the design requirement target costs met, not demanded weights. Figure 4.7 shows the part target costs in the row under design requirements. These targets equate to the relative number of customer needs each part ultimately satisfies.

4.6 Part Review and Corrective Action

Once the target costs for the parts characteristics have been determined, the process of review begins. Cost deployment is a heuristic tool, not an optimization model, so the results should be treated as such. If a part is slightly over or under target, it is not always necessary to complete a formalized analysis. But, for significant discrepancies, simultaneous design and production review is required, and this can be separated into two elements: 1) Review of the QFD methodology and 2) Bottleneck engineering [111].

The former entails a reassessment of the original customer and design requirements to find latent elements which the part characteristics in question might be addressing [112]. If this approach yields no new customer needs for reallocation of costs, then bottleneck engineering is required for the part.

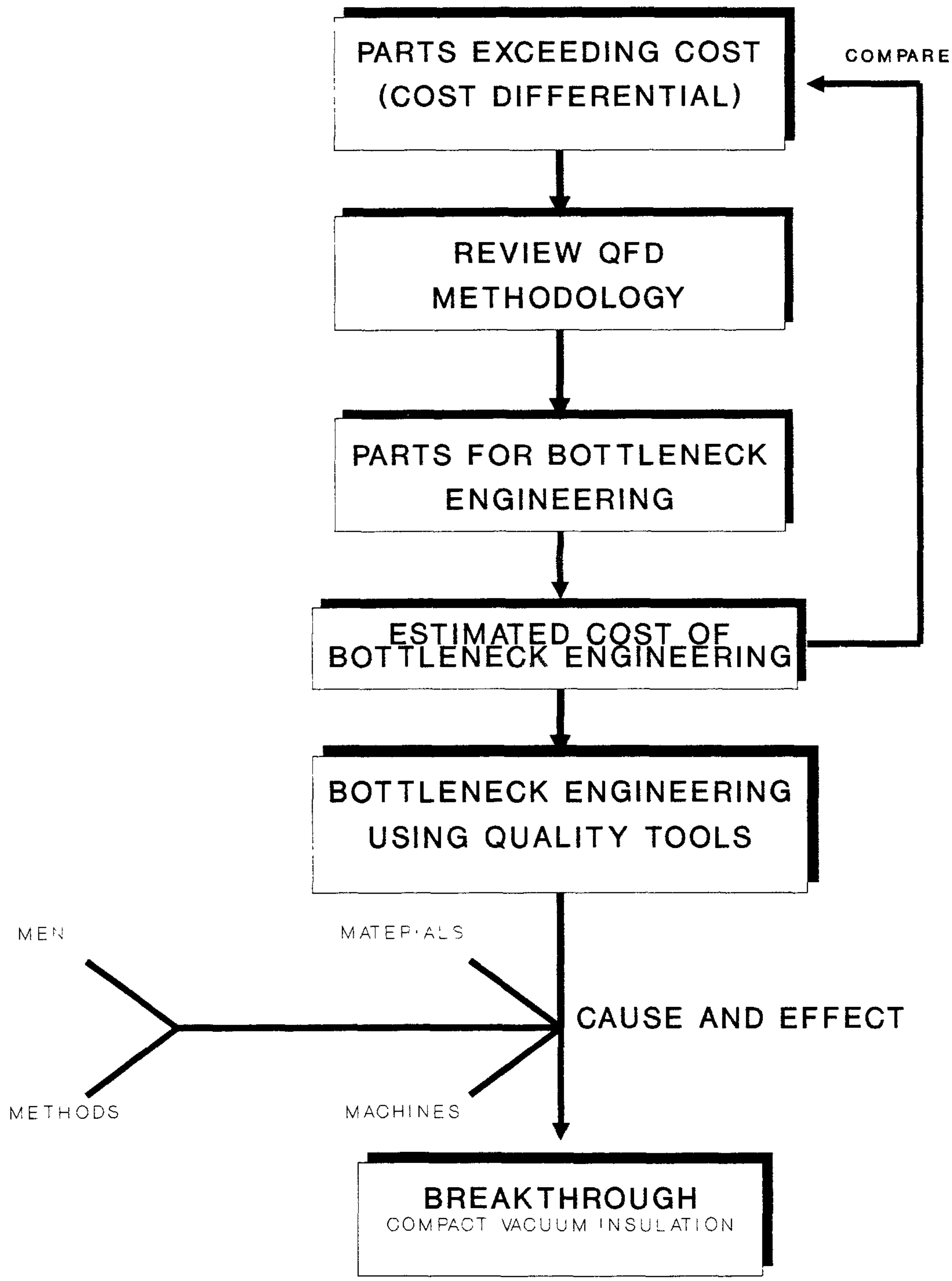

Figure 4.8 Part cost review.

Bottleneck engineering (BNE) is a systematic approach to technological innovation. Figure 4.8 diagrams how a BNE approach might develop after a part has been singled out for excessive cost.

After the forementioned preliminary review of the quality deployment, costs are estimated for potential BNE courses of action. The estimate generated here is compared to the cost differential between the part target and quote. Cost-benefit analysis (CBA) should be performed at this point to either justify or deem inappropriate the BNE study. In the event of a negative conclusion, the part quote might remain, or the part might be eliminated from the design.

If CBA justifies the bottleneck engineering procedure, several techniques are available encompassing a wide range of expertise.

Through finite element analysis (FEM), a part is dissected to its most minute elements, and each is evaluated and either retained, improved upon, or eliminated based on functional contribution and necessity [113]. This method is closely related to reverse engineering , but differs in that the product or part being "torn down" is a company's own, not the competition's.

On the manufacturing side, design for manufacturability (DFM) tools can be utilized to evaluate handling and processing, while enhancing quality [114]. As shown by Das

[115], these DFM tools are part of a concurrent engineering approach which evaluates against not only the target cost, but against product feasibility and competitive benchmarks. Thus, a well defined DFM scheme can drive out costs by facilitating the manufacture of the product and individual parts.

Total Quality Management (TQM) tools such as cause and effect diagrams, pareto diagrams, affinity mapping, control charts, and more enable a quality improvement team to solve organizational (quality) obstacles [116]. This of course includes parts which overrun objective costs.

By defining the problem at hand as a specific part, or family of parts, which are too costly, employee focus groups can attack and quickly solve the issue, often at the floor level. This is one of the most powerful philosophies of TQM - employee involvement and problem solving - and it should be utilized not only for BNE, but for any relevant problem.

CHAPTER 5
PERTINENT ISSUES AND OVERALL CONCLUSION

5.1 Preferred Practices

Since the advent of QFD experimentation and application in the United States, sets of preferred practices have evolved within the individual companies employing the method. This is in agreement with what many QFD experts and heavy users suggest - that the process should be slowly ingrained and adapted to the individual organization [117].

Among the lessons learned by various companies in the past few years have been that QFD development should be limited to three months per exercise, teams should consist of less than 10 members, initial input should be done without the aid of software, and that the size of each matrix should be limited to 60 by 60 [118].

Even prior to QFD exercises, issues sometimes need to be addressed within certain companies to ensure that any gains are realized by the process. Communications gaps and a lack of a total quality committment are hurdles that QFD and other quality assurance methods can not readily overcome. Adams and Gavoor [119] have investigated and addressed issues pertinent to this subject at Rockwell International.

Digital Equipment Corporation (DEC) has had substantial experience with QFD at a number of corporate levels, and

Cohen [120] has described the approach to QFD that the company elected from experience.

To counteract resistance to burdensome exercises, DEC has broken teams and planning matrixs into subgroups, thereby eliminating charts with excessive cells. Charts are created as large as five feet long, and several feet high to enable the team to see the chart together, thereby promoting interaction and understanding [121]. Especially critical customer needs may have sole planning matrices developed, to properly examine all altenatives while avoiding an overdeveloped single chart. In addition, to truely capture customer desires, the company engages in the unique process of inviting the customers to help fill in the QFD chart [122].

5.2 Software and Consulting Services

5.2.1 Software

Although many experts suggest that working with paper is superior to conducting QFD exercises with the help of software programs [123], these programs nonetheless offer some advantages, and these are:

- Facilitation of complicated data entry.
- Automatic data calculation and analysis.
- Formation of the structural matrix.
- Documentation and repeatability during updates.
- Support of additional functions such as benchmarking and process charts.

Currently there are four available PC-based QFD software packages, excluding the programs offered by the major QFD consulting firms.

QFD/CAPTURE - Enables users to perform quality function deployment, customer and competitive analysis, and creates the house-of-quality and related matrixes. This package uses emerging industry standard data conventions (ASI). Requires at least 640K RAM on an IBM or compatible PC with a hard drive, on both floppy disk sizes.

QFD Designer Version 2.0 - Fully supports both ASI and Goal methodologies, and takes advantage of Windows graphics, enabling simultaneous viewing of matrixes. Features include expanded math functions, data analysis, customized matrixes, and help. Requires a minimum of an IBM 386 with Windows and a hard drive; available on both floppy disk sizes.

QFD/FOCUS - Facilitates the creation of a house-of-quality, and allows the addition of subsequent information to the original. Hard copies can be generated, and the software requires an IBM PC or compatible.

QFDplus - Creates Quality Function Deployment matrices in conformance to ASI guidelines. The package utilizes Windows for grapical displays, and includes benchmarking, help functions, and linkage to CAD packages which accept DXF files. Requires an IBM PC or compatible with a hard drive, and preferably a HP LaserJet II printer. This program is only available to Ford Motor Company suppliers and affiliates, on either high density floppy disk size .

5.2.2 Consulting Services

Consultation and training are offered by several U.S. firms for both introductary and advanced QFD applications. The two prominent consultants in the area are the forementioned American Supplier Institute (ASI) and Goal/QPC. As outlined in Chapter 2, the ASI offers a four-phased system that helps make trade-offs during the development cycle, while Goal/QPC suggests a system of connected matrices to improve decision-making throughout a company [124].

If in-house training is preferred to outside consulting and seminars, there are additional options. As AT&T and other corporations have found, internal quality management consulting and training services offer the advantage of a ready knowledge of internal culture and products [125]. For example, at AT&T Bell Laboratories, the Quality Process Center provides expert guidance in tailoring QFD to technical areas. This department also evaluates software packages and counsels organizations about which packages best suit their needs [126].

For companies lacking the resources to intiate programs similar to those forementioned, Technicomp of Cleveland, Ohio, offers a video-based training method for QFD. This system offers an introduction to QFD, the house-of-quality, and the voice of the customer. In addition, the two generally accepted QFD methodologies are overviewed, and a start-up pilot is supplied.

5.3 Overall Conclusion

In keeping with the research objective outlined at the beginning of this paper, both QFD and the integrated cost deployment methodology have been presented.

With regard to QFD, several general and specific corollaries can be drawn. First, it is evident that QFD usage should not be relegated the singular function of product design realization, because the system both contributes significantly within an integrated quality system, and facilitates policy decisions. Second, the method should not be looked upon as a panacea for problems such as poor management or lack of planning - it is a tool and should be used as such. In addition, a QFD exercise should never become so burdensome as to overshadow the primary objective, which is the product design itself.

Based on the completion of a group of house-of-quality matrices, it is my subjective conclusion that the matrices should first be developed manually on a large chart, and then inputted into a software package for analysis. On this point, I am in agreement with numerous experts who have found large charts easier to conceptualize than single-page printouts.

The cost deployment exercise demonstrated that this heuristic tool can focus attention on seemingly insignificant parts of a product, respective of price.

As an example, the refrigerator parts allotted the highest target cost in the exercise were the compressor, the insulation, and the condenser. Of these, the target for insulation initially might be considered very high, taking into account that currently, refrigerator insulation is simply foam. However, further investigation reveals that the insulation effects the size, weight, freezing functions, and cooling functions. Indeed, a perfectly insulated (hypothetically) refrigerator would require almost no compressor capacity. In addition, with the impending ban on CFC's, current insulation and refrigerants are to be eliminated.

Compact Vacuum Insulation (CVI) is a high-technology alternative to foam insulation that could revolutionize the appliance industry [127]. A 1/10" thick CVI panel has the same thermal resistance as 1" thick foam insulation, without CFC's, but at a higher price. Thus, if the refrigerator developed in the exercise utilized this product, it would exceed any comparable product on the market, so the cost would be justified. Parts over cost would subsequently be analyzed through bottleneck engineering.

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