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Improving Customer Satisfaction in an R&D Environment

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IMPROVING CUSTOMER SATISFACTION IN AN R&D ENVIRONMENT

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Abstract

Satisfying customer needs is critical to the sustained competitive advantage of service suppliers. It is therefore important to understand the types of customer needs which, if fulfilled or exceeded, add value and contribute to overall customer satisfaction. This study identifies the needs of various research and development (R&D) customers who contract for engineering and design support services. The Quality Function Deployment (QFD) process was used to organize and translate each customer need into performance measures that, if implemented, can improve customer satisfaction. This study also provides specific performance measures that will more accurately guide the efforts of the engineering supplier. These organizations can either implement the QFD methodology presented herein or extract a few performance measures that are specific to the quality dimensions in need of improvement. Listening to "what" customers talk about is a good first start.

Keywords: Continuous improvement; quality management; customer satisfaction; engineering services; productivity.

Introduction

Internal suppliers to research and development (R&D) customers must do more than just meet technical specifications or deliver services on time and within budget. Even if internal suppliers fulfill these basic requirements above all others, customers will inevitably be lost. This is because customers expect to have these types of basic needs met. For example, R&D customers take for granted that their suppliers will provide a technically competent staff who will deliver services on time and within budget constraints. Therefore these service characteristics no longer differentiate service suppliers. So no matter how well a supplier fulfills or even exceeds basic (expected) customer needs, customer satisfaction will remain unaffected. Internal suppliers must therefore look to other types of customer needs in order to satisfy customers and thereby retain them.

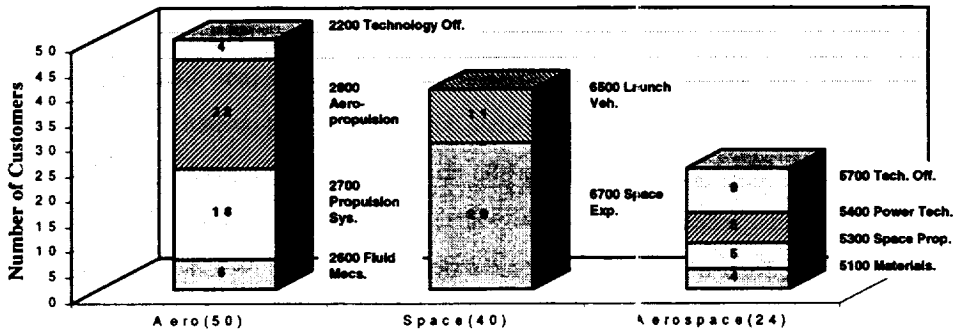
Fortunately customers will usually talk about needs and expectations that are important to them—given an opportunity. Proactive communication strategies rather than reactive strategies provide the best opportunities for

suppliers to gather this type of information. Such strategies must aim to discover, identify, fulfill, and exceed as many explicit customer needs as possible. Suppliers can then offer competitive services that match the full range of customer needs which have the strongest influence on customer satisfaction. The Total Quality (TQ) framework offers an exceptional management tool that determines and accurately translates customer needs into specific actions that will yield services that satisfy or even excite customers.

Quality Function Deployment (QFD) is a powerful communication tool within the TQ framework that identifies, prioritizes, and ultimately links the voice of the customer to the various functions of the supplier's organization. QFD uses the customer's perspectives and inputs to identify product and service quality characteristics that are important and add value to customers. For example, an internal QFD application will often involve a solution that incorporates input from internal functions like marketing, production, or research and development. Representatives from each of these functions work as a team to develop the QFD matrices, often called houses, which prioritizes customer needs in a format that can be used to create products and services that satisfy customers. These concerted efforts result in effective improvements that add value to what customers want and thus will be more likely to purchase.

Obtaining the Voice of the Customer at LeRC

A QFD study was conducted at NASA Lewis Research Center (LeRC) in Cleveland, Ohio. The study identified research and development (R&D) customer requirements for an internal engineering and design service supplier and translated these requirements into performance measures. The research was sponsored by a Sample Directorate (SD) at NASA LeRC. SD is an internal engineering service supplier to internal customers from the Aeronautics, Aerospace, and Space Directorates (customer segments) within the center. Each customer segment can be further described by either mission or branch function. The key departments (customers) that purchase SD's services are provided in Figure 1. These customers can either utilize the internal engineering and design service supplier (SD) or they may contract with external engineering and design service suppliers for similar jobs.



Note: Information provided by the SD Administrative Support Branch

Figure 1 List of SD's Key Customers

Until recently, SD has sustained the majority of the total hours used by SD's research customers. However, recent data shown in Figure 2 indicates that SD's research customers are increasing their use of these support service contractors for engineering services.

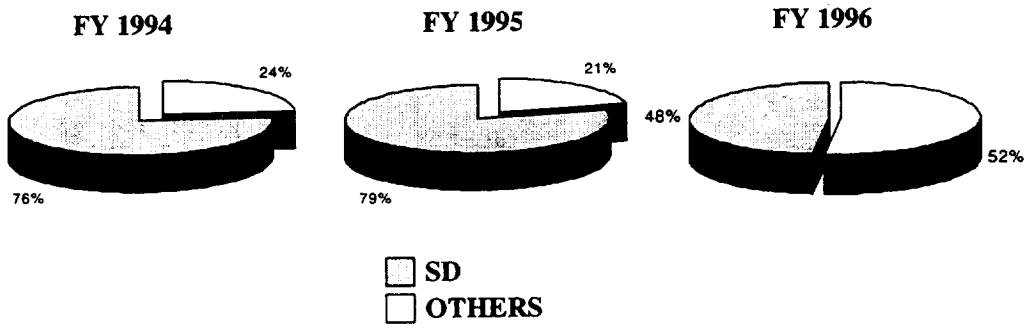


Figure 2 Percentage of Total Hours Used By Aero, Space, and AeroSpace Customers between the Engineering Directorate and Others

This graphic indicates that SD realized a marginal gain of 3% of total customers from Fiscal Year 94 to Fiscal Year 95. Yet the percentage of SD's total customers significantly diminishes from 79% in Fiscal Year 95 to 48% in Fiscal Year 96 (a 31% decrease).

One way to address service related factors which may be contributing to this trend is to implement strategic service improvements that are likely to increase customer satisfaction. QFD was therefore selected as an ideal method to discover and prioritize SD's customer requirements sufficiently enough to develop customer oriented service improvements and priorities.

The specific goals of this research include the development of a prioritized list of customer requirements in order of importance, a list of performance measures that will cause incremental changes needed to improve the service process, and a competitive performance assessment of SD and its competitors. Quality practitioners agree that the benefits of quality improvements are best realized when service suppliers understand the fundamental needs of their customers and provide products and services that meet or exceed these needs (McDermot and Emerson, p. 61). The QFD process proved to be effective in achieving these goals.

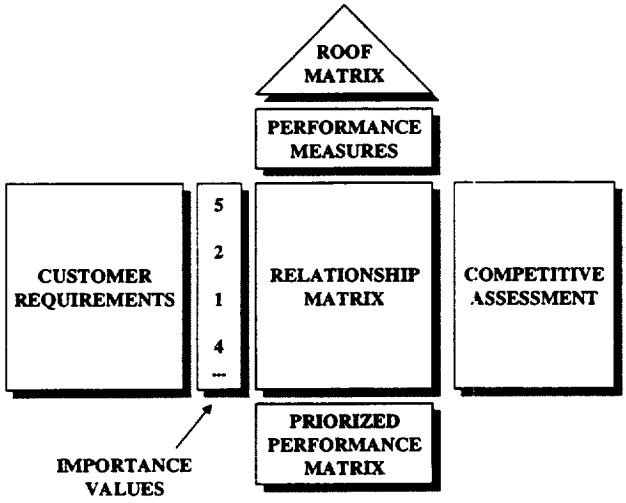


Figure 3 The Generic House of Quality

Methods To Construct the QFD House of Quality (HOQ) Matrix

This research focuses on the development of the House of Quality (HOQ). Figure 3 shows a generic simplification of a typical "textbook" QFD matrix. To describe the basic QFD procedure, a brief description of each matrix element used in this study is summarized below.

Preliminary Studies Were Conducted

Data collection began with the review of SD's database compiled from customer feedback surveys. A series of orientation interviews were conducted in small groups with SD managers, project leaders, and project engineers. The participants discussed their understanding of SD's customer needs, how diminishing resources affect SD's ability to meet and exceed customer needs, SD's capability to fulfill or exceed the needs of customers, and trends in loss or gain in business.

Customer Focus Groups Generated Customer Requirements

A series of customer focus groups was conducted to generate a list of the customers' root needs. The focus groups technique for obtaining customer information was selected to minimize bias and to conserve time. This technique was also used because it provides greater insight into customer perceptions and choice behavior (Technicomp, p. 36; Rust et al., pp. 23-35). Research by Griffin and Hauser on the effectiveness of focus groups and one-to-one interviews (Griffin and Hauser, pp. 12-14) was used as a guide in determining the sample size of this study. At least ten (10) customers from each segment were selected. In total, thirty-two (32) customers participated in this study. An attempt was made to include two (2) or three (3) representatives from each customer segment per focus group. However, schedule conflicts forced the scheduling of candidates based solely on availability. Five (5) focus groups

were ultimately formed. The focus group activities generated the customers root needs which were recorded on the QFD HOQ using QFD Capture for Windows.

The focus group participants were later surveyed using a mailed questionnaire. The customer survey questionnaire collected three types of information: demographic data, customer importance ratings for each customer root need, and competitive assessment ratings.

The demographic section of the questionnaire (Part I) collected customer information pertaining to directorate type, management level, degree level, and length of employment. The importance rating section (Part II) was designed using AHP protocol. The Analytical Hierarchy Process (AHP) obtains ratio-scale data by using paired comparisons to determine customer judgments of one need against others on the same hierarchy level. This study used AHP to obtain the importance data. The AHP technique involved presenting pairs of customer requirements to respondents, selecting the requirement in each pair that is more important, and then, indicating how much more important the one requirement is to the other using a value from a graduated scale. The results of this technique provide numerical weights for each requirement that indicate its relative importance to all others. The advantage of AHP is the ratio-scale data that results. Ratio-scale data is ideal for QFD applications because it not only indicates the need's order of importance but also the relative importance of each customer need with respect to all others. Inconsistency is an inherent risk associated with this technique. However, there are several computer programs that can be used to test for these aberrations (Cohen, pp. 96-97).

The following AHP equation was used to determine the number of paired comparisons for each category of customer needs.

$$N = \frac{n(n-1)}{2}$$

where n is the number of customer needs per category and N is the total number of paired comparisons for that category. Saaty's 9-point scale, which rates the intensity of importance of the customer need was also used. Customers were asked to score the importance of the need using 1 to indicate that both needs were equally important and 9 to indicate that one customer needs was absolutely more important than the other. All customer needs were judged in this fashion.

The competitive assessment section (Part III) collected quantitative ratings to indicate how well SD and its competitors fulfilled each customer need. Competitive assessments were obtained by asking the R&D customers to score the percentage of which each need was fulfilled by SD and its competitors. A 10-point scale was used where 0 indicated not fulfilling a specific need at all and 10 indicated fulfilling 100% of a specific need.

Of the 32 questionnaires that were mailed, a total of 24 questionnaires were returned yielding a 75% response rate. The response rate for each useable part of the questionnaires is shown in Figure 4.

Questionnaire Part		Useable Questionaires Returned	Response Rate
Part I	Demographic Information	24	75%
Part II	Importance Ratings	27	56%
Part III	Competitive Assessment	20	53%

Figure 4 Survey Responses

Customer Needs Were Organized into a Hierarchy

Consistent with the AHP theory, the customer needs were organized into a functional hierarchy. Functional hierarchies differ from ordinary structural hierarchies in that functional hierarchies decompose broad, overall categories into their constituent elements according to their relationships. Structural hierarchies on the other hand arranges constituent parts in descending order according to specific structural properties like color, shape, and size (Saaty, p. 28).

"Each set of elements in a functional hierarchy occupies one level in the hierarchy. The top level is called the focus and consists of only one element: the broad, overall objective. Subsequent levels may have several elements—between five and nine. Because the elements within each level are compared with one another, the elements in each level must be related and on the same order of magnitude. If the disparity between elements is great, they should belong to different levels" (Saaty, p. 28). "Therefore, to arrange a functional hierarchy, group simple elements in clusters of other related elements and let the very complex elements stand alone. Then arrange the simple clusters of elements into the overall hierarchy so that they represent the decomposition of the more complex elements" (Saaty, p. 29). Four levels of customer needs resulted from this exercise.

Figure 5 shows the hierarchy of customer needs used for this study. The first level of customer needs represent the global categories: "Understand My Circumstances," "Understand NASA," and "Provide Engineering Expertise." The second level of the hierarchy was constructed using customer needs that generally describe the first level of customer needs. The order of magnitude of the second level customer needs was slightly less than the first level of needs. The third level of customer needs were those which provided more descriptive detail of the second level of needs. The fourth and final level contained the minutia or the lowest level of detail. It is important to note that each level contained groupings of customer needs on the same order of magnitude. That is, since the elements in one level are to be compared with each other and then with the criterion in the next level, the elements within each level must be on the same order of magnitude.

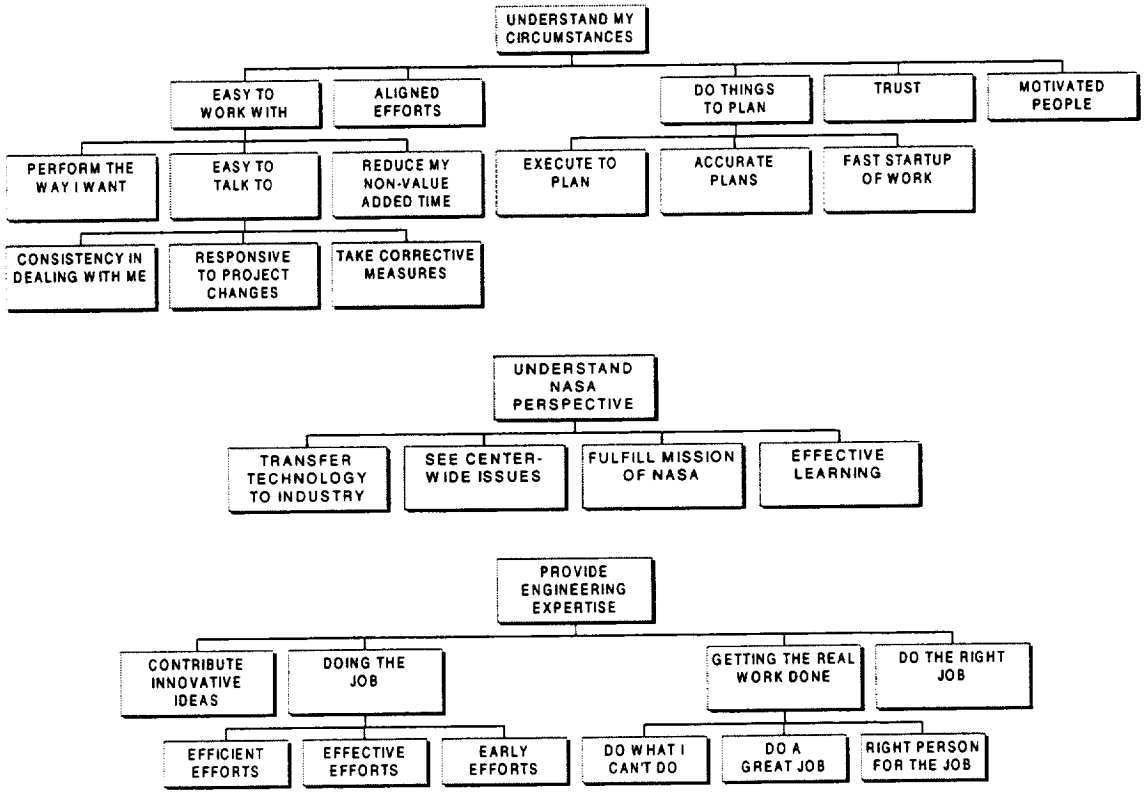


Figure 5 Hierarchy of Customer Needs

Importance Values Were Calculated

Having collected the paired comparison data from the customer questionnaires, the mechanics of AHP was used to obtain the priority matrix associated with each cluster of customer needs. AHP recognizes this operation an eigenvalue problem in which the following procedure was used (Saaty. pp. 94-95):

A. Computed the matrix of eigenvectors
B. Computed the matrix of eigenvalues
C. Selected eigenvectors with the largest eigenvalue
D. Normalized eigenvector matrix to get composite priority vector containing relative weights of each requirement in the hierarchy
E. Repeated steps a through d for all levels and clusters of customer needs
F. Determined the overall weight by multiplying the weight of the lowest requirement in hierarchy by the weight of the next highest level.

The importance values for each survey were obtained using this procedure. Each survey was analyzed separately; however, since twenty-four (24) surveys were returned, arithmetic averages were calculated and recorded on the final HOQ. Figure 6 lists each customer need and its percentage of importance

Understand My Circumstances		Understand NASA's Perspective	
Aligned Efforts	8.90%	Transfer Technology to Industry	2.60%
Easy to Work with		See Center-wide Issues	3.70%
Perform the Way I Want	2.60%	Fulfill Mission of NASA	3.00%
Reduce my Non-Value-Added Time	1.40%	Effective Learning	2.90%
Easy to talk to		Provide Engineering Expertise	
Consistency in Dealing with me	0.20%	Contribute Innovative Ideas	6.20%
Responsive to Project Changes	0.60%	Doing the Job	
Take Corrective Measures	0.80%	Efficient Efforts	6.00%
Do Things to Plan		Effective Efforts	8.30%
Execute to Plan	5.00%	Early Efforts	2.30%
Accurate Plans	2.80%	Getting the Real Work Done	
Fast Start-up of Work	2.40%	Do What I can't Do	3.40%
Trust	10.10%	Do a Great Job	1.60%
Motivated People	5.70%	Right Person for the Job	4.00%
		Do the Right Job	15.40%

Figure 6 List of Customer Needs and Importance Ratings

Competitive Assessments Were Determined

The purpose of the competitive assessment was to quantify the customers' perception of how well the current engineering and design services met their needs. Again, since twenty-four (24) surveys were returned, arithmetic averages were calculated and recorded on the final HOQ. For example, the performance values assigned to each need on the HOQ were derived by adding the values (ratings) of each need over all questionnaires and then dividing that sum by the total number of responses to a specific need. Four organizations were assessed in addition to SD.

The sum of the squared differences (errors) was used to analyze the assessment data and to determine the organizations having the best overall performance. The mechanics of this method involved: calculating the difference between the actual performance rating for each customer need and the ideal performance rating of 10, where 10 represented total fulfillment of the need. The calculated difference is then squared and added with all others to show the organizations furthest away from the ideal. These organizations were readily apparent because they had the largest sum of squared difference. In other words, the organization having the smallest sum of squared difference was considered to have the best overall performance.

The assessment results are shown in Figure 7. The most striking conclusion to be drawn from Figure 7 is that SD is not as competitive as Companies A, B, or C at fulfilling the total needs of their customers. In fact, SD is currently the furthest away from the ideal level of performance. The implication of these findings clearly underscores the need

for SD to develop a strategy for improving its performance in fulfilling customer needs in order to be competitive. Otherwise, SD's current customer base will likely continue to erode unless it improves its performance in satisfying customers.

These conclusions indicate that SD is not as competitive as Company A or Company B at fulfilling the total needs of the customer and is currently the furthest way from the ideal level of performance. The implication of these findings clearly underscores the need for SD to develop a strategy for improving its performance in fulfilling customer needs in order to be competitive. Otherwise, SD's current customer base will likely continue to erode unless it improves its performance in satisfying customers.

	ED	Comp A	Comp B	Comp C	Comp D	Squared Differences SD	Comp A	Comp B	Comp C	Comp D
Understand My Circumstances										
Aligned Efforts	5.32	8.27	7.29	7.40	6.50	21.94	3.00	7.37	6.76	12.25
Easy to Work with										
Perform the Way I Want	5.47	8.27	7.71	7.40	6.17	20.49	3.00	5.22	6.76	14.69
Reduce my Non-Value-Added Time	5.21	7.17	7.04	7.00	7.00	22.94	8.03	8.79	9.00	9.00
Easy to talk to										
Consistency in Dealing with Me	6.53	7.57	7.81	7.80	7.00	12.07	5.92	4.81	4.84	9.00
Responsive to Project Changes	6.26	8.17	7.96	7.60	6.67	13.96	3.36	4.14	5.76	11.11
Take Corrective Measures	6.28	8.23	7.68	7.40	6.67	13.85	3.12	5.39	6.76	11.11
Do Things to Plan										
Execute to Plan	6.47	8.17	7.61	7.40	6.50	12.45	3.36	5.73	6.76	12.25
Accurate Plans	5.67	7.17	6.89	6.80	6.00	18.78	8.03	9.65	10.24	16.00
Fast Start-up of Work	5.37	7.53	7.04	6.80	5.67	21.45	6.08	8.79	10.24	18.78
Trust	5.79	7.03	6.89	7.00	5.67	17.73	8.80	9.65	9.00	18.78
Motivated People	5.74	7.07	7.39	7.60	6.83	18.17	8.60	6.80	5.76	10.03
Understand NASA's Perspective										
Transfer Technology to Industry	4.89	5.07	5.07	7.60	6.33	26.12	24.34	24.29	5.76	13.44
See Center-wide Issues	5.16	5.67	5.50	4.80	4.80	23.45	18.78	20.25	27.04	27.04
Fulfill Mission of NASA	5.42	6.27	5.86	5.20	5.20	20.97	13.94	17.16	23.04	23.04
Effective Learning	5.42	6.63	6.14	7.00	6.33	20.97	11.33	14.88	9.00	13.44
Provide Engineering Expertise										
Contribute Innovative Ideas	5.72	7.23	6.21	7.60	7.50	18.30	7.65	14.33	5.76	6.25
Doing the Job										
Efficient Efforts	5.05	6.93	6.64	7.00	6.00	24.48	9.40	11.27	9.00	16.00
Effective Efforts	5.26	7.40	6.50	8.00	7.00	22.44	6.76	12.25	4.00	9.00
Early Efforts	5.63	7.13	6.57	7.00	6.17	19.08	8.22	11.76	9.00	14.69
Getting the Real Work Done										
Do What I can't Do	6.63	7.27	7.29	8.20	7.83	11.35	7.47	7.37	3.24	4.69
Do a Great Job	5.74	6.47	6.50	7.20	6.17	18.17	12.48	12.25	7.84	14.69
Right Person for the Job	5.05	7.30	6.57	7.60	7.67	24.48	7.29	11.76	5.76	5.44
Do the Right Job	5.53	7.23	6.82	7.80	7.00	20.01	7.65	10.10	4.84	9.00
Service Provider Individual Average*	**5.64**	**7.18**	**6.83**	**7.18**	**6.46**					
Sum of the Squared Differences						**443.64**	**196.64**	**244.00**	**196.16**	**299.75**

*where 10.00 represents meeting 100% of the need.

Figure 7 Analysis of the Competitive Assessment Results

By combining the competitive assessment results and customer importance values, SD can identify and understand the customer needs that require immediate action - see Figure 8.

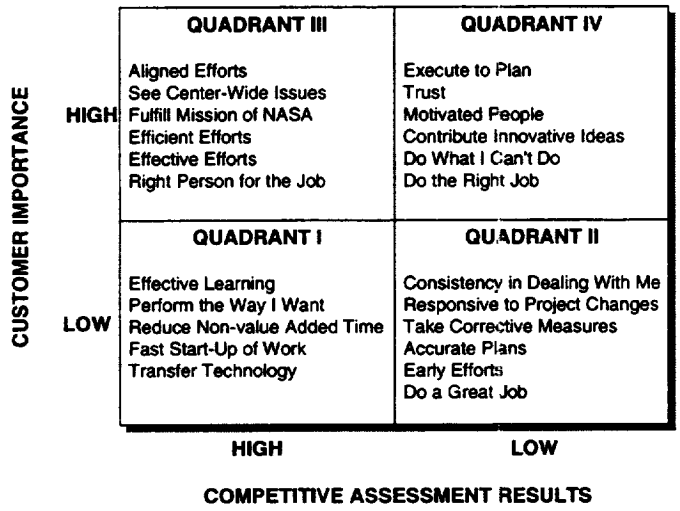


Figure 8 Plot of Important Customer Needs vs. SD's Competitive Assessment Results

Several managerial implications result from this technique. For example, customer needs for which SD's performance is low and the customer cares little about should be ignored For needs about which the customer cares little and SD's performance is high, SD should consider reallocating resources being used to fulfill these needs. Needs that are important to customers but SD is relatively poor at fulfilling are critical for SD to address because Company A and Company B fulfill these needs well. These needs include "Aligned Efforts", "Effective Efforts", and "Efficient Efforts" and combine to 27% of the total importance. See Figure 6 for importance percentages.

Customer Needs and Performance Measures Were Related

SD must be able to measure progress toward a desired goal in order to improve quality. A team of SD managers was formed to identify and list the significant and measurable characteristics of SD's performance and business parameters which, if monitored, would have a favorable impact on customer satisfaction. The team of mangers also provided consensus judgments which indicated strength of relationship between each measure and customer need. The final results of these discussions were recorded on the QFD HOQ matrix using QFD Capture for Windows. Specifically, the SD QFD Management Team identified twenty-four (24) performance measures that correspond to each of the customers' needs. Each measure was related to each customer need using the relationship matrix. The relationship matrix was an intermediate step in calculating the strength of each engineering measure to each customer need. Each relationship cell contains a numerical value or symbol of the value to represent this relationship. Four

types of judgments were used for this study: not related, weakly related, moderately related, and strongly related. For example, if performance measures are not related to a specific customer need, any change in the direction of goodness will not produce a noticeable change in customer satisfaction. If performance measures are weakly related to the customer requirements, then relatively large performance changes in the direction of goodness will produce little change in customer satisfaction (Cohen, pp. 141-142).

Final values for each measure are expressed in terms of percent of importance of the measure. These values were calculated using deployment normalization or the weighted distribution approach. This technique was used in order to determine the relative importance of each measure on the total needs of the customer. Describing the measure in these terms provides a quantitative expression of its order of importance as well as its relative importance to the total needs of the customer and to the total list of measures themselves. The mechanics of this approach involved: adding each row of values in the relationship matrix, dividing the values within each row by the row's total, multiplying the ratios within each row by the customer importance rating, and adding each column to determine the total importance of each measure. The advantage of the weighted distribution technique is that measures can be combined to have more impact on the total needs of the customer. For example, the first six (6) performance measures combine to equal 55% of the total importance to customers. Therefore, SD should combine customer needs that were identified as being most important to customers in order to improve service and deliver high levels of satisfaction. Furthermore SD managers must determine an appropriate target value for each measure that will be of a magnitude capable of being perceived by the majority of its customers. Goal values for this study were chosen to be "7", which would bring SD's level of performance on par with the competition.

The QFD House of Quality Was Prioritized

The completed SD QFD HOQ was prioritized. See Figure 9 on page 13 for a graphic illustration of the prioritized QFD matrix. Customer importance values and associated customer needs were placed in ascending order as well as SD's importance values and associated performance measures.

The prioritized QFD matrix resulted in two conclusions: requirements having the greatest importance to customers are the following:

A. Do the Right job
B. Trust
C. Aligned Effort
D. Effective Efforts
E. Contribute Innovative Ideas
F. Efficient Efforts

Among the performance measures providing the greatest contribution to the total importance to the customer's needs are as follows:

A. Decrease the number of major milestones changed because of engineering
B. Decrease the number of project hours or dollars increased after the project midpoint
C. Increase the percentage of original major milestones met

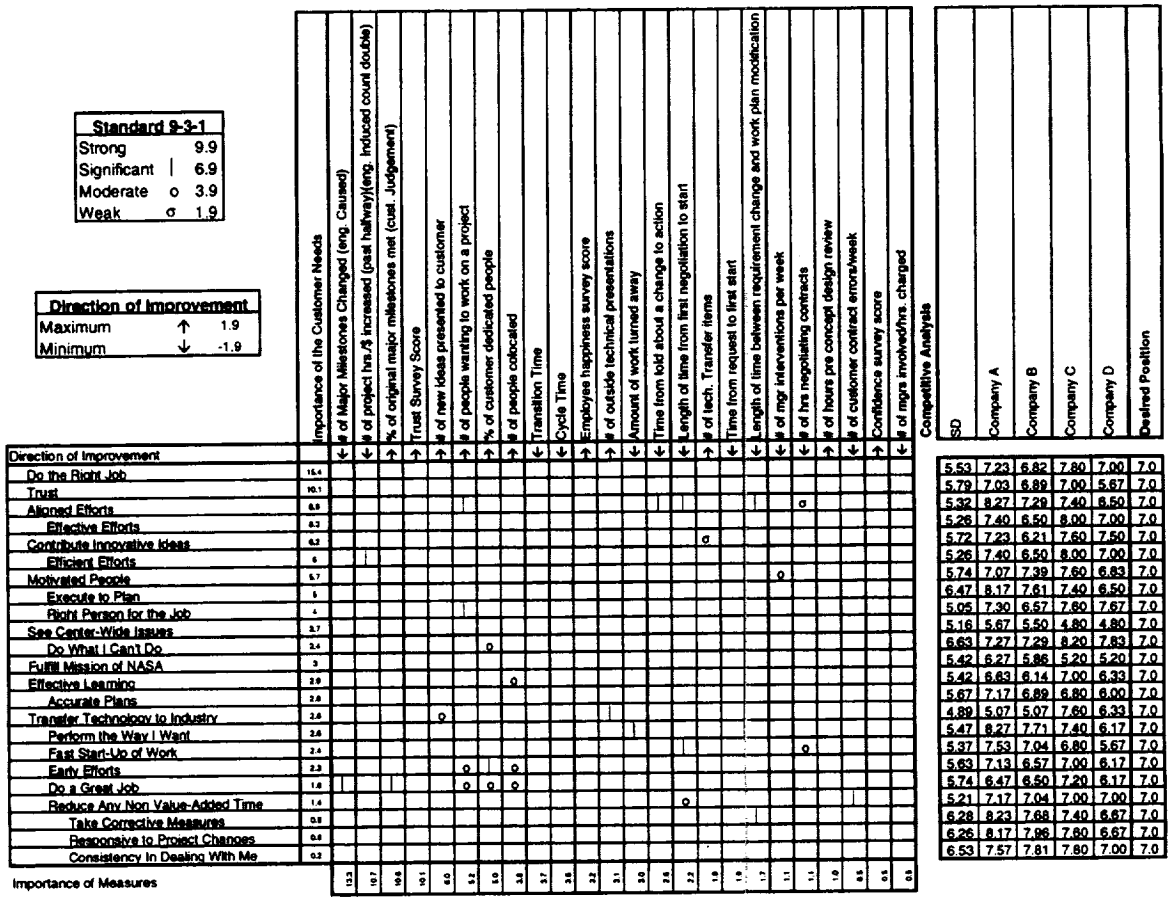


Figure 9 The Prioritized SD QFD HOQ Matrix

Managerial Implications of the QFD Study Results

Listening to the voice of the customer is vital in maintaining a standard of high quality for which customers are willing to pay a reasonable price. QFD is an outstanding tool that uses the customer's voice to make the necessary incremental quality improvements that involve elements within the entire organization. QFD was first introduced in 1972 within the Kobe Shipyards of Mitsubishi Heavy Industries. Here QFD was employed as a disciplined approach to align business practices and procedures. Since then QFD has become a popular management tool for a variety of industries. This study used QFD as a proactive communication approach to understand customer needs. This study provides a viable example of how QFD can be effectively used in an R&D setting. Using the QFD framework not only helped to identify internal R&D customer requirements, but also prioritized the corrective action to be done in order of importance to the customer.

While pleasing customers will not necessarily generate new customers, it will however help to retain those already hard earned. R&D service suppliers must be able to fulfill more than just the basic customer needs. Service characteristics like competent personnel and accurate design drawings are a few of the basic technical needs that

customers have come to expect. Now service suppliers must also tend to the soft needs or the non-technical needs of customers as well. For example, customer root needs like trust, effective efforts, aligned efforts, and do the right job are very important factors contributing to how customers assess the value of a particular service. Since customers seemingly care about both the service delivered as well as the processes that support the delivery, service suppliers must package these intangible, soft skills around these core technical competencies (hard skills).

The goal of any quality improvement is to get customers excited about the service so that they will be willing to make long-term purchases. Achieving this goal becomes the reward for successfully managing the customer's attention. That is, customer attention is aroused when suppliers systematically integrate the customers 'voiced' needs into all aspects of the service delivery process. Customers then get the sense that their needs were acknowledged and are thus more likely to purchase services and remain loyal. Customer loyalty is the ultimate reward to responsive customer service. Listening to the voice of the customer is the first step towards building long-term customer relationships.

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13. ABSTRACT ***(Maximum 200 words)***

Satisfying customer needs is critical to the sustained competitive advantage of service suppliers. It is therefore important to understand the types of customer needs which, if fulfilled or exceeded, add value and contribute to overall customer satisfaction. This study identifies the needs of various research and development (R&D) customers who contract for engineering and design support services. The Quality Function Deployment (QFD) process was used to organize and translate each customer need into performance measures that, if implemented, can improve customer satisfaction. This study also provides specific performance measures that will more accurately guide the efforts of the engineering supplier. These organizations can either implement the QFD methodology presented herein or extract a few performance measures that are specific to the quality dimensions in need of improvement. Listening to "what" customers talk about is a good first start.

14. SUBJECT TERMS

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