# Preliminary System Design And Plan For The Initial Implementation Of Total Quality Management In An Engineering Services Firm

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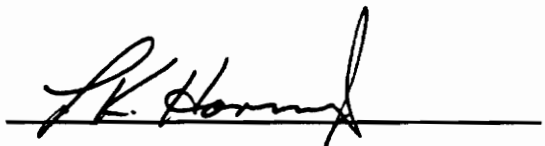

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## (ABSTRACT)

Recent changes in the world have deeply affected the defense environment in the United States. A significant reduction in threat, a change in existing threat, and a downsizing/reconfiguration of the defense program is inevitable. This decrease in the defense budget will result in an increase in competition for contracts from the federal government. Engineering Services Firms must be able to provide higher quality, innovative products at a lower cost to their customer faster than ever before.

With the trend toward a global economy and increasing global competitiveness, there exists a need for a firm to change its current operating and management systems to continuously increase the quality of the outputs and the processes that produce these outputs, to remain top in their industry. One method of achieving this is to manage the processes of the firm through the implementation Total Quality Management.

This project demonstrates the use of the systems engineering approach to develop a preliminary system design and plan for the initial implementation of Total Quality Management in an Engineering Services Firm.

**Preliminary System Design And Plan For The Initial Implementation Of Total Quality Management In An Engineering Services Firm**

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## 1. Purpose of Project

The purpose of this project is to demonstrate knowledge of systems theory, the system life cycle and the use of the systems engineering approach. Then, develop a preliminary system design and plan to implement Total Quality Management enhancements in an Engineering Services Firm. This paper will describe or define the necessary terms used in the context of the project, show the need for this change in the existing system, and provide a preliminary design for a plan to implement this change into the system. Closing will include some general comments of implementing such a change and a recommendation of topics for further research.

This research effort found many different definitions and descriptions for some of the key terms. Some were directly in the context of this project. Definitions that are directly from a specific source are referenced. However, many of the descriptions and definitions provided in this paper are the result of interpretations from many different sources for the purpose of this project. Descriptions and definitions were combined and interpreted for use in the scope and context of this project.

This paper is divided into the following sections in effort to document the research and conclusions of the project.

**Section 1.** Provides purpose of the project with an over view of the paper.
**Section 2.** Provides a general description of the "system" and its operating environment as it will be used in the context of this paper. Further, it provides a brief description of the systems engineering approach including the

systems engineering process.

**Section 3.** Provides a description of the Engineering Services Firm in the system context, its organization and operating environment.

**Section 4.** Provides a description of Total Quality Management. Brief background information is followed by a description of its elements and how it can be implemented into an existing system.

**Section 5.** Provides the present need and benefits for implementing the concepts and principles of Total Quality Management into an Engineering Services Firm.

**Section 6.** Provides a preliminary system design and plan for the initial implementation of Total Quality Management enhancements in an Engineering Services Firm. A system design specification is provided followed by a step by step approach for implementing Total Quality Management to improve the firms' processes thereby increasing the quality of the products and services produced.

**Section 7.** Provides some general concluding remarks on tailoring and implementing Total Quality Management in an Engineering Services Firm in the Defense Service Industry.

**Section 8.** Provides some topics for further research that was beyond the scope of this project.

## 2. Project Methodology

This section provides definitions of system related terms and determines the context to which key terms of the project are defined. Then, provides a description of the focus of the project methodology - the systems engineering approach and the system engineering process

### 2.1 The Concept Of "System"

#### 2.1.1 Definition

There exists many variations of the definition of "system." For the intent and purpose of this paper, system will be defined as

> "An interrelated set of elements, organized in a hierarchical structure, engaged in various processes that convert input to output to achieve a common goal."

Figure 2-1 provides a simple illustration of a system.

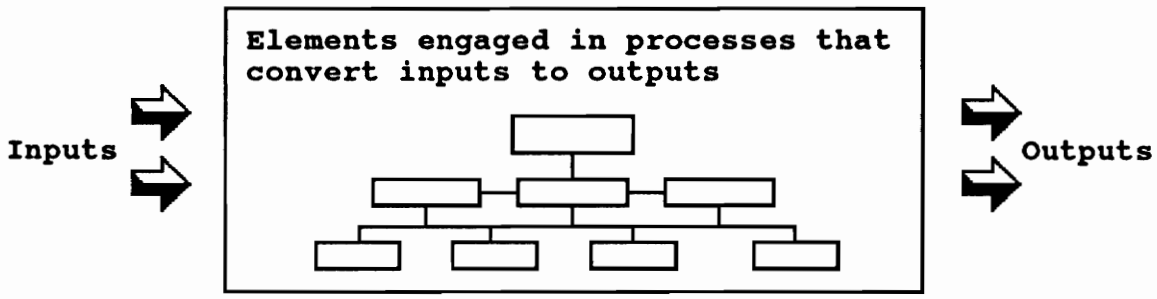



**Figure 2-1 The System**

#### 2.1.2 System Life Cycle

Every system has a life cycle that begins with a need. This need initiates conceptual design for the development of

the system. There are three major stages in the design phase of the system life cycle - conceptual, preliminary and detailed.[54] These stages include concept exploration, alternative/trade studies and analyses, risk analyses in performance and cost analyses. The next three phases - development, test and evaluation - occur simultaneously and are iterative and provide feed back to the design phase. A major objective during these phases is to develop the system according to preliminary design, test the feasibility and performance of the system design and to evaluate the results to ensure design requirements are being met. As the system development matures, the design of the system progressively becomes more detailed. The iterative nature of these processes will provide a robust design of the system.

The major objective of the production phase is to produce and deliver a fully supported system that meets the design specifications at optimal cost.[54] Then the system will be ready for deployment and use. The next three phases - operation, maintenance, and support - also occur simultaneously. During its operations by users, it includes modifications to the system as required as well as training and technical support as necessary. Further, any maintenance such as spare parts and documentations are included in this phase.

Finally, as the system becomes obsolete, it needs to be disposed. Any part of the system that is salvaged may be used as input for another system design or in the upgrading and improvement of the existing system.

In summary, the life cycle of a system consists of a need, design, development, test, evaluation, production, operation, maintenance, support and disposal. Figure 2-2 illustrates the system life cycle.

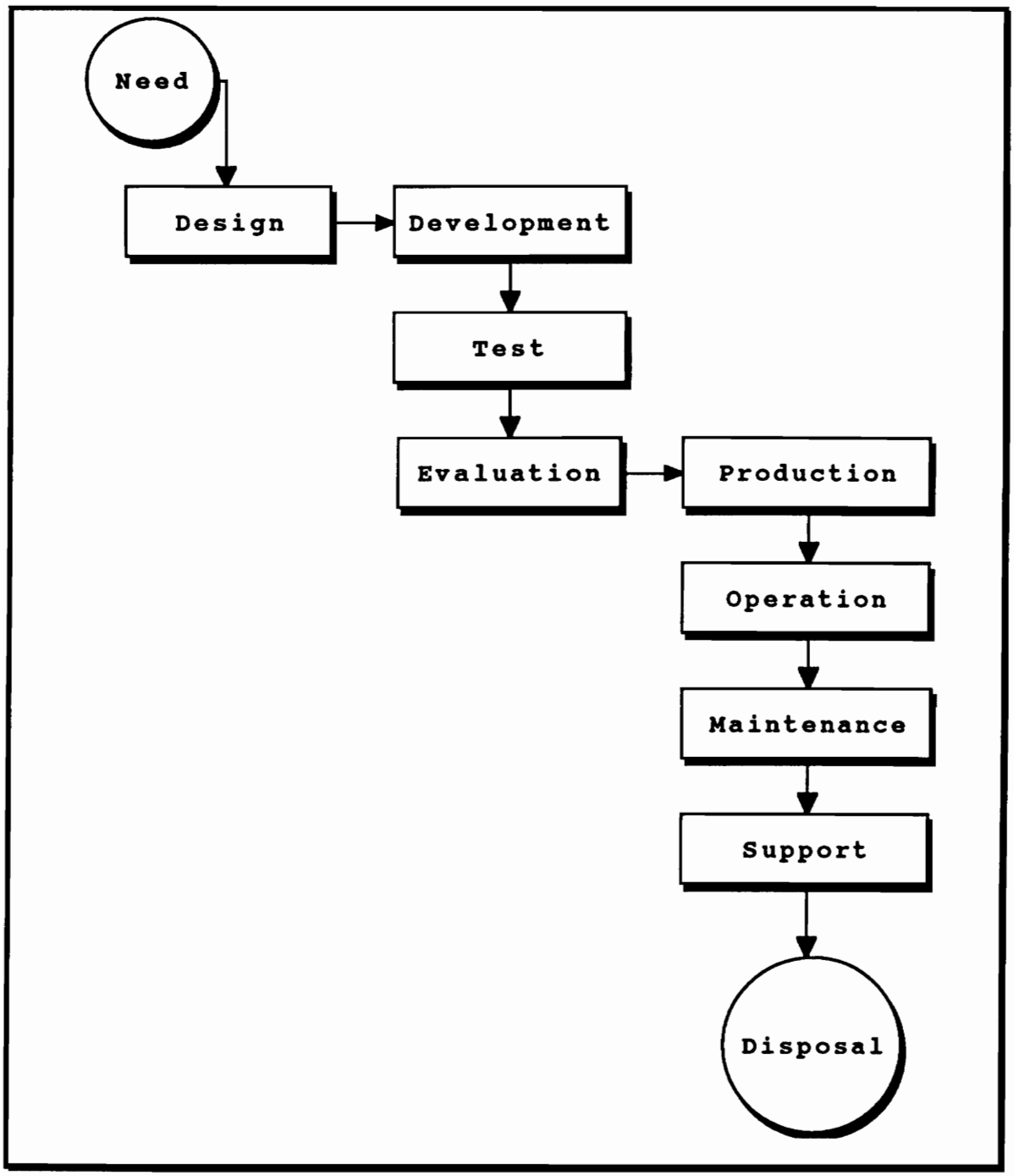



Figure 2-2 System Life Cycle

### 2.1.3 Environment

The environment for a system

- completely encloses the system
- includes only those things which influence the system
- provides constraints on the system.

The system gathers inputs from its environment and produces an output for its environment within its constraints. There are several variables from the environment that effect the system. These include

- The market condition
- State of technology
- Resources
- Overall culture.

The system itself is at times an environment for the processes. There are some internal processes for which the inputs are from within the system and outputs are produced for the system.[18] Figure 2-3 illustrates the processes, the system and its environment.

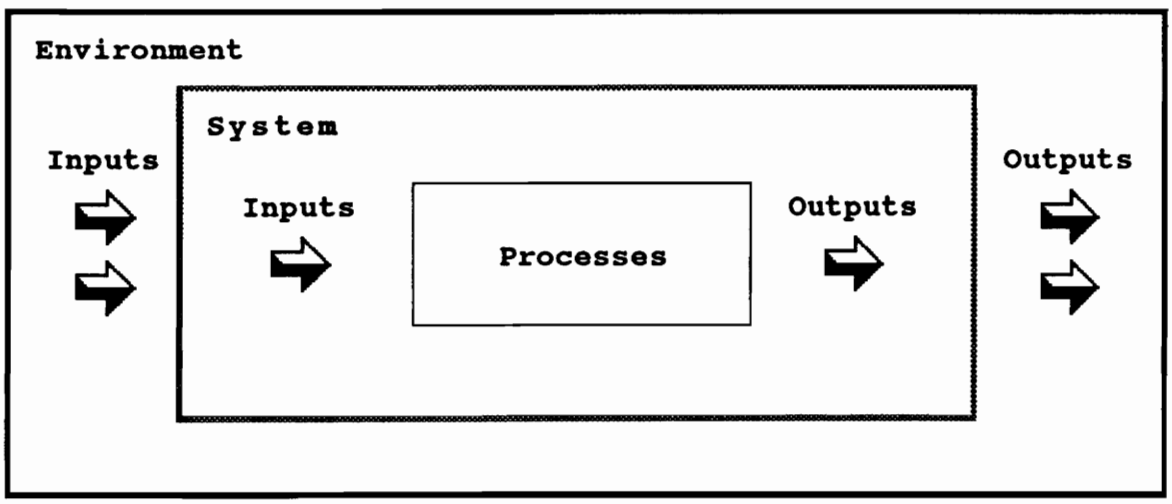



**Figure 2-3 The System And Its Environment**

## 2.2 Systems Engineering Approach

In the past when industrial systems were simpler, it was relatively easy to design and develop a system and to see the effect of a change within the system and its environment. However, modern large-scale systems are complex.[54] They are made up of many elements or subsystems engaged in many different processes to produce its outputs. It is difficult to readily observe the effect of a change that one element has on other elements, the system or its environment. Subsequently, it has become increasingly difficult to design, develop, and field modern systems.

To address this difficulty, the design, development, and the fielding of modern systems are currently being accomplished through the application of a generic process called the systems engineering process.

## 2.3 Systems Engineering Process

The Systems Engineering Process can be defined as "an iterative, logical, disciplined process ensuring the effective and efficient integration of all scientific and management principles in the evolution of a system." The systems engineering process can be applied to all phases of the life cycle of the system - design, development, test, evaluation, production, operation, maintenance, support and disposal. The systems engineering process also ensures the integrity of the system being designed by allowing for traceability of the design process through its documentation requirements. The characteristics and requirements in systems development does vary, therefore the systems engineering process allows for tailoring in its application.

The steps of the systems engineering process can be defined separately, however, they are interdependent and interrelated.[53] The steps in the process are

- Function analysis
- Synthesis
- Evaluation and Decision
- Description of system

The systems engineering process is an iterative process that allows for the continuous refinement of the change being implemented as well as the methods used to implement the change. A feedback mechanism exists within the process to further define and refine the change into the system. Figure 2-4 provides a graphic of the systems engineering process.

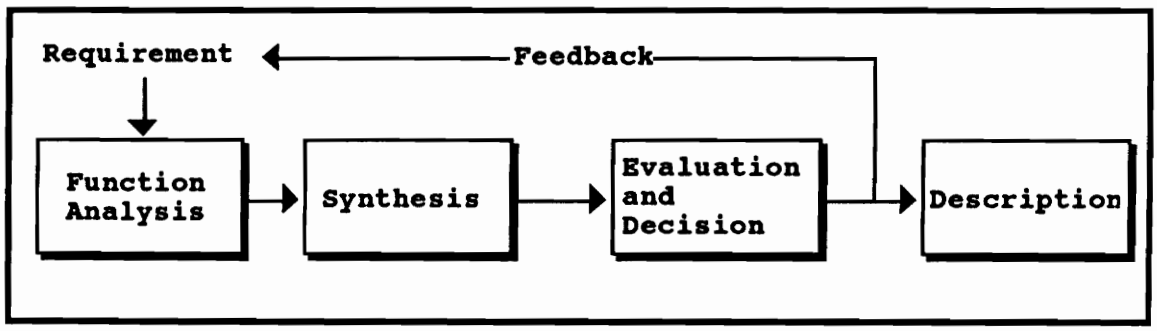



**Figure 2-4 The System Engineering Process**

### 2.3.1 Function analysis

A function is an action or a task to be accomplished as a part of a process that will produce an output for the system.

The objective of this step is to define a baseline of functions in the system followed by the identification of the

interrelationships of the functions along with their performance requirements.[53] The input requirements for each function and the output of each function will be identified.

One other aspect to be considered at this time is the identification of time critical functions and variables that may affect the timely completion of the function.[53]

### 2.3.2 Synthesis

Synthesis is used to develop preliminary concept descriptions. This step will develop the "how to's" for the functions identified in the previous step.[53]

One primary tool used to accomplish this task is the use of schematic block diagrams (SBD) to define modular units as shown in Figure 2-5. Modular units are characterized by

- single, independent function
- single logical task
- single entry and exit point
- separately testable.[54]

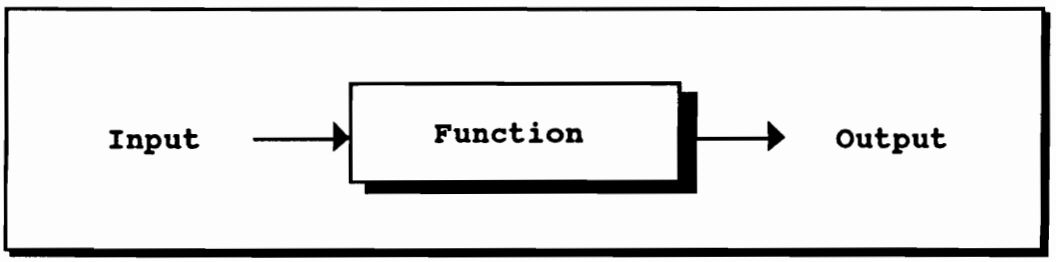



**Figure 2-5 Generic Schematic Block Diagram**

### 2.3.3 Evaluation and Decision

The objective of this step is to evaluate the data gathered and to select the best combination of functions to meet the objectives of the firm.[53] This decision process requires the consideration of alternatives. Each decision made at this point needs to be based on facts, have specific objectives, with specific criteria in terms of requirements met, schedule and cost.

### 2.3.4 Description

The objective of this step is to describe the new system or the existing system with the differences caused by the implemented change. It will include a description of all elements and their effectiveness supported by engineering data. The data includes specifications with design and detailed reports. The amount of data at each phase of system development gets progressively more detailed as the system matures and is deployed.

## 3. The Engineering Services Firm: A System Definition

An Engineering Services Firm (ESF) is a system consisting of an interrelated set of elements (facilities, personnel, equipment, etc), organized in a hierarchical structure (President, upper management, mid- and low level managers, supervisors, etc.) engaged in processes (planning, programming, management, research, development) for a common goal (to increase the value of the firm over time).

An ESF has broad base of capabilities in engineering, sciences, and program management disciplines required to support complex systems development in concept definition, development, test, evaluation, and production, operation, maintenance and support. An ESF provides the technical and management expertise in the development and acquisition of systems.

### 3.1 Elements

The elements of the firm are allocated throughout the firm according to the tasks being performed. The following is a brief description of each.

Facilities. Many ESFs have a primary facility and other field facilities located throughout the country close to the customer for specific contracts should it be cost effective.

Personnel. Personnel in an ESF are diversified. They include all levels of education, expertise in many technical and management disciplines to include engineering, sciences, program management, accounting/finance, contracts as well as administrative support. Each facility is staffed according

to the needs of the customer that is being supported. Each department contains management, technical and administrative personnel skilled in the particular technical field.

Equipment. Equipment includes all items required to produce the output such as computers, software, office equipment, supplies, etc.

## 3.2 Organization

The organization for each ESF is unique. An ESF may be organized into divisions according to the major segments of business and operations. Figure 3-1 illustrates a top level organization of an engineering services firm. Within these divisions are departments as illustrated in Figure 3-2a and 3-2b.

The support divisions (Figure 3-2a) perform the processes that support the day to day operations of the firm. The technical divisions (Figure 3-2b) perform the processes that are directly involved in the production of outputs - products or services - that are provided to customers. These divisions are separated by major business segments. Further, each division is departmented according to disciplines or scientific expertise.

The management structure of the ESF is hierarchical in nature - Management, Supervisors, Technical Staff, Administrative Support (Word Processing and Graphics). Each department reflects this as shown in Figure 3-3.

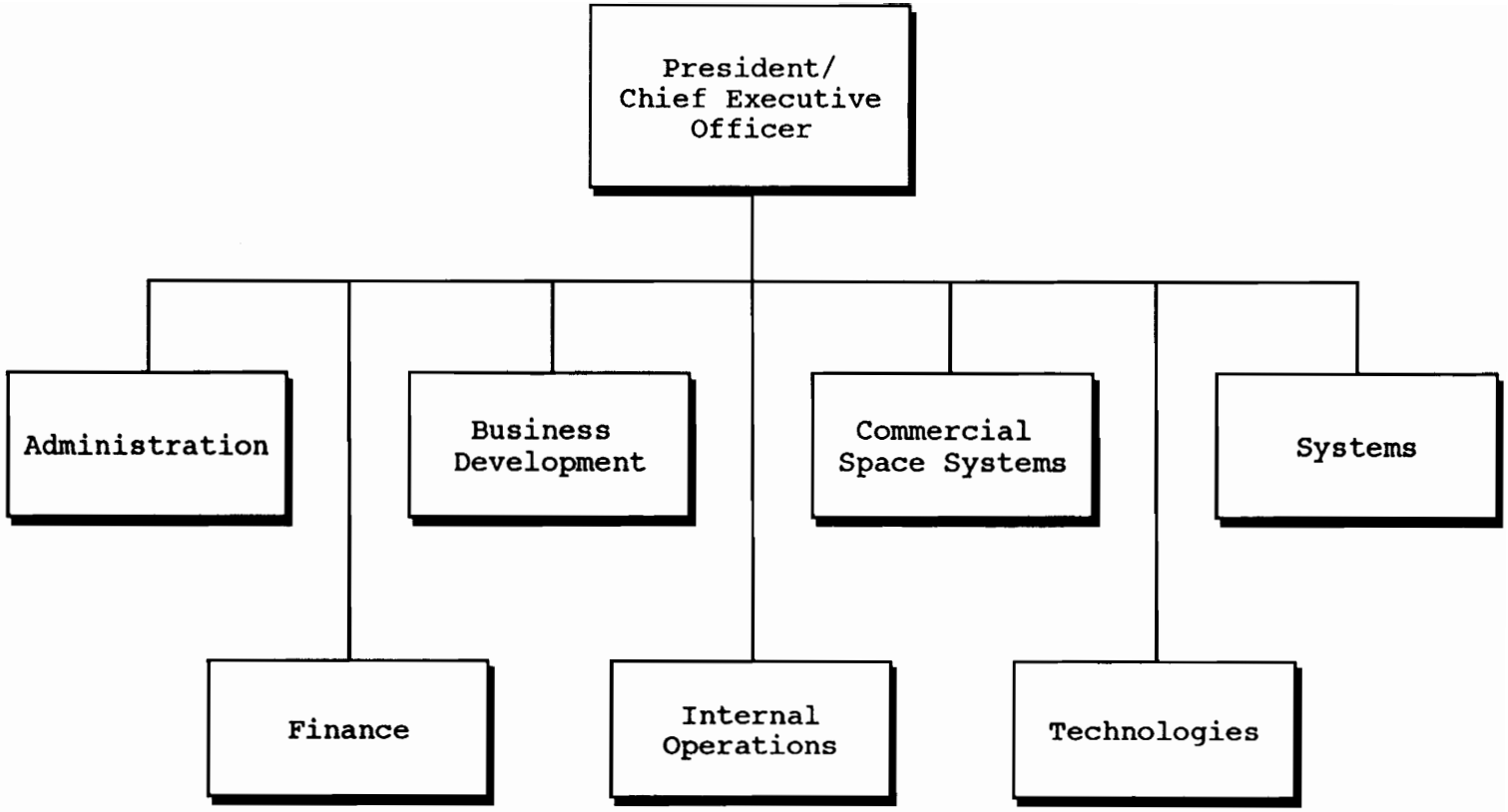



**Figure 3-1 ESF Organizational Chart**

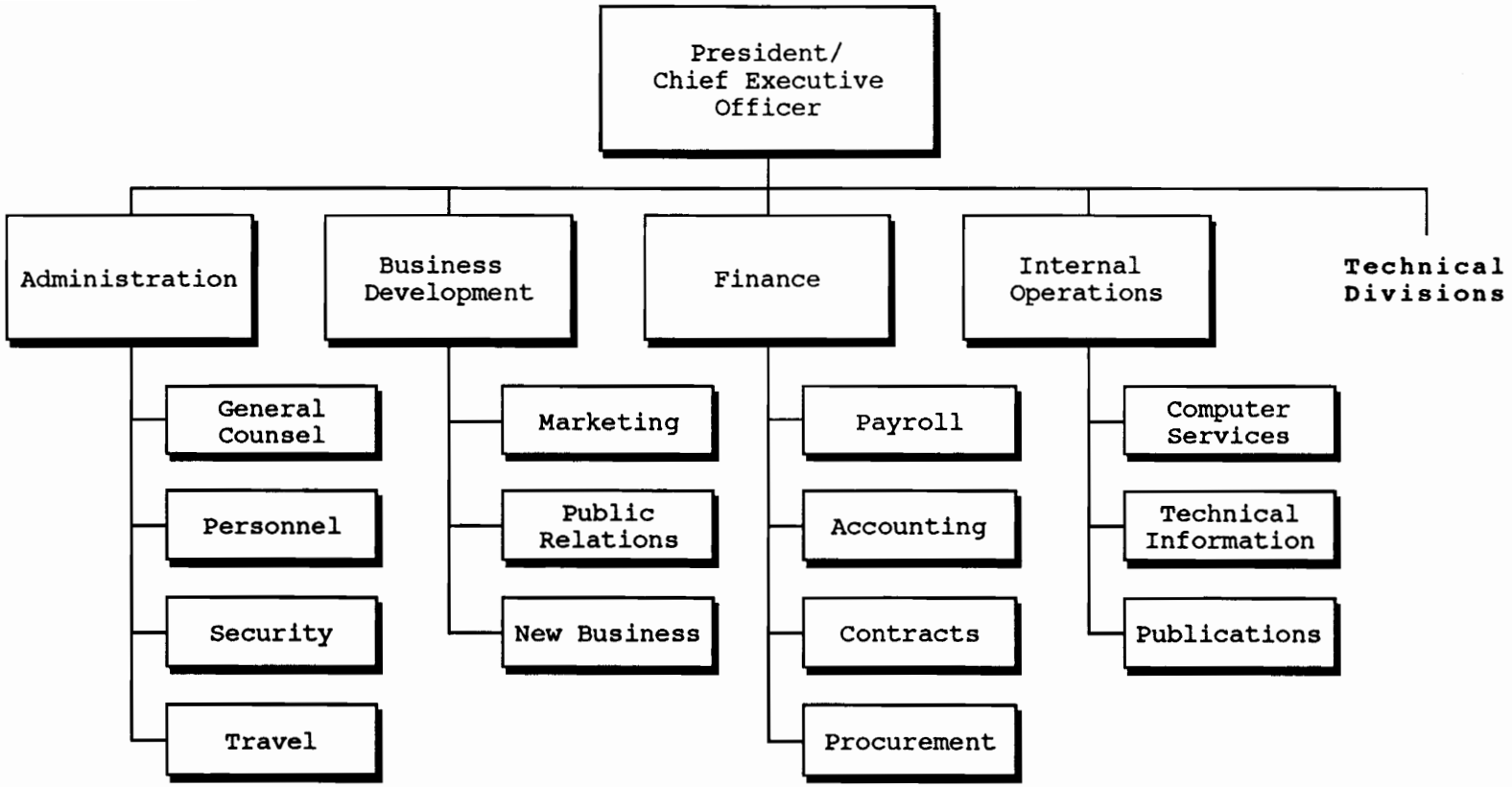



**Figure 3-2a Support Divisions**

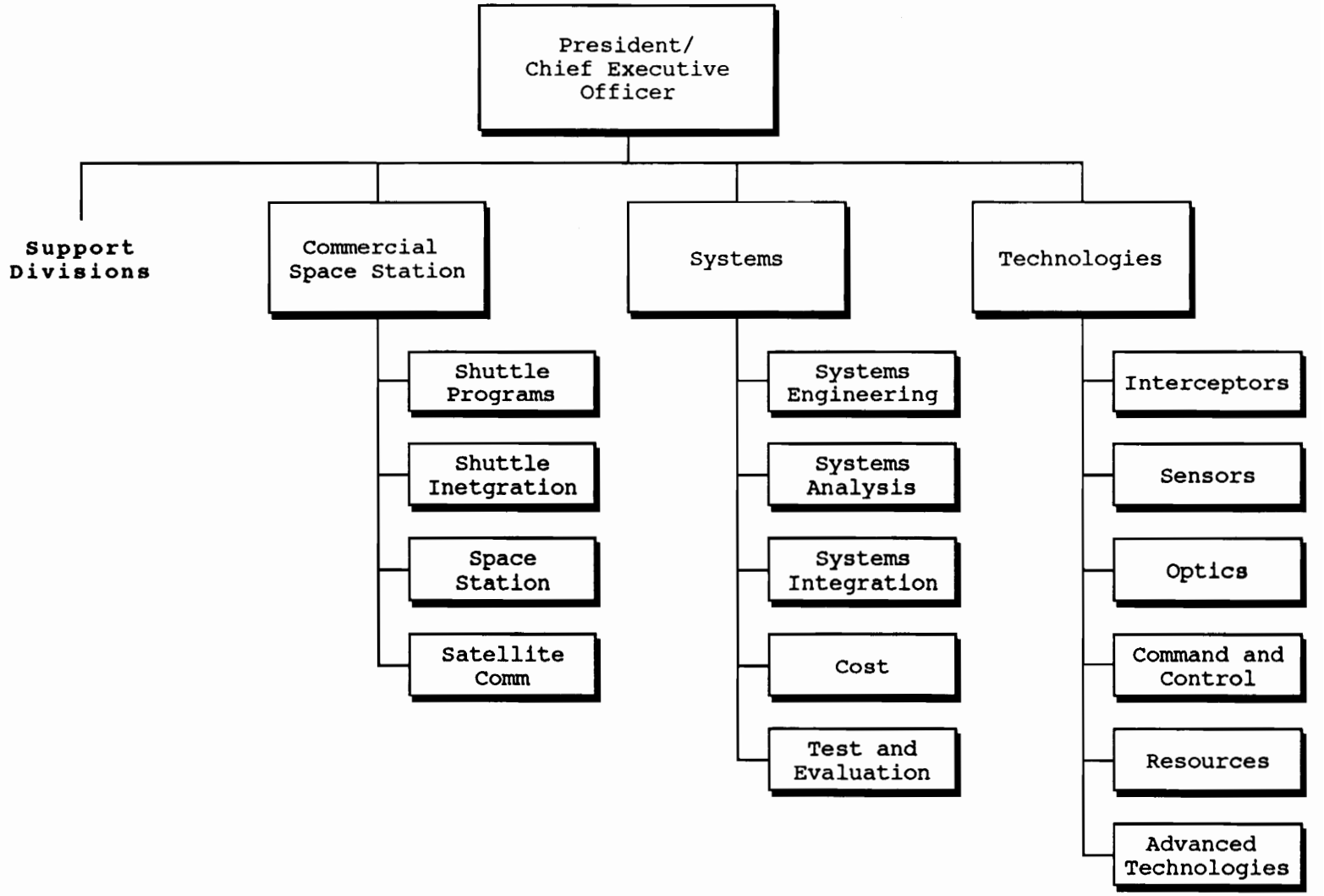



**Figure 3-2b Technical Divisions**

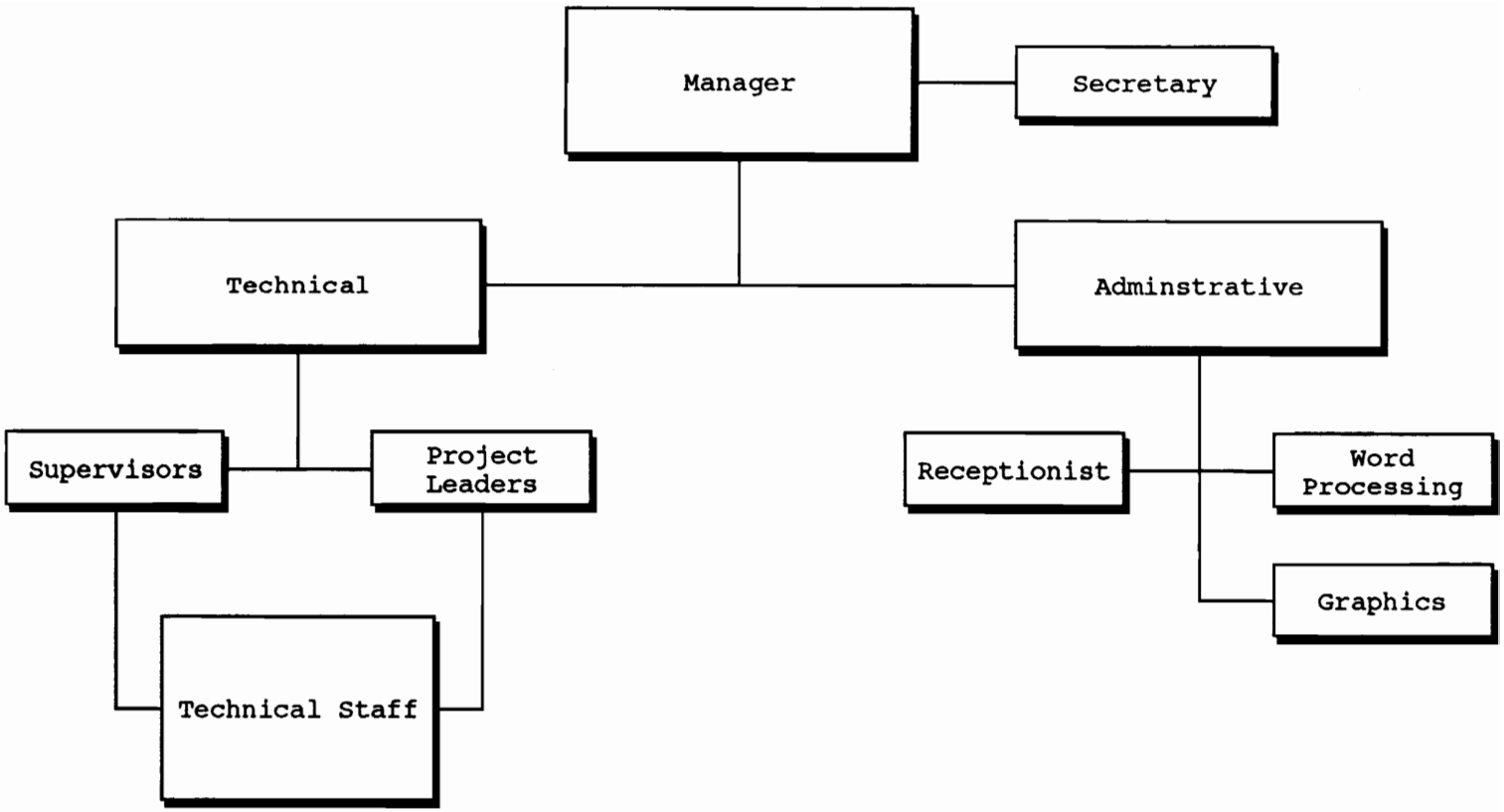



**Figure 3-3 Departmental Management Structure**

## 3.3 Processes

Processes transform user requirements (input) into a service or a product (output) through a series of interrelated tasks. Each task converts inputs such as information, material, etc into outputs which then may be an input for the next task. Work flows from one task to another increasing the value added to the product as it proceeds through the process until the final product is produced. Figure 3-4 illustrates a generic process.

Often, the developments of some complex products require the expertise of many scientific disciplines resulting in a process with tasks that cross departmental boundaries. When more than one department is involved in the production of an output, it includes all levels of personnel - technical, administrative, and management - contributing to the complexity and the difficulty of managing the process.

There are three types of processes in system development and acquisition. These are

- Physical processes used to manufacture, deliver, and support the end item
- Information processes used to plan, develop, manufacture, deliver and support the end item
- Management processes that determine the structure in which the physical and information processes will operate.[26]

An ESF performs the information and management processes for system development while providing independent analyses of physical processes. They gather, use and distribute information from all sources involved in system development and acquisition.

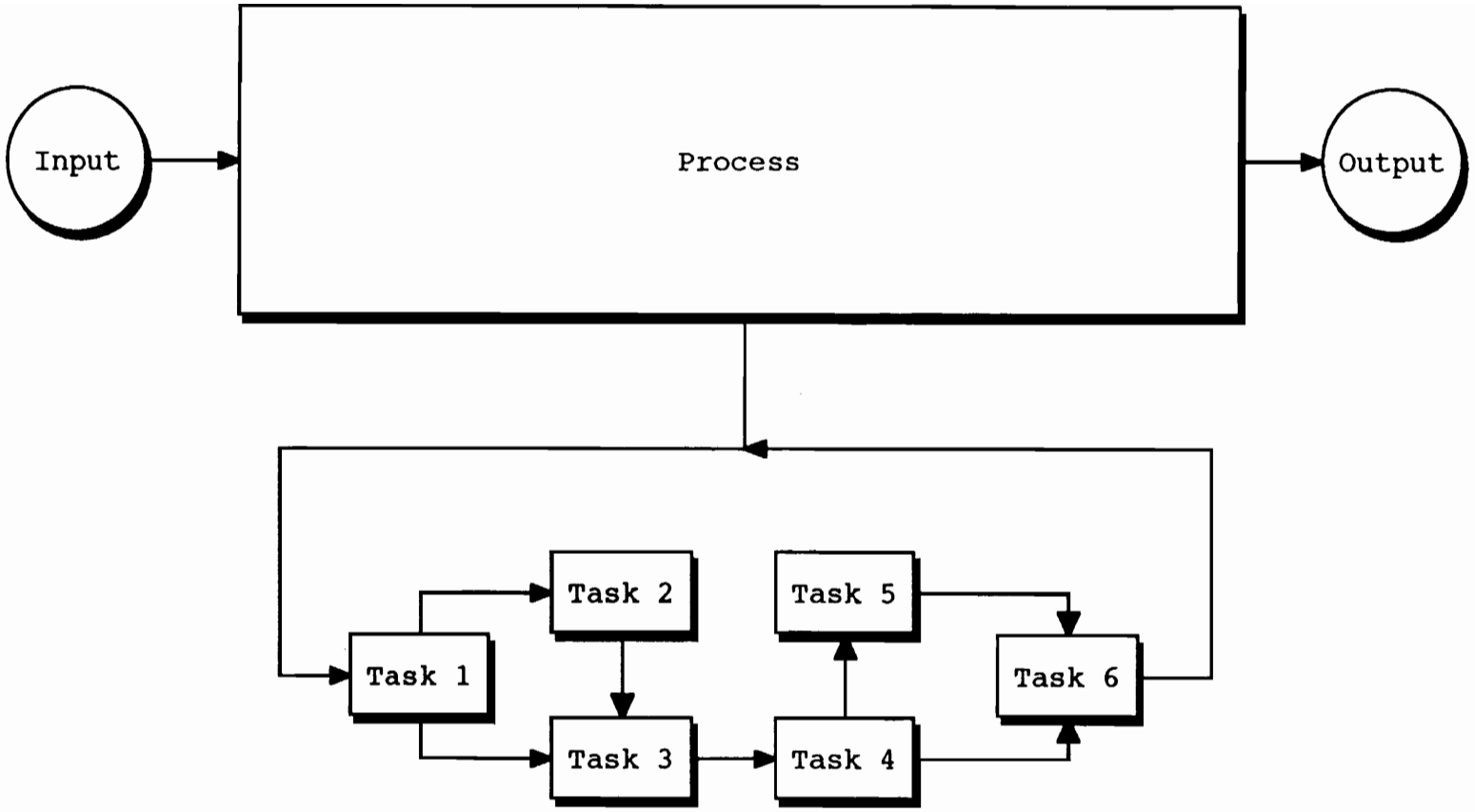



**Figure 3-4 Flow of Generic Process**

In the firm, these processes are in two categories - those that are directly or indirectly related to the development of the output for the firm. The staff within the technical divisions participate in those processes directly related to the production of the products and services of the firm. While the staff in the operational divisions perform the processes that indirectly related such as the personnel, payroll and travel. They support the smooth operations of the firm.

The various levels of management within the divisions and in line with the CEO provide support to both processes. They perform functions that support the end item such as the allocation of resources and the management review processes prior to delivery of the end item. However, they also support the end item indirectly by working on the processes that produce the output. These tasks include reviewing processes to optimize them to increase effectiveness, to reduce cost and increase the profitability of the firm.

### 3.3.1 Output

The product of an organization is the tangible unit that most closely represents its mission.[22] ESF produces outputs that are tangible products, however, other outputs are services - technical and management expertise. These services are, many times, not "tangible" products. They are continuous technical or management support provided on demand by an employee at the customer's facility or through other forms of communications - such as telephones. The tangible products produced by the ESF include technical documents resulting from this continuous support. Examples of these include

- Systems engineering Documentation - including technical, planning, management and integration documents (Figure 3-5)
- Technical Reviews on above documents
- Document updates
- Point Papers
- Briefings
- On the spot technical/management support

- System Engineering Mangement Plan
- Interface Control Documents
- Trade Study Reports
- Risk Analysis Management Plan
- Survivability/Hardness Plan
- Design Review Data Packages
- Mission Analysis Reports
- Functional Analysis Documentation
- Reliability Plan
- Maintainability Plan
- Safety/Hazard Analysis Plan
- Human Engineering Plan
- Integrated Logistics Support Plan
- Test And Evaluation Master Plan
- Production Engineering Plan
- Operational Requirements Document
- System Concept Paper

**Figure 3-5 Partial List of Systems Engineering Documents[53]**

### 3.3.2 Inputs

There are three major inputs used to produce the outputs listed above. The principle input used in Engineering Services Firm is information. Information includes data that which is gathered from the staff of

different departments and the technical information center within the ESF. Another source for information is from the operating environment - other firms and government agencies and the Services (Armed Forces Agencies) involved in the development and acquisition of systems. The second major input is a knowledge base that exists within the firm from years of experience in specific fields - defense, satellite, space, aircraft systems, etc. The third major input is existing military/defense specifications/requirements for documents. These include many Department of Defense directives, guides, and instructions, military specifications and standards. It can also include document formats that exist internally to the ESF.

Other inputs include budget - internal or contractual, resources and schedule.

### 3.3.3 Tasks

The three categories of tasks performed by the ESF are

- Management
- Technical
- Administrative.

Although these tasks are performed repetitively it is the different technical and administrative combination of the tasks required for different outputs that make each process unique and non-repetitive.

Technical and management tasks performed within the processes of the ESF include the following.

- Conducting Systems Analysis
- Managing Programs

- Integrating/coordinating internal functions as well as other participants in the operating environment
- Conducting Trade or Alternative Studies
- Collecting and Managing Information
- Developing Systems engineering Technical and Management Documents
- Reviewing Systems engineering Technical and Management Documents developed by others in the operating environment
- Developing Point Papers and Briefings.
- Conducting Independent Verification and Validation

These technical tasks, supported by administrative tasks such as word processing and graphics, followed by overall reviews conducted by project leaders and managers make up the processes that convert inputs into the products and services of the ESF.

### 3.4 Environment

The environment in which the ESF operates is the Service Industry within the Department of Defense. This environment possesses characteristics that are unique and set itself apart from the manufacturing industry and the service industry in the private sector such as banks, restaurants, power, and telephone companies. The variables from the environment that have an impact on the development of the output include

- Information availability
- Completeness of information received as a part of the input
- Existence of specifications for document

- Subject of the output
- Schedule
- Resource availability
- Technical Approach
- Personalities of those involved in the process

### 3.4.1 The Service Industry

The national economy is classified into the manufacturing and non-manufacturing industries. Of the non manufacturing industries, it is further divided into service and non-service industries. Collectively, service industries account for two-thirds of the national economy.[43]

Service is, "Work performed for someone else." The service industry exists because it can out perform those they serve in meeting their own needs.[43] The service industry possesses certain characteristics that are unique, some of which are described below.

No One Specific Product Line. The output of the service industry is not one specific product line of "widgets." The specific products and services provided by the ESF to its environment vary according to requirements.

Non-repetitive Processes. There is no assembly line of repetitive processes used to produce the output. Although the development of documents or the technical and management tasks provided may seem repetitive, each process differs depending upon variables such as subject matter, schedule, funding and resources. The effect of these variables on the process results in a unique process for each output.

Direct Contact with Customer.[43] Unlike the manufacturing industry, the ESF provides its products or services directly to its customer, sometimes without an opportunity for quality inspection. In either case, there is no "middle man." Consequently, the employees of the ESF have many contacts with its customers. This serves as an opportunity to set up a unique relationship between the ESF and the customer. As a result of frequent interactions with the customer, the personalities of those involved become critical to task performance and the feedback from the customer on the quality of services provided.[43]

### 3.4.2 Defense Service Industry

With 5 million civilians and military employees, the federal government is the nation's largest employer as well as the largest customer and suppliers of services.[4] The Department of Defense (DoD) is engaged in the development and acquisition of defense systems for use by the Services (Army, Air Force, Navy, and Marines). However, these defense agencies and Services do not possess all of the technical and management expertise required in system development. Especially in modern times, with the use of advanced technologies, the development of a single system can require the expertise of many different fields requiring exceeding the expertise in a single company. For the development and acquisition of these systems, DoD agencies and the Services solicit the expertise from many different firms that possess expertise in specific technology areas required.

Since the development and acquisition of these complex systems require the participation of many different organizations' coordinations and integration is critical to ensure synergistic development. Further, the traceabilities

of all developments are required in the DoD acquisition process. To assist them, government agencies solicit the assistance of firms that provide technical and management services to integrate and coordinate the various organizations as well as document the development and acquisition of systems. Figure 3-6 shows the flow of requirements and the players in the defense acquisition process.

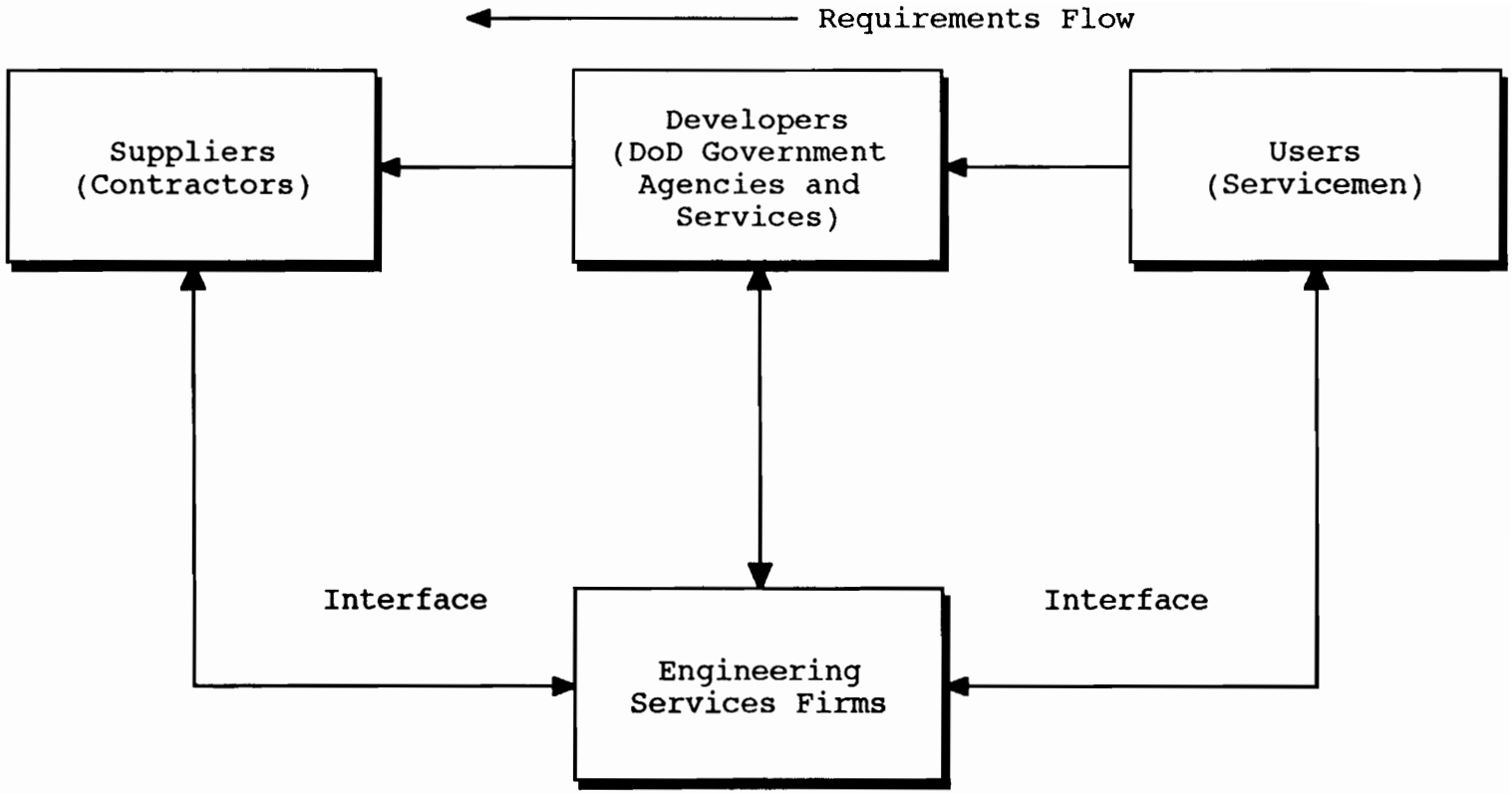



**Figure 3-6 Defense Environment**

# 4. Total Quality Management: A System Definition

## 4.1 Background

Traditionally, quality has been checked at the final stage in product development by inspecting the product and rejecting those that did not meet the predetermined standards - a reactive procedure.[46] However, this method does not pin point where, in the process of product development, a problem exists. Subsequently, there is no guarantee that the same defect will not be present in the next batch for inspection.

The basic philosophy of quality control has its origins in the United States. At the turn of the century, the "father of formal business management," Frederick W. Taylor, introduced the organizational chart proposing a separate inspection function to ensure all parts would match up properly.[2] Hence, the earliest mention of quality control was by inspection. This process of quality control was used in the manufacturing industry.

An expansion of quality control took place in the 1950's when Armand V. Feigenbaum stated that quality should also be the responsibility of the service industry.[2] At approximately the same time period, Philip Crosby, introduced the idea that quality is a matter of expectations. If mistakes are expected, mistakes will be made. If the goal is no defects, workers will work toward that goal and improve quality on the way.[2]

However, quality is best known for its application to the Japanese manufacturing industry in the past 40 years, post World War II.[38] On July 13, 1950, Dr W. Edwards Deming addressed the presidents of Japan's leading companies

beginning the quality effort in Japan.[49] And in 1951, Dr Joseph Juran, published the first edition of the Quality Control Handbook giving the economic aspect to quality as avoidable and unavoidable costs. The unavoidable costs are those related to improving quality where as avoidable costs include cost of rework and failure. The Japanese implemented these concepts of quality into the development of their strategy in their industries resulting in the development of advanced industrial processes that produce one of the highest quality products in the world.

## 4.2 Definition of Total Quality Management

Total Quality Management has been described in many ways using a variety of combinations of the same words. Words such as

- customer satisfaction, customer focus
- continuous process improvement
- continuous quality improvement
- meeting and exceeding customer requirements
- process management

Although there are many different definitions of TQM, for the intent and purpose of this analysis, TQM is defined as

> "The comprehensive method for continuously improving the quality of the product of the firm by managing and improving the processes of the firm producing the output through feedback and corrective action."

TQM is an iterative process similar to the system engineering process. It is an iterative process that relies on feed back to make it better or more detailed. TQM focuses on the improvement of the quality of the product by identifying and analyzing problems within the processes of product development. Then provides methods to develop the solutions

to remove the causes that allowed the problem to exist. Further, TQM integrates the customer into the decision processes that affect the quality of the output. Figure 4-1 shows the differences between traditional quality control and the concepts of TQM.[48]

| Focus Area | Quality Focus | |
|---|---|---|
| | Traditional | Total Quality Management |
| Definition | Product oriented | Customer oriented |
| Quality Priority | Behind cost, schedule | First. Often the Driver |
| Focus | Short term | Balance of short and long term |
| Emphasis | Identification of error | Prevention of errors |
| Cost | Increased with quality inspection | Decrease with quality emphasis |
| Cause of Errors | Specific; mistakes at a certain point | Common; ineffective process |
| Responsibility for Quality | Inspectors, Supervisors, Management | All |
| Organizational Culture | Identification of cause | Investigate |
| Organizational Structure | Hierarchical, static | Flat, integrated and fluid |
| Problem solving | Management | All |

**Figure 4-1 Differences Between Traditional and TQM Quality Concepts**

## 4.3 Quality Environment

There are four critical conditions that need to exist in an environment for TQM to succeed. These conditions include:

- Senior Management Commitment
- Customer Focus
- Employee Involvement
- Continuous Improvement

If all four of these conditions are present and supported, the steps of process management can be integrated into an existing system.

### 4.3.1 Senior Management Commitment

TQM requires the leadership and commitment of senior managers. Since quality improvement frequently requires an attitudinal and behavioral change within the organization, management must be the initiator of change.[25] They must

- Establish the "cultural environment," one that will encourage and accept changes brought on by the implementation of TQM concepts. (Figure 4-2 compares the current culture of and the culture necessary for TQM to succeed.)
- Make TQM a part of the strategic planning, budget process, and performance reviews.
- Put forth quality implementation goals, both long-, mid-, and short-term.
- Provide resources, training, and tools to implement TQM concepts at all levels.
- Develop award and recognition program.

| Change | From Current Culture | To TQM Culture |
|---|---|---|
| **Mission** | Bottom line; maximum return | Satisfy customer, continue to improve |
| **Customer Requirements** | Incomplete, ambiguous understanding | Seek out and satisfy internal and external requirements |
| **Objectives** | Short term | Balance of short and long term |
| **Suppliers** | Unidirectional; minimum cost | Partnership |
| **Improvement** | Corrective Action | Anticipate changes and improve |
| **Role of Managers** | Plan, organize, assign, control and enforce | Communicate, Coach, establish trust |
| **Rewards and Recognition** | Pay by job; few team incentives | Individual and group recognition and rewards |
| **Measurements** | Data gathering for problem identification | Data gathered to understand processes and continuous improvement effors |
| **Jobs and People** | Functional, management controlled | Work teams, integrated functions |
| **Problem solving** | Unstructured, individualistic | Participative, interdisciplinary |

**Figure 4-2 Cultural Changes Required**

Senior managers must communicate to the mid-, and lower-level managers what are important. If senior management is focused on schedule of deliveries or the cost of a particular project, that will be what is communicated to the mid-, and lower-level managers and to the general employees.[46] If the focus is cost for senior management, cost will be the focus for the rest of the employees. Senior management must also communicate to the firm that the focus is on the concepts of TQM and that advancement in the firm rests with participation. Management at all levels will be held accountable for the quality of their products.[13] Management will have the ultimate responsibility for the product not the workers. It must be noted that although the workers do work in the processes within the system, it is the management that works on the improvement of those processes within the system.[38]

### 4.3.2 Customer Focus

Quality begins and ends with the customer.[19] Therefore all involved in the quality process must know who their customers are as well as their requirements. TQM focus on the customer ensures that the definitions and measures by which customer requirements for product or service quality are analyzed, change with the changing needs of the customer. This focus on customers includes both the internal and the external customers. In the Defense Industry, there are multiple layers of customers. It is the customer that determines for all sellers, the terms and conditions under which it will purchase goods. They provide all constraints and limitations such as schedule and budget. This focus places some of the burden of determining quality standards on the customer. Therefore, they need to be intricately

involved in determining the quality measures and the baseline requirements for the output.

Not all of the employees in the firm are in direct contact with the external customer. However, all who are in the process of producing the output have internal customers - those who are next in the line of tasks.[19] These internal customers may be a supervisor, manager, or co-worker. The satisfaction of each internal customer requirements will ensure that the external customer will be satisfied as long as internal requirements are derived from external customer requirements.[18]

### 4.3.3 Employee Involvement

Employee involvement through participation rather than control is critical to the successful implementation of TQM. TQM encourages the development of teams at all levels - from senior management executive steering committees that address overall planning and goal setting for the firm to working teams that address the

- identification of problems
- identification of improvement opportunities
- proposal of problem solving/improvement plans.

Through these teams, the employees feel a personal worth in the firm. They will do their best when they know they can influence decisions that affect the quality of the work they perform and the working environment. This leads to an increase the employee's commitment to the firm, high morale and improved productivity.

Since employees are involved in the processes that produce all products and services, these teams allow the decisions to be made at the lowest possible level at which

the knowledge and understanding of the problem exist. After all, these are the people who know the processes best, will perform the functions that will produce the product, and act upon the recommended improvements. Their participations in the identification of the problems or improvement opportunities and the subsequent plans that address them give the employees a stake in the success or failures of the plan.

To effectively integrate the general employee, they must be made aware of the impending change.[13] Proper training is required for the employee to understand the intent of implementing TQM concepts in their firms. The employee needs to be provided with the proper tools to do his or her part in the improvement process. Training includes seminars and workshops and formation of pilot quality improvement teams.

Further, TQM assumes that competent, dedicated employees will make the greatest contributions to the firm.[13] Therefore, incentives, rewards and recognitions need to be provided to maximize their potential, to initiate innovative ideas, recognize their contributions and to further motivate employees.

### 4.3.4 Continuous Improvement.

A major TQM concept is to continuously improve not to implement a one time improvement effort. It is to always look for better ways to satisfy the customers, internal and external. High priorities are on continuous incremental improvements called Kaizen. The application of Kaizen to everyday work as illustrated in Figure 4-3 is the key to successful improvement.[64] Another method is to identify potential improvement opportunities or problems and provide for planning and implementation of corrective action. Then,

evaluate through reporting/feedback system. As the results are analyzed, other improvement opportunities and problems are identified thus resulting in continuous improvement. This concept is illustrated in Figure 4-4.

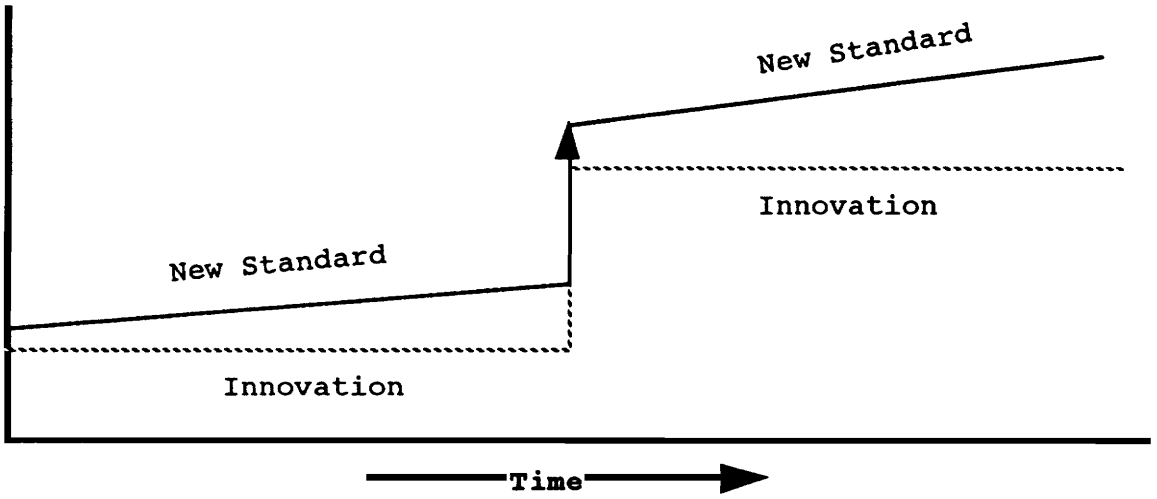
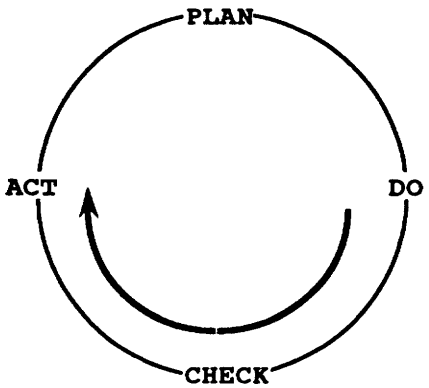



**Figure 4-3 Incremental Improvement[64]**




**Plan:** Senior Mangement Planning
Develop Vision
Set Goals

**Do:** Training
Define Processes
Identify Customers
Establish Measures

**Check:** Evaluate Measures

**Act:** Implement changes according to information
Take Corrective Action

**Figure 4-4 Plan - Do - Check - Act[32]**

## 4.4 Elements of TQM

If the conditions as described above exist within a system, the final step to improvement is to manage and improve upon the processes of the firm. A consistent process

improvement cycle identifies processes of the firm, establishes the owner of each process, establishes measures, identifies and prioritizes improvement opportunities, and implements solutions. But it does not stop there. It monitors the solution implemented and if ineffective, proposes new solutions and as those problems are solved, continues to find other improvement opportunities. Figure 4-5 shows a graphic of the process improvement cycle.

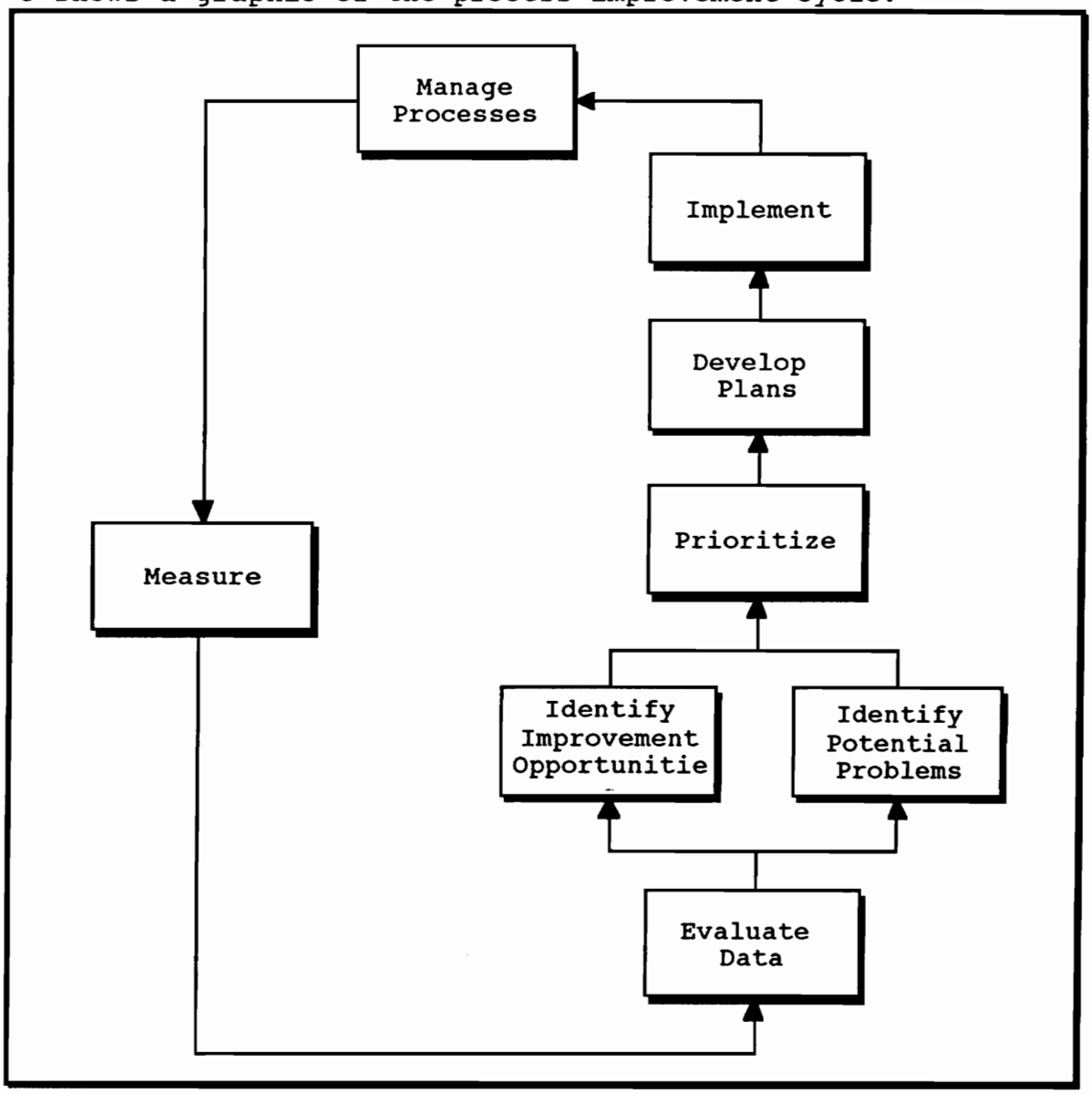



**Figure 4-5 Process Improvement Cycle**

The objectives of process management are to manage the processes of the firm to:

- Produce output that is consistently the same quality over time
- Produce products and services that meet the needs and expectations of the customer
- Perform the above at economical cost and on time.[1]

Basic features of process management are definition, ownership, measurements, and corrective action. The differences of these features between the manufacturing and service industries are shown in Figure 4-6.

| Features | Manufacturing Industry | Service Industry |
|---|---|---|
| Process Definition | Formally Documented | Little/None, or Unintegrated |
| Ownership | Clearly Defined | Ambiguous/Multiple Ownership |
| Measurements | Established | Often Non-Existent/ Qualitative |
| Corrective Action | Performed | Done Reactively, if Performed |

**Figure 4-6 Basic Features of Process Management**

In the manufacturing industry, the processes required to produce a certain "widget" is fully established. The mission of the manufacturing firm is to produce a certain number of these widgets of a certain specification with minimal defects. The process to produce a widget is a set of repetitive tasks with predetermined set of control points to

measure the quality. The ownership, of the process is clearly defined - be it the employee, the line supervisor or the floor manager. The boundaries and the interfaces between processes or sub-processes are already clearly defined and formally documented. Quality control is performed after the widgets are produced by eliminating or correcting those widgets that were not up to the predetermined standards of quality.

In the service industry, the processes for producing outputs differ depending upon the output being produced because the output may be either a product or a service. Therefore, the processes are not as clearly repetitive, do not have consistent control points nor do they have consistent boundaries or interfaces. Many complex processes cross over the organizational lines involving employees and managers of several departments and divisions. Consequently, the ultimate ownership of any process becomes ambiguous.

This approach of managing a series of work activities as a process has been used successfully in the manufacturing industry for many years.[24] This approach of managing processes can be also applied to the service industry as shown by the work performed by F. M. Connell Jr. It was found that by implementing controls at the front end of the process, a dramatic reduction in error rate occurred at the end.[24]

The consequences of not managing a set of tasks as a process are

- Lack of understanding of how a total process really works
- Inability to assess effectiveness of the process

- Inability to achieve true control of the operations.[24]

The end result is operating in a reaction mode. In this mode of operation, there may not be enough information to trace back to the root cause of a problem.[24]

The proper management of the processes within a firm can be achieved by implementing the following steps.[24]

- Establish Process Definition Capability
- Establish Process Ownership
- Establish Measurement Program
- Evaluation and Corrective Action

### 4.4.1 Establish Process Definition Capabilities

A process is a series of interrelated tasks that takes an input, performs a value added task, and produces an output. In order to manage processes, all involved must have an understanding of

- All processes that exist within the firm
- All outputs from each process
- All tasks in each process
- All inputs from each process
- The flow of tasks and information within each process

The processes of the firm must first be defined in order to manage them. One method of defining processes is through input-task-output analysis (described briefly in Appendix 1). Input-task-output analysis is a systems analysis approach of defining a process by listing all outputs of the firm, each activity or task that provides the outputs and the inputs required to perform the tasks to produce these outputs. Another method is through process

analysis, first developed in IBM Sweden by Jan Nordstrom.[24] This is a step by step systems analysis approach to define all tasks of a process. It focuses on the interrelated tasks that cross departmental boundaries which make up each process. Its objective is to develop new processes through simplifying and combining tasks.

Defining processes include identifying the boundaries and interfaces of the processes.[44] Work flows between major sections, departments and divisional boundaries. Most often, these boundaries are set up based on organizational rather than functional considerations. The definition of process must include the establishment of these boundaries through the identification of customer/supplier relationships. They are also the points at which the output, at different phases of its development, where a product or information enters or leaves the firm, department, task or facilities. Interfaces are points where customer and suppliers exchange information and be a focal point for real or potential problems.[25]

The processes as defined during this phase need to be continuously reviewed to ensure that it is improved upon, eliminating those tasks that are non value adding while adding those tasks are required to meet the customers changing needs.

### 4.4.2 Establish Process Ownership

An owner of a process has the responsibility of ensuring the delivery of a high quality product to the customer. The owner coordinates all tasks of the entire process and is ultimately accountable for the output produced. Criteria for the overall owner include decision

making authority and the power to implement decisions and changes.[44]

Ownership must also be established for each sub process. Establishing the ownership of a process or sub process is facilitated by the boundaries and interfaces previously identified. For simple processes or tasks that are contained within one department or section of a firm, this is fairly simple. However, for complex processes crossing functional, departmental and location boundaries, establishing ownership becomes more difficult.[6]

Ownership of each process will vary according to the particular subject of the required and will be established as the requirement is available.

### 4.4.3 Establish A Measurement Program

> *"When you can measure what you are speaking about and express it in numbers, you know something about it; and when you cannot measure, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge but you have scarcely in your thought advanced to the stage of science" Lord Kelvin*[57]

Lord Kelvin expresses the importance of measurement and the capability to measure in order to fully understand a subject. Measurement is one way to monitoring the implementation of any change into an existing system is important in determining the effect of that change on the system. Further, the success or failure cannot be determined with credibility without supporting factual data.

The initiation of a sound measurement program is focused and capable of being flexible, adaptable and dynamic to the changes that may occur.[31] Questions such as - For what will these measures be used? In what format should they be collected? Some specific purposes of measures include the following.

- To identify and focus improvement efforts.
- To quantify requirements
- To document/monitor change/achievements
- To determine effectiveness
- To justify commitment of resources

Identify and Focus Improvement Efforts.[64] Since management cannot expect to improve all areas immediately, they need to first identify all areas that require improvement. Then these areas should be prioritized so improvement efforts can be focused. Finally, gather measurement information to analyze. As areas show improvement, move onto and focus on other areas but also monitor previous areas to ensure they remain up to standards. For example, perhaps for the first year, the firm will focus its improvement efforts on communications, internal and external. Then, subsequent years focus on customers, employees, training, critical processes, etc.

Quantify Requirements. As stated by Lord Kelvin, all measures must be quantified in order to understand its implications and be properly used in analysis. The needs and wants of the customer's quality measures must be transformed into quantifiable requirements. Determining these quantifiers can be one of the most difficult steps in the implementation of quality concepts in any firm. These requirements must be developed with the customers, internal and external through customer analyses.

Document Achievements/Progress. Progresses need to be documented to ensure that no effort is duplicated. Achievements should be documented to show traceability of improvement efforts to specific achievements. Failures also need to be identified to correct for subsequent changes. Documenting all efforts related to a specific change assists in future planning.

Determine Effectiveness. It is through measurements that the management will be able to see improvements in performance and quality. Also, measurements show the effectiveness of specific efforts to problems to which they are applied.

Justify commitment of resources.[23] Management will not commit many resources - money, personnel - unless they can see the measurable effects of the impending change. Measurements allow management to make decisions and plans based on fact. Measures will provide management with the data for justification of resources committed. Also, recorded measures will provide justification for increased commitment.

### 4.4.4 Evaluation and Action

One of the most crucial steps in process management is evaluation and feedback.[23] Information critical to the improvement of process need a reliable reporting system that will feedback data to those that will use them. Results of these evaluations will be used to further the improvement process by identifying points of potential problems and improvement opportunities. Without proper feedback channels from all levels, there will be deficiencies in coordination and integration.[23]

## 4.5 Tools and Techniques

The implementation of TQM concepts requires the use of many tools and techniques. Some of which already existed as management tools while others have been developed to aid the implementation of TQM. These tools include subjective and statistical techniques of determining standards, collecting, analyzing, and evaluating data.[64] Some are

- Benchmarking*
- Block Diagrams*
- Brainstorming*
- Cause and Effect Analysis*
- Customer Needs Analysis
- Decision Matrix*
- Histograms*
- Impact/Changeability*
- Input/Output Analysis*
- Nominal Group Technique*
- Pareto Diagram*
- Questionnaires

(*) Described briefly in Appendix 1.

## 4.6 Summary

Figure 4-7 shows the elements of TQM in its environment.

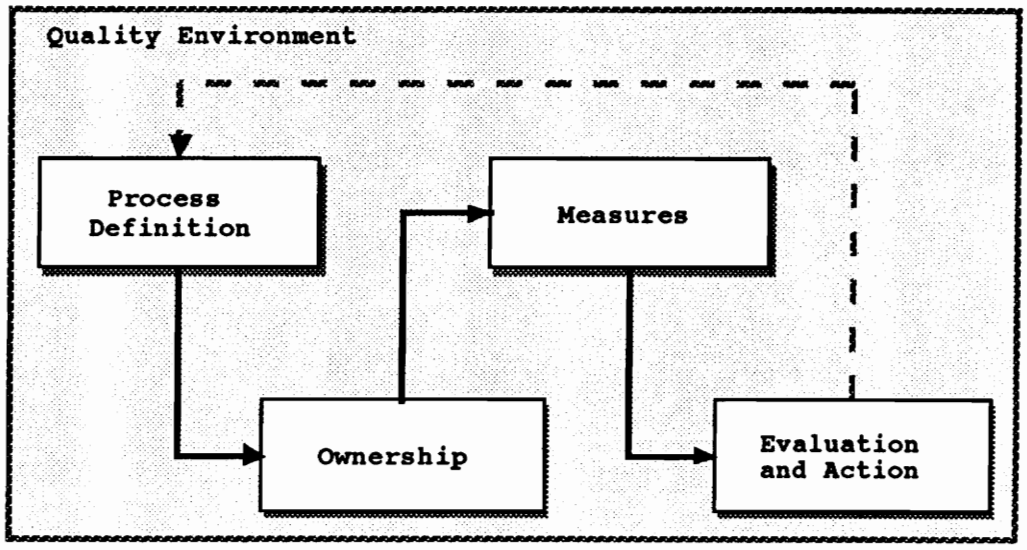



**Figure 4-7 TQM and Its Environment**

## 5. Existing Need For Implementing Total Quality Management In An Engineering Services Firm

In order to develop a new system or implement a change into an existing system, there must be a demonstrated need for it. The following present the need for implementing Total Quality Management enhancements (the change) into an Engineering Services Firm (the existing system).

In the world of increasing competitiveness and global economy, a firm must constantly seek to enhance its operating and management systems to increase the quality of the outputs and the processes that produce these outputs to remain among the top in its industry. In the past two decades, firms in the manufacturing industry have made conscious decisions to invest a sizable portion of their operating budget to implement TQM to improve the quality of their products and their processes.

The service industry has been slow to follow, however, since the concept of quality has become the single most competitive factor in today's service industry, the implementation of quality efforts should gain momentum.[7]

### 5.1. Customer Demand

The Department of Defense has become an educated customer. Observing the marked and documented improvements of the manufacturing industry, they are now demanding the implementation of the TQM concepts into the defense acquisition processes. The federal government has been experimenting with modern quality management since the mid 1980's.[4] To increase awareness of the principles and techniques of TQM among Federal Managers, and to help

executives implement the concepts into their organizations, the Federal Quality Institute was established. To further imply the seriousness of their intentions, a Presidential Executive Order 12647 (27 April 1987) established a government wide program to improve the quality, timeliness and efficiency of services provided by and for the federal government.

Other incentives for implementing TQM concepts in the Department of Defense can be seen by the initiatives taken by the Federal Government in the past few years. These include

- July 12, 1988 - The House Republican Research Committee Task Force on High Technology and Competitiveness published a paper titled "Quality as a Means to Improving Our Nation's Competitiveness."
- August 1988 - DoD published the "Total Quality Management Master Plan."
- October 5, 1988 - Mr Jack C. Strickland, Director, Industrial Productivity and Quality, OASD (P&L), briefed "Total Quality Management Institutionalization."
- January 1989 - DoD published the "Total Quality Management Education and Training Strategy For The DoD Acquisition Work Force."
- March 23, 1989 - DoD published DoD 5000.51-G, "Total Quality Management - A Guide For Implementation. (Draft)"

Following this lead, many of the DoD agencies and the Services began their own TQM programs. Some Memorandums written on TQM by these DoD agencies and the Services are briefly summarized in Appendix 2.

Some agencies have begun to award contracts to those companies that can show the application of TQM concepts in their organizations have resulted in documented improvements in the quality of products and services provided to their customers, even if the cost is higher than the lowest bidder. For example, during the Second National Total Quality Management Symposium and Exhibits, Mr Sagan from the Communications and Electronics Command (CECOM) in Fort Monmouth New Jersey, illustrated the presence of TQM as a criteria in the proposal evaluation process. CECOM awarded a particular contract to a firm that implemented TQM. The firm was not the lowest bidder. The lowest cost firm later sued CECOM. However, the courts upheld CECOM's decision stating that the difference in cost was justified by the winning contractor's implementation of TQM in their processes of producing outputs and the increase in quality as a result. They concluded that the implementation of TQM directly affects the quality of the products and services delivered during the course of the contract.

During the same symposium, Major General Charles Henry, Commander, Defense Contract Management Command discussed that some defense agencies allow up to 20% cost differential for organizations who have implemented some concepts of TQM such as statistical process control, and can show that the results of such implementation has impacted the quality of the products and services of that firm.

Further, nine out of fourteen major Air Force Commands have active quality implementation programs.[41] The Air Force Systems Command discussed the implementation of TQM concepts into the Request For Proposal process to increase communications between them and the contractors by allowing information to be distributed to the potential contractors.

They have an ongoing effort to eliminate the "bidder's conference" for a one-on-one conferences. Also, they are using a clean sheet approach to examine the RFP process to eliminate unnecessary, non-value added functions.

Many award programs have been initiated within the last five years to recognize those government agencies and private industry that have successfully implemented the concepts of TQM and have documented their progress. Many states' congressional representatives also have established awards at the state and local level to recognize companies' achievements in quality improvements. The following briefly describes some awards that exist at the national level.

The Malcolm Baldridge National Quality Award. Assigned to the Department of Commerce, the National Institute of Standard and Technology has responsibility for the creation and management of this award program. An annual award that promotes awareness of quality as an increasingly important element. Up to two awards are given in each of three categories - Manufacturing, Service, and small business. Award recipients may publicize and advertise the receipt of this award, however, they must also share their information on successful quality strategies.

NASA Excellence Award For Quality and Productivity. This award was established to encourage superior quality and productivity in the aerospace industry. It is an annual award given to NASA's contractors, subcontractors and suppliers.

Quality Improvement and Prototype Award. Assigned to the Office of Management and Budget, the purpose of this award is to recognize organizations that have successfully adopted

Total Quality Management principles and thereby improved the efficiency, quality and timeliness of their services or products. Further, to use the winners as models for the rest of government.

Presidential Award for Quality and Productivity Improvement. The purpose of this award is to recognize excellence in Federal service and provide a model of quality improvement for other government agencies. Evaluated by a panel of private and public management experts.

## 5.2 Changing Defense Environment

Recent changes in the world, such as the reunification of East and West Germany and the sweeping changes in the Soviet Union, have deeply affected the defense environment in the United States.[41] Is it necessary to keep building the defense industry at the current rate? Is it now time for a reduction in the US defense program? Question such as these have brought new factors into the defense industry. Due to the significant reduction in threat and the changing nature of the existing threat, the downsizing/reconfiguration of the US military and the defense program is inevitable.

Further, the decrease in the defense budget resulting from these changes will show in reduced sales of military systems. One result will be an increase in competition among all firms competing for contracts from the federal government.[38] The ESF must be able to provide higher quality, innovative products at a lower cost to the customer faster than ever before.

Total Quality Management has become a focal point for improvement for upper management of firms across entire US

industries and 90% of the Fortune 500 executives say that "quality is now a survival issue for American Business."[48]

## 5.3 Changing Attitude of the Employee

Recently, there has been a change in the expectations of the employee from his job. Today's employee is more highly trained and motivated than ever before[46] and demands greater satisfaction from his job. Many want more responsibilities, better and meaningful work - he needs and wants to be challenged at the work place For many, it is not enough to just do what he's told and take a pay check home. If the type of job satisfaction is not available at his present job, many will go and many have gone elsewhere.[6]

The turnover and training time for new employees to replace dissatisfied workers are a major concern for management. In order to maintain expertise in the field, firms need to retain these employees.

Employees also need to be recognized when his or her suggestions have improved a product or reduced costs. Something other than an "attaboy or attagirl."[21] Incentives and awards will bring innovative ideas under consideration by management from those who know the processes best - those who work the processes.

## 5.4 Interdependence

Many of the products produced by the ESF is the result of the integration of information from more than one department. The work required to develop and produce a single product can and will cross over the established organizational boundaries. Staff from many departments will

create outputs to be used as inputs for others and still another department will integrate all inputs into a single product. The development of these types of products creates interdependency among departments.

Total Quality Management encourages the development of teams with representatives from each participating department to optimize this development process. These teams will gain knowledge and understanding of others in the process and their requirements. They can work to identify and address issues of cross departmental conflicts and eliminate costly rework in product development.[30]

## 5.5 The Cost of Quality

The highest quality is to deliver to the customer, a product or service that meets his requirements, the first time - "do it right the first time." The cost associated with not doing things right the first time, identifying the defect, correcting that defect and preventing that defect from happening again is defined as the "cost of quality."[19] This cost is divided into three different categories.

- Prevention Cost
- Inspection/Correction Cost
- Field Failure Cost[19]

Prevention Cost. This cost is the investment the firm will make in investigating existing processes to identify points of potential problems thus preventing errors or rework. This cost will translate to a lower number of corrections and rework once the output is produced.

Inspection/Correction Cost. The task of reviewing/inspecting the work of others is a traditional role of quality control

in any firm. Correcting errors from products can be costly depending upon the extent of each error. However, the identification of any error or the lack of some quality attributes in a product will not necessarily identify the point where the error occurred nor where an improvement opportunity exists. The time taken for rework can cause a delay in the delivery of that product. Further, it will impact the timely delivery of other products currently being worked by those who are addressing the problem identified.[19]

Field Failure Cost. These are errors or lack of quality that are identified after initial delivery to the customer. Whether it is an error that requires a recall for repair or does not meet the original specifications of the customer, the cost at this point can be the costliest of all. Although the cost to fix the problem at this point is high, a dollar amount cannot be placed on the lack of confidence in the firm from the customer. The dissatisfied customer may or may not tell the firm the specific problem with the product. However, the complaints from them may reach the ear of future customers and can undermind the firm's reputation.[19]

The relative cost of the three costs of quality can be illustrated as a pyramid as shown in Figure 5-1.[19] The cost of preventing error or building in quality is the point of least cost while the cost of fixing the problem after the delivery may at times become immeasurable.

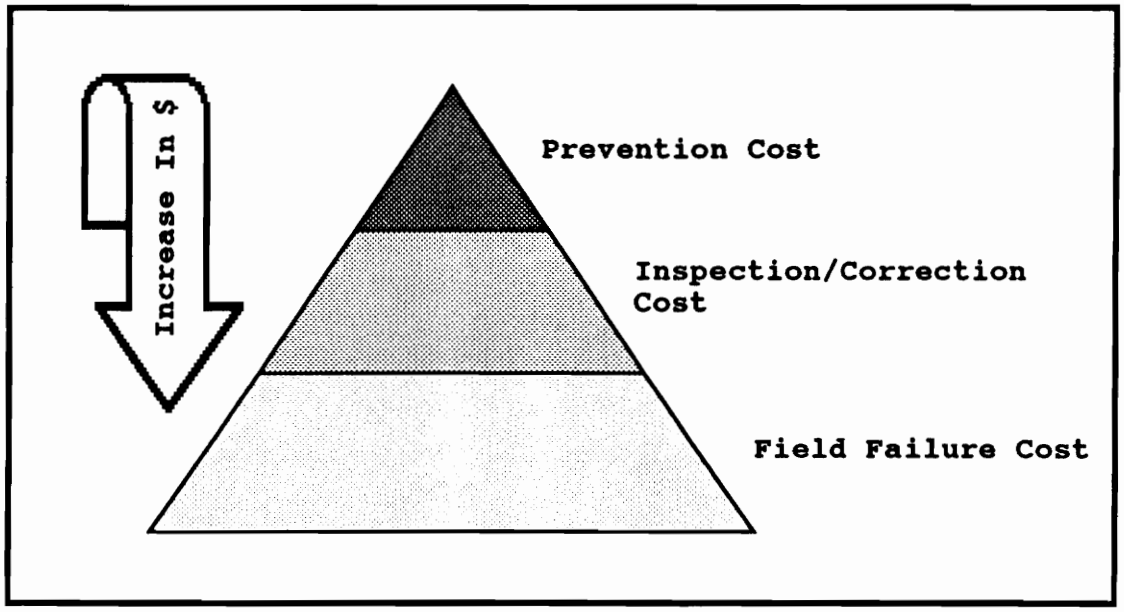



**Figure 5-1 Increasing Cost Of Quality**

## 5.6 Benefits

The benefits of successfully implementing TQM concepts can be seen through:

- Increase in Morale
- Satisfied Customers
- Marketability
- Reduced Cost of Production[43]

Morale. Effective training, participative decision making - empowering the employee and recognizing them with awards results in an increase in the quality of work, its environment and productivity from the employee. Educating employees in the entire production process results in workers with better knowledge and understanding of other functions in the process and the requirements of others. Communicating and cooperating employees in the production process will reduce rework and wasted efforts.

Satisfied Customers. Integrating the customer in determining the criteria for quality products will ensure that products will meet his standards of quality. Learning more about the customer's needs and wants of products will serve to increase customer satisfaction

Marketability. Becoming the finalist or being awarded one of the quality award can serve to increase the marketability of the firm as will the documented increase in the quality of the products and processes of the firm. Further, firms supported by satisfied customers can count on the loyalties of those customers.

Reduced Cost of Production. Reduced rework and less adjustments be in during or after development will result in reduced expenses and the overall cost of production.

And, if all of the above conditions exist, they will contribute to increasing the overall profitability of the firm over time.[43]

## 6. Preliminary System Design And Plan For The Initial Implementation Of Total Quality Management In An Engineering Services Firm

Since the need for the implementation of Total Quality Management has been established, the next step is to present a preliminary design and plan for implementing this change into the Engineering Services Firm.

The system design includes trade off analysis and studies investigating the cost and risk of implementing TQM as well as a description of system elements and its specifications. Implementing TQM does require a sizable investment for training up front. Studies supporting positive returns and low risk with TQM are needed to provide to management to justify the commitment of resources. These studies and analysis are beyond the scope of this report.

The implementation of TQM will be a gradual and iterative process. This initial implementation plan needs to be tested through pilot programs. Data gathered needs to be evaluated and the lessons learned used to further refine this plan. As small pilot programs begin to successfully integrate TQM into there every day operation, the design and plan will become more detailed and implementation increase until it is throughout the entire firm.

The maintenance and support of this implementation are inherent in TQM. Progress will be documented, measured, evaluated, and resulting information used to improve the implementation process and finalizing the overall plan.

This section provides the system elements followed by the initial implementation plan.

## 6.1 System Elements

The preliminary plan includes all major steps required to initiate the implementation of TQM in an Engineering Services Firm. The following is a list of system elements and the design specifications.

1.0 Create A Quality Environment
- 1.1 Establish Training Program
- 1.2 Establish Teams
- 1.3 Set Goals and Vision
- 1.4 Establish Awards and Recognition Programs

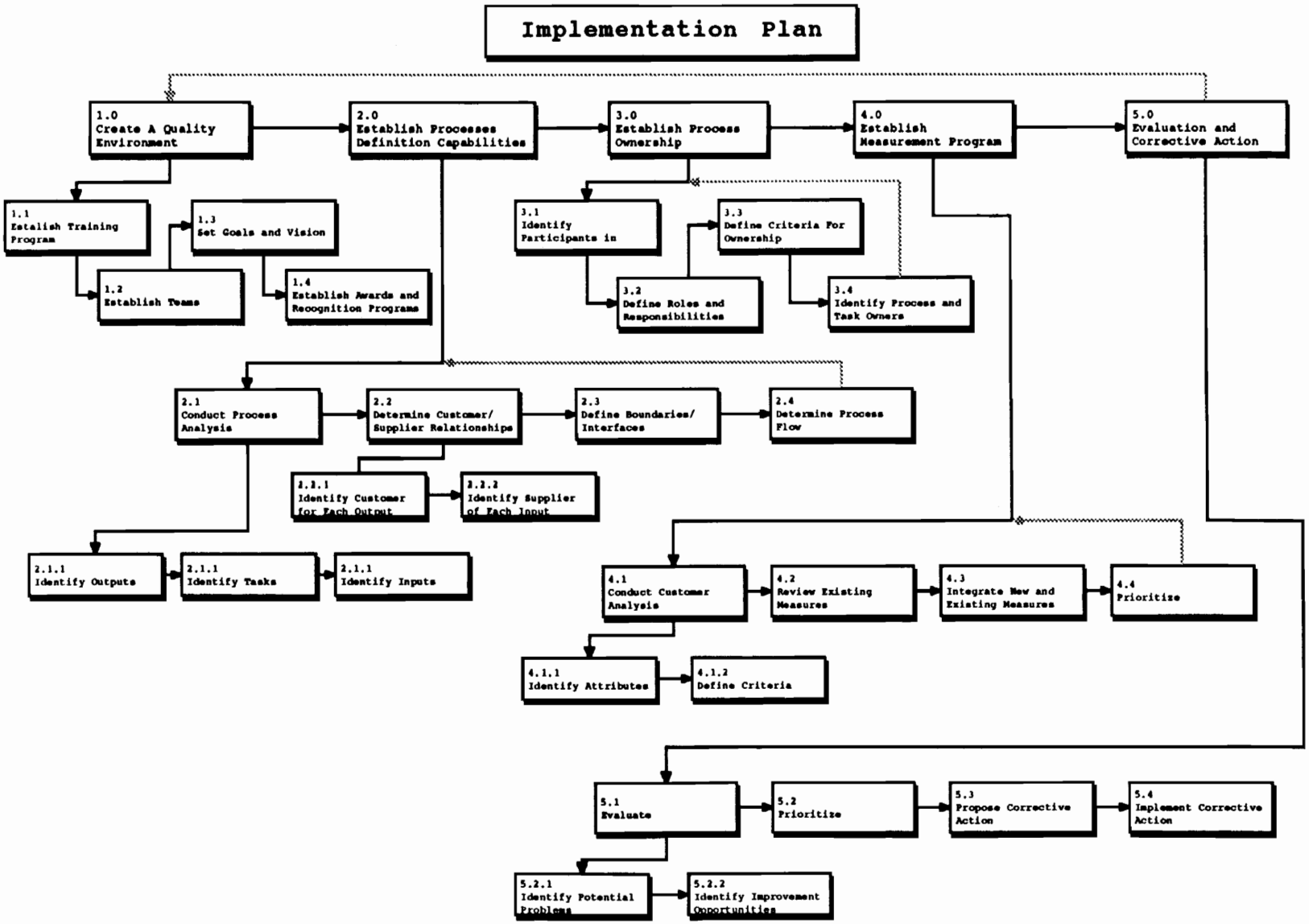
2.0 Establish Process Definition Capabilities
- 2.1 Conduct Process Analyses
  - 2.1.1 Identify Outputs
  - 2.1.2 Identify Tasks
  - 2.1.3 Identify Inputs
- 2.2 Determine Customer/Supplier Relationships
  - 2.2.1 Identify Customer for Each Output
  - 2.2.2 Identify Supplier of Each Input
- 2.3 Identify Boundaries/Interfaces
- 2.4 Determine Process Flow

3.0 Establish Process Ownership
- 3.1 Identify Participants of Entire Process
- 3.2 Define Roles and Responsibilities
- 3.3 Define Criteria for Ownership
- 3.4 Identify Process and Sub-process Owners

4.0 Establish Measurement Program
- 4.1 Conduct Customer Analyses-Internal/External
  - 4.1.1 Identify Attributes
  - 4.1.2 Define Criteria
- 4.2 Review and Integrate New and Existing Measures
- 4.3 Prioritize

6.0 Evaluate and Corrective Action
- 6.1 Evaluation
- 6.2 Prioritize
- 6.3 Propose Corrective Action
- 6.4 Implement Action

Figure 6-1 shows the functional flow for the implementation plan.




6-1 Functional Diagram

## 6.2 Discussion Of System Implementation Plan

> *"It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who would gain by the new ones."*
>
> Machiavelli, *The Prince* 1513

### 6.2.1 Create A Quality Environment

A quality environment can only be fully realized through management commitment. Management approach needs to be changed from the traditional, authoritative to the participative style as shown in Figure 6-3.[46]

| Old Management Approach | New Management Approach |
|---|---|
| Authoritarian | Participative |
| Fear Of Knowledge | Open Discussion |
| Fear Of Job Loss | Job Security |
| Status Quo | Continuous Improvement |
| Rigid, Extensive Policies And Procedures | Policies Of Continuous Improvement |
| "Beat On" Suppliers Distant From Market | Work With Suppliers Close To Customers |
| Specialists In Statistics, Industrial Engineering | Every Employee Trained In Basic Tools |
| Focus On Results - Bottom Line | Focus On Causes Of Problems |

**Figure 6-3 Traditional Vs New Management Approach**

Because TQM requires an organizational change, the more people that are involved, the better its chance of success. There will be increased commitment and support throughout the organization if all are involved.

The tasks for this step include

- Establishing training programs
- Establishing teams
- Setting initial goal and vision for the firm
- Establishing award and recognition programs

6.2.1.1 Establish Training Programs

*"The only thing more expensive than education is ignorance." Benjamin Franklin.* Training every employee in the firm on the concepts and principles of TQM is an important step to make them more aware and receptive to this change. This does require a show of commitment and support by the senior management as employees will be out of their own jobs for a certain amount of time while attending training seminars.

This training program needs to be initiated at the senior management level, then mid- and low-level managers then proceed to every employee in the firm. Senior management needs to learn their role in showing commitment and developing overall firm strategy for implementation. The mid and low-level managers need to be trained in their new roles as managers in participative environments. Through education, general employees will be prepared for their roles in the overall plan and fully understand the value and method of the potential for TQM.[46] Training is cannot just be an overview or few day seminars. Refreshers for some employees need to be planned. Further, advanced training for a

selected few (facilitators) will be required. The facilitators will be trained to lead the teams and group efforts. They will have specialized training in the application of tools and techniques of TQM.

6.2.1.2 Establish Teams

As employees become educated, teams need to be established for further employee participation. Typically, the first teams are executive steering committees made up of the senior management of the firm. This team sets the initial goals, vision and direction for the firm. Then other teams are formed with representatives from all divisions and departments that use structured problem solving tools and techniques to identify problems and improvement opportunities within their departments, divisions, and processes. Using some of these same tools and techniques, they will evaluate each situation, prioritize the actions to be taken and assist in the development of plans to implement action.

The role of a facilitator in the teams is very important to get desired results from team efforts. He needs to have leadership skills in dealing group interaction. He monitors the group to maintain track or focus on the topic of discussion. He will lead the use of the structured problem solving or idea generating tools during the group sessions. The facilitator needs to provide the right feedback during and at the close of group meetings.

6.2.1.3 Set Goals and Vision

Initially, overall goals and vision for the entire firm may be set by the management in steering committees. However, they should provide for flexibility so that

employees may begin their participation by providing their own suggestions that may be more relevant and integrate these suggestions. People will be more vested if they are involved in the setting of the goals and vision for the firm as opposed to being told by the management. Further, goals for departments and divisions should be set to reflect overall goals and will support reaching those goals. These goals and visions need to be communicated through subsequent general meetings and through other forms of communication that exist within the company such as newsletters and bulletin boards.

It must be remembered that both long and short term goals need be established at this point. Since TQM enhancements are geared toward improvements in the long term, incremental improvements are important to see results now. Short term goals need to be established from long term goals so that as short term goals are reached, long term goals become closer.

#### 6.2.1.4 Establish Award and Recognition Programs

Many firms do currently have suggestion boxes and award employees for those suggestions that are used and are beneficial to the company. Other firms have incentives for proposal development.

This award program needs to be different. It is a comprehensive system that used to provide motivation and incentives for employees to generate innovative ideas and participate in problem solving teams. With TQM, these suggestions for improving processes or solving problems will come as a result of team efforts. Therefore, the program should stress the team nature of improvement efforts to eliminate the internal competition within a team. The

program needs to stress the scale of time or cost saved or the increase in the quality of a product. Depending upon the scale of contribution, forms of awards may be in promotions, merit raises and bonuses or on a smaller scale, luncheons and senior management recognition.

6.2.1.5 Summary

Figure 6-4 is a summary of all tasks, outputs and tools and techniques used for this step.

| TASKS | OUTPUT |
|---|---|
| 1. Establish Training Programs | Training programs at various levels<br>- Senior Management<br>- Mid To Low Level Management<br>- General Employee Awareness<br>- Facilitator |
| 2. Establish Teams | Steering Committees (Senior Management)<br>Process And Quality Action Teams -<br>Representatives From All<br>Facilitator - Dynamic, Sharp Individual |
| 3. Set Goals And Vision | Initially Set By Steering Committees<br>Revised With Employee Participation |
| 4. Estalish Award And Recognition Program | To Provide Incentives For Original, Innovative Ideas<br>Team Focused<br>Merit Based<br>In Form Of Recognitions, Awards, Bonuses, Merit Based Raises, Promotions |

**Figure 6 - 4 Summary For Creating A Quality Environment**

### 6.2.2 Establish Process Definition Capabilities

For each major product of the ESF, there needs to clearly defined and documented process that produces that product so that the processes can be managed. As stated previously, the ESF does not yet have clearly defined and documented processes for the work performed for their customer because it varies according to the product or service.

In order to begin to manage processes, all processes of the ESF need to be defined and documented for each major product or service of the firm through Process Action Teams using the tools and techniques available.

The tasks for this step are to

- Analyze processes
- Determine customer/supplier relationships
- Define boundaries and interfaces
- Determine process flow

#### 6.2.2.1 Conduct Process Analysis

To begin process analysis for a specific product, all outputs, related tasks, and inputs required within the process need to be identified. One method for accomplishing this task is to use a combination of Input/Output Analysis, block diagrams, and group idea generating techniques such as brainstorming and the Nominal Group Technique.

The team that performs this analysis needs to consist of representatives - management, technical and administrative - from all departments and divisions that are involved in the production of that specific document. Figure 6-5 shows some

outputs, tasks, and inputs internal to the process for technical document development.

| Outputs | Tasks | Inputs |
|---|---|---|
| Typed Formatted Draft | Word Processing | Rough Draft |
| Sketched Charts | Develop Charts | Knowledge Base |
| Computer Graphics | Graphics | Hand Sketched Charts |
| Rough Draft of Document | Integrate, Format Text and Graphics | Typed Text, Graphics, DoD 5000.2-M-1 |

**Figure 6-4 Partial List of Outputs, Tasks and Inputs**

6.2.2.2 Determine Customer and Supplier Relationships

One reason for identifying the customer and supplier in the process within this group is to better understand their needs and roles in the process. As employees learn more about the tasks of others in the process, they will be better able to meet each other's needs. The producer/supplier will be in direct contact with their customers during these team meetings so their requirements can be easily determined.

For each output in the example above, the origination (supplier) of the input and the destination (customer) of the output should be listed. Figure 6-5 shows the supplier and customer for each of the output listed in Figure 6-4.

| Supplier | Outputs | Customer |
|---|---|---|
| Adminstrative Staff | Typed Formatted Draft | Technical Staff |
| Technical Staff | Sketched Charts | Graphics Department |
| Graphics Department | Computer Graphics | Technical Staff |
| Technical Staff | Rough Draft | Adminstrative Staff |

**Figure 6-5 Partial List of Customers and Suppliers for Each Output**

It must be indicated on the list of customers and suppliers the specific department or division. Further, as each customer and supplier is identified, simple block diagrams need to be used to show the flow of information. For example, Figure 6-6 shows a block diagram of the development of a handwritten draft of a section of a document (output) developed by a technical staff member (task) from an existing base of knowledge and specifications (input) to be typed by a secretary. In this case, the technical staff member is the supplier and the administrative staff member, the customer.

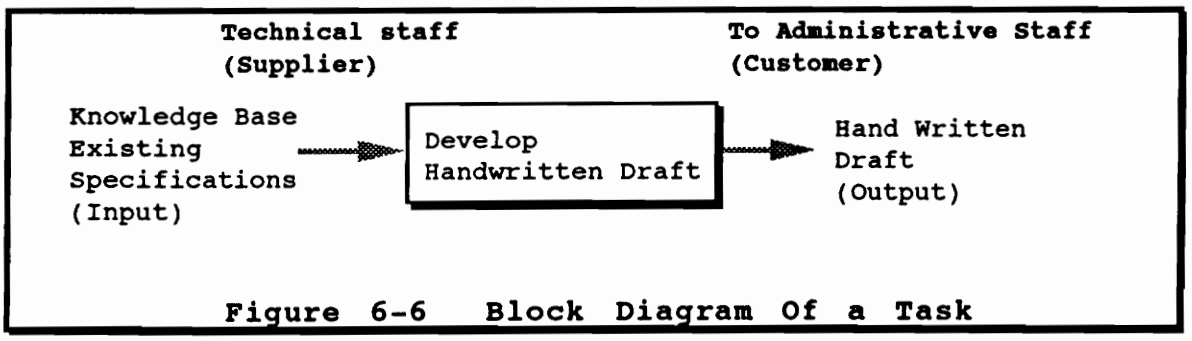



**Figure 6-6 Block Diagram Of a Task**

Then, to show the flow of tasks, individual block diagrams need to be connected. Figure 6-7 shows several block diagrams linked together showing the flow of tasks as well as the inputs and outputs of each.

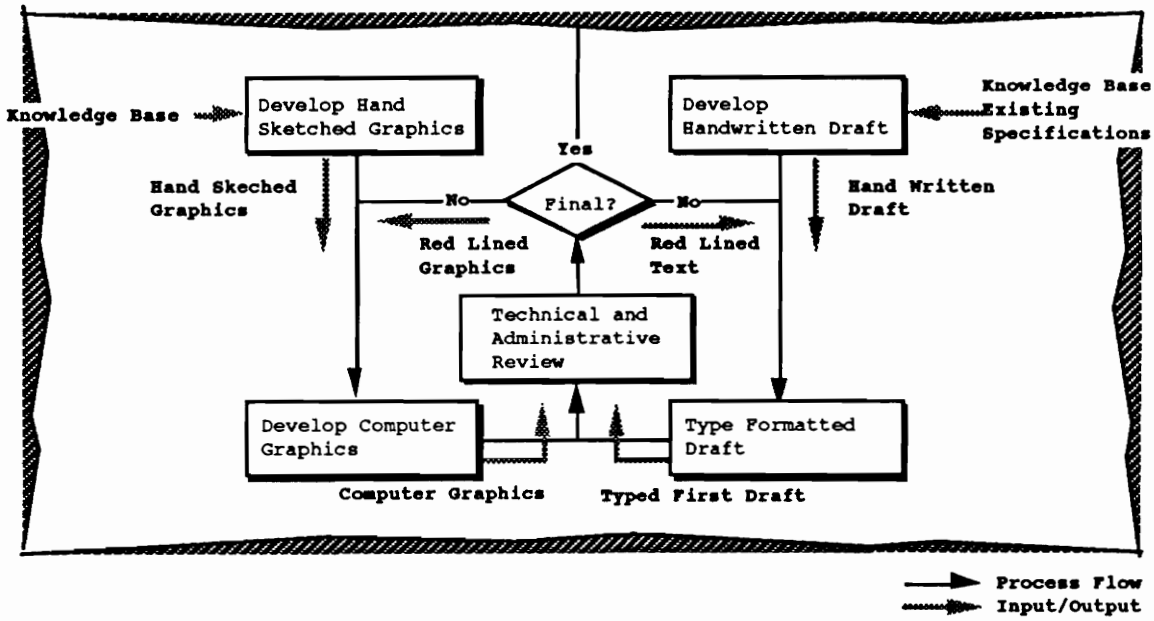



**Figure 6-7 Partial Process Flow**

6.2.2.3 Define Boundaries and Interfaces

Boundaries and Interfaces need to be established at points where the output and input are exchanged. The outputs of the input/output analysis and the block diagrams, facilitate defining boundaries and interfaces. The cross over of responsibilities to other departments does contribute to the difficulties of establishing the boundaries and interfaces of the process. However, it does not make the task impossible. Boundaries are points where an input or and output crosses over a department, organization or facility while interfaces can be between people within a process such as

- technical staff and the administrative staff
- administrative staff to administrative staff
- technical staff to management
- technical staff to external customer
- management to external customer

within the process. Figure 6-8 shows the boundaries and interfaces in the example in Figure 6-7.

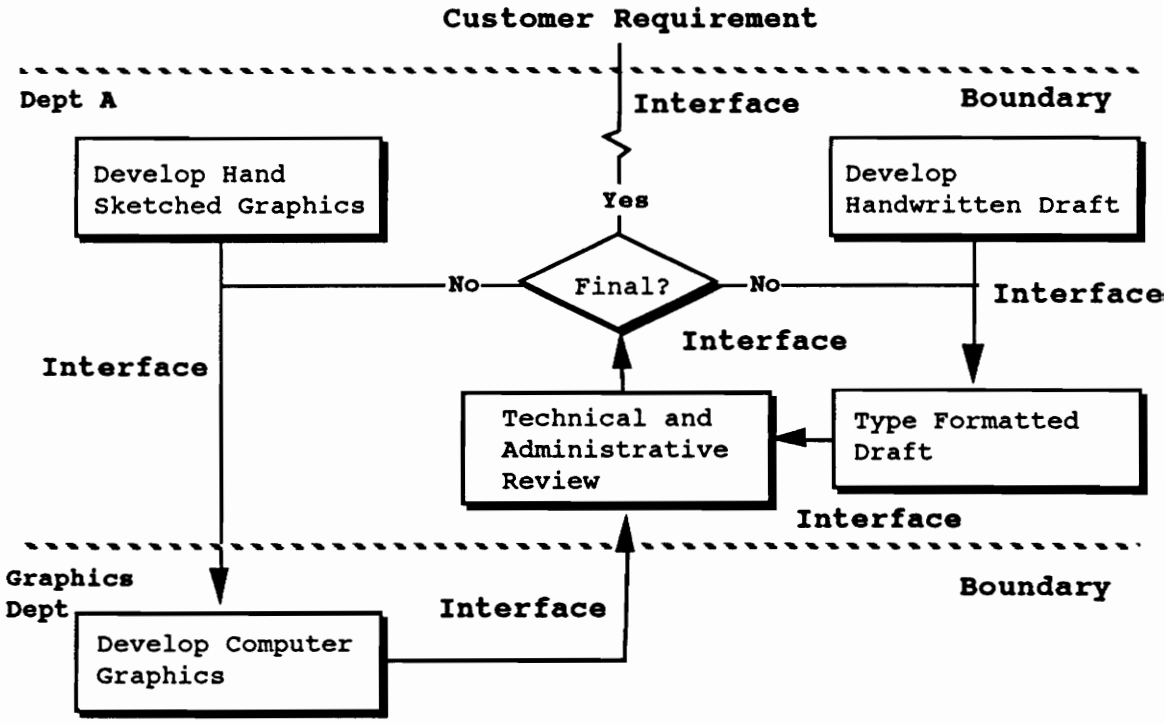



**Figure 6-8 Boundaries and Interfaces In A Process**

6.2.2.4 Determine Process Flow

Using the outputs of all tasks the entire flow can be determined in a flowchart format with supporting documentation. This flowchart will serve as a starting point for improving processes. Since the process is now clearly defined and documented, it can be continuously improved upon as it is reviewed. In order to continuously improve this or

any process, each task needs to be reviewed in the future to ensure that it is indeed a specific value adding task in the process of developing the output. If not, the task should be eliminated or combined with others that will make the process less complex and more efficient.

#### 6.2.2.5 Summary

Figure 6-9 is a summary of all tasks, outputs and tools and techniques used for this step.

| TASKS | OUTPUTS | TOOLS/TECHNIQUES |
|---|---|---|
| 1. Conduct Process Analyses - Identify Outputs, Tasks, Inputs | List Of Outputs, Inputs, And Tasks For Each Process | Brainstorming<br>Interviews<br>Nominal Group Technique |
| 2. Determine Customer/ Supplier Relationships | List Of Customers And Suppliers With Each Output<br>Block Diagrams Of Each Task | Block Diagrams<br>Brainstorming<br>Nominal Group Technique |
| 3. Define Boundaries/ Interfaces | Sections Of Processes Identifying The Boundaries And Interfaces | Interviews<br>Questionaires |
| 4. Determine Process Flow | Flow Chart Of Each Process | Block Diagrams<br>Flow Charting |

**Figure 6 - 9 Summary For Establishing Process Definition Capabilities**

### 6.2.3 Establish Process Ownership

Jobs in the assembly line of a manufacturing firm have clearly defined roles and responsibilities for individuals. Each of the processes has established owners and sub-process owners that do not change as long as the product being produced does not change. There is not much room for cross over of responsibilities.

In an ESF, roles and responsibilities for participants are not as clearly defined as they are in the manufacturing firms. For example, many technical staff members have become proficient with desktop publishing software such as word processors, graphics and spreadsheets. The technical staff member will write directly to a word processor skipping over a preliminary typing draft by a secretary. Then, he reproduces multiple copies of the draft for further review by peers or management. This contributes to the ambiguity of process ownership and the cross over of responsibilities between technical and administrative staff members. If the document contains many sections, each section could be inconsistent in text and format because there is no common typist. Further, a morale problem can result when a technical staff member is required to do repetitive tasks that require far less knowledge than he possesses such as typing or reproducing of documents.

Although ownership is established for processes developing specific deliverables, many other processes do not have established owners. The owner is established according to the subject or the availability of the staff at the time the requirement is delivered.

The tasks for this step are to

- Identify the participants of a process
- Define roles and responsibilities of each
- Identify criteria for ownership

### 6.2.3.1 Identify Participants of the Process

All participants of the process from all participating departments and divisions need to be identified such as the

- managers that allocate resources and determine schedules
- technical staff that will develop the technical content for the document
- and administrative staff that support the technical development.

For example, for a particular document, there may be 3 sections requiring expertise in three specific fields relating to three different departments. The technical staff of each department will require administrative support for typing and simple graphics. More sophisticated graphics will be forwarded to the graphics department in another division. Security support will be required for compliance with industry and government specifications. Each group and individual in the process need to be identified.

### 6.2.3.2 Define Roles and Responsibilities

The technical and management staff members roles and responsibilities include

- Developing their own output
- Integrating of internal outputs (project leaders)
- Reviewing administrative outputs

- Reviewing output for technical and administrative errors.

The administrative staff needs to

- Integrate different sections into one document
- Develop and Integrate graphics
- Ensure uniformity format - conformance to firm or customer specifications

Security staff needs to

- Ensure format is in compliance with industry and government specifications
- Review for consistency
- Review for all security markings

There is an overall process owner and a sub-process owner. The roles and responsibilities for the Process Owner include the following. Those for the sub process owner are similar but on a smaller scale - it will be only apply to a specific sub-process.

- Ultimately accountable for overall product quality
- Organize and coordinate tasks
- Allocate necessary resources
- Document process
- Track progress

#### 6.2.3.3 Identify Criteria for Ownership

As stated in the previous section, process owners have a big responsibility. They are soley accountable for the overall quality of the product produced by the process. To ensure that they have the means and resources to accomplish their responsibilities, they need to have at least the following criteria.

- Authority to allocate resources

- Authority to implement changes
- Understanding of all tasks of the process

When a task of a process enters into another department, an owner needs to be designated to ensure that the tasks for that department will be completed consistent with the overall format and on time. This will be the sub-process owner. The number of sub-process owners will vary according to the complexity of the process. Although the sub-process owners can be a project leader or a member of the technical staff, the overall process owner must at a management level to have the criteria stated above.

Prior to initiating any process, the owner of the process and all sub-process owners need to be identified.

6.2.3.5 Summary

Figure 6-10 is a summary of all tasks, outputs and tools and techniques used for this step.

| TASKS | OUTPUTS | TOOLS/TECHNIQUES |
|---|---|---|
| 1. Identify Participants Of Entire Process | List Of All Participants Of Each Process | Brainstorming |
| 2. Define Roles And Responsibilities | For Each Participant, Set Of Roles And Responsibilities - Including Process And Sub-process Owners | Brainstorming<br>Management Direction |
| 3. Define Criteria For Ownership | List Of Criteria For Process And Sub-process Owners | Brainstorming<br>Management Direction |
| 4. Identify Process And Sub Process Owners | List Of Owners And Sub-process Owners For Existing Products | Management Direction |

**Figure 6 - 10 Summary For Establishing Ownership**

### 6.2.4 Establish Measurement Program

There are two approaches to measurement - optimistic and pessimistic. Optimistic approach to measurement is to measure the percentage "good." The goals set will be defensive - 100% on-time deliveries, 100% technical accuracy, etc.[9] This type of measurements is good for the firm in times of proposals but does not serve as a motivator. The other approach is to focus on the inverse and measure the defects or set offensive goals such as striving toward zero-defects. There are several reasons to use the second approach of measurement in the improvement process.

- Tendency to manage by exception - attention is given to those that are perceived as problems. Management "greases the wheel that squeaks."
- The perception that a 2% late delivery is worse than 98% on-time deliveries. The first flags a problem while the latter seems acceptable.[9]

The tasks for this step are to

- Understand customer requirements
- Review existing measures
- Integrate new and existing measures
- Prioritize measures

#### 6.2.4.1 Conduct Customer Analysis

In order to best serve the customer, the producer must understand how the customer will use his output - his requirements.[16]

- Will it be used as a reference material?
- Will it be a section of a technical document?

- What is the format of the output?
- Where will it go next?

6.2.4.1.1 Identify Attributes

To facilitate the identification of requirements for internal or external customers, they should be segmented for analysis. The collection of requirements can be accomplished in a variety of ways including interviews, the "mystery shopper" technique[32], and questionnaires.

Interviews. Interviews can be informative, however, it can become lengthy and not result in specific attributes because there is a high chance of discussion outside the topic. For best interview sessions with the customer, the topics of discussions should be outlined specifically and the discussions remain focused. However, interviews will provide the customers a chance to express his own opinions about his own topics in addition to the those presented to him. The topics for discussion or quality requirements for a product can be identified using group idea generating techniques such as brainstorming and the Nominal Group Technique. For example, for technical document development, a team consisting of representatives of that process can develop a list as to what they perceive as quality requirements. This can serve as a catalyst during the customer interview.

"Mystery Shopper" technique.[32] This method of gathering customer requirements are another form of an interview, however, there is no preconceived agenda and the customer is providing only what he sees as important in a product.

Questionnaires. Questionnaires for the customers will gather more specific information, however, developing the questions

will require more work than generating topics for discussion during interviews. The same techniques will be used such as brainstorming and the Nominal Group Technique, however, the final format for the questionnaire needs to be more structured. Questions need to be structured in a way as to direct the customer response. A question to gauge customer satisfaction of a certain product needs to provide choices to avoid the "average" response. For example,

| **Provide These** | **instead of** | **These** |
|---|---|---|
| highly satisfied | | highly satisfied |
| somewhat satisfied | | satisfied |
| slightly satisfied | | unsatisfied |
| unsatisfied | | |

One specific method of identifying attributes is the Customer Window™ technique developed by ARBOR, INC. This can be applied to both internal and external customers. Figure 6-10 is an example of the Customer Window™ that will be used in gathering customer requirements. The purpose of the customer window™ is to prioritize attributes and to focus improvement efforts. The customers should be segmented, internal or external or management, technical and administrative, so trends can be determined. The questionnaires or list of requirements to which they are responding can be developed as described previously in this section.

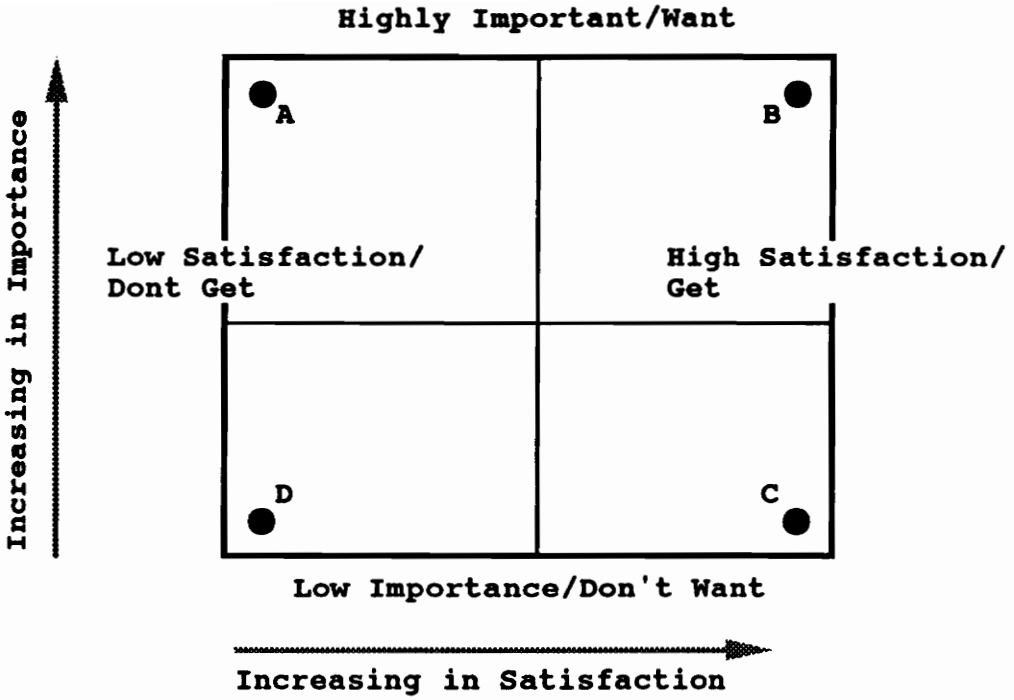



**Figure 6-11 Customer Window™**

Customers are to place their quality requirements somewhere in the four quadrants. The firm's attention should be focused on those placed in the quadrant where point A is since this quadrant represents requirements of high importance but low customer satisfaction. Point B represents those requirements that are important to the customer with which the customer is satisfied. Point C is in the quadrant where customer satisfaction is high, however, the requirements are of low importance to the customer. The last quadrant represents those requirements with which the customers are not satisfied, however, those requirements are not important to the customer anyway.

Customer quality requirements for a product, gathered using techniques including the those described above, can be translated into attributes for measurement. The first step

is to determine whether the attribute is expected, specified, exciting.[32]

Expected. Expected quality attributes are those that the customer expects in all outputs such as a document free of typographical errors.

Specified. Specified are those attributes specifically asked for by the customer such as a format of the output - disk or hard copy.

Exciting. Exciting attributes are those that are not quite the standard but nice to have, such as color graphics. However, it should not alter the satisfaction of meeting other attributes, such as on time delivery. Over time, the customer will come to expect the exciting attributes and new attributes will be categorized as exciting.

Once the attributes are identified and categorized, the criteria for measurement need to be determined for each.

6.2.4.1.2 Define Criteria

In a survey of Federal executives, 49% said that the lack of dependable ways to measure quality is a major obstacle to implementing quality management. This is similar in the private sector.[4] The task of developing and establishing a reliable measurement program is indeed difficult, however, it is not impossible. It needs to be attempted one step at a time.

The quality attributes selected will be both qualitative and quantitative. In order to have a sound reliable measurement system, the attributes need to be some how quantified. Defining criteria for the attributes, will require teams using tools such as brainstorming, Nominal

Group Technique and other idea generating methods to generate potential criteria to measure.[9]

6.2.4.2 Review Existing Measures

Prior to implementing TQM enhancements, the ESF may have an established measurement method to measure the performance of the firm. These existing measures need to be reviewed to determine their relevance to the quality of the product as seen by the customer.[9] Some measures may need to be revised to fit those measures gathered during customer analysis.

For example, one measure the firm may be currently tracking is the number of deliverables made to the customer on a monthly basis. This measure of performance does have an indication that much work is being completed by the firm, however, it does not indicate the number of documents delivered on time nor the technical accuracy of the document. Therefore, this measure may be improved upon by adding ratios such as

$$\frac{\text{The number of documents delivered on time}}{\text{Total number of documents delivered}}$$

over a certain period of time or

$$\frac{\text{The number of acceptable technically accurate documents}}{\text{The number of documents delivered on time}}$$

6.2.4.3 Integrate New and Existing Measures

In selecting final attributes from new and existing measures, these two things should be kept in mind. The measures should be simple and minimized in number.[9]

Simple. Those involved must fully understand each attribute. Complexity will only add to the confusion and will not provide concise data. Ensure that these attributes are not too subjective.[31]

Minimize number of measures. When selecting measures, the fewer the better. If there are too many, employees and customers will concentrate on a few. Analyzing the use of large number of measures has revealed redundancies.[9]

6.2.4.4 Prioritize measures

As can be seen in the customer window™, not all requirements are equally important to each customer. Some are definitely more important than others. These factors need to be considered when prioritizing measures using customer input, such as customer window™, as well as team input through idea generating techniques. All measures should be prioritized and weighted according to their importance to the overall quality of the product. Also, the importance of one attribute will vary with different customer segments.

For example, the quality attributes for a technical document can include, among others, on time delivery, technical accuracy, completeness, format consistency and security compliance. For example, the weight for each attribute may be as follows.

| Attribute | Customer Segment: Technical Customer | Customer Segment: Security Customer |
|---|---|---|
| On time delivery | 10 | 15 |
| Technical accuracy | 50 | 5 |
| Completeness | 20 | 15 |
| Format consistency | 10 | 15 |
| Security compliance | 10 | 50 |
| Total | 100 | 100 |

The weight of each measure of quality and the subsequent priority of each measure needs to be determined for each product and customer segment in the process as well as for the overall process and the external customer.

6.2.4.5 Summary

Figure 6-12 is a summary of all tasks, outputs and tools and techniques used for this step.

| TASKS | OUTPUTS | TOOLS/TECHNIQUES |
|---|---|---|
| 1. Conduct Customer Analyses - Identify Attributes And Criteria | List Of Quality Attributes And Measurement Criteria For Each Customer Segment | Interviews<br>Brainstorming<br>Customer Window ™<br>Nominal Group Technique<br>Questionnaires |
| 2. Review Existing Measures | List Of Applicable Exiting Attributes And Criteria | Brainstorming<br>Nominal Group Technique |
| 3. Integrate New And Existing Measures | List Of Attributes And Criteria For Monitoring | Nominal Group Technique |
| 4. Prioritize | List Of Prioritized Quality Attributes Per Customer Segment | Nominal Group Technique<br>Interviews<br>Questionnaires |

**Figure 6 - 12 Summary For Establishing A Measurement Program**

### 6.2.5 Evaluation and Action

Measuring the right things are just as important as measuring. During evaluation of the overall implementation process, measures that do not add to the improvement process will be eliminated while others will be added to the measurement system.

The tasks for this step are:

- Evaluation - Identify problem areas/improvement opportunities
- Prioritize
- Propose Corrective Actions
- Implement Action

#### 6.2.5.1 Evaluation

The information needs to be evaluated and areas of problem and potential improvement areas need to be identified and prioritized in the order that they should be addressed.

The most important role for measures is to stimulate improvement.[23] Thorough evaluation of data gathered and the resulting input in future product development planning is critical to the continuous improvement cycle. Because the measurements are both qualitative and quantitative, there are both subjective and statistical methods of evaluation. Subjective evaluations include extensive reviews of questionnaires and surveys, cataloging subjective summarizations of feed back and is susceptible to a wide range of interpretations.[43] Tools and techniques of evaluation such as the Cause and Effect Analysis or Impact/Changeability analysis, can be used. For quantified

data, statistical tools and techniques of evaluations are available. Some of these tools and techniques are summarized in Appendix 1.

The purpose of evaluating measures is to

- Ensure customer (internal or external) requirements are being met in products delivered
- Locate problems within a process
- Identify areas for improvement
- Identify new areas for improvement planning

Evaluation should also review the type of measures being collected and the value of each in the evaluation of the product or process. It should result in the elimination of measures that do not impact the improvement process and identify and implement new measures that will. Measures that are not used are just a waste of time.

An evaluation of product quality measures may result in one of two conditions.

- Product has fewer attributes or does not meet all predetermined requirements
- Product has more attributes than required and exceeds all predetermined requirements.[22]

It must be understood that the identification of a specific problem within the process through evaluation is not to single out an individual or group to blame, it is to isolate a problem to better understand it and to develop solutions to improve the process and product quality.

The improvement efforts for these conditions differ. The first condition represents an opportunity to improve the

quality of the product. The process needs to be adjusted to include steps that will address those attributes that are not currently addressed. However, the second condition shows that an improvement is required in the product development because the process has used more resources than necessary in developing the product. The process should be reviewed to eliminate functions of the process that are non value added.

Further, new areas of improvement should be identified as current focused areas begin to meet and exceed their goals.

#### 6.2.5.2 Prioritize

The problems and improvement opportunities identified during evaluation need to be prioritized in the order that they will be addressed. This also needs to be addressed in a team environment using a tool such as the Nominal Group Technique or the Impact/Changeability analysis.

#### 6.2.5.3 Propose and Plan Corrective Action

Solutions to problems or methods to plans to take advantage of improvement opportunity need to be proposed and planned. The corrective actions need to be able to solve the problem, be cost effective and timely. Again, the Nominal Group Technique can be effectively used to generate potential corrective actions and to select the most promising. As the plan is being developed and finalized, management needs to be presented with the proposal to gain their support.

Planning for the action selected should have contributions of all employees involved in the process. The plan will have a better chance of success since employees

have a stake in it and therefore be more willing to ensure its success. During the planning, management need to be kept informed of the details through periodic briefings and reviews since many employees do not have experience in developing plans.

#### 6.2.5.4 Implement Action

All that is left to do is to implement the corrective action plan and to monitor its progress. Managers need to assist and support this final phase, also, as the general employee has had little previous experience in implementing any plan.

#### 6.2.5.5 Summary

Figure 6-13 is a summary of all tasks, outputs and tools and techniques used for this step.

| TASKS | OUTPUTS | TOOLS/TECHNIQUES |
|---|---|---|
| 1. Evaluate | List Of Problems And Improvement Opportunities | Pareto Diagram<br>Histogram<br>Cause And Effect Analysis<br>Impact Changeability<br>Etc... |
| 2. Prioritize | List Of The Above Prioritized | Nominal Group Technique<br>Interviews |
| 3. Propose and Plan Corrective Action | Solutions To Designated Problems and Improvement Opportunities | Nominal Group Technique<br>Cause And Effect Analysis<br>Impact/Changeability |
| 4. Develop Plan And Implement Action | Plan For Implementing Solutions<br>Implementation Of Plan | N/A |

**Figure 6 - 13 Summary For Evaluation And Action**

## 7. Conclusions

The concepts of Total Quality Management as applied to Engineering Services Firms in the Defense Industry may be difficult to implement, but not impossible. It is the resistance of this impending change to the existing "system" from those within the system, that may be difficult to overcome. Those who resist do so because change brings with it uncertainty. The less that is known of this change, the more it will be feared or resisted. TQM supports and mandates education and training for all within the system because the success of TQM is dependent upon participation by everyone. Instead of quickly pointing out major difficulties of implementing TQM concepts or why its concepts cannot be applied to the service industry, time and resources should be used to find ways around these difficulties and to cultivate the positive ways to tailor the concepts to each firm.

TQM experts do not proclaim to have the instant cure to miraculously "fix" all things. The concepts of TQM are to assist in the self help process of continuous improvement for all things; to focus on customers, be they internal or external, and their requirements; to learn ways to anticipate changes in their requirements; and to always deliver a continuously improving, high quality product. TQM solicits and encourages suggestions from all involved in the development of a product and successfully use these suggestions to continuously improve the products and the processes that develop these products.

The concepts of TQM should be implemented into the culture of the firm and the defense services industry. To be successful, clear and realistic scope and goals need to be

determined. The development of the strategy and planning for all changes forthcoming are critical to its success. Also important is the method used to communicate the company vision to all employees. In doing so, senior management plays a critical role in the success or failure of their total quality improvement programs. They must ensure that enough resources (dollars or personnel) are committed in educating and training everyone in the firm about TQM and the tools and techniques to be used because TQM cannot succeed without participation from everyone.

Further, the changes should be implemented into the system gradually or in phases - isolated to relatively simple processes in the beginning involving only a few levels of employees and departments. As the knowledge base increases within the firm as employees are educated through training and application of some simple TQM concepts, implementation can be more complex and widespread throughout the firm involving multiple levels of employees and departments.

Finally, as in the implementation of any change into an existing system, it must be carefully monitored and evaluated. Careful measures should be taken and reported to be evaluated for its input value in the continuous improvement cycle. Analyzing reports of lessons learned from specific incidences during implementation are valuable to management in planning future improvement efforts and in determining whether or not predetermined goals have been met. The emphasis in Total Quality Management is to continuously improve upon these predetermined specifications and to strive for even higher quality or to find improvement opportunities in other aspects of the operations.

Most importantly, TQM takes time. Time to train and to educate everyone in the firm in the need for this change, what to expect in the near term and long term, and the tools that will be used by all. More time will be needed to analyze each concept and tailor each to fit into the firm's own visions and goals. Still more time will be required to develop a reporting system for measures. Improvement or increase in quality needs to be viewed as a journey not a destination.[49] There are no specific templates to buy, there are only tools and techniques to assist in this process. Each firm and industry are unique with their own environment and the variables that affect it, therefore, each must take the time to it needs to extract from TQM concepts what is valuable to them.

Firms in the Defense Services Industry should be wise as to fully accept the challenge of implementing total quality management concepts into its culture in its entirety. Those that only coat the surfaces of their firm with TQM concepts and not truly integrate these concepts will become apparent as Department of Defense become educated customers. These firms that are superficial will be extremely behind the power curve and may lose significant market share as they fall further behind in the development of competitive products in the global market. Firms within the industry should assist each other in the practices of TQM as encouraged and promoted by the award programs available.

> ***"The goal of total quality improvement often seems remote and out of reach. Others have taken the journey. Their knowledge and experience can benefit you."***[57]

## 8. Recommendations

Since the implementation of Total Quality Management concepts into the Defense Industry is relatively new, there are many specific areas of application that still need to be explored. Also, many Engineering Services Firms will be investigating the potential for implementing these concepts into their own firms. During the research efforts for this project, opportunities arose to review the processes of existing engineering services firms and their existing implementation efforts.

This paper demonstrated a need for change and developed a preliminary design and plan for implementing Total Quality Management into an Engineering Services Firm. Implementing this change will require many of the same documentations required for documenting the system engineering approach such as those listed in Figure 3-5.

Topics for further projects could include the following.

<u>Conduct Tradeoff Analysis.</u>

- Define analysis objectives and requirements
- Define the need, the user, and the availability of resources bounding the scope of the analysis
- Identify alternatives for consideration or develop specific alternatives for analysis
- Describe each alternative
- Formulate selection criteria
- Numerically weight each selection criteria according to relative importance in determining effectiveness

- Evaluate alternatives
- Performance sensitivity check

Develop Test and Evaluation Master Plan.

- Address objectives, issues and interface/coordination of implementing the change
- Discuss management of the test program including the roles and responsibilities of those involved.
- Include an integrated schedule for the test program
- Discuss the developmental and operational testing and the performance requirements for each.
- List and discuss resources for test including the identification of special resources. Include specific quantities, types and configurations.

Risk Analysis And Management. Document analysis through the Risk Management Program Plan, Sensitivity Analysis, Handling Plans and reduction reports.

- Risk Assessment - examine situations and identify all areas for potential risk such as funding, schedule, contract relationships, and political.
- Risk Analysis - conduct analysis to determine probability of events and the consequences associated with their occurrence to discover the cause, effects, and magnitude of the risk perceived, and to develop and examine alternative options throughout all phases of the system life cycle

- Risk Handling - develop techniques and methods to reduce or control risk such as avoidance, prevention, assumption, transfer, knowledge and research for those identified in the previous step

Address Life Cycle Cost.

- Conduct a Life Cycle Cost (LCC) analysis to investigate the total cost of implementing TQM enhancements into an engineering services firm from start to finish, identify life cycle cost drivers.
- Develop a Life Cycle Cost Plan to describe the approach for integrating LCC into the design and management.
- Develop a Life Cycle Cost Estimate to serve as a cost baseline for the implementation of the change including a list of all actions in the all phases with associated cost.

Developing a Detailed Plan For Implementation.

- Determining Measures for the Defense Services Industry - investigating existing measures and finding new measures through customer research and analyses.
- Determining the Quantifiable Criteria for the Measures - investigate the subjectivities of service oriented quality measures and develop a method of quantifying each measure.
- Customer Analyses in the Defense Services Industry - investigate the different levels of customers within the Defense Services Industry. Segment and analyze specific requirements for each customer.
- Process Definition in Engineering Services Firms - investigate processes that develop the products and services in an Engineering Services Firm. Flow chart each existing processes and using the tools and techniques

of TQM, improve upon these processes to produce improved quality products.

Investigating the Defense Environment.

- Process Definition in the Defense Acquisition Process - analyze the defense acquisition process by flow charting the process. Eliminate non-value added steps within the process while adding new steps that will enhance the process.
- Roles of teams in the Defense Service Contracts - investigate the potential for better teaming arrangements within the defense industry. Redraw the lines of "prime" and "sub" to satisfy the external customer - the government - to increase the quality of the products, processes. Analyze process ownership of major products to ensure that the expertise of the entire team is optimized to deliver the best quality product to the customer.

# Bibliography

## Bibliography


1. Armentrout, Daryl R., Engineering Productivity Management and Performance Measurement." Journal of Management in Engineering, Vol. 2, No. 3, July, 1986
2. Blakeslee, Sandra, "Restoring Quality in Quality Control," The changing Technology.
3. Brown, Mark G., and Raynold A. Svenson, "Measuring R&D Productivity." Research Technology Management, July-August 1988
4. Carr, David and Ian Littman, "Quality in the Federal Government." Quality Progress, September 1990.
5. Denton, D. Keith and Thomas P. Kowalski, "Measuring Nonconforming Costs Reduced Manufacturer's Cost Of Quality In Product By $200,000." IE, August 1988
6. Dorin, Fred, "6 Leverage Factors for Improving White Collar Productivity: Engineering and Research and Development," Managers Notebook, American Productivity Center, Vol 3, No. 5
7. Elshennawy, Ahmad K. and Behshid Farsad, "Definig Service Quality Is Difficult For Service and Manufacturing Firms," IE, March 19, 1989
8. Feighery, Daniel J., "Total Quality Management and Government Test and Evaluation," ITEA Journal, Volume XI (1990), No. 3
9. Felix, Glenn H., and James L. Riggs, "Productivity Measurement by Objectives." National Productivity Review, Autumn 1983.
10. Fuchsberg, Gilbert, "The Gurus of Quality Are Gaining Clout," The Wall Street Journal, November 27, 1990
11. Hauser, John R., and Don Clausing, "The House of Quality," Harvard Business Review, May-June 1988, p.63
12. Harrington, Hugh J. and Jack B. ReVelle , "Total Quality Issues and Activities in the Defense Industry." Industry Applications
13. Katzen, Jack, "Katzen On Quality," Dimensions, June 1988
14. Kidd Jr., George J., A Quality Program in Research and Development," 1990-Juran Institute Conference-Atlanta
15. Imre, John V., "TQ Improvement, A Resource Guide To Management, Boeing Aerospace Company." 1987
16. Labovitz, George H. "Keeping Your Internal Customers Satisfied," The Wall Street Journal, July 6, 1987

17. Labovitz, George H. and Y. S. Chang, "Anatomy of an Award-Winning Quality Plan." Organizational Dynamics, Inc., Burlington, MA

18. Labovitz, George H. and Y. S. Chang, "Managing the Internal Customer/Supplier Chain." Organizational Dynamics, Inc., Burlington, MA

19. Labovitz, George H. and Y. S. Chang, "Quality Costs: The Good, The Bad and The Ugly," Organizational Dynamics, Inc., Burlington, MA

20. Labovitz, George H. and Y. S. Chang, "The Quality Advantage." Organizational Dynamics, Inc., Burlington, MA

21. Labovitz, George H. and Y. S. Chang, "Tough Questions Senior Managers Should Be Asking About Quality." Organizational Dynamics, Inc., Burlington, MA

22. Lawton, Robin L., "Creating a Customer-Centered Culture for Service Quality." Quality Progress, May 1989

23. Liker, Jeffrey K. and Walton M. Hancock, "Organizational Systems Barriers to Engineering Effectiveness." IEEE Transactions on Engineering Management, Vol. EM-33, No.2, May 1986

24. Melan, Eugene H., "Process Management." 1986-ASQC Quality Congress Transaction,

25. Melan, Eugene H., "Process Management: A Unifying Framework for Improvement." National Productivity Reivew, Vol. 8, No.4, Autumn 1989

26. Melan, Eugene H., "Quality Improvement in an Engineering Laboratory." Quality Progress, June 1987

27. Moore, W. Savage, "Singing the same 'Total Quality' Song," National Defense, March 1990

28. Morrison, "Quality Quest," Government Executive, June 1988

29. Moser, Martin R., "Measuring Performance In R&D Settings." Research Management, September-October 1985

30. Pines, Ellis, "TQM: The First Three Years," A&DS, Sep/Oct 1990, p27-30

31. Rossier, Paul E., and D. Scott Sink, "What's Ahead for Productivity and Quality Improvement," Aerospace and Defense, March 1990, p.25-31

32. Saunders, David, "Measuring Customer Satisfaction." 2nd National TQM Symposium, ARBOR Inc., November 1990

33. Schainblatt, Alfred H., "How Companies Measure the Productivity of Engineers and Scientists." Research Management, May 1982

34. Schrader, Lawrence J., "An Engineering Organization's Cost of Quality Program." Quality Progress, January 1986

35. Smith, Thomas W., "Managing Quality in Corporate Research Laboratories," 1990-Juran Institute Conference-Atlanta

36. Strickland, Jack C., "Key Ingredients to Total Quality Management," Defense, March/April 1989, p.17-21

37. Strickland, Jack C., "Total Quality Management," Army Research, Development and Acquisition Bulletin, March-April 1988

38. Stuelpnagel, Thomas R., "TQM." National Defense, November 1988

40. Thomas, Clarence, "Improving Federal Work Quality." The Bureaucrat, Summer 1986

41. Varian, Tom, "Beyond the TQM Mystique," Organizational Dynamics, Inc., Burlington, MA

42. Zimmerman III, Charles D., and John W. Enell, "Service Industries," Quality Control Handbook

43. Army Field Manual, System Engineering, FM 770-78, April 1979

44. "AT&T, Process Quality Management & Improvement Guidelines," AT&T Bell Laboratories, 1989

45. "Basic Proposal Factors and Subfactors To Be Evaluated," Briefing from the Communications and Electronics Command, Second National Total Quality Management Symposium and Exhibits, December 14-16, 1991

46. "Desktop Guide for Continuous Quality Improvement." Boeing Defense & Space Group, Military Airplanes Division, July 1990

47. "Defense: Budget Stretching in DoD's Backyard." Aviation Week & Space Technology, June 19, 1989

48. Executive Briefing, Organizational Dynamics Incorporated, Burlington, MA

49. Fact Sheet, Program Manger's Notebook, Defense Systems Management College, February 1989, No. 1.13, TQM

50. "From Top Secret to Top Priority: The Story of TQM," Aviation Week and Space Technology, May 21, 1990, p s5-s50

51. "Impediments in Implementing TQM in the Service Industry." Second National Total Quality Management Symposium and Exhibits, December 14-16, 1991

52. MEASURING WHITE COLLAR WORK, American Productivity and Quality Center, Houston, TX, August 1988

53. QUALITY EDUCATION SYSTEM FOR THE INDIVIDUAL, Phillip Crosby Associates, Inc., Winter Park, Florida, 1988

54. SYSTEM ENGINEERING, Army Field Manual, FM 770-78

55. SYSTEM ENGINEERING MANAGEMENT GUIDE, Defense Systems Management College, December 1986, 1990

56. TELEDYNE BROWN ENGINEERING, QUALITY, STRATEGY AND PLANNING REPORT, Organizational Dynamics Inc. May 8, 1990

57. THE ECONOMIC ANALYSIS OF INDUSTRIAL PROJECTS, Lynn E. Bussey, Prentice Hall, Inc., Englewood Cliffs, NJ 07632, 1978

58. "The How To's of Productivity Measurements," Xerox Corporation

59. "The Request For Proposal Process, Identifying customer Requirements," Management Track of the Second National Total Quality Management and Exhibits, December 14-16, 1991

60. The Role of Statistics In Quality Management

61. TOTAL QUALITY IMPROVEMENT, A RESOURCE GUIDE TO MANAGEMENT INVOLVEMENT, Boeing Aerospace Company, 1988

62. Total Quality Management Education and Training Strategy for the Acquisition Work Force, Department of Defense, January 1989

63. TOTAL QUALITY MANAGEMENT MASTER PLAN, Department of Defense, August 1988

64. TQM, A GUIDE FOR IMPLEMENTATION (DRAFT), DoD 5000.51-G, Mar 23, 1989

# APPENDIX A

## A Summary of Tools and Techniques of Total Quality Management

## THE TOOLS AND TECHNIQUES USED IN IMPLEMENTING TOTAL QUALITY MANAGEMENT

Implementing Total Quality Management is difficult for many organizations. In order to ease this difficult and painful implementation process, there are many generic tools and techniques currently available for planning and designing products and services. Tools and techniques have been developed specifically for the purpose of aiding the implementation of TQM. However, others are existing techniques with documented successes in accomplishing their objectives that have been adapted for the purposes of TQM. The disciplined and systematic use of these tools and techniques can be the basis for continuous improvement

Many of these techniques involve the use of teams or groups for generating ideas, setting priorities, analyzing problems, and assessing situations. The groups are ledby a "facilitator" who keeps the discussions in focus and moving toward accomplishing the objectives of the meeting. The facilitator position requires specific training far beyond the one or two day training to be given to the general employees at the start of the TQM implementation. Those chosen to be facilitators must be dynamic and be thoroughly trained in the methods and techniques of "facilitating" meetings and discussions.

Immediately following is a brief description of each including when and how each can and can be used.

## BENCHMARKING

**Description**

- Method of measuring against those of recognized leaders in a common market.
- Establishes priorities and targets.
- Used to evaluate present situation and to set goals for the future.

**Method**

1. Identify items to benchmark (the key characteristics directly related to customer requirements).
2. Determine who among direct competitors and/or non competitors, with similar operations thatmay be the best in their market (perhaps a quality award winner).
3. Collect data using contacts, surveys, journals, etc.
4. Place in order from best to worst, place your organization within the list.
5. Evaluate.
6. Set improvement goals, where difficiencies exist in your product
7. Object is to be able to be on the top of the list after TQM implementation.

## BLOCK DIAGRAMS

**Description**

- Shows the flow of tasks in the process of developing a product or a service.
- Blocks showing actions and lines with arrows showing flow.
- Usec to develop an understanding of current process
- Usec to show where boundaries and interfaces exist.

**Method**

1. Use results of Input/Output Analysis.
2. Place each task in a box, show inputs going into the box and the output that results from that task.
3. Show where the input came from - was it an output of a different task within the group/another department or did it come from another organization?
4. Continue until all tasks have been connected, accounting for all inputs and outputs.
5. Place the name of the individual or group performing the task in each task box.
6. Evaluate and correct as necessary until the process under analysis has been completely reflected in the diagram.

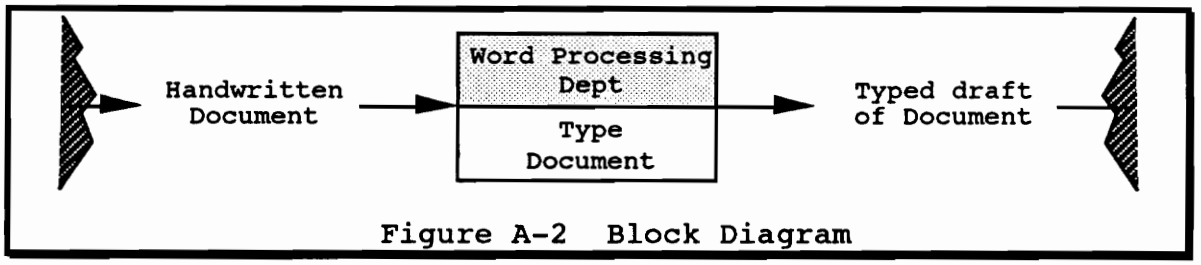



Figure A-2 Block Diagram

## BRAINSTORMING

**Description**

- an idea generating technique consisting of three phases generation, clarification, and evaluation.
- To collect improvement opportunities for problem identification.
- To establish goals and objectives.
- To identify inputs, outputs, tasks, causes and potential solutions.
- To produce a number of ideas in a short period of time.
- Provides for full participation from all in group.
- Documents knowledge or ideas from all
- Allows for discussion of ideas

**Method**

1. Clearly state topic or problem. Ensure all have a common understanding.
2. Ask each member to present an idea one at a time. If a member has none at the time, he may pass and contribute one later should the idea of another trigger one.
3. Recorder documents topic and each suggestion for all to see.
4. Record each suggestion exactly as given. Make no judgements.
5. After ideas have been exhausted, clarify each idea recorded.
6. Select ideas worth investigating through a vote.

## CAUSE AND EFFECT ANALYSIS (FISHBONE DIAGRAM)

**Description**

- A graphic tool to analyze problems.
- Uses lines and symbols to represent relationships between a given problem and potential causes.
- Assists in reaching a common understanding of problems.
- Identifies existing knowledge of the problem as well as the unknowns.
- Used when a problem area has been identified and defined.
- Used to generate a list of potential solutions

**Method**

1. Name an effect experienced as a result of a problem. Place in box and draw an arrow leading to it (arrow represents direction of influence).
2. Decide major categories of causes.
3. Place in boxes and place parallel to the main arrow. Connect boxes to main arrow using diagonal lines.
4. Brainstorm for more detailed causes. Place these causes underneath each category.
5 Identify the possible root causes. Eliminate causes that do not apply.
6. Prioritize remaining causes.

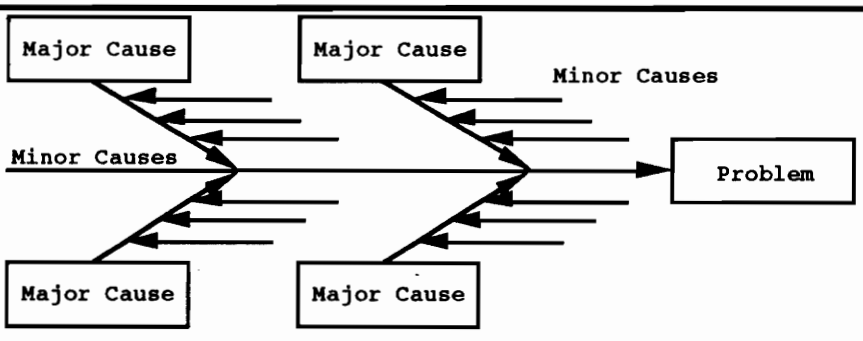



Figure A-3 Cause and Effect Diagram

## CONTROL CHARTS

**Description**

- Monitor ongoing performance of a process.
- Show departures from a standard, objective.
- Used to study process capability, to define quality objectives.
- Based on four concepts
  - All processes fluctuate with time
  - Individual points are unpredictable
  - A stable process fluctuate randomly (can be predicted)
  - An unstable process does not fluctuate randomly (cannot be predicted)
- Can be used to determine whether or not the processes are staying within limits.

Some examples are

1. Attributes Control Chart. Especially useful in analyzing white collar applications. The chart shows the presence or absence of a specific attribute.

2. Variables Control Chart. Statistical chart based on numerical measurements. The measurable quality is the variable.

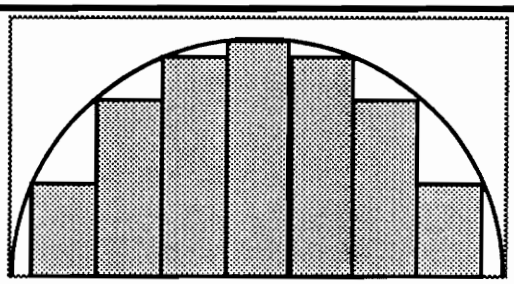
## HISTOGRAM

**Description**

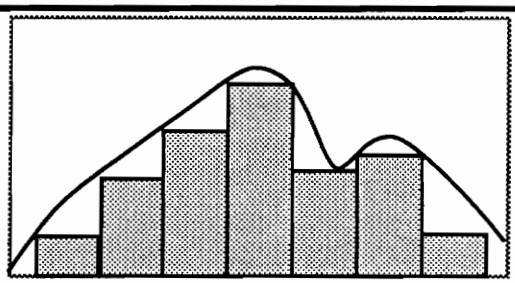
- Column graph used to show variability within a process
- Information represented by a series of equal-width columns of varying heights. Width - an interval within the range of observations. Height - the number of observations within a given interval.
- Quick method for assessing improvement effort in an area.
- Used for comparing actual and predicted data.
- Used when quick view of process variability is needed.
- Used prior to selecting process for improvement.

**Method**

1. Collect data using a check sheet predetermined for type of data required.
2. Count total number of data points.
3. Arrange data points in ascending order.
4. Determine range of data subtract smallest from largest
5. Determine number of columns in histogram.
6. Divide range by number of columns to determine width.
7. Put class interval scale on the horizontal axis.
8. Put frequency scale on vertical axis (number or percent of observations).
9. Draw the height of each column.



a. Shows Normal Distribution



b. Shows Skewed Distribution

Figure A-4 Histogram

## IMPACT/CHANGEABILITY

### Description

- Method of ranking a list of problems based on impact and resolution.
- Provides an objective method for reduction of problem lists.
- Prioritizes those problems with the greatest impact and those easiest to resolve.
- Used when prioritizing problems to be resolved.

### Method

1. State all potential projects as problem statements.
2. Rate each problem according to the three-point scale shown in Table A-1a.

| Impact | Changeability |
|---|---|
| (1) Little or no impact | (1) Difficult |
| (2) Some impact | (2) Moderate |
| (3) High impact | (3) Easy |

**Table A-1a Scale for Impact/Changeability**

3. Prioritize by information in Figure A-1b.

| Priority | Ranking (Impact, Changeability) |
|---|---|
| 1 | (3,3) |
| 2 | (3,2) |
| 3 | (2,3) |
| 4 | (2,2) |

**Table A-1b Scale for Prioritization**

4. Select areas for improvement through both the priority and ranking provided in Step 3 or through group consensus.

## INPUT/OUTPUT ANALYSIS

**Description**

- Systematic method for identifying interdependency problems by defining objectives and listing inputs and outputs for major tasks, functions, individuals.
- Used for defining process and task flow.
- Used to clarify roles and responsibilities and eliminate duplication.
- Used to gain a better understanding of the processes and the roles of others in that process.
- Used to open up the lines of communications between different groups and departments.

**Method**

1. Isolate a single product from all products and services provided to external customer.
2. For that product, list all internal outputs.
3. List the related task for each output and the inputs necessary for production.
4. Establish internal customers and suppliers for each output.
5. Define boundaries and interfaces.

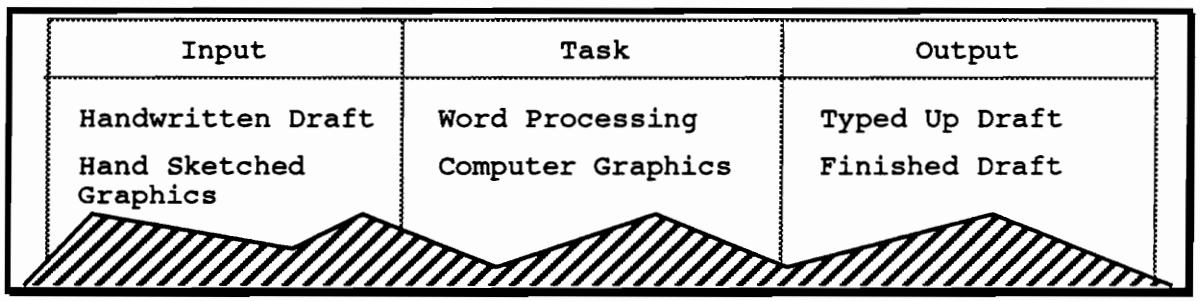



**Figure A-5 Steps 2 and 3 of Input/Output Analysis**

## NOMINAL GROUP TECHNIQUE

**Description**

- Structured group decision-making process
- Similar to brainstorming except ideas are written down prior to suggesting to all.
- Each idea stated in "round-robin" fashion.

**Method**

1. Clearly state topic or problem. Ensure all have a common understanding.
2. Recorder documents topic and each suggestion in full view of all.
3. Ask each member to write down ideas (Approximately 10 min).
4. Ask each member to present idea one at a time.
5. Record each suggestion exactly as given. Make no judgements.
5. After ideas have been exhausted, clarify each idea recorded - combine like ideas, eliminate duplications.
6. Have each team member silently review the list of ideas and select and write down their individual top 5 from the list.
7. Collect all list. Tabulate. Select top five most commonly chosen ideas to develop.
8. Develop an action plan

## PARETO DIAGRAM

**Description**

- Specialized column graph used to prioritize problems.
- Chart arranged in descending order - highest bar on left and others in decreasing order to the right.
- Each bar represents relative contribution of each problem or cause.
- Uses a cumulation line to show the cumulative contribution of causes.
- Priniciple - few causes typically account for most problems (80-20 rule - 80% of the problem is resulted from 20% of the causes).
- Focus on highest leverage items for immediate improvement.
- Used for
  - identifying problems or improvement opportunities
  - seeking main causes
  - prioritizing solutions.

**Method**

1. Select problem.
2. Collect data using a standard unit of measurement for each (frequency of occurrence - X amount of times over Y period of time, cost - $X in the past Y period of time, etc).
3. Compare cause relative to all other causes.
4. List causes on horizontal axis in order descending order.
5. Place frequency or cost on the vertical axis.
6. Plot data using blocks.
7. Draw cumulative line.

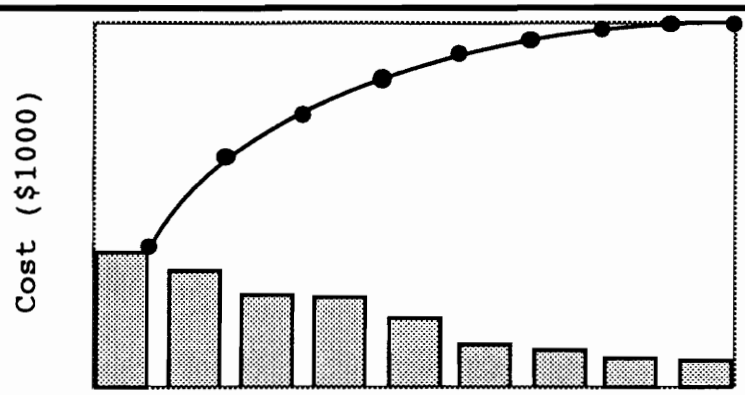



Figure A-6 Pareto Diagram

# APPENDIX B

## A Summary of DoD and Service Memorandums on Total Quality Management

## 1. DEPARTMENT OF DEFENSE

### a. Office of the Secretary of Defense

1. SECDEF memorandum, 30 March 1988
   Subject: Department of Defense Posture on Quality

   SUMMARY: DoD, its contractors, and their vendors should focus on quality as the means for achieving higher levels of performance. All acquisition managers should be trained to apply TQM. 12-point "DoD Posture on Quality" is established.

2. USD(A) memorandum, 19 August 1988
   Subject: Implementation of TQM in DoD Acquisition

   SUMMARY: TQM will be applied to the acquisition of defense systems. The Defense Acquisition Board will act as the DoD steering group for TQM implementation. Military and Defense agencies are directed to
   - Develop a plan for TQM implementation
   - nominate a SES Flag level TQM focal point

   Attachment 1 - definition of DoD TQM
   Attachment 2 - identifies preparatory TQM implementation activities, provides a bibliography

3. DoD document, August 1988,
   SUBJECT: Total Quality Management Master Plan

   SUMMARY: Presents TQM concepts for DoD activities. Describes methodology for implementing TQM. Plan establishes goals and announces planned actions and milestones to implement TQM in DoD.

4. USD(A) memorandum, 12 January 1989
SUBJECT: TQM in Acquisition and the Transition from Development to Production

SUMMARY: Announces a change to DoD 4245.7-M, Transition from Development to Production, to guide both the military and private sectors of the defense community in the adoption and use of TQM principles. Identifies new and proven TQM techniques. New TQM critical path template places TQM at the top of the template network rather than under "Management." In the event of a conflict, TQM template takes precedence.

5. DoD document, January 1989
SUBJECT: TQM Education and Training Strategy for the DoD Acquisition Work Force.

SUMMARY: Provides broad guidelines for planning and coordinating a TQM education and training program. Describes

- educational requirements for TQM awareness
- Program goals, guidelines, and resources available.

Long-, mid-, and short-range goals identified

6. USD(A) memorandum, 9 March 1989
SUBJECT: Concurrent Engineering - A TQM Process.

SUMMARY: Identifies examples of concurrent engineering contribution to meeting objectives of TQM. Enclosure provides guidance for use of Concurrent Engineering in four areas.

7. OSD memorandum, 1 May 1989
SUBJECT: Improving the Acquisition Process - Buying Best Quality

SUMMARY: DoD must seek continuously measures to increase productivity to live within budget. TQM and "Best Value" contracting are key elements for increased productivity. Contractors who provide "Best Value" by consistently delivering on time while improving quality should be rewarded. DoD will continue to use competition to bring about an environment that encourages the pursuit of TQM.

8. DoD Directive 5000.51 (Draft)
SUBJECT: TQM

SUMMARY: Established DoD policy for TQM and assigns responsibilities for TQM implementation in DoD. Defense Council on Integrity and Management Improvement is responsible for implementing TQM. USD(A) is the office of primary responsibility for development of TQM policies and procedures.

9. DoD 5000.51-G (Draft), 23 March 1989
SUBJECT: TQM - A Guide For Implementation

SUMMARY: Supports DoD 5000.51. Presents TQM strategy with fundamental concepts. Presents a seven-step model for continuous process improvement including tools and techniques

**b. Defense Communications Agency**

1. DCA memorandum for USD(A), 23 November 1988
   SUBJECT: Implementation of TQM in DoD Acquisition

   SUMMARY: Provides as an enclosure DCA TQM Implementation Plan in response to USD(A) memorandum 19 August 1988, same subject. The plan integrates TQM throughout the DCA acquisition process and makes it an integral part of strategic planning philosophy for DCA.

**c. Defense Contract Audit Agency**

1. DCA memorandum for USD(A), 3 November 1988
   SUBJECT: Implementation of TQM in DoD Acquisition

   SUMMARY: In response to USD(A) memorandum 19 August 1988, same subject. DCA supports initiative but relies on cross-servicing arrangement for acquisition of equipment and supplies and therefore not participate in the acquisition aspects of TQM. However, are reviewing areas that TQM can be a benefit.

**d. Defense Intelligence Agency**

1. DIA memorandum for USD(A), 28 November 1988
   SUBJECT: Implementation of TQM in DoD Acquisition

   SUMMARY: In response to USD(A) memorandum 19 August 1988, same subject, provides DIA TQM Implementation Plan(Draft).

**e. Defense Investigative Service**

1. DIS memorandum for USD(A), 4 November 1988

SUBJECT: Implementation of TQM in DoD Acquisition

SUMMARY: In response to USD(A) memorandum 19 August 1988, same subject. Although DIS does not perform major acquisition of systems will implement TQM in acquisition of equipment, supplies, facilities and services. Plan for TQM in Acquisition is attached with schedule of implementation actions.

**f. Defense Logistics Agency**

**g. Defense Mapping Agency**

1. DMA memorandum for USD(A), 9 November 1988
   SUBJECT: Implementation of TQM in DoD Acquisition

   SUMMARY: In response to USD(A) memorandum 19 August 1988, same subject. A productivity improvement program and acquisition streamlining exists at DMA. A DMA TQM Implementation Plan attached.

**h. Defense Nuclear Agency**

1. DNA memorandum for USD(A), 3 November 1988
   SUBJECT: DNA TQM Implementation Plan

   SUMMARY: In response to USD(A) memorandum 19 August 1988, same subject. DNA enclosed their plan establishing short-, mid-, and long-range goals.

## 2. DEPARTMENT OF THE ARMY

### a. Office of the Secretary of the Army

1. Memorandum, 14 September 1988
   SUBJECT: Army TQM Program

   SUMMARY: Distributes USD(A) memorandum 19 August 1988, Subject: Implementation of TQM in DoD Acquisition to all Army Staff elements. While oriented principally to the acquisition community, TQM principles apply equally to all other Army communities i.e. engineering, logistics. All are requested to incorporate these principles in their every day business and as part of all Army programs.

2. USA memorandum, 2 November 1988
   SUMMARY: Army Implementation Plan for TQM

   SUBJECT: Forwards the Army TQM Implementation Plan for use throughout the acquisition community. Describes strategy for implementation, prescribes tasks and establishes task element milestones.
   - Annex A - DA posture on TQM
   - Annex B - Description of current initiatives directly related to TQM

3. ASA memorandum for Program Executive Officers, 4 November 1988
   SUMMARY: TQM Implementation Plan

   SUBJECT: Encloses the TQM Implementation Plan and requests widest distribution. Recognizes that the relationship between the TQM management structure and the PEOs is not clearly defined. However, keep all

PEOs and program offices be kept informed on proposed TQM activities.

**b. Army Material Command**

## 3. DEPARTMENT OF THE AIR FORCE

### a. Office of the Secretary of the Air Force

1. HQAF memorandum for ALMAJCOM-SOA/CC, 26 May 1988
SUBJECT: DoD Posture on Quality - INFORMATION MEMORANDUM

SUMMARY: Attaches SECDEF memorandum, 30 March 1988, same subject. Support and involvement of Commanders at all levels essential. Required to support in full and circulate the SECDEF memorandum throughout command.

2. OASAF memorandum, 29 November 1988
SUBJECT: AF Acquisition Policy on Implementation of TQM - ACTION MEMORANDUM (ACQUISITION POLICY 88M-004), addressed to AFCC, AFLC, AFSC

SUMMARY: TQM is a management process directed at establishing organized process improvement activities in a totally integrated effort directed toward improving performance at every level. Objectives listed to ensure TQM becomes an integral part of the AF acquisition process.

2. OASAF memorandum, 29 November 1988
SUBJECT: Implementation Plan for TQM in AF Acquisition - INFORMATION MEMORANDUM.

SUMMARY: AF strongly supports the DoD mandate for implementation of TQM throughout DoD acquisition. An AF Executive Council on Acquisition TQM chartered to

provide a senior Intra-AF coordinating and advisory body.

- Attachment 1 - charter for F Executive Council on Acquisition TQM
- Attachment 2 - new AF Acquisition Policy 88M-004 on TQM
- Attachment 3 - AF Policy Letter #6: R&M Variability Reduction.

**b. Air Force Logistics Command**

1. Hq AFLC/QP TQM Training Development Plan, 10 March 1989

SUMMARY: Provides guidelines for planning and development of TQM training program for the AFLC.

## 4. DEPARTMENT OF THE NAVY

### a. Office of the Secretary of the Navy

1. USN Memorandum for USD(A), 4 November 1988
   SUBJECT: DEPARTMENT OF THE NAVY TQM IMPLEMENTATION PLAN

   SUMMARY: Response to USD(A) memorandum, 19 August 1988, Subject: Implementation of TQM in DoD Acquisition. TQM philosophy incorporated into the Navy's Productivity Plan and Guiding Principles in 1987. Many have already initiated TQM.
   - Appendix A - background information
   - Appendix B - improvement program strategies
   - Appendix C - goals and suggested action items for TQM transition
   - Appendix D - details of TQM organizational structure

2. USN Memorandum, 8 November 1988
   SUBJECT: TQM, distributed to top level Navy Staff elements

   SUMMARY: Memorandum implements SECDEF memorandum, 30 March 1988, Subject: DoD Posture on Quality which is an enclosure. DON is implementing TQM. A DON TQM Executive-Level Steering Group is being chartered.