The Pennsylvania State University

The Graduate School

Department of Civil Engineering

QUALITY FUNCTION DEPLOYMENT: A METHOD FOR IMPROVING CONTRACT SPECIFICATIONS IN THE US CORPS OF ENGINEERS

A Thesis in

Civil Engineering

by

Alan Michael Dodd

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 1997

DISTRIBUTION:

A - Public Release; Unlimited Distribution

I grant the Pennsylvania State University the nonexclusive right to use this work for the University's own purposes and to make single copies of the work available to the public on a not-for-profit basis if copies are not otherwise available.

Alan M Dodd

Alan Michael Dodd

We approve the thesis of Alan Michael Dodd.

	Date of Signature
Gary R. Smith Associate Professor of Civil Engineering Thesis Advisor	10/10/97
H. Randolph Thomas, Jr. Professor of Civil Engineering.	[illegible]
Hossam El-Bibany Assistant Professor of Architectural Engineering	10/29/97
Paul P. Jovanis Professor of Civil Engineering Head of the Department of Civil and Environmental Engineering	11/10/97

ABSTRACT

The purpose of this thesis is to evaluate the use of Quality Function Deployment (QFD) as a management tool to benefit US Army Corps of Engineers' project managers. The United States Army Corps of Engineers is one of the largest construction management organizations in the world, annually performing over 3.5 billion dollars worth of work. The project manager has primary responsibility within the Corps to ensure the design both fulfills user's requirements and is prepared correctly, and that quality control/assurance procedures are correctly administered.

QFD was developed by the Japanese in 1972 to improve quality and lower costs in industrial and business related fields, by assuring all of a company's operational decisions are driven by customer needs. It uses a set of matrices to relate customers wants and needs with project specifications and requirements. Through this process, shortcomings, redundancies, or conflicts in specifications are identified and resolved. Critical material requirements and construction processes are identified, allowing the user to focus the project delivery system on fulfilling customer requirements.

The scope of this research is limited to development of a procedure for integrating QFD into the Corps of Engineers' design/construction delivery process. The procedure was applied to a Corps' construction project to evaluate its feasibility for contributing to the delivery process.

QFD assists project managers to clearly identify and prioritize customer requirements in development of the conceptual and final design. It is best suited to projects involving repetition of units or when higher-than-average quality is demanded. Managers are able to make better-informed decisions made during the delivery process, resulting in a better customer satisfaction. QFD is time consuming and requires very technological knowledge; the process must be streamlined and automated before it could be effectively integrated into the construction process.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENTS

Appreciation is extended to Dr. Gary R. Smith, Associate Professor of Civil Engineering, who served as graduate advisor and thesis committee chairman. Your concern for student development and personal mentoring greatly enhanced the construction management program, both in and out of the classroom. Without your guidance, completion of this thesis would not have been possible. Appreciation is also extended to the members of the committee, Dr. H. Randolph Thomas and Dr. Hossam El-Bibany, for their support and interest in this effort. The different perspectives and recommendations you have given me have greatly influenced my overall understanding of this topic and allowed me to develop a much better thesis. I also wish to thank the Baltimore District, US Army corps of Engineers, and in particular Mr. Thomas Rowe, for your contribution to this research. Your advice and input have been invaluable, without it I would not have been able to complete much of this work.

Chapter 1

INTRODUCTION

Prelude

On March 22, 1995, a Presidential Memorandum was issued for all executive departments and agencies that addressed improving customer service through benchmarking and continual improvement of customer service standards. This was an extension of Executive Order 12862, issued on September 11, 1993, that required all agencies within the United States government to develop customer service plans to improve performance by identifying customer requirements, implementing service standards which prioritize those requirements, and measuring success at fulfilling demands. To comply with the directive, the US Army Corps of Engineers (USACE) is focusing on identifying customers' needs and requirements and developing ways to improve its services. The Corps conducted a survey of 480 customers in April of 1995; it identified that, although customers are generally satisfied with services provided, improvements are most needed in two areas: 1) providing timely service, and 2) reasonable cost for services (USACE, 1995). In any construction project three factors, time, cost, and quality, are balanced; a change in one can affect the other two. To maintain standards in quality, errors or design omissions are compensated for through additional time (project delays) and/or additional cost. In 1986, the Federal Commission of Engineering and Technical Systems, National Research Foundation, directed the Building Research Board to conduct a study of quality control on federal construction projects. The study found that projects constructed by the Corps of Engineers had an average cost growth of approximately 6 percent, attributable primarily to design error and owner changes (Ledbetter, 1991). When the design is correct and representative of the user needs, few change orders are needed. However, when numerous changes are needed to correct deficiencies, generally productivity suffers, delays occur, and project costs rise (Thomas, 1990). To improve customer service, the Corps must reduce project delays and cost increases, while maintaining its standards of quality. One method of achieving this goal is by improving the quality of designs prior to commencing construction. The Corps must improve its design process by accurately identifying and translating user requirements into the plans and specifications, prior to beginning construction. By starting with a better design, there will be fewer changes required, resulting in fewer delays and cost increases, and a more satisfied customer. This research effort was undertaken to develop a management tool for Corps of Engineer Project Managers to use to during the design/construction process which will reduce changes required during construction by identifying user requirements up-front and ensuring the design integrates those priorities.

Objective

The purpose of this thesis is to evaluate a management tool which can be beneficial to Corps of Engineers' project managers. The Corps of Engineers operates under several constraints, including numerous federal laws, regulations, and statutes. Any tool developed would have to work within the policies established by the Corps, and be able to complement other methods and procedures currently being used. This thesis therefore will have three objectives:

1) To model the project delivery process by which plans and specifications are developed, from conception to final award of the contract, within a Corps of Engineers District Office.

2) To develop a procedure for using Quality Function Deployment (QFD) in construction design as a means of ensuring customer demanded quality throughout the project delivery process.

3) To apply the developed procedure to a recently constructed project and make recommendations concerning the future use of Quality Function Deployment within the Corps of Engineers' project delivery process.

Research Methodology

The research methodology is divided into five phases as follows:

Phase one. Obtain necessary documents, perform preliminary interviews, and locate available references that define the current process used within the Corps of Engineers to prepare contract specifications. Research the use of Quality Function Deployment in construction and other applications.

Phase Two. Review documents and other materials to develop a model of how contract specifications are prepared by Corps of Engineer personnel. Validate the proposed model by comparing it to the actual process followed during programming of project within the Corps of Engineers' Baltimore District. Develop QFD procedure to be used in construction management process.

Phase Three. Working with the Baltimore District, Corps of Engineers, identify a construction project as a survey sample. Obtain project specifications, customer requirements at project initiation, and other information to begin QFD analysis.

Phase Four. Prepare QFD analysis of the project to compare user requirements with specifications prepared by Corps personnel.

Phase Five. Perform a comparison analysis of data acquired in the previous two phases to determine the effectiveness of the Corps specification development process and make recommendations regarding further development of Quality Function Deployment.

Chapter 2

US ARMY CORPS OF ENGINEERS

Background

The United States Army Corps of Engineers is one of the largest construction management organizations in the world, annually performing over 3.5 billion dollars worth of work. The Corps of Engineers plans, designs, builds, and operates numerous water resource and other civil works projects throughout the world. Their projects include maintenance of several hundred harbors and waterways, production of one-fourth of the nations hydroelectric power, and operation of several hundred reservoirs, providing flood damage reduction and water storage. The Corps of Engineers also provides military construction for the Army and Air Force, and design and construction management support for other Defense and Federal Agencies. The Corps designs and manages construction of numerous military facilities such as ranges, barracks, maintenance facilities, and other training and quality of life facilities. The corps provides management services for more than 12 million acres of land where Army and Air Force installations are located (USACE, Mission).

To provide effective management worldwide, the US Corps of Engineers is broken down into twelve divisions and forty districts, with each division managing up to six districts (see

Figure 2-1). The Office of the Chief of Engineers (OCE) has overall responsibility for managing the program, developing policies, procedures, and standards for the Corps. In many cases, a District covers a large geographic area and it is necessary to further divide them into Area Offices. The Area Office establishes project offices at construction sites as necessary. A District, depending on its mission, is responsible for completing construction at the annual rate of $30 million to several hundred million dollars.

Military Design / Construction Process

Although the Corps of Engineers primarily uses a traditional design-bid-build delivery

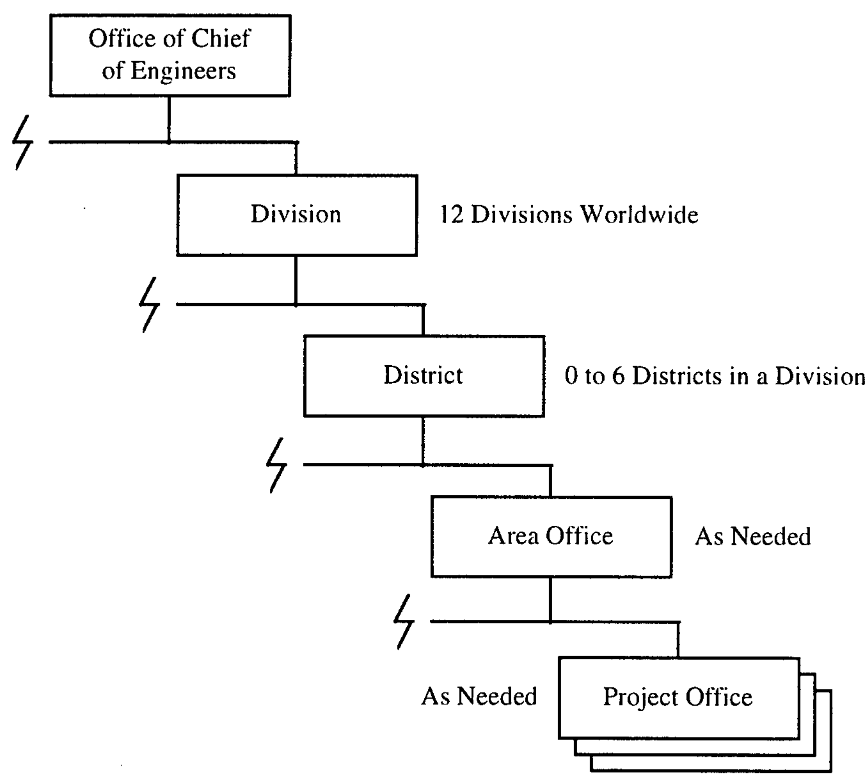


Figure 2-1 Corps Construction Organization

system, it has in recent years begun use of design-build as a method of project delivery. The increasing use of design-build reflects an increased demand for rapid delivery of a project. Although on any project deviations occur, the general steps involved in the process are as follows (See Figure 2-2):

1) Project Initiation: The project begins with receipt of the DD1391 (Directive) which provides design information and funding for the project. DD1391s are prepared by user organizations and submitted as part of the Department of Defense Budget, approved by Congress. Once the Federal Budget is approved, directives are forwarded to the Corps of Engineers for action. The DD1391 contains design criteria and funding information. During this phase, the District will develop a project management plan, including selection of a delivery system, appointment of a project manager, and tentative schedule for completion.

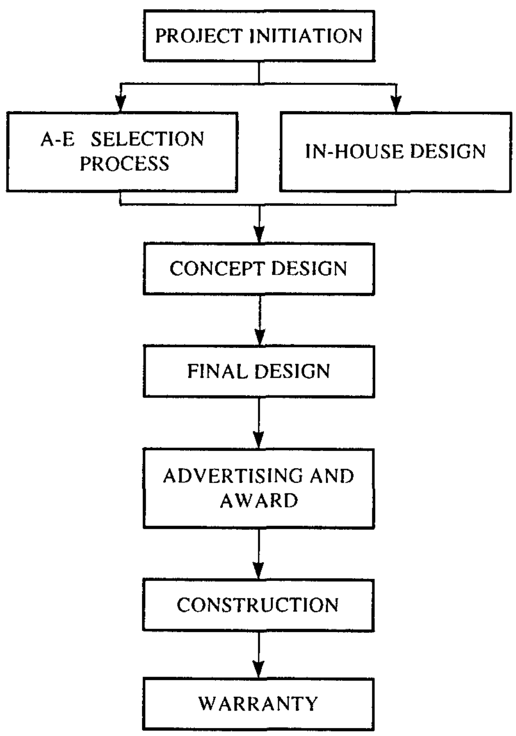


Figure 2-2 Military Design / Construction Process

2) Design Selection and Concept Design. The District Engineer and project manager decide whether to perform design work in house or to contract an A&E firm to provide design services. Once the design method is determined, and an A&E firm selected if necessary, the design is completed in two phases. In the concept-design phase a preliminary design is completed. The preliminary design is focused on size and capacity decisions, selection of major structural components (concrete vs. steel structural system), and economic studies. The design is reviewed to ensure design requirements are fulfilled and a value engineering study is performed. The conceptual design is checked to ensure adequate funding is available to complete construction.

3) Final Design. The A&E firm or in-house design section completes a detailed design of the project. Using the preliminary design as a basis, the project is broken down into its components, analyzed, sized, and engineered to comply with standards of safety and performance. Every element of the project is analyzed, resulting in the preparation of plans and specifications, which will be used to construct the project.

4) Advertising and Award. The Corps solicits construction firms to bid on the project. The Corps uses a competitive bidding system and the project is awarded to the lowest qualified bid submitted. In order to submit a bid, contractors are prequalified by the Corps, reducing the risk of contractors defaulting or providing inferior workmanship.

5) Construction. Contractors construct the project according to the plans and specifications. Corps personnel coordinate work between separate contractors, issue change orders as required

to modify the plans and specifications, and audit performance to ensure compliance with the contract.

6) Warranty. The completed project is guaranteed to perform as designed for a given period of time, usually one year. The contractor is expected to repair or correct deficiencies discovered (i.e. a leaky roof due to faulty construction) at no further cost to the government.

Quality Control/Assurance Procedures

Although there are several definitions of quality in construction, this thesis will use the definition provided by the Building Research Board (Ledbetter, 1991):

> Quality is conformance to adequately developed requirements. This definition indicates that a quality constructed facility will result provided that several conditions are met:
>
> 1. Contract documents comprise a clear, complete, and accurate description of the facility to be constructed, correctly conveying the intent of the owner regarding the characteristics of the facility needed to serve his or her purposes.
>
> 2. The contract documents define a constructed facility considered acceptable under the applicable regulatory codes and standards of professional practice, in terms of its reliability, the ease with which maintenance and repairs can be performed, the durability of its materials and operating systems, and the life safety provided to its users.
>
> 3. The facility is constructed in accordance with those documents.

The Federal Acquisition Regulation (FAR) establishes the procedures used by federal agencies in the acquisition of supplies and services with Congressionally appropriated funds. The FAR, along with the Federal Procurement Policy Act of 1974, changed the procedures used by the Corps of Engineers to manage construction projects. Prior to the FAR, the Corps executed its own Quality Control measure to dictate quality on projects. Construction specifications were very rigid; many were combined method and performance specifications, which directed how results were to be obtained in addition to what the results were to be. A large staff of inspectors would ensure compliance through aggressive inspections and quality control testing. The cost of this system was significant, adding up to six percent to the total cost of a project (Moore, 1980).

Manpower and funding constraints forced the Corps and other government agencies to look at other ways of delivering quality. The Corps was one of the first government agencies to change to the new system of quality management. Part 52 of the FAR, "Contract Clauses", states that contractors are responsible for maintaining an adequate inspection system and performing inspections which ensure the work called for in the contract conforms to contract requirements. Corps personnel would provide quality assurance, inspecting primarily to ensure contractor quality control mechanisms are working properly. Contractor Quality Control allowed the Corps to substantially reduce manpower requirements and overhead costs, while theoretically providing the same level of quality to customers (Moore, 1980). As part of the contract requirements, contractors submit a quality control plan, outlining the testing and inspection procedures they will use to ensure the product they provide complies with the plans and specifications. The role of the project manager is to provide quality assurance for the Corps of Engineers, ensuring the plans and specifications will fulfill the users requirements and that the contractors quality control system is functioning adequately. As part of quality assurance, when mistakes or discrepancies between the plan and user requirements are discovered, the project manager submits changes to the contractor to correct the deficiency.

Initiatives to Improve the Process

Although the change to a contractor quality control system reduced the overhead and management problems associated with quality control inspections, there are still numerous challenges to providing quality construction. The Building Research Board reported that a 1990 study showed more than one-third of projects fail to meet budget objectives, a similar portion finish behind schedule, and only about 80 percent meet technical objectives. In 1988, Executive Order 12552 directed the implementation of Total Quality Management in government activities. TQM revolves around teamwork, an integrated effort by all participants to produce a quality product. In the construction industry, there is an adversarial relationship between owners, contractors, and designers. Under TQM, the three parties work together to resolve disputes (Ledbetter, 1991). As part of this process, the Corps introduced partnering into its management practices. As part of the pre-construction process, Corps representatives, contractors, and designers attend a joint partnering workshop. The workshop is used to develop team spirit, plot project goals, identify critical issues, develop dispute resolution methods, and as a group develop an implementation plan. Throughout the construction process the 'partnership' is used to resolve differences and reduce conflicts. Although differences still occur, partnering has significantly reduced the number of projects, which have gone to court to resolve differences.

Chapter 3

QUALITY FUNCTION DEPLOYMENT

Background

Quality Function Deployment (QFD) originated in Japan in the late 1960's. As an international leader in the production of low-cost steel, Japan desired further expansion into the shipping industry. Faced with the challenge of building supertankers in its Kobe shipyard, one contractor, Mitsubishi, turned to the government for help developing the complex logistics required for building cargo ships. The Japanese government contracted several university professors to create a system, which would ensure each step of the construction process was linked to fulfilling a customer requirement. The developed process is known today as QFD (Guinta, 1993). QFD was first introduced in 1972 by Professor Yoji Akao at the Tamagawa University in Tokyo and has since been introduced into numerous other industrial and service applications throughout the world. (Fowler, 1991).

Quality Function Deployment, as defined by Akao (1990), is:

> Converting the consumers' demands into "quality characteristics" and developing a design quality for the finished product by systematically deploying the relationships between the demands and the characteristics, starting with the quality of each functional component and extending the deployment to the quality of each part and process. The overall quality of the product will be formed through this network of relationships.

In Japanese, "deployment" has a much broader meaning than it's English translation; referring to an extension or broadening of activities (Sikorski, 1990). QFD is a planning tool which ensures the *voice of the customer* is deployed throughout the product planning, design, and production stages. The goal of QFD is to learn exactly what customers want, then using a logical system determine how to best to fulfill those needs within available resources. It ensures everyone in an organization works together to give the customers exactly what they want (Guinta, 1993). Guinta provides the following way of viewing QFD:

1. What *qualities* does the customer desire?

2. What *function(s)* must this product serve and what functions must we use to provide this product or service?

3. Based upon the resources we have available, how can we best provide what our customer wants?

Advantages and Disadvantages

The value of QFD is that customer needs are clearly defined up-front, resulting in a better design and requiring fewer changes during the production phase. Projects are traditionally defined by three factors: cost, time, and quality. Improving one factor often requires a tradeoff in another. During the design process, many decisions are made regarding materials to be used, construction techniques, etc. In making these decisions, approximately 80% of the projects overall costs are locked in, before any construction has been started. When changes are required early in the planning process, they can easily be integrated into the plan with minimal effects; problems found later in the process have a greater impact to fix them (See Figure 3-1). Although using a QFD approach increases the time and cost associated with initial project planning and development, it will result in time and dollar savings downstream from reduced changes and conflicts during production (Hybert, 1996). A producer of QFD training videos, Technicomp. Inc., reported QFD produced 30% to 50% reduction in engineering charges, 30% to 50% shorter design cycles, 20% to 60% reduction in start up costs, and 20% to 50% reduction in warranty costs (Kinni, 1993)

The QFD Process

The QFD process is an orderly sequence of activities for evaluating customer requirements and developing a product. QFD uses a series of matrixes to organize, analyze, and compare information about a product. QFD integrates these matrixes and charts into a system (a matrix of matrixes) to realize customer requirements, functions, quality requirements, parts definitions, breakthrough methods and manufacturing (construction) requirements (Mallon, 518). The number of matrixes in a QFD study can range from four to thirty (Mallon - King, 1987, Hauser and Clausing, 1988, Ross, 1988), although the quality matrix or "House of Quality" is often the only one used. Most manufacturers break the process into four phases (See Fig 3-2). The QFD phases are a guide through the product development cycle from design to production. At each stage, the items which are most important, require new technology, or are of high risk to the organization are carried to the next phase.

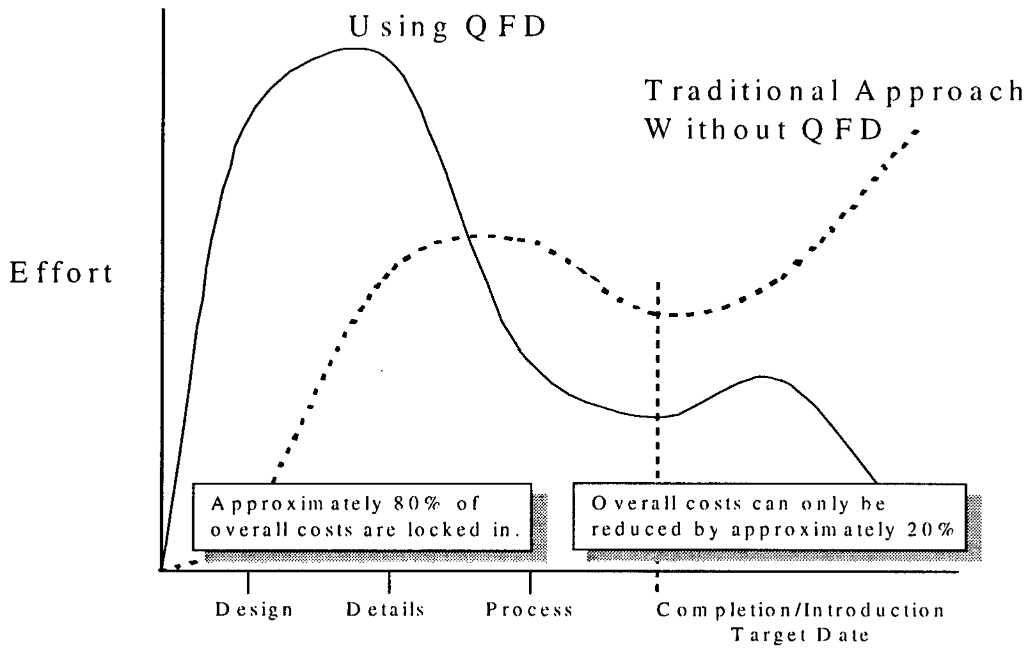


Figure 3-1 Paradigm shift: QFD vs. traditional US business methodologies. (From Guinta, 1993)

Guinta, (1995) describes the four phases as:

1) Design. The customer helps define product or service requirements. A QFD matrix is used to translate customer requirements into design requirements. Design requirements are ways in which the design team is able to satisfy the customer requirements. After evaluation, the most important design requirements are carried into the next phase.

2) Details. The details and components necessary to produce the product or service are determined. Details most critical to fulfilling product requirements specified by the customer are carried into the third phase.

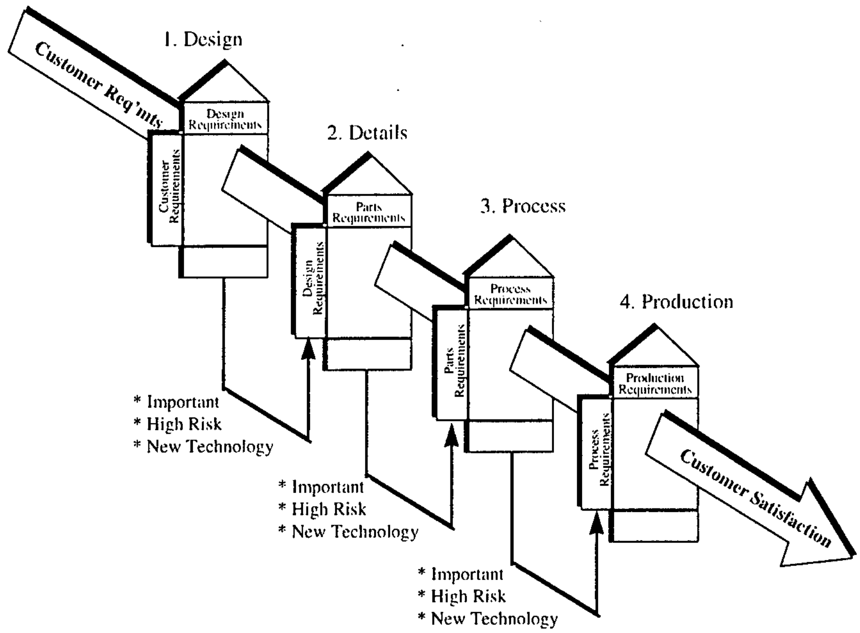


Figure 3-2 The Four Phases of QFD (from Guinta, 1988)

3) Process. The processes needed to produce the parts and components are developed. The processes most critical to fulfilling customer product requirements are carried into the fourth and final phase.

4) Production. Production requirements for producing the product are developed. The production methods will enable the company to produce a high-quality product that meets customer's requirements.

QFD Matrix Analysis.

The heart of QFD is the matrix analysis. Numerous references (Eureka, 1993, Guinta, 1995, Akao, 1990) explain in detail how to perform the analysis. The calculations can be easily performed using a simple spreadsheet program. This section uses a conventional House of Quality to describe the parts of the matrix, however a spreadsheet version will be used in further sections (See Figure 3-3). The same analysis method is used to complete subsequent matrixes in each phase.

The process begins with a determination of project scope. The project manager defines the product or service to be studied. Key elements to consider include a) is there a need for a QFD study, b) what is the purpose of the QFD study, c) how will the study be accomplished, and d) who will accomplish the study? The project manager identifies up-front what problems are to be solved using QFD. The manager recruits individuals from all areas involved in the product development (marketing, product planning, product design and engineering, process development, manufacturing, assembly, sales and service) to be part of the QFD team (Eureka, 1994). Typically, the ideal group is three to seven people with the needed expertise. If possible, the people chosen should want to participate. Their willingness to participate will improve the development process (Sikorski, 1990). A QFD facilitator or trainer may be used to familiarize team members with the rationale, vocabulary, and techniques of QFD.

Customer Requirements

The strength of QFD is in the identification of customer's requirements during the beginning of the process. The QFD team must understand the customer and their needs, both spoken and unspoken. Guinta (1993) breaks customer requirements down into four categories:

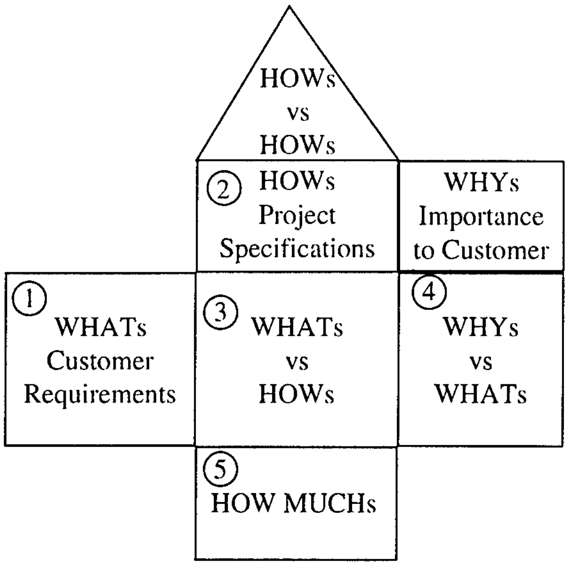


Figure 3-3 The Matrix

1) Expecters. The basic qualities or characteristics a customer expects will be part of the product or service. Customers rarely ask about expecters, because they anticipate them as part of the standard features (i.e., a new building will meet current building codes).

2) Spokens. Specific features customer says they want in a product of service. These are normally communicated verbally or in writing as specific items the customer requires (i.e., square footage requirements, certain number or types of rooms, color or fixture requirements)

3) Unspokens. Specific product or service characteristics a customer does not convey, but are still important and cannot be ignored. The QFD team must rely upon its

expertise and breadth to uncover unspokens. Typically unspokens fall into one of three groups:

a) Didn't remember to tell you. The customer forgot to state everything they needed (i.e., special storage area for a certain type of equipment). Often when programming large projects, the customer is so overwhelmed with details and time constraints, important details are forgotten, poorly defined, or omitted.

b) Didn't want to tell you. The customer does not want to reveal all their requirements. The customer tries to give the minimum amount of information for the project, and only reveals details when pressed for more information (i.e., information regarding a patented process to develop computer chips).

c) Didn't know what it was. The customer does not know how to express the requirements. When dealing with an inexperienced owner they are unaware of the options they can specify and, therefore, request something less than they really want (i.e., customer requests a 10x10 ft storage area when they actually wanted a classified storage vault with an automatic alarm system, humidity controls, and high fire protection capabilities).

4) Exciters. These are unexpected features of a product or service, which a customer does not request, but is pleased when he gets them. The features may be easy or inexpensive to provide, use of a new technology, or inclusion of a new feature. These often begin as unique features, with customers paying a premium for them, later to

become and industry standard (i.e., adding color dies to a concrete slab to improve the architectural appearance).

Development of the QFD Matrix

The QFD team uses the following five steps to complete a matrix:

1) Identify customer needs (WHATS). (Ref. 1, Figure 3-3) The interdisciplinary team defines the product or service as a function of customer demands and functions. Customer demands are defined as a statement of what the customer wants and needs, using the four types of customer requirements defined above, in the customer's language. Functions describe a level of performance the customer expects the product to be able to deliver. Demands are gathered from customer interviews and surveys, focus group data, observation of satisfiers and dissatisfiers, and other sources. Often there are more customers to be considered other than the end-user/owner (i.e. real-estate agents, operations and maintenance personnel), and their demands should also be considered. The team consolidates the list to eliminate duplicate entries and groups demands into categories (affinity categories), listed on the left side of the matrix. To provide the required definition, each WHAT item is refined into one or more substitute quality elements. In Figure 3-4, a new homeowners requirements are refined. Care must be taken when consolidating to not loose the original meaning of the customer demands.

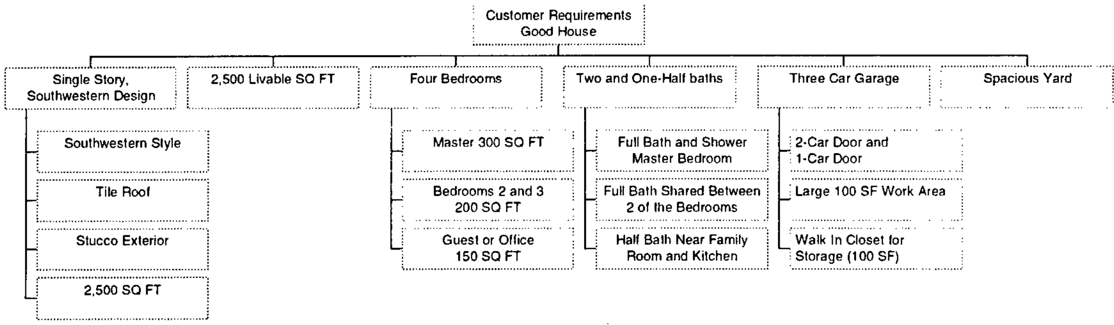


Figure 3-4 Defining Customer WHATs

2) List project / process characteristics that will meet the customer needs (HOWs). (Ref. 2, Figure 3-3). Determine which quality characteristics (specifications) are applicable for the project. Customer requirements are translated into technical requirements and specifications that satisfy the demands. HOWs are simply what the organization can measure and control in order to ensure they are going to satisfy the customer's requirements. The team consolidates technical requirements and decides on a value for each specification that fulfills the user demands.

The final part of the step requires evaluating the correlation between HOWs (the roof of the house of quality) (See fig 3-5). Relationships are rated as either strong positive, positive, negative, strong negative, or non-existent. A positive relationship is one in which an increase in one will cause an increase in the other; a negative relationship is one in which an increase in one causes a decrease in another. This helps to assess effects when a trade off between requirements is necessary.

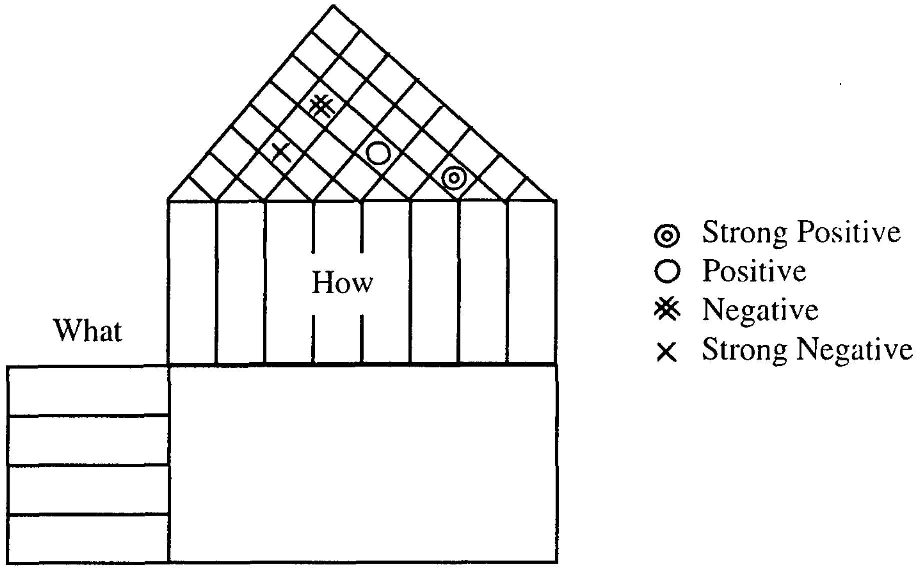


Figure 3-5 Correlation Matrix (From Eureka, 1994)

3) Determine Relationship between Customer Needs (WHATs) and Project Characteristics (HOWs). Customer needs are compared to project specifications to determine how well specifications fulfill customer needs. Relationships are rated as weak, medium, or strong, with a corresponding value of 9, 3, or 1 (See Figure 3-6). Shortcomings are identified, where customer requirements are not fulfilled by any specifications, or unnecessary specifications are included which do not address customer requirements.

4) Market Evaluation (WHYs). Customer Needs (WHATs) are rated from 1 (minor importance) to 5 (extremely important) from the viewpoint of the customer. The team works with the customer to prioritize the list (Ref. 4, Figure 3-3). Care must be taken to not give the same priority rating to every customer demand, otherwise; in effect, none are prioritized. One technique often used is to stress 'if only one demand could be fulfilled, what would it be', and add demands to the list one at a time until the priority is set. Competitive evaluations are often

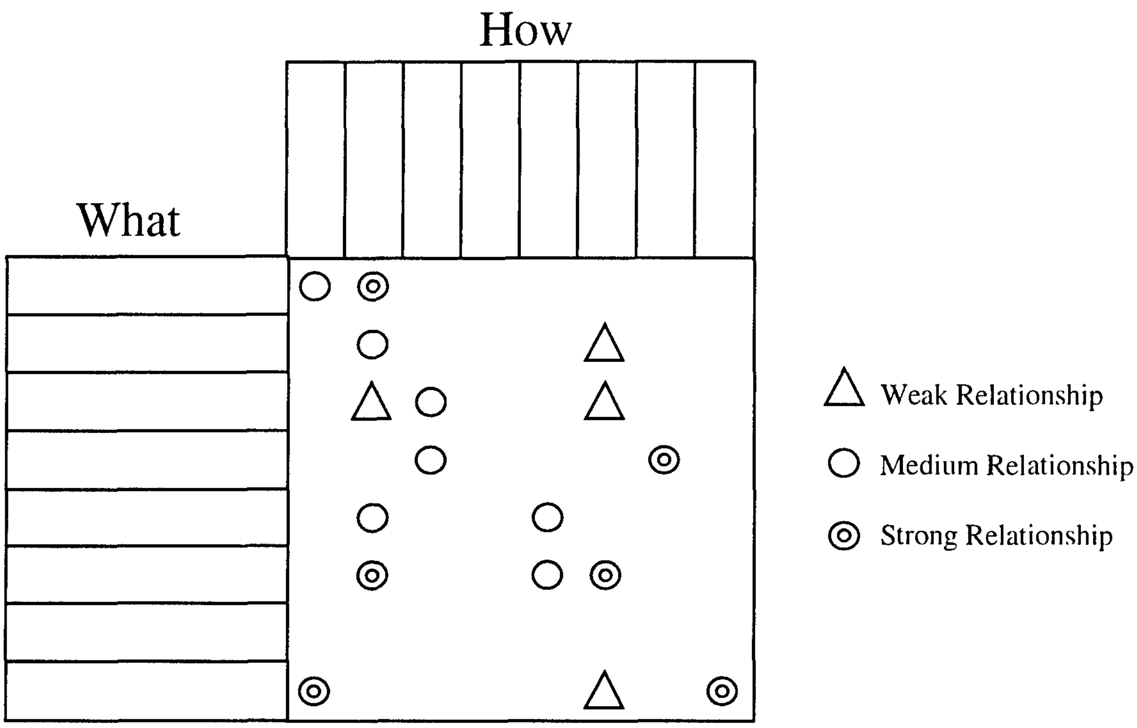


Figure 3-6 Whats vs. Hows (From Eureka, 1994)

used to highlight strengths and weaknesses in the competition that can be exploited. The WHYs are used to determine how the customer needs (WHATs) will be prioritized.

5) Determine Targets (HOW MUCHs). Determine targets values for specifications (HOW MUCHs) which reflect priorities (WHYs). Importance Factors (IFs) for each specification is determined by summing the relationship factor, determined in Step 3, multiplied by its priority rating, determined in step 4. The IF identifies which product requirements are most critical to fulfilling customer requirements and should be assigned more stringent controls. In subsequent phases of the QFD analysis, the HOWs are deployed using the HOW MUCHs as a priority rating. By focusing on customer requirements, the end product should reflect a higher quality as measured by customer needs, and a lower cost by not producing to too high a standard or forcing additional work to be done to correct a deficiency.

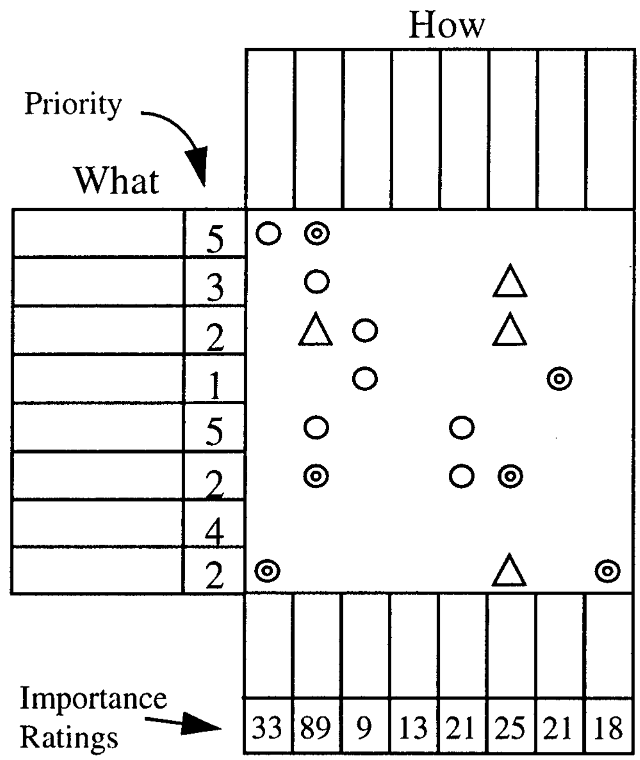


Figure 3-7 Importance Ratings to Determine How Much

Quality in Construction

There is no single standard of quality within the construction industry. What is considered good quality in a warehouse project would be substandard for construction of a microcomputer chip plant; each project has its own standards, based on engineering analysis, user requirements, and special needs. Many decisions regarding standards of quality and customer requirements are made early in the construction process, often during the conceptual or preliminary design phases. Integration of a QFD analysis would assist project managers by identifying the purpose of the project and owner requirements and expectations. By clearly identifying the customer requirements, in particular expecters and unspokens, the project team can focus on customer priorities throughout the design process Barrie and Paulson (1992) define quality as having three elements:

1) Quality Characteristics. One or more properties that define the nature of a product for quality control purposes. Quality characteristics include dimension, color, strength, etc.

2) Quality of Design. When developing a design, engineers specify not only quality characteristics for materials to be used, but also acceptable variance from the specified value. Requiring too high a material standard, or too tight a tolerance, results in increased cost and delays due to rework. Likewise too low a standard, or loose a tolerance, results in use of failure-prone materials and poor workmanship, increasing long-term costs. A quality design is therefore one in which the standards specified are most economical and functional for the project, conforming to minimum required standards.

3) Quality of Conformance. Once the design is completed, quality of conformance is the degree to which the physical work conforms to the design.

Within the construction industry, projects are often managed through time schedules and project budgets. To manage a project within cost and time constraints, contractors will compromise quality, selecting minimally acceptable quality materials to reduce costs, or accepting minimum standards in workmanship to stay on schedule. Often the substandard quality is not identified until after completion of the work, resulting in rework, lower than expected performance, and general dissatisfaction by the owner. This has resulted in a general impression quality in construction is declining, and an increased use of courts to remedy disagreements. Hybert (1996) contends the problem is the construction process does not emphasize what a customer requires in developing a project. He attributes this to five primary reasons, that a quality-based approach could help solve:

- Poor up front definition of customer needs.
- Incomplete evaluation criteria for awarding the contract (an overemphasis on price).
- Poor planning of the project activities.
- Poor assimilation of necessary midstream project changes (driven by problems or improvements discovered during the project).
- Metrics and rewards driving the wrong performance.

QFD Research in the Construction Industry

Since its conception over twenty years ago, the use of Quality Function Deployment has primarily been centered in the manufacturing industry. Although its success in manufacturing is clearly established, its use in other applications has been limited. Sikorski (1990) uses QFD to estimate impacts on quality and productivity in the design-construction industry; he concluded that QFD can be used to evaluate success at fulfilling customer requirements. Hybert (1996) describes integration of QFD into the contracting process; he concluded that implementation of a QFD based system would benefit both owners and contractors.

Akao (1990) provides a model for QFD use in the construction industry, as well as a description of its use by the Taisei Pre-Fab Construction Company in development of factory-manufactures, multiple, multiple-family housing over a ten-year period. Taisei has found they have been able to continuously improve quality, while maintaining the balance between construction and quality.

Mallon and Mulligan (1994) explain the use of QFD to redesign a computer room. They found that QFD will not reduce the cost or time associated with a projects initial design, but through the reduction or elimination of redesign, construction costs and delays will be reduced. A study conducted by Burati and Farington in 1987 reported that such deviations accounted for 12.4% of the total-in-place-cost of projects, design deviations accounted for 9.5% of this amount.

In research conducted at VTT Building Technology, Antti, Mikko, and Petri (1995) adapt QFD to the construction industry in Finland. Their study used QFD in three projects, programming of an apartment block, design of a restaurant, and structural design of an industrial building. The study found that although QFD does speed up the design process and make it more responsive to customer needs, QFD is not a substitute for engineering expertise. Its greatest benefits lie in identification of customer requirements (often not clearly defined), enhancing the decision-making process later on.

QFD in the ACOE Phases of Construction Project

Figure 3-8, integrates the use of QFD into the construction sequence used by the Corps of Engineers. The QFD process is modified to reflect the complexities involved with construction projects and the design process. To perform a QFD analysis on every part of a project would be very long and tedious; critical components are therefore identified and a subsystem analysis is performed. In development of matrixes to develop manufactured housing, Akao identifies three types of analysis which could be performed in construction (Akao, 1990):

1) Demanded quality deployment flow. The demanded quality for a product is translated or deployed into demanded quality for its components, materials, and the processes required to construct the product.

2) Function flow. The demanded quality is defined by certain functions. The required functions are deployed into required functions for components, materials, and construction processes. Function flow analysis can be very useful when introducing new or unfamiliar technology.

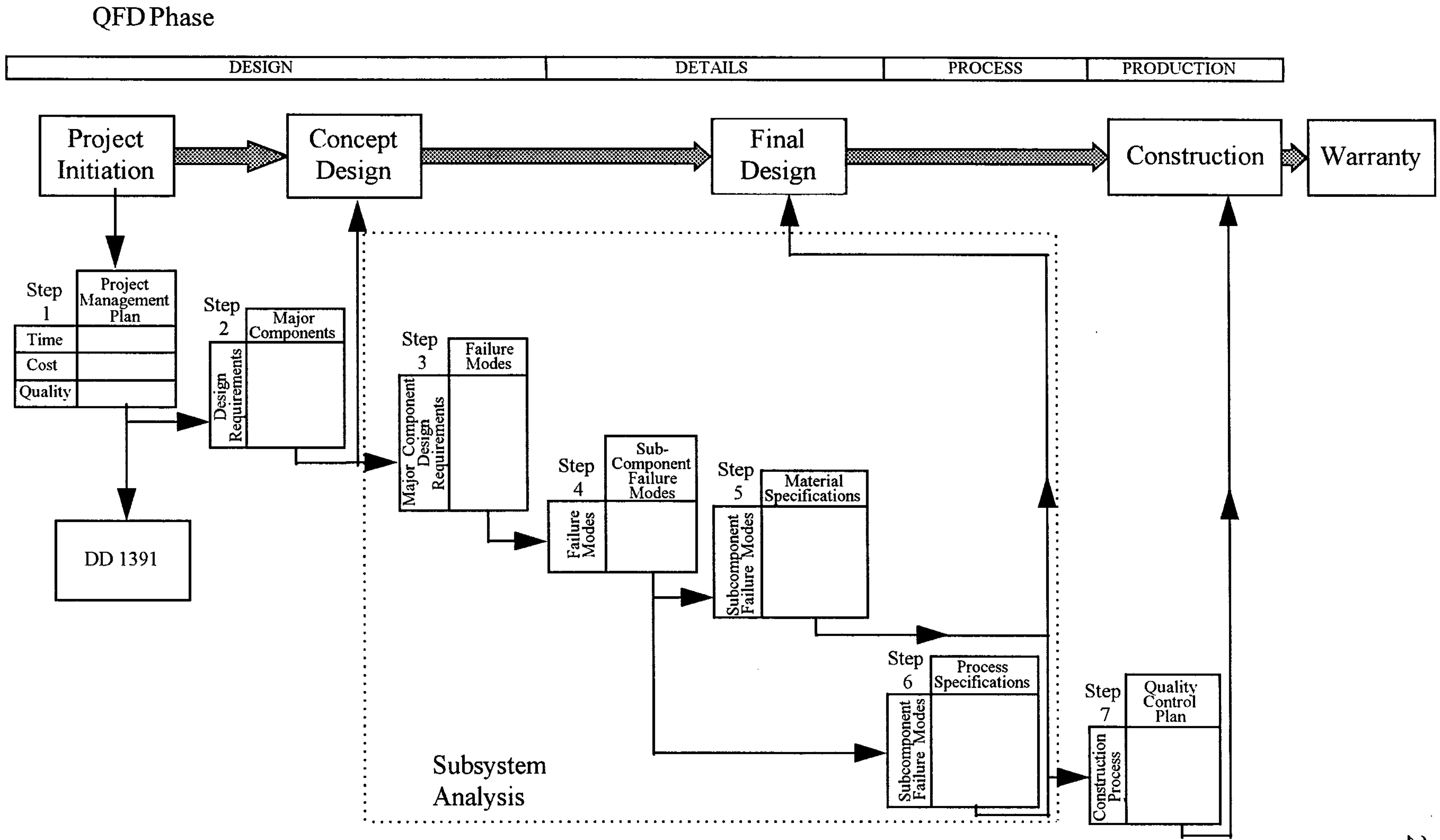


Figure 3-8 QFD in Construction

3) Failure Mode Tables. The demanded quality is defined by failure modes of the product. The failure or lack of quality is deployed into the components, materials, and construction processes.

The analysis must also take into account necessary qualities of construction. Akao (1990) states:

> The quality function deployment . . . may be effective for translating user requirements into housing quality, but that alone cannot build a house. For example, the user expects that the quality of a foundation of a building to be adequate and generally does not express much interest in it. It is therefore not that important in quality deployment. Since the foundation is an important component of the building, however, we must remember that the necessary qualities of housing must be figured into the engineering, regardless of the user's demand.

Particularly when dealing with inexperienced customers, many demands are expecters and unspokens. It is therefore particularly important in construction that the right people are selected to serve on the project team; people who understand both user requirements and the relationship between numerous engineering components. A typical QFD team should include, but is not limited to, the following: the project manager, a user representative, architectural, mechanical, and other design engineers, a security manager, and a post/facility maintenance team representative. Using the procedure outlined in figure 3-8, the team should complete the following steps to perform the QFD analysis:

Step 1) Development of a Project Management Plan. The project is initiated by a customer identifying a requirement to the facility Directorate of Public Works or the Corps of Engineers. Through meetings with the user agency, customer requirements and priorities are identified, as well as a time schedule required for completion. Special requirements (such as higher than normal security needs) are identified through regulations, technical manuals, or project reviews by outside agencies. Customer requirements are deployed into technical design requirements and functions, which are used to prepare the DD 1391 and conceptual design.

Step 2) Design Requirements vs. Major Components. Customer requirements are compared to project major components during development of the conceptual design. The design requirements and priorities established in step 1 are used to guide the design team in the development of space requirements, etc. and incorporation of special needs. The team assigns a relationship factor (9,3, or 1) corresponding with each design requirement and major component; using the priorities established an importance factor (degree of importance) for each component is calculated. In development of the conceptual design, many organizations utilize a standardized Work Breakdown Structure (WBS) to describe the work elements of a project (See figure 3-9). Major components used at this level would be comparable to the subfacility/subarea detail designator in the WBS.

Step 3) Major Component Design Requirements vs. Failure Modes. To reduce matrixes to a manageable size, a subsystem analysis (steps 3 through 7) is performed for critical components; as time and/or money permits additional components can be analyzed. Critical components may be further divided into sub-components, using a WBS or other method, to allow focusing on a particular assembly (such as the building security system, part of the electrical system). The same procedure of assigning relationship factors and calculating importance factors is used to identify the most critical failure modes for the component.

CLASSIFICATION OF ACCOUNTS
BASIC NUMBERING FORMAT

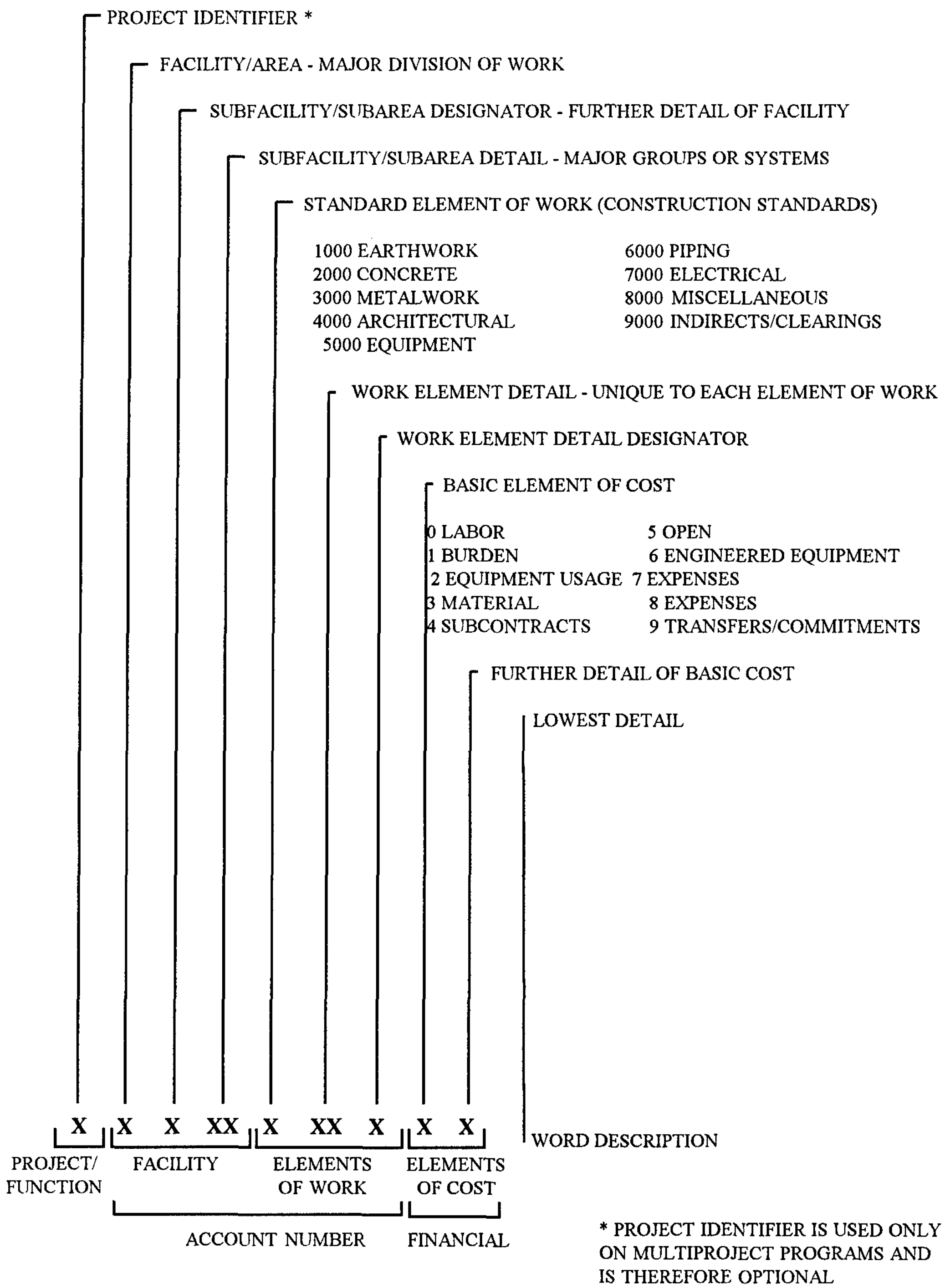


Figure 3-9 Work Breakdown Structure for a Major Project (From Barrie and Paulson, 1992)

Step 4) Component Failure modes vs. Subcomponent Failure Modes. For each critical component, design requirements are further defined by comparing component failure modes to subcomponent (individual part) failure modes. Subcomponent failure modes result from insufficient quality materials being used or poor quality control during construction. Using relationship factors and importance factors, the most critical subcomponent failure modes are identified.

Step 5) Subcomponent Failure modes vs. Material Specifications. For each critical component, subcomponent (part) failure modes are compared to contract material specifications. Using relationship factors and importance factors, critical specifications are identified, and more stringent requirements and tolerances incorporated into the specifications. Critical material specifications are further deployed to step 7 for development of the quality control plan.

Step 6) Subcomponent Failure modes vs. Process Specifications. For each critical component, subcomponent (part) failure modes are compared to contract process specifications. Using relationship factors and importance factors, critical specifications are identified, which may be given more stringent controls (method specifications). Critical processes are deployed to step 7 for development of the quality control plan.

Step 7) Quality Control Plan. For each critical component, the critical construction process and material specifications identifies in steps 5 and 6 are compared to production requirements. Production requirements are used to develop schedule milestones, and select critical quality control procedures, which should be included in the quality assurance plan.

Chapter 4

QFD IN THE CONCEPTUAL DESIGN

Introduction

To further explain the use of QFD in the programming of a construction project, a case study was developed using a project recently completed by the Corps of Engineers. The case study is based on integration of a hypothetical QFD team in the design process. Development of customer requirements and priorities was completed through discussion with the project manager; based on historical records from the project history, the project directive (DD 1391), and his personal experience managing the project. This chapter will focus on integration of QFD analysis in the conceptual design stage.

Project Background

As part of the 1993 Congressional Base Realignment and Closure (BRAC) decision, Vint Hill Farms Station, VA was identified for closure. The Operations and Security Group (OSEG), located at Vint Hill Farms, therefore required a new headquarters and training facility be constructed at Ft Belvior, VA. The project was managed by the Baltimore District, US Army Corps of Engineers. The project directive (see Appendix B) and conceptual design were developed in late 1994 with an estimated cost of $4.9 M. Architectural services were contracted with an outside A&E firm; the final design was completed in Feb 1996. Bidding was conducted in March of 1996 as a lump-sum project, and construction began soon afterwards. The OSEG facility was completed in Feb 1997.

Customer Requirements

The user and primary customer for this project was OSEG. Secondary customers identified include the Directorate of Public works, Ft. Belvior who would be responsible for maintenance of the facility, and the Corps of Engineers, who were responsible for construction. Due to the classified nature of work to be performed in the facility, the design required detailed coordination with the Ft. Belvoir physical security agency and review for compliance with numerous physical security requirements. The QFD process begins with the project manager assembling the QFD team and defining a scope of analysis. The scope is defined by answering the question "What are the important qualities of this training and administrative facility?" The resulting list should capture all the customer requirements for the completed project. Based on input from the project manager regarding the project initiation, the following list reflects what the QFD team would have completed at this point in the procedure:

1) Expecters

- Adequate structural performance in building
- Low maintenance
- Attractive building design
- Complies with applicable regulations and statutes
- Completed as quickly as possible

2) Spokens

- Sufficient administrative and storage space for entire group
- Classified storage areas and arms room
- Conference room
- Learning center
- Applied instruction classrooms with team rooms

- Photo laboratory
- Uninterrupted operations for communications systems
- Controllable access to building sections
- Secure communication requirements
- Intrusion Detection system
- Integrated alarm system
- Backup generator and power supply system
- Handicap accessible

Once the team agrees on customer requirements, they would begin to develop the project management plan.

Matrix 1: The Project Management Plan

In development of the first matrix, customer requirements (WHATs) are broken down into three affinity categories, time, cost, and quality (See figure 4-1). During the projects conceptual design early completion was desirable, however staying within the approved budget and providing adequate quality, particularly regarding security, were viewed as more important by OSEG and the Corps of Engineers. The priorities assigned by the hypothetical QFD group reflects the priorities established at that point in time. Each requirement was broken down into substitute quality characteristics and prioritized from 1 to 5, with 5 being the highest priority. There is a natural tendency to assign high values to all the requirements; however, this will tend to negate those few requirements that are the utmost priority to the customer. While the team assigns priorities, it also reviews the customer requirement list to ensure no requirements are missing. Upon completion, the team reviews the list of customer requirements and priorities to ensure correctness and a proper balance of highs to lows; it may take as many as three reviews to compile a priority list, which adequately reflects the customer's true requirements.

Customer requirements assigned the highest priorities were as follows:

- Structural durability of building
- Building adequately support loads (sturdiness)
- Ability to conduct uninterrupted operations (both due to reliability of components and fewer requirements to shut down classified operations while repair personnel are working)
- Security of facility

WANTs	REQUIREMENTS Quality Characteristics	WHATs Substitute Quality Characterisitcs	Customer Priority
On Time	Minimum Design Delays	No unforseen conditions	3
		Drawings correct	3
		Shop Drawings approval	1
	Minimum Contractor Delays	No Sequence problems	2
		No Material Delays	2
		Good Productivity	3
		No rework	4
		Minimum change orders	3
Cost	Minimum Material Cost Increase	Changes in quantity	3
		unit cost firm	4
		Material expediting	3
	Labor	Labor costs fixed	4
		Minimum rework	3
		Labor hours fixed	4
	Equipment	Equipment requirements known	3
		Equipment costs fixed	4
		Good Productivity	2
Building Quality	Structural Performance	Durable Building	5
		Isolates outside environment	3
		Sturdy - supports loads	5
		Withstand weather extremes	3
		Energy efficient	3
	Functional Quality	Good use of space	3
		Fixtures perform as req	4
		Easy access to all rooms	3
		Adequate Storage	2
		Easy to maintain	3
	Design Quality	Attractive appearance	1
		Rooms fullfill purpose or use	3
	Social Quality	Fits in with environment	1
		Environmentally Sound	2
	Special Concerns	Uninterupted Operations	5
		Security	5
		Handicap Accessable	2

Figure 4-1, Customer Requirements (WHATs), OSEG Facility

Conceptual Design

In development of the conceptual design, the QFD team would select design requirements (HOWs) which reflect ways in which the Corps would satisfy customer requirements. The project management plan includes two types of HOWs: project delivery system HOWs, and design requirement HOWs. The project delivery system HOWs validate decisions made by the project team regarding selection of the delivery system (design-build, design-bid-build, or separate prime contracts) and the design method (in house design or contracting an outside A&E firm). Although decisions regarding project delivery cannot be made solely using QFD, it does provide insight as to critical factors within each system which affect quality and should be considered when making decisions.

Design requirements are the project's technical characteristics that are incorporated into the design to fulfill customer requirements (See figure 4-2). Design requirements are further broken down into more detailed requirements. As an example, one of the most important customer requirements is to provide adequate security for the facility. This requirement involves specifying certain material qualities and components (i.e., the strength of security vault doors), and providing certain functions (i.e., ability to detect unauthorized access to a restricted area). In answering how to provide adequate security, the team would come up with the following list, which was used to develop figure 4-2:

- Design special areas for classified work
- Construct a sturdy building which limits unwanted access and observation
- Construct a security fence to limit access to the building

Delivery system						Design Requirements																						
Delivery System			Design		Contractor Selection	Good Space Allocation			Sturdy Building			Low Maintenance			Good Environment Controls			Limits Unwanted Access						Uninterupted Power Supply			Auto Emerg System	
Design-Build	Design/bid/build	Seperate Contracts	In House	Contract A-E firm	Contractor Selection	Administrative Area	Classroom	Special Purpose Areas	Supports Loads	Durable Components	Fixtures Perform as Required	Fixtures don't break	Long lasting interior finishes	Exterior stands up to weather	Temperature controls	Protection from weather effects	Noise Control	Intrusion detection system	Security fence	Security Lighting	Classified Storage Area	Controlled access	Secure Commo system	Adequate Power source	Backup Generator	Energy monitoring & control sys	Fire suppresion	Water detection system

Figure 4-2, Design Requirements (HOWs) OSEG Facility

- Install an intrusion detection system which would detect unwanted individuals
- Install security lighting which assists in the detection of unwanted personnel
- Construct a secure storage area to protect items when assigned personnel are not present
- Develop a system to control access into the building
- Provide systems to allow secure communication
- Provide a backup system to ensure security measures continue to operate during power failures

There are three steps involved in completing the first matrix: a) evaluate the relationships between customer requirements (WHATs) and design requirements (HOWs), b) calculate an importance factor (IF), and c) calculate a priority for each design requirement (See Figure 4-3).

Project Management Plan
OSEG Training Facility

CHARACTERISTICS (HOWs)

WANTs	REQUIREMENTS Quality Characteristics	WHATs Substitute Quality Characterisitcs	WHYs	Delivery system: Delivery System			Delivery system: Design		Delivery system: Contractor Selection	Design Requirements: Good Space Allocation			Sturdy Building			Low Maintenance			Good Environment Controls			Limits Unwanted Access						Uniterupted Power Supply			Auto Emerg System	
			Customer Priority	Design-Build	Design/bid/build	Seperate Contracts	In House	Contract A-E firm	Contractor Selection	Administrative Area	Classroom	Special Purpose Areas	**Supports Loads**	Durable Components	Fixtures Perform as Required	Fixtures don't break	Long lasting interior finishes	Exterior stands up to weather	Temperature controls	Protection from weather effects	Noise Control	Intrusion detection system	Security fence	Security Lighting	Classified Storage Area	Controlled access	Secure Commo system	Adequate Power source	Backup Generator	Energy monitoring & control sys	Fire suppresion	Water detection system
On Time	Minimum Design Delays	No unforseen conditions	3	3	9	9	3	9																								
		Drawings correct	3	3	9	9	3	9		1	1	1																				
		Shop Drawings approval	1	9	3	1	9	3																								
	Minimum Contractor Delays	No Sequence problems	2	9	3	1	3	9	3																							
		No Material Delays	2						9																							
		Good Productivity	3	3	9	3			9																							
		No rework	4	1	3	3			9																							
		Minimum change orders	3	9	3	3	3	9																								
Cost	Minimum Material Cost Increase	Changes in quantity	3	1	9	9			9																							
		unit cost firm	4	1	9	9																										
		Material expediting	3																													
	Labor	Labor costs fixed	4	1	9	9																										
		Minimum rework	3	3	3	3			3																							
		Labor hours fixed	4	1	9	9																										
	Equipment	Equipment requirements known	3	3	9	9																										
		Equipment costs fixed	4	3	9	9																										
		Good Productivity	2						9																							
Building Quality	Structural Performance	**Durable Building**	5										9	9	9	9	9	9										3			1	1
		Isolates outside environment	3												9	9		9	9	9	3	9	9	3				3	9	9	3	3
		Sturdy - supports loads	5										9	9	3													3	3			
		Withstand weather extremes	3										9	9		3		9	3	9											3	3
		Energy efficient	3											3	9			9	9	9				1			1	3	3	9		
	Functional Quality	**Good use of space**	3							9	9	9	1												9							
		Fixtures perform as req	4							3	3	3		3	9	3						9	9	9	3	9	9	9	9	9	9	9
		Easy access to all rooms	3							3	3	3														9						
		Adequate Storage	2							3		9													9							
		Easy to maintain	3											9	9	9	9	9											9			
	Design Quality	Attractive appearance	1							1	1	1					9	9														
		Rooms fullfill purpose or use	3							9	9	9							3	3	3	9			9							
	Social Quality	Fits in with environment	1											3	1																	
		Environmentally Sound	2												9																	
	Special Concerns	Uninterupted Operations	5																3	3	3	9	3	3	9	3	9	9	9	9	3	3
		Security	5									3		9								9	9	9	9	9	9	3	9			
		Handicap Accessable	2							3	3	3											1			3						
		Importance Factor		130	318	294	42	102	141	91	85	118	120	213	196	120	81	162	87	105	33	180	125	108	174	129	129	144	204	135	74	74
		Weighted Percentage		4.5	11	10	1.5	3.5	4.9	3.2	2.9	4.1	4.2	7.4	6.8	4.2	2.8	5.6	3	3.6	1.1	6.2	4.3	3.7	6	4.5	4.5	5	7.1	4.7	2.6	2.6
		Priority								2	2	3	3	5	5	3	2	4	2	2	1	4	3	3	4	3	3	3	5	3	2	2

Tot	Max
2887	213

RELATIONSHIP FACTOR

STRONG	9
MEDIUM	3
WEAK	1

Fig 4-3 OSEG Facility Customer Requirements vs. Design Requirements

a) Evaluating Relationships. The relationship between WHATs and HOWS are evaluated as either strong (9), medium (3), weak, (1), or nonexistent (0).

b) Calculating IFs. To calculate the IFs for a matrix design requirement (HOW), each customer relationship factor (from a, calculated above) is multiplied by the respective priority associated with the customer requirement (WHAT). For each design requirement this quantity is summed to determine the IF.

c) The weighted percentage for each design requirement is calculated by dividing its IF by the sum of IFs for the matrix. This gives an indication of the relative importance of each design requirement (HOW) to fulfilling customer requirements (WHATs). The priority for each design requirement is calculated by dividing its IF by the greatest IF in the matrix.

In example, the highlighted portions of figure 4-3 are used to calculate the IF and priority for the design requirement to supports loads under sturdy building. There are four customer requirements (WHATs) which have a relationship factor other than 0:

Customer Requirement	Priority	Relationship Factor (RF)	Priority*RF
Durable building	5	9	45
Sturdy - supports loads	5	9	45
Withstand weather extremes	3	9	27
Good use of space	3	1	3
Total (IF)			120

For the matrix, the total of all the IFs (TOT) is 2887. The highest IF calculated (MAX) was for the design requirement to use durable components, with an IF of 213. For the design requirement support loads, the weighted percentage is calculated to be IF/TOT = 120 / 2887 = 4%. The corresponding priority, on a scale of 1 to 5, is 5*IF/MAX = 5*120/213 = 3.

Matrix 2: Customer Requirements vs. Major Components

Once the project management plan is completed, design requirements and corresponding priorities are deployed into the second matrix, Design Requirements vs. Major Components (see figure 4-4). During development of the conceptual design, design team typically develops a conceptual estimate by dividing the project into major components and making rough calculations regarding square footage, major components, and design. Using generic unit costs based on quality levels (economy, average, luxury) for each component, the rough costs are calculated; the estimated project cost is then included in the DD 1391 (See Appendix B). While this analysis is being performed, a second QFD matrix is also developed. In the second matrix, the QFD team uses the HOWs from the first matrix (Design Requirements) as WHATs. The team then identifies which components will satisfy the design requirements. In this project, fourteen components were identified which make up the facility. The same procedures are used to evaluate relationships and calculate final priorities. From this analysis, three components receive a priority of 4 or 5, indicating a high correlation to customer satisfaction. The team identifies these components for further analysis during the detailed design phase:

- Exterior Walls
- Electrical System
- Security System

Customer Requirements vs Major Components OSEG Training Facility

Design Requirements	Substitute Quality Characterisitcs	WHYs: Customer Priority	Security Fence	Foundation	Floor	Exterior Walls	Interior Partitions	Structural Frame	Roof System	Interior Finishes	Electrical system	Plumbing system	HVAC System	Security System	Fire Detection System	Furnishings	Tot	Max
Good Space Allocation	Administrative Area	2			3	9	9											
	Classroom	2			3	9	9											
	Special Purpose Areas	3			3	9	9											
Sturdy Building	Supports Loads	3		9	9	9	3	9	9									
	Durable Components	5	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
	Fixtures Perform as Required	5									3	9	9	9	9	9		
Low Maintenance	Fixtures don't break	3									9	9	9	9	9	9		
	Long lasting interior finishes	2			9	9	9			9								
	Exterior stands up to weather	4		3		9		3	9									
Good Environment Contr	Temperature controls	2				9			9				9					
	Protection from weather effects	2			3	9			9									
	Noise Control	1				9	9											
Limits Unwanted Access	Intrusion detection system	5	9			3					9			9				
	Security fence	3	9											3				
	Security Lighting	3									9			9				
	Classified Storage Area	4					9				9			9				
	Controlled access	3	9			9					3			9				
	Secure Commo system	3									9							
Uninterupted Power Sup	Adequate Power source	3									9		9					
	Backup Generator	4									9			9				
	Energy monitoring & control syst	3									3		9					
Auto Emerg System	Fire suppresion	2										3			9			
	Water detection system	2					9				3							
	Importance Factor		144	82	116	274	192	82	145	62	306	117	189	288	127	112	2235	306
	Weighted Percentage		6	4	5	12	9	4	6	3	14	5	8	13	6	5		
	Priority		2	1	2	4	3	1	2	1	5	2	3	5	2	2		

MAJOR COMPONENTS

RELATIONSHIPS

STRONG	9
MEDIUM	3
WEAK	1

Fig 4-4 OSEG Facility Design Requirements vs. Components

Chapter 5

QFD TO IMPROVE QUALITY IN THE FINAL DESIGN

Introduction

In the previous chapter critical components were identified during development of the conceptual design. As the design team progresses into final design, QFD can be integrated into the design process to improve the quality of those components. As time and/or cost permits, other components can be analyzed to improve the design. As previously discussed, in the construction industry owners often expect structures and components will perform at a certain level (the industry standard), and have no other spoken or unspoken requirements. When a wall or other component fails to perform in the expected manner; however, there is a perceived lack of quality. The failure could be as extreme as a catastrophic failure (collapse) of a section, or as minor as a window that does not secure properly, allowing drafts to enter the room. A failure is any way in which the component detracts from the expected performance; a quality product is therefore one in which failures, both extreme and minor, are reduced or eliminated. Quality is improved by identifying modes in which failure may occur in the component, and applying controls to reduce or eliminate the failure. QFD accomplishes this by identifying critical sub-components, materials and construction processes that contribute to component failures, guiding preparation of construction specifications and the quality control plan. This chapter uses QFD analysis in two ways; first, to design quality into the construction of exterior walls, and second, to develop a system which fulfills the functional requirement for security.

Matrix 3: Designing Quality into Exterior Walls

During the conceptual design, exterior walls received a priority rating of 4, indicating a high correlation between quality construction of the walls and fulfilling customer requirements for the overall project. Analysis of the exterior walls begins with the QFD team asking "What are the required qualities of an exterior brick wall?" Using the design requirements (WHATs) of figure 4-4, the team begins to develop the first component matrix. This analysis is more technically oriented, and may require the addition of engineers or design personnel to the QFD team. The QFD team identifies HOWs for exterior walls that will satisfy customer requirements. Since 'expecters' for structural components often define customer requirements, it is preferable to focus the analysis on component failure modes, to more accurately reflect the customer's true requirements. During development of HOWs, the team should identify as many failure mechanisms as possible; then, through grouping of similar items, reduce the list to a manageable number of the most likely failure modes (See figure 5-1). As in the previous chapter, the team completes the matrix by evaluating relationships and calculating final priorities for each failure mode (See figure 5-2).

FAILURE MODES																										
Appearance											Structural					Environmental Controls										
Int Surface						Ext Surface					Systems					Heat			Water				Vapor		Air	
Stains Easily	Breaks during normal use	Windows / Doors break easily	Coverings separate from wall	Cracks	Joints visible	Ext materials break/chip	Mortar decays	Efflorescence	Cracks from foundation settling	Joints/corners separate	Wall Buckles or Collapses	Doors/windows do not secure properly	Joints Separate	Does Not Support roof	Connections Fail	Poor Insulation Value	Windows/Doors allow leakage	Penetration at joints	Water Penetration through Wall	Leakage at Window / Door	Leakage at joints	No drainage in wall cavity	Does not ventilate	Mildew Damage	Windows do not open	Allows Drafts

Figure 5-1 Exterior Wall Failure Modes

Matrix 4: Subcomponent Failure Modes

Once component failure modes are identified, the QFD team must determine how failures in the subcomponents (parts) that comprise the wall contribute to the overall component failure. The failure modes identified in the matrix 3 (figure 5-2) become the WHATs; the team must determine HOWs which reflect subcomponents failures which would cause failure in the component. Failure could be caused either by improper or low quality materials being used, or through improper performance during construction. This analysis is shown in figure 5-3. Once again, the team uses grouping of similar items to reduce list of failure modes to a manageable number. Completion of this matrix requires an understanding of the complex relationship between wall performance, material properties, and construction techniques; and is best performed by a dedicated committee with the required technical skills. Once the analysis of

Design Requirements vs
Failure Modes
Exterior Walls
OSEG Training Facility

Design Requirements	WHATs Substitute Quality Characteristics	WHYs: Customer Priority	HOWs: Appearance – Int Surface: Stains Easily	Breaks during normal use	Windows / Doors break easily	Coverings separate from wall	Cracks	Joints visible	Appearance – Ext Surface: Ext materials break/chip	Mortar decays	Efflorescence	Cracks from foundation settling	Joints/corners separate	Structural Systems: Wall Buckles or Collapses	Doors/windows do not secure properly	Joints Separate	Does Not Support roof	Connections Fail	Environmental Controls – Heat: Poor Insulation Value	Windows/Doors allow leakage	Penetration at joints	Water: Water Penetration through Wall	Leakage at Window / Door	Leakage at joints	No drainage in wall cavity	Vapor: Does not ventilate	Mildew Damage	Air: Windows do not open	Allows Drafts	Tot	Max
Good Space Allocation	Administrative Area	2															3														
	Classroom	2															3														
	Special Purpose Areas	3															3														
Sturdy Building	Supports Loads	3		1						3		1		9		3	9	9													
	Durable Components	5	3	9	9	3	9		9	9	3	9	1	9	3	3		3								3	3	1			
	Fixtures Perform as Required	5			3										9					3			3								
Low Maintenance	Fixtures Don't Break	3			3															1			1								
	Long Lasting Interior Finishes	2	9			9	9	1																			9				
	Exterior Stands up to Weather	4			3				9	9	3	9															1	1			
Good Environment Controls	Temperature Controls	2													3				9	9	3								3		
	Protection from Weather Effects	2													3					9	3	9	9	3					3		
	Noise Control	1													1																
Limit Unwanted Access	Intrusion Detection System	5			1										1																
	Security Fence	3																													
	Security Lighting	3																3													
	Classified Storage Area	4																													
	Controlled Access	3												9	9																
	Secure Commo System	3																													
Uninterrupted Power Supply	Adequate Power Source	3																													
	Backup Generator	4																													
	Energy Monitor & Control Systen	3																													
Auto Emergency System	Fire Suppression	2																													
	Water Detection System	2																													
	Importance Factor		33	48	86	33	63	2	81	90	27	84	5	99	105	24	48	51	18	54	12	18	36	6	0	15	37	9	12	1096	105
	Weighted Percentage		3	4	8	3	6	0	7	8	2	8	0	9	10	2	4	5	2	5	1	2	3	1	0	1	3	1	1		
	Priority		2	2	4	2	3	0	4	4	1	4	0	5	5	1	2	2	1	3	1	1	2	0	0	1	2	0	1		

RELATIONSHIPS

STRONG	9
MEDIUM	3
WEAK	1

Figure 5-2 OSEG Facility Exterior Wall Design Requirements vs. Failure Modes

Component vs. Subcomponent Failure Modes OSEG Training Facility

			WHYs	HOWs SUBCOMPONENT FAILURE MODES: Brick					CMU Block			Mortar					Reinforcement				Cavity				
Failure modes		WHATs Substitute Quality Characteristics	Customer Priority	Broken during delivery	Cracked after installation	Stained	Not straight	Seperates from Wall	Does not support loads	Cracks	Not straight	Does not bond properly	Cracks	Allows water, air penetration	Mortar dams behind brick	Sloppy appearance	Insufficient bonding length	Insufficient strength	Improper positioning	Anchors & ties break	Flashing imp positioned	Wall retains water	Vapor barrier fails	Weep holes blocked	Support angles fail
Appearance	Int Surface	Stains Easily	2																						
		Breaks during normal use	2																						
		Windows / Doors break easily	4																						
		Coverings separate from wall	2																	3					
		Cracks	3						3																
		Joints visible	0																						
	Ext Surface	Ext materials break/chip	4	9	9																				
		Mortar decays	4			1	1				1	9	9	3		3									
		Efflorescence	1			9																			
		Cracks from foundation settling	4		9				1	9		3	9				3	9							
		Joints/corners separate	0		9		9	9	9	9		3	9	9		1	9	3	3	3					9
Structural Systems		Wall Buckles or Collapses	5		9		3	9	9	9	3	9	9			1	9	9	3	9					9
		Doors/windows do not secure properly	5				3		3							3									
		Joints Separate	1						9			9					9	9							
		Does Not Support roof	1						9				9					9							
		Connections Fail	2						9			9						9							9
Environmental Controls	Heat	Poor Insulation Value	1																						
		Windows/Doors allow leakage	3																						
		Penetration at joints	1		3							9	3	3											
	Water	Water Penetration through Wall	1		9			3				9													
		Leakage at Window / Door	2																						
		Leakage at joints	0		3								3	3											
		No drainage in wall cavity	0				1								9						9	9		9	
	Vapor	Does not ventilate	1																					9	
		Mildew Damage	2																				9	3	
	Air	Windows do not open	0																						
		Allows Drafts	1							3			3	3											
		Importance Factor		35	126	16	36	47	115	82	18	139	134	19	0	33	67	122	15	48	0	0	16	12	66
		Weighted Percentage		2	7	1	2	2	6	4	1	7	7	1	0	2	4	6	1	3	0	0	1	1	4
		Priority		1	5	1	1	2	4	3	1	5	5	1	0	1	2	4	1	2	0	0	1	0	2

Figure 5-3 OSEG Facility Exterior Wall Component vs. Subcomponent Failure Modes

Component vs. Subcomponent Failure Modes OSEG Training Facility

			WHYs	HOWs: Precast				Joints		Insul		Coping			Wallboard					Int Finish			Windows & Doors							
Failure modes		WHATs Substitute Quality Characteristics	Customer Priority	Concrete cracked, chipped	Connections fail	Allows water penetration	Grouting fails	Allows water, air penetration	Allows cracking to occur	Low R value	Does not adhere properly	Allows water penetration	Does not attach properly	Metal corrodes	Cracked	Joints visible	Not attached properly	Stained	Water Damaged	Paint chips/ marks	Sloppy work	Baseboards not attached	Does not fit properly	Does not secure properly	Does not open close easily	Allows water penetration	Allows drafts, air penetration	Poor thermal properties	Tot	Max
Appearance	Int Surface	Stains Easily	2															9	3	9										
		Breaks during normal use	2												9		3			3		9								
		Windows / Doors break easily	4																				9	9	9					
		Coverings separate from wall	2														9			3										
		Cracks	3												9															
		Joints visible	0													9	3				9									
	Ext Surface	Ext materials break/chip	4	9										3																
		Mortar decays	4																											
		Efflorescence	1																											
		Cracks from foundation settling	4	9					9																					
		Joints/corners separate	0																				9							
Structural Systems		Wall Buckles or Collapses	5		9		9		3																					
		Doors/windows do not secure properly	5																					9	3					
		Joints Separate	1						3																					
		Does Not Support roof	1																											
		Connections Fail	2		9		9						9																	
Environmental Controls	Heat	Poor Insulation Value	1							9																		9		
		Windows/Doors allow leakage	3								3												9				9			
		Penetration at joints	1					9			9												9							
	Water	Water Penetration through Wall	1			3						3							3											
		Leakage at Window / Door	2																9				3			9				
		Leakage at joints	0			9		9																						
		No drainage in wall cavity	0																											
	Vapor	Does not ventilate	1																											
		Mildew Damage	2																											
	Air	Windows do not open	0																						9					
		Allows Drafts	1					9							3								9				9			
		Importance Factor		71	64	5	64	13	54	8	13	3	22	12	49	1	21	14	23	26	1	21	78	82	56	15	28	8	1894	139
		Weighted Percentage		4	3	0	3	1	3	0	1	0	1	1	3	0	1	1	1	1	0	1	4	4	3	1	1	0		
		Priority		3	2	0	2	0	2	0	0	0	1	0	2	0	1	1	1	1	0	1	3	3	2	1	1	0		

Figure 5-3 (cont) OSEG Facility Exterior Wall Component vs. Subcomponent Failure Modes relationships and failure modes is completed, the team will have identified the most critical failure modes for subcomponents, which would cause customer requirements to not be fulfilled. The following failure modes were identified achieving a priority of 4 or higher:

- Bricks - cracked after installation
- CMU Block - does not adequately support loads
- Mortar - does not properly bond
- Mortar - cracks after hardening
- Reinforcement - insufficient strength

Matrix 5 & 6: Specification Development and the Quality Assurance Plan

Subcomponent failure modes are then deployed to the final two matrixes, comparing failure modes to the construction specifications. To keep matrixes to a manageable size, and to facilitate development of a quality assurance plan, material properties and construction processes are separated. In general, Corps of Engineers' specifications are organized with material properties contained in part 2 of the specification; construction processes and execution are contained in part 3. During the conceptual design, the project manager and/or design team identifies which specification sections are required from the Corps of Engineers General Specifications. As the final design is developed, specifications are modified as necessary to fulfill engineering requirements.

In development of matrix 5, subcomponent failure modes are compared to material specifications (figure 5-4). The QFD team begins by identifying HOWs from the Corps of Engineer General Specifications. To keep the matrix size to a manageable size, only those specification paragraphs directly related to fulfilling customer requirements for exterior walls are

SUBCOMPONENT FAILURE MODES		WHYs: Customer Priority	03450 Arch Concrete: 1.3.2 Connections	1.3.3 concrete strength	1.4 Submittals	2.1 Materials	2.2 Casting Reqs	04200 Masonry: 1.2 Submittals	1.4 Delivery, Handling, Storage	2.2 Clay or Shale Brick	2.4 CMU	2.10 Mortar	2.11 Grout	2.12 Anchors, ties, bar positioners	2.13 Joint Reinforcement	2.14 Reinforcing Bars	2.15 Control joint keys	2.17 Insulation	2.18 Flashing	2.19 Weep Hole Ventilators
Brick	Broken during delivery	1						3	9	9										
	Cracked after installation	5								9										
	Stained	1						3		9										
	Not straight	1																		
	Seperates from Wall	2																		
CMU Block	Does not support loads	4									9									
	Cracks	3									9									
	Not straight	1																		
Mortar	Does not bond properly	5										9								
	Cracks	5										9								
	Allows water, air penetration	1																		
	Mortar dams behind brick	0																		
	Sloppy appearance	1																		
Reinforcement	Insufficient bonding length	2																		
	Insufficient strength	4												9		9				
	Improper positioning	1																		
	Anchors & ties break	2												9		9				
Cavity	Flashing imp positioned	0																	9	
	Wall retains water	0																		
	Vapor barrier fails	1																		
	Weep holes blocked	0																		9
	Support angles fail	2												9						
Precast	Concrete cracked, chipped	3		9		9	9													
	Connections fail	2	9																	
	Allows water penetration	0											9							
	Grouting fails	2											9							
Joints	Allows water, air penetration	0																		
	Allows cracking to occur	2													9		9			
Insul	Low R value	0																9		
	Does not adhere properly	0																9		
Coping	Allows water penetration	0																		
	Does not attach properly	1																		
	Metal corrodes	0																		
Wallboard	Cracked	2																		
	Joints visible	0																		
	Not attached properly	1																		
	Stained	1																		
	Water Damaged	1																		
Int Finish	Paint chips/ marks	1																		
	Sloppy work	0																		
	Baseboards not attached	1																		
Windows & Doors	Does not fit properly	3																		
	Does not secure properly	3																		
	Does not open close easily	2																		
	Allows water penetration	1																		
	Allows drafts, air penetration	1																		
	Poor thermal properties	0																		
	Importance Factor		21	23	0	23	23	5	11	57	64	88	23	77	17	55	17	7	0	4
	Weighted Percentage		2	3	0	3	3	1	1	6	7	10	3	9	2	6	2	1	0	0
	Priority		1	1	0	1	1	0	1	3	4	5	1	4	1	3	1	0	0	0

SUBCOMPONENT FAILURE MODES		WHYs: Customer Priority	05120 Str Steel: 1.3 Submittals	2.1 Structural Steel	2.5 High strength bolts and nuts	2.6 Carbon steel bolts	05500 Metal: 2.1 Alum finishes	2.11 Expansion Joint covers	06100 Rough Carpentry: 1.2 Submittals	2.1 Lumber	2.2 Anchor bolts and nails	06200 Finish Carpent: 1.2 Submittals	2.1 Wood items	2.2 Nails	07920 Joint Sealing: 2.1 Backing	2.6 Elastometric Sealant	2.9 Preformed sealant
Brick	Broken during delivery	1															
	Cracked after installation	5															
	Stained	1															
	Not straight	1															
	Seperates from Wall	2															
CMU Block	Does not support loads	4															
	Cracks	3															
	Not straight	1															
Mortar	Does not bond properly	5															
	Cracks	5															
	Allows water, air penetration	1															
	Mortar dams behind brick	0															
	Sloppy appearance	1															
Reinforcement	Insufficient bonding length	2															
	Insufficient strength	4															
	Improper positioning	1															
	Anchors & ties break	2															
Cavity	Flashing imp positioned	0															
	Wall retains water	0															
	Vapor barrier fails	1															
	Weep holes blocked	0															
	Support angles fail	2															
Precast	Concrete cracked, chipped	3															
	Connections fail	2															
	Allows water penetration	0															
	Grouting fails	2															
Joints	Allows water, air penetration	0						9									9
	Allows cracking to occur	2						3									
Insul	Low R value	0															
	Does not adhere properly	0															
Coping	Allows water penetration	0															9
	Does not attach properly	1											9				
	Metal corrodes	0					9										
Wallboard	Cracked	2															
	Joints visible	0															
	Not attached properly	1															
	Stained	1															
	Water Damaged	1															
Int Finish	Paint chips/ marks	1															
	Sloppy work	0															
	Baseboards not attached	1										9	9				
Windows & Doors	Does not fit properly	3															
	Does not secure properly	3															
	Does not open close easily	2															
	Allows water penetration	1														3	
	Allows drafts, air penetration	1														3	
	Poor thermal properties	0															
	Importance Factor		0	0	0	0	4	10	0	0	0	0	7	14	0	5	5
	Weighted Percentage		0	0	0	0	0	1	0	0	0	0	1	2	0	1	1
	Priority		0	0	0	0	0	1	0	0	0	0	0	1	0	0	0

SUBCOMPONENT FAILURE MODES		WHYs: Customer Priority	08110 Doors and Frames: 2.1 Doors and Frames	2.3 Thermal insulation	2.6 Weatherstripping	08520 Windows: 1.2 Window performance	2.1 Window types	2.2 Weatherstripping	2.4 Accessories	2.7 Manual control system	08700 Hardware: 2.3 Hinges	2.4 Locks	2.7 Door closing devices	09250 Gypsum Wallboard: 2.1 Stud walls	2.4 Gypsum board	2.5.1 Taping	2.5.2 Finishing compound	2.5.4-9 Fasteners	09900 Painting: 1.2 Submittals	2.1 Paint
Brick	Broken during delivery	1																		
	Cracked after installation	5																		
	Stained	1																		
	Not straight	1																		
	Seperates from Wall	2																		
CMU Block	Does not support loads	4																		
	Cracks	3																		
	Not straight	1																		
Mortar	Does not bond properly	5																		
	Cracks	5																		
	Allows water, air penetration	1																		
	Mortar dams behind brick	0																		
	Sloppy appearance	1																		
Reinforcement	Insufficient bonding length	2																		
	Insufficient strength	4																		
	Improper positioning	1																		
	Anchors & ties break	2																		
Cavity	Flashing imp positioned	0																		
	Wall retains water	0																		
	Vapor barrier fails	1																		
	Weep holes blocked	0																		
	Support angles fail	2																		
Precast	Concrete cracked, chipped	3																		
	Connections fail	2																		
	Allows water penetration	0																		
	Grouting fails	2																		
Joints	Allows water, air penetration	0																		
	Allows cracking to occur	2																		
Insul	Low R value	0																		
	Does not adhere properly	0																		
Coping	Allows water penetration	0																		
	Does not attach properly	1																		
	Metal corrodes	0																		
Wallboard	Cracked	2													9					
	Joints visible	0														9	9			
	Not attached properly	1												9				9		
	Stained	1													9					
	Water Damaged	1																		
Int Finish	Paint chips/ marks	1																	3	9
	Sloppy work	0																		
	Baseboards not attached	1																		
Windows & Doors	Does not fit properly	3	9			3	9													
	Does not secure properly	3	9						9			9	9							
	Does not open close easily	2	9						9	9	9									
	Allows water penetration	1	3		9			9												
	Allows drafts, air penetration	1	3		9			9												
	Poor thermal properties	0	1	9		9														
	Importance Factor		75	3	14	11	25	14	45	18	18	27	27	7	21	0	0	7	3	8
	Weighted Percentage		8	0	2	1	3	2	5	2	2	3	3	1	2	0	0	1	0	1
	Priority		4	0	1	1	1	1	3	1	1	2	2	0	1	0	0	0	0	0

Tol	Max
881	88

RELATIONSHIPS

STRONG	9
MEDIUM	3
WEAK	1

Figure 5-4 OSEG Facility Exterior Wall Subcomponent Failure modes vs. Material specifications

used in the analysis (Only those specifications which address HOW a failure mode (what) will be prevented or controlled). Relationship factors and specification priorities are calculated as in previous matrixes. For each specification, the priority reflects its importance to preventing failure modes and therefore fulfilling customer requirements. Based on the traditional engineering analysis performed during the final design and the priorities resulting from this analysis, specification values are modified as necessary. For construction of exterior brick walls, the analysis identified six specification paragraphs with priority 3 or greater, indicating a high correlation to fulfilling customer requirements:

Specification	Paragraph #
04200, Masonry:	2.2 Clay or Shale Brick Properties
	2.4 Concrete Masonry Units
	2.10 Mortar
	2.12 Anchors, ties, bar positioners
	2.14 Reinforcing bars
08110, Doors and Frames	2.1 Doors and Frames

During the analysis, material specifications are also compared to each other. As can be seen in Figure 5-5, specifications are generally specific with few redundancies. The construction manager ensures better quality for high priority items during development of the project's quality assurance plan, by either by dictating higher material quality standards within the specification or requiring tighter inspection standards for materials as part of the contractors quality control plan. Quality assurance inspectors would conduct inspections and evaluations during construction to

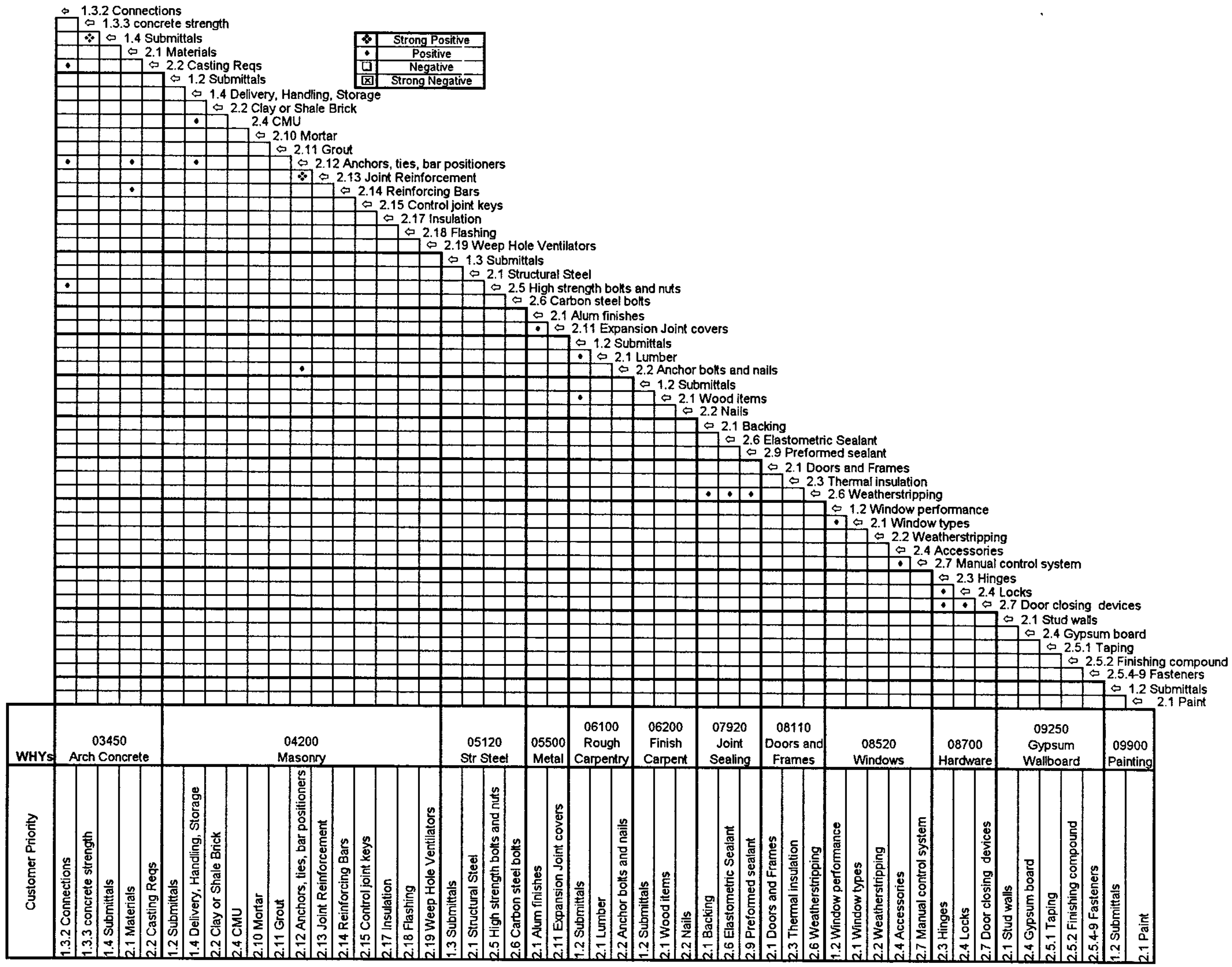


Figure 5-5 OSEG Facility Exterior Wall Material Specification Correlations

ensure materials being used comply with the critical specifications and material testing is being conducted properly.

During comparison of subcomponent failure modes to process specifications (figure 5-6), generally the same subcomponents received higher priorities. Seven specifications were identified as having a priority of 3 or greater:

Specification	Paragraph #
04200 Masonry	3.9 Mortar
	3.10 Reinforcing Steel
	3.14 Control Joints
	3.15 Brick Expansion Joints
	3.16 Shelf Angles
08110 Doors and Frames	3.1 Installation
08520 Windows	3.1 Installation

Once again specifications were compared to each other; the comparison is found in figure 5-7.

Based on this analysis, during completion of the final design the design team is able to specifically address those critical failure modes that detract from fulfilling customer requirements. By identifying critical specifications, the designer can specify higher quality material be used for those specification, and more stringent requirements on the construction process be adhered to (a combination dictating both method and performance), as well as additional quality control requirements. Figure 5-8 represents the general process used in

		WHYs	03450 Arch Concrete				04200 Masonry																			05120 Str Steel		06100 Rough Carpentry				06200 Finish Carpent		07600 Metal work		07920 Joint Sealing		08110 Doors and Frames		08520 Windows		08700 Hardware		09250 Gypsum Wallboard					09900 Painting						
SUBCOMPONENT FAILURE MODES		Customer Priority	3.1 Erection	3.2 Joint Sealing	3.3 Cleaning	3.5 Defective work	3.1 Environmental Requirements	3.2 Laying Masonry Units	3.2.3 CMU (filling cells)	3.2.4 Clay Bricks	3.2.6 Cutting & Fitting	3.2.5 Tolerances	3.2.7 Jointing	3.4 Weep holes	3.5 Composite walls	3.9 Mortar	3.10 Reinforcing Steel	3.11 Joint Reinforcement	3.12 Placing Grout	3.14 Control Joints	3.15 Brick expansion joints	3.16 Shelf angles	3.19 Anchorage to concrete & Steel	3.21 Insulation	3.26 Test Reports	3.1 Erection	3.2 Bearing Plates	3.1 Installation of Framing	3.6.2 Corner Bracing	3.6.3 Blocking	3.6.4 Nailing Strips	3.4 Molding & Int trim	3.7 Woodwork items	3.4 Connections	3.7 Flashings	3.1 Surface Prep	3.2 Application	3.1 Installation	3.2 Field Painted Finish	3.1 Installation	3.2 Adjustments	3.1 Application	3.2 Operational Test	3.1.1 Int Wall framing and openings	3.1.2 Wall control joints	3.4 Application of Gypsum board	3.5 Taping and finishing	3.7 Patching	3.2 Surface Prep	3.3 Mixing and thinning	3.4.3 Application 1st coat	3.4.6 Fillers	3.4.9 Epoxy coating	3.7 Surfaces to be painted	3.10 painting schedule
Brick	Broken during delivery	1																																																			
	Cracked after installation	5					3				3						3				9																																
	Stained	1																							3																												
	Not straight	1						9				9	3																																								
	Seperates from Wall	2						1							3		3					9	9																																
CMU Block	Does not support loads	4							9													3																																	
	Cracks	3									3						9	9		9																																			
	Not straight	1										9																																											
Mortar	Does not bond properly	5						3	1				3			9																																						
	Cracks	5														9				3	3				9																												
	Allows water, air penetration	1											3			9																																					
	Mortar dams behind brick	0																																																			
	Sloppy appearance	1											9																																								
Reinforcement	Insufficient bonding length	2														3	9																																				
	Insufficient strength	4																																																				
	Improper positioning	1																					9																																
	Anchors & ties break	2															9	9.				9	9																																
Cavity	Flashing imp positioned	0																																	9																				
	Wall retains water	0																																	3																				
	Vapor barrier fails	1																																																			
	Weep holes blocked	0												9																																							
	Support angles fail	2																				9	3																																
Precast	Concrete cracked, chipped	3	9			3																																																
	Connections fail	2	3			3																9																																
	Allows water penetration	0		9		3													3																																			
	Grouting fails	2				3													9																																			
Joints	Allows water, air penetration	0		3															9	9																9	9																		
	Allows cracking to occur	2	3														1	3		9																																			
Insul	Low R value	0																																																			
	Does not adhere properly	0																						9																															
Coping	Allows water penetration	0																																																			
	Does not attach properly	1																																9																					
	Metal corrodes	0																																																			
Wallboard	Cracked	2																																									9											
	Joints visiible	0																																										3	9	9	9				9		9	9
	Not attached properly	1																																									9		9									
	Stained	1																																											9	3		1		3		9	9	9
	Water Damaged	1																																											9			3				9		9
Int Finish	Paint chips/ marks	1																																															3			9		3
	Sloppy work	0																																														3						
	Baseboards not attached	1																													9	9																						
Windows & Doors	Does not fit properly	3																																			9		9															
	Does not secure properly	3																																			3		3		9	9												
	Does not open close easily	2																																			3		3	3														
	Allows water penetration	1																																			9		9			9												
	Allows drafts, air penetration	1																																			9		9															
	Poor thermal properties	0																																																			
	Importance Factor		36	3	0	22	14	28	42	0	22	18	32	4	5	102	85	48	26	63	55	86	43	4	45	0	0	0	0	0	0	7	7	7	0	4	4	54	0	54	6	27	32	23	0	19	2	0	3	3	2	0	20	5	15
	Weighted Percentage		3	0	0	2	1	3	4	0	2	2	3	0	0	9	8	4	2	6	5	8	4	0	4	0	0	0	0	0	0	1	1	1	0	0	0	5	0	5	1	2	3	2	0	2	0	0	0	0	0	0	2	0	1
	Priority		2	0	0	1	1	1	2	0	1	1	2	0	0	5	4	2	1	3	3	4	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	1	2	1	0	1	0	0	0	0	0	0	1	0	1

Tot: 1074 Max: 102

Figure 5-6 OSEG Facility Exterior Wall Subcomponent Failure Modes vs. Process Specifications

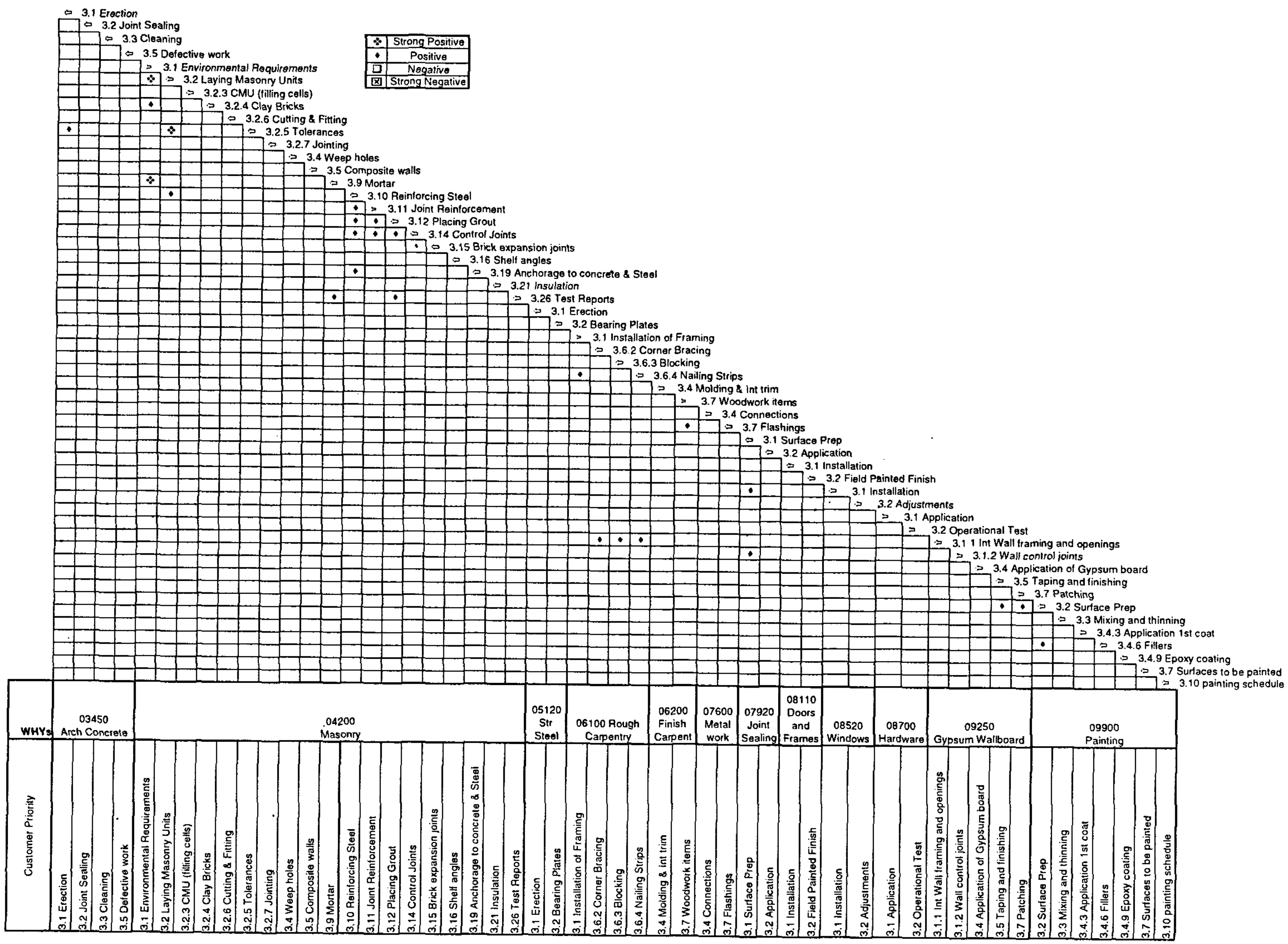


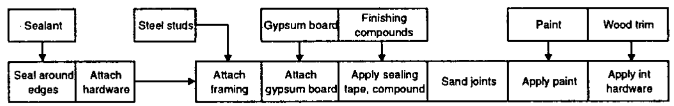
Figure 5-7 OSEG Facility Exterior Wall Process Specification Correlations

EXTERIOR WALL PROCESS STAGE CHART

		CMU	Mortar		Steel	ties, anchors			Joint Material		Brick	Mortar		Weep holes				Arch concrete	Grout		Windows & doors	
	Surveying			CMU erection	Insert Reinf	Insert anchors /ties	Joint mortar	mortar cure		Expansion joint			Brick Erection	Insert weep holes	Expansion joints	Joint mortar	mortar cure			Attach arch concrete		Insert window/door
Material Quality Chars																						
2.2 Clay or Shale Brick											9											
2.4 CMU		9																				
2.10 Mortar			9									9										
2.12 Anchors, ties, bar positioners						9																
2.14 Reinforcing Bars					9	3																
In-process tests																						
1.3.3 concrete strength																		9				
3.9 Mortar			9				3					9				3						
3.26 Test Reports			9								9	9							9			
3.2 Operational Test																						
Product Failure Modes																						
Int surface breaks during normal use																						
Int surface windows / doors break																						9
Int surface cracks																						
Ext surface materials break / chip										9			9		9							
Ext surface mortar decays			9					9									9					
Ext surface cracks from foundation settling					9	9				9												
Structure wall buckles or collapses				9	9																	
Hardware doors/windows do not secure properly																						9
Process Failure Modes																						
3.9 Mortar			9	3			9	9				9	3			9	9					
3.10 Reinforcing Steel					9																	
3.14 Control Joints				3			9			9												
3.15 Brick Expansion Joints															9							
3.16 Shelf angles						9																
3.1 Door & Frame Installation																						9
3.1 Window Installation																						9

Figure 5-8 OSEG Facility Exterior Wall Process Chart and Quality Assurance Plan

EXTERIOR WALL PROCESS STAGE CHART



Material Quality Chars

	Seal around edges	Attach hardware		Attach framing	Attach gypsum board	Apply sealing tape, compound	Sand joints	Apply paint	Apply int hardware
2.2 Clay or Shale Brick									
2.4 CMU									
2.10 Mortar									
2.12 Anchors, ties, bar positioners									
2.14 Reinforcing Bars									

In-process tests

	Seal around edges	Attach hardware		Attach framing	Attach gypsum board	Apply sealing tape, compound	Sand joints	Apply paint	Apply int hardware
1.3.3 concrete strength									
3.9 Mortar									
3.26 Test Reports									
3.2 Operational Test		9							

Product Failure Modes

	Seal around edges	Attach hardware		Attach framing	Attach gypsum board	Apply sealing tape, compound	Sand joints	Apply paint	Apply int hardware
Int surface breaks during normal use				9	9				3
Int surface windows / doors break		9							
Int surface cracks					9	9			
Ext surface materials break / chip									
Ext surface mortar decays									
Ext surface cracks from foundation settling									
Structure wall buckles or collapses									
Hardware doors/windows do not secure properly	3	9							

Process Failure Modes

	Seal around edges	Attach hardware		Attach framing	Attach gypsum board	Apply sealing tape, compound	Sand joints	Apply paint	Apply int hardware
3.9 Mortar									
3.10 Reinforcing Steel									
3.14 Control Joints									
3.15 Brick Expansion Joints									
3.16 Shelf angles									
3.1 Door & Frame Installation	9	9							
3.1 Window Installation	9	9							

Figure 5-8 (cont) OSEG Facility Exterior Wall Process Chart and Quality Assurance Plan construction of exterior brick walls; for each step in the process, critical failure modes and high priority specifications are identified. The QFD team is able to develop a quality assurance plan that focuses on compliance with the highest priority specifications. The project manager uses this information to evaluate and approve the contractor's quality control plan, ensuring critical concerns are addressed in the plan. As part of the quality assurance plan, inspectors would evaluate the procedures used by the contractor to ensure compliance, and reduce failure modes.

Designing for the Functional Quality of Providing Security

In figure 4-4, Facility Design Requirements vs. Components, the security system received a priority of 5, indicating a high importance in satisfying customer requirements. Analysis of the security system begins with a review of customer requirements. During development of customer requirements in chapter 4, several requirements were identified regarding security needs. As in the previous example, the QFD team must answer the question "What are the desired qualities of a security system?" To provide for security requirements involves the performance of several components; walls must withstand penetration, doors and locks must restrict movement, and the electrical system must be able to detect unauthorized intruders and automatically notify the proper authorities. In developing a QFD analysis for security, the team identified three functions that the facility must fulfill to satisfy customer requirements:

- Preventing unauthorized access
- Protecting items within the facility
- Detecting unauthorized persons

Fulfilling requirements involves several components; the failure of any would result in an overall failure to provide security. A failure mode analysis is therefore used again to develop the matrix. Figure 5-9 compares design requirements to failure modes for security. The failure modes are then deployed to figure 5-10, which compares component to subcomponent failure modes. As in the previous example, the design team can then evaluate individual specifications to determine those most critical to minimizing or eliminating failures, and improving quality.

Customer Requirements vs Failure Modes
Provide Security
OSEG Training Facility

DESIGN REQUIREMENTS	Substitute Quality Characteristics	WHYs	Gaps allow passage	Gates do not secure	Knocked down easily	Breached easily	Allow unauthorized access to roof	Does not segregate interior access	Do not secure properly	Breached easily	Do not automatically close	Allows viewing of classified operations	Phones traffic can be intercepted	Power supply fails	Fire damage of materials	Water damage of materials	Rusting of weapons, etc	Exterior lighting fails	Security cameras fail	Communication to fence gate fails	Intrusion detection system fails	Alarm system fails to alert Provost Marshall	Allows unauthorized access to security vaults	Tot	Max
			FAILURE MODES																						
			Prevent Unauthorized Access											Protect Items				Detect Unauthorized Persons							
			Fence			Walls			Doors/windows									Exterior			Interior				
Good Space Allocation	Administrative Area	2						3																	
	Classroom	2						3																	
	Special Purpose Areas	3						3																	
Sturdy Building	Supports Loads	3																							
	Durable Components	5				9			9																
	Fixtures Perform as Required	5			9	9	9		9																
Low Maintenance	Fixtures don't break	3	9	9		9																			
	Long lasting interior finishes	2																							
	Exterior stands up to weather	4							3																
Good Environment Controls	Temperature controls	2															3								
	Protection from weather effects	2															9								
	Noise Control	1																							
Limits Unwanted Access	Intrusion detection system	5																	3		9	9	9		
	Security fence	3	9	9	9																				
	Security Lighting	3																9							
	Classified Storage Area	4						9															9		
	Controlled access	3	9	9			9	9	9	9	9	9								9			9		
	Secure Commo system	3											9												
Uninterupted Power Supply	Adequate Power source	3												9											
	Backup Generator	4												9											
	Energy monitoring & control syste	3																							
Auto Emerg System	Fire suppresion	2													9										
	Water detection system	2														9									
	Importance Factor		79	79	68	112	69	85	125	27	27	27	27	66	16	16	28	23	15	27	45	45	109	1115	125
	Weighted Percentage		7	7	6	10	6	8	11	2	2	2	2	6	1	1	3	2	1	2	4	4	10		
	Priority		3	3	3	4	3	3	5	1	1	1	1	3	1	1	1	1	1	1	2	2	4		

RELATIONSHIPS

STRONG	9
MEDIUM	3
WEAK	1

Fig 5-9 OSEG Facility Provides Security Design Requirements vs Failure Modes

Failure Modes vs Subcomponents Provides Security OSEG Training Facility

SUBCOMPONENT FAILURE MODES

FAILURE MODES			WHYs: Customer Priority	Fence – Barrier: Material breaks	Fence – Barrier: Sections not joined properly	Fence – Barrier: Can be climbed over	Fence – Barrier: Bottom not secured to ground	Fence – Support: Poles not secured in ground	Fence – Support: Poles not erect	Fence – Hardware: Bolts can be removed	Fence – Hardware: Gaps between pole and fence material	Fence – Hardware: Clamps break	Fence – Hardware: Hinge, latch breaks	Walls – Exterior: Not sturdy construction	Walls – Exterior: Does not limit access to building	Walls – Int: Does not restrict interior movement	Walls – Int: No protection of classified materials
Prevent Unauthorized Access	Fence	Gaps allow passage	3	9	9	3	9				9	9					
		Gates do not secure	3	3					9	3			9				
		Knocked down easily	3					9	9	9		9					
	Walls	Breached easily	4											9			
		Allow unauthorized	3												9		
		Does not segregate	3													9	9
	Doors / Windows	Do not secure properly	5														
		Breached easily	1														
		Do not automatically close	1														
		Allows viewing of	1														
	Commo	Phones traffic can be	1														
Protect Items		Power supply fails	3														
		Fire damage of materials	1														
		Water damage of	1														
		Rusting of weapons, etc	1														
Detect Unauthorized Persons	Exterior	Exterior lighting fails	1														
		Security cameras fail	1														
		Communication to fence	1														
	Interior	Intrusion detection system	2														
		Alarm system fails to alert Provost Marshall	2														
		Allows unauthorized access to security vaults	4														
		Importance Factor		38	28	9	28	24	53	34	28	53	28	40	25	30	30
		Weighted Percentage		4	3	1	3	2	5	3	3	5	3	4	2	3	3
		Priority		3	3	1	3	2	5	3	3	5	3	4	2	3	3

FAILURE MODES			WHYs: Customer Priority	Doors/ Windows – Item: Easily broken or breached	Doors/ Windows – Item: Allow viewing into classified areas	Doors/ Windows – Hardware: Can be opened from exterior	Doors/ Windows – Hardware: Do not secure properly when closed	Doors/ Windows – Hardware: Hardware can be easily broken	Electrical System – Power: Power fluctuations damage equipment	Electrical System – Power: Can not operate during power loss	Electrical System – Power: Circuit breakers trip often	Electrical System – Fire: Does not detect fire	Electrical System – Fire: Does not alert personnel	Electrical System – Fire: Does not alarm fire department	Electrical System – Water: Does not detect water	Electrical System – Water: Does not start water pumps	Electrical System – Rusting: Does not detect humidity in vaults	Electrical System – Rusting: Does not remove moisture
Prevent Unauthorized Access	Fence	Gaps allow passage	3															
		Gates do not secure	3															
		Knocked down easily	3															
	Walls	Breached easily	4															
		Allow unauthorized	3															
		Does not segregate	3															
	Doors / Windows	Do not secure properly	5			9	9											
		Breached easily	1	9				9										
		Do not automatically close	1				9											
		Allows viewing of	1		9													
	Commo	Phones traffic can be	1															
Protect Items		Power supply fails	3						9	9	9							
		Fire damage of materials	1									9	9	9				
		Water damage of	1												9	9		
		Rusting of weapons, etc	1														9	9
Detect Unauthorized Persons	Exterior	Exterior lighting fails	1							9	9							
		Security cameras fail	1															
		Communication to fence	1															
	Interior	Intrusion detection system	2															
		Alarm system fails to alert Provost Marshall	2															
		Allows unauthorized access to security vaults	4															
		Importance Factor		10	10	45	55	10	24	32	32	6	6	6	6	6	6	6
		Weighted Percentage		1	1	4	5	1	2	3	3	1	1	1	1	1	1	1
		Priority		1	1	4	5	1	2	3	3	1	1	1	1	1	1	1

FAILURE MODES			WHYs: Customer Priority	Electrical System – Commo: Allows unauthorized monitoring	Electrical System – Commo: Cannot remotely access gate into facility	Electrical System – Commo: Does not allow monitoring of IDS	Electrical System – Intrusion Detection system: Motion detector in vaults fail	Electrical System – Intrusion Detection system: Door sensors fail	Electrical System – Intrusion Detection system: Sound detectors fail	Electrical System – Intrusion Detection system: Electronic access controls fail	Electrical System – Intrusion Detection system: Wiring system fails	Electrical System – Intrusion Detection system: Alarm fails to alert PMO	Electrical System – Intrusion Detection system: Exterior motion detector fails	Electrical System – Lighting: Power failure to exterior lights	Electrical System – Lighting: Lights do not activate automatically	Electrical System – Lighting: Insufficient illumination for cameras	Electrical System – Cameras: Do not work	Electrical System – Cameras: Insufficient coverage	Electrical System – Cameras: Bad connection to monitor screen	Max	Tot
Prevent Unauthorized Access	Fence	Gaps allow passage	3																		
		Gates do not secure	3																		
		Knocked down easily	3																		
	Walls	Breached easily	4																		
		Allow unauthorized	3																		
		Does not segregate	3																		
	Doors / Windows	Do not secure properly	5																		
		Breached easily	1																		
		Do not automatically close	1																		
		Allows viewing of	1																		
	Commo	Phones traffic can be	1																		
Protect Items		Power supply fails	3	9																	
		Fire damage of materials	1																		
		Water damage of	1																		
		Rusting of weapons, etc	1																		
Detect Unauthorized Persons	Exterior	Exterior lighting fails	1											9	9	9					
		Security cameras fail	1													9	9	9	9		
		Communication to fence	1		9																
	Interior	Intrusion detection system	2			9	9	9	9	9	9		9				9	3	3		
		Alarm system fails to alert Provost Marshall	2									9									
		Allows unauthorized access to security vaults	4				9	9		9											
		Importance Factor		24	10	16	55	55	16	55	16	16	16	8	8	14	22	11	11	1062	55
		Weighted Percentage		2	1	2	5	5	2	5	2	2	2	1	1	1	2	1	1		
		Priority		2	1	1	5	5	1	5	1	1	1	1	1	1	2	1	1		

STRONG	9
MEDIUM	3
WEAK	1

Figure 5-10 OSEG Facility Provides Security Component vs Subcomponent Failure Modes

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The objective of this study was to evaluate the use of QFD as a management tool to benefit project managers within the Army Corps of Engineers. As the primary construction management service for the Department of Defense and other government agencies, the Corps must provide a timely, cost effective, quality product to its customers. Executive Order 12862 established that those services would be based on identification and fulfillment of customer requirements. Quality Function Deployment, as a management tool, assists project managers to clearly identify customer requirements and emphasize those requirements throughout the project delivery process. In both the conceptual and final design, QFD was able to provide useful information to the project design team. By emphasizing fulfillment of customer requirements during the design process, the Corps should be able to improve service by reducing the number of design changes required after construction has begun.

During the conceptual design, QFD identified which components were most critical to fulfilling customer requirements. As the project's cost is analyzed, the QFD analysis could be used to support decisions to require a higher level of quality (and therefor a higher cost per unit quantity) for certain components. Other less critical components could suffice with average or economy quality levels, while still fulfilling customer requirements. The analysis also identifies which components should receive priority for further analysis during completion of the final design.

The biggest benefit of QFD analysis occurs when integrating it into the final design. During the QFD analysis, the most critical failure modes or failures to fulfill customer requirements are identified. As the final design is completed, critical construction specifications can be made more stringent to reduce or eliminate the failure modes. The analysis also allows the quality control and assurance plans to focus on eliminating failure modes during the construction process. Through the use of QFD analysis, the Corps should be able to improve the quality of its construction delivery process by focusing the design process on providing for customer requirements, and minimizing quality control problems and design changes.

Limitations

The use of QFD in today's construction industry is clearly limited by the realities of cost and time constraints. QFD analysis will increase the cost and time associated with planning stages; owners may not be willing to pay for these 'additional' services or wait for the analysis to be completed without being able to see the long term benefits. Prior to beginning a QFD study there must be a commitment to the methodology; including additional training for personnel and longer planning time required for QFD sessions. The QFD process is time intensive to prepare the numerous matrixes; until computer software is developed which facilitates the analysis, it will continue to be an encumbering process.

Finally, an analysis of structural components requires the QFD team to understand the intricate relationships between materials, construction processes, and performance of completed components. A building component such as a brick wall is actually a composite of many vastly different materials. A QFD team would require several individuals with specialized knowledge to adequately evaluate material performances, their relationship to failure modes, and requirements during the construction process. To effectively support QFD teams for every project managed by the Corps of Engineers would require a significant commitment of personnel

Recommendations

The use of QFD to improve the current project delivery process clearly warrants further investigation by the Corps of Engineers. Due to the increased lead time and cost associated with the procedure, it would be best used when the benefits can be applied to future projects, as in a phased barracks or housing project. QFD analysis also can benefit the corps when developing projects with higher than usual quality requirements. Through clearly identifying customer requirements and prioritizing them during design, the Corps should be able to better provide for the customer.

The most difficult part of the analysis involves development of the matrixes requiring failure mode analysis. To effectively develop the analysis requires specialized knowledge and skills. Due to the generic nature of many components in construction (such as brick walls), however, a dedicated committee assembled by the Corps could develop matrixes to support the Corps of Engineer General Specifications. Once a projects' QFD team completes the conceptual design (step 2 of figure 3-8), it could use the pre-formatted matrixes to augment the process.

QFD provides the project manager with a systematic method of compiling and analyzing customer needs. Further research needs to be conducted on streamlining the procedure; to reduce the time spent developing charts and matrixes. Additional research also needs to be conducted on using QFD analysis to calculate target values for the specifications.

BIBLIOGRAPHY

Akao, Yoji (1990). *Quality Functional Deployment: Integrating Customer Requirements into Product Design.* G.H. Mazur, trans., Productivity Press, Cambridge, MA.

Barrie, Donald S. and Boyd C. Paulson (1992). *Professional Construction Management: Including C.M., Design-Construct, and General Contracting.* McGraw-Hill, Inc., New York.

Brown, Patrick G. (1991). *QFD Echoing the Voice of the Customer*, AT&T Technical Journal, Naperville, IL.

Cohen, Lou (1995). *Quality Function Deployment: How to make QFD work for you.* Addison-Wesley Publishing Co., Reading, MA.

Crow, Kenneth. (1996) "Customer Focused Development with QFD", DRM Associates.

Daetz, Douglas (1989) "QFD: A method for Guaranteeing Communication of the Customer Voice Through the Whole Product Development Cycle" Conference *Record - International Conference on Communication,* v 3, p 1329 - 1333.

Department of the Army. Corps of Engineers (USACE). Mission of the U.S. Army Corps of Engineers (USACE) August, 1994.

Eureka, William E. and Nancy E. Ryan (1995*). Quality up, Costs Down : a Manager's Guide to Taguchi Methods and QFD.* ASI Press ; Irwin Professional Pub, Burr Ridge, Ill.

Eureka, William E. and Nancy E. Ryan (1994*). The Customer-Driven Company : Managerial Perspectives on Quality Function Deployment.* ASI Press ; Irwin Professional Pub, Burr Ridge, IL

Ermer, Donald S. "Using QFD Becomes an Educational Experience for Students and Faculty" *Quality Progress*, May, 1995, 131-136.

Foo, Suantong and Jamshid C. Hosseini. (1995) "A Framework for Analyzing Perceptual Quality in Manufacturing" Department of Management, College of Business Administration, Marquette University, Milwaukee, Wisconsin.

Fowler, Theodore C. (1991). "QFD - Easy as 1-2-3", *SAVE Proceedings* (Society of American Value Engineers), Dayton, OH, p 177 - 182.

Franceschini, F. and S. Rosetto (1995) "QFD: The Problem of Comparing Technical/Engineering Design Requirements" *Research in Engineering Design,* v 7, n4, p 270-278.

Gluchkovsky, Eli A. et. al. "Avoid a Flop: Use QFD with Questionnaires" *Quality Progress*, v 28, n6, Jun. 1995, p 57-62.

Graessel, Bob and Pete Zeidler. "Using Quality Function Deployment to Improve Customer Service" *Quality Progress*, Nov., 1993, p 59 - 63.

Guinta, Lawrence R. (1993) *The QFD book: The Team Approach to Solving Problems and Satisfying Customers Through Quality Function Deployment.* AMACOM, New York

Hashimoto, Yoshitsugu (1986) *Improving Productivity in Construction Through QC and IE.* Asian Productivity Organization, Tokyo.

Hauser, J. R. and Clausing, D. (1988). "The House of Quality." *Harvard Business Review*, 66(3):63-73.

Havener, Cliffon L. "Improving the Quality of Quality" *Quality Progress*, Nov., 1993, p 41 - 44.

Hunter, Michael R. and Richard D. Van Landingham. "Listening to the Customer Using QFD" *Quality Progress,* April, 1994, p 55 - 59.

Hybert, Pete. "Five Ways to Improve the Contracting Process" *Quality Progress*, Feb., 1996, p 65 - 70.

Kinni, Theodore B. (1993) "What's QFD?" Industry Week, 1 Nov. 1993, v242, n 21, p31.

Lakka, Antti, Vainio Mikko, and Laurikka Petri (1995) *Quality Function Deployment, QFD in Construction*, VTT Research Notes 1685.

Ledbetter, William B. and Adrew C. Lemur, ed. (1991) *Inspection and Other Strategies for Assuring Quality in Government Construction.* Committee on Inspection for Quality Control on Federal Construction Projects, Building Research board, Commission on Engineering and Technical Systems, National Research Foundation, Washington, D.C. , National Academy Press.

Maier, Mark W. (1995). "Quantitative Engineering Analysis with QFD." Electrical and Computer Engineering, University of Alabama in Huntsville, Huntsville, AL.

Mallon, J.C. and D.E. Mulligan (1993) "Quality Functional Deployment - A System for Meeting Customer Needs." *Journal of Construction Engineering and Management*, ASCE, 119(3) September, pp. 516-531.

Mears, Peter (1995). *Quality Improvement Tools and Techniques.* McGraw Hill, New York.

Moore, William B. (1980). *An Assessment of Construction Quality Management in the Corps of Engineers.* Masters Degree Thesis, Pennsylvania State University.

Pyzdek, Thomas and Roger W. Berger, ed. (1992) *Quality Engineering Handbook.* ASQC Quality Press, Milwaukee.

Ross, P.J. "The Role of Taguchi Methods and Design of Experiments in QFD" *Quality Progress*, Jun. 1988, p 41 - 47.

Shillito, M. Larry (1994) *Advanced QFD: Linking Technology to Market and Company Needs.* John Wiley & Sons, Inc, New York.

Sikorski, Charles S. (1990). *Product and Process Integration for the U.S. Design-Construction Industry.* PHD Thesis, Texas A&M University.

Swanson, Roger. "Quality Benchmark Deployment" *Quality Progress*, Dec. 1993, p 81 - 84.

Thomas, H. R. and Gary R. Smith (1990). *Loss of Construction Labor Productivity Due to Inefficiencies and Disruptions: The Weight of Expert Opinion.* Report to the Pennsylvania Transportation Institute, Pennsylvania State University, University Park, PA.

Wasserman, Gary S. "On How to Prioritize Design Requirements During the QFD Planning Process" *IIE Transactions*, May, 1993, pp. 59 - 65.

Appendix A

GOVERNMENT EXECUTIVE ORDERS AND POLICY MEMORANDUMS

Executive Order 12862
Setting Customer Service Standards

September 11, 1993

Putting people first means ensuring that the Federal Government provides the highest quality service possible to the American people. Public officials must embark upon a revolution within the Federal Government to change the way it does business. This will require continual reform of the executive branch's management practices and operations to provide service to the public that matches or exceeds the best service available in the private sector.

Now, Therefore, to establish and implement customer service standards to guide the operations of the executive branch, and by the authority vested in me as President by the Constitution and the laws of the United States, it is hereby ordered:

Section 1. Customer Service Standards. In order to carry out the principles of the National Performance Review, the Federal Government must be customer-driven. The standard of quality for service provided to the public shall be: Customer service equal to the best in business. For the purposes of this order, "customer" shall mean an individual or entity who is directly served by a department or agency. "Best in business" shall mean the highest quality of service delivered to customers by private organizations providing a comparable or analogous service.

All executive departments and agencies (hereinafter referred to collectively as "agency" or "agencies") that provide significant services directly to the public shall provide those services in a manner that seeks to meet the customer service standard established herein and shall take the following actions:

(a) identify the customers who are, or should be, served by the agency;
(b) survey customers to determine the kind and quality of services they want and their level of satisfaction with existing services;
(c) post service standards and measure results against them;
(d) benchmark customer service performance against the best in business;
(e) survey front-line employees on barriers to, and ideas for, matching the best in business;
(f) provide customers with choices in both the sources of service and the means of delivery;
(g) make information, services, and complaint systems easily accessible; and
(h) provide means to address customer complaints.

Section 2. Report on Customer Service Surveys. By March 8, 1994, each agency subject to this order shall report on its customer surveys to the President. As information about customer satisfaction becomes available, each agency shall use that information in judging the performance of agency management and in making resource allocations.

Section 3. Customer Service Plans. By September 8, 1994, each agency subject to this order shall publish a customer service plan that can be readily understood by its customers. The plan shall include customer service standards and describe future plans for customer surveys. It also shall identify the private and public sector standards that the agency used to benchmark its performance against the best in business. In connection with the plan, each agency is encouraged to provide training resources for programs needed by employees who directly serve customers and by managers making use of customer survey information to promote the principles and objectives contained herein.

Section 4. Independent Agencies. Independent agencies are requested to adhere to the order.

Section 5. Judicial Review. This order is for the internal management of the executive branch and does not create any right or benefit, substantive or procedural, enforceable by a party against the United States, its agencies or instrumentalities, its offices or employees, or any other person.

/s/
William J. Clinton

The White House
September 11, 1993

[About HHS]
[Consumer Information]

[News & Public Affairs]
[Policy Information]

[What's New]
[Employee Information]

[Search]
[Partner Gateway]

[HHS Agencies on the Internet]

Back to the HHS Home Page

THE WHITE HOUSE

WASHINGTON

March 22, 1995

MEMORANDUM FOR HEADS OF EXECUTIVE DEPARTMENTS AND AGI

SUBJECT: Improving Customer Service

In the first phase of this Administration's reinventing government initiative, I established the principle that government must be customer-driven. Executive Order No. 12862, "Setting Customer Service Standards," called for a revolution within the Federal Government to change the way it does business. The initial agency responses to that order, including the service standards published in September 1994, have begun the process of establishing a more customer-focused government. For the first time, the Federal Government's customers have been told what they have a right to expect when they ask for service.

In the second phase of reinventing government ("Phase II"), this effort should be continued and integrated with other restructuring activities. The first question agency restructuring teams should ask is whether a program or function is critical to the agency's missions based on "customer" input. To carry out this Phase II effort and assure that government puts the customer first, I am now directing the additional steps set forth in this memorandum.

Actions. The agencies covered by Executive Order No. 12862 are directed as follows:

1. In order to continue customer service reform, agencies shall treat the requirements of Executive Order No. 12862 as continuing requirements. The actions the order prescribes, such as surveying customers, surveying employees, and benchmarking, shall be continuing agency activities. The purpose of these actions will remain as indicated in Executive Order No. 12862 -- the establishment and implementation of customer service standards to guide the operations of the executive branch.

2. Agencies shall, by September 1, 1995, complete the publication of customer service standards, in a form readily available to customers, for all operations that deliver significant services directly to the public. This shall include services that are delivered in partnership with State and local governments, services delivered by small agencies and regulatory agencies, and customer services of enforcement agencies.

3. Agencies shall, on an ongoing basis, measure results

achieved against the customer service standards and report those results to customers at least annually. Reports should be in terms readily understood by individual customers. Public reports shall be made beginning no later than September 15, 1995. Measurement systems should include objective measures wherever possible, but should also include customer satisfaction as a measure. Customer views should be obtained to determine whether standards have been set on what matters most to the customer. Agencies should publish replacement standards if needed to reflect these views.

4. Development and tracking of customer service measures, standards, and performance should be integrated with other performance initiatives, including Phase II restructuring. Customer service standards also should be related to legislative activities, including strategic planning and performance measurement under the Government Performance and Results Act of 1993, reporting on financial and program performance under the Chief Financial officers Act of 1990, and the Government Management and Reform Act of 1994. Operating plans, regulations and guidelines, training programs, and personnel classification and evaluation systems should be aligned with a customer focus.

5. Agencies shall continue to survey employees on ideas to improve customer service, take action to motivate and recognize employees for meeting or exceeding customer service standards, and for promoting customer service. Without satisfied employees, we cannot have satisfied customers.

6. Agencies should initiate and support actions that cut across agency lines to serve shared customer groups. Agencies should take steps to develop cross-agency, one-stop service to customer groups, so their customers do not needlessly go from one agency to another. Where possible, these steps should take advantage of new information technology tools to achieve results.

The standard of quality we seek from these actions and the Executive order is customer service for the American people that is equal to the best in business.

Independent Agencies. Independent agencies are requested to adhere to this directive.

Judicial Review. This directive is for the internal management of the Executive Branch and does not create any right or benefit, substantive or procedural, enforceable by a party against the United States, its agencies or instrumentalities, its officers or employees, or any other person.

/s/
William J. Clinton

Appendix B

PROJECT DIRECTIVE (DD 1391) OSEG PROJECT

DRAFT
11/1/94

	95	44499 W	REVISION DATE: 26 OCT 1994
ARMY		BCA (AS OF 10/26/1994 AT 14:30:32)	10 JUN 1994
		LAF=1.03	

Fort Belvoir
Virginia

Ops & Training Facility, 300 Area

141 84 44499 4,900

PRIMARY FACILITY				3,859
Administration	SF	13,675	93.69	(1,281)
Classroom	SF	4,125	99.86	(412)
Special Purpose	SF	16,633	101.47	(1,688)
Emergency Generator	KW	50	574.43	(29)
Intrusion Detection System	LS	--	--	(21)
Total from Continuation page				(428)
SUPPORTING FACILITIES				557
Electric Service	LS	--	--	(60)
Water, Sewer, Gas	LS	--	--	(35)
Paving, Walks, Curbs And Gutters	LS	--	--	(169)
Storm Drainage	LS	--	--	(80)
Site Imp(185) Demo( )	LS	--	--	(185)
Information Systems	LS	--	--	(28)
ESTIMATED CONTRACT COST				4,416
CONTINGENCY PERCENT (5.00%)				221
SUBTOTAL				4,637
SUPERVISION, INSPECTION & OVERHEAD (6.00%)				278
TOTAL REQUEST				4,915
TOTAL REQUEST (ROUNDED)				4,900
INSTALLED EQUIPMENT-OTHER APPROPRIATIONS				(457)

Construct an operations and training facility. Project includes administrative and special purpose space consisting of company storage areas, logistics and supply, operations center, isolation area, classified storage, medical aid station, conference room, learning center, arms room, copier rooms, student administrative area, student lounge, and computer room. Work also includes space for general and applied instruction classrooms with team rooms, photo laboratory and classroom storage. An emergency generator, secure communications system, automatic fire suppression system, and a water detection alarm system are required. Install an Instrusion Detection System (IDS). Connect Energy Monitoring and Control System (EMCS). An uninterrupted power system is required to accommodate the main computer, telephone and security systems. Humidity and temperature controls will be provided. Supporting facilities include utilities, electric service, fire protection, and alarm systems, paving, walks, curbs and gutters, parking, storm drainage, security lighting and fencing with controlled access, access roads, .ormation systems, and site improvements. Access for the handicapped will be provided. Heating will be provided by a dual-fired system. Air-conditioning (127 tons) will be provided by a self-contained unit. Provide comprehensive

95 44499 W REVISION DATE: 26 OCT 1994
ARMY BCA (AS OF 10/26/1994 AT 14:30:32) 10 JUN 1994
LAF=1.03

Fort Belvoir
Virginia

Ops & Training Facility, 300 Area 44499

9. COST ESTIMATES (CONTINUED)

Item	U/M	QTY	Unit COST	Cost ($000)
PRIMARY FACILITY (CONTINUED)				428
EMCS Installation	LS	--	--	(6)
Building Information Systems	LS	--	--	(422)

Description of Proposed Construction: (Continued)
building and furnishings related interior design services.

11. REQUIREMENT: NONE ADEQUATE: NONE SUBSTANDARD: NONE

PROJECT:
Construct an operations and training facility. (New Mission)

REQUIREMENT:
This project is required to provide administrative, training, and special purpose space for US Army Operations Security Evaluation Group (OSEG). OSEG evaluates the security systems of Department of Defense (DOD) facilities and other sensitive facilities worldwide. OSEG is currently stationed at Vint Hill Farms Station, Virginia, occupying substandard facilities. Vint Hill Farms Station has been identified for closure under Base Realignment and Closure (BRAC) 93 decision. OSEG is scheduled to relocate to Fort Meade under that BRAC 93 decision, but desires to relocate to Fort Belvoir, Virginia. There are no permanent facilities available at Fort Belvoir in which to relocate this activity.

CURRENT SITUATION:
This activity is currently located at Vint Hill Farms Station, Virginia. Vint Hill Farms Station has been identifed for closure under the Base Realignment and Closure (BRAC) 93 decision. OSEG is scheduled to relocate to Fort Meade under this BRAC 93 decision but desires to relocate to Fort Belvoir, Virginia, where their Headquarters Command is located. The current OSEG facilities complex at Vint Hill Farms Station is classified as a restricted site. At the present time the unit occupies ten trailers and two permanent buildings. While the permanent buildings are in relatively good condition, the trailers have deteriorated. Vint Hill Farms Station engineers have classified them as uneconomically repairable.

IMPACT IF NOT PROVIDED:
If this project is not provided, this activity will not be located near their Headquarters Command. Adequate facilities will not be available at either Fort Meade or Fort Belvoir to accomodate the relocation of the OSEG under BRAC 93

ARMY	95	44499 W	REVISION DATE: 26 OCT 1994
		BCA (AS OF 10/26/1994 AT 14:30:32)	10 JUN 1994
		LAF=1.03	

F..t Belvoir
Virginia

Ops & Training Facility, 300 Area 44499

IMPACT IF NOT PROVIDED: (Continued)
decision.

ADDITIONAL:
This project has been coordinated with the installation physical security plan, and all required physical security and/or combatting terrorism (CBT/T) measures are included. This project complies with the scope and design criteria of DOD 4270.1-M, Construction Criteria, that were in effect 1 January 1987, as implemented by the Army's Architectural and Engineering Instructions (AEI), Design Criteria, dated 9 December 1991 and all subsequent revisions.

Peter J. Geloso
COL, EN
Garrison Commander

ESTIMATED CONSTRUCTION START:	NOV 1995	INDEX: 1986
ESTIMATED MIDPOINT OF CONSTRUCTION:	JUN 1996	INDEX: 2015
ESTIMATED CONSTRUCTION COMPLETION:	FEB 1997	INDEX: 2056

95 44499 W REVISION DATE: 26 OCT 1994
ARMY BCA (AS OF 10/26/1994 AT 14:30:32) 10 JUN 1994
LAF=1.03

Fort Belvoir
Virginia

Ops & Training Facility, 300 Area 44499

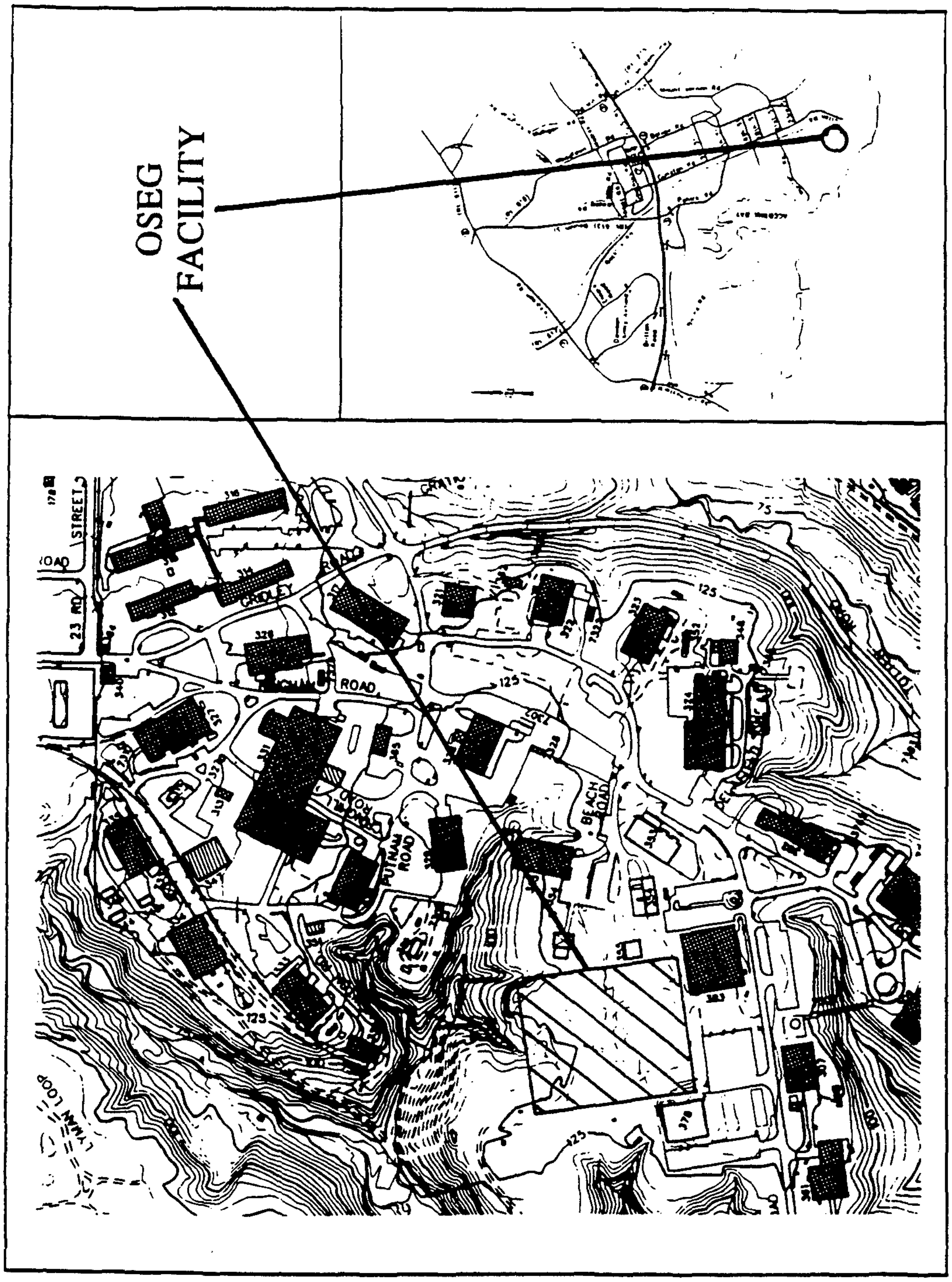
			U/M	Qty	Unit Cost	Cost ($000)
2.A PRIMARY FACILITY.						
2.A1	GENERAL.					
1.0)	61050	Administration	SF	13,675	93.69	(1,281)
2.0)	17120	Classroom	SF	4,125	99.86	(412)
3.0)	14184	Special Purpose	SF	16,633	101.47	(1,688)
4.0)	81190	Emergency Generator	KW	50	574.43	(29)
5.0)	88040	Intrusion Detection System	LS	--	--	(21)
6.0)	88090	EMCS Installation	LS	--	--	(6)
2.A2	INFORMATION SYSTEMS.					
1.0)	80800	Building Information Systems	LS	--	--	(422)
2.B SUPPORTING FACILITIES.						
2.B1	Electric Service		LS	--	--	(60)
1)		500 MCM Direct Burial	LF	600	37.74	23
2)		Dist Trsfmr Pad Mtd	KV	500	45.90	23
3)		Street Lighting	LF	600	24.11	14
4)		Manholes	EA	2	33.17	0
2.B2	Water, Sewer, Gas		LS	--	--	(35)
1)		8 inch RPVC, Water	LF	600	37.43	22
2)		6 Inch VCP, Sewer	LF	400	19.89	8
3)		Sanitary Sewer Manhole	EA	3	303.11	1
4)		Fire Hydrant	EA	2	2,088	4
2.B4	Paving, Walks, Curbs And Gutters		LS	--	--	(169)
1)		A/C Surface, 1-1/2 Inch	SY	7,800	6.97	54
2)		Base Course, Unclass, 8 inch	SY	8,000	5.80	46
3)		Subbase Course, Unclass, 6 inch	SY	8,200	2.79	23
4)		Curb & Gutter, 6 in x 18 in	LF	2,500	16.59	41
5)		Sidewalks	SF	1,400	2.89	4
2.B5	Storm Drainage		LS	--	--	(80
1)		12 Inch RCP	LF	900	26.68	24
2)		18 Inch RCP	LF	400	36.11	14
3)		Drop Inlets	EA	5	1,270	6
4)		Headwalls	EA	2	1,073	2
5)		Stormwater Management Pond	SY	400	81.60	33
2.B6	Site Improvement/Demolition		LS	--	--	(185
1)		Site Clearing	AC	4	3,372	13
2)		Haul & Spread	CY	4,000	17.65	71
3)		Grading, Rough	SY	14,500	4.83	70
4)		Grading, Fine	SY	2,650	1.17	3
5)		Grass Seeding	SY	3,200	.84	3

95 44499 W REVISION DATE: 26 OCT 1994
ARMY BCA (AS OF 10/26/1994 AT 14:30:32) 10 JUN 1994
LAF=1.03

..rt Belvoir
Virginia

Ops & Training Facility, 300 Area 44499

		U/M	Qty	Unit Cost	Cost ($000)
6)	Landscaping	LS	--	--	25
2.B7	Information Systems	LS	--	--	(28)
1) 80800	Information Systems	LS	--	--	28



12