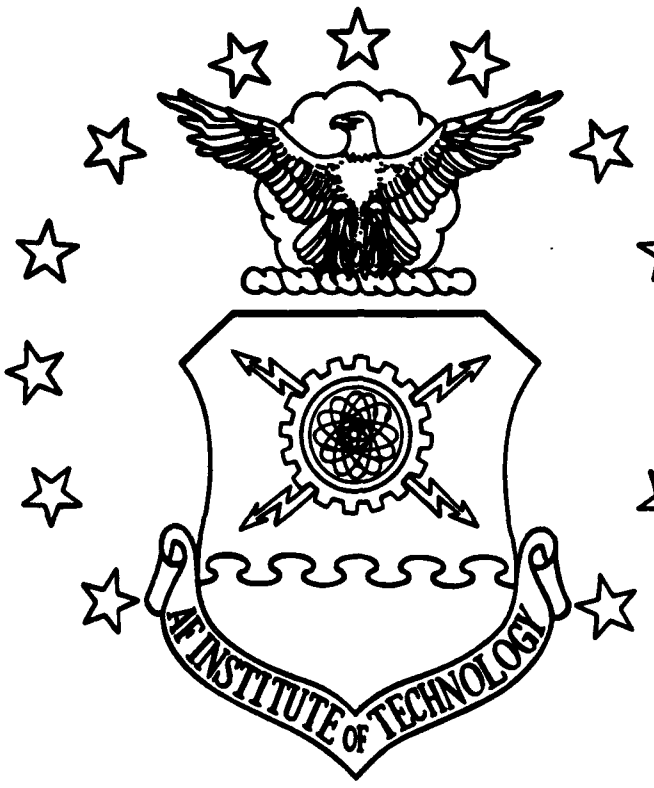

AN ANALYSIS OF TOTAL QUALITY MANAGEMENT IN AERONAUTICAL SYSTEMS DIVISION

THESIS

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AFIT/GSM/LSG/91S-6

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THESIS

Presented to the Faculty of the School of Systems and Logistics of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Systems Management

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Preface

This study grew out of my sincere desire to really learn, not just become familiar with, Total Quality Management. I had heard the names Deming, Juran, Ishikawa, Shewart; but I didn't fully understand this philosophy of continual improvement that had totally turned a nation around. I still don't fully understand everything about this subject. It is rich, certainly more complex than the slogans so often attached to it: "Do it right the first time," "Zero defects," and others. More importantly, I am more convinced than ever that it is **powerful**, but to experience the true power will require discarding a lot of conventional notions about what is correct and essential in our organizations and in our relationships with others. To this end, the Aeronautical Systems Division has made a start, but only a start. Much remains to be done if we are truly to be committed to continual improvement.

I am indebted to Lt Col John W. Shishoff, my thesis advisor who was most patient and supportive as I struggled to complete this work. I am also indebted to my wife, Deanie, and my little girls for reminding me what is truly important. Most of all, I acknowledge my Lord and Savior, Jesus Christ, without whom none of my accomplishments, great or small, would ever be.

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Abstract

This study investigated the major schools of thought on various aspects of quality management and quality improvement. Areas covered included definitions of waste and quality, views on the cost of quality, tools and techniques used for quality improvement, and management philosophies and frameworks for continuous improvement. In addition, this study analyzed the structure and training content of the current Total Quality Management program at Aeronautical Systems Division (ASD). Pre- and post-test surveys on employee attitudes toward organizational effective were analyzed from the Advanced Cruise Missile System Program Office (SPO), the F-15 SPO, and the ASD Deputy Chief of Staff for Human Resources (ASD/DP). Data was supplemented with semi-structured, personal interviews with ASD personnel involved in TQM. Survey analysis showed that the ACM SPO significantly improved, ASD/DP significantly digressed, and the F-15 SPO remained basically consistent. This led to the conclusion that ASD allows too much flexibility in the implementation of TQM in the three-letter organizations. This conclusion was supported by the personal interviews, which revealed a disparity in the amount of commitment to

TQM between organizations and a basic lack of support for emphasizing quality over deadlines and suspenses.

AN ANALYSIS OF TOTAL QUALITY MANAGEMENT IN AERONAUTICAL SYSTEMS DIVISION

I. Introduction

Background

> With the storehouse of skills and knowledge contained in its millions of unemployed, and with the even more appalling underuse, misuse, and abuse of skills and knowledge in the army of employed people in all ranks in all industries, the United States may be today the most underdeveloped nation in the world. (Deming, 1986:6)

With this statement, Dr. W. Edwards Deming focuses attention on what he believes to be the incredible waste throughout American industry, including manufacturing, service, and government service (Deming, 1986:xi). Deming places the blame for this waste, this lack of productivity, squarely in the hands of top management. According to Deming, only the transformation of American management will fix the problem (Deming, 1986:ix).

Those familiar with quality management techniques in use today will recognize that most are specifically designed to combat various types of waste. Concern over waste has existed for a long time; in the 1920s, Henry Ford dealt specifically with waste in his book Today and Tomorrow, "...which Toyota people diligently studied later" (Suzaki,

1987:10). However, many quality management principles trace their genesis to World War II.

World War II is generally regarded as being an extremely productive time in the United States, at least in the industries directly supporting the war effort. Certainly tremendous amounts of aircraft, tanks, rifles, ammunition, and other materials were produced in short amounts of time. However, in World War II, "sixty percent of aircraft destined for the Far East proved unserviceable; fifty percent of electronic devices failed while still in storage, the service life of electronic devices used in bombers was a mere twenty hours, and seventy percent of naval electronic devices failed" (Gill, 1991:8). Obviously, Americans had problems with poor quality and waste.

Still, American industry thrived after the war. With basically the only industrial complex untouched by the ravages of war, American corporations found a world market that would buy whatever goods they could produce, a market of "unparalleled demand and no competition" (Walton, 1986:8). Large production lots, combined with this type of market and profits, lead to little concern for waste and quality. With enough good parts to keep workers busy and plenty of profits to cover the scrap and rework of defective parts, companies were not too concerned with waste (Schonberger, 1982:2).

This prosperous era, combined with "abundant space, energy, and material resources" of Western countries, particularly the United States, led to the evolution of a throw-away society (Schonberger, 1982:4).

> As Western consumers became more accustomed to annual style changes and "planned obsolescence," a "throw-away society" replaced earlier generations of careful quality-conscious buyers. The industrial engine ran on the talents of designers, packagers, and advertisers. Turning out new goods quickly and keeping well-stocked shelves of finished goods and components became a path toward profitability. Waste in the form of defective parts, or shelves full of "passable" ones, was not a dominant concern. (Schonberger, 1982:4)

For Japanese industry and the people of Japan, post-war conditions were grim. All major cities, with the exception of Kyoto, had received enormous aerial bombardment damage, and 668,000 civilians had died. The industrial base was destroyed. Then in 1947, the Supreme Command for the Allied Powers, headed by General Douglas MacArthur, invited Dr. W. Edwards Deming to "help prepare for the 1951 Japanese census" (Walton, 1986:10). Deming had earlier worked in designing sampling techniques for the 1940 United States census (Walton, 1986:7).

During that first visit to Japan, Deming became as familiar as possible with Japanese culture and many of their people. Later in 1950, the Union of Japanese Scientists and

Engineers (JUSE[1]), with Managing Director, Kenichi Koyanagi, invited Deming to teach Japanese researchers, plant managers, and engineers quality control methods. JUSE members had studied and were taken with the statistical quality control techniques of Walter A. Shewhart from Bell Telephone Laboratories. Dr.Deming had worked with Shewhart earlier, and some of JUSE's members knew Deming from his earlier trip to Japan. Deming agreed, and on June 16, 1950, he arrived in Tokyo to begin. Teaching them the importance of the consumer and how to constantly improve quality to make "Made in Japan" a symbol of quality rather than inferior goods, Deming predicted they could capture world markets in five years. "Within four years, buyers all over the world were screaming for Japanese products" (Walton, 1986:14). So appreciative were the Japanese, they established the Deming Prize in 1951, an award recognizing individual and company accomplishments in statistical theory and applications and contributions to quality. The award is still given today (Walton, 1986:6,10-15; Schonberger and Knod, 1991:142).

In the United States, however, Deming's work went largely unnoticed. He was known more for his accomplishments as a statistician than for his work in Japan (Walton,

[1] The group that became JUSE after the war was initially formed to support the war effort, and was later "held...together after the War with a new aim, the reconstruction of Japan" (Deming, 1986:487).

1986:12). Besides, as mentioned above, the post- war productivity of American industry led most companies to be relatively unconcerned about quality improvement. At least two events helped shake Western industry, American industry in particular, out of its complacency and put it on the road to quality improvement.

First was "the raw material shortages beginning about 1971" coupled with "the OPEC-induced oil shock of 1973" (Schonberger, 1982:4). The industrial world was forced to consider ways to lower costs by reducing the amount of critical materials used, including eliminating wasteful practices. The Japanese, who should have been hurt most by such circumstances, since most of their energy and raw materials are imported, used the techniques they had learned to "gain economic ground rather than [lose] it" (Schonberger, 1982:5). Western industries, on the other hand, urged economic and political solutions (Schonberger, 1982:5-6). Western industries had ignored the tools they needed to adequately respond, tools the Japanese had learned well (Schonberger, 1982:5-6).

Secondly, Deming was "'discovered' in America" (Walton, 1986:17). On June 24, 1980, the National Broadcasting Corporation (NBC) broadcast "If Japan Can...Why Can't We?", and the final fifteen minutes of the broadcast was devoted to Deming's work at Nashua Corporation, a company in Nashua, New Hampshire. During the broadcast, Dr.Deming chastised

American management, saying that the only reason that American companies had not enjoyed the same success as Japanese companies was lack of a goal, knowledge, and determination (Walton, 1986:18-19).

Quality Management in the Department of Defense and the Air Force

Ways of ensuring quality products that meet users' needs and are produced in as economical a manner as possible has never been more important to DoD and the Air Force. The United States has long pursued a policy of producing smaller quantities of higher quality weapons, recognizing that the peacetime economy and the American public would not support budgets necessary to build enormous stockpiles of weapons. In addition, the increasing destructive power of weapon systems means that one fighter today can deliver more ordnance over greater distances than entire squadrons of aircraft in World War II. However, when producing small quantities of weapon systems, it is vital that they be high quality, reliable systems.

Additionally, due to today's budget constraints and the on-going, significant reductions in Air Force manpower levels, doing more with less is no longer just a cliché. It is imperative that the Air Force not respond to its resource shortages the way industry responded in the 1970s. The Air Force must not look to external remedies, but must rather work, within itself and with its defense contractors, to

further eliminate waste and improve quality to meet the aerospace defense needs of the United States. The American public deserves and expects no less.

Since 1980, quality management and quality improvement techniques have been studied world-wide, and that interest has extended to the Department of Defense (DoD) and the Air Force. "In February 1986 . . . Presidential Executive Order 12552 (revised April 1988, Executive order 12637) was signed with the aim of making government agencies significantly more productive by 1992" (Springs, 1989:1). In 1988, a DoD Total Quality Management (TQM) Master Plan was established (Springs, 1989:29).

Since new and innovative ways of producing high quality weapon systems with fewer resources are vital to an effective national defense, the Air Force acquisition community has begun to implement TQM. TQM is a management philosophy that involves everyone, from the highest levels to the lower-level workers, in a process of continuous quality improvement (Oliver, 1990). In 1988, Aeronautical Systems Division (ASD), the largest product division within Air Force Systems Command[1], contracted with The Cumberland Group to train its personnel in Total Quality Management (TQM) principles and techniques. The process of continuing

[1] Air Force Systems Command is the major command responsible for the acquisition of the Air Force's weapon systems. It will merge with Air Force Logistics Command in 1992 to form Air Force Materiel Command.

training and implementation of TQM continues today (Ball, 1991).

Difficulties in Implementing TQM

However, champions of quality improvement techniques do not universally agree on how organizations should go about improving quality (Gurus of TQM, 1990). In fact, many theorists and management consultants with various approaches to TQM have jumped into the fray, most referring to Deming, Juran, or Crosby. The number of opinions and their typically general nature lead many to state that TQM is merely doing things smart; it's all common sense. Yet experience has shown that certain "common-sense" techniques may work well in one organization and fail in another.

Others question the overall, long-term effectiveness of TQM techniques within the Air Force bureaucracy. For example, despite the Air Force's emphasis on TQM, many defense contractors believe the emphasis is more on talk than action. They charge that cost is often still the prime consideration in awarding contracts (Aerospace, 1990: 70). Other critics point to the old way of doing business that is still seen today. To illustrate, they assert that many DOD contracts not only emphasize cost, but also "sometimes arbitrary program schedules" (Smith, 1989: 60). Another concern includes the disparity between TQM's philosophy of long-term relationships with suppliers and commitment to

long term improvements, and the Air Force's inability to award multi-year contracts and the requirements to have full and open competition for most new efforts. In addition, contracts that tell contractors how to accomplish contract requirements are perceived as continuing problems (Smith, 1989:59-60).

Problem Statement

There is a large body of literature concerning TQM philosophies and techniques, accompanied by differing opinions on the nature of the change TQM appears to be making in Air Force acquisition practices. Because these efforts are extremely important to the Air Force, this study will conduct a comprehensive review of the literature on quality management. Then, this study will examine ASD's TQM program in light of the literature and attempt to discover which TQM techniques ASD has embraced and assess the effectiveness of ASD's quality improvement efforts.

Research Objectives

The following research objectives will guide this study effort.

1. Explore the various perspectives on quality management to understand their similarities and differences.

2. Understand the basic tenets and the implementation of ASD's TQM program.

3. Discover and document areas where ASD's TQM program has succeeded, and areas where ASD's TQM program has failed to produce substantive improvement or has done harm.

4. Determine if there are current practices and/or organizational factors at ASD that significantly hinder the long-term effectiveness of TQM.

Research Questions

The following investigative questions were used to accomplish the objectives of the study:

1. Who are the primary people involved in the development of quality improvement philosophy and techniques?

2. How do the main approaches to TQM differ, and in what ways are they similar?

3. In what areas have ASD organizations shown significant improvement since implementing TQM? What factors contributed to that success?

4. In what areas have ASD organizations shown little or no improvement (or digressed) since implementing TQM? What factors contributed to that failure?

5. Are there current barriers (organizational, legal, procedural, etc.) to the long-term effectiveness of TQM in ASD organizations?

Scope and Limitations

This research will primarily be limited to an assessment of the primary theories and approaches to TQM. The study of Air Force development and application of TQM techniques is focused on the weapon systems acquisition environment at Aeronautical Systems Division (ASD) at Wright-Patterson Air Force Base, Ohio. While one might expect findings to be applicable to other Air Force procurement divisions, the applicability to different Air Force organizations and other DOD agencies may be severely limited.

In addition, the assessment of TQM effectiveness at ASD is limited to an empirical analysis of survey data from three representative organizations within ASD. No information on the validation of the survey instruments was found, though The Cumberland Group survey has been administered nationwide and has a database of approximately 35,000 respondents. Standardized metrics and data collection across organizations within ASD does not exist at this time.

II. Methodology

The purpose of this chapter is to describe the various research strategy alternatives and the situations or research questions each strategy can best address. Then the rationale for the method selected to answer each research objective is explained, along with a description of exactly what was done to conduct the research.

Research Purposes

Emory describes several broad types of research. At a very basic level is reporting, research that is simply designed to collect and report some data and/or statistics. Next is an exploratory study, where the researcher knows too little about the subject matter to propose hypotheses. This study is aimed, therefore, in accumulating knowledge about the subject matter. Another type of research is the descriptive study. Here the researcher tries to "make a profile of a group of problems, persons, or events . . . [by answering] the who, what, when, where, how questions rather than the why questions" (Emory, 1985:8-9). Next is a follow-on to the descriptive study that adds the step of prediction. Finally, the explanatory study attempts to explain the causes of the phenomenon under observation. Thus in describing these research types, Emory develops three basic

purposes of research: exploration, description, and explanation (Emory, 1985:8-10).

Research Strategies

Yin describes five research strategies that can be used. The proper selection of a research strategy is based on three variables: the form of the research question, the extent of control the researcher has over the behavioral events being studied, and the degree of focus on contemporary events versus historical events. Table 2-1 summarizes the conditions relevant to each research strategy (Yin, 1984:16-17).

Yin believes that the "most important condition for differentiating among the various research strategies is to identify the type of research question being asked" (Yin, 1984:19). To elaborate, he points out that many "what" questions are exploratory and can be addressed by all five strategies. However, more definitive "what" questions, like "how much" or "how many" are best addressed by survey or archival analysis. "How" and "why" questions are explanatory in nature and appropriately addressed by case studies, histories, and experiments. Once the type of research question is determined, the other factors (control over behavioral events and contemporary focus) can be used to narrow the strategy selection. Finally, Yin states that the strategies are not mutually exclusive, and more than one

Table 2-1

Relevant Situations for Different Research Strategies (Yin, 1984:17)

Strategy	*Form of Research Question*	*Requires Control Over Behavioral Events?*	*Focuses on Contemporary Events?*
Experiment	how, why	yes	yes
Survey	who, what,* where, how many, how much	no	yes
Archival analysis	who, what,* where, how many, how much	no	yes/no
History	how, why	no	no
Case study	how, why	no	yes

*"What" questions, when asked as part of an exploratory study, pertain to all five strategies.

strategy can be used in a research study (Yin, 1984:17-20).

Selecting Research Strategies for Each Research Objective

With this information, we now examine each research objective, the research strategy alternatives for addressing each objective, and the rationale for the research strategy or strategies selected. Finally, for each objective, exactly how the research was conducted is described.

Objective 1: Explore the Various Perspectives on Quality Management to Understand Their Similarities and Differences.

Selection of Research Strategy. This objective is exploratory in nature and intended to focus on the perspectives of established authorities in quality management. As such, it seeks to answer who these authorities are, what are their perspectives, how are their perspectives similar, and how are their perspectives different? The obvious choice is an archival analysis, since this strategy involves examining the documents and other written products a subject produces (Yin, 1984:18). As a type of archival analysis, a literature review is a natural choice, since all major authorities on this subject have published works. In addition, Emory states than an "obvious first step in an exploratory study is to do a literature search. It is inefficient to discover anew . . . what has been done by others already." (Emory, 1985:62).

How the Research Was Done. Therefore, this objective was accomplished via a comprehensive review of the literature. The review explored the writings of Deming, Juran, Crosby, Garvin, Ishikawa, Goldratt, and others. Various definitions of quality were explored, along with theories concerning the cost of quality. In addition, important tools and techniques of quality management were

studied. Finally, management philosophies or frameworks for quality improvement were examined.

Objective 2: Understand the Basic Tenets and the Implementation of ASD's Total Quality Management (TQM) Program.

Selection of Research Strategy. This objective is concerned with questions of who and what: of what does ASD's TQM program consist, and who are the main participants? According to Table 2-1, a survey or archival analysis would be appropriate. However, a survey's focus is on contemporary events, although it is possible to survey people concerning past events. Since ASD's TQM program was being developed in 1987 and 1988, and many key participants in those early stages were difficult to locate or identify, an archival analysis of existing documentation was chosen as the best method of accomplishing this objective. At the same time, it was understood that certain details about the beginning of ASD's TQM program would not be documented. Therefore, the value of personal interviews with individuals aware of that history was recognized. Personal interviews were the logical choice for obtaining this information. A semi-structured approach to the interviews was taken, since the interviews would only be used to fill in gaps in archival information, gaps that were unknown at the beginning of the study.

How the Research was Done. This objective was accomplished by reviewing documentation of the ASD TQM program, including training materials, supplied by the ASD Total Quality Management Office (ASD/TQ). This documentation provided a written record and description of ASD's TQM program, the objectives it was designed to meet, and the specific content of ASD's training program. Semi-structured personal interviews with personnel from ASD/TQ were used to fill in gaps in archival documentation.

Objective 3: Discover and Document Areas Where ASD's TQM Program Has Succeeded, and Areas Where ASD's TQM Program Has Failed to Produce Substantive Improvement or Has Done Harm.

Selection of Research Strategy. This objective focused on questions of what and how much: what areas have experienced change as a result of ASD's TQM program and how much change has been experienced? Again referring to Table 2-1, appropriate strategies include survey and archival analysis. A survey instrument or personal interviews could be used to address this objective, but the clear focus is on change. This recommends a pre-test, post-test design if a survey instrument is used, and the time allowed for this study precluded a meaningful test of this kind. Personal interviews could be done to discover individuals' opinions of where ASD's TQM program has helped improve organizational and individual performance. Finally, archi-

val analysis of existing documentation or measurements could be located and analyzed to answer this objective. Since part of ASD's TQM program was the use of periodic survey instruments to help gauge organizational development in TQM, archival analysis of these surveys was chosen as the primary research method. At the same time, semi-structured personal interviews of a small sample of ASD personnel was also chosen to augment the archival analysis, since all organizational effects of change are difficult to capture with a survey.

How the Research was Done. This objective was accomplished by examining results of surveys conducted within ASD prior to and during TQM implementation. Typically, before an organization within ASD begins TQM training, an initial survey is given to a representative sample of the organization's personnel to gauge initial attitudes about various factors in the organization. Then during the TQM training and implementation, some organizations periodically survey again to determine changes as a result of the TQM program.

After a thorough search through ASD/TQ's organizational files and after contacting several ASD organizations, it became apparent that many organizations did not keep survey data or decided to stop surveying during implementation of TQM. Time limitations and the apparent scarcity of data led to the selection of three ASD organizations to be reviewed.

The organizations included ASD/DP, a staff organization; the F-15 SPO, a tactical aircraft System Program Office (SPO); and the Advanced Cruise Missile (ACM) SPO, a Special Access Required, strategic nuclear cruise missile program. These organizations were selected for the following reasons. First, all three had pre-test, post-test surveys. DP and ACM had been surveyed in 1989 and 1991, and F-15 had been surveyed in 1990 and 1991. Second, the two primary types of surveys were represented in these organizations. DP and ACM used a survey instrument created by The Cumberland Group. The same survey was given to a cross-section of all of ASD at the beginning of ASD's TQM program, making it possible to compare DP's and ACM's initial survey responses with ASD-wide responses. This would help establish how representative DP and ACM were of ASD as a whole. F-15 used a survey created within the F-15 SPO, a practice becoming more common within ASD. Third, these three organizations represent three main divisions of organizations in ASD. DP is a staff, support organization. F-15 is a major acquisition program. ACM is a major acquisition program from the classified, black/gray environment. Personnel must be briefed on the program before they can work in the organization and have access to certain information.

Appendices A and B contain the text of the two surveys, as well as the category of each question. The Cumberland Group assigns their questions to one of eleven categories,

as listed in Table 2-2. Most of the categories are self-explanatory, and a careful reading of the questions in the appendices will help reveal the category meanings. For the F-15 SPO survey, the author used his own judgement to assign each of the F-15 questions to one of The Cumberland Group's question categories. This facilitated analysis of broad trends and changes across organizational lines by analyzing the degree of change by question category.

Table 2-2

The Cumberland Group Question Categories

PLANNING
REVIEW
ACCOUNTABILITY
REWARDS
COMMUNICATIONS
PARTICIPATIVE INVOLVEMENT
CUSTOMER FOCUS
ALIGNMENT
READINESS FOR CHANGE
OTHER
SURVEY REACTIONS

Results within the organizations over time were studied, as well as the overall positions of the organizations relative to an initial, ASD-wide survey. The analysis of the survey data concentrated on broad trends rather than detailed statistical analysis, since the only data widely available were mean responses from ordinal-level scales. Particular emphasis was placed on areas where there had been significant improvement and the areas where there had been little or no improvement.

The survey analysis began by plotting ACM and DP mean responses by question against each other and the ASD baseline survey. This provided a rough idea of how typical ACM and DP are in relation to other ASD organizations, as well as their relationship to each other.

Second, the change for each question for each organization was calculated and plotted by organization. For the plot, the data was sorted from least improvement (or greatest decline, or negative change) to most improvement. For ACM and DP, any changes at or equal to plus or minus 0.25 were considered significant (The Cumberland Group's significance criteria). For the F-15 SPO, changed questions falling at or below the tenth percentile and changed questions falling at or above the ninetieth percentile were considered to have changed significantly (see the discussion of this criterion in Chapter IV). Lines were drawn on the

various plots to easily show where there was significant change.

Third, those questions that increased or decreased significantly were grouped by question category to look for trends of improvement or decline. This analysis helped pinpoint areas that changed significantly across organizational lines.

Finally, survey data and analysis was supplemented through interviews. While gathering information on ASD's TQM structure, TQM training program, and TQM survey data, semi-structured interviews were conducted with several ASD personnel. Most of the people interviewed were directly involved or had been directly involved in some aspect of TQM in a three-letter organization. The questions posed were

Table 2-3

Semi-structured Interview Questions

In what areas (if any) has TQM improved your organization, in what areas (if any) has TQM hurt your organization, and in what areas (if any) has TQM made no difference?
How can TQM be improved in your organization?
Is management in your organization supportive of TQM?

general in nature (see Table 2-3), and opinions naturally varied. Because of the semi-structured nature of the interviews and the relatively small response size, only trends emphasized by most respondents were considered worthy of reporting in this study.

Objective 4: Determine if There Are Current Practices and/or Organizational Factors at ASD that Significantly Hinder Long-term Effectiveness of TQM.

Selection of Research Strategy. This objective suggests questions of what, how and why: what practices hinder long-term effectiveness, how do these practices hinder long-term effectiveness, and why do they have this effect? The "why" aspect of this question, with its focus on contemporary events, suggests a case study approach. The "what" and "how" could be addressed by survey or archival analysis. However, the thrust of this objective was to tie the first three objectives together. In other words, we discovered in Objective 1 what theories and practices were advocated by the authorities in TQM. We discovered in Objective 2 exactly how ASD's TQM program was structured and what things were emphasized in its TQM training. We evaluated the effectiveness of ASD's TQM program in Objective 3. Objective 4 then asked for a comparison of the findings of the previous three objectives to determine if any cause and effect relationships can be at least postulated. Therefore, Objective 4 was accomplished by an archival analysis, if you

will, of the data and analysis that resulted from Objectives 1, 2, and 3. Findings from Objective 4 are in Chapter V, while results from Objectives 2 and 3 are in Chapter IV.

How the Research was Done. This objective was accomplished by comparing the TQM program at ASD, as discovered in Objective 2 and Objective 3, to the writings reviewed during the literature review (Objective 1). After a summarization of findings from Objectives 2 and 3, possible organizational factors that could hinder the long-term effectiveness of TQM were suggested.

Finally, recommendations for further improvements at ASD and ideas for future research were listed.

III. Perspectives on Quality Management

There is a wealth of literature from various sources involving quality improvement philosophies and techniques. While many think quality improvement is simply "doing things smart," a careful review of the literature reveals an assortment of theories and methods which are not always based on the same underlying assumptions.

This chapter discusses the definitions of waste and quality, various views of the costs of quality, and some basic tools and techniques used to improve quality. It concludes by summarizing the ideas of many individuals. Not all of them are directly connected with the quality movement, however most are considered authorities in managing and improving quality in organizations and products. Some are literally pioneers in the field.

Definition of Waste

As discussed in Chapter I, quality improvement methods can be viewed as ways of eliminating waste. Mr. Fujio Cho of Toyota Corporation defines waste in this way:

> anything other than the minimum amount of equipment, materials, parts, space, and worker's time, which are absolutely essential to add value to the product. (Suzaki, 1987:8)

Using this definition of waste, Mr. Kiyoshi Suzaki has found that in many factories, resources like people, material, and

machines are used unproductively (wasted) over 95% of the time (see Figure 3-1). When a worker is fixing a broken machine, producing a defective product, waiting for instructions or materials, or waiting for an inspector to approve his work; his work time is not adding value to the product. Rather, Suzaki point out, his work is adding cost to the product (Suzaki, 1987: 10-11).

Suzaki describes seven prominent types of waste defined by Toyota Corporation. They are delineated in Table 3-1 and

Table 3-1

The Seven Wastes (Suzaki, 1987:12)

1. Waste from Overproduction
2. Waste of Waiting Time
3. Transportation Waste
4. Processing Waste
5. Inventory Waste
6. Waste of Motion
7. Waste from Product Defects

discussed in detail below.

Waste from Overproduction (Suzaki, 1987:12-13). One of the worst wastes, overproduction uses excess raw materials and labor to produce what is not immediately needed resulting in increased inventory levels. Increased inven-

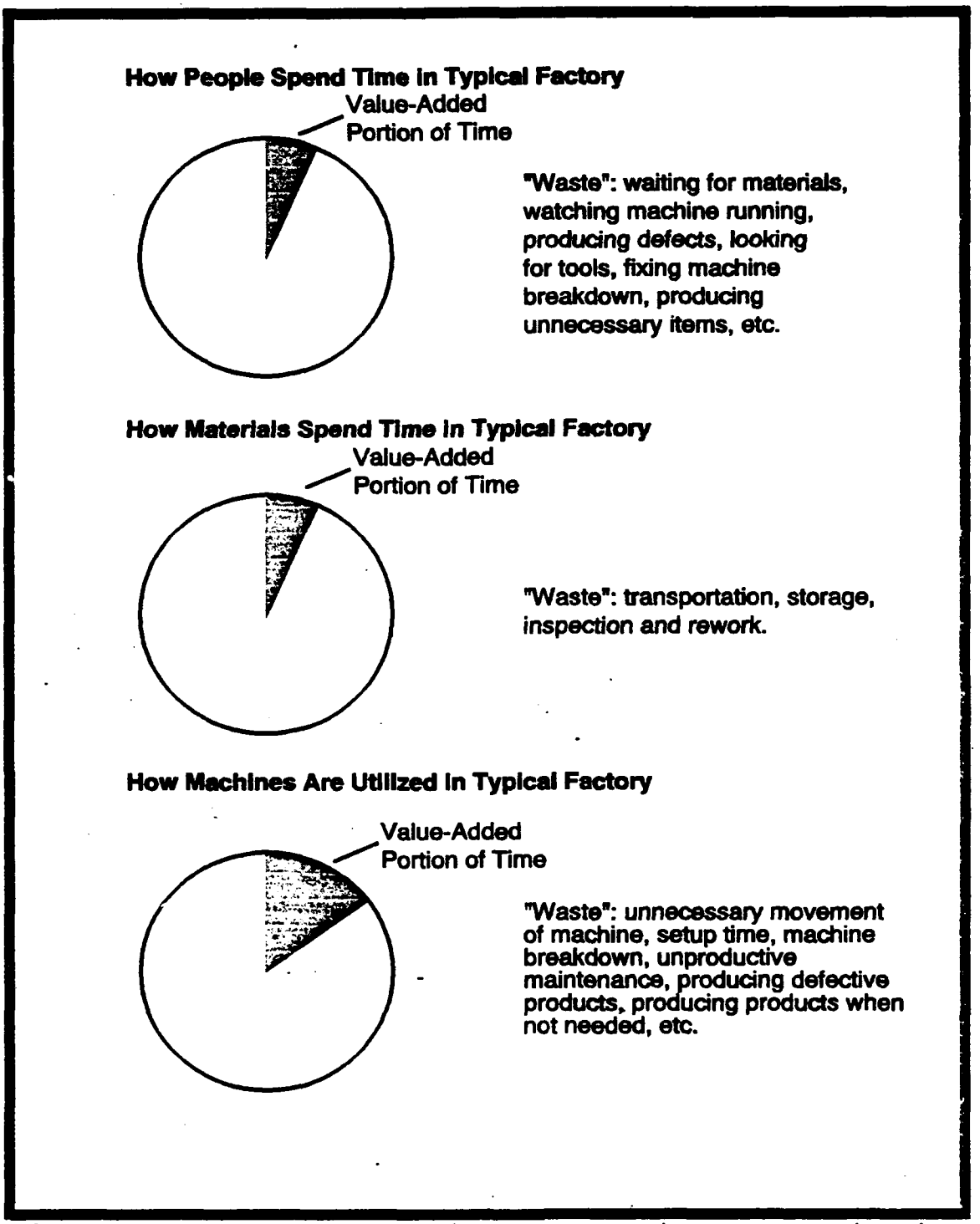

Figure 3-1. How Man, Material, and Machines Spend Time in the Factory (Suzaki, 1987:11)

tory requires more space, people, and equipment to watch, track, and protect it; and it can also distract people from the things that should demand their attention. Workers can be distracted from working on more important and immediate tasks; management, seeing people and machines almost constantly utilized, may mistakenly believe that more machines, materials, and people are needed. This waste is best fought by everyone considering the next process as their customer and producing only that amount requested by their customer (an idea pioneered by Dr. Deming). Of course, the items the customer requires should be produced "...at high quality, low cost, and at the time needed."

Waste of Waiting Time (Suzaki, 1987:14). Waste from overproduction often hides waiting time waste, since resources appear to be busy most of the time. However, once the problem of overproduction is dealt with and we know only what is needed is being produced, workers and machines should be visibly idle when their necessary work is done. This makes waiting time easy to spot and allows supervisors to "...better assess the capacity and control the situation more readily."

Transportation Waste (Suzaki, 1987:14-15). Transportation waste involves handling material far too often or transporting material greater distances than is required. Material may be delivered initially to a warehouse, only to be unloaded, stored, and cataloged until needed. When the

material is needed, it must be handled again to be loaded, transported to the station that needs the material, and unloaded. Poor layouts often contribute to this problem as well, with material following erratic paths from station to station before becoming a finished product.

Processing Waste (Suzaki, 1987:15). The manner in which material is processed may be a source of waste. For example, unnecessary finishing or painting may be required. Physical layout of machines may cause operators to exert more effort in loading or handling material than they would have to if the layout were better planned. The manufacturing process itself may be ill-designed, causing the operator to do some work by hand to finish the part, where more thought to manufacturability up front might have eliminated the need for the extra work.

Inventory Waste (Suzaki, 1987:16-17). Closely related to overproduction, inventory wastes resources. "Excess inventory increases the cost of a product. It requires extra handling, extra space, extra interest charges, extra people, extra paperwork, and so on." Efforts to reduce inventories include eliminating obsolete materials, producing only those items that are required by the "customer" (the next process), purchasing materials in small lot sizes, and actually manufacturing products in small lot sizes. Excess inventories may be compared to the water level in a lake, with a stream of raw materials flowing into it, a

stream of finished products flowing from it, and rocks (or problems in the organization) on the bottom. The water level hides the rocks on the bottom, but as excess inventories are reduced, problems become visible; problems like poor scheduling, quality problems, poor housekeeping, line imbalances, communication problems, and others. Suzaki emphasizes his point by saying that "...excess inventory is the root of all evil."

Waste of Motion (Suzaki, 1987:17-18). Recall the definition of waste discussed above: waste is anything that does not add value to the product, and that includes wasted motion. In this framework, movement does not equal work. People may be kept busy all day long looking for tools, materials, other people they need to coordinate with, or simply walking around. This activity does not add value to the product; it adds costs.

Waste from Product Defects (Suzaki, 1987:18-19). Defects cause problems and waste down the line. Operators at later stations have to adjust their schedules to accommodate and repair the defects. In many cases the defect is not found before the product reaches the final customer, resulting in increased costs due to warranty claims, larger staffs to deal with such claims, additional delivery costs, and potential loss of market share. To reduce defects, a system capable of identifying defects and defect-causing conditions that allows "...anyone present to take immediate

corrective action" must be put in place. Time-saving advances without such a system merely ensures that one will produce defective parts at faster and faster rates.

With a better understanding of exactly what waste is, we can now turn to defining quality. We will see that one very general definition of quality may be the absence or reduction of waste. Taguchi's ideas are particularly suited to this view, as we shall see below.

Definitions of Quality

In general, when we wish to discuss a particular subject, we begin by defining our terms. In this case, however, there is not one, universally held definition of quality.

Exactly what does it mean to say that this car is of higher quality than that car? When we say we want to improve the quality of a product or process, exactly what do we mean? Is quality a relative measure, meaningless except for comparison, or can quality be discussed for a single item? Is quality conformance to specified requirements, or does it go beyond mere minimum requirements? We will see that there are many diverse ideas.

Webster defines quality as

> degree of excellence; degree of conformance to a standard; inherent or intrinsic excellence of character or type; superiority in kind. (Webster, 1981:1858)

These definitions only marginally help us. "Degree of excellence" and "excellence of character or type" is subjective and provides no operational definition that can be objectively applied to determine the absence or presence of quality. "Conformance to a standard" seems to make sense, but it says nothing about the adequacy of the standard. "Superiority in kind" implies comparison with a similar product or service, suggesting that considerations of quality of a monopoly product or service are oxymoronic. Obviously, this definition leaves much to be desired.

Garvin's Dimensions of Quality. David A. Garvin asserts that quality has eight dimensions (see Table 3-2). The dimensions are intended to be mutually exclusive, and it is clearly possible for a product to be considered high in some areas and average or low in others (Springs, 1989:5). They are discussed below.

Performance refers to "...the primary operating characteristics of a product" (Springs, 1989:5). In other words, performance describes the main purpose the product was designed to fulfill.

Features describe "...secondary characteristics that supplement the product's basic functioning" (Springs, 1989:5). To illustrate, the ability of a car to transport people and cargo from one place to another is its primary performance. Features might include additional capabilities

Table 3-2

Dimensions of Quality (Garvin, 1983:35; Schonberger and Knod, 1991:141)

1. Performance
2. Features
3. Reliability
4. Conformance to Manufacturing Specifications
5. Durability
6. Serviceability
7. Aesthetics
8. Perceived Quality
9. Value
10. Responsiveness
11. Humanity
12. Security
13. Competency

Note: Schonberger and Knod's dimensions are shaded.

like power windows, plush seat covers, and a premium sound system.

Reliability is "...the probability of a product's failing within a specified period of time" (Springs, 1989:6).

Conformance describes how well the product meets predetermined specifications (Springs, 1989:6). Note that

it makes no assumptions about the appropriateness of the specifications.

Durability refers to "the amount of use one gets from a product before it fails" (Springs, 1989:6).

Serviceability characterizes "the speed, courtesy, and competence of repair" (Springs, 1989:6).

Aesthetics is a subjective dimension that refers to how a customer feels about the appearance, sound, taste, texture, or smell of a product (Springs, 1989:6).

Perceived Quality describes the customer's perceived quality of a product. Since the customer rarely has perfect knowledge of a product, perceptions of product quality can be very important (Springs, 1989:6).

Schonberger and Knod's Added Dimensions of Quality. Schonberger and Knod point out that Garvin's quality dimensions focus heavily on the manufacturing environment. They add five additional dimensions in an attempt to expand the concept of quality more directly to consumer relations and service (Schonberger and Knod, 1991:141). These dimensions are also listed in Table 3-2 (Schonberger and Knod's additions are shaded) and discussed below.

Value reflects the consumer's concern for quality that justifies the price (Schonberger and Knod, 1991:141).

Responsiveness expresses the dimension of timeliness--how long it takes to receive some product or service (Schonberger and Knod, 1991:141).

Humanity refers to responsiveness to human needs, including sensitivity, courtesy, credibility, clear and effective communication, ease of communication, and understanding (Schonberger and Knod, 1991:141).

Security is "freedom from danger, risk or doubt" (Schonberger and Knod, 1991:141).

Finally, **competency** means having the skills and knowledge to provide the requested goods and services.

Deming's Definition of Quality. Most definitions of quality recognize this multi-dimensional aspect of quality. For example, Deming acknowledges that "the quality of any product or service has many scales" (Deming, 1986:169). He points out that the definition of quality depends on the person defining it. The production worker might define quality as being able to take pride in his work; the factory manager might define quality in terms of meeting specifications (Deming, 1986:167-173). In general, however, Deming believes productivity is improved by decreasing variability in a product or service (Springs, 1989:18). According to Deming, good quality is "a predictable degree of uniformity and dependability, at low cost, and suited to the market" (Springs, 1989:18).

Taguchi's Definition of Quality. Deming's belief in decreasing variability agrees with Genichi Taguchi's view of product quality. To Taguchi, "products have characteristics that describe their performance relative to customer

requirements or expectations" (Ross, 1988:1). These characteristics are often diverse, yet

> [t]he quality of a product is measured in terms of these characteristics. Quality is related to the loss to society caused by a product during its life cycle. A truly high quality product will have a minimal loss to society as it goes through this life cycle. The loss a customer sustains can take many forms, but it is generally a loss of product function or properties. Other losses are time, pollution, noise, etc. If a product does not perform as expected, the customer senses some loss. After a product is shipped, a decision point is reached; it is the point at which the producer can do nothing more to the product. Before shipment the producer can use expensive or inexpensive materials, use an expensive or inexpensive process, etc.; but once shipped, the commitment is made for a certain product expense during the remainder of its life. (Ross, 1988:1)

Since Japan imports most of its natural resources, the perspective of looking at product defects in terms of loss to society as a whole, not just a particular company, is easily accepted in Japan. This perspective argues against defining quality strictly in terms of adherence to specifications, as Crosby advocates (Ross, 1988:7; Crosby, 1979:8).

As an example, consider a specification on the amount of force necessary to close the hood on a car. If a customer has to strain too hard to close the hood; he will complain, and the hood will need to be adjusted by the dealer (for this example, assume the hood adjustment is a warranted item and costs the dealer $50). If the hood is too loose, the wind may cause it to fall shut too often, and

the customer would again require it to be adjusted (Ross, 1988:3-4).

The view that quality is strictly conformance to requirements is shown in Figure 3-2. Notice there is a lower specification limit (LL) and an upper specification

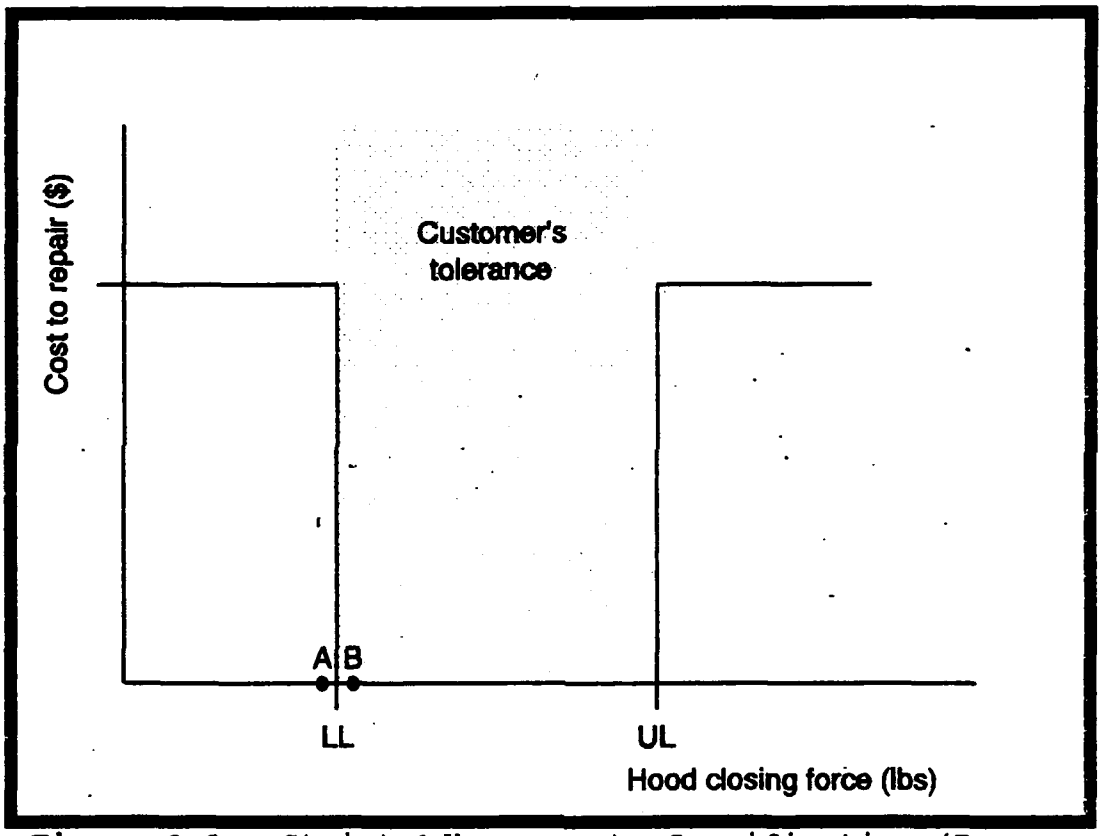

Figure 3-2. Strict Adherence to Specification (Ross, 1988:4)

limit (UL), since no specification can be met exactly. This philosophy claims the customer is satisfied as long as the closing force is within the tolerance band bounded by the lower and upper specification limits (Ross, 1988:3-4).

To Taguchi, the customer is happier the closer the closing force is to the specified, or nominal, value. As the actual closing force moves away from this nominal value, the customer experiences greater and greater degrees of loss. Therefore, the difference between points *A* and *B* in Figure 3-2, to the producer, appears to be the difference between a satisfied and unsatisfied customer and the full cost of the repair. To the customer, however, there is very little difference between *A* and *B*. Taguchi believes a different model (see Figure 3-3), the Taguchi loss function, better explains the relationship between cost and actual closing force. In other words, quality (loss to society) is improved (minimized) by reducing variability (Ross, 1988:4-5).

Crosby's Definition of Quality. Crosby is a proponent of the view of quality expressed above in Figure 3-2. To Crosby, "quality is conformance to requirements; it is precisely measurable; error is not required to fulfill the laws of nature" (Crosby, 1979:8). To talk about quality, we must define measurable requirements. Once we have carefully defined exactly what our requirements are, quality or the lack of quality is determined by comparing the product or service to the requirements. Only conformance to requirements can be considered quality (Crosby, 1979:15,37-39).

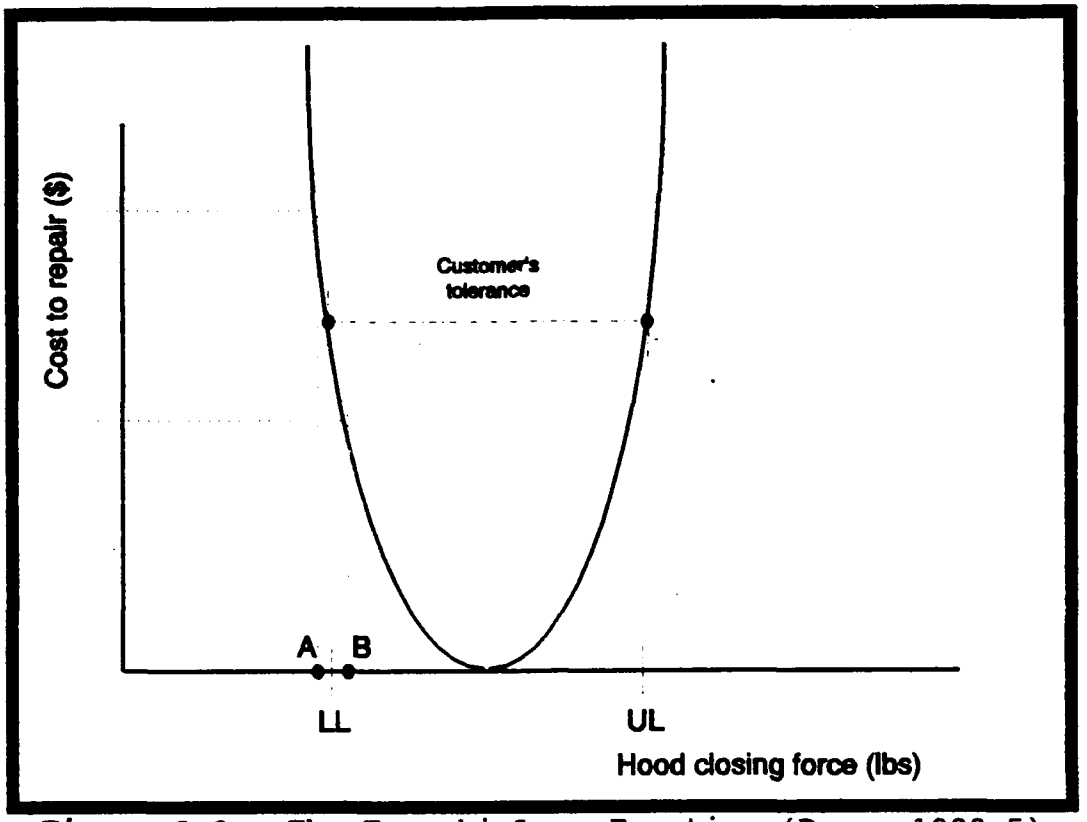

Figure 3-3. The Taguchi Loss Function (Ross, 1988:5)

Juran's Definition of Quality. Like Taguchi, Juran sees quality through the eyes of the consumer, the person who uses the end product or receives the service. Though a product may have various dimensions of quality, "an essential requirement of [a product] is that [it will] meet the needs of those members of society who will actually use [it]" (Juran and Gyrna, 1980:1).

> This concept of *fitness for use* is a universal. It applies to all goods and services, without exception. The popular term for fitness for use is *quality*, and our basic definition becomes: *quality means fitness for use*. (Juran and Gyrna, 1980:1)

Since a product may be used in a variety of ways by a variety of people, a product must be fit for a variety of uses, each of which Juran calls a *quality characteristic*. These characteristics include structural attributes (e.g. length, frequency, viscosity), sensory attributes (e.g. taste, beauty), ethical attributes (e.g. courtesy, honesty), commercial attributes (e.g. warranty), and others. Juran also groups quality characteristics into *parameters* of fitness for use. Two of the primary parameters are quality of design and quality of conformance (Juran and Gyrna, 1980:1-2).

Quality of design refers to differences in grades or intentional variations in quality. For example, automobiles come in different sizes, are equipped with different levels of accessories, differ in appearance and comfort, etc. These intentional, designed differences reflect varying degrees of quality of design (Juran and Gyrna, 1980:2).

In contrast, "quality of conformance is the extent to which the goods and services conform to the intent of the design" (Juran and Gyrna, 1980:2). For example, two identical cars have the same quality of design, but if one will start and the other will not, the quality of conformance is vastly different between the two.

Another way of phrasing this is that quality of design means providing product features that meet the varying needs of customers, while quality of conformance means freedom

Table 3-3

Definitions of Quality (Juran, 1989:16)

PRODUCT FEATURES THAT MEET CUSTOMER NEEDS	FREEDOM FROM DEFICIENCIES
Higher quality enables companies to:	Higher quality enables companies to:
Increase customer satisfaction	Reduce error rates
Make products salable	Reduce rework, waste
Meet competition	Reduce field failures, warranty charges
Increase market share	Reduce customer dissatisfaction
Provide sales income	Reduce inspection, test
Secure premium prices	Shorten time to put new products on the market
The major effect is on sales	Increase yields, capacity
Usually, higher quality costs more	Improve delivery performance
	Major effect is on costs
	Usually, higher quality costs less

from deficiencies (Juran, 1989:15-16). The distinctions between these different types of quality (fitness for use) is summarized in Table 3-3.

Note from Table 3-3 that Juran asserts that improving quality of design typically costs more money, while improving quality of conformance usually decreases costs. Given Juran's definition of quality, this assertion seems plausible, and it provides a good transition to discussing various views on the cost of quality.

Cost of Quality

While everyone would agree that better quality is a worthy goal, there no consensus on the affordability of

quality improvement. Some argue that there is a point where increasing quality is not economically viable or rewarding; while others believe it is always in a firm's long-term, best interests to improve quality. Again, Dr. Garvin's work will assist us in exploring this issue.

In addition to distinguishing the dimensions of quality discussed earlier, Garvin also identifies five distinct ways of thinking about quality, two of which are discussed here. The product approach of economics sees quality differences as measurable variations in one or more of the dimensions of quality. In this view, improved quality means better performance, better reliability, more features, and/or other improvements. However, these improvements require better materials, more manhours, and/or other resources that add cost to the product. In other words, improved quality increases costs (Garvin, 1983:28). In contrast, the manufacturing-based approach "expects that quality improvements result in lower costs because it is thought that preventing defects is cheaper than correcting them" (Gill, 1991:98).

The key to understanding these disparate views of quality is understanding the different assumptions each approach makes about firms producing products. Since microeconomics generally assumes that the primary goal of firms is profit maximization, it is assumed that firms produce in the lowest cost manner, provided their markets have intense price competition. This implies that any increase in prod-

uct quality will result in increased costs. However, the manufacturing-based approach does not assume that firms are necessarily operating optimally. Advocates of this approach believe that if firms concentrate on improving quality and preventing defects, they will find their scrap, rework, and warranty expenses falling, more than compensating them for higher, up-front investments (Gill, 1991:99).

Garvin believes that either view may be applicable, depending on the type of firm one is observing.

> Garvin observes that among homogeneous product businesses, quality is often defined as "meeting specifications," and that such a view is likely to result in an observed inverse relationship between quality and cost. In contrast, differentiated captial goods businesses (such as major DOD suppliers) are more likely to equate quality with performance features and this suggests a positive relationship between quality and cost. (Gill, 1991:99)

In making the above distinctions, Garvin is restating Juran's two primary parameters of quality discussed above (refer to Table 3-3) on Page 3-17. Juran noted the same cost relationship between these two types of quality (Juran, 1989:16). Therefore, it is clear that the definition or type of quality being considered has a direct impact on the relationship between quality improvement and the cost of quality.

Many quality management advocates do not make the distinctions that Juran and Garvin make regarding types of quality. They refer to quality as conformance to certain

requirements or fitness for a particular use, rather than as performance features or quality of design. By limiting discussion to these dimensions of quality, they simply assert that quality improvement always reduces overall costs and benefits the organization through increased market share and larger profits. Philip Crosby puts it this way:

> Quality is free. It's not a gift, but it is free. What costs money are the unquality things--all the actions that involve not doing jobs right the first time.
>
> Quality is not only free, it is an honest-to-everything profit maker. Every penny you don't spend on doing things wrong, over, or instead becomes half a penny right on the bottom line. (Crosby, 1979:1)

Recall from our earlier discussions, however, that Crosby only recognizes quality as conformance to requirements. In fact, Crosby rejects defining quality in terms of luxury, additional features, or other characteristics that would fall into Juran's *quality of design* category; unless (of course) luxury characteristics and additional features are clearly delineated in the product's requirements. Adding requirements to some base level may add to a product's cost; but once those requirements are set, quality is defined as the degree of conformance to those requirements; and improving quality is always cheaper. It is cheaper and better to do things right the first time than to have to do them over later (Crosby, 1979:14-15).

Deming asserts that those who search for the point where it is no longer cost effective to improve quality do

not truly understand the effects of quality improvement (Walton, 1986:26). He describes the benefits of continuous quality improvement as a chain reaction (see Figure 3-4), a continuous cycle of improvement that is beneficial to the organization. In fact, he attributes Japan's remarkable

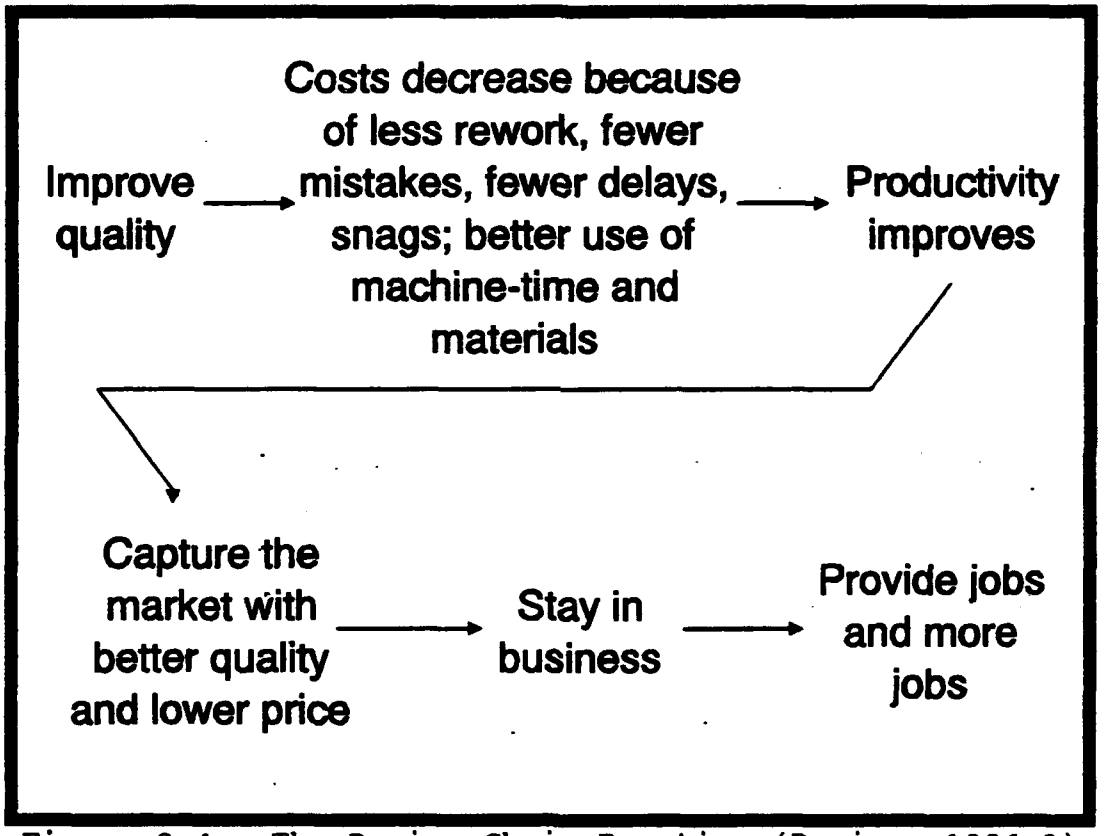

Figure 3-4. The Deming Chain Reaction (Deming, 1986:3)

industrial rebirth after World War II to the basic philosophy of this chain reaction.

> the...chain reaction became engraved in Japan as a way of life. [It] was on the blackboard of every meeting with top management in Japan from July 1950 onward. (Deming, 1986:3)

Note that in Deming's chain reaction, improving quality never becomes too expensive.

This view of the cost of quality is contrary to some long-standing conventional wisdom, however. For example, consider the traditional view of Department of Defense reliability improvement warranties. "Presently, DOD is required to purchase warranties[1] on all weapon systems which cost more than $100,000 per unit or whose total procurement costs exceed $10 million" (Gill, 1991:100). If it can be shown that the warranty is not cost effective, the requirement may be waived (Gill, 1991:100). Thus, DOD's warranty policy implicitly assumes that there is a cost involved in requiring a product warranty, and it is possible for the government's costs to repair the system over its life cycle to be less than the increased procurement costs due to a required warranty.

Figure 3-5 describes how a contractor supposedly determines the level of reliability he should achieve in a product to maximize profits. This figure is based on a variety of assumptions. Assuming that the contractor wishes to maximize profits, that his total revenue on a contract is negotiated with the government, that the total quantity (Q) is fixed, that his compensation for a warranty is indepen-

[1] The warranty must cover (as a minimum) design and manufacturing requirements, material and workmanship defects, and essential performance requirements (Gill, 1991:100)

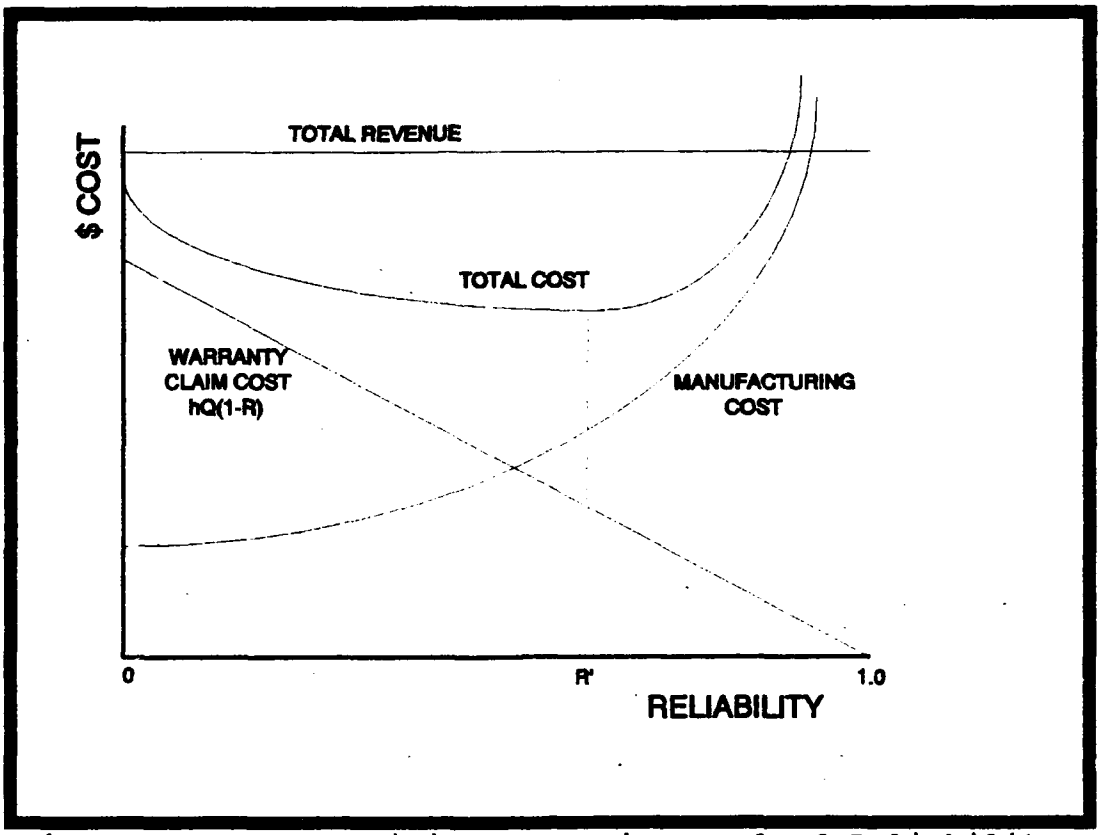

Figure 3-5. Determining Economic Level of Reliability (Gill, 1991:102)

dent of the number of product failures, and that the penalty payment per failure is "h" dollars; the contractor will pick a level of reliability (R') such that total cost is minimized and total profit is maximized. Notice that another assumption is that total manufacturing cost increases at an increasing rate as reliability improves, implicity assuming that greater reliability is achieved only through "costly measures such as better parts, parallel redundant systems, and extensive testing ('burn-in') of components" (Gill, 1991:103). If this is true, then the contractor should

increase reliability "to the point where savings in warranty claim costs are just offset by the resulting increase in manufacturing cost" (Gill, 1991:103). As mentioned above, this point is R' (Gill, 1991:101-103).

This traditional view seems intuitive. Constructing a product that never breaks (100% reliable) seems practically impossible, and surely the costs of approaching 100% reliability would be enormous. However, this view, characterized by Figure 3-5, focuses only on one category of quality costs, while it ignores or assumes away other categories of quality costs.

Listed in Table 3-4 are four categories of quality costs that have been defined by "the pioneers of quality management" (Schonberger and Knod, 1991:151). "Prevention and appraisal costs ensure and control quality; internal failure and external failure costs are losses from defective process output" (Schonberger and Knod, 1991:151).

Figure 3-5 depicts only prevention costs--the costs of making a product more reliable to avoid failures. In contrast, Figure 3-6 shows the traditional view of how all these quality costs interact. Like the warranty cost model depicted in Figure 3-5, this model of quality costs shows prevention and appraisal costs increasing at an increasing rate we approach 100% quality. However, this model also shows internal and external failure costs descreasing as we approach 100% quality. As we move from left to right,

Table 3-4

Four Categories of Quality Costs (Schonberger and Knod, 1991:151)

Prevention Costs
Appraisal Costs
Internal Failure Costs
External Failure Costs

approaching the minimum total cost point, an increase in prevention and appraisal costs results in a greater decrease in failure costs. At the total cost point, an increase in prevention and appraisal costs should result in an equal decrease in failure costs. To the right of the minimum total cost point, however, additional investments in prevention and appraisal do not reap equivalent decreases in failure costs. In other words, it is economically unjustifiable to improve quality beyond that point (Schonberger and Knod, 1991:151-152). Juran refers to this minimum total cost point as the optimum quality costs (Juran and Gyrna, 1980:26).

While Figure 3-6's depiction of failure costs is sensible (failure costs logically approach zero as quality becomes perfect), the idea that prevention and appraisal costs approach infinity near perfect quality is a problem. "Infi-

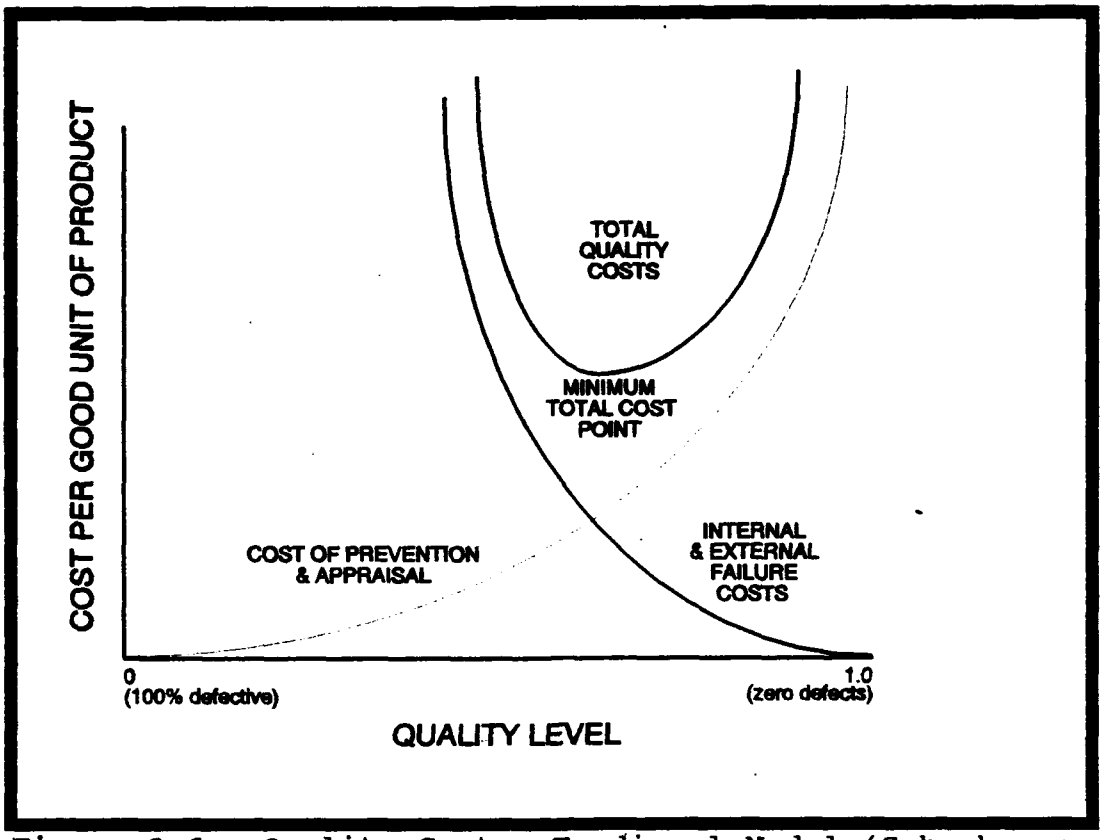

Figure 3-6. Quality Costs: Tradional Model (Schonberger and Knod, 1991:152; Juran and Gryna, 1980:27)

nite cost as the price of success does not sit well with continuing-improvement or zero-defects proponents" (Schonberger and Knod, 1991:152). Consumers are also leery of this view of quality costs, as it naturally leads managers to assume that there is a point where it is better to live with defects (and their business and legal implications) rather than producing defect-free products (Schonberger and Knod, 1991:152).

Therefore, some have suggested a revised view of this traditional model of quality costs. While the traditional

view believes most improvement comes through expensive, innovative breakthroughs in technology, many now believe that most quality improvements are the product of smaller, incremental, and continuous improvements (Schonberger and Knod, 1991:152-153). Schneiderman believes we should view the costs of quality on this basis; he points out there is no mathematical requirement for an optimal value of total costs somewhere between zero and 100% quality. In fact, he believes total quality costs could continue to decrease as we appoach 100% quality, reaching a minimum at that point (Schneiderman, 1986:28-31). This model of quality costs is depicted in Figure 3-7.

Finally, taking the preceeding view one step further, it is possible for prevention and appraisal costs to reverse their trend of increasing as quality improves and actually begin to decrease as we approach defect-free products (see Figure 3-8). This can occur as everyone in an improving organization makes prevention a part of his job, and prevention activities are simplified and made easier and cheaper to perform. Additionally, prevention and appraisal activites can be automated. Some, like inspection, can even be totally eliminated.

Tools and Techniques for Quality Improvement

Now that we have an understanding of quality, the wastes that quality improvement attacks, and the cost of

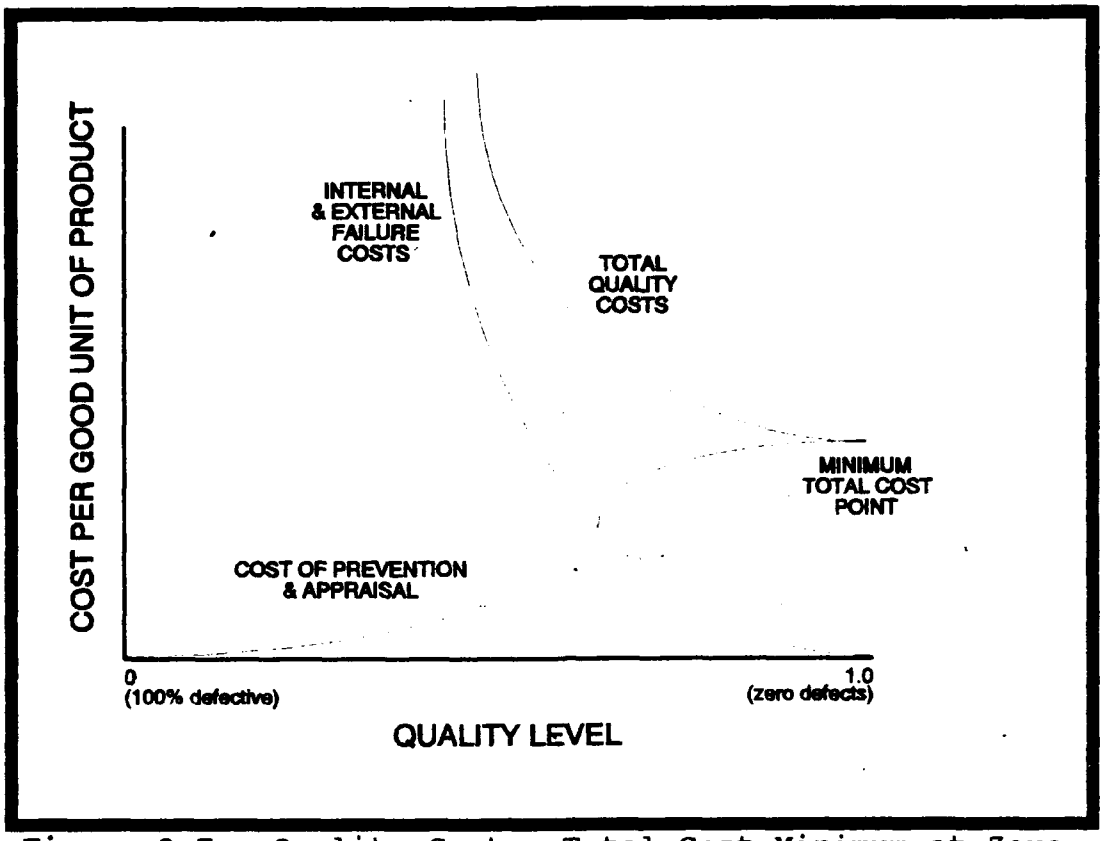

Figure 3-7. Quality Costs: Total Cost Minimum at Zero Defects (Schonberger and Knod, 1991:153)

improving quality, we need to examine some of the tools and techniques used in various organizations to improve quality.

Ishikawa divides statistical methods of improving quality into three categories. The categories and what they include are included in Table 3-5 below. The intermediate and advanced methods listed are beyond the scope of this paper and will not be discussed here. In fact, Ishikawa and Deming both point to the need for acknowledged experts in statistical theory and its application to oversee the work of beginners and provide adequate training (Ishikawa,

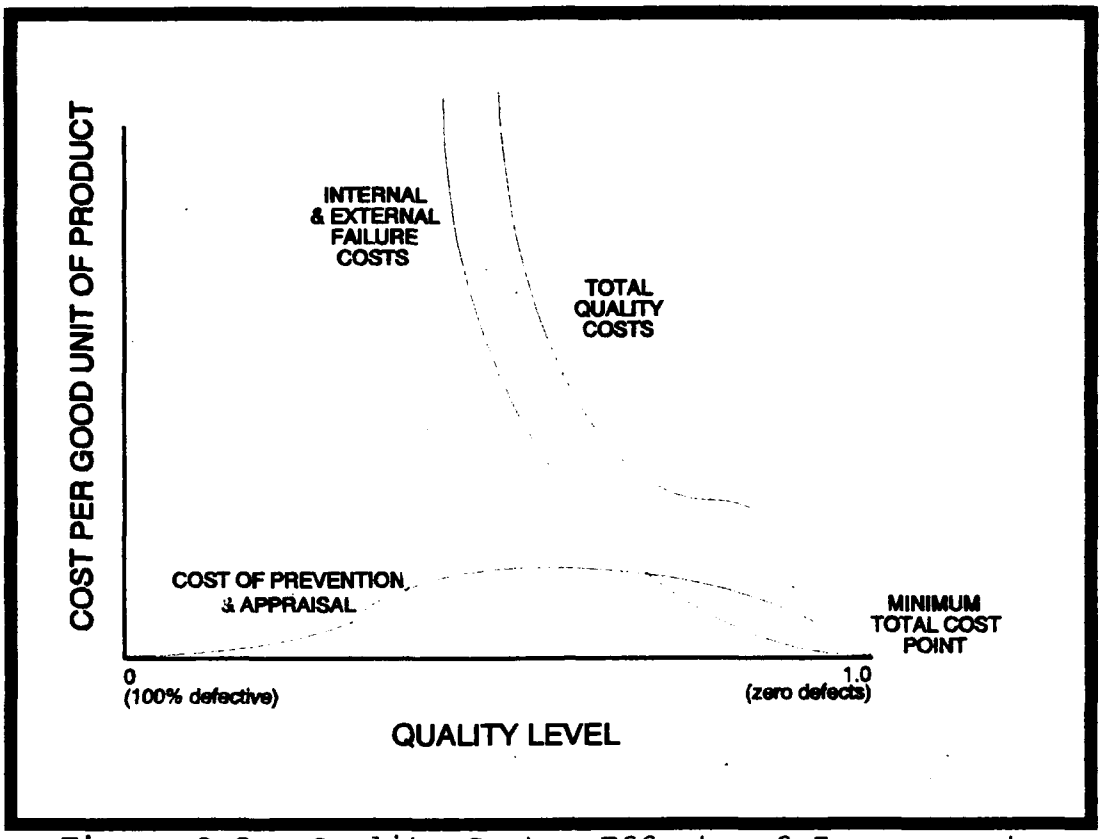

Figure 3-8. Quality Costs: Effects of Improvement through Simplification (Schonberger and Knod, 1991:154)

1985:199-202; Deming, 1986: 131-312, 466-468). Since these intermediate and advanced methods delve deeper into statistical theory, we will restrict our attention to the elementary statistical methods that Ishikawa claims are essential for everyone in an organization, from the top executive to the line worker, to understand and be able to use (Ishikawa, 1985:198). We will discuss selected examples of Ishikawa's elementary methods in more detail, as well as some additional techniques that are not necessarily statistical.

Table 3-5

Ishikawa's Taxonomy of Statistical Methods (Ishikawa, 1985:198-199)

1. **ELEMENTARY STATISTICAL METHODS**
   1. Pareto chart
   2. Cause and effect diagram
   3. Stratification
   4. Check sheet
   5. Histogram
   6. Scatter diagram
   7. Graph and control chart

2. **INTERMEDIATE STATISTICAL METHODS**
   1. Theory of sampling surveys
   2. Statistical sampling inspection
   3. Various methods of making statistical estimates and tests
   4. Methods of utilizing sensory tests
   5. Methods of design of experiments

3. **ADVANCED STATISTICAL METHODS**
   1. Advanced methods of design of experiments
   2. Multivariate analysis
   3. Various methods of operation research

Pareto Chart. Pareto analysis is a means of "isolating the *vital few* from the *trivial many*. The vital few are the factors that account for the largest part of the total" (Gitlow and Gitlow, 1987:82). Figure 3-9 is an example of a Pareto chart that shows the potential causes of a product defect (delivery, raw materials, etc.) and indicates number of defects attributable to each cause. In this way the chart helps focus attention on the primary causes of defects and helps avoid spending a great deal of time and other resources attacking insignificant causes of product defects

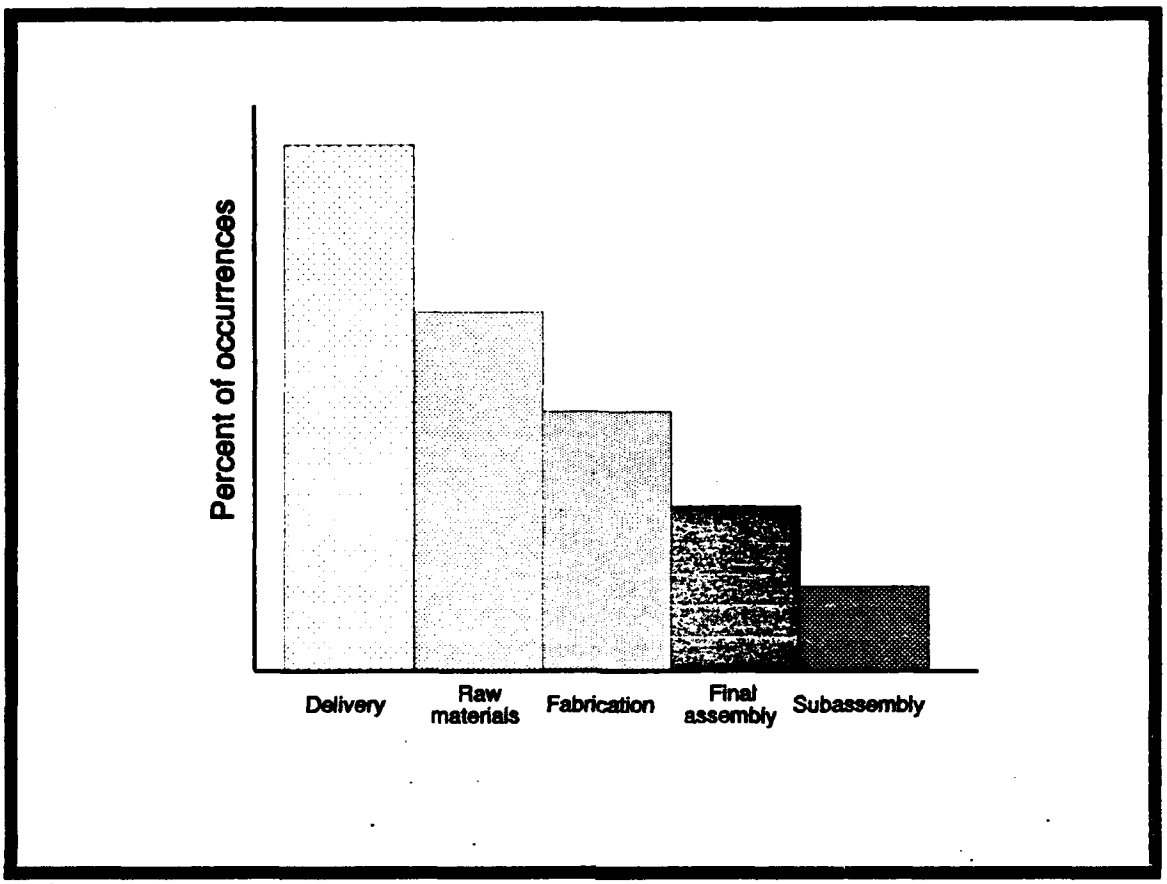

Figure 3-9. Pareto Chart (Schonberger and Knod, 1991:666)

(Schonberger and Knod, 1991:666).

Cause and Effect Diagram. This tool is also referred to as an Ishikawa diagram or as a fishbone chart. The central spine represents an important process, problem, or quality characteristic. Bones that connect directly to the spine are primary contributors to the characteristic of interest, and other bones connect to contributors that they affect. A fishbone chart for the process of delivering goods by truck to customers is shown in Figure 3-10.

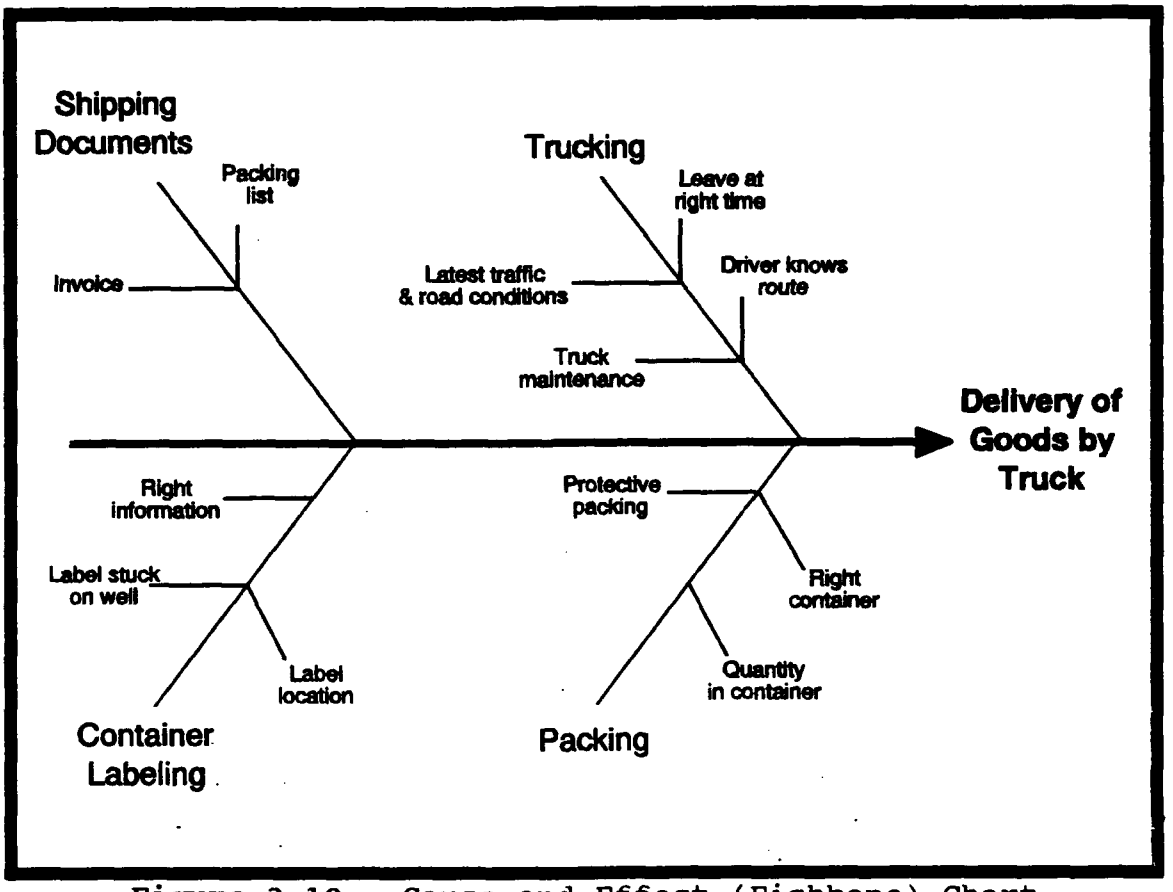

Figure 3-10. Cause and Effect (Fishbone) Chart (Schonberger and Knod, 1991:667)

Check Sheet. A check sheet is simply a form used to collect information about problems, completed tasks, or other items. A company interested in what types of injuries its employees were receiving might establish a check sheet to track types of injuries. After a period of time, the "checks" (injuries) would be added for each type of injury, providing information on trends or problem areas (Gitlow and Gitlow, 1987:82-83).

Histogram. A histogram is typically represented as a bar graph that indicates the frequency of each particular measurement in a group of measurements. For example, Figure 3-11 depicts a histogram displaying the number of

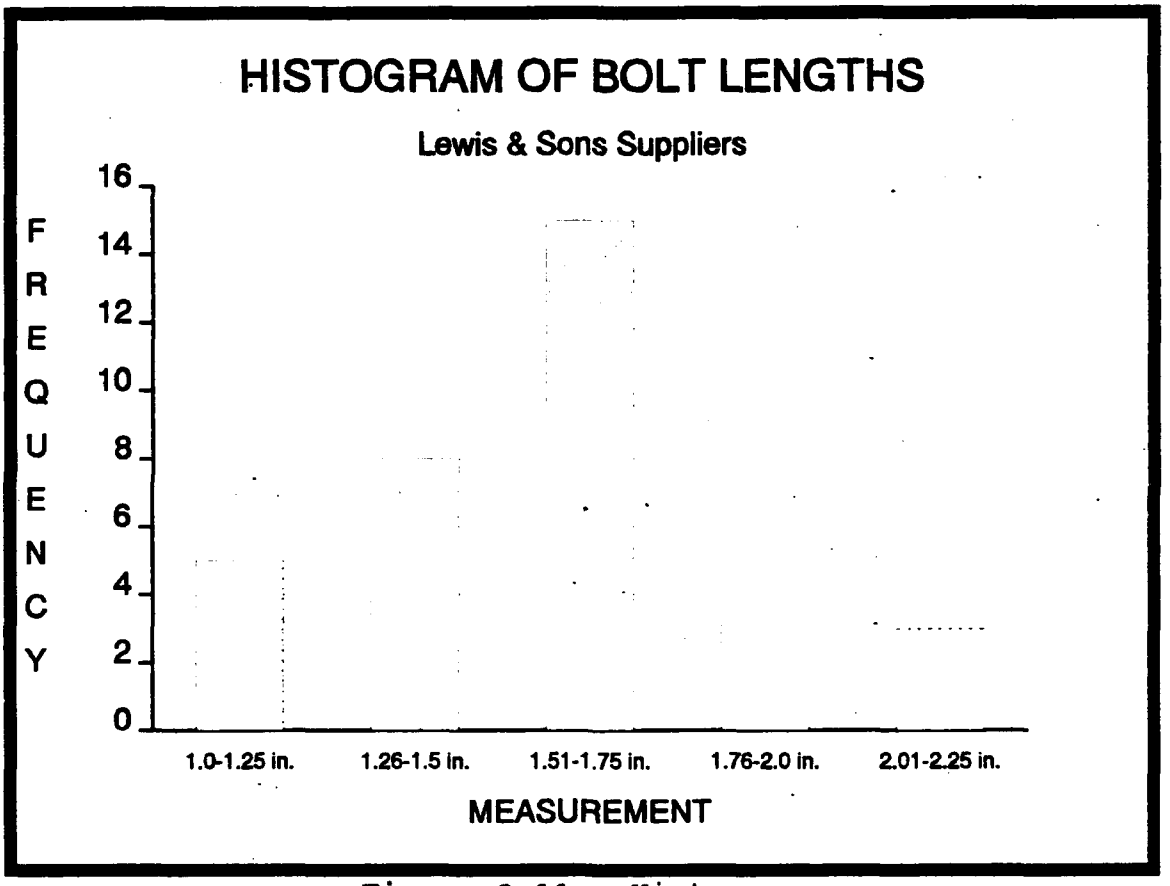

Figure 3-11. Histogram

bolts of various lengths received from a supplier. "Histograms provide valuable information concerning the variability present in a process" (Gitlow and Gitlow, 1987:85).

Scatter Diagram. A scatter diagram is used to graphically show the relationship, or correlation, between two variables. Whenever we suspect there is a relationship between two different variables, we can simply measure both variables a number of times and plot them on a graph, with one variable on the x-axis and the other on the y-axis. For example, if we were interested in examining the relationship between cure time and strength of inner tubes, we might produce a scatter diagram like Figure 3-12. Figure 3-12 indicates that increasing curing times increases the strenght of the inner tube to a point, after which the strenght of the inner tube begins to decline.

Flow Chart. Flow charts are diagrams of a process or system that helps people visualize the important components and better understand how the process or system actually works (Gitlow and Gitlow, 1987:80). A flow chart is often the first thing a team will do when working to improve a process, since it is imperative that everyone on the team understand and agree on exactly what the process is before they can effectively work together to improve it. Flow charts can range from simple block diagrams as illustrated in Figure 3-13, or they can be quite elaborate with different symbols for distinct elements of the process (Walton, 1986:102-103).

Brainstorming. Brainstorming is a technique to get the maximum number of ideas out of a group. Each team member,

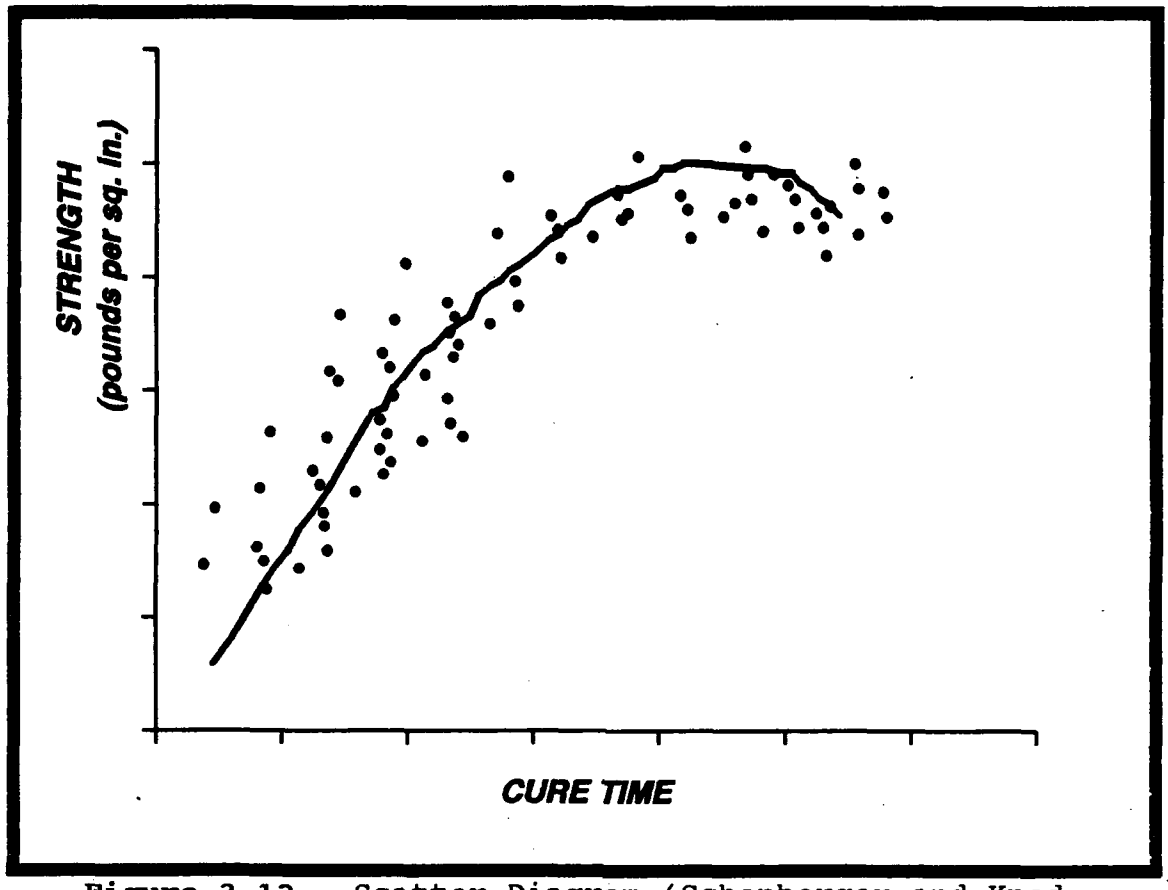

Figure 3-12. Scatter Diagram (Schonberger and Knod, 1991:668)

working alone, generates a list of ideas for how to approach a particular challenge or problem. Then the team members meet and each person shares one idea at a time until all ideas are listed or displayed. No questions are allowed except those necessary to clarify an idea. No value judgements are allowed; since we want to ensure that no one is afraid to share any idea, no matter how wild or off-base it may seem. A silly idea that is shared might trigger a very useful idea from someone else. After everyone's list is

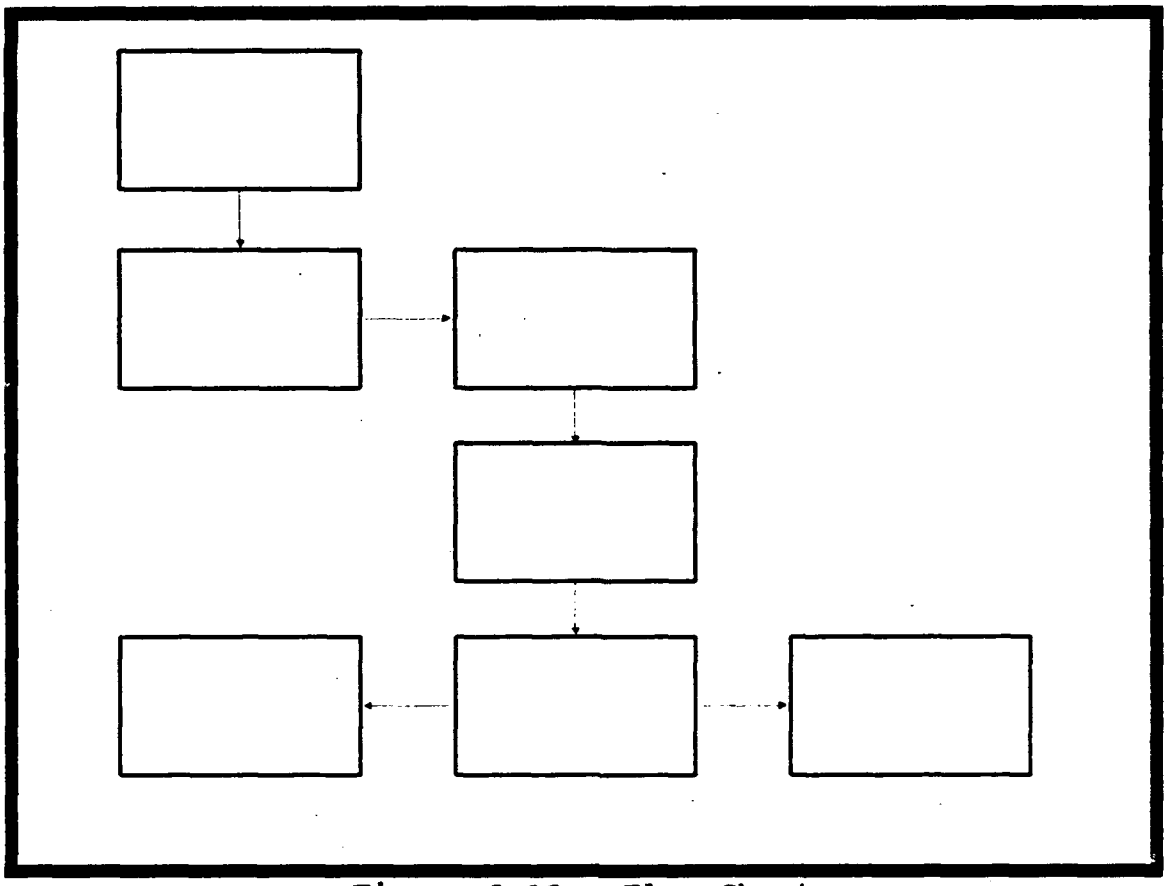

Figure 3-13. Flow Chart

exhausted, members are asked if they have any other ideas. When no one can come up with any additional ideas, the brainstorming session is over.

Control Chart. Control charts are used to study the variation in a process. Their use was pioneered by Dr. Walter Shewhart, a physicist with Bell Labs. A control chart is used to differentiate between common and special variation in a process (Gitlow and Gitlow, 1987:86). Common variation, also known as random or chance variation, is the

inherent variation in a system or process due to chance; all systems and processes have variation. Special variation, also referred to as assignable variation, is due to an assignable or specific cause or source. Intervention to correct a special cause of variation is appropriate; intervention when the cause is common may cause more system variation and problems (Gitlow and Gitlow, 1987:74; Schonberger and Knod, 1991:641; Walton, 1986:115).

For example, suppose we are producing bolts, and we want their lengths to be 1.5 inches. If a bolt is produced that is 1.56 inches long, we need to know if the .06 inch variation from the desired length is due to a specific cause (an untrained worker produced the bolt, a forklift ran into the cutting machine and knocked it out of adjustment, etc.) or if the variation is due to a common cause (inherent, normal variation of the bolt production process). An excellent summary of the differences between common and special variation is in provided by Juran in Table 3-6.

Some researches estimate that special variation accounts for only fifteen percent of the problems in a process, while Deming believes that only six percent of problems are due to special variation (Gitlow and Gitlow, 1987:74; Deming, 1986:314). This is important to understand, since workers in the system can properly be held responsible for special causes of variation; but common

Table 3-6

Distinction Between Common and Special Causes of Variation (Juran and Gryna, 1980:289)

Random Causes	*Assignable Causes*
	Description
Consists of many individual causes	Consists of one or just a few individual causes
Any one random causee results in a minute amount of variation (but many random causees act together to yeild a substantial total)	Any one assignable cause can result in a large amount of variation
Examples are human variation in setting control dials; slight vibration in machines; slight varition in raw material	Examples are operator blunder, a faulty setup, or a batch of defective raw material
	Interpretation
Random variation cannot economically be eliminated from a process	Assignable variation can be detected; action to eliminate the causes is usually economically justified
When only random variation is present, the process is operating at its best; if defective are still being produced, a basi process change must be made or the specifications revised in order to reduce the defectives	If assignable variation is present, theprocess is not operating at its best
An observation within the control limits of random variation means the process should not be adjusted	An observation beyond control limits usually means the process should be investigated and corrected
With only random variation, the process is sufficiently stable to use sampling procedures to predict the quality of total production or mak process optimization studies	With assignable variation present, the process is not sufficiently stable to use sampling procedures for prediction

causes of variation, inherent in the system and more difficult to control, are out of the workers' control and must be addressed by management. Control charts help to point out if there are any special causes of variation operating in a system or process. When all special causes of variation have been eliminated, a process is considered to be in statistical control. Only after statistical control has been achieved can management take on the more difficult task of improving the process and reducing common variation (Schonberger and Knod, 1991:642-647; Walton, 1986:115).

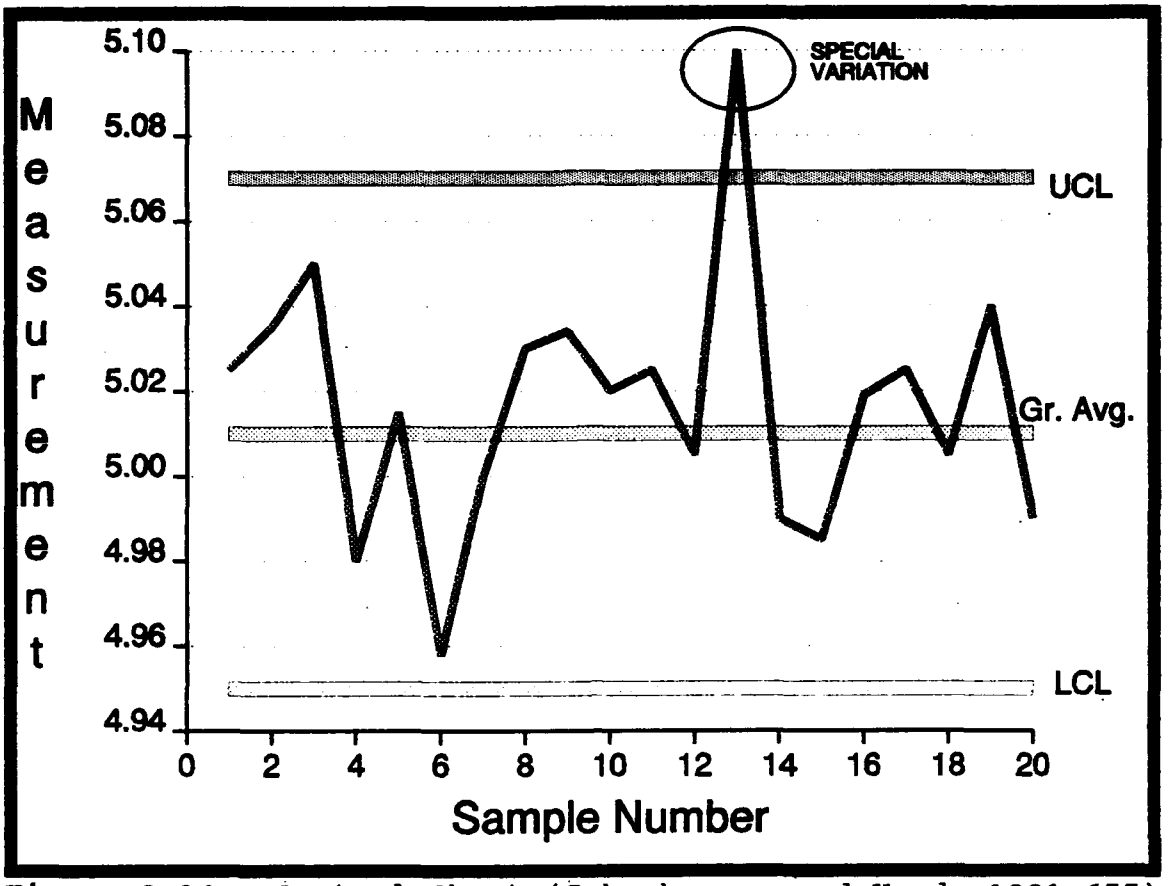

Figure 3-14. Control Chart (Schonberger and Knod, 1991:655)

Figure 3-14 is an example of a control chart. To construct a control chart, we must first decide what characteristic of interest will be studied. The type of control chart we use depends on the characteristic of interest. If we track sample averages of some measurements, we will use an $\bar{X}$ *chart* (read X-bar). Using sample ranges results in an *R chart*. Plotting percent defective in each sample creates a *p chart*, while plotting the number of defects in each sample creates a *c chart* (Juran and Gyrna, 1980:290).

Using the $\bar{X}$ chart as an example, the next step is to take samples of a certain size periodically at uniform time increments. The sample averages are calculated and plotted on a chart, with time or sample number on the x-axis. Finally, when enough samples have been collected, the grand average (average of all the sample averages) is plotted across the chart as a straight line horizontal to the x-axis. Using elementary statistical formulas and tables, upper and lower control limits are calculated and placed on the chart as horizontal lines, parallel to the x-axis, above and below the grand average. Points outside of the control limits indicate special causes of variation[1] (see the circled data point in Figure 3-14). In addition, even if all sample averages are within the control limits, abrupt shifts or distinct trends in the data may also indicate special variation. The other types of control charts are created in a similar way (Walton, 1986:113-118; Schonberger and Knod, 1991:651-656; Juran and Gyrna, 1980:287-290).

It is important to remember two things (at least) about control charts. First, the characteristic being tracked and measured must be operationally defined (Deming, 1986:276-292; Gitlow and Gitlow, 1987:87). An operational definition is one that communicates the same thing to different people.

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[1] "The formula for the control limits is designed to provide an economic balance between searching too often for special causes when there are none and not searching when a special cause may be found" (Walton, 1986:115).

If we are counting and plotting the number of defective parts in a sample, we must know what we mean by a *defective* part. How do we determine if a part is defective? Deming points out that an operational definition involves a procedure; "[a]ny physical measurement is the result of applying a given procedure" (Deming, 1986:280). I know a part is defective if I follow an established procedure and use specified tools to measure certain characteristics of the part and then compare against standards of "acceptable" or "defective." Second, the control limits on control charts are not specification limits; specification limits or goals have no place on a control chart. A control chart tells us about the statistical *control* of a process. The *capability* of the process (how well the process produces a product that conforms to specifications) is another matter. Once process control has been achieved, we can then concentrate on addressing the capability of the process (Schonberger and Knod, 1991:642-657).

Finally, a word should be said about when to use the various tools discussed above. Control charts are used to track a single characteristic of interest. Determining what characteristic to track is critical, and data collection itself may be difficult or time-consuming. Therefore, before using this tool that concentrates on one variable in the process, the other tools mentioned above can be used. For example, we might begin by creating a flow chart to

ensure everyone agrees on the basic process and terms. The next step might be analyzing problems with a Pareto chart to find the area or areas where most of the problems occur. A Cause and Effect chart describing those few key areas might then begin to provide some clues for the characteristics that should be tracked and measured. Some problem areas, particularly in service industries and the office, require only the more general-purpose tools and analysis just described; and control charts and detailed statistical analysis may be inappropriate or unnecessary (Schonberger and Knod, 1991:664-670; Gitlow and Gitlow, 1987:80-88).

Quality Management Philosophy and Principles

We now turn to a summary of the management philosophies and principles of some of the more influential individuals in the quality movement. This is important since any emphasis on improving quality will require change and an atmosphere that is conducive to change. This is the realm of management. It is particularly important when we remember Deming's assertion that the vast majority of quality problems are due to common variation of the respective systems or processes, and these systems or processes can only be changed by management. This study will help us understand the overall frameworks or management philosophies within which the quality information, tools, and techniques dis-

cussed above may be applied. No informed research in quality management would be complete without such a review.

W. Edwards Deming. Deming believes the responsibility for decline of Western industry rests with the Western style of management (Deming, 1986:18). For management to be effective, it must recognize the difference between a stable system and an unstable one (Walton, 1986:xii). A system must first be made stable before the process can be continuously improved (Schonberger and Knod, 1991:640-650), and the responsibility for the improvement of a stable system "rests totally on the management" (Walton, 1986:xii). Failure to understand this principle has allowed Western management to pursue policies that are devastating (Walton, 1986:xii).

Deming's Fourteen Points and Seven Deadly Diseases (Deming, 1986; Walton, 1986). Deming's management philosophy, his theory of management, is expressed in his Fourteen Points for Management and his Seven Deadly Diseases (see Table 3-7). We now elaborate on some of these items.

Points 1, 2, and 5. Constancy of purpose and the new philosophy refer to a managerial commitment to continual improvement and long-term thinking. We cannot be so involved in today's problems and "fires" that we neglect giving attention to the long-term, best interests of our organizations and people. We must also adopt a new philosophy that refuses to tolerate defects, people inadequately

Table 3-7

Deming's Fourteen Points for Management and Seven Deadly Diseases (Deming, 1986:23-125; Walton, 1986:34-36)

14 Points	*7 Deadly Diseases*
1. Create constancy of purpose for improvement of product and service.	1. Lack of constancy of purpose
2. Adopt the new philosophy.	2. Emphasis on short-term profits
3. Cease dependence on mass inspection.	3. Evaluation of performance, merit rating, or annual review
4. End the practice of awarding business on the basis of price tag alone.	4. Mobility of mangement
5. Improve constantly and forever the system of production and service.	5. Running a company on visible figures alone (counting the money)
6. Institute training.	6. Excessive medical costs
7. Adopt and institute leadership.	7. Excessive costs of liability, swelled by lawyers that work on contingency fees
8. Drive out fear.	
9. Break down barriers between staff areas.	
10. Eliminate slogans, exhortations, and targets for the workforce.	
11. Eliminate numerical quotas.	
12. Remove barriers that rob people of pride of workmanship.	
13. Encourage education and self-improvement for everyone.	
14. Take action to accomplish the transformation.	

trained, accepted levels of mistakes, and a lack of commitment to excellence. Continual improvement is the key, not just meeting specifications. Eliminating special causes of variation does nothing to improve a process; it merely puts the process back where it should have been anyway. If the control limits of the process then include the specification limits, the process of improvement is not unnecessary and must not be forgotten. Only by working to decrease process variation do we improve. This kind of continual improvement results in distributions of quality characteristics that are

so narrow that specification limits and outdated standards disappear over the horizon. Management must create an environment where it is clear that efforts to increasing quality and productivity will always be encouraged (Deming, 1986:24-28, 49-52).

Point 3. To achieve quality, however, outmoded methods must be challenged and eliminated. Mass inspection is one of these. Inspecting a product after it is produced or inspecting a service after it is performed, using customer surveys or relying heavily on after-the-fact customer service departments, come too late to affect the quality of the product or service. A much better way is to attack the process to reduce variation and ensure quality at the end (Deming, 1986:28-31).

Point 4. In addition to the price, quality must be a consideration in selecting suppliers. Awarding business on price alone has three main drawbacks. First, it typically leads to more than one supplier, thereby compounding the problem of variation. It is difficult enough to work with one supplier to reduce variation and improve quality. With multiple suppliers, not only must we be concerned with variation within each supplier, but we must also try to control the variation between suppliers. Second, it encourages buyers to jump from supplier to supplier in search of the lowest price, often not allowing enough time to work with any one supplier to build working rela-

tionships and improve products. Third, it leads to reliance on specifications, which become barriers to further improvement. As discussed above, continual improvement will leave specifications far behind. Only a long-term relationship of trust with a purchaser will provide the incentive for a supplier to risk innovation and substantive process improvements (Deming, 1986:31-48; Walton, 1986:62-65).

Point 6. Management must take steps to ensure that all workers are adequately trained. On-the-job training, where worker trains worker, transmits and increases variation. When one worker trains another, he can only pass on how he does the work. Some of what he does is probably correct, and some is probably wrong; he teaches both. It is just like the game where people sit in a circle and pass a message around the circle by whispering it to the next person. By the time it gets around the circle, the message may be totally distorted beyond its original meaning. Pass it on to two or three other circles, and it will almost certainly be completely different in meaning from the original. Such is the result of months and years of continuing on-the-job training. Instead, workers must be trained in the significance of variation, given a working knowledge of the tools to control variation, and trained in the proper process. Then, when the practice of continual improvement changes the process, more training must take place. Finally, we know that enough training has taken

place when a worker's performance is in statistical control (Walton, 1986:68-69).

Point 13. Education and self-improvement is not the same as the training of Point 6. Good people are not in short supply; the shortages are at the high level of knowledge in every field. Rather than searching for the immediate benefits of further education to the organization or emphasizing study for an immediate concern, management should encourage the long-term education and self-development of people (Deming, 1986:86).

Points 7 and 12. Leadership is essential in successful, improving organizations. Management must lead by eliminating barriers that prevent people from taking pride in their work. These barriers include poor training, emphasizing numbers over quality, management refusing to listen to employee suggestions, poor tools, poor materials, lack of job definition, lack of performance feedback, and numerical quotas. Managers often do not know the work they supervise. Since they are uncomfortable with the problems and challenges of the work, they seek refuge in numbers and quotas, in performance ratings. They forget fundamental laws of mathematics: in any rating system, at least one person must be below average; in a group of twenty people doing the same job, two will fall in the bottom ten percent. Managers must take responsibility for the success or failure

of their people (Deming, 1986:54-59, 77-85; Walton, 1986:70-71).

Point 8. Fear kills productivity, innovation, improvement. Managers create fear by focusing on quotas or other numbers, management objectives, or goals, and then rewarding those who meet these standards and punishing those who do not meet the numbers or goals, all without regard to variability or statistical control. An employee may not be able to meet established goals because the system she must work in is not in statistical control. Or worse, the system may be in statistical control, but stabilized well below the established goal. Management must ensure that people who point out problems and work to avoid producing poor quality can do so without fear of losing their jobs or future promotions (Deming, 1986:59-62; Walton, 1986:72-73). "No one can put in his best performance unless he feels secure . . . . Secure means without fear, not afraid to express ideas, not afraid to ask questions" (Deming, 1986:59).

Point 10. Slogans, exhortations, and targets for the work force do not help, and often hurt, because they are intended for the wrong people. Management does not understand the importance of variability or process control, and simply believes that by exhorting workers to work harder and produce quality work, quality will improve. Yet, the majority of quality problems are the result of common varia-

tion of the system, and the workers can not do anything about it; management provides and must address the system. Encouraging workers to do better without providing them with a capable, controlled system and the proper tools and training leads to resentment, fear, and mistrust. Numerical quotas are not compatible with continuous improvement, and send a signal that quality is important only if the quota is met. Quotas also obscure the true purpose of the job. For example, a woman hired to answer the telephone, make reservations, and give information for a major airline was given a quota of twenty-five calls per hour. Is her job to give each caller her full attention and courteous satisfaction or is her job to complete twenty-five calls per hour? Numerical goals for management are just as damaging. Increasing sales or decreasing costs by a certain percentage, without a plan and without a knowledge of the state of control and capability of the process, is management without knowedge--management by fear (Deming, 1986:65-76). Deming puts it this way:

> If you have a stable system, then there is no use to specify a goal. You will get whatever the system will deliver. A goal beyond the capability of the system will not be reached.
>
> If you have not a stable system, then there is again no point in setting a goal. There is no way to know what the system will produce: it has no capability. (Deming, 1986:76)

Point 14. To accomplish the transformation of management needed to focus the organization on continuous

Table 3-8

The Shewart Cycle (Deming, 1986:88)

Step 1	What could be the most important accomplishments of this team? What changes might be desirable? What data are available? Are new observations needed? If yes, plan a change or test. Decide how to use the observations.
Step 2	Carry out the change or test decided upon, preferably on a small scale.
Step 3	Observe the effects of the change or test.
Step 4	Study the results. What did we learn? What can we predict?
Step 5	Repeat Step 1, with knowledge accumulated.
Step 6	Repeat Step 2, and onward.

improvement, Deming recommends the Shewart Cycle. In Japan, the cycle is referred to as the Deming Cycle; some call it the Plan, Do, Check, Act (PDCA) Cycle. Whatever the name, the cycle consists of six steps, listed in Table 3-8. The first, basic step is to study the process or processes involved to determine what changes might improve it. The next step is to organize a team with the proper expertise to address the process under consideration. Then the team can determine the data they need and if new data is required. A plan is developed detailing what will be done to change the process. After the plan is developed, the team is ready to carry out the changes, preferably on a small scale; there is

always the possibility that a change may induce unexpected variation in the process. The team observes and analyzes the results, learns from them, and begins the cycle anew. Finally, in addition to the Shewart Cycle, Deming says it is vital that everyone in the organization think of the next person in the process as their own customer, a customer that must be satisfied with his work. "Everyone has a customer" (Walton, 1986:86-87).

Standing in the way of this transformation of management are seven deadly diseases. According to Deming, the sixth and seventh diseases are peculiar to American industry (Deming, 1986:98). The first five are discussed below.

Disease 1: Lack of Constancy of Purpose. The opposite of Point 1, this disease is marked by emphasis on short-term dividends and benefits, rather than the more lasting and longer-term advantages of a commitment to continual improvement (Deming, 1986:98).

Diseases 2 and 3: Emphasis on Short-term Profits and Evaluation of Performance, Merit Rating, or Annual Review. These diseases are closely related. Annual performance rating or review encourages short-term thinking and planning. A worker's incentive is to do things in the short-term that set him apart from his peers and provide a strong basis for his performance report. Instead of encouraging teamwork and decisions that have the greatest potential of increasing the long-term effectiveness and perfor-

mance of the organization, workers are encouraged to think only about the near-term and themselves in comparison to their coworkers. In addition, Deming claims that performance ratings focus management's attention on the end product rather than on leadership to help people improve. Performance appraisal also increases performance variation, as people who get rated lower try to understand why others were promoted ahead of them and then try to emulate them. The result, Deming says, is impairment of performance (Deming, 1986:101-120; Walton, 1986:90-92).

Disease 4: Mobility of Top Management. To be committed to long-term change and improvement, managers must be around long enough to build relationships with people and understand the organization. As Deming puts it, "Mobility from one company to another creates prima donnas for quick results. People require time to learn to work together" (Walton, 1986:92-93).

Disease 5: Running a Company on Visible Figures Alone. The bottom line says little about what is really important in an organization. No one knows what one dissatisfied customer costs a company in future business, nor how much new business one perfectly satisfied customer can generate. "The most important figures that one needs for management are unknown or unknowable" (Deming, 1986:121-124).

Joseph M. Juran. Juran points out that the management of quality uses very familiar managerial processes: planning, control, and improvement. These three steps, applied to quality management, are known as the Juran Trilogy (Juran, 1989:20).

Quality Planning. "This is the activity of developing the products and processes required to meet customers' needs" (Juran, 1989:20). The first step is to determine who the customers are. Customers are defined as anyone who uses the output from a particular process. This means we must not only consider the eventual end-user of a product or service, but also those internal customers within the organization. These internal customers are those who use the output of one particular process as an input to another process, and so on. Second, we must determine the needs of the customers. Since there are a variety of customers, they do not all have the same needs. Particular attention should be paid to the needs of the next process. Third, we should develop product features that respond to customers' needs. Interaction with customers to determine their needs naturally leads to identification of product features that address those needs. Continual communication with customers ensures that the features as envisioned and developed are actually the features the customers had in mind. Fourth, processes must be developed capable of producing these product features. Finally, the processes and plans that are

developed are transferred to operations to be used (Juran, 1989:20, 89-93).

Quality Control. This process is nothing more than comparing actual quality performance to planned quality performance (goals) and taking action when quality goals are not achieved. Upper management should take the lead in developing the strategic quality goals of the organization that sets the stage. They should then ensure a control system is established for control. This system includes units of measurement, methods of measurement, control charts, and other statistical methods (Juran, 1989:21, 150-175).

Quality Improvement. This process involves managerial "breakthrough," and is concerned with increasing the level of quality performance. The first step is to "establish the infrastructure needed to secure annual quality improvement" (Juran, 1989:21). Management must do this by establishing quality goals, providing resources, reviewing progress, rewarding and recognizing contributions to improvement, and becoming involved in the quality improvement process. This infrastructure development may be done by a quality council of senior management. Next, specific quality improvement projects must be identified. Ideas can come from employees, research, customers, or other sources. Then, each project should be assigned to a special team with the responsibility to successfully complete the project.

Finally, management must ensure that the project teams have the necessary training and resources to properly diagnose and solve the problem (Juran, 1989:21, 28-70).

Philip B. Crosby. Crosby believes that it is difficult to have substantive discussions about quality because everyone is for it. Exactly what everyone is for when they say they believe in quality is hard to determine, however. Crosby begins by pointing out five erroneous assumptions about quality.

"The first erroneous assumption is that quality means goodness, or luxury, or shininess, or weight" (Crosby, 1979:14). People who hold this assumption are thinking of quality as a measure of comparison between two or more things, a measure of relative worth. Crosby believes the only comparison that determines quality is the comparison of the product to its requirements. When quality is defined as conformance to requirements, quality becomes measurable (Crosby, 1979:14-15).

"The second erroneous assumption is that quality is an intangible and therefore not measurable" (Crosby, 1979:15). On the contrary, when quality is defined as conformance to requirements, it becomes precisely measurable. Deviations from requirements, or nonconformance, is then the lack of quality. This nonconformance costs money. Therefore, quality can be measured by the cost of quality, the costs of doing things wrong. These costs fall into three categories:

appraisal costs, prevention costs, and failure costs (Crosby, 1979:15-16).

"The third erroneous assumption is that there is an 'economics' of quality" (Crosby, 1979:16). Those who believe there is a point where they can no longer afford to improve quality do not understand the definition of quality. Defined as conformance to requirements, it is **always** cheaper to do it right the first time (Crosby, 1979:16).

"The fourth erroneous assumption that causes problems is the one that says that all the problems of quality are originated by the workers. . . ." (Crosby, 1979:16). Management is responsible for the majority of quality problems, because management creates the system within which the workers function. Therefore, the workers have very little control over the dominant causes of poor quality (Crosby, 1979:16-17).

"The fifth erroneous assumption is that quality originates in the quality department" (Crosby, 1979:17). The quality department is responsible for quality education, quality measurement, and advising others on ways to improve quality. However, managers of all departments of an organization must take responsibility for the quality of their departments' work.

To replace these erroneous assumptions, Crosby defines four quality absolutes. The first absolute has already been discussed above: the definition of quality is conformance

to requirements. The second absolute says that the system that leads to quality is prevention, not appraisal. Inspecting and evaluating after the fact is expensive, wasteful, unreliable, and does nothing to improve the product. Preventing the error in the first place is the key. As Crosby states it, "the error that does not exist cannot be missed" (Crosby, 1984:67). The third absolute describes the performance standard for quality as zero defects. Acceptable quality levels and other measurements only establish a number of percentage of defects that will be accepted. Define the requirements, and then accept nothing that does not meet those requirements. The fourth absolute asserts that the measurement of quality is the price of nonconformance. This includes all the costs associated with doing things wrong. It is always cheaper to do things right (Crosby, 1984:59-86).

Crosby's Fourteen Steps for Quality Improvement

(Crosby, 1979:112-119). Finally, Crosby outlines his fourteen steps of quality improvement. These steps are outlined and discussed below.

Step 1: Management Commitment. Management must be committed to quality improvement; should set the tone with a straight-forward, easy-to-understand quality policy; and must communicate that commitment and policy to the organization.

Step 2: Quality Improvement Team. High-level representatives from each department in the organization should form the Quality Improvement Team. The team's purpose is to implement and oversee the quality program of the organization.

Step 3: Quality Measurement. At the start, the status of quality in the organization must be determined. This involves determining quality measurements for all areas of the organization. Then the measurements can be taken and areas for improvement can be identified. Crosby acknowledges that coming up with measurements is often difficult, and he encourages management to allow the workers to participate in defining appropriate metrics.

Step 4: Cost of Quality Evaluation. The comptroller, with help from the various departments in the organization, should determine the cost of quality in the organization. Initial estimates will be shaky and low, but it is a necessary step. While the cost of quality should not be seen as an absolute measurement of performance, it helps prioritize the areas where corrective action will have the largest effect.

Step 5: Quality Awareness. Perhaps the most important step of all, this is the process of sharing with all members of the organization the current status of quality and the cost of quality. This helps everyone understand the problem and why certain things need to change.

Step 6: Corrective Action. As all members of the organization are involved in understanding the status and cost of quality, the resulting dialogue will produce ideas for corrective actions. Management must cultivate an environment where all individuals acquire the habit of identifying and helping correct problems.

Step 7: Establish an Ad Hoc Committee for the Zero Defects Program. This committee is responsible for understanding and communicating the meaning of zero defects throughout the organization.

Step 8: Supervisor Training. All managers should be formally educated about the fourteen step program before it is implemented. Once the program has begun, it is imperative that all managers understand it, support it, and are able to explain it to their people.

Step 9: Zero Defects Day. The establishment of zero defects as the goal of the organization should be done in a unique way and done throughout the organization in one day.

Step 10: Goal Setting. This step involves all supervisors sitting down with employees and collectively establishing goals as a team. Crosby recommends 30-, 60-, and 90-day goals.

Step 11: Error Cause Removal. This step establishes a process where individuals are encouraged to describe any problem that keeps them from reaching their

goals or performing to the zero defects standard. Then the problems can be studied and attacked.

Step 12: Recognition. Individuals who meet their goals or perform outstanding acts should be recognized. Crosby believes it is better if there is no differentiation among the people recognized. In addition, he feels that financial rewards are inappropriate; recognition is what is important.

Step 13: Quality Councils. These groups are formed from quality professionals and team leaders throughout the organization. They meet to discuss what has been accomplished and to communicate ways to improve further.

Step 14: Do It Over Again. Continual education, reevaluation, and goal-setting is necessary to keep the quality goals in the forefront of the organization. Personnel turnover and the passing of time must not cause quality improvement efforts to diminish.

Eliyahu M. Goldratt (Goldratt, 1990:3-76). Goldratt proposes a way of looking at organizations, determining what to act upon, and attacking problems in his Theory of Constraints. First, he points out that all organizations were created for some purpose, and every action taken by any part of the organization should be judged by its impact on that purpose. Therefore, before we can deal with any problems or the improvement of any subsystem, we must define the goal of the organization and the metrics we will use to assess the

impact of any proposed action on the overall goal. Once this is done, we can move on to a five step process for focusing our attention on the important few things in the organization that really matter.

Step 1: Identify the System's Constraints. A constraint is anything that keeps us from achieving better performance against the organization's overall goal. After the constraints are identified, they should then be prioritized in terms of their impact on the goal.

Step 2: Decide How to Exploit the System's Constraints. By this, Goldratt means to manage all the other elements of the system--the non-constraints--to supply everything the constraints can take, but no more. Since the system's performance versus the organizational goal is limited by the constraints, it makes no sense for the other resources to produce more than the constraints can handle.

Step 3: Subordinate Everything Else to the Above Decision. This step simply means once you decide how to best manage the system to feed the constraints, live by those decisions. Since the constraints limit the organization's performance, concentrate on managing the constraints. Goldratt quickly points out that improvement is not impossible, however. Once the constraints have been identified and the system's elements are set up to feed the constraints, the next step is to reduce the limiting impact the constraints have on the goal.

Step 4: Elevate the System's Constraints. Since the constraints limit performance versus the goal, concentrate on ways to increase the level of activity the constraint can handle. It might mean purchasing another machine, eliminating processing steps, changing a design so that a constraint is no longer needed, or some other such action. The idea is to minimize the limiting effect of the constraint.

Step 5: If in the Previous Steps a Constraint has been Broken, Go Back to Step 1. As Step 4 is proceeding, some constraints may be broken. In other words, a work-around is found or the constraint is elevated to the point where it is no longer constraining the system. Then the process starts all over again as we look for more constraints. Every system has at least one.

To Goldratt, this is the way to achieve continuing improvement. However, continuing improvement means change. As Goldratt points out, any improvement is a change. The Theory of Constraints speaks to the process of continual change, and restates the five steps above in a different way:

Step 1: What to Change? Pinpoint the Core Problems. We must first decide what we should change and what we should leave alone. Goldratt proposes a logic that, rather than relying on examples, relies on the situation itself. This method of proof, called Effect-Cause-Effect,

is used in all hard sciences, and Goldratt believes it can be used to analyze situations and determine core problems.

Step 2: To What to Change To? Construct Simple, Practical Solutions. Goldratt believes core problems are intuitively known by people in the organization, but that the problems still exist because accepted, compromising solutions have not worked. He proposed the Evaporating Cloud method of constructing simple solutions, without compromise. The Evaporating Cloud technique breaks apart the problem and the terminology of the problem to show where established assumptions and ideas were not valid. As the old assumptions and poor terminology are gradually eliminated (evaporated), a simple solution emerges.

Step 3: How to Cause the Change? Induce the Appropriate People to Invent Such Solutions. People resist and fear change because they don't understand it. If they can be led in a way that they invent solutions/improvements for themselves, change will become exciting rather than fearful. Goldratt proposes using the Socratic method to help people to take themselves through the logical paths to a simple solution.

IV. ASD TQM Review and Analysis

As mentioned in Chapter II, the first step in this part of the research is a review of Aeronautical Systems Division (ASD) Total Quality Management (TQM) documents to discover how TQM has been implemented at ASD. We then move to an empirical evaluation of TQM effectiveness within three ASD organizations.

A Brief History

ASD's active involvement in TQM came quickly on the heels of increased Department of Defense (DoD) emphasis on TQM. Presidential Executive Order 12552, signed in February 1986 and revised by Presidential Executive Order 12637 in April 1988, challenged all federal agencies to improve their productivity by three percent per year. Agencies were "required to develop and implement an annual productivity plan and to assess their progress on a yearly basis" (Springs, 1989:1). In March 1988, then Secretary of Defense Frank Carlucci issued the Department of Defense Posture on Quality letter. The letter emphasized the importance of TQM for continuous improvement and as a strategy to meet the President's productivity goals. Secretary Carlucci particularly stressed the importance of TQM in weapon systems acquisition. (Carlucci, 1988).

By the time Secretary Carlucci issued his policy letter, ASD had already taken steps to implement TQM. ASD conducted a source selection in 1987 to select a contractor to train its personnel in TQM. In 1988, The Cumberland Group was awarded the contract. The TQM program established by ASD and The Cumberland Group is described below.

ASD's TQM Philosophy

ASD's desire for change was based on the realization that the same factors at work in private industry driving corporations to improve quality are also at work in the DoD. The shrinking of the defense industrial base, the rise in international competition in defense-related technologies, the future prospects of declining defense budgets, the increasing costs associated with the lack of quality, and the public's apparent growing mistrust of the defense acquisition process all pointed to need for changes in the way the DoD does business. (Aeronautical, 1989:4)

ASD believes TQM is the proper response to these defense challenges.

> TQ combines those elements necessary for a cultural change, and its conceptual tools include an emphasis on quality, customer orientation, and continuous improvement. It requires education of the workforce, and participative involvement of those who will be impacted by these changes. The DOD community has acknowledged both the requirement for, and the value of TQ. (Aeronautical, 1989: 5)

ASD's overall approach to TQM is guided by its vision statement, a statement "of what the organization is, what it is trying to achieve, . . . designed to create a visual image of ASD, its customers, and its suppliers" (Aeronautical, 1989:6). ASD's vision statement is included in Table 4-1.

Table 4-1

The ASD Vision Statement (Aeronautical, 1989:6)

We are the Aeronautical Systems Division, the center of excellence for research, development and acquisition of aerospace systems.

We work together to create quality systems for combat capability to ensure we remain the best Air Force in the world and preserve the American way of life forever.

Along with ASD's vision statement, then ASD Commander, Lieutenant General Mike Loh, established seven principles to "serve as guideposts and benchmarks for measuring success" (Aeronautical, 1989:6). These guiding principles are listed in Table 4-2.

ASD's TQM program strives to incorporate each of a number of quality fundamentals. These fundamentals are believed to be crucial to a well-balanced, complete quality program. They are discussed below:

Conformance to Requirements (Aeronautical, 1989:8). To take the definition of quality from the subjective realm to

Table 4-2

ASD Principles (Aeronautical, 1989:6)

1. *Change the culture - make the Total Quality approach A WAY OF LIFE.*
2. *Know and satisfy our customer's needs.*
3. *Delegate responsibility and authority - accept accountability.*
4. *Give EVERYONE a stake in the outcome.*
5. *Set goals, compete, measure progress, and reward.*
6. *Create a climate of pride, professionalism, excellence, and trust.*
7. *Strive for continuous improvement - make it better.*

the objective domain, ASD defines quality as "conformance to requirements." By implication, the process of setting requirements becomes vital. Therefore, ASD stresses ensuring that requirements are systematically determined, properly agreed upon, coordinated, officially sanctioned, adequate, and necessary. In this way, quality can be measured as conformance (or non-conformance) to stated requirements.

Prevention (Aeronautical, 1989:8). ASD firmly believes that redoing things add costs, not value. Developing a system of defect prevention, rather than defect detection, is considered the best way to produce excellent quality at low cost.

Do It Right the First Time (Aeronautical, 1989:9). Closely related to the first two fundamentals above, this phrase refers to accomplishing correct requirements the first time, thereby linking quality and productivity. ASD advocates perfection, defined as meeting requirements every single time.

Measurement (Aeronautical, 1989:9). ASD's stated purpose for measurement is to facilitate improvement. Before one can improve, however, one must know what needs corrective action. To that end, they advocate measurement in four areas: cost of quality (investment to produce quality versus the costs of poor quality), project measurement (tracking improvement projects), department measurement (measuring the conformance to requirements of the products and services provided by ASD), and culture (tracking the growth of the quality culture at ASD).

Customer/Supplier Partnership (Aeronautical, 1989:9-10). ASD believes that continued improvement requires better relationships and partnerships, both between organizations within ASD and between ASD and its suppliers and customers.

Involvement (Aeronautical, 1989:10). ASD asserts that its people are its most important asset. As such, the greatest potential for improvement will come only when all people are involved in TQM. Active participation of all

employees will provide the greatest opportunities for substantive change.

Continual Improvement (Aeronautical, 1989:10). Success is not the result of complacency. ASD believes that a process of continuous improvement is vital.

ASD's TQM Structure (Aeronautical, 1989:12-13)

At the top level, ASD has two main organizations to aid TQM implementation.

ASD/TQ. This is a small office, headed by a Colonel, responsible for coordinating internal ASD TQM activities, as well as external initiatives with weapon system contractors.

ASD TQ Executive Steering Committee. This committee consists of a cross-section of ASD top management, as well as two members from industry (The National Security Industrial Association), who determine and monitor the ASD vision and overall goals. The committee also promotes a quality culture within ASD and to aerospace defense contractors. Finally, they initiate ASD-wide Critical Process Teams (explained below) and initiate appropriate action based on team recommendations.

Each three-letter organization in ASD has an internal TQM organization like that depicted in Figure 4-1. Although most three-letter organizations are represented on the Executive Steering Committee and ASD/TQ is available to provide training and assistance, the three-letters are given

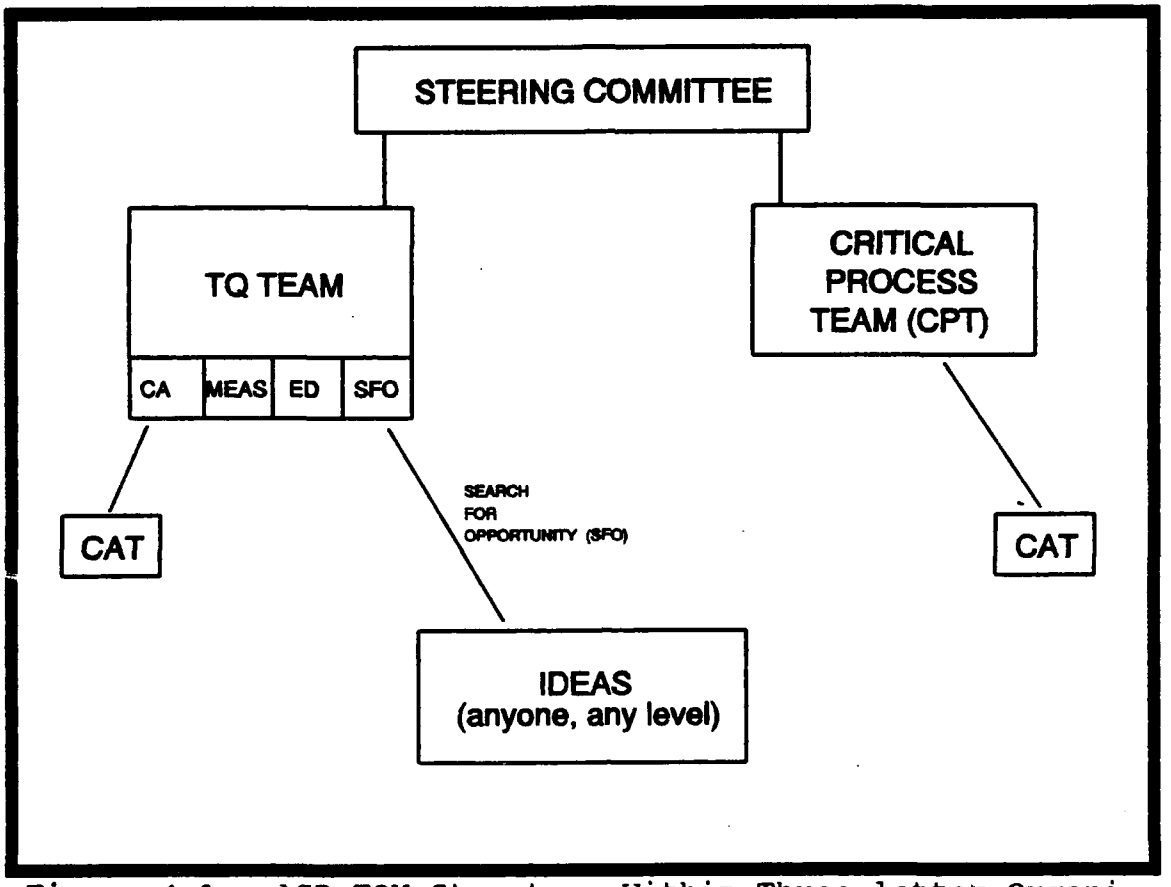

Figure 4-1. ASD TQM Structure Within Three-letter Organizations (Aeronautical, 1989:12)

the latitude to modify the structure of their respective TQM organizations to fit their needs (Ball, 1991).

Steering Committee. This group is made up of the upper management in the organization. They oversee, plan, and guide the TQM activities within the organization. They also determine the organizational vision and overall organizational goals.

TQ Team. This team is responsible for managing the problem solving system. This problem solving system has four separate subsystems.

Corrective Action. This subsystem uses Corrective Action Teams (CATs) to solve problems identified by employees.

Measurement. This subsystem is responsible for determining what can be measured and tracked to gauge progress.

Education. This subsystem publicizes the benefits of the TQM process and educates employees about how to function within the TQM system as set up by the organization.

Search for Opportunities (SFOs). This subsystem uses employee-generated ideas for improving the system. The group in charge of SFOs maintains direct contact with the originator of an idea and the group handling its resolution, ensuring that the idea is fully considered and dealt with.

Corrective Action Teams (CATs). These are ad hoc teams created to address a specific problem. The team leader receives training in problem solving techniques and group dynamics, and the team is handpicked based on the expertise needed to solve the particular problem assigned to the team. After researching the problem, the team recommends a solution to the person or persons with the authority to implement the solution.

Critical Process Teams (CPTs). These teams are generally longer term than CATs, since they specifically address critical processes. These processes typically have a large impact on the organization's performance and influence many different groups and disciplines. A CPT may, in the course of defining and researching a process, establish CATs to work specific, smaller parts of the overall problem process.

ASD TQM Training

ASD provides training to its personnel in a variety of ways. The Cumberland Group was hired to establish the training program and conduct initial surveys of employee opinions about and attitudes toward their respective organizations and missions (Aeronautical, 1989:14). This training is slowly being taken over by ASD employees, although The Cumberland Group still does all the Executive Workshops. Many organizations are creating in-house employee surveys (Ball, 1991).

The training is divided into Executive Workshops (for top leadership of an organization), Management Action Workshops (for middle management), TQ Team Training (for the TQ Team members), Critical Process Team Training, and Corrective Action Team Training. Top and middle management are led through the formulation of organizational visions and goals, as well as the creation of action plans for improvement. The TQ Teams are taught quality fundamentals and how

to create and operate the TQ Team in their organizations. Critical Process Teams are trained in process management, team development, continual improvement methodology, effective meeting skills, and group problem solving techniques and tools. The Corrective Action Team training is for individuals who will lead Corrective Action Teams. They receive training primarily in problem solving techniques. These problem solving techniques include brainstorming, cause and effect diagrams, nominal group technique, check-sheets, graphs, histograms, Pareto diagrams, and process analysis (Aeronautical, 1989:14).

Survey s

This section analyzes the surveys introduced in Chapter II. Conclusions drawn as a result of this analysis are discussed in Chapter V. Figure 4-2, Figure 4-3, and Figure 4-4 show the average responses by question number for the initial surveys in the Advanced Cruise Missile (ACM) System Program Office (SPO) and in ASD Personnel (ASD/DP). For comparison, the average responses from The Cumberland Group's initial ASD-wide survey is included in the figures.

Note that for the most part, all the responses were very similar for most of the questions. This indicates that there were few significant differences between ACM and DP at the start of their TQM training, and that both organizations could be considered typical of ASD at that time. Finally,

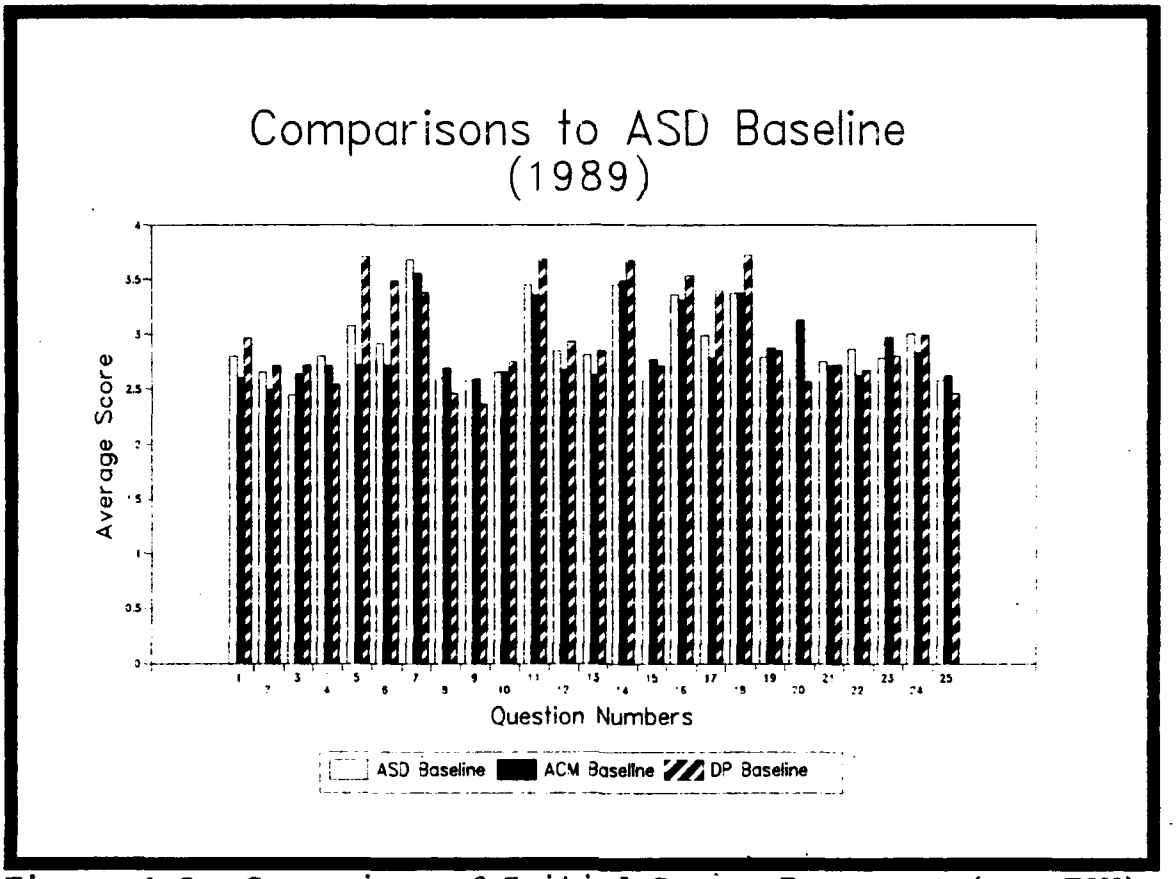

Figure 4-2. Comparison of Initial Survey Responses (pre-TQM), Questions 1-25

note that where DP differs from ASD and ACM, DP is often higher than the ASD and ACM responses. This will be significant later when we look at DP's post-TQM survey results. The F-15 SPO is not included here, since their survey was created internally and is not common to the surveys reviewed here.

Next we turn to an analysis of the changes that occurred in each organization. The initial survey responses were subtracted from the new survey responses to get a net

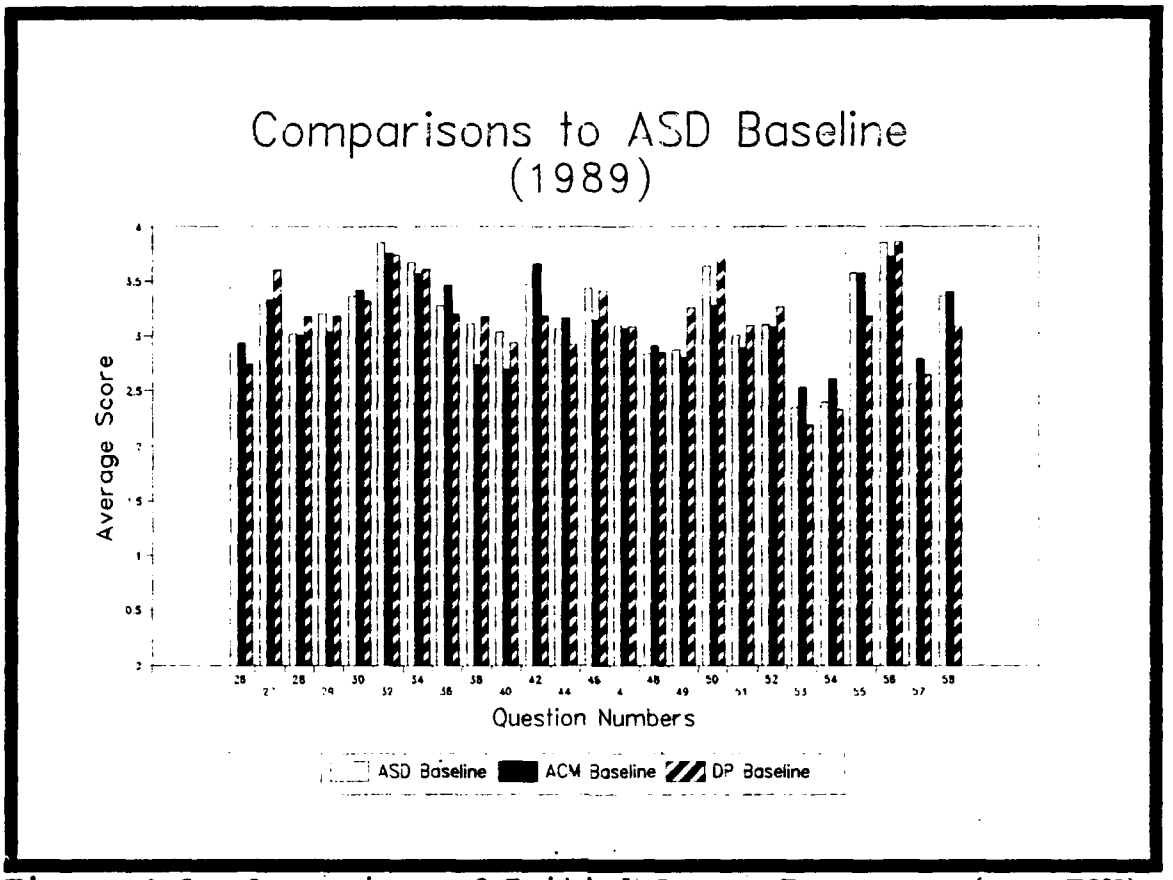

Figure 4-3. Comparison of Initial Survey Responses (pre-TQM), Questions 26-58

decrease or increase, and then the changes were sorted from least (or most negative) to highest.

The ACM SPO is shown in Figure 4-5. Notice that there is a definite positive, improving trend. The lines at positive and negative .25 indicate The Cumberland Group's criteria for a statistically significant change. Given this criteria, it's apparent that several questions experienced statistically significant improvement, while only two sig-

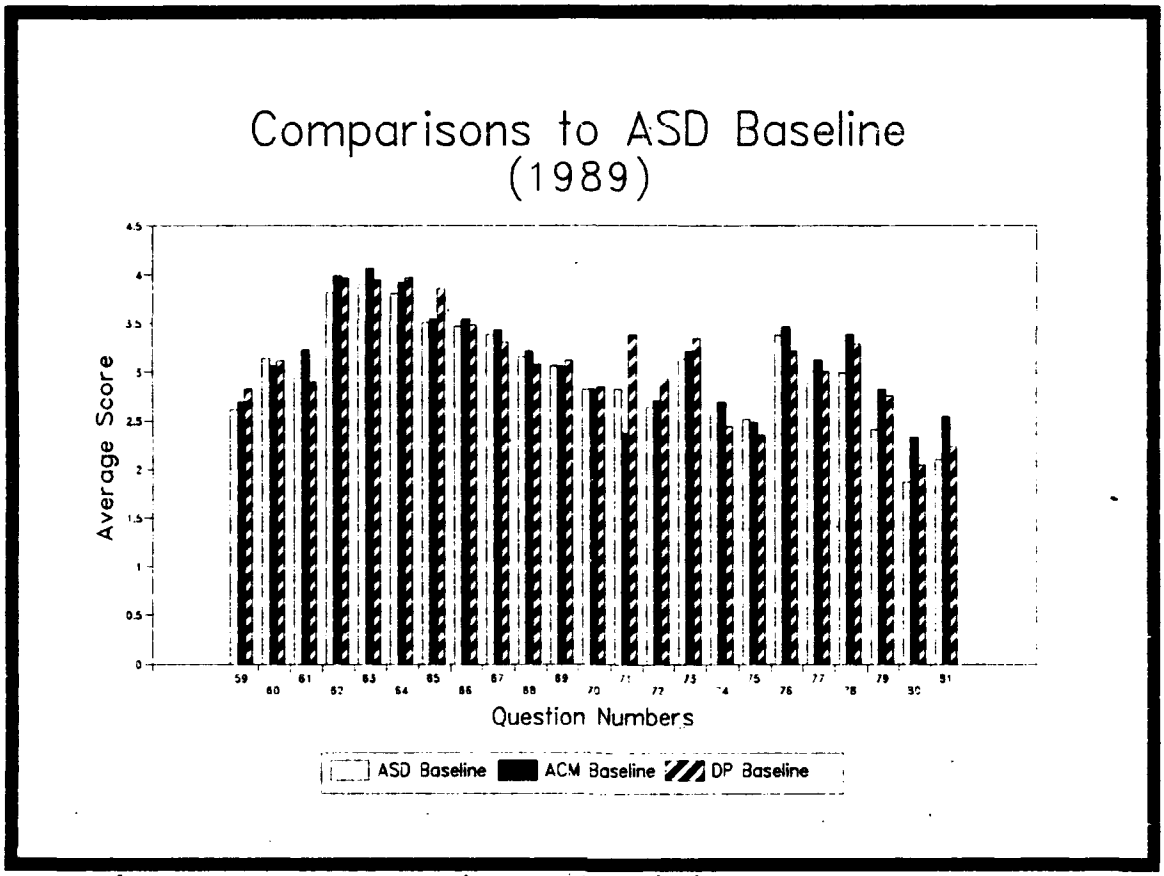

Figure 4-4. Comparison of Initial Survey Responses (pre-TQM), Question 59-81

nificantly declined (and both of these were opinion questions about the survey instrument itself).

ASD/DP is shown in Figure 4-6. DP seems to have experienced just the opposite results from ACM. Here we see no significant improvements, many significant declines, and a definite downward trend in people's opinions and attitudes about the organization.

The F-15 SPO is shown in Figure 4-7. We cannot assume The Cumberland Group's criteria for statistically significant change applies to the F-15 internal survey. The F-15

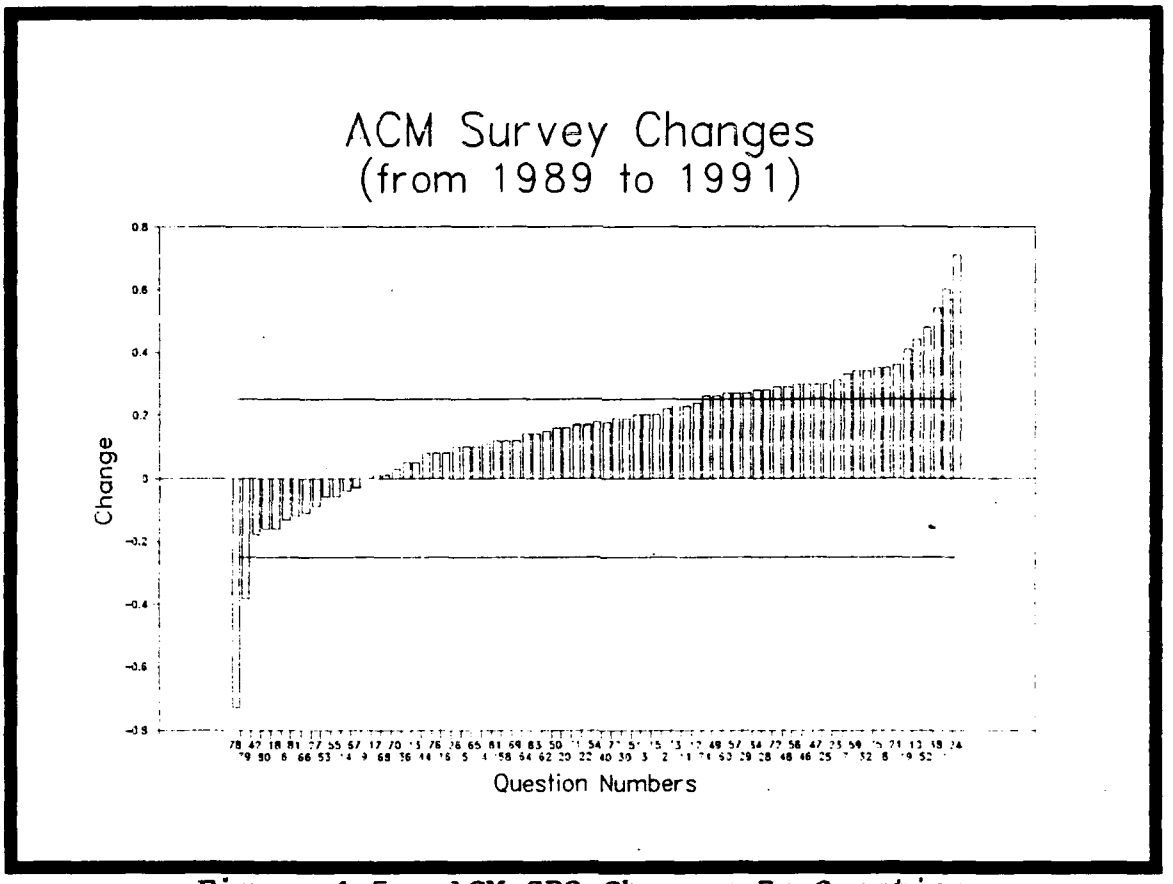

Figure 4-5. ACM SPO Changes By Question

instrument has not been tested for construct validity or reliability, and it has not been administered to a large group of people like The Cumberland Group's survey. So, a different, more conservative criterion for significant change was needed. In other words, we would expect greater variability in responses for the F-15 survey, so we would expect a significant change to be much greater than the .25 criteria used for The Cumberland Group Survey. Accordingly, a very conservative criterion was used. Only questions that

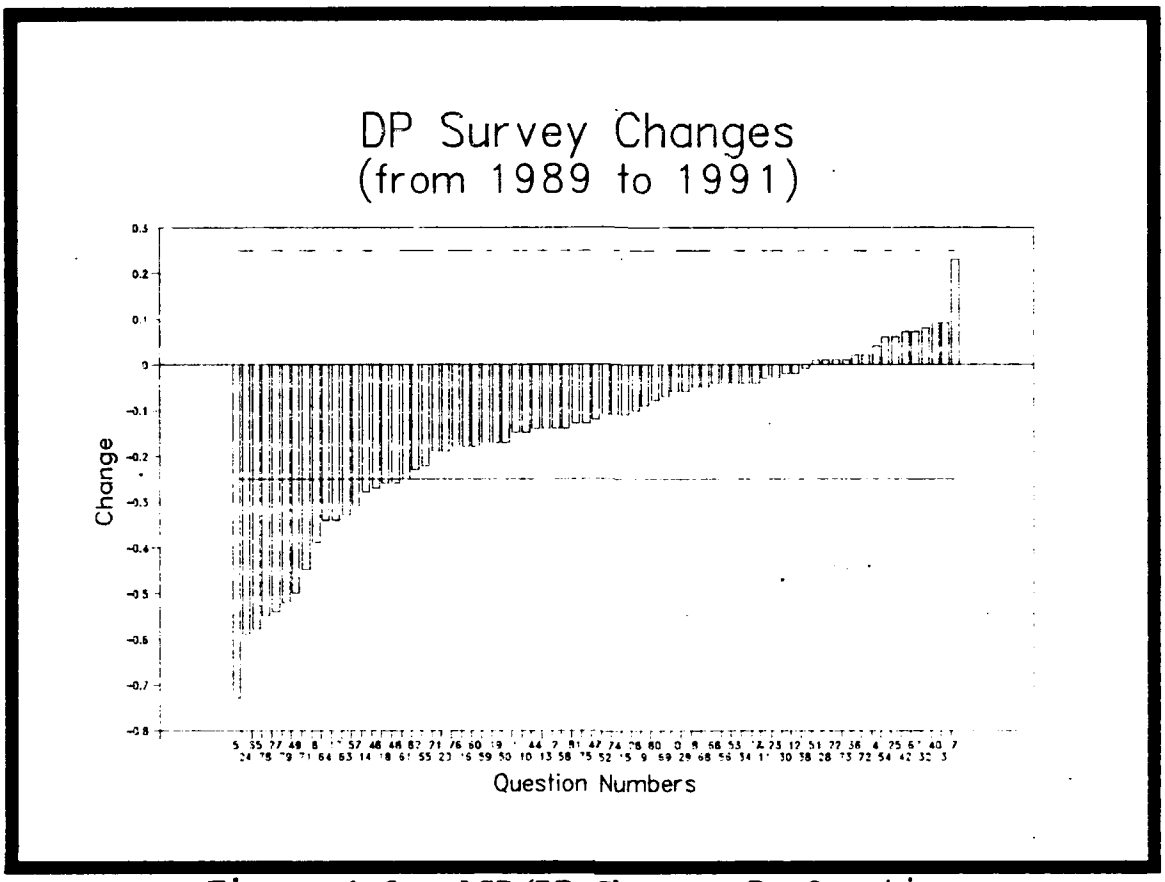

Figure 4-6. ASD/DP Changes By Question

fell in the bottom and top ten percent of the range of changes were considered significant. Said another way, when the questions were arranged in order from largest negative change to largest positive change, only the questions falling at or below the tenth percentile and those questions falling at or above the ninetieth percentile were considered to have significantly changed. It appears from Figure 4-7 that this criterion for significance is sound, as it clearly separates the questions with the largest change from the

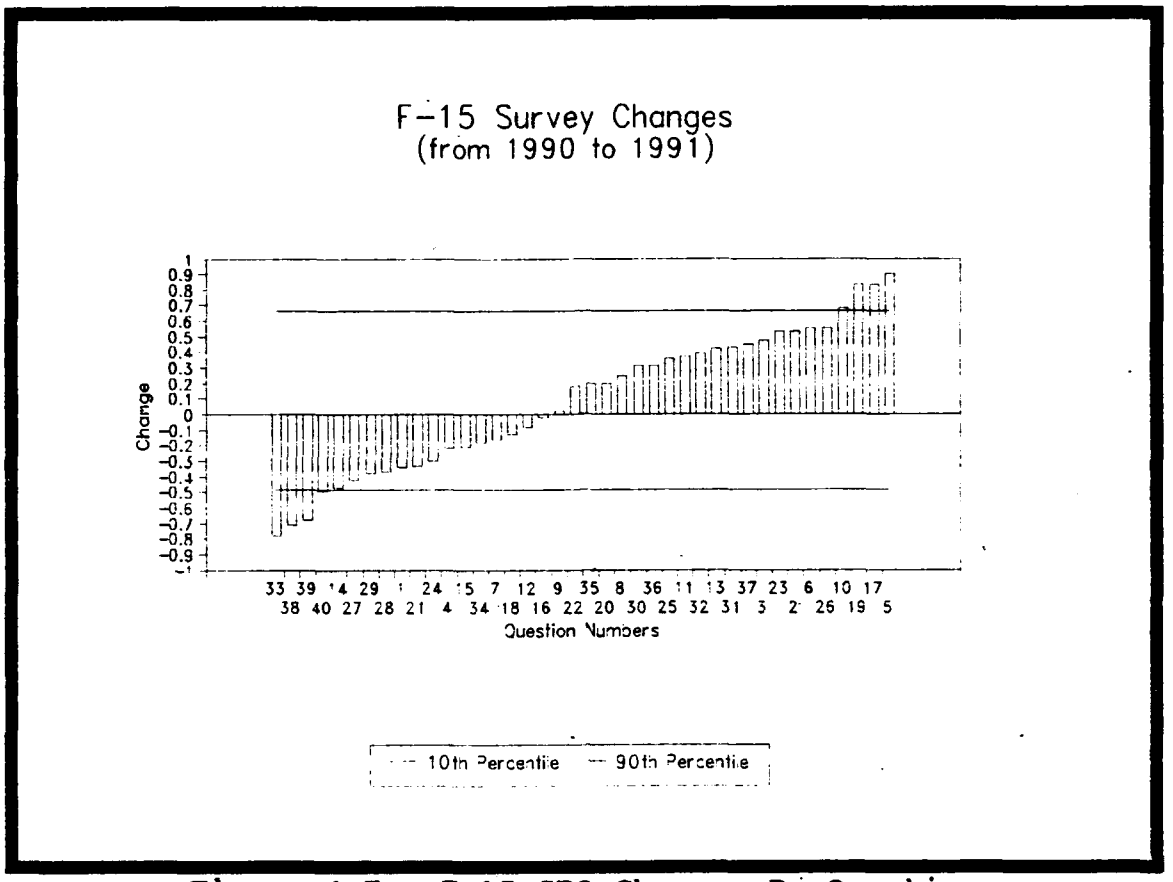

Figure 4-7. F-15 SPO Changes By Question

bulk of the data. Therefore, it seems the F-15 experience was basically a neutral one, with an almost symmetric distribution of questions distributed around zero (no change). However, it is important to remember that the recorded changes for the F-15 SPO occurred over a one year period, versus two years for ACM and DP.

Finally, we look at the changes by question category. Figure 4-8 displays the number of questions in each category that improved significantly, as well as the number of ques-

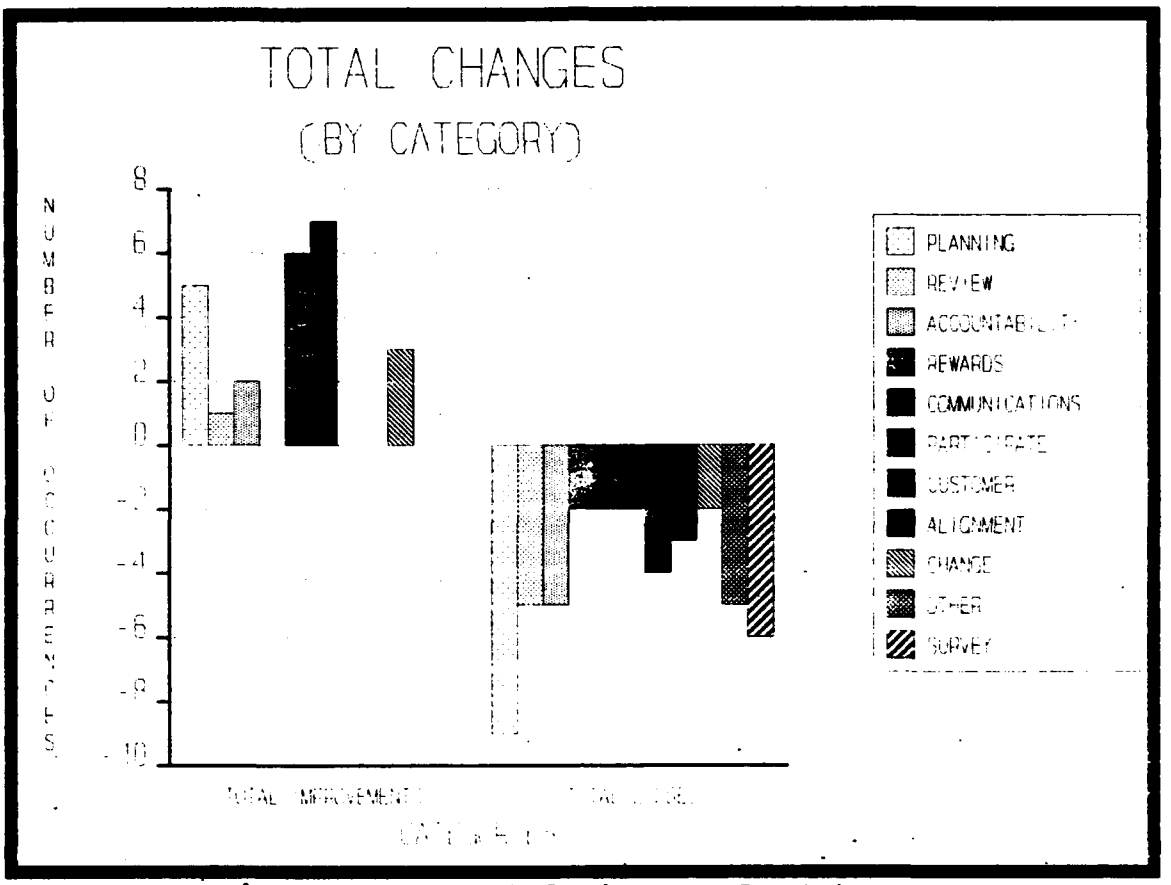

Figure 4-8. Total Changes By Category

tions in each category that declined significantly. Figure 4-9 then summarizes by showing the net number of questions that significantly improved or declined by category. Note that this figure shows the net changes first with DP's results included, and then without DP's results. This was done to determine if overall trends were adversely influenced by DP's low scores and declining trends.

Notice that communications and participative management are the only areas that showed significant net gain. Cate-

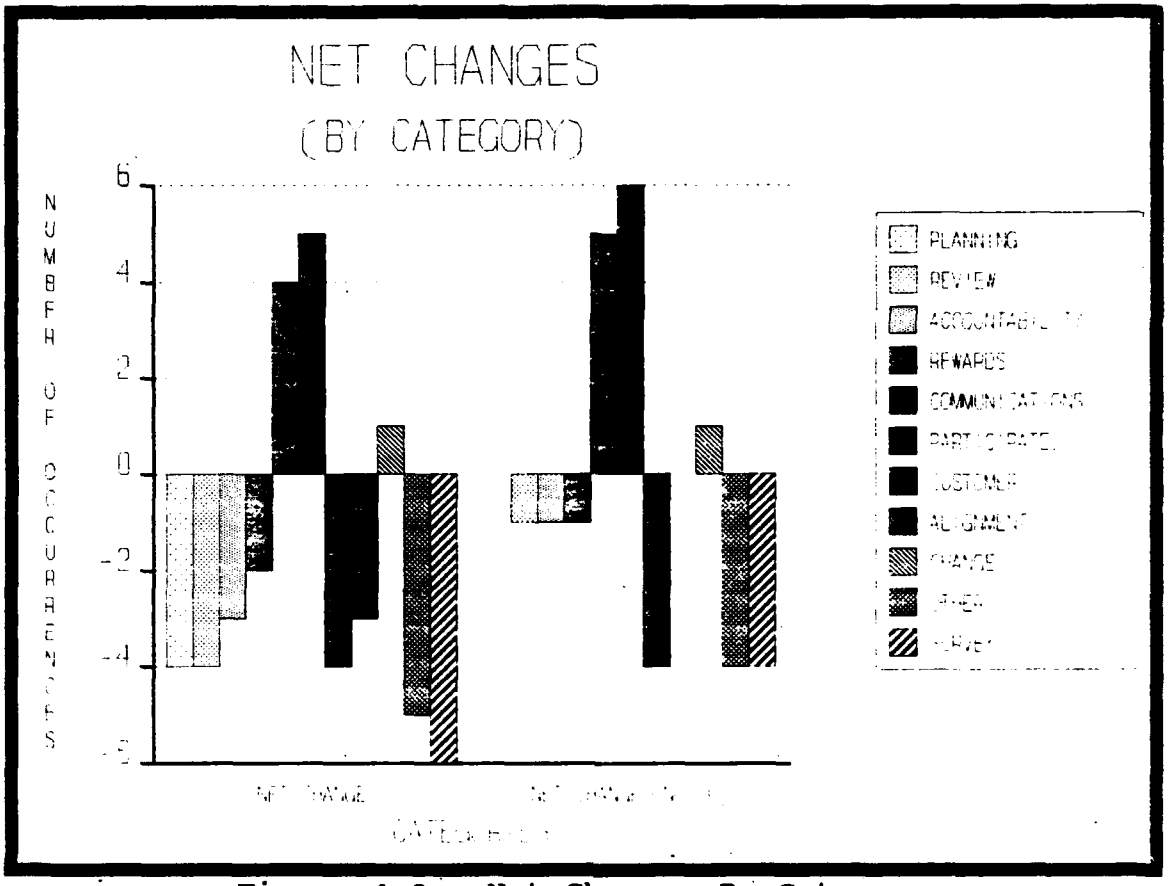

Figure 4-9. Net Changes By Category

gories that appear to have declined are alignment with the organizational mission, opinions about the survey instrument itself, and other areas (see questions in Appendices A and B listed in the "other" category).

Semi-structured Interview Results

As discussed in Chapter II, only trends emphasized by most respondents were considered worthy of reporting in this study. There were two such areas:

Variable Management Commitment. Respondents from different organizations had different impressions of the amount of management commitment, and a few organizations are known for their management commitment to TQM. The trend was toward lower levels of management commitment, however, as evidenced by the second are below.

Quality Lower Priority Than Meeting Schedules and Deadlines. The opinion was common that despite TQM, there is often little upper management support for delaying work to ensure a quality product. When suspenses and other pressures are brought to bear, many claim that they feel the old, familiar pressure to put out the fire, regardless of the long-term implications.

V. Conclusions and Recommendations

After reviewing the TQM literature, examining ASD's TQM organization and training program, and analyzing changes in three ASD organizations during TQM implementation, the following conclusions are suggested.

Conclusions

Aeronautical Systems Division's (ASD) Total Quality Management (TQM) program appears to be primarily an effort to establish quality circles and an enhanced suggestion program within the various three-letter organizations. Other quality activities ASD is attempting with industry are beyond the scope of this work, which focuses on the impact of TQM on the ASD organizations. As such, there appears to be evidence that ASD's TQM structure and process improves communications both inside the individual organizations and between organizations, as well as participative involvement of ASD personnel. ASD's TQM program is still relatively young, and these improvements are commendable.

However, it is discouraging to see practically no substantial improvement in other important areas; like planning, review, accountability, and customer focus. It is also alarming to see that in certain cases, TQM may be associated with digression in an organization (e.g. ASD

Personnel, ASD/DP). DP's TQM Chairperson, Ms. Maggie Grace, said that DP and The Cumberland Group felt the decline in many areas may have been the result of heightened expectations for the organization in a TQM environment, and that they were encouraged that they had improved in specific areas they had emphasized, such as communications and recognition/rewards. Ms. Grace could offer no other explanation for the decline (change in top management or large organizational turmoil, for instance) (Grace, 1991). However, the data simply does not support the assertion that DP experienced any statistically significant improvement on any one question (using The Cumberland Group's definition of significance), much less an entire category.

Perhaps the flexibility given to each ASD organization in tailoring its own TQM program partially explains the wide disparity of results between the Advanced Cruise Missile (ACM) System Program Office (SPO) and DP. There certainly does not appear to be strong control or direction coming from top management at ASD to the three-letter organizations. For example, ASD/TQ, the office set up to implement and coordinate ASD's TQM program, appears to have very little knowledge of exactly what individual organizations are doing nor how they are doing with their TQM implementation.

As stated in Chapter II, in looking through ASD/TQ's files, only a handful of surveys or other measurement

instruments was found, with very little information on activities within the organizations. In fact, with a few notable exceptions, there is a lack of useable metrics to track progress across organizational lines or within individual organizations.

Concerning ASD's training program, it is well-grounded in group dynamics and quality improvement theory, yet it provides only elementary tools. No evidence was found indicating more advanced statistical training was being offered. Control charts and their use were not addressed in the training literature. Without an understanding of the type of variation leading to problems, management's attempts at corrective actions could make the variation and the problem worse. This follows Deming's comment that management must understand the underlying causes of variation before acting.

Finally, two things stood out in the semi-structured interviews with several ASD personnel involved in TQM. First, it is apparent that top management's involvement in and support of TQM varies drastically from organization to organization. The literature is absolutely adamant that substantive quality improvement will only come if commitment to improvement starts at the top. The reason is simple: most quality problems result from characteristics of the process or system, or common variation. Management is the only group that can adequately address these concerns.

Secondly, the opinion is widely held that despite TQM, there is often little upper management support for delaying work to ensure a quality product. When suspenses and other pressures are brought to bear, many claim that they feel the old, familiar pressure to put out the fire, regardless of the long-term implications.

Still, ASD's TQM program is an obvious step in the right direction. Wide-spread training in elementary process analysis and quality improvement techniques, combined with a system for employee suggestions that actively tracks each suggestion to resolution, is a good, healthy start. But it must not stop there.

Three of Deming's seven deadly diseases point to areas that may easily have more lasting effects on the quality of ASD's work in the future than the areas addressed so far. Only top management can effectively address them.

Emphasis on Short Term & Lack of Long-range Planning. The military acquisition system is filled with incentives for short-term thinking and dis-incentives for long-term thinking. From Congressional resistance to multi-year funding to the pressures for concurrency, rarely does the acquisition officer have time to simply plan the best, long-term course of action. The next factor exacerbates the problem even more.

Merit Rating Systems and Annual Evaluation of Performance. As discussed earlier in Chapter III, Deming asserts

the annual rating of performance kills teamwork and ensures people will emphasize short-term thinking. If you know you will be rated against your peers within the next year, the pressure is on you to do something--anything--to stand out from the crowd. And if this isn't enough, the next factor almost ensures that long-term planning that is in the best interests of the overall organization will not take place.

Mobility of Management. Military budget cuts may do more to help this problem than anything else. However, local commanders still have the option of moving people frequently between jobs at a single operating location, like ASD. Anyone that has worked in a SPO for any length of time knows that the "going-away luncheon" is a very common occurrence. Even with Permanent Change of Station assignment frequencies significantly diminished due to limited travel budgets, movement between jobs at ASD could continue unabated. In the author's opinion, SPOs are typically very different, almost to the point of being independent companies. Contract structures and clauses are different, contractors are different, external organizational interfaces are different; causing each SPO to develop its own personality and culture. In many cases, it takes at least twelve to eighteen months to become familiar enough with all the nuances of a new organization to begin to make a truly substantive contribution. With this background, its apparent that moving people freely between SPOs every two to

four years may not be wise. While having a variety of jobs within the same SPO could be beneficial, shuffling people frequently between programs would appear to feed inefficiency and practically guarantee quality problems.

Ideas for Future Research

Much work needs to be done in designing reliable metrics for the SPO and support environments. Work in developing and validating such measures could go a long way in diagnosing the progress of ASD's TQM program. A particular measure of interest is the level of quality commitment within an organization, particularly the management of the organization.

Also, more detailed work could certainly be done in collecting and analyzing existing information, involving many more ASD organizations than were included in this study. It may be difficult, however, to locate and combine all the different organizational measures into a valid, ASD-wide tool to gauge progress.

In addition, research into how ASD is pursuing quality initiatives with defense contractors and integrating quality initiatives with Federal Acquisition Regulation requirements could be of value.

Finally, research that attempts to expand the use of statistical process control charts to the office environment could be fruitful in determining special and common causes

of variation is the day-to-day work in the SPO or support environment.

Final Remarks

ASD has taken a large, sincere step in the right direction to improve the quality of ASD's work. However, much remains to be done.

Stronger leadership from top management should ensure that all organizations take TQM seriously, and that means supporting slipped suspenses and program dates when necessary to guarantee a quality product. In addition, it may mean providing more structure for the TQM program within organizations. This study's results indicate, with the wide disparities between ACM's improvement and DP's decline, that the "same" program applied in very similar organizations at the outset may produce drastically different results. It may even do harm. If this is true, part of the solution may be to take some of the flexibility out of the hands of the three-letter organizations. Applying a quality improvement program poorly may be worse than having no program at all.

Finally, expanded use of statistical process control charts, where applicable, should be pursued. This simply follows Deming's assertion that unless the variability of a process in understood, management does not truly know what to do. In fact, the results of misplaced action could feed variation instead of improving the process.

Appendix A. The Cumberland Group Survey Questions

Questions 53, 54, and 77 are phrased such that the higher the score, the lower the satisfaction. In the data analysis in Chapter IV, the scores on these questions were inverted about the median to make it easier to sort responses graphically. In addition, selected questions ask the respondent to rate how he/she *would like* the organization to be. These questions were not used in the data analysis in Chapter IV.

The rating key used by respondents was as follows:

To a very little extent	1.0
To a little extent	2.0
To some extent	3.0
To a great extent	4.0
To a very great extent	5.0

#	*CATEGORY*	*QUESTION TEXT*
1.	Planning	To what extent are there specific goals or targets for quality improvement in this organization?
2.	Planning	To what extent does your work group have specific, measurable goals for improvement?
3.	Participative Involvement	To what extent are you asked for your thoughts/ideas on how to improve quality?
4.	Review	To what extent are you aware of the cost of defective work in your department?
5.	Review	To what extent is your work measured against specific performance standards?
6.	Review	To what extent is your work measured against specific quality standards?

#	CATEGORY	QUESTION TEXT
7.	Participative Involvement	To what extent do you feel free to suggest changes that would allow you to perform your job more effectively?
8.	Participative Involvement	To what extent do changes occur as a result of your suggestions?
9.	Planning	To what extent do different departments/units plan together and coordinate their efforts?
10.	Accountability	To what extent does this organization respond to employee concerns about quality?
11.	Accountability	To what extent does this organization respond to customer concerns about quality?
12.	Communications	To what extent are you told what you need to know to do your job the best possible way?
13.	Communications	To what extent do you get adequate feedback about how you are doing in your job?
14.	Rewards	To what extent is doing the job right the first time more important than just getting it done?
15.	Rewards	To what extent does this organization reward people for doing a quality job?
16.	Review	To what extent is doing quality work important in the appraisal of your performance?
17.	Accountability	To what extent are people in this organization held accountable for producing quality work?
18.	Accountability	To what extent are you held accountable for producing quality work?
19.	Planning	To what extent does this organization have clear-cut, reasonable goals and objectives?

#	CATEGORY	QUESTION TEXT
20.	Participative Involvement	To what extent does this organization have a real interest in the welfare and satisfaction of those who work here?
21.	Other	To what extent is this organization generally quick to use improved work methods?
22.	Planning	To what extent are work activities sensibly organized in this organization?
23.	Participative Involvement	To what extent are people above your supervisor receptive to suggestions and ideas coming from subordinates?
24.	Planning	To what extent are the equipment and resources you have to do your work with adequate, efficient, and well-maintained?
25.	Participative Involvement	When decisions are made, to what extent are the persons affected asked for their ideas?
26.	Participative Involvement	In this organization, to what extent are decisions made at those levels where the most adequate and accurate information is available?
27.	Planning	To what extent do you understand how your department/unit's goals fit in with the total organizations's goals?
28.	Planning	To what extent have you received the training you need to perform well in your job?
29.	Review	To what extent are your skills and abilities being used?
30.	Participative Involvement	To what extent is your supervisor receptive to suggestions and ideas from your work group?
31.	Participative Involvement	To what extent would you like your supervisor to be receptive to suggestions and ideas from your work group?

#	CATEGORY	QUESTION TEXT
32.	Participative Involvement	How approachable is your supervisor?
33.	Participative Involvement	How approachable would you like your supervisor to be?
34.	Review	To what extent does your supervisor maintain high standards of performance?
35.	Review	To what extent would you like your supervisor to maintain high standards of performance?
36.	Participative Involvement	To what extent does your supervisor encourage the persons who work for him/her to work as a team?
37.	Participative Involvement	To what extent would you like your supervisor to encourage the persons who work for him/her to work as a team?
38.	Review	To what extent does your supervisor provide help, training, and guidance so that you can improve your performance?
39.	Review	To what extent would you like your supervisor to provide help, training, and guidance so that you can improve your performance?
40.	Communications	To what extent is your supervisor helpful in counseling you about your performance?
41.	Communications	To what extent would you like your supervisor to be helpful in counseling you about your performance?
42.	Accountability	To what extent do persons in your work group maintain high standards of performance?
43.	Accountability	To what extent would you like persons in your work group to maintain high standards of performance?
44.	Participative Involvement	To what extent do persons in your work group work toward team goals?

#	CATEGORY	QUESTION TEXT
45.	Participative Involvement	To what extent would you like persons in your work group to work toward team goals?
46.	Communications	To what extent is information about important events and situations shared within your work group?
47.	Planning	To what extent does your work group plan together and coordinate its efforts?
48.	Planning	To what extent does your work group plan and coordinate work activities effectively with other related work groups?
49.	Planning	To what extent are the performance goals of your work group clearly defined?
50.	Communications	To what extent have you made your product/service requirements clear to the suppliers of products/services to your work group?
51.	Review	To what extent have the suppliers of products/services to your work group complied with your product/service requirements?
52.	Accountability	To what extent does this organization try to improve quality?
53.	Review	To what extent does this organization get bogged down in a lot of "red tape"?
54.	Review	To what extent do you get hemmed in by long standing rules and regulations?
55.	Other	To what extent are the people in your department/unit receptive to the introduction of new technology?
56.	Rewards	To what extent is producing a quality product/service for our customers important in this organization?

#	CATEGORY	QUESTION TEXT
57.	Participative Involvement	To what extent does this organization encourage reasonable risk taking to improve performance?
58.	Participative Involvement	To what extent are you allowed to make decisions affecting how you do your job?
59.	Communications	To what extent is information about the level of quality performance communicated within your organization?
60.	Other	To what extent are you satisfied with your job?
61.	Other	To what extent are you satisfied with this organization?
62.	Alignment	To what extent are you aware of your organization's mission?
63.	Alignment	To what extent do you agree with your organization's mission?
64.	Alignment	To what extent do you understand your organization's mission?
65.	Alignment	To what extent do you think attention to the mission will improve performance in your organization?
66.	Customer Focus	To what extent is your work group's relationship with your internal customers cooperative?
67.	Customer Focus	To what extent is your work group's relationship with your internal suppliers cooperative?
68.	Customer Focus	To what extent are activities effectively coordinated between your work group and your internal customers?
69.	Customer Focus	To what extent are activities effectively coordinated between your work group and your internal suppliers?
70.	Customer Focus	To what extent does your department receive constructive feedback from internal customers and suppliers?

#	CATEGORY	QUESTION TEXT
71.	Review	To what extent does your department have work standards or other criteria which enables measurement of performance?
72.	Review	To what extent is your department receptive to having its performance measured by its internal customers/suppliers?
73.	Review	To what extent would your department benefit from having its performance measured by its internal customers/suppliers?
74.	Readiness for Change	To what extent are innovation and risk taking encouraged in this organization?
75.	Readiness for Change	To what extent is the job you have now free from a lot of "red tape" in getting things done?
76.	Readiness for Change	To what extent are you encouraged to show initiative and exercise judgment?
77.	Readiness for Change	To what extent is higher management resistant to change?
78.	Survey Reactions	To what extent is filling out this survey a good way for employees to let management know what they think?
79.	Survey Reactions	To what extent do you think that improvements can occur as a result of this survey?
80.	Survey Reactions	To what extent have improvements occurred as a result of previous surveys?
81.	Survey Reactions	To what extent are the results from surveys such as this used constructively in this organization?

Appendix B. The F-15 SPO Survey Questions

Respondents rated each question with an integer value on a scale of 1 to 10, with 1 representing "Very Bad or Not At All" and 10 representing "Very Good or All The Time."

#	*CATEGORY*	*QUESTION TEXT*
1.	Readiness for Change	To what extent is it important to you that we in VF[1] be able to improve the way we do things?
2.	Readiness for Change	To what extent does VF appear quick to use improved work methods?
3.	Participative Involvement	To what extent are your proposals accepted when you propose a better way to do something?
4.	Review	To what extent does it appear that your supervisors want to help you succeed in your job?
5.	Readiness for Change	To what extent is VF open to change?
6.	Communications	To what extent are the people who receive your reports, briefings, letters, studies, etc. happy with your work?
7.	Alignment	To what extent are you aware of what the Air Force pays VF to do?
8.	Alignment	To what extent does VF do the job the Air Force pays it to do?
9.	Alignment	To what extent do you clearly understand your department's mission?
10.	Planning	To what extent is duplication of effort avoided in VF?
11.	Accountability	To what extent is the work you originate done right the first time?

[1] ASD/VF is the office symbol of the F-15 SPO.

#	CATEGORY	QUESTION TEXT
12.	Rewards	To what extent is the work you originate accepted "as is" the first time you submit it?
13.	Accountability	To what extent is other peoples' work done right the first time?
14.	Planning	To what extent do you have clear cut and reasonable goals established in your department?
15.	Participative Involvement	To what extent do you feel you're part of a team in your department?
16.	Planning	To what extent are you provided with the resources you need to do your job right?
17.	Communications	To what extent are communications within VF effective and sufficient?
18.	Planning	To what extent do VF people/departments work well with each other?
19.	Participative Involvement	To what extent are VF people asked for their input on VF decisions that will affect them?
20.	Rewards	To what extent does doing your job well lead to recognition and respect?
21.	Participative Involvement	To what extent does your supervisor encourage exchange of ideas and opinions?
22.	Participative Involvement	To what extent does your supervisor use group meetings to solve problems?
23.	Communications	To what extent is communication within your office effective?
24.	Communications	To what extent are your supervisor's instructions adequate to enable you to meet his/her expectations?
25.	Planning	To what extent are work activities sensibly organized in your office?

#	CATEGORY	QUESTION TEXT
26.	Communications	To what extent do you get adequate constructive feedback about how you are doing in your job?
27.	Planning	To what extent does your work contribute to the VF mission?
28.	Other	To what extent are you satisfied with your job?
29.	Readiness for Change	To what extent do you think the Front Office Group (FOG)[1] supports TQ?
30.	Readiness for Change	To what extent do you think the 3 Letter directors support TQ?
31.	Readiness for Change	To what extent do you think the 4 Letter supervisors support TQ?
32.	Planning	To what extent are Operating Instructions[2] and regulations followed?
33.	Communications	To what extent are you aware of your job description and expectations?
34.	Communications	To what extent does what you actually do match your job description?
35.	Review	To what extent is your job performance accurately measured?
36.	Planning	To what extent do meetings you attend start and end on time?
37.	Planning	To what extent are meetings you attend effective?
38.	Planning	To what extent are meetings you attend necessary?
39.	Other	To what extent is your knowledge of TQ effective/necessary?

[1] The Front Office Group, or FOG, is the commander of the SPO (a colonel) plus his deputy and assistant program directors.

[2] Operating Instruction are typically internal procedures developed inside the SPO.

#	CATEGORY	QUESTION TEXT
40.	Other	To what extent do you believe that TQ is making real and lasting changes for the better in the way VF business is conducted?

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Vita

Captain Mark D. Caudle was born on 7 May 1962 in Elkin, North Carolina. He graduated Salutatorian of Alleghany High School class of 1980, and then matriculated at the University of North Carolina at Chapel Hill. While there, he enrolled in the Air Force Reserve Officer Training Corps on scholarship. He graduated in December 1984 with a Bachelor of Arts Degree in Mathematics, and was commissioned in January 1985. He was assigned to the Deputy for Airlift and Flight Trainer Systems at Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, in February 1985, where he served as a program analyst. After working a variety of programs there, he was transferred to the C-17 System Program Office (SPO). Later, he was assigned to the Advanced Cruise Missile SPO as the project officer for all mission critical computer resources on the missile. He was a distinguished graduate of Squadron Officer School in February 1990, and he entered the School of Systems and Logistics at the Air Force Institute of Technology in May 1990. Captain Caudle and his wife, Deanne, have two children: Catherine, age 3; and Stephanie, age 8 months.

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13. ABSTRACT *(Maximum 200 words)*
This study investigated the major schools of thought on various aspects of quality management and quality improvement. Areas covered included definitions of waste and quality, views on the cost of quality, tools and techniques used for quality improvement, and management philosophies and frameworks for continuous improvement. In addition, this study analyzed the structure and training content of the current Total Quality Management program at Aeronautical Systems Division (ASD). Pre-and post-test surveys on employee attitudes toward organizational effectiveness were analyzed from the Advanced Cruise Missile System Program Office (SPO), the F-15 SPO, and the ASD Deputy Chief of Staff for Human Resources (ASD/DP). Data was supplemented with semi-structured, personal interviews with ASD personnel involved in TQM. Survey analysis showed that the ACM SPO significantly improved, ASD/DP significantly digressed, and the F-15 SPO remained basically consistent. This led to the conclusion that ASD allows too much flexibility in the implementation of TQM in the three-letter organizations. This conclusion was supported by the personal interviews, which revealed a disparity in the amount of commitment to TQM between organizations and a basic lack of support for emphasizing quality over deadlines and suspenses.

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