CANADIAN AEROSPACE INDUSTRY

HANDBOOK ON

TOTAL QUALITY MANAGEMENT

AIAC
Aerospace Industries Association of Canada / Association des industries aérospatiales du Canada

Industry Canada Industrie Canada

"You don't have to do these things. Survival is not compulsory."

W. Edwards Deming

HANDBOOK ON TOTAL QUALITY MANAGEMENT

CANADIAN AEROSPACE INDUSTRY

Aeronautics Branch
Manufacturing and Processing Industries
Industry Canada

November 1993

ACKNOWLEDGMENTS

Many people took part in the preparation of this handbook. It is the result of close cooperation between members of the Total Quality Committee of the Aerospace Industries Association of Canada (AIAC), other members of the AIAC and the Aeronautics Branch of Industry Canada. The handbook evolved as part of the action plan resulting from a previous joint project in which aerospace companies were surveyed to assess their TQM needs and current progress.

The government project director was Roger Saberton, Director, Propulsion and Aircraft Systems Directorate, Aeronautics Branch, Industry Canada, and the industry project director was Stuart Alexander, Director of Corporate Programs, Spar Aerospace, and Chairman of the AIAC Total Quality Committee. Bob Atkinson of the Aeronautics Branch of Industry Canada was the project coordinator.

The industry contributors who took time to provide valuable input and advice during development of the handbook are as follows:

Stuart Alexander, Spar Aerospace Limited
Peter Boag, Aerospace Industries Association of Canada
Peter Broadhurst, Litton Systems Canada Limited
Terry Brooks, Canadair Aerospace Group
René Deland, Bell Helicopter Textron
Alan Duffy, Productivity Improvement Centre, Durham College
Julius Gabriel, Spar Aerospace Limited
Bob Hamaberg, Standard Aero Limited
Peter Holt, Paramax Systems Canada Inc.
Ken Kivenko, AlliedSignal Aerospace Canada
Ian Leishman, Orenda Division, Hawker Siddeley Canada, Inc.
George Lie, General Electric Aircraft Engines Ltd.
Jeff Pritchard, Vac-Aero International Inc.
Ross Pritchard, Vac-Aero International Inc.
Peter Rethazy, AlliedSignal Aerospace Canada
Susan Sande, Paramax Systems Canada Inc.

We would also like to thank the following individuals/companies who provided case studies demonstrating how TQM principles and methods are successfully being applied by Canadian aerospace companies:

Ken Kivenko, AlliedSignal Aerospace Canada
René Deland and *Elizabeth Busse*, Bell Helicopter Textron
Ian Leishman, Hawker Siddeley Canada, Inc., Orenda Division,
Larry McHenry and *Lennox Vaillancourt*, Haley Industries Limited
Steven Petgrave, Litton Systems Canada Limited
Charlie Mason, Menasco Aerospace Limited
Peter Holt, Paramax Systems Canada Inc.
Bill Beckett, Pratt & Whitney Canada
Magued Iskander, Spar Aerospace Limited
Brian Lanoway, Standard Aero Limited

A special note of thanks to Alan Underdown of A. Underdown & Associates who had the difficult task of bringing it all together. He achieved remarkable success.

Typesetting of the manuscript was done by Susie Simpson of the Aeronautics Branch of Industry Canada. Her expert capabilities and diligence are well reflected in the final product.

Credit is also given to Catherine Brieger and her staff in the Communications Branch of Industry Canada for editing and proofreading the final manuscript.

CONTENTS

PREFACE

Quality is one of the most important strategic issues facing Canadian industry in the 1990s. Arguably, it is the most important. It is no longer business as usual, the norm is no longer acceptable quality, it is superior quality. Quality is an entry ticket to the global market. Companies that refuse to accept this premise are unlikely to survive this decade.

Dramatic quality and productivity improvements are possible through the proper application of the principles of Total Quality Management (TQM). Your competitive position depends upon achieving similar quality gains as your competitors and it is a moving target as these competitors continuously improve what they do. TQM is not a quick one-time fix, it requires patience, time, and commitment. Companies have to actively embrace TQM. Passive acceptance is not enough. Company management must become leaders of the process, they must demonstrate their commitment through actions, not just words. Everyone in the company must understand that TQM can make a difference, that it can make an improvement in their lives. They have to understand what their role is in the process. Management and employees can then work together to continually improve the way the company does business and really make TQM work.

This handbook is about understanding TQM. There are many fine books on TQM on the market today. Many of these books deal with the various aspects of TQM in far greater detail than this handbook. But the intent of this handbook is not to provide a rigorous analysis of the principles of TQM, rather it is to provide an overview of these principles and then link them to the company's operation by providing examples and case studies which clearly demonstrate how the principles are applied. The handbook was written for the aerospace industry and is based upon extensive input by aerospace sector companies.

This initiative is an excellent example of industry and government working together to enhance the productivity, product quality, and general competitiveness of Canadian industry. All concerned with its production hope readers will find it useful.

W.C. Weston
Acting President
Aerospace Industries
Association of Canada

Harry Swain
Deputy Minister
Industry Canada

Chapter 1

INTRODUCTION

PURPOSE OF THE HANDBOOK

If you are reading this, it is likely that you are interested in what makes TQM different from other approaches to business management. Why should our company spend time to explore this philosophy? Does it have a special advantage? Is this another management fad or something more fundamental? How can we get started in TQM? This handbook will hopefully convince you, if you are not already convinced, that TQM is vital to your company's future success. It will also provide the basic practical information needed to undertake TQM within your company.

The handbook is intended to be useful to all companies and employees in the Canadian Aerospace Industry. It has the following objectives:

- strengthening the commitment of Canadian aerospace companies and employees to TQM;
- improving understanding of TQM's main principles and demonstrating their applicability within the aerospace industry;
- clearing up confusion resulting from the differing terminologies, methods, and philosophies that are used in discussions on TQM;
- providing a means for sharing practical experience in TQM implementation in aerospace companies (lessons learned, key success factors), through case studies; and
- providing references to more detailed sources of information.

This handbook was produced as a joint venture between the Aerospace Industries Association of Canada (AIAC) and the Aeronautics Branch of Industry Canada (IC). It is designed to meet the needs of Canadian aerospace companies for an authoritative, user-friendly and, above-all, practical desktop guide to TQM.

The handbook contains a review of TQM principles and practices which draws on the writings of the world's best known quality experts as well as first-hand experience within the aerospace industry. Several executives from Canadian aerospace companies were involved in adapting the material to fit the industry's needs and operating environment, as well as contributing case studies based on first-hand experience with implementing TQM.

HOW TO USE THIS HANDBOOK

Your use of this handbook will depend on the current situation concerning quality management within your company, as well as your responsibilities. The handbook is not intended to replace your company's own TQM handbook, if you already have one. It should, however, prove useful as a source of supplementary information. Your company may also wish to use it as a company handbook if it does not already have one. Regardless of how the handbook is used, you will also want to read other material and speak to people who have practical experience in implementing TQM.

Some of the topics in this handbook deal with activities which have traditionally been considered "management topics". In a TQM environment, employees at all levels can become involved in some of these activities and should have a basic understanding of the others. We therefore encourage all employees within the industry to read the entire handbook, even the parts that may seem to be oriented toward senior management. Not everyone is going to be, or wants to be, a manager. On the other hand, increasing everyone's understanding of what is going on in management will benefit the entire company.

There are many different approaches to implementing TQM. No one approach is the "right way" since circumstances vary from one company to another, even within a given sector such as aerospace. This handbook discusses a "general" approach, based on the principles and practices which most experts agree on. It also points out where differences exist and emphasizes the need to tailor TQM to your own company's unique situation.

Chapter 2

THE IMPORTANCE OF TQM TO THE CANADIAN AEROSPACE INDUSTRY

In this chapter, we provide an overview of the Canadian aerospace industry, including: how the industry is structured, the nature of its products and who its customers are. We then outline the major challenges facing the industry and the crucial role that TQM can play in meeting these challenges. Finally, we add a word of caution for those who are about to embark on the TQM journey.

STRUCTURE OF THE CANADIAN AEROSPACE INDUSTRY

Canada's aerospace industry comprises some 300 companies offering specialized capabilities for research, development, manufacture, marketing and support of complete aircraft, aircraft systems and components, avionics and defence electronics, space equipment, defence systems and services. The industry employs nearly 60 000 people, with an additional 35 000 employed by over 100 firms that indirectly participate in the industry. The industry reported sales of $9.0 billion in 1992; export sales accounted for $6.0 billion.

Canada's aerospace industry typically produces about 7% of the western world's freely traded aerospace requirements. The industry is technology-intensive and is a leading exporter of manufactured, advanced technology equipment. It is a major contributor to Canada's trade balance. Characteristically, the industry is oriented towards niche markets and is heavily reliant on access to export markets. About 70% of sales are to civilian markets, while the remainder are defence-related. The United States is the principal export market for the industry's products.

The companies that make up the Canadian aerospace sector are generally divided into three tiers:

The first tier, which accounts for some 45% of the industry's annual output, consists of the largest companies (over 2 000 employees). These companies have integrated design, development, manufacture, marketing and support facilities for either complete aircraft, aero-engines, space systems or avionics systems, including defence electronics. Products of first tier companies include commuter/regional aircraft, corporate aircraft, small aero gas turbine engines, communications satellites, space systems and aircraft simulators.

The second tier of the Canadian aerospace industry is composed of about 40 medium-sized companies, which collectively account for about 45% of the industry's output. These companies are primarily suppliers of proprietary products and built-to-print components, most of which are sold to foreign aerospace principal manufacturers. This tier also includes companies that provide repair and overhaul services. Typical products of second tier companies include civil helicopters, subcontract manufacturing services for foreign and domestic aircraft manufacturers, aircraft navigational and defence electronic systems, missile systems, aero-engine repair and overhaul services, anti-aircraft defence systems, electronic controls for aircraft systems and major sub-assemblies such as wings, fuselage components, flight controls and landing gear for all types of aircraft.

The third tier comprises more than 100 companies, mostly small businesses with annual aerospace output less than $20 million. Collectively, these companies account for the remaining 10% of the industry's total output. With the exception of a small number of firms having an integrated capability to design, develop, manufacture, market and support proprietary products, the third tier companies are predominantly suppliers of subcontract products and services. Typical services and products include precision machining, metal coating, heat treating, fabrication and casting. Most of their work is done in support of first and second tier companies.

From a TQM perspective, the implication of this diversity is the need to be flexible in implementing TQM. Given the wide variety of company size, operating environments, products processes and customers, no one model will fit all situations. Companies need to adapt/tailor TQM to fit their own circumstances. As you use this handbook, remember that it is not prescriptive – what works for one company may not work for another.

CHALLENGES FACING THE CANADIAN AEROSPACE INDUSTRY

The Canadian aerospace industry is broadly based, diverse and outward looking. It has exhibited one of the highest sales growth rates among the top seven of the world's aerospace industries over the past decade. With exports accounting for over 71% of sales, the industry has shown continuously that it can compete in the global marketplace. However, the industry, like its foreign counterparts, faces a number of challenges which, if not met, are likely to limit its future growth. These challenges, which involve managing unprecedented technological and market change, are listed below.

CHALLENGES FACING THE GLOBAL AEROSPACE INDUSTRY

- World defence markets will continue to contract as a result of budget reductions in Canada, the U.S. and elsewhere.
- The protracted economic recession has curtailed the demand for large civil transport aircraft and component products, probably, until the late 1990s.
- The helicopter market in general will experience slow growth as will the commuter and the business aircraft markets.
- The Southeast Asian aerospace industries present new competitive threats to the second and third tier sub-sectors.
- The aerospace component market is becoming increasingly globalized and more competitive.
- The industry in the U.S. and Europe will continue to restructure and consolidate, with new alliances being formed.
- The foreign primes are decreasing their supplier base and entering into long-term agreements with some of those remaining.
- Suppliers, particularly those in the second tier, will have to increasingly share program risk with the primes and assume higher levels of system integration responsibilities.
- Competition is creating a greater emphasis on product and service quality; at the same time profit margins are falling.
- Advanced manufacturing technologies, such as computer-aided design (CAD), computer-aided manufacturing (CAM), computer numerical control (CNC) machines, robotics, expert systems and electronic data interchange, are becoming increasingly important.
- Customer expectations are rising in terms of risk sharing, lead time reduction, warranties and product support, e.g. maintenance service agreements (MSAs).

These challenges are formidable. However, the industry has faced challenges in the past and succeeded. It is probably ahead of its foreign competition in terms of conversion to civil markets. There will be targets of opportunity over this decade for those companies that are creative and competitive in most areas and these will contribute to continued growth of the overall sector in the next decade.

According to the 1990-1991 Aerospace Industry Profile, produced by Industry, Science and Technology, first and most second tier companies are expected to sustain their competitive strengths in the 1990s. This will happen because of continued high levels of R&D activity to maintain technical excellence, through the implementation of continuous process improvement practices to drive down production costs, as well as the development of strategic alliances to facilitate access into new markets. However, some second and third tier firms within the industry, particularly those involved in build-to-print activities, will need to strengthen their competitive positions by accelerating their adoption of best-practice production techniques to enhance productivity and quality.

THE ROLE OF TOTAL QUALITY MANAGEMENT

Meeting the exacting requirements of its customers, in the face of increasing worldwide competition, will be critical to the continued success of the Canadian aerospace industry. Indeed, this increasing competition is causing customers' needs to become more demanding. It is therefore essential that Canada's aerospace firms develop business strategies that focus on customers' needs and continuous improvement in the delivery of what customers want, when they want it. **These are central principles of TQM.**

TQM provides a strategy for meeting customer demands for quality, delivery and price, and remaining competitive in the global aerospace market. Adoption of TQM strategies and techniques can enable the Canadian aerospace industry to:

- improve product and service quality;
- increase productivity and lower production costs;
- reduce lead times and improve schedule flexibility;
- expand the role of R&D and innovation and shorten the product development cycle;
- respond quickly to changing customer needs;

- make better use of available financial and human resources;
- accelerate the adoption of advanced manufacturing technologies; and
- establish productive intra-industry alliances.

Adoption of the TQM philosophy is no longer optional. Our competitors are adopting TQM and our customers are increasingly making it a condition of doing business. In other words, TQM is becoming a prerequisite for business success. Without it you may not even be able to enter the race, let alone compete!

Cancellation of program provides "Wake-up" call at Rockwell International's Missile Systems Division. Although cancellation of its AGM-130 missile program for the U.S. Air Force was bad news at the time, it led to a TQM-based turnaround. The cancellation occurred after a period of poor customer relations, late deliveries, and quality problems. In addition to the demise of the AGM-130, the division had problems with its Hellfire missile for the U.S. Army, which was one year behind in delivery schedule.

Starting in 1986, the Rockwell Division implemented its own version of TQM, known as the "Right Way to Manage." The initiative reportedly places emphasis on continuous improvement and employee involvement. Key elements of the cultural change were to replace what had become an adversarial relationship with its customer with a cooperative one, and to convince employees that management's new emphasis on employee involvement was real.

Since this initiative began, the improvements have been dramatic. By 1990, the production time for the Hellfire had been reduced by 50%, daily production increased by 260% and sales per employee increased by 105%. Rockwell's share of sales of this product to the U.S. Army went from 35% to 100%. Increased employee involvement has resulted in cost savings, for example, $90 000 annually from reduced absenteeism and $9 500 from a single employee suggestion: changing the size of the drums in which circuit cards are dipped.

Customer representatives indicate that their relationship with the company improved significantly. Besides better morale, employees have benefitted through annual profit sharing of several hundred dollars.

(based on *Rockwell Credits Total Quality Turnabout for Rescuing Division*—Jack Weible, June 4, 1990 issue of Defence News)

According to the Strategic Planning Institute, quality is the single most important factor affecting an organization's long-term performance (see, for example, *A Passion for Excellence*—Tom Peters and Nancy Austin). Poor quality causes non-competitive products and services due to schedule delays, poor yields, excessive re-work, high scrap rates, and costly support. Not surprisingly, there is a positive statistical correlation between product quality and critical financial measures such as net profit and return-on-investment (ROI). Your company's investment in Total Quality Management can result in a substantial ROI. Measurable cost savings due to process improvements can be achieved within 6-12 months of beginning TQM implementation. According to the U.S.

Department of Defense Reliability Analysis Centre, a reduction in operating costs of 15 to 25% after 2 to 3 years is not uncommon.

In general, awareness of TQM in the Canadian aerospace industry is high. However, there is much work left to do in implementation. This was confirmed in a 1991 ISTC/AIAC survey of Canadian aerospace companies. Furthermore, comparison of the survey results with similar data on U.S. aerospace companies, indicated that the Canadian industry lags its U.S. counterpart in TQM implementation. While most experts agree that TQM is critical to long-term competitiveness, and that quality improvements contribute to cost reduction and profitability, the fundamental "mind-shift" and culture change necessary for effective TQM implementation has not yet occurred.

A WORD OF CAUTION

Many knowledgeable people within the industry are convinced of the critical importance of TQM, however, we must add this cautionary note: There have been disappointments associated with TQM initiatives, including some notable ones in the aerospace industry. Successfully implementing TQM, particularly under the fierce economic pressures which companies face today, is a formidable job.

According to the Conference Board of Canada, about 70% of TQM efforts fail. The authors and supporters of this handbook believe that TQM initiatives fail because of a lack of proper planning, poor understanding of TQM principles, or insufficient commitment on the part of senior management, not because TQM is the wrong approach. We hope that this handbook will help your company avoid these problems.

The following chapters provide a guide for making TQM a reality in your organization. If you still have doubts, Chapter 10 provides concrete examples of successful TQM strategies and practices in the Canadian aerospace industry. As you use this handbook, remember that the ultimate objective is meeting customer demands for quality, delivery and price. It is not an easy journey, but one that will be worth the effort!

Chapter 3

PRINCIPLES OF TQM

WHAT IS QUALITY?

Just about everyone has some ideas on what quality is: products that don't break, use of expensive materials, friendly service, etc. All of these ideas contain truth about quality and will be useful to those of us who want to provide high-quality products and services. However, to manage quality, we need to be a bit more analytical in our definition.

There are numerous definitions of quality. Business managers and quality experts alike have trouble agreeing on a single one. They would, however, virtually all agree on the best place to look for high-quality products and services — in the hands of satisfied customers. Below, we provide some representative definitions of quality to illustrate not only how they vary but more importantly, how they are similar:

- "fitness for purpose or use" — *Joseph Juran*
- "conformance to requirements" — *Philip Crosby*
- "the totality of features and characteristics or a product or service that bear on its ability to satisfy stated or implied needs" — *International Organization for Standardization (ISO)*
- "Doing the right things right the first time on time all the time and always to the customer's satisfaction" — *the Quality Management Institute (Canada)*
- "Treating every customer with integrity, courtesy, and respect" — *Patrick Townsend,* quality consultant
- "Value-for-money, meeting customers' requirements at as low a cost as possible" — a widely stated view

Here is what some Canadian aerospace companies say about quality:

> "all of the characteristics of a product or service that bear on its ability to satisfy stated or implied needs" — *AlliedSignal Aerospace Canada*

> "providing customers with products and services that consistently meet their needs and expectations .... customers judge quality in terms of their needs, expectations and available alternatives" — *Paramax Systems Canada*

> "Quality is conformance to your customers' requirements ... not elegance, status, or high price, although they may be the result of quality." — *Computing Devices Company*

Clearly what these definitions have in common is the idea that quality means successfully satisfying the customers' needs and requirements. Customers' needs are the fundamental things: safety, comfort, getting their work done on time and within budget. Customers' requirements, on the other hand, deal with the specifics of how products and services meet these needs: functional specifications of a safety system, dimensions of passenger seats, delivery schedules for component parts, absence of defects, etc. The terms, "customers' needs" and "requirements" are often used interchangeably.

In the aerospace industry, customers' needs and requirements are very diverse. **Figure 1** shows, in general terms, how a wide range of aerospace operations are linked together to produce a final product — an aircraft in service. We call this a quality and value-added chain since both quality and value are added at each stage. The product and service characteristics which define quality vary along the chain but always depend on the needs and requirements of customers for the outputs of each stage. Regardless of where you work along this chain, your immediate customers' quality requirements are linked to the needs and requirements of the customers at the end of the chain — the passengers, flight crew, maintenance crew and owners of the aircraft.

Although quality requirements within the aerospace industry are diverse (ranging from comfort in an aircraft cabin to strict dimensional tolerances of parts), quality at all stages can be managed using a common set of principles and many of the same techniques. Of course, knowledge about quality management is not a substitute for the technical and business knowledge specific to your part of the business. Both types of expertise are important and must be used in order to meet your customers' quality requirements.

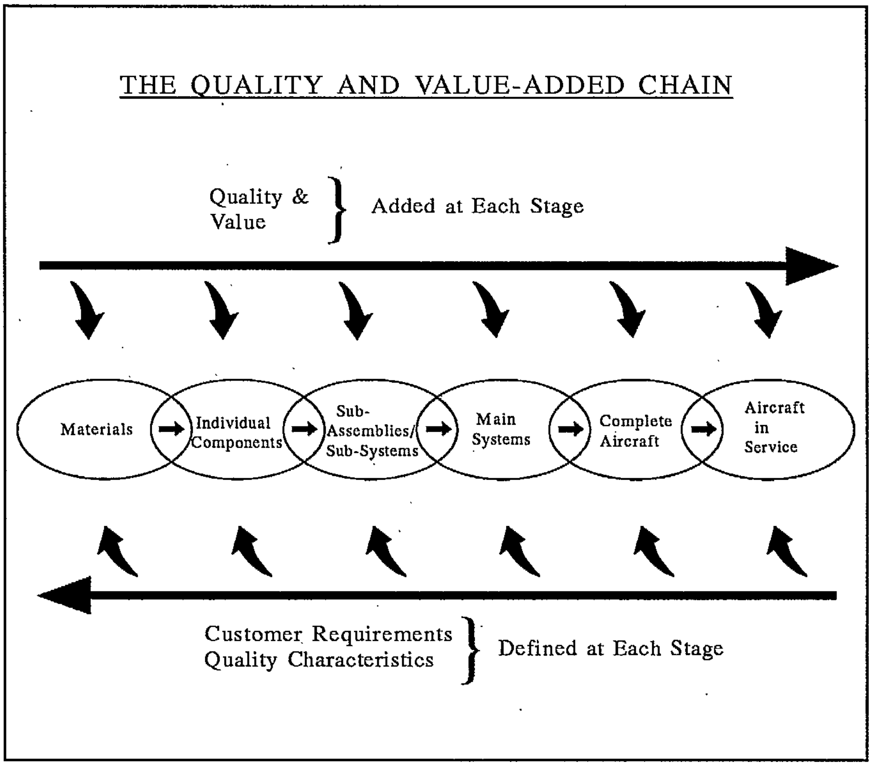


Figure 1 — The Quality and Value-Added Chain

WHAT IS TOTAL QUALITY MANAGEMENT?

While there are many definitions of TQM, they have much in common. For example, here are some descriptions of TQM provided by representatives of Canadian aerospace companies:

- "TQM is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. TQM is the application of quantitative methods and human resources to improve processes, products and services for the benefit of the customer, members of the organization and society. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach focused on continuous improvement" — *AlliedSignal Aerospace Canada*

- "TQM is our process to achieve Total Customer Satisfaction by ensuring that the systems, products and services we deliver conform to requirements and fully meet our customers' expectations and needs" – *Paramax Systems Canada*

- "[our] Total Quality Management Process is a corporate-wide problem-solving and process-improving methodology. It is a disciplined approach for management and employees to manage quality" – *Computing Devices Company*

- "A Total Quality organization focuses on running effective systems – it is market driven, maximizes ownership, operates in the simplest possible structure and systems, operates effective measures of performance and has good communication procedures" – *Orenda Division, Hawker Siddeley Canada*

From these definitions, and many others, we can identify four essential elements that must be present in any approach to TQM:

Focus on the Customer: Customers include everyone for whom we provide a product or service, within the company or outside. Their needs and requirements are our highest priority. In a TQM company, all procedures, activities and organizational structures are designed to produce products or services which meet and, if feasible, exceed customer requirements.

Management Leadership: In a TQM company, managers achieve their objectives by leading, coaching and supporting, rather than by directing and controlling. The move to TQM must be led by senior management, with all other levels of management providing their complete support. Every manager must apply TQM principles and methods to his or her own work and support the use of TQM by the people who work for them.

Employee Involvement: Employees in a TQM company are highly motivated but that is only part of the picture. They also have the knowledge and responsibility to play a major role in achieving quality. In a TQM company, employees work on improving the processes they carry out and decision-making is moved as close as possible to where the impact of the decision happens. Some call this empowerment.

Continuous Improvement: TQM stresses the need to analyze and continuously improve all of a company's products, services and processes (administrative, technical, managerial, and manufacturing). Employees at all levels – often working in teams, backed up by management, and supported by specialists where necessary – analyze and improve their own work processes. Measurements are used extensively, by everyone, to guide process improvement and monitor progress in achieving the company's goals.

We have shown these elements as the "Four Pillars of TQM" in **Figure 2**.

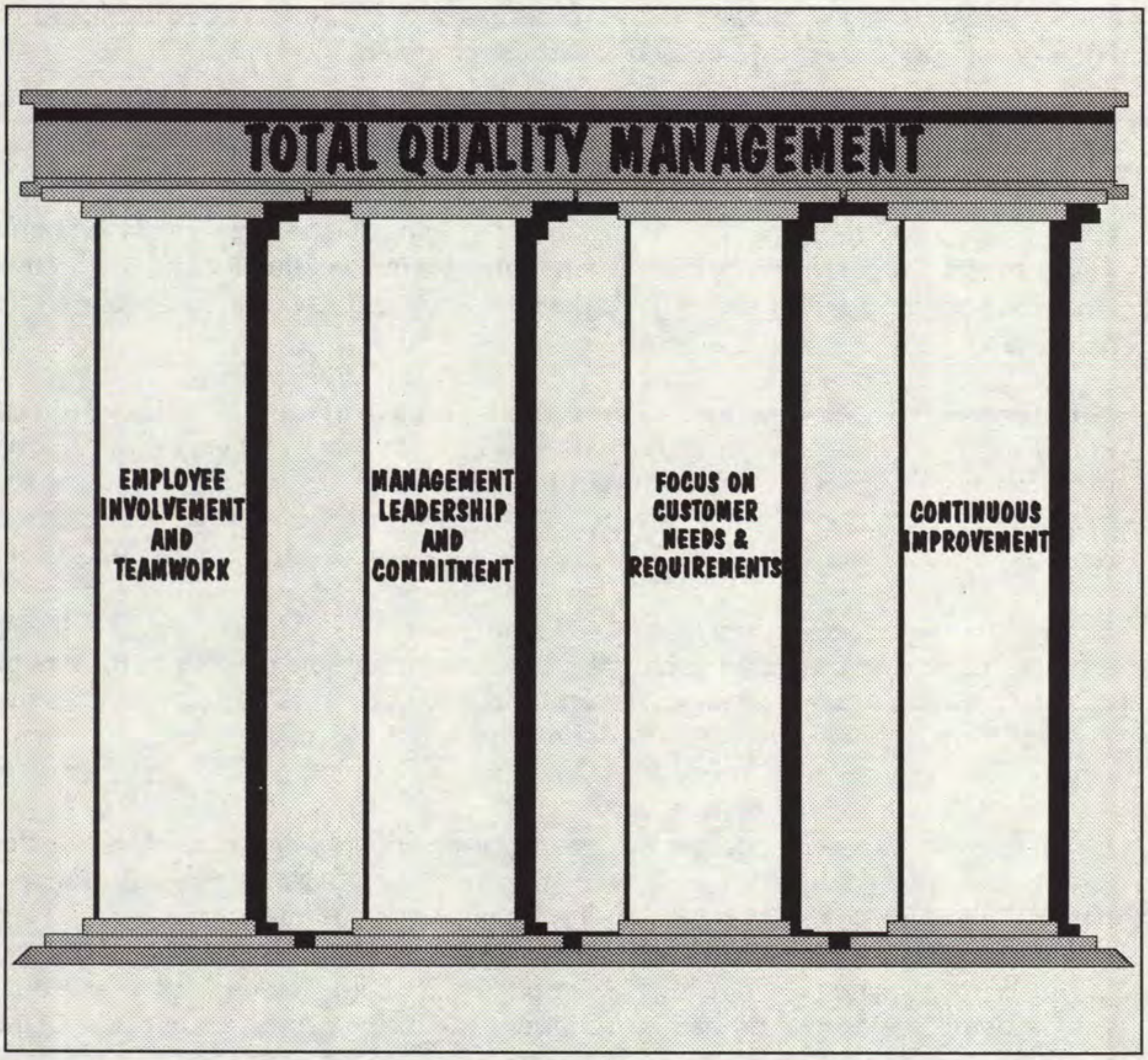


Figure 2 — Four Pillars of TQM

Note: There are important elements of TQM, not shown in Figure 2, which are inherent in our four TQM pillars. For example, the important role of **customer-supplier relationships** is inherent in Focus on the Customer, and Continuous Improvement, **systematic support** is part of Management Leadership, and Continuous Improvement.

Does TQM apply to everything? It certainly does! TQM deals with managing quality – not only the quality of manufactured products but also of services and of all the activities (business processes) that occur within companies.

We should also understand what TQM is not:

- *management by objectives:* TQM involves measuring progress but not setting arbitrary objectives. According to J. Edwards Deming, one of the most influential TQM experts: "a quota is a fortress against improvement of quality and productivity, I have yet to see a quota system that includes any trace of help to anyone to do a better job."

- *management by exhortation:* some companies attempt to achieve quality improvements by using slogans, posters, special events and just generally "talking it up." Relying on "cheerleading" without taking other steps to build a winning team may boost motivation in the short-run. In the long-run, however, these gains are replaced by cynicism and a credibility problem that will hamper future efforts.

- *just another management program:* TQM is an approach to doing business. It is not a program, although specific quality improvement programs may be defined as part of TQM. Computing Devices Company refers to the "Total Quality Management Process," underscoring that TQM is not a program; it has no specified end – neither in calendar time nor in numerical goals.

- *a scheme to make you work harder:* most people are already working harder these days because they know their prosperity depends on it. TQM provides the means to help people work smarter. It also makes work a lot more interesting.

- *part of a downsizing program:* many companies are being forced to downsize due to very difficult business conditions throughout the global aerospace market. TQM is not specifically about downsizing. It can increase productivity, which admittedly is sometimes associated with downsizing. However, it can also improve your company's products, profitability and market share as well as freeing up resources to pursue new business opportunities – thus protecting existing jobs and creating new ones.

- *a specific group of analytical tools or management techniques:* it is true that TQM involves using various problem-solving tools and management techniques (e.g. SPC, teams, etc.), however, TQM is more than just a set of tools – it is a way of doing business.

What is the relationship between TQM, Quality Assurance and Quality Control? A Quality Assurance system is a set of well-defined activities designed to provide confidence that a product or service fulfils quality requirements. Quality Control refers to the process of measuring conformance to requirements by comparing actual with standard characteristics and acting to correct the difference. "Quality Assurance" and "Quality Control" are often used interchangeably, referring to the actions performed to ensure the quality of a product, service or process. TQM is not a substitute for quality assurance but adopting TQM will likely influence how quality assurance is carried out in your company.

What's the difference between TQM and other approaches such as Customer-Driven Quality, Total Customer Service or Excellence? Improvement methods or programs under a variety of names may incorporate some or all of the elements of TQM as discussed in this handbook. Certainly, characteristics such as excellent, customer-driven, and world-class are consistent with TQM. Very often, existing management practices and improvement programs can be incorporated into, or evolve into, TQM.

Hughes Aircraft's quality journey leads to Total Quality Management. The experience of this company with quality programs is representative of many companies in the industry. Hughes has had two programs available for several decades that encourage employees to devise process improvements: the Cost Improvement Program and the Performance Improvement Program. As of 1989, these programs had saved over a hundred million dollars.

In the 1970s the company used quality circles to generate improvements from workers, with variable success. According to senior research specialist Hugh Harrington, "they began with great success, but often took weeks or months to decide on a problem on which to focus, and after even more time came up with a set of recommendations that were presented to management. Sometimes the problems were critical; sometimes the solutions were valid; and sometimes the recommendations were implemented." A byproduct of this variable success was disillusionment.

Clearly a more comprehensive approach was needed. In the early 1980s, Hughes planned and began implementing a Total Quality Management program which has continued to evolve.

(based on *Hughes Aircraft Manages Total Quality Control in a DoD Environment*, Hugh Harrington and Jack ReVelle, Industrial Engineering, Vol. 21, No. 12, Dec. 1989.)

Chapter 4

PROCESS IMPROVEMENT METHODS

Successful implementation of TQM involves more than everyone being customer-oriented and having a good environment to work in. It includes a systematic approach to analyzing and improving quality. Some of the tools to facilitate this approach are described in this chapter. These methods are not just for managers and quality specialists. Every employee can become involved in using them.

PROCESS IMPROVEMENT STRATEGIES

The concept of continuous improvement was introduced in Chapter 3. To achieve success, companies must improve their products and services, cash-flows, return-on-investment, growth rates and above all, customer satisfaction. Improvements in these areas can be achieved by focusing on the processes which affect them. With TQM, you can analyze your company's activities by considering individual processes — transformations of inputs (materials, actions, methods and operations) into desired outputs (products, information, services, results). Each process has customers (either internal or external) for its outputs and suppliers for its inputs. The people who carry out the process (the process owners) are customers for the outputs of other processes. **Figure 3** illustrates the process concept in general terms.

Before proceeding with our discussion on process improvement methods it is worthwhile to mention some **key objectives of process improvement**. These include making changes such as:

- reduction of variation in process variables and product characteristics affecting quality;
- reduction of non value-added work within processes; and
- process simplification.

Successfully making the above changes results in the following business benefits:

- improved product quality (fewer defects, better performance, etc.);
- improved productivity (reduced costs and cycle time); and
- increased customer satisfaction, leading to higher sales and profitability.

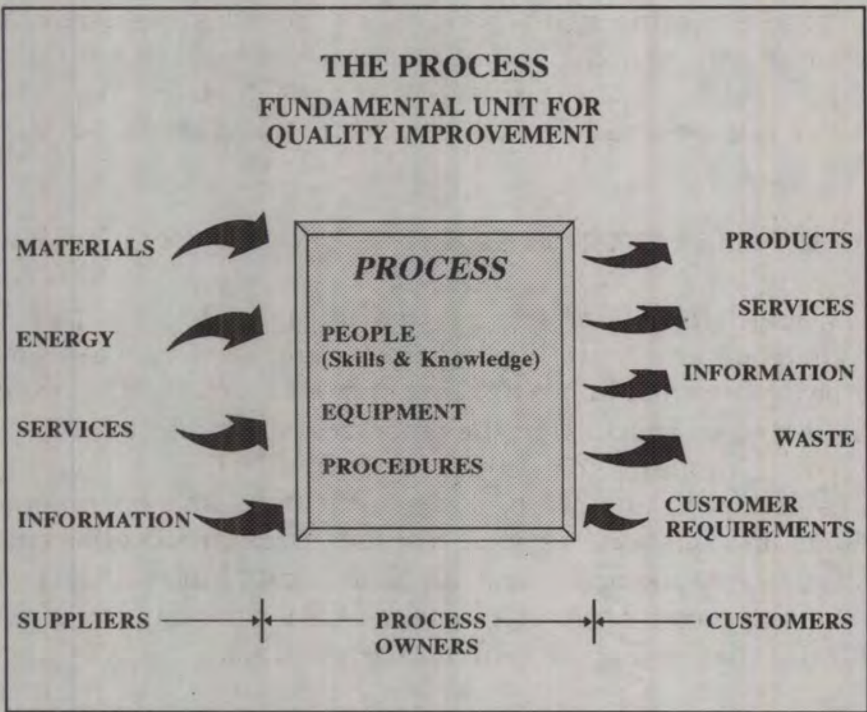


Figure 3 — The Process

Conventional management has focused on controlling process outputs. TQM emphasizes controlling the process inputs and transformation procedures to ensure the outputs are as desired. This is a powerful approach to improvement: studies indicate that 80 to 85% of the defects in products and services come from processes while only 15 to 20% result from the people who produce them.

To be effective, process improvement should follow a system or strategy. **The Shewhart, or Plan-Do-Check-Act (PDCA) Cycle**, named after the well-known quality control expert, Walter A. Shewhart, provides a general **process improvement strategy**. It involves a repetitive cycle of: 1) **Plan** a change; 2) **Do** it by trying it out – this is where improvement efforts often end, they shouldn't! 3) **Check** to see how effective the change really is; and 4) take **Action** to ensure that the improvement will be permanent (i.e. that the problem does not recur). The cycle is repeated, continually improving the process and its resultant quality. **Figure 4** illustrates the PDCA Cycle.

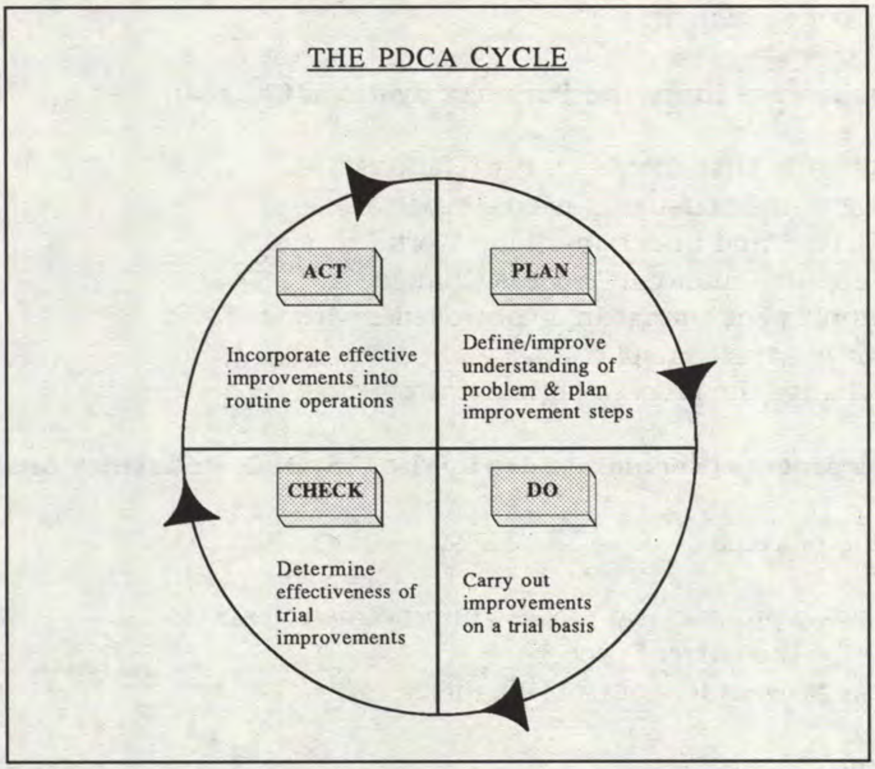


Figure 4 – The PDCA Cycle

TQM-oriented companies often use continuous improvement strategies which are similar to the PDCA Cycle but are tailored to their own needs and management approach. Following are examples of continuous improvement strategies used within the aerospace industry:

A six-step process (from "Quality Management in Control Data" — Computing Devices Canada):

Step 1: Define the problem
Step 2: Identify possible causes
Step 3: Evaluate possible causes
Step 4: Make a change
Step 5: Test the change
Step 6: Take permanent action

A seven-step process (from the Paramax Systems Canada):

Step 1: Identify customer/supplier relationships
Step 2: Determine customer needs/expectations
Step 3: Define (and understand) the Work Process
Step 4: Identify Candidate Process Change
Step 5: Implement change in a controlled environment
Step 6: Evaluate effects of change
Step 7: Change the process permanently

An eight-step process (Recommended by the U.S. DoD, Reliability Analysis Centre):

Identify the process:

i. Select the process and process improvement team
ii. Describe the current process
iii. Assess process for control/capability

Improve the process:

iv. Theorize for improvement
v. Plan experiment to test theory
vi. Do experiment and analyze results
vii. Compare results with theory
viii. Change process or theory

How far can continuous improvement be taken? Conventional wisdom would expect continuous improvement efforts to be limited by diminishing returns: beyond an optimum amount of effort, further effort would not be cost-effective. Many TQM practitioners, however, do not consider this to be true. They point out that poor quality costs money, in the form of scrap, re-work, warranty costs and lost business, sometimes even lawsuits. They question if it ever makes sense to accept a certain level of poor quality being passed on to the customer.

Obviously, companies need to prioritize improvement efforts to achieve the highest return and to monitor the costs and benefits of quality improvement efforts. However, the TQM approach does not set an upper limit for quality.

Continuous and "discontinuous" improvement: You may be asking what we mean by "continuous" – does this include only small incremental improvements – what about major innovations ("discontinuous" improvements)? By continuous improvement we mean repetitive, small incremental changes to existing processes (moving up the "learning curve") **and** the introduction of major changes or entirely new processes (jumping to a new learning curve) at the right time. Both types of improvement are part of an ongoing (continuous) effort to improve quality.

An example of a "discontinuous" improvement would be the complete re-engineering of a process, e.g. modifying assembly lines by turning them into autonomous work cells. It could also mean throwing away old procedures that no one follows (e.g. eliminating unnecessary approvals). As Ken Kivenko, President of AlliedSignal Aerospace Canada, has said: "Don't do 'effectively' that which shouldn't be done at all." For example, don't collect data unless it is used to make decisions.

Process flow charting (also called process mapping) is generally the first step in process improvement. This is the case for both small incremental improvements and re-engineering of business processes to accomplish major improvements. Flow charts describe the main inputs, steps, branches, and outputs of a process, and show how the steps are interrelated, using standard and easily recognizable symbols. They are especially useful for describing the actual path that a product or service follows and then designing potential improvements. **Figure 5** is a flow chart for a hypothetical process, illustrating the standard symbol conventions.

Figures 6 and 7 illustrate flow charts for the production of a fabricated metal aircraft part, before and after an improvement project undertaken at **Hawker-Siddeley's Orenda Division**. The process improvement reduced non value-added (NVA) by eliminating unnecessary degrease, deburr and part movement operations, and through rearranging and combining operations. This type of process improvement has enabled the company to achieve significant reductions in NVA, leadtimes and inventories. (Note that these process flow charts differ from Figure 3 in that they show individual steps of the process.)

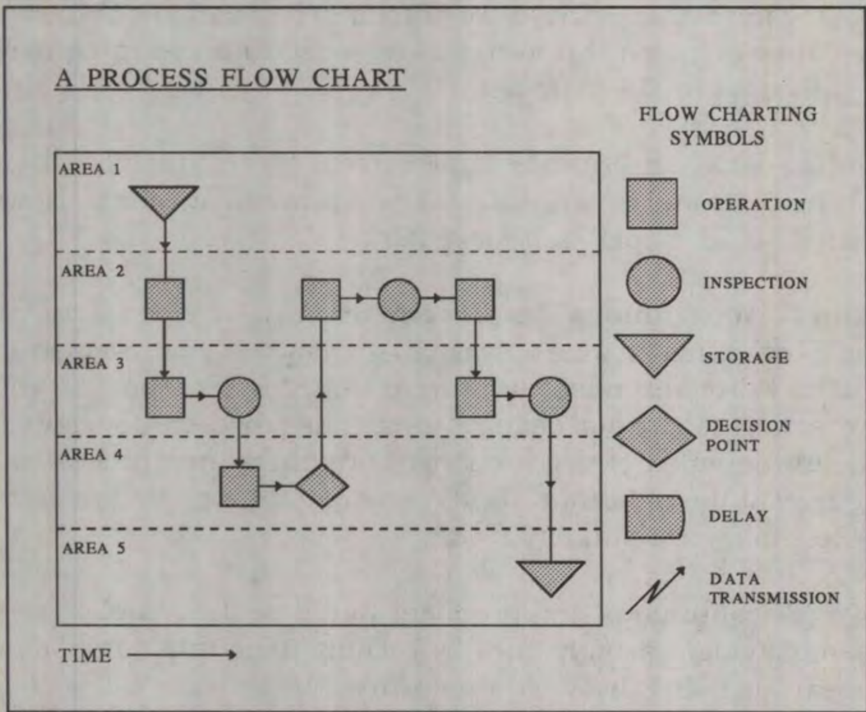


Figure 5 – A Process Flow Chart

Flow charts can be applied to any process, simple or complex, from billing a customer to assembling large and complex products. Typically, they are constructed by teams of employees with the most knowledge about a specific process. They meet and agree on a flow chart that best describes how the process actually works. Then, they construct a flow chart that describes how it should work. Where the two charts are different becomes the focus for improvement. The flow chart of the current process can also be used as a basis for further data gathering and analysis using other continuous improvement tools described later in this chapter.

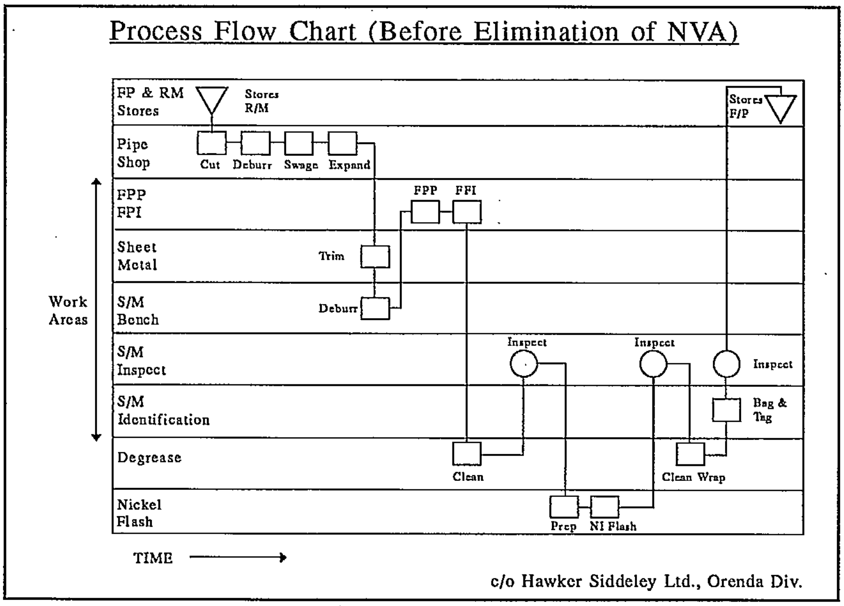


Figure 6 — Process Flow Chart (Before Elimination of NVA)

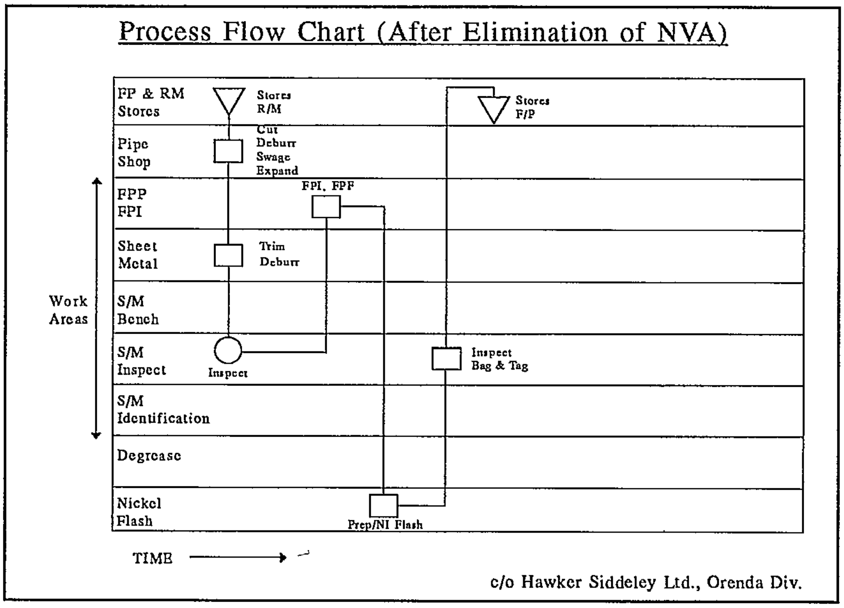


Figure 7 — Process Flow Chart (After Elimination of NVA)

STATISTICAL METHODS

Producing high quality products and services, and operating high quality processes, requires that we understand, and then control, the factors which cause variation affecting quality. This can be accomplished using statistical methods, which are sometimes referred to as **Statistical Process Control (SPC)** or **Statistical Quality Control (SQC)** methods. Statistical methods can be used for both quality control and quality improvement.

When the methods are used to monitor and control processes on a day-to-day basis, they are sometimes called "on-line SPC" methods. The use of statistical methods for quality improvement is sometimes called "off-line SPC" because it is not linked directly to day-to-day operations. Most of these methods are not new – some of them originated as far back as the 1920s. However, their application to industrial processes is relatively new.

Statistical methods can be used to control and improve quality for any process involving goods, services, or information. It is not necessary for all employees to become master statisticians in order to use these methods and achieve practical results. Several of the methods discussed below can be learned and applied by virtually everyone in the company. All that is needed is their willingness to get involved, some training, and support from management.

In a conventional quality control system, one deals with whether the key characteristics of products fall inside or outside of specifications (e.g. whether product dimensions are within engineering tolerances). If they fall within specifications, no problem! If they fall outside specifications – we inspect out the bad ones.

How detailed should process mapping be? At General Dynamics, of Fort Worth, Texas, process improvement teams use a three-stage approach to process analysis. The first step involves a macro-level analysis, "the view at 100 000 feet," to analyze the basic elements of its business. Key questions at this stage include: "What are we trying to produce?" How much does it cost? What is the percentage of re-work? What do our internal/external customers think? The mid-level view, "at 50 000 feet," allows a team to watch a given product flow through the business cycle. The key question at this stage is "Does each step add value or simply add cost?" The micro view ("at 10 000 feet") provides functional details of the process.

It is not necessary to analyze all processes at the micro level. Pareto analysis (discussed later in this chapter) can be used at the mid-level to choose areas for which the micro-level analysis should be performed.

(based on *Process Management Brings Quality in Daily Work to Life*, Leon Dodd, Journal for Quality and Participation, January/February 1992)

There are two problems with this approach: 1) There are less expensive ways to provide your customers with defect-free products; and 2) Just because a product meets specifications does not mean that it is the best possible from the customer's viewpoint.

Two very important TQM principles should be considered here:

i. It is less costly to prevent errors than to identify and correct them.

ii. Any deviation of a product's key characteristics from their optimum values is going to have some negative effect.

This does not mean that we give up on inspection and correction of errors, or that no deviation can be tolerated. It does mean that we should emphasize error prevention and constantly look for ways to reduce variation. The statistical methods used in TQM enable this by allowing us to look at:

i. How key variables affecting the quality of our products, services and processes vary (from unit to unit and with time);

ii. What causes this variation; and

iii. How we can reduce the variation.

Key variables in product quality, or **key characteristics**, are defined as features whose variation has the greatest impact on quality from the customer's perspective. They should not be confused with flight safety or design features which are sometimes called critical characteristics in the aircraft industry. Key characteristics may or may not also be categorized as critical characteristics. Key process variables (or process parameters) are those which contribute to variation of key characteristics.

In order to analyze, and then reduce variation, we need a way to visualize it. We could start by making a large number of measurements of the variable that we are interested in and then make a graph showing the frequency with which measured values occur. (In practice, we plot the number of measurements which fall within small intervals along the range of possible measured values.) **Figure 8** illustrates the general appearance of this type of graph. It often looks like a bell-shaped curve and can be described mathematically as a **normal distribution**. The mathematics describing this type of curve are quite interesting; however, we can learn some useful things about variation without getting into them.

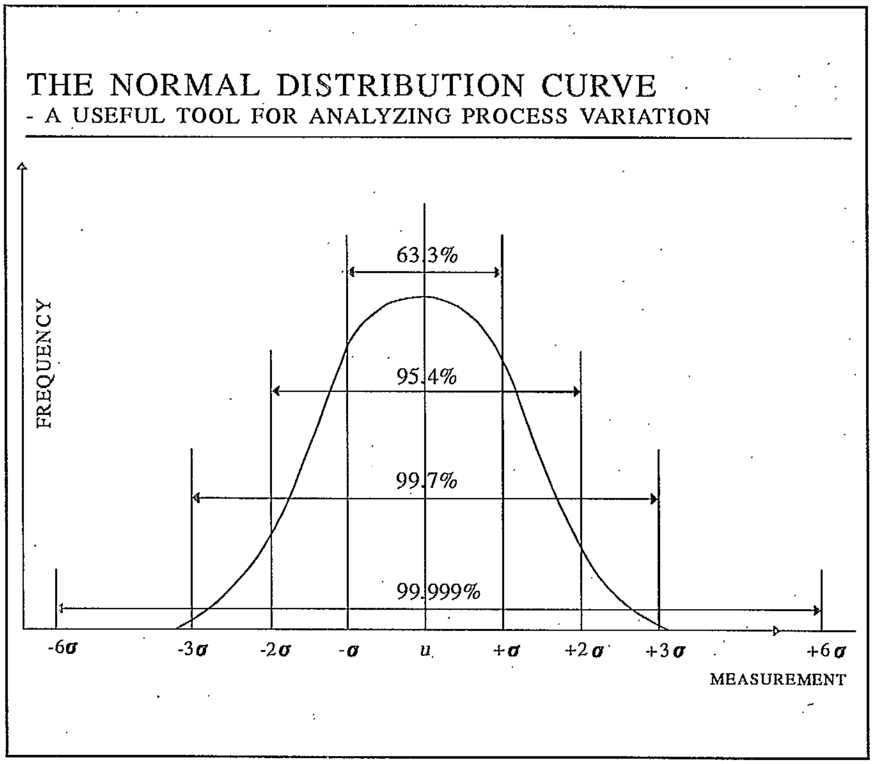


Figure 8 – The Normal Distribution Curve

Note that the curve is symmetrical around a central value which is also the most frequently occurring value. This is the mean of the distribution, mu (μ). The "spread" of values, above and below the mean, is defined by the standard deviation, sigma (σ). For this type of curve, one can expect that 63% of the measurements fall within +/- one sigma; 95% of measurements fall within +/- two sigma; 99% fall within +/- three sigma; and 99.999% fall within +/- six sigma.

In the real world, variation does not always look exactly like these curves, even if a very large number of measurements are made. For example, some processes may have a distribution curve with more than one peak, or the curve may not be symmetrical. Nevertheless, the normal distribution curve provides a useful model to approximate variation related to quality.

Figure 9 shows three different curves having different amounts and types of variation. These curves could be considered to represent three different processes designed to accomplish the same thing but differing in how they do it. For example, they could represent different machines, operators or machine settings. Superimposed on the curves is the target value for the variable of interest (central dotted line) and the upper and lower tolerance limits.

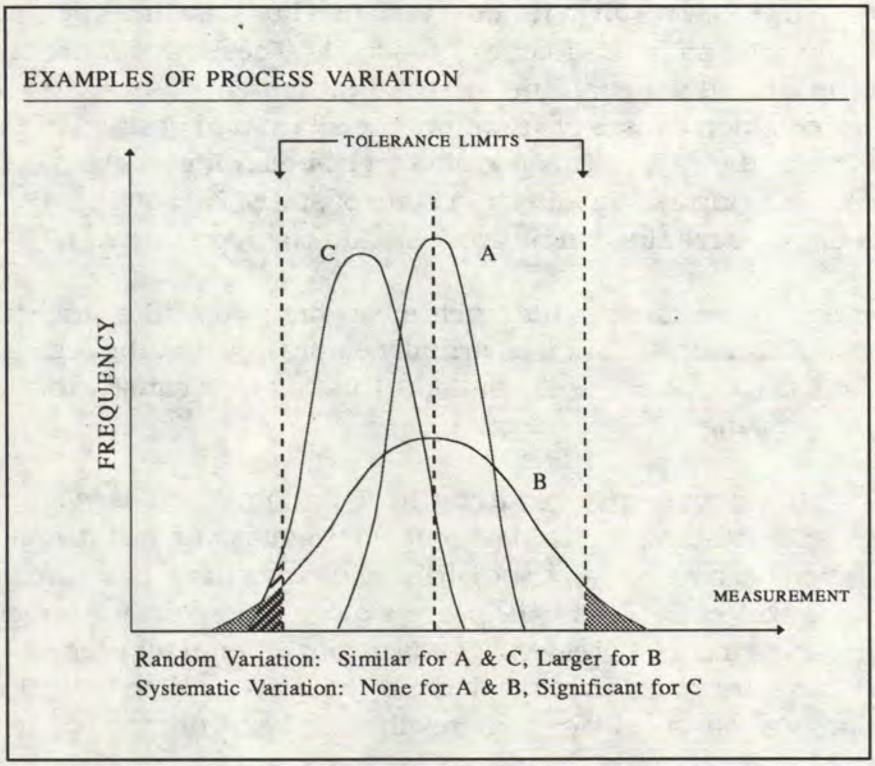


Figure 9 – Examples of Process Variation

Curves A and B are centred exactly on the target value – their mean values coincide with it. However, not all of the measurements coincide exactly with the target value. They lie on either side of it with fewer and fewer measurements occurring as we move away from the target value. This type of variation is known as **random variation**. It results from several causes which, over time, tend to produce equal amounts of positive and negative deviations from the target value. Curve B has a greater amount of random variation than Curve A. Curve C has a similar amount of random variation as Curve A, however, its mean does not coincide with the target value. Process C has a tendency to produce values less than the target value. This is known as **systematic variation** or **bias**.

A significant proportion of the measurements made on processes B and C fall outside the tolerance limits. These measurements (shown as shaded areas) correspond to unacceptable products or process conditions.

There are causes of variation which are inherent to processes – they do not change as time passes. Usually, they result in random variation but sometimes systematic variation is inherent to the process (an "off-centre" process). These causes are called **common causes of variation.** If we continue to make measurements on a process which is affected only by common causes of variation, the shape and position of the distribution curve would remain the same. This is called an **in-control process** – one in which the statistical measure being evaluated is in a state of statistical control. (Variation among the observed sampling results can be attributed to common causes.)

Processes are usually designed so that their mean value coincides with the target value. In other words, systematic variation is virtually eliminated and the remaining variation, which is random, is common cause variation. This common cause variation can also be minimized by optimizing the process design.

Sometimes, circumstances arise resulting in variation which is not inherent to the process. These circumstances give rise to **special causes of variation**. When special causes of variation become active, the distribution curve (if we have time to measure it) changes its shape and/or position – the process mean drifts from the target value and/or the spread of measurements increases. This is an **out-of-control process** – one in which the statistical measure being evaluated is not in a state of statistical control. (The variations among the observed sampling results can be attributed to special causes.)

Later in this chapter, we discuss control charts, which are used to monitor processes and determine if they are in or out of control. First, however, we discuss how variation affects quality.

How can we compare the actual level of process variation with what is required for good quality? One widely-accepted approach is based on **process capability**, which compares the amount of variation with specified tolerance limits. The **process capability ratios**, C_p and C_{pk}, are calculated from the tolerance limits, target value, measured mean and standard deviation. Both ratios involve a comparison of the tolerance (in the numerator) with the measured process variation (in the denominator). When the tolerance is larger than the variation, the ratios are greater than one, signifying a capable process.

Formulae for the capability ratios are as follows:

$$C_p = \frac{USL - LSL}{6 \text{ sigma}}$$

C_{pk} = Smaller of:

$$\frac{USL - Mean}{3 \text{ sigma}} \quad \text{and} \quad \frac{Mean - LSL}{3 \text{ sigma}}$$

where:

USL = Upper specification limit

LSL = Lower specification limit

Sigma = Standard deviation of measurements on the process variable

note:

(USL - LSL) = Tolerance

C_p is a useful measure of process capability for centred processes, i.e. the process mean equals the target value.

C_{pk} should be used if the process is not centred.

A process is capable if the appropriate ratio (C_p or C_{pk}) is greater than one.

C_{pk} is more widely applicable since it accounts for the effect of both random and systematic variation. A capable process, which has a C_{pk} greater than one, is one which is in-control and has a degree of variation which is consistent with the process requirements. **The key thing to keep in mind is that as variation increases, process capability decreases.** In Figure 9, only process A is capable.

The conventional view of variation is that there is no loss in quality if product characteristics are within tolerance limits, and a major quality loss if they are outside the limits. In practice, the accumulation of small variances can lead to "tolerance stack-up" resulting in improper fit among parts which individually are within tolerance. This results in greater re-work, uneven production flow, higher tool maintenance costs, lower yield, and higher inspection costs. The customer may also experience loss through reduced performance or premature failure.

The negative effect of variation, even within tolerance limits, can be illustrated using the Total Loss Function, shown in **Figure 10**. Notice that the loss function is zero only for the target value of the quality characteristic. As we move away from the target value, in either direction, we face increasing losses.

Processes A and B both produce results that are within tolerance limits. However, look at the overlaps (shown as shaded areas) between the distribution curves and the loss function. These areas are proportional to the quality losses resulting from variation. These quality losses are significantly greater for process B, the more variable one.

It is usually not practical to determine the actual shape of the Total Loss Function, however, knowing that such a function exists helps us to keep in mind that: 1) all variation in key characteristics and process parameters reduces quality to some extent; and 2) spending on quality improvements is reasonable as long as they produce larger savings for either the producer or customer.

Motorola's Six Sigma Program saves hundred's of millions: Motorola's Six Sigma approach to quality has achieved tremendous results – annual savings of several hundred million from reduced defects and inspection needs alone. While the company is best known as a consumer electronics firm, its Government Electronics Group uses the same quality program as the rest of the company to produce aviation electronics. Products include the Kk.45 target detection device for the U.S. Navy's Standard Missile and the DKW radar transponder, used on target drones.

Six Sigma refers to a defect level of 3.4 per million or 99.999% defect free manufacturing (See Figure 8). Starting at a defect level of 7 000 per million in 1986, Motorola has achieved and, in some cases, surpassed the Six Sigma quality level. The program emphasizes the importance of defect prevention and makes extensive use of SPC.

Although the Six Sigma program receives a lot of external publicity, the company's quality program involves more than SPC. Motorola places much emphasis on management leadership, employee involvement and customer satisfaction – and was the first winner of the Malcolm Baldrige National Quality Award, which has broadly-based criteria. Motorola's approach to Total Quality has enabled it to compete successfully in a world marketplace.

(based on *Motorola Nears Quality Benchmark After 12-Year Evolutionary Effort*, David Hughes, Aviation Week & Space Technology, Dec. 9, 1991)

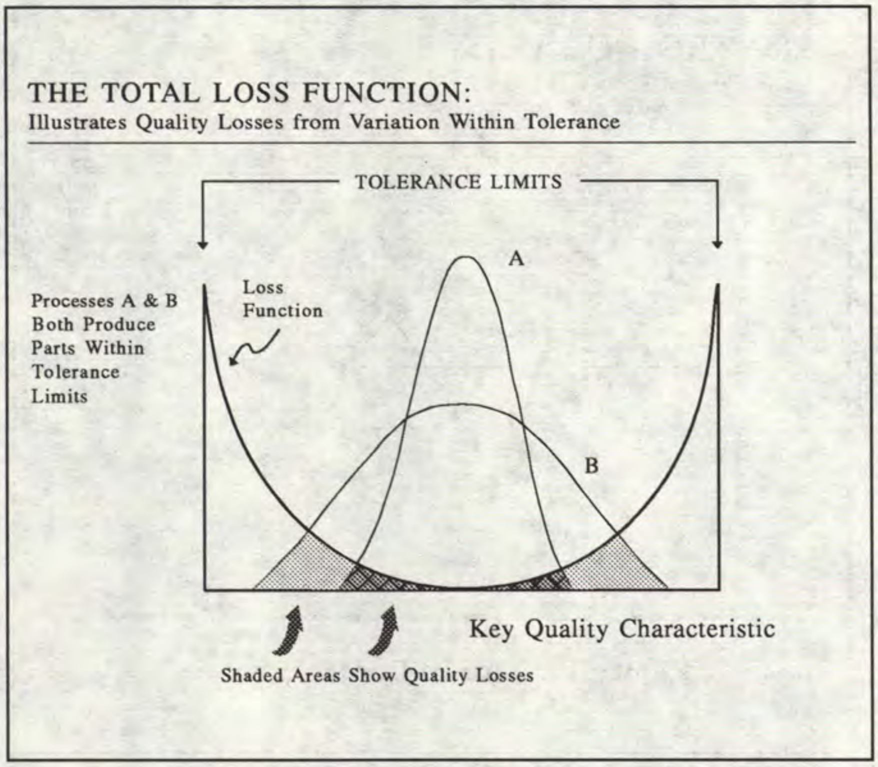


Figure 10 – The Total Loss Function

Control charts are a graphical method of recording measurements of a process variable or output characteristic in order to characterize the common and special cause variability of a process and determine if it is in-control or out-of-control. They provide a visual description of process variability versus time which is easily understood.

Figures 11 and 12 illustrate control charts for hypothetical in-control and out-of-control processes. The dotted lines are control limits, which separate the zones of stability (no action required), warning (possible problems and the need to seek additional information) and action. These correspond to variation about the target value of plus or minus one, two and three sigma.

Employees can use control charts to monitor processes on an ongoing basis. When something in the process changes, or a distinct trend or pattern is identified, they make a decision to adjust the process, shut it down, or call for assistance. Control charts are also used in process improvement projects to evaluate trial improvements.

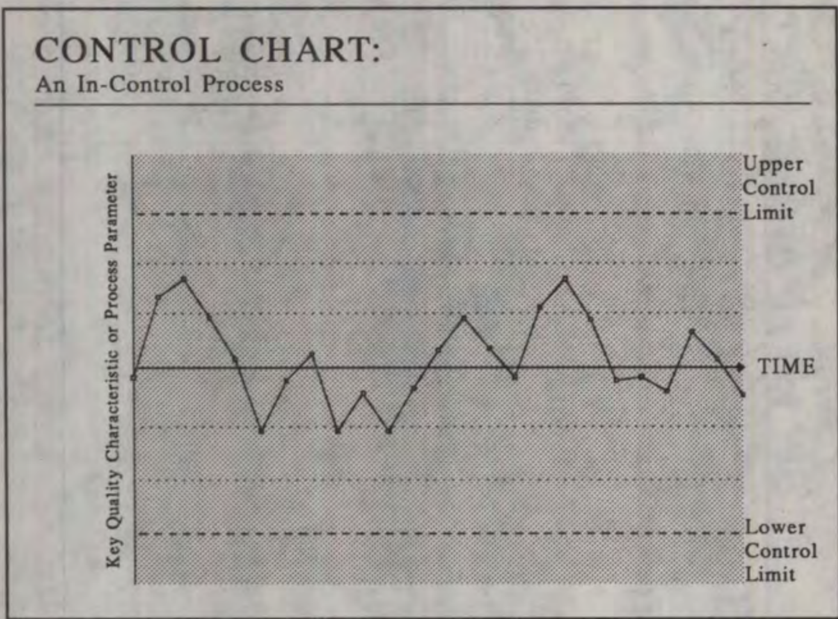


Figure 11 — An In-Control Process

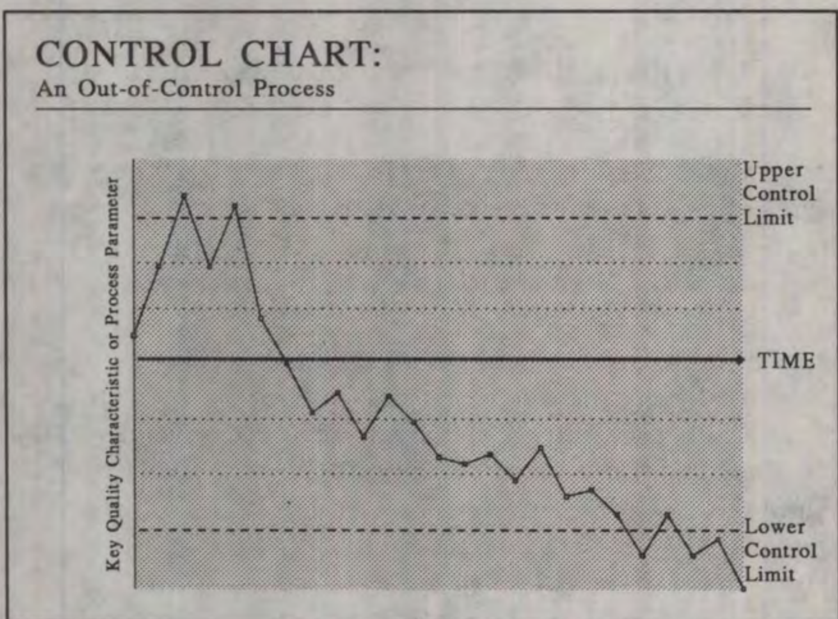


Figure 12 — An Out-of-Control Process

Check Sheets provide a means of monitoring how often various quality-related events happen (e.g. defects or other quality problems). They are a first step in moving from opinions to facts in problem-solving. Designing a check sheet involves specifying the type of event to be monitored and time period for data collection. Often, the data from the check sheet can be visualized using graphical methods such as scatter diagrams and histograms, discussed below.

Scatter diagrams are graphical techniques used to analyze the relationship between two variables (e.g. process capability versus tool life). The two sets of data are plotted on a graph, with the y (vertical) axis being used for the output variable and the x (horizontal) axis being used for the input variable. The graph shows correlations between the variables, either positive, negative or none.

Figure 13 shows an example scatter diagram in which a negative correlation between variables A and B is clearly seen. This means that higher values of variable A (process capability) usually occur with lower values of variable B (tool life). It is not absolute proof that variable A is affected by variable B since they may both be affected by some other variable which we have not measured. It would, however, suggest looking for possible reasons why variables A and B are related in this manner. Knowledge about the process is important in interpreting these diagrams.

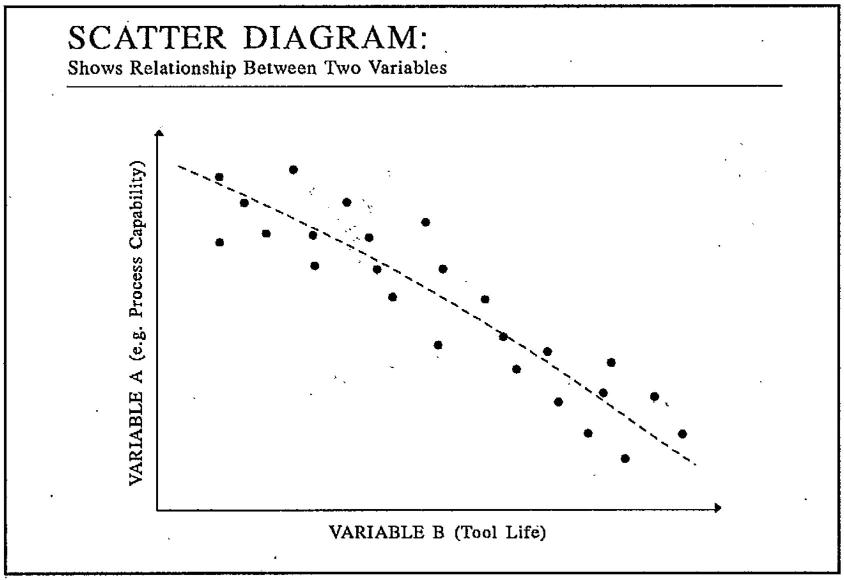


Figure 13 — Scatter Diagram

Histograms are graphs showing the statistical distribution of a measured quantity in equal intervals. They provide a visual description of the variability of measured characteristics – including most frequent values and range of variation. Histograms are closely related to the distribution curves shown in Figures 9 and 10. These curves can be thought of as histograms in which the width of the intervals is extremely small and the number of measurements is extremely large. **Figures 14** and **15** show histograms for capable and non-capable processes.

Pareto Analysis is a graphical tool for ranking causes of process variation or quality problems from most significant to least significant. It can help us, in the words of J. Juran, "to distinguish between the vital few and the trivial many." For example, we may want to identify the main reasons for delays in delivery of software subroutines or the causes of defects in an aircraft part.

The technique, which is named after the 19th century engineer and economist, Vilfredo Pareto, is based on the principle that a relatively small number of causes make the greatest contribution to the observed effect (often called the "80/20" rule because roughly 80% of the effect results from 20% of the possible causes).

Figure 16 shows a Pareto analysis of software development problems which was produced during a process improvement effort at **Paramax Systems Canada**. The causes of software development problems were identified and are listed below the chart. These problems represent process improvement opportunities.

Taguchi Methods (named after Genichi Taguchi, the Japanese quality expert who has taught them) are a group of statistically-based methods used to improve the design of products and processes in order to maximize quality. The initial steps involve determining the key characteristics of the product, and the relevant process variables which affect quality from the customer's viewpoint.

Statistically designed experiments are then carried out in order to analyze variation during production and use, and the resulting effect on quality. The aim is to determine optimum values for product design parameters and process variables, given customer requirements and variation in both production and in-use conditions. These optimum settings will give rise to "robust" products and processes – those that maintain quality in spite of variation in production and in-use conditions. In determining optimum parameters and allowable tolerances, trade-offs between costs of production or operation and the losses acceptable to the customer arising from performance variations are considered using the Total Loss Function, discussed earlier.

HISTOGRAMS

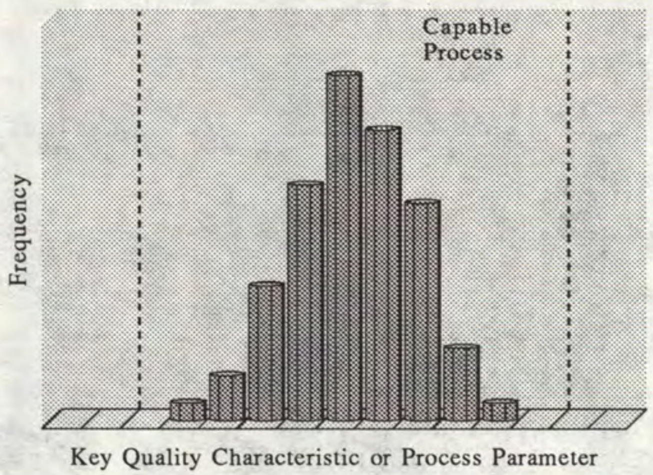


Figure 14 — Capable Process

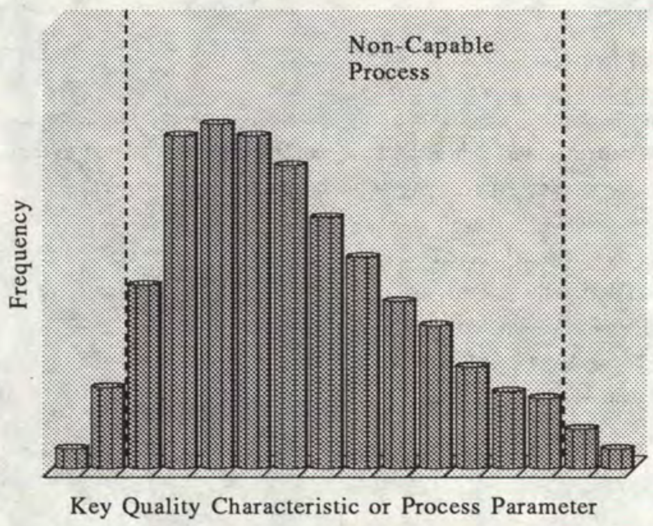
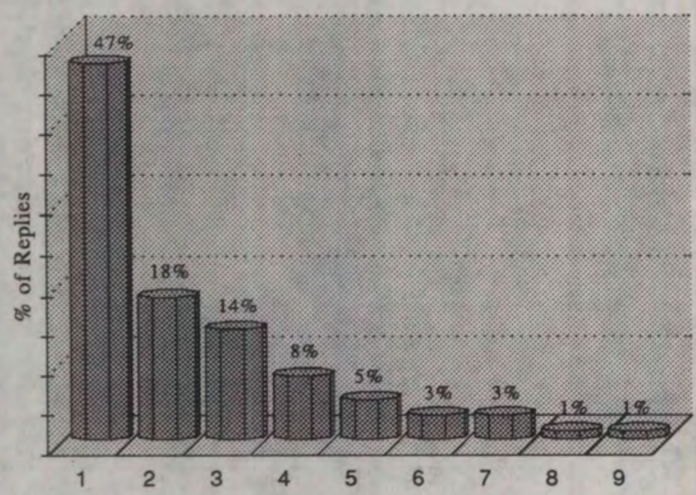


Figure 15 — Non-Capable Process

PARETO ANALYSIS OF SOFTWARE DEVELOPMENT PROBLEMS



c/o Paramax Systems Canada

Figure 16 — Pareto Analysis

Category of Problem:

1. Incomplete/changing/segmented Software Requirements Specification.
2. Review-process deficiencies short on people, time and attention to technical detail.
3. Inadequate systems engineering at the beginning of the project.
4. Shared design/development responsibility.
5. Lack of system level specifications.
6. Program design difficulties.
7. Unavailability of required Quality Assurance Personnel.
8. Major changes made without proper review.
9. Inexperienced design engineers.

Statistically designed experiments (also considered part of Taguchi Methods) provide a means of dealing with large numbers of possible combinations of variables and sources of variation using a manageable number of experiments. They involve varying more than one parameter within each experiment in a manner that will allow separation of the effects of different variables during the analysis stage. The variation of relevant production and in-use variables is characterized and causes are assigned where feasible. Variation is classified, according to its controllability, as inner (controllable under normal operating conditions), outer (not controllable), and in-between (controllable using non-routine procedures). A strategy for eliminating sources of variation can then be formulated.

Statistical design of experiments is not unique to Taguchi. However, Taguchi has enlarged its scope of application, linked it to the cost of quality through the use of the Total Loss Function and provided an approach for dividing complex problems into manageable steps.

TEAM PROBLEM-SOLVING METHODS

In a TQM company, quality improvement initiatives are often undertaken by teams of employees. In this section, we discuss some of the methods which are used by teams to generate ideas, identify causes of problems and potential solutions.

Brainstorming is an activity used to generate lots of ideas on a particular subject, for example, how to improve a product or find the cause of poor quality. In a brainstorming session, participants are encouraged to generate lots of ideas using their experience and imagination to the fullest extent. While the ideas should remain centred around the problem at hand, they are not evaluated during the session. In an effective session, ideas are generated without fear of rejection or jockeying for position, and new ideas often flow from one to another. Evaluation and refinement of the ideas is done later. Brainstorming sessions can be extremely productive, allowing all participants a chance to express their ideas and concerns. The outputs come from the team, not from individuals.

Causal chain analysis is a powerful weapon to attack a complex problem where the root cause may be several steps away from the obvious symptom. It is used to find the root cause of a quality-related result or situation by identifying each link in the cause-and-effect chain that connects the starting-point situation back to the root cause. Team members deduce links by repeatedly asking two questions: 1) What is the situation (or effect)? and 2) Why?

Cause and effect diagrams are graphical tools for analyzing process variation or other quality issues. They assist teams to consider all the potential causes of a problem or effect under consideration, and can be used in conjunction with brainstorming, causal chain analysis and Pareto analysis. The diagrams are also called Ishikawa diagrams (after the quality expert who has advocated their use) or fish-bone diagrams (because of their shape). **Figure 17** shows a schematic cause-and-effect diagram. Causes would be written along the lines of the diagram (where the numbers are now). In practice, the diagram is often made on a blackboard during a problem-solving session and is somewhat more irregular. **Figure 18** shows a highly detailed cause-and-effect diagram produced by AlliedSignal Aerospace Canada.

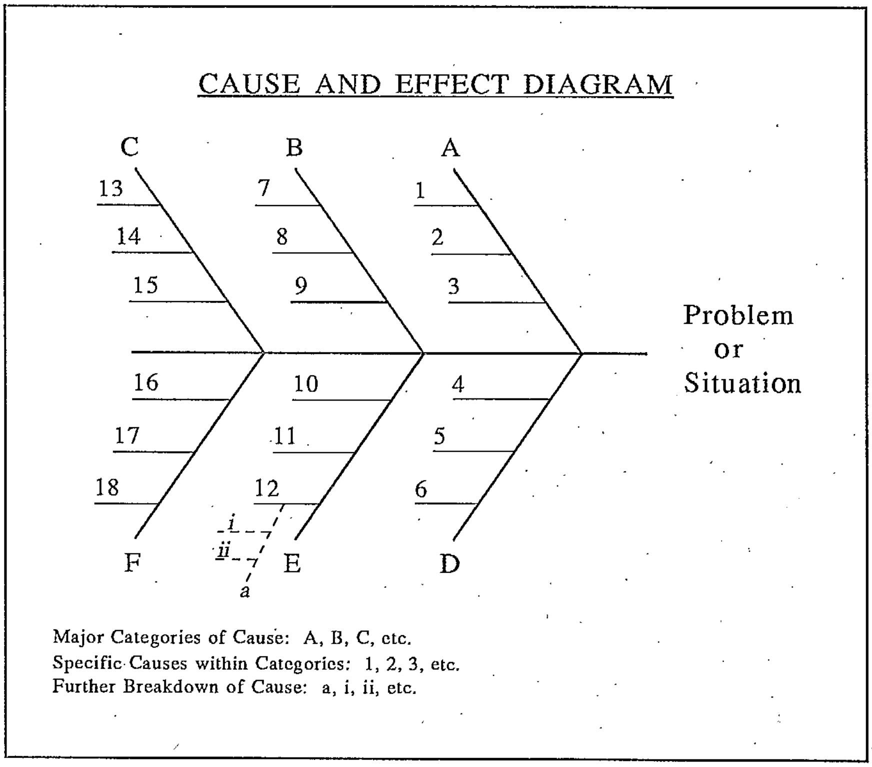
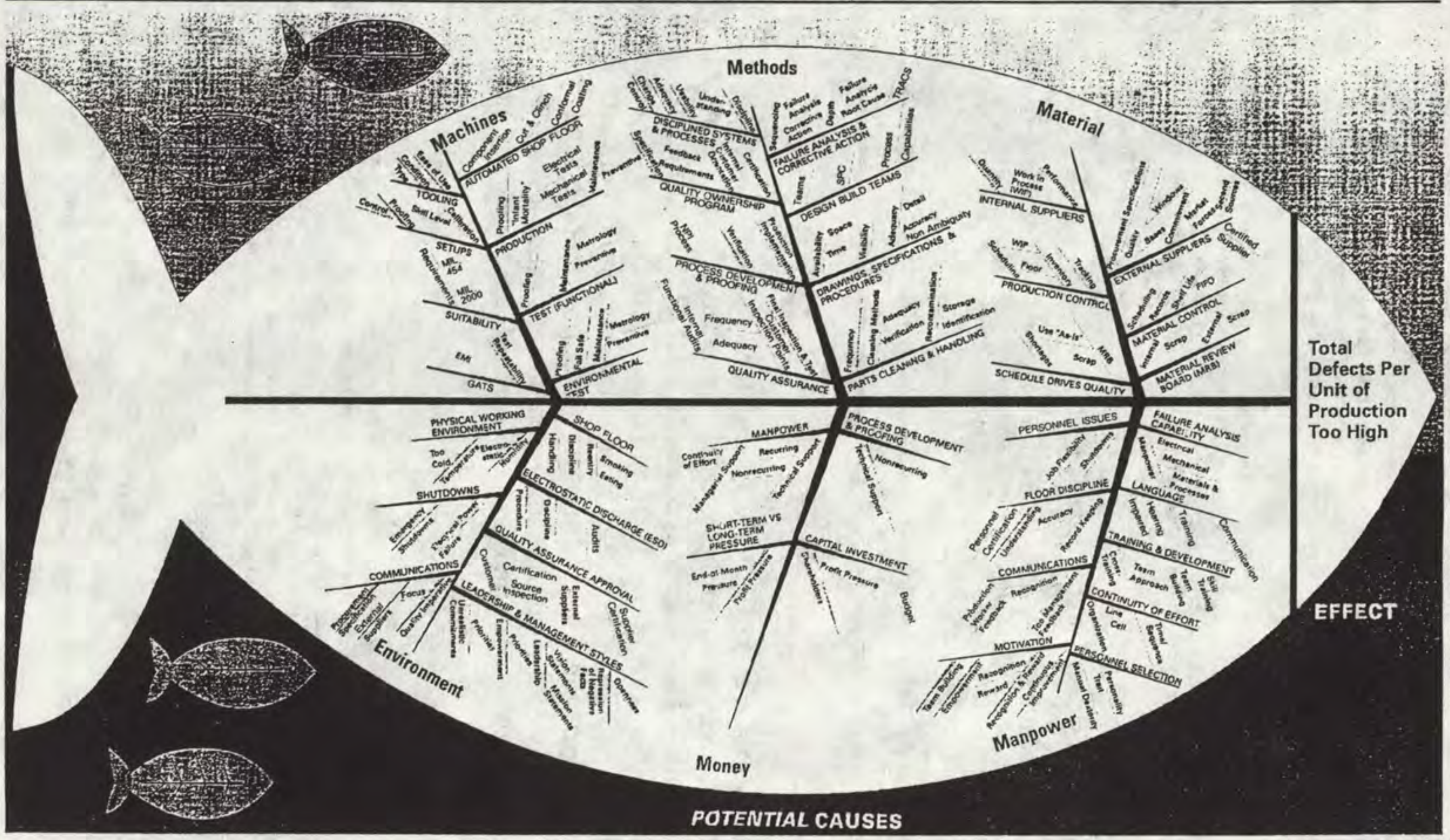


Figure 17 — Cause and Effect Diagram

Production Controller Assembly



AlliedSignal Aerospace Canada

AlliedSignal AEROSPACE

Figure 18

Boeing Materiel uses an internal survey to set the stage for process improvement. With the help of consulting firm IRD/Macro International, the firm surveyed its employees to determine how work is actually performed and obtain their perspectives on quality. The project, conducted by a team of Boeing employees and consultants, enabled Boeing Materiel to understand and improve its business processes.

The team utilized IRD/Macro International's RENEW software to collect and analyze data on work patterns, including actual time spent by employees on all tasks (not just those in their job description) and their perceptions of quality problems. Using the software, the team classified business processes in terms of relationship to the organization's mission, activity cost, and cost of poor quality.

Using Pareto analysis, the team determined that 15% of all activities accounted for approximately 60% of labour costs. The organization's major business processes were mapped and the extent of fragmentation, redundancy and misallocation of work in each activity was also analyzed.

The results of this analysis were presented to management and used to make improvements such as elimination of non value-added work and rework, and reduced cycle time. Employees appreciated the opportunity to analyze their processes. Said one employee: "I knew I spent some time correcting others' errors, I just never knew how much."

(based on *Taking Quality Beyond the Awareness Stage*, Charles Wetzel and Nancy Yencho, Journal for Quality and Participation, Jan/Feb 1992)

Affinity diagrams are particularly useful for sorting through the deluge of ideas generated during a brainstorming session. To produce a diagram, team members identify items (ideas, causes, effects, products, needs, etc.) which may be relevant to the problem at hand. These items can be written on post-it notes or cards and arranged randomly on a table or wall. The team then searches for common factors and relationships that tie the different items together and sort the items into several logical groups. Appropriate names are then invented for the categories of organized items. The finished diagram provides an overview of the important elements of a problem and how they are related.

Canadian aerospace companies use SPC methods to reduce variability. Chapter 10 contains two case studies describing how Canadian companies (Hawker Siddeley and Menasco) have used SPC methods to reduce variability in production processes. The case studies illustrate the use of histograms, control charts and other statistical methods, as well as describing how causes of variation were identified and eliminated.

Forcefield analysis provides a means of analyzing the interrelationships between the factors affecting the output of a process. The forcefield diagram defines the current situation and desired outcome, and identifies forces which are driving the situation toward the desired outcome as well as restraining forces. Opposing forces which are related are paired or placed in close proximity. Below is an example of forcefield analysis, provided by Paramax Systems Canada, showing some driving and retraining forces associated with the desired outcome of greater employee involvement in TQM:

AN EXAMPLE FORCEFIELD DIAGRAM
Factors Affecting Employee Involvement in TQM

Current State: Incomplete participation in TQM by personnel

Desired Outcome: Everyone participates in TQM

Driving forces			Restraining Forces
Customer satisfaction	→	←	Lack of customer orientation
Job security	→		
		←	Skepticism
Employee satisfaction	→	←	Resistance to change
Reduced costs	→		
		←	Time and cost to change
Increased productivity	→		
		←	Process improvement takes time
Faster growth	→		

Forcefield analysis facilitates devising ways to accentuate the positive (strengthening driving forces) and to eliminate the negative (restraining forces).

Pratt & Whitney Canada uses Kaizen teams to make significant manufacturing improvements. Kaizen is a Japanese word which corresponds to the TQM concept of continuous improvement. The company's 10-member Kaizen (or continuous improvement) teams typically include an area's Manufacturing Line Manager, departmental supervisor, and several operators and representatives from other organizations such as Engineering, Plant Engineering, and Materials & Procurement.

To implement the Kaizen concept, P&WC utilized coaching from Japan's Shingijutsu company. During an intensive Kaizen workshop, six teams analyzed current work flow within their departments, mapped their manufacturing processes, identified and eliminated unnecessary steps and put the processes back together in more logical, efficient arrangements.

The results achieved were impressive: travel distances for parts during manufacturing, lead times (the time it takes to deliver a part), and set-up times were reduced to less than 10% of previous values. Manufacturing Line Managers will follow up on the implementation of changes identified during sessions. The company will hold regular Kaizen sessions in the future, and has established a core team.

(based on a report in P&WC News, Vol. 8, No. 2, May, 1993)

Chapter 5

MEASUREMENT OF QUALITY AND PRODUCTIVITY

In this chapter, we discuss the measurement of quality and productivity. In a TQM company, measurement is an essential part of improvement strategies at the process, departmental and company-wide levels. All employees, not just management, are involved in measurement and in using the results.

Before getting into details, there is one question which deserves consideration: Should productivity measurement and improvement be considered part of TQM? The answer is yes, absolutely. Total Quality is defined as the quality of products, services **and** processes – thus productivity measures are important measures of the quality of processes. Productivity is an element of Total Quality.

From the perspective of a productivity specialist, one could also say that quality is a part of productivity. For example, economic productivity can be defined as:

$$\text{Economic productivity} = \text{Output value/Input value}$$

$$= \frac{\text{Output volume}}{\text{Input volume}} \times \frac{\text{Output unit price}}{\text{Input unit cost}}$$

The economic productivity depends not only on the ratio of the output to input volume but also on the ratio of output price to cost – and price will depend on how valuable the product is to customers (its quality). Thus the economic productivity, as defined above, incorporates quality. Our choice of words is not important as long as we understand that quality and productivity are highly interdependent and are clear on what we are going to measure and why.

To succeed at continuous improvement, it is vital that we measure the right things – those which are relevant to customer satisfaction. We need to identify which processes and outputs are affected by quality and productivity problems and assign priorities to improving them. We then need to measure our progress in improving these processes and outputs. Measuring the quality and productivity of our products, services and processes allows us to accomplish both these objectives. Below, we cover a broad range of quality and productivity measurements. They are not all-inclusive – there are likely to be situations where other measurements are needed.

It is important to keep in mind that the scale of measurement is changing as customer expectations increase. For example, where defect levels used to be expressed as percentages, they are now given in parts per million (ppm). Measures of timeliness previously given in weeks are now given in days. The bar is continuously being raised.

MEASUREMENT OF QUALITY AND CUSTOMER SATISFACTION

Quality measurement requires determining: 1) customers' needs and requirements and 2) the extent to which these needs and requirements are met ("conformance to requirements") and, possibly, exceeded. As discussed in Juran's *Quality Control Handbook* (4th ed., McGraw-Hill, 1988), understanding customer needs and requirements is not a trivial task. It is important to recognize the existence of stated and unstated needs, as well as perceived and real (functional) needs. Equally important is to realize that customers and suppliers often use different terminology in discussing needs. As noted in Chapter 3, customer "needs" and customer "requirements" are often used interchangeably in the quality literature.

From the viewpoint of a company, relevant customer needs are those which the customer attaches economic value to – that is, they are willing to pay for. The highest quality product will offer the best combination of meeting customer needs and competitive price. This will lead to sales, and subsequently, customer satisfaction and more sales.

Quality measurement should start at the design stage. Customer requirements should be analyzed and product features needed to meet these needs should be identified. One system for doing this, called Quality Function Deployment, is discussed in the section on product development in Chapter 9.

Once a product is in production, the quality of the manufacturing, sales and customer service processes will impact on customer satisfaction and costs. One measure of process quality is the fraction of process output which is defective, usually expressed in parts per million (ppm), e.g. ppm of defective solder joints for a particular soldering operation. Another process quality measure is the First Pass Yield, defined as the fraction of product from a production run (before inspection and rework operations) which meets quality requirements.

As discussed in Chapter 4, process variation is a source of poor quality, as characterized by the Total Loss Function. The process capability indices, C_p and C_{pk}, which vary inversely with the variability of key process variables and key product characteristics, are therefore measures of process quality. They are sensitive to quality variations, even for processes whose outputs are within quoted tolerances.

Poor process quality may be compensated for by inspection and re-work, however, it will show up in low productivity and high costs. The measurement of productivity and the cost of poor quality is discussed later in this chapter.

Customer satisfaction is arguably the central issue in determining product and service quality. Both informal and formal methods are used for determining customer needs and measuring customer satisfaction. More formal approaches include: customer surveys, in-depth interviews, focus groups, brainstorming sessions and feedback sheets. A comprehensive discussion of these methods, which are part of the field of market research, would be too lengthy to include here. We have included, in point-form at the end of this chapter, some of the main considerations in their use. Informal information exchange, whether within the company or with external customers, is at least as important as these more formal methods.

Fokker management make a special effort to listen to customers. Executives of this Netherlands based company routinely hold conferences with customers to hear their comments on Fokker aircraft, even on those such as the F-27 and F-28, that are no longer in production. The company has committees, operating outside the normal supervisory organization, to which employees submit suggestions for product and process improvements. Top suggestions are rewarded financially and publicized throughout the company.

(based on *Competition and Tighter Budgets Push Aerospace Firms Toward TQM*, Bruce A. Smith, Aviation Week and Space Technology, Dec. 9, 1993)

Note that we are interested in the requirements of both our internal and external customers. When this type of fact-finding and analysis is applied to the requirements of external customers, it is part of market research. When it is applied to internal customers' requirements, we call it process improvement. In fact, the distinction is somewhat artificial since TQM also involves improvement of processes at the interface between customer and supplier firms, carried out by teams having members from both companies.

Measures of customer satisfaction can be both qualitative and quantitative. Examples of quantitative measures include: the percentage of customers indicating a particular level of satisfaction (e.g. very satisfied, somewhat satisfied, etc.) on a customer survey or the number of customer complaints or change requests over a given time period. A quantitative measure used by AlliedSignal Aerospace Canada is the Customer Satisfaction Index, defined as the average of the delivery rating and quality rating for each customer, weighted by the dollar value of sales.

PRODUCTIVITY MEASUREMENT

To have a complete picture of the company, we need to measure the productivity of individual processes (**micro measurements**) and of functional departments, business units and the entire company (**macro measurements**). Below, we discuss productivity measurement at the micro (process) level. This is followed by a brief discussion of macro measurements. Micro measurements are needed to support process improvement efforts – to test trial improvements and to verify that permanent improvements are successfully made.

Productivity measurement requires determining the ratio of output volume or value to input volume or cost for relevant input factors. For example:

Labour productivity:

$$\frac{\text{(Number of units manufactured/shift)}}{\text{(Number of person-hours worked/shift)}} \quad \text{or} \quad \frac{\text{(Value of production/shift)}}{\text{(Labour costs/shift)}}$$

Machine productivity:

$$\frac{\text{(Number of units manufactured/shift)}}{\text{(Machine time/shift)}} \quad \text{or} \quad \frac{\text{(Value of production/shift)}}{\text{(Machine costs/shift)}}$$

Material productivity:

$$\frac{\text{(Number of units manufactured/shift)}}{\text{(Material consumed/shift)}} \quad \text{or} \quad \frac{\text{(Value of production/shift)}}{\text{(Material costs/shift)}}$$

Other relevant input factors could include energy or purchased services. Among these measures, labour productivity has historically been the most widely used. In recent years, there has been decreasing emphasis on this measurement, particularly among world-class companies where competitiveness is more closely linked to time-based measures (see below).

Below are some additional important measures of productivity:

Timeliness Measures answer the questions: "Are we on time?" and "Do we meet our customers' requirements regarding schedules?" For example:

Product lead time	= Time from request to delivery
Process lead time	= Time taken to produce outputs after receiving inputs
Actual lead time minus quoted lead time	= Number of days early or days late

Turnaround time is similar to process lead time but usually refers to a complex task consisting of several processes.

(The above timeliness measures could apply to the delivery of a product to external customers or of intermediate output to internal customers.)

Aircraft on Ground (AOG) Response Time	= Time that a customer's aircraft is delayed for take-off because of a problem with a manufacturers' component or sub-system. (i.e. time from when the manufacturer is notified to when the problem is fixed.)

Efficiency measures answer the question: "What percentage of our resources goes into useful products and what percentage goes to produce waste?" For example:

Labour efficiency =

$$\frac{\text{Number of hours worked/shift less number of hours on rework/shift}}{\text{Number of hours worked/shift}}$$

Machine efficiency =

$$\frac{\text{Total machine time/shift less machine time on (scrap, rework, downtime)/shift}}{\text{Total machine time/shift}}$$

Material efficiency =

$$\frac{\text{Number of (good) units produced/shift} \times \text{Average material used per unit}}{\text{Total material used/shift}}$$

Productivity measures for information and ideas: These outputs are sometimes difficult to measure quantitatively. For example, (number of good ideas/hour) is not practical since it is difficult to quantify "good ideas." Even in cases where there is a more measurable output unit, care should be exercised. For example (number of lines software code/hour) doesn't take into account the efficiency of the code. In fact, using less code to perform a particular function can contribute to a higher quality program. Similarly, measures such as (number of papers published) or (number of patents obtained) are dubious – they are not necessarily related to value provided to customers. It would also not be practical to measure the quality of an idea, or the elegance of an analysis.

There are, however, a number of outputs which can be used in productivity measurement:

(Number of milestones achieved)/(Number of milestones promised)

(Number of drawings reworked)/(Total drawings)

(Number of software change requests)/(Total hours worked)

(Number of drawings overdue)/(Total drawings)

Although measurement of outputs is sometimes impractical, it is still usually possible to monitor processes in a way that supports improvement efforts. Consider the following measures which do not include outputs but are clearly related to productivity:

(Actual cost* of work completed)/(Estimated cost*)

* labour cost (hourly rates x hours worked)

(Overtime hours)/(Total hours worked)

(Actual time to complete task)/(Estimated time**)

** For some tasks, it is possible to develop rules-of-thumb (time to do drawings of a given complexity, management/designer effort ratios, etc.). These rules can be developed by building a database of times to perform tasks.

One way to approach process improvement is to ask, upon completion of a task: "What have I learned to reduce the cost of this type of task by, say, 5%?" Improvements can be subsequently tried and if they result in a cost/time reduction, the database can be updated.

Macro measurements are concerned with the performance of organizational units (the entire company, functional departments, business units). They are needed to:

- make strategic decisions concerning products, markets and technology;
- provide reward and recognition; and make decisions on compensation and advancement based on fact, rather than opinion; and
- monitor the gains made through TQM, in order to adjust the TQM implementation plan.

Examples of macro measurements include:

- revenue per employee;
- value-added per employee;
- revenue/(total wage and benefit cost); and
- value-added/(total labour and capital cost).

where value-added =

revenue minus cost of all purchased goods and services

= net profit + depreciation + labour cost

MEASUREMENT OF COSTS

To have a complete picture of productivity and quality, we need to know the cost of each of our processes, including total costs and quality-related costs. We also need to understand the relationship between product cost, features and quality. In this section, we discuss three interrelated methods used to achieve these objectives: Activity-Based Costing, Cost-of-Quality measurement and Value Engineering.

Activity-based costing (ABC) is a method for allocating all costs, including overhead costs, to the processes and products which actually incur them. It is an effective tool for eliminating unnecessary costs (those that do not add value) and to justify new investments (those that will add value). It can be applied to all business processes, including R&D. This is particularly useful since about 85% of a product's lifetime costs, including maintenance and repair expenses, are locked in during the design and development stage.

Conventional cost accounting methods allocate overhead based on labour. While this was reasonable when labour was the biggest single direct cost, it no longer makes sense since automation has substantially reduced the relative size of direct labour costs. Also, conventional methods do not assign a value to quality-related costs such as rework or bottlenecks. Consequently, they provide little incentive to reduce them. By allocating costs more realistically to products and processes, ABC provides useful information for improving processes. It is used in conjunction with other TQM methods such as flow charting and cross-functional teams.

The **cost of quality** includes all the costs associated with achieving the required quality and dealing with failures to do so. These can be divided into three categories:

1. Prevention (training, pre-production design, SPC, quality planning, quality system audits & assessments).

2. Inspection (receiving inspection, in-process inspection, tests, etc.)

3. Failure/Errors: 1) internal failure (scrap, rework, spoilage, re-test, downtime); and 2) external failure (lost business, warranty charges, returned material, allowances, loss of customer goodwill, etc.)

The first two categories are known as **costs of control** whereas the last category represents the **cost of failure to control** quality. You may well ask why it is meaningful to place costs associated with achieving, and not achieving, quality in the same category. The answer is simple: the total cost of quality represents the resources used to achieve quality or deal with the consequences of not doing so. Few companies today are fully aware of the nature and amount of their true quality costs, however experts believe them to be significant. Estimates for the cost of quality in North American industry range from 5 to 40% of sales.

British Airways Technical Workshops makes Cost of Quality an important element of its TQM approach. This 1 200 person organization, part of the Engineering Branch of British Airways, began its TQM journey in 1987. In addition to surveying employees, customers and suppliers on quality issues, senior and middle management were asked to assess how their staff spent time on the three categories of quality activity: prevention, appraisal and dealing with failure.

The results showed that 19.4% was spent on prevention, 6.8% on appraisal, and 22.9% on failure. Examples of prevention include activities involved in the intake program for new aircraft and components, and the forward planning of supplies which are likely to be needed in the future. Appraisal includes the re-checking of work done by engineers. Failure includes incorrect parts delivered by stores, spare parts stored in the wrong location, time spent in obtaining approval for drawing and design changes, and reworking units which fail in final test.

The Cost of Quality results helped identify areas which were later tackled by Quality Improvement Groups. Management is convinced that these results also contributed to getting people committed to TQM.

(based on an article in Managing into the '90s).

Some of the activities which can be performed more effectively if the cost of quality is known, include:

- setting quality goals and monitoring progress toward them;
- determining the relative cost-effectiveness of different quality management activities;
- providing a basis for budgeting and, ultimately, cost-control;
- facilitating comparison with other costs;

- providing information for quotations on products or contracts having rigorous quality requirements; and
- keeping an organization focused on improving quality.

One of the main points made in the previous chapter was that it is more effective to control the inputs to a process and the process itself than to control its outputs. Put another way, it is less expensive to prevent poor quality products from being produced than to eliminate them by inspection, and even less expensive than dealing with the results of poor quality.

The cost of quality provides a means of tracking these expenses – to see how much quality is costing and measure progress in improvement efforts. Before adopting TQM, **the costs of failure usually account for 80 to 85% of the total cost of quality** while the costs of control usually account for 15 to 20%. With successful implementation of TQM, prevention costs increase somewhat but there is a much larger decrease in inspection and failure costs. The initial increase in prevention costs represents an investment which can provide an extremely high rate-of-return. **Figure 19** illustrates how the various components of the cost of quality are affected as successful TQM implementation proceeds.

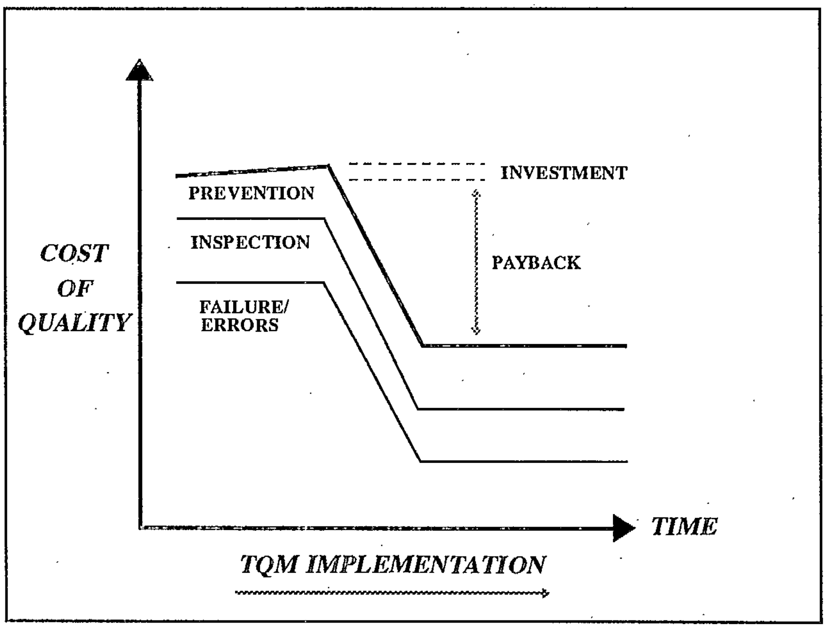


Figure 19 – Cost of Quality

To understand why effort on prevention is such a good investment, consider your own experience in dealing with errors. Most of us would agree that it costs a lot more to deal with a problem after it has happened than it costs to prevent it. (As the garage mechanic said in an advertisement for Fram oil filters, "You can pay me now [for a new oil filter] .... or pay me later! [for a new engine].")

Placing the emphasis on prevention, by designing quality into products and processes, is not the conventional way of doing things. When a customer complains about quality, the first reaction of some companies is to increase the number of inspectors. By doing this, have they increased the quality of the product? At best, this action may have detected some defective parts that may have otherwise slipped through to the customer, but this does absolutely nothing to prevent defects from being made. Many managers are concerned with productivity but do not realize that placing too much reliance on inspection to meet quality targets has a negative effect on productivity. Experience has shown that reducing the rate of defects increases both profitability and production capacity.

Can the statistical methods and other techniques in TQM do away with all forms of inspection? Most people in the Quality field would say that this is not realistic – that there will always be some form of inspection required as a second line of defence. For example, a recent international quality study, which examined numerous companies and correlated quality practices with performance, concluded that companies should "design in" **and** "inspect in" quality. (Ernst & Young and American Quality Foundation International Quality Study.)

Value engineering is a technique for evaluating the design of products to ensure that their essential functions are provided at minimum cost. It involves a systematic analysis of a product's functional requirements and costs and a search for the design which achieves these requirements at the minimum total cost.

The basic principle of value engineering is to challenge the status quo – to ask the question: Could it be done for less cost just as well? One begins by defining the cost problem and then searching for alternative ways to reduce the cost. Creative thinking is required and often involves participation of people from engineering, production, purchasing, quality, and marketing in brainstorming sessions.

Value engineering can play a role in quality improvement since it seeks to maximize value received by the customer per unit cost. Most value engineering studies result in product or process simplification (part consolidation, weight reduction, combining operations, etc.). Potential benefits include: increased reliability, maintainability, producibility, performance and reduced production.

The following equations, taken from Juran's *Total Quality Control Handbook* (4^{th} ed., McGraw-Hill, 1988), illustrate the relationship between quality and value:

$$\text{Value} = \frac{\text{Satisfaction of customer desire}}{\text{Selling price}} \qquad \text{(market definition)}$$

$$= \frac{\text{Functional requirements \& quality specifications}}{\text{Cost to produce}} \qquad \text{(producer definition)}$$

BENCHMARKING

Benchmarking is a method of comparison against some standard of excellence. It was pioneered by Xerox Corporation in the 1970s, as part of their response to international competition in the photocopier market, and originated from reverse engineering of competitors' products. Its scope was then enlarged to include business services and processes. Xerox now benchmarks nearly 240 performance elements although, when they started benchmarking several years ago, considerably fewer elements were benchmarked. Benchmarking of business processes is usually done with top performing companies in other industry sectors. This is feasible because many business processes are essentially the same from sector to sector.

Benchmarking teams can consist of up to 12 employees. The teams work independently, setting their own schedule. Investigations take from one to 12 months and typically involve three to six companies. Comparing performance levels is only the preliminary phase of benchmarking. The bulk of the effort involves an analysis of how and why these performance levels are achieved.

Xerox has developed a 10-step model for benchmarking which is summarized below:

1. Identify what is to be benchmarked; it can be a service, process, or practice – the goal is to determine whether the area of interest is managed in the best possible way.

2. Identify comparative organizations (benchmarking partners); they can be other operating units within the company, competitors, unrelated companies; they should be leaders in the area being benchmarked.

3. Determine the data collection method and collect data; measurements must be chosen to provide a meaningful comparison; collection usually involves in-person meetings and site visits of areas being benchmarked.

4. Determine current performance levels; this includes identifying gaps between the organization and its benchmarking partners.

5. Determine future performance levels; forecast the expected improvements of benchmarking partners so that goals set for the improvement program will not become quickly outdated.

6. Communicate the benchmark findings and gain acceptance from senior management and employees who will be asked to make improvements; present the methodology, findings and strategy for improvements.

7. Establish objectives; after concurrence on findings and strategy, the team presents final recommendations on goals and how the organization must change to attain them.

8. Develop action plans for each objective; they should be designed to gain the required support within the organization.

9. Implement specific actions and monitor progress; this includes collecting data on new levels of performance; using problem-solving teams to investigate problems; and adjusting the improvement process if goals are not being met.

10. Recalibrate benchmarks; benchmarks are re-evaluated and updated, based on the most recent performance data.

This ten-step process closely parallels the PDCA Cycle and other process improvement methods discussed in Chapter 4. However, companies who undertake benchmarking find that it is a very complex process. We recommend that before undertaking benchmarking, those involved should read literature such as Robert Camp's book, *Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance* (Quality Press, 1989), and talk with companies who have benchmarking experience.

AlliedSignal Aerospace Canada has used cross-sectoral benchmarking to identify world-class performance in environmental auditing and health & safety programs.

GE's Best Practices method is designed to eliminate the "not invented here" syndrome. There are many different approaches to systematic performance comparisons among companies. GE's approach differs from Xerox's Benchmarking in that it does not start out by focusing on specific functions, e.g. order processing. Instead, it seeks to answer the question: "What's the secret of your success?"

GE people visit a company and examine management methods to learn what's best about them. The write-up is shared with the company visited and, in turn, the company can also visit GE. Learnings have been in areas such as: management job assignment, process ownership, product development lifecycles, inventory management.

(based on *Control Your Destiny or Someone Else Will*, Noel M. Tichy and Stratford Sherman, Doubleday, 1993)

SUPPLEMENTARY MATERIAL FOR CHAPTER 5

COMPARISON OF SURVEY METHODS*

In-person Interviews:

- Response rate close to 100%.
- Most effective method of asking open-ended questions; can lead to information on new opportunities, previously unknown problems.
- Provides highly personal approach to dealing with customers.
- Relatively higher cost per interview; requires significant interviewee time.
- Not suitable for obtaining data from large sample (for statistically valid sample).
- Not efficient for closed-ended questions.
- Interviewer must have sufficient subject knowledge and interviewing skills.

Telephone Surveys & Interviews:

- Response rate approximately 75%.
- Cost per respondent is lower than in-person interviews, higher than mail surveys.
- Uses mix of closed and open-ended questions.
- Interview length limited to 20 to 40 minutes depending on respondent interest in topic.
- May be suitable for obtaining data from large sample (for statistically valid sample).
- Suitable for asking questions on sensitive topics, if confidentiality is provided.

* Material on survey methods, appearing in this section, is based on TQM publications supplied by the Director General Quality Assurance, Department of National Defence.

- Interviewer must have good communications skills; required level of subject knowledge dependent on mix of open and closed-ended questions.

Mail Surveys:

- Response rate: 40 to 50% is good.
- Uses mostly closed-ended with some open-ended questions.
- Most useful method for obtaining data from large sample (for statistically valid sample).
- Lowest cost per respondent for large enough sample sizes; however set-up costs are relatively high.
- Suitable for asking questions on sensitive topics, if confidentiality is provided.
- Use carefully; some companies have been inundated with survey questionnaires.

Focus Groups: (Group interview with discussion)

- Response rate: 100% is possible.
- Uses open-ended questions.
- A synergistic effect can be achieved in that comments from one person may stimulate ideas from the group.
- Interviewer must have ability to handle group dynamics – communication and motivations skills.
- Can be very expensive (several hundred dollars per respondent) if done by outside consultants in specialized facility.
- Not suitable for obtaining data from large sample (for statistically rigorous surveys).
- Can be combined with administered questionnaire on closed-ended questions (see the following).

Administered Questionnaires: (To a group)

- Response rate: 100% is possible.
- Types of questions similar to mail survey.
- Opportunity to provide verbal briefing to respondents.
- Can be combined with focus groups, workshops, meetings, etc.
- Length should be limited if survey is combined with other activities.

TYPES OF SURVEY QUESTIONS

Open-Ended Questions:

Example: "What improvements would you like to see in our customer service?"

Advantages: This technique is better able to provide for the complete range of responses. It is useful if not all response categories are known. More opportunity for creativity and self-expression.

Disadvantages: You must categorize the answers. These questions are harder to code and analyze statistically. More time is required to answer. This type of question assumes that not all response categories are known. Quality of answers will vary, including some worthless responses. These questions have a high refusal rate and require higher writing and communication skills in the respondents.

Closed-Ended Questions:

Example: "Which aspect of our customer service do you feel most needs improvement?" Check one.

Technical knowledge of personnel	( )
Response time	( )
Amount of personnel time provided	( )
Availability of product performance data	( )

Advantages: Answers are more comparable from individual to individual. Makes it easier for respondents to comment on sensitive or unpleasant subjects. Easier to answer, analyze and code. Requires a shorter time to answer.

Disadvantages: This type of question may lead the respondent. May not cover the range of respondents' answers. May result in guessing.

Note: Closed and Open Ended Questions can be combined:

"Which aspect of our customer service do you feel most needs improvement?" Check one.

Technical knowledge of personnel	( )
Response time	( )
Amount of personnel time provided	( )
Availability of product performance data	( )
Other (Please Specify):	

____

____

SURVEY PROCESS CHECKLIST

SURVEY AIM: Establish the aim of the survey.

DATA REQUIREMENT: Define the exact data to be collected.

DEFINE POPULATION: Identify target segment of population and profile target segment.

SURVEY TYPE: Determine type of survey to be used.

QUESTION FACTORS: Consider the sequence and type of questions. Develop the questions. Consider respondent population. Are questions easy to read, unambiguous, relevant, appropriate?

FORMAT FACTORS: Establish the survey format (cover sheets, respondent protection, professionalism of presentation, check sheets, etc.)

PRETEST: Conduct a small trial, obtain feedback, and amend as necessary. Final review of survey questionnaire and respondent list.

EXECUTION OF SURVEY: Conduct the survey. Follow up if necessary to encourage respondents to return requested information. A follow-up strategy can significantly increase return rates.

ANALYSIS: Analyze the data. Prepare reports as necessary and provide feedback to respondents as applicable.

Chapter 6

EMPLOYEE INVOLVEMENT

Effective employee involvement is an essential element of TQM. Without it, the methods discussed in previous chapters are of limited use. This chapter discusses the way people work, and how they see their roles within a TQM company. It also discusses what it takes to create the environment necessary for TQM to succeed.

TQM AND ORGANIZATIONAL CULTURE

"TQM can't thrive in an environment where every action is directed; where people aren't encouraged to think, to communicate, to experiment with change, to examine the things we do and processes in which we work" – *the Paramax Systems Canada TQM Manual*

Moving from conventional management to TQM requires a profound change in the "organizational culture" – the way that all employees view their company and their jobs. Below are some of the characteristics of the organizational culture in a TQM environment:

Everyone has a customer orientation. Employees at all levels are concerned with their (internal and external) customers' needs. This includes everyone from the boardroom to the mailroom. Besides satisfying their immediate customers, people understand how their job contributes to meeting the needs of the company's external customers.

Workers are highly involved in the control and improvement of their activities. With TQM, all employees work with management to improve quality. This goes far beyond providing a suggestion box for employees' ideas. Employees take a significant share of the responsibility for quality and productivity. To do this, they rely on a greater degree of training, support and access to information than seen in conventional companies. They are also given recognition and rewards in proportion to their contributions.

Managers spend more time leading and coaching and less time administrating and controlling. They recognize the importance of individual workers' contributions to the quality effort and share "management type" information with them. In order to create a company-wide team, managers must be willing to communicate effectively with their employees and share responsibility.

Relatively more time is spent on systematic improvement than on "fighting fires." Conventional management practices often emphasize short-term results at the expense of the long-term. With TQM, short-term and long-term considerations are balanced. People spend less time fixing problems and more time preventing them and improving the business. According to one aerospace executive: " ... [a TQM company] is an agreeable place to be. Fewer hassles, fewer on-the-job fire drills, fewer crash projects to fix defects and errors, fewer times when you have to say: Uh-oh!"

TQM creates a "no blame" environment. Traditionally, management has blamed the worker for quality problems. TQM-oriented managers accept the fact that 80 to 85% of quality problems result from "the system" (poor product design, worn tools and equipment, inadequate measurement devices, poor materials, inefficient procedures, inadequate training, etc.) rather than the workers. Management and their employees cooperate to establish an atmosphere which promotes the exchange of information and ideas needed to improve the system.

Workers are motivated to achieve because: 1) people naturally like to do a job well; and 2) getting the job done well results in reward and recognition. In the words of one aerospace CEO: "If you don't really believe that people would prefer to do those things which will get them rewarded and recognized, rather than those things which will get them criticized and punished, you aren't going to implement TQM."

Cooperation among employees, rather than competition, is emphasized. The organizational culture under conventional management is often based on the existence of "win-lose" (or "zero-sum") situations for many of the factors affecting employees' ability to perform and the quality of work life. These include information, knowledge, responsibility and recognition and reward. In a TQM company, these areas are treated as "win-win" situations. All employees are involved in internal customer-supplier relationships with other employees. The emphasis is on interdependence – not independence.

Innovation and appropriate risk-taking are encouraged. TQM companies place a high value on new ideas and expect them to come from all parts of the organization. There is a willingness to try new approaches, even if they involve risk – provided that a reasonable effort has been made to analyze the situation. The search for new ideas is driven by a sense of urgency – to improve products, services and processes.

Spar Aerospace uses teamwork to achieve speed and customer satisfaction on a complex project. TQM is not only for large scale production, it is just as relevant to short-run and custom projects. The case study in Chapter 10 tells how a team at Spar used TQM principles to "get it right the first time."

Empowerment. Some TQM practitioners use this expression to represent an ideal of employee involvement. An empowered employee is given the means and opportunity to make decisions which traditionally would be made higher up the chain.

Power is transferred according to a process which is properly documented and understood by the parties. A crucial element is establishing mutual trust. This should build up during the process as successes are achieved and employee scepticism, and the reluctance of managers to let go, gradually decrease.

CHALLENGES IN IMPLEMENTING CULTURAL CHANGE

Organizational culture does not happen by accident – it is the result of a company's business history, including its external environment and influential mangers – and changing it is not accomplished overnight. Below, we briefly review the typical organizational culture under "conventional" management and discuss what happens during the transition to TQM. This is a simplified picture since it ignores the fact that every company is different.

During the lifetime of many companies, a gradual change occurs. The initial stages of companies are characterized by some confusion and anxiety but also by excitement and hope. Decisions are based on the influence of one or a few dynamic individuals. As the company matures, procedures become more formalized, and management involves more administration than leadership. Often, the focus of everyone's attention is the internal distribution of power and resources, instead of the company's customers and competitors. During this period, business problems arise – costs increase faster than prices, market conditions change. Often, the company has difficulty dealing with these problems.

Management then looks for solutions such as cost-cutting, market strategies and motivational programs. Although some gains are made, by and large, these programs do not succeed in re-inventing the company. As a result of difficult business conditions and a series of programs which do not deliver what they promise, there is chronic uncertainty among management and workers about the effectiveness of further actions. This is often the point where management makes a decision to implement TQM. There may have even been a couple of false starts at it.

The transition from a conventional to TQM management style subjects all employees to a great deal of stress. They do not believe that the transition is going to happen until it does – then they go into shock. There is a tendency to mark time from that day onward. Often the management change is accompanied by business crisis conditions, loss of jobs and budgets. To add to this feeling of loss, familiar roles and procedures also disappear.

People can have several reactions to the stress, including:

a) **disorientation:** losing sight of where one fits into the scheme of things; spending energy on what to do, rather than how to do it;

b) **disidentification:** spending time reminiscing about how it used to be;

c) **disengagement:** people acknowledge change but emotionally disconnect themselves from it; they put effort into maintaining a low profile, avoiding responsibility; and

d) **disenchantment:** people react emotionally, with anger and frustration. They feel like victims, and their attitude can spread to others.

The internal transition takes time. There is a significant time lag between: 1) formal policy changes; 2) stated acceptance of these changes by all employees; and 3) real acceptance of them. Productivity during this time period suffers in proportion to the stress level. If the stress level is too high, the implementation effort can fail – TQM is rejected by the organization somewhat like an unsuccessful organ transplant.

How can we deal with these problems and ensure a successful transition to a TQM organizational culture? Admittedly, this is not easy, but it is do-able and has been done by many companies. Careful planning is needed to deal with cultural change and employee involvement. The emphasis should be on minimizing the transition stress rather than the transition time. Rather than trying to speed up the transition, act to reduce the stress levels.

It is essential for senior management to establish a common vision and values and to demonstrate commitment to them. No less important is the need for training employees at all levels. This training is required to explain the new vision and values and to provide the inter-personal and technical skills needed to operate according to them.

Considerable attention should be given to dealing with resistance to change. Tactics such as autocratic decrees, avoidance of the individuals and their concerns, or heroic statements and pep talks are not helpful in responding to what is essentially an emotional situation. A proper support strategy involves thorough and ongoing discussion: listening to peoples' concerns in a non-judgemental manner, showing that they are understood, explaining the reasons for, and objectives of, the change, and engaging them: asking for understanding, agreement and ideas.

Below, we discuss the roles of management and non-management employees in making the change to a TQM culture.

THE ROLE OF MANAGEMENT

To be effective, the far-reaching changes from a conventional to a TQM style of management must be made from the top down. Managers at all levels, and particularly senior management, must be directly involved in TQM planning and implementation. Management's commitment and involvement should be real, highly visible and unwavering. Once management makes a commitment to TQM, employees will be watching closely to see if they follow through. Unless employees are fully convinced of management's commitment to TQM, the effort will not succeed.

To illustrate the critical importance of management commitment and support, here are some common causes of failure in TQM implementation:

- Management misused it;
- Management didn't participate in it;
- Management feels that the employees, not management, are the problem;
- Management is unwilling to make a long-term commitment; and
- Management does not make it a part of the business activity.

The table on the next page summarizes the major changes needed to move from a conventional to a TQM style of management.

There is considerable variation in management style among companies with "conventional" as well as TQM management styles. Even if your company has not yet adopted TQM, you may still have made, at least partially, some of the changes shown in the table. On the other hand, a formal decision to adopt TQM does not mean that a TQM organizational culture has been achieved.

Changing from a command-and-control to a leadership/coaching style is not easy. In fact, it can be a cultural shock! It requires a conscious shift from managing tasks to leading people; assisting them to take on a greater degree of responsibility for the control and improvement of their own work.

DIFFERENCES BETWEEN TOTAL QUALITY MANAGEMENT AND CONVENTIONAL MANAGEMENT

Conventional		TQM
several levels; decisions made at relatively high level	→	fewer levels; decision-making moved closer to where it is implemented
authoritarian, administrative	→	leadership, coaching
information held closely	→	more sharing of information
rigid policies and procedures	→	policies that inspire continuous improvement
experts responsible for quality	→	everyone responsible for quality
focus on managing outputs	→	focus on managing process inputs and the process itself
adversarial relationship with suppliers	→	informal and formal partnerships with suppliers
distant from market	→	close to customers

While TQM changes the working environment of all employees, the first-line supervisor seems to have the most amount of change to make. In the past, people were promoted from the shop floor because they were hard workers, not because they had excellent communication skills or knew how to motivate others. This often resulted in losing exemplary workers while gaining ineffective supervisors. TQM calls for a new role for the supervisor and more autonomy for the hourly worker. The traditional role of the supervisor has been putting out fires. Under TQM it will be that of a coach and problem-solver.

Short Brothers PLC demonstrates how management leadership and commitment to TQM achieve results. In 1987, the UK-based company (part of the Bombardier group) launched its TQM initiative and, from the beginning, management leadership was a key element of Short's TQM strategy. The initiative began with Board level approval and has been championed by the firm's Managing Director, Roy McNulty. In addition, the firm's Management Committee has treated TQM as a priority item.

Management statements were backed up by the creation of a Company Quality Council and allocation of resources to the initiative, including a Total Quality Centre with its own conference room. Managers' attendance at TQM meetings is mandatory. The message was driven home, first to managers, and then to all employees that TQM is more than just a program, it is essential to the company's long-term survival.

During the first two years of the initiative, all of Short's 9 000 plus employees received TQM awareness training and the top 300 managers attended a 3-day course. This accomplishment resulted in the company winning the UK's National Training Award. Once the TQM awareness level throughout the firm was high, management developed and implemented a TQM plan involving 275 improvement projects. Team leaders participated in planning, including setting schedules. Progress on these projects is monitored by management.

The company's TQM initiative has begun to pay significant dividends, including documented savings of 6.5 million pounds by the end of its second year and 12 million pounds by the end of year four. This resulted from 500 completed projects involving 36% of the firm's employees. The positive results have caused support for TQM to grow, convincing even the sceptics.

(based on a paper by Brian Ambrose, Short Brothers, presented at the Euroqual Conference, Amsterdam, 1992)

Essential steps for management to take include:

- becoming knowledgable about TQM principles and methods;
- communicating the urgency of adopting TQM to employees;
- supporting their efforts by providing: a clear mandate, encouragement, and the necessary time and resources to undertake process improvement; and
- leading by example: using TQM methods to improve managerial processes.

THE ROLE OF NON-MANAGEMENT EMPLOYEES

The initial reception which non-management workers give TQM will depend on the prevailing climate of worker-management relations and the outcomes of previous management initiatives. It is fair to say that some so-called TQM initiatives have been misused by management as a mechanism for downsizing or achieving productivity targets – of course, they failed as TQM. Non-management workers are aware of these situations, whether they occurred in their own company or in others. It is up to management to "sell" them on TQM and then deliver what is promised.

When non-management employees first hear about TQM, they generally have a number of concerns, particularly with respect to job security, work-load and job responsibilities. If TQM is successfully implemented, it will contribute to job security since it will lead to new business. Rather than merely adding extra work, TQM enriches the quality of working life by making jobs more meaningful. Under TQM, employees are given a greater insight into the processes which they operate, responsibility for exercising greater control over them, and the opportunity to contribute to their improvement.

To make TQM work, both management and workers need to develop and maintain strong communications. For example, workers and management should discuss issues and changes facing the company such as the impact of automation, technological change, and international competition. Good communications requires actions as well as words. In one aerospace company, management found that clean rooms and security restrictions had isolated employees from management – who could no longer could see the "old shop floor." This was remedied when management made a conscious decision to regularly visit work areas and talk to employees.

Employee involvement in design of new facility leads to early pay-off for Boeing. When Boeing designed a new sheet metal fabrication plant in Auburn, Washington, workers played a major role in the design process. About 250 employees participated, with union support, in formulating recommendations for the new facility. Their recommendations covered areas such as: job design, reward systems, recruitment, and factory lay-out.

Working in teams, the employees consolidated an initial list of 4 500 recommendations to 142, many of which were implemented. Some of the recommendations dealt with quality of work-life issues such as: elimination of status symbols, a no-smoking policy, and formation of a joint union-management committee to deal with ongoing work-life issues. Other recommendations involved job descriptions and procedures.

Results have been impressive – the average flow time for sheet metal parts was reduced from forty days to four days, resulting in a major reduction in inventory, less floor space and faster response to customers.

Training was an important element of the process, which began with employees meeting in their union hall to learn about high performance organizations. Further knowledge was obtained through reading, training from external experts and visits to other sites.

(based on *Beyond Quality: How 50 Winning Companies Use Continuous Improvement*, J. Bowles and J. Hammond, G.P. Putnam & Sons, 1991)

Labour unions should be brought in as partners when and wherever possible. Prior to implementing TQM, senior management should discuss the objectives and methods of TQM with them to ensure understanding and to enlist their support. As the quality effort develops, union leaders and company management can work together on setting goals and quality improvement initiatives.

Essential steps for non-management employees to take include:

- trust management's word concerning the TQM objectives and plans, and that TQM is not just another program;
- expect management to follow through;
- be willing to work with management to make TQM a success;
- become knowledgeable in TQM principles and methods;
- acquire new interpersonal and analytical problem-solving skills;
- take greater responsibility for the quality of their work; and
- participate in process improvement efforts.

TRAINING AND TQM

TQM training is not just for managers, it's for all employees. The training should not be limited to general awareness. It should also include problem-solving methods and teamwork. With the proper training, all employees can use these methods to control and continuously improve the processes they work on.

The level of technical detail provided in training courses should be consistent with the employees' job responsibilities. Although some statistical methods used in TQM are complicated, a number of the methods are straightforward (e.g. Control Charts, Check Sheets, Flow Charts, Cause and Effect Diagrams and Pareto Analysis).

Training does not have to be boring. It can be delivered using techniques which involve employee participation and are entertaining as well as informative. For example, Pratt & Whitney (USA) has developed a demonstration of TQM principles called "The Ping Pong Factory[R]" which is available in video format. In this demonstration, a team of participants from the audience redesign a hypothetical process – resulting in highly visible improvement (see Newsletter for Quality and Participation, June/July 1991, p.8).

> **Employees at British Aerospace's Hatfield site achieve Total Quality results.** At this UK facility, which houses the engineering team for the BAe 146 and production work on the BAe 146 and Airbus aircraft, cellular manufacturing, JIT and self-inspection have been implemented. Key to their success has been developing employees' understanding that co-workers in the next cell are their internal customer. Over an 18 month period, nearly all 3 500 employees at the site have been trained in holding quality improvement meetings. These one-hour, weekly meetings are used to solve quality problems.
>
> The company holds an annual "Quality Day" at which employee teams receive prizes for improved cell operations that have saved money. As of the end of 1991, these improvements were estimated to have saved about $1.8 million.
>
> (based on *TQM Allows European Aerospace Firms To Devote New Attention to Quality*, C.A. Shifrin and M. Mecham, Aviation Week & Space Technology, Dec. 9, 1991)

Some examples of training objectives are provided below:

- explaining the need for improvement as well as its individual and collective benefits;
- communicating the organization's quality vision, values and goals;
- developing a common language to talk about quality-related issues;
- defining the structure and process through which quality improvement takes place;
- clarifying everyone's responsibilities; and
- providing people with tools and techniques to manage the quality of their work.

Chapter 7 discusses how to implement a training program which is integrated with overall TQM implementation.

RECOGNITION AND REWARD

"While all of us work to earn a living to provide for ourselves and our families, we also work to achieve something, to be part of something bigger than ourselves, to make a contribution that has relevance and meaning and, in the process, we not only expect to be paid but we hope to be respected, trusted and valued, and to be recognized" – Lawrence Bossidy, CEO, AlliedSignal Corporation (USA), writing in the company's newsletter, Horizons, Vol. 5, No. 6, June 1992.

Recognizing and rewarding employee contributions to quality is an essential component of TQM. By recognition, we mean a non-monetary means of expressing appreciation, whereas reward refers to a financial benefit. Both recognition and reward are used in TQM companies, however most companies favour emphasizing recognition. In the discussion below, "recognition" includes both recognition and reward.

TQM provides employees with the opportunity to make a real contribution to their company's success. If they know that their managers and fellow employees depend on them for high quality work, and respect them for it, their work will be deeply rewarding. A formal reward and recognition system can reinforce this knowledge among employees. It is not, however, a substitute for the changes in management style that were discussed earlier in the chapter. The TQM management style includes informal recognition (positive feedback for a job well done) and constructive criticism (searching for solutions rather than assigning blame) when things do not go well.

Designing a recognition system, like other managerial processes, should utilize TQM methods such as those discussed in Chapter 4. The first step is to identify the customers of the process and analyze their needs. Determining how management policies and practices impact on recognition would also be part of the analysis. If the current practices impede giving credit where it is due, they should be modified. New ideas could be generated using brainstorming, and the new system could be tested and improved using the PDCA Cycle.

> **Canadair has received six successive Pride in Excellence awards from Boeing**, which are given annually to suppliers who achieve or exceed Boeing's quality specifications. A commitment to quality has also helped Canadair enter new markets, such as making components for the Airbus A330 and A340 programs.
>
> At Canadair, these recognition events are "milestones" along the road of continuous improvement. As Bombardier's President and CEO, Raymond Royer, wrote in a special Quality Month supplement in Canadian Business: "We may admit to pride in our record but we cannot allow complacency. Quality is not a static value. Expectations constantly increase. Competitors are continually advancing their products and striving to improve their standards. This is why focus on the customer will always remain the driving force behind company-wide efforts to attain excellence."

The recognition/reward system should be supported by a corporate policy which assigns it a high priority. It should also contain guidelines for use by the managers and employees who operate the system. There should be some flexibility built into the guidelines so that managers can adapt them to their own area.

The system should give recognition to outstanding efforts in Total Quality such as customer satisfaction, developing and implementing process improvements, innovation and leadership. The emphasis should be on recognizing team efforts, although individual efforts should not be ignored. Individual recognition should be based mainly on contribution to team efforts. Above all, the system must reinforce the message that the way to advance in the organization is to support TQM.

Continuous improvement results from the cumulative effect of many small improvements and, occasionally, larger ones. The recognition system should take this into account by providing a range of awards. Some companies present items such as pins or plaques to outstanding employees at annual get-togethers, or at impromptu meetings in the cafeteria. One organization places large "Q" stickers on the office doors or at the workstations of high performers.

The team that designs the recognition system, in consultation with other employees, will have no trouble coming up with suitable ideas for recognition awards and activities. Some suggestions for recognition are provided on the table below. Keep in mind that these are symbols of what is really important: recognition, by management and one's peers, for what one does for a living. Participation by these groups is therefore the most important part of the process. They should be present during the presentation, and the reasons for the award should be made clear to everyone involved.

SUGGESTIONS FOR TANGIBLE RECOGNITION

(JUST A FEW OF MANY POSSIBLE APPROACHES)

WHAT TO RECOGNIZE	Verbal Acknowledgement	Written Acknowledgement	Mementos (Plaques, Trophies, etc.)	Special Refreshments	Breakfast	Luncheon	Dinner	Theatre Tickets	Department Award	President's Award
Individual or team effort, initiative or achievement that results in major added value	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual or team effort, initiative or achievement that results in significant added value	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Individual or team effort, initiative or achievement that results in added value	✓	✓	✓	✓	✓	✓	✓			
Unusual individual or team effort	✓	✓	✓	✓	✓					
Unusual individual or team initiative	✓	✓	✓	✓	✓					
Unusual individual or team achievement	✓	✓	✓	✓	✓					

c/o AlliedSignal Aerospace Canada

GE's Work-Out — a powerful tool for Total Quality. In the early 1980s, GE's CEO, Jack Welch, initiated a period of rapid organizational change at GE, with the aim of increasing the company's competitiveness. The changes were far-reaching, involving acquisitions and divestitures, de-layering of management and downsizing. Welch wanted a leaner, more efficient organization with a more participative style of management. While not formally called TQM, the sought-after cultural changes were consistent with TQM principles.

Changing the size and structure of the organization could be done by directive, however, changing the organizational culture was much more complicated. Although there were employees at all levels who supported the move to participative management, there were managers and supervisors who did not. Often their people continued to use procedures which were time-consuming and did not add value. They coped with the reduced resources, not by becoming more efficient, but by working overtime to do the same amount of work. Welch found that financial controls, training, and communications alone, were not sufficient to produce the sought-after cultural change throughout the organization. A more direct method of reaching all GE employees was needed.

In 1988, Welsh and other senior managers developed a concept which generated widespread employee participation and management response. The concept, which became known as Work-Out, involves groups of employees meeting in a "town-meeting" format to discuss issues and problems of concern. The meetings are run by a facilitator and the employees' boss is not present. During the meetings, employees generate ideas for improvement which are consolidated into a manageable number of items and prioritized. The boss is present on the final day and has to make on-the-spot decisions on the proposals brought forward: yes, no, or target for further study and resolve within a month. A key feature of Work-Out is that the output from a session should be a list of actionable items.

As an example of the effectiveness of Work-Out: Work-Out proposals saved the GEAE plant in Lynn, Massachusetts over $200 000 in 1991. One idea, to build protective shields for griding machines, based on an employee design, resulted in GEAE bringing this work in rather than contracting it out, and reducing costs to $16 000 from $96 000. In this case, workers increased their job security by showing how it would save the company money.

In 1992, Welsh asked GEAE to reduce its inventories by $1 billion, which would result in a net income of $750 million (equal to the income obtained during the 1980s which were "boom years.") During a Work-Out session, it was decided that the business could increase its efficiency enough to halve the time between customer orders and delivery of finished engines. This would boost cash flow and cut inventories by 40%, enabling GEAE to reach Welch's goal. The new goal, established at Work-Out, is to increase inventory turnover from 2.8 to 4 turns/year.

Since its inception, the uses and methodology of Work-Out have evolved. The initial goal was to generate widespread buy-in to participative management and to eliminate unnecessary work, thus increasing real productivity while reducing stress from overwork. Momentum was gained by going after "the low hanging fruit" — problems which could be fixed relatively easily with resultant benefits. These initial Work-Out sessions involved large groups of employees whose jobs might not be directly related. Work-Out subsequently became a regular part of GE's approach to continuous improvement. Work-Out sessions typically involve groups of people who normally work together, i.e., cross-functional teams of finance, manufacturing, purchasing and marketing, responsible for a particular product. Sessions have a mandate to solve particular business problems and employ continuous improvement tools such as Process Mapping. Work-Out sessions sometimes involve customers and suppliers as well as GE employees.

Work-Out is also being used to have workers participate in developing a new paradigm for GE, redefining it as boundaryless organization; i.e., without boundaries between functional departments and between levels of management and workers. A new Work-Out initiative, began in 1992 is the Change Acceleration Program. This involves using Work-Out to develop a new type of GE manager: professional change agent.

Writes Noel Tichy, a long-time consultant to GE: "as a formal mechanism for sustaining a revolutionary process — and for transferring real power to employees — Work-Out is unsurpassed so far. But for those tempted to try the program themselves, I offer this caution: GE's already successful transformation is what enabled Work-Out to succeed. Without that foundation ..... I doubt if Work-Out's techniques would have much effect. As Welsh says, 'you better be lean before you play these games'."

(based on *Control Your Destiny or Someone Else Will*, by Noel M. Tichy and Stratford Sherman, Doubleday, 1993)

Chapter 7

PLANNING AND IMPLEMENTING TOTAL QUALITY MANAGEMENT

INTRODUCTION

Now that you have gained some insights into TQM, you have probably reached the stage where you are asking "How does my organization get started in TQM?" By allocating the time to read this far, you have in fact started the process. Congratulations!

This chapter provides a general approach for planning and implementing TQM which incorporates some of the successful approaches that have been used by others. It is important to remember that there is no one "right way" to accomplish this. You will want to tailor the approach for your organization's particular circumstances.

Reading about how other companies have succeeded (and sometimes failed) in their TQM efforts, and talking to people who have first-hand experience, will provide valuable insight for your company's TQM initiative. However, you will be implementing TQM in an environment with its own unique business pressures, technology and people considerations. Your enthusiasm and ingenuity, and those of your colleagues, are as critical to success as is knowledge of TQM principles and techniques. Books are great but there's nothing like trying to do something to understand what the book meant!

In this chapter, we discuss the following major steps in TQM implementation:

- Conducting an initial assessment;
- Establishing management commitment;
- Defining the company's quality vision, values and goals;
- Creating awareness and commitment among all employees;
- Planning for Total Quality;
- Organizing for Total Quality;

- Establishing a TQM training program;
- Mobilizing Quality Improvement teams;
- Undertaking Quality Improvement projects;
- Building management systems that support TQM;
- Measuring progress; and
- Sustaining momentum.

THE INITIAL ASSESSMENT

In order to successfully plan for TQM, management will need an accurate picture of the current situation concerning the organizational culture and the management of quality within the company. Common objectives for initial assessments include:

a. Determining the company's strengths and weaknesses as perceived by your customers and employees.

b. Identifying the existing culture and management style of the organization.

c. Evaluating the effectiveness of the company's current management and quality systems.

d. Identifying key processes to target for change.

e. Providing a baseline against which improvement efforts can be measured.

There are a number of methods available for conducting assessments. For example:

- Criteria used by national quality awards (Japan's Deming Award, the U.S. Malcolm Baldrige Award, and the Canada Awards for Business Excellence).
- Proprietary assessment methods such as Philip Crosby's Quality Management Maturity Grid.

- Assessments designed to prepare companies for quality systems certification based on quality standards such as the ISO 9000 standard. (Note that these assessments do not cover the full scope of TQM. For example, ISO 9000 does not include customer satisfaction.)

Your company may already be using, or planning to use, assessment methods which overlap with the scope of the initial TQM assessment. In this case, you should: 1) identify those assessment objectives needed to support the TQM initiative which are not met by current assessment activities; and 2) conduct a separate TQM assessment to fill in the gaps.

There are several options for assessment personnel, including employees in your company or in related firms and outside consultants. There are advantages and disadvantages to each. External consultants can bring specialized experience and detached objectivity to the assessment. In-house personnel generally understand your business better than outsiders. Regardless of which approach you use, the assessment will require resources – either staff time or consulting costs. If in-house staff are used, they should receive training in how to conduct assessments. Some companies use a "combination approach" in which an external consultant is involved in activities such as training in-house personnel, assisting in the design of the assessment and interpretation of the results.

An effective assessment cannot be done from an office chair – it requires meeting with your organization's customers and employees and asking them what is done well and what needs improvement. Keep in mind that employees are internal customers for many of the outputs of the company's processes. The perceptions of customers and employees are essential to the assessment – even if they do not coincide with management's current view. Accept their input without challenge and search for common perceptions of your organization.

Once the input has been collected and summarized, senior management should involve as many of your organization as practical in discussing it. Rather than looking for solutions to problems right away, the objective is to understand the input as fully as possible. The assessment results will be used in subsequent steps which are discussed in the next few sections.

ESTABLISHING MANAGEMENT COMMITMENT

"They [Quality Circles] were here and there in several divisions .... but they died on the vine because there was no strong top management support and environment that would encourage them to grow." – *executive in a North American aerospace company*

Successful TQM implementation requires strong leadership and support from senior management. The organization's leaders must view TQM as the business strategy most likely to achieve results. Applying individual TQM techniques, without management commitment and an overall total quality strategy, is unlikely to produce the results which your company requires to increase its competitiveness.

> **Standard Aero begins a TQM-oriented initiative by talking to customers.**
>
> In 1989, Standard Aero undertook a competitive initiative known as its World Best Project. The initiative was first applied to its largest business unit, the T56 engine line. Before undertaking a redesign of this business unit, the company assessed its current performance in the T56 repair and overhaul marketplace. To do this, members of the redesign task force visited 16 current, past and potential customers from Anchorage to Miami to obtain customer input. See the case study in Chapter 10 for details.

Once senior management has made the decision to adopt TQM, but prior to the development of a detailed implementation plan, all managers should become familiar with the TQM philosophy and methods. This can be done through internal meetings and training seminars. Middle management should subsequently be involved in planning and implementing the TQM initiative.

DEFINING QUALITY VISION AND VALUES

Once the input from the assessment has been fully analyzed, senior management should define the company's quality vision and values. This is not a separate process from strategic planning – it is a key element of it. Your company's strategic plan will include a mission and objectives which define the company's quality vision. The mission and objectives may also be backed up by statements of company values – things which are to be considered important by everyone in the firm. In fact, the distinction between quality vision and values is somewhat artificial – you can convert one to the other by re-phrasing. The important thing is that you have a set of clear, positive statements indicating what is important and what is to be achieved with respect to Total Quality.

Below are some examples of aerospace companies' quality vision and value statements which you might find useful.

EXAMPLES OF QUALITY VISION STATEMENTS

"To achieve quality and excellence in everything we do."

"To employ the best practices throughout our company, and to have an empowered work force that continuously improves the processes we use."

"To build lasting partnerships with quality suppliers."

"To ensure effective oversight by management committed to Total Quality and to meeting our public responsibilities."

"Each function and stage in our development, manufacturing and service processes must work together with our suppliers to receive defect-free input in order to produce defect-free output."

"Each function and employee must assume the responsibility of establishing a continuous quality-improvement process."

"No operating decision will be allowed to impact negatively on the quality of our products and operations."

"Provide innovative systems, products and services that conform to requirements and meet customer needs and expectations .... to achieve total customer satisfaction."

"To be recognized for integrity and ethical behaviour."

"Make Total Quality a way of life."

"To release the full capabilities and talents of our people."

EXAMPLES OF QUALITY VALUES

"Quality is everyone's job."

"Quality improvements result from management leadership."

"No level of defects is acceptable."

"There must be a commitment to continuous improvement."

"Quality improvement reduces costs."

"Teamwork works."

"You make the difference."

"Anything can be improved."

"Our seven key values are: customers, integrity, people, teamwork, speed, innovation and performance."

The above may look to some like "motherhood and apple pie" type statements, but they do provide a starting point for TQM if everyone in your company, starting with senior management, does their best to live up to them. The values which are actually held within a company determine, to a great extent, how work is accomplished. They control how employees interact with each other and with customers. Managers must continually demonstrate commitment to the quality vision/values by expecting and supporting actions which are consistent with them. They must be used as the yardstick for all of the company's policies and procedures, for example: making training programs and budgets consistent with the value statement that "People are our biggest resource."

The quality value statements described above represent qualitative goals for TQM. Many companies with experience in TQM consider that quantitative goals are essential to success. These could be based on the quality and productivity measurements discussed in Chapter 5 and should be part of the overall strategic plan.

CREATING AWARENESS AND COMMITMENT AMONG ALL EMPLOYEES

It is essential to get a majority of employees to "buy in" to the improvement process in order to produce sufficient momentum to convert the rest. They will need to understand why and how changes are to be made, if they are going to support them. Above all, they should be aware of management's commitment.

Management should communicate the company's quality vision and values at every opportunity. This activity should be started well before TQM implementation begins. Management should explain the TQM initiative to employees in the context of the business challenges facing the company. Employees should be encouraged to raise questions and management should provide a timely response.

Awareness can also be raised through TQM training, written material (such as this handbook), videos, and presentations by customers, suppliers and other external people. During the early stages of raising awareness throughout the company, some employees at all levels will demonstrate a strong interest. These key employees should be recruited to become actively involved in the TQM initiative. Throughout the course of TQM implementation, management should recognize those responsible for progress with due ceremony and symbols.

PLANNING FOR TOTAL QUALITY

While planning is usually undertaken by a small group (or steering committee), led by senior management, input should be obtained from the others in the organization as well as its customers and suppliers. In particular, having middle management and the company union assist in planning will help gain their support. It is essential that the management team doing the planning receive training in TQM principles and methods prior to undertaking this task.

The implementation plan should include tasks and milestones, and set an affordable, realistic budget allowing for both cash expenditures and employee time. It should establish policies regarding employee involvement. For example, is participation in process improvement teams voluntary or mandatory? Will hourly employees be paid for after hours training and meetings? The role of external consultants and training firms should also be decided.

The plan has to coordinate a wide range of mutually dependent activities. For example: 1) before undertaking projects, quality improvement teams need the proper training and a mandate; 2) process improvements may require making changes in management style and working environment, as well as technical changes; and 3) a reward and recognition system should be in place within a reasonable time period – this could require changing current human resources policies. Finally, the sponsors and persons assigned to implement each activity should be clearly identified.

ORGANIZING FOR TOTAL QUALITY

Developing an organizational structure to support your company's quality improvement efforts is an essential element for success. This structure should:

- not be overly complicated or bureaucratic;
- be tailored to the company's size, business and market;
- look as much like (and eventually merge with) the company's formal organizational structure as possible;
- facilitate the downward flow of quality goals, values, objectives and support;
- facilitate the upward flow of improvement ideas, employee concerns and quality-related information; and
- provide linkages among the TQM activities of employees throughout the company.

The TQM implementation organization is often led by a quality council (or steering committee) of top managers. This council develops the organization's quality strategy, including objectives and implementation plans.

Large organizations often use a two-tier system in which a second quality council focuses on tactical issues and reports directly to the Executive Steering Committee, which focuses on strategic issues. They may also have a separate quality council for different geographic regions and divisions.

The bulk of the TQM implementation effort involves quality improvement initiatives applied to individual business processes. These are carried out by teams whose members work at all levels and areas within the organization. These teams are formed to address specific quality issues and have finite lifetimes.

Figure 20 shows how the various parts of the TQM initiative are often organized. This is not a rigid model — the details will vary with the circumstances of individual companies.

Implementing the TQM plan in an orderly fashion requires coordination among the various groups involved in the effort. This can be facilitated by having members of the first and second tier quality councils act as leaders of quality improvement teams. The heads of the second-tier quality councils usually have membership on the senior quality council.

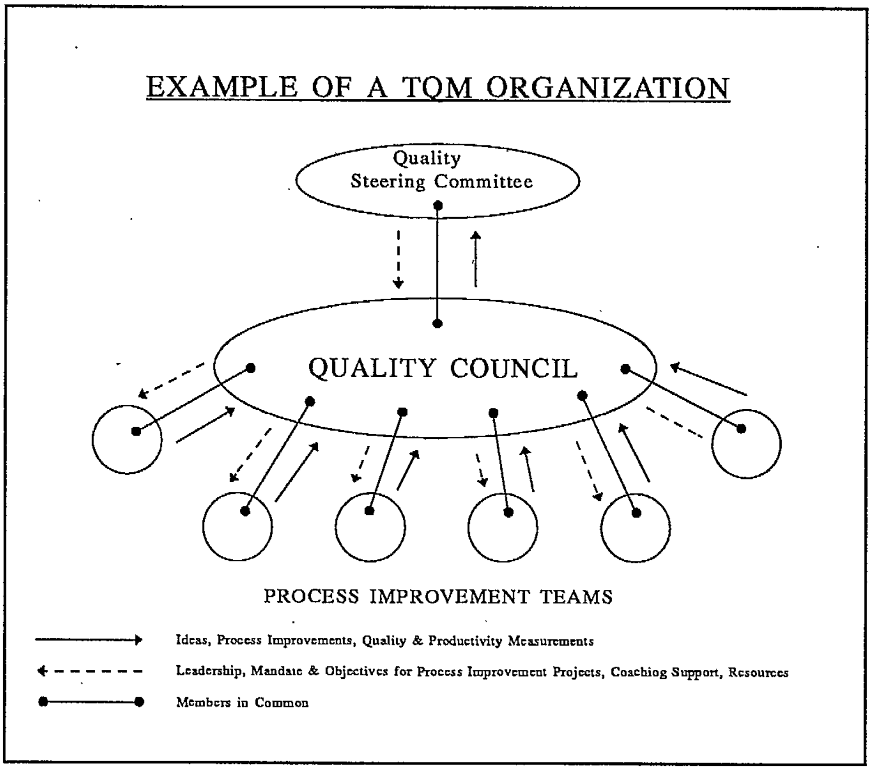


Figure 20 — Example of a TQM Organization

The quality councils should take care not to over-plan the initiative. Over-planning can lock people into methods and solutions which are less than optimum. Giving people more room to manoeuvre requires a conscious effort on the part of management who are often accustomed to giving explicit directions.

Another useful step is to appoint a TQM coordinator who is responsible for training, mobilizing and providing assistance to quality improvement teams. Depending on the size of the company, the following options could be considered:

- The TQM coordinator may be a full-time or part-time position and may head up a TQM resource group. Members of this group act as team facilitators, teach TQM methods and operate the organizational infrastructure that supports TQM.
- The TQM coordinator and TQM resource staff may or may not be separate from the Quality Assurance (QA) group. Companies should consider having the TQM group separate from the traditional QA group so that they do not get labelled as inspectors or auditors. If they are separate, the TQM coordinator should report to senior management, not the QA manager.
- In large companies, there may be TQM coordinators for each division.

TQM does not eliminate the QA group. They will still have the primary responsibility for assuring compliance with quality standards. Their role as independent auditors can also be expanded, beyond compliance with quality standards, to include measuring progress in TQM implementation. As experienced Quality professionals, they are a source of personnel for the TQM resource group described above and are the "keepers of the tools" used by everyone else to measure and report on quality. They can also assist in developing partnerships with customers and suppliers and monitor any quality requirements established by customers.

ESTABLISHING A TQM TRAINING PROGRAM

In Chapter 6, we discussed the importance of training for TQM and indicated some training objectives. In this section, we discuss the training needs of employees with different responsibilities, and how to set up a TQM training program.

In a TQM company, training is a significant and ongoing investment. It should be integrated with the entire TQM implementation effort. Before deciding on the content of training, it is useful to perform a needs assessment, considering both the TQM implementation plan and existing knowledge levels. The table on the next page indicates some training needs of employees with different responsibilities within the company.

Your company's training plan should specify who will provide the training and what training materials will be used. It is useful to investigate several TQM consulting/training organizations and available training materials. Make sure that they understand your specific needs and will design the training appropriately. Many training suppliers are willing to provide brief introductory sessions at no cost.

Training can be coordinated with the formation and activation of Quality Improvement Teams. Teams should be trained on: holding effective meetings, teamwork and cooperation, identifying internal and external customers, setting goals, problem-solving methods and measuring results. Responsibility for team-based training initially belongs to the facilitator and is gradually shifted to the team leader & members. Key employees who will act as internal trainers and facilitators will need additional training, such as train-the-trainer courses, and exposure to a variety of TQM concepts from independent sources, educational institutions and established corporations.

One approach that some companies have found useful involves starting with an initial team of key employees which receives training and undertakes a pilot project. After proper training, they can then become facilitators within each department when the network of teams is expanded.

TQM TRAINING NEEDS

	Senior Management	Middle Management	Team Leaders	All Employees	Timing
Basic TQM principles				✓	Early
Inspiring change	✓				Early
Satisfying customers				✓	Early
The assessment process	✓	✓			Early
Promoting quality and participation	✓	✓			6 mo.
Designing involvement systems	✓	✓			6 mo.
Involving labour unions	✓	✓			6 mo.
Facilitating teams	✓	✓	✓		6 - 18 mo.
Training and coaching	✓	✓			6 - 18 mo.
Statistical methods				✓	6 - 18 mo.
Team problem-solving methods				✓	6 - 18 mo.
Process planning and improvement				✓	6 - 18 mo.
Auditing		✓	✓		6 - 18 mo.

Facilitators are an essential resource. The question is, should companies develop this resource internally or acquire it externally? As discussed in the case study in Chapter 10, Litton Systems Canada analyzed this problem strategically and has developed a strong in-house facilitator capability.

After receiving training, people should put their TQM skills to work as quickly as possible. The old adage "If you don't use it, you lose it" is relevant here. "Just-in-time" training means scheduling training in anticipation of upcoming quality improvement activities. It will minimize the loss of knowledge and enthusiasm between training and mobilization of Quality Improvement Teams.

MOBILIZING QUALITY IMPROVEMENT TEAMS

Quality Improvement Teams (also known as Process Improvement Teams, Process Action Teams, Cross Functional Teams, etc.) provide the basic vehicle for involving all employees in TQM. By working in teams, employees can apply their talents and knowledge to improving the processes which they operate.

Critical success factors for Quality Improvement Teams include: 1) a clearly defined mission and objectives; 2) ongoing support from management; and 3) adequate training. Management has the primary responsibility to define and communicate the mission and objectives of teams. The teams should also have an opportunity to identify and recommend additional objectives to management. Management support for teams includes: 1) ensuring access to the resources needed to accomplish their objectives; 2) responding to requirements which arise during projects; 3) acting on the results of the teams' work; and 4) recognizing accomplishments. Teams should not be activated until management support is assured.

Teams usually consist of four to eight members. The team leader is usually the manager or key employee responsible for the process which the team is working on. Team members should include those working in the process as well as its customers and suppliers. It is useful to include employees having a range of perspectives on the process. Organizations differ concerning whether teams should contain only volunteers or whether participation in teams should be a condition of employment. Our view is that, in a TQM company, participation in teams should be part of the job description of all employees. On the other hand, people should not become team members before they are ready.

During the early stages of TQM, each team should work with a facilitator. Facilitators are the team leaders' primary resource and should complement, not replace, the leader. They can help the leader prepare for team meetings, facilitate the meetings, review progress and provide training in basic TQM methods.

A Boeing-Menasco Aerospace team improves 737 main landing gear. The team included representatives from the Menasco Aerospace's Production and Quality departments and Boeing Engineering, Materiel and Procurement. The team performed a Pareto analysis of 737 landing gear discrepancy reports to identify which manufacturing operations produced the majority of discrepant parts. The analysis identified the boring of trunnion link lugs in the landing gear's outer cylinder as a major source of excess variation.

The next step was to identify the part's key characteristics that would be measured to provide information on how the boring operation was performing. The trunnion link lug bore location most significantly affected fit, performance and service life. Using control charts, the team found significant lot-to-lot variation in the hole's x-coordinate. Investigating the cause of this variation revealed that the holding fixture was responsible. Part of the improvement process involved analyzing and improving the measurement processes themselves through a gauge repeatability study and ensuring that operators used correct procedures to collect data.

Both Menasco Aerospace and Boeing have achieved cost savings through reductions in rework, scrap and rejection tags. Annual savings on the main landing gear are estimated at approximately $200 000.

In 1992, Boeing awarded Menasco a President's Award for Excellence in the Major Outside Production category.

(based on articles in Quality Breakthrough Magazine and the March 1993 newsletter of the Aviation/Space & Defence Division of ASQC)

Their goal is to work themselves out of a job by developing a self-sufficient team and team leader – a process which takes from several weeks to several months. Large companies, that have a separate TQM resource group, can draw on them for full-time facilitators. Normally each full-time facilitator can work with three to four teams (fewer if they are also providing training). Smaller companies can utilize key employees as facilitators on a part-time basis.

Team meetings should concentrate on objectives and be conducted in a business-like manner with a proper agenda and recording of minutes. The agenda should deal with the following three areas: 1) team building; 2) learning TQM methods; and 3) process improvement. Initially, team meetings should concentrate on training and initial application of problem-solving methods and teamwork. Later, when the team is working primarily on process improvement, some time should be devoted to further learning on an ongoing basis. Overall, most of the available time should be devoted to process improvement activities. This work should be undertaken in a systematic manner, using the PDCA Cycle or similar process improvement strategy. An example team meeting checklist is included at the end of this chapter.

Quality Improvement Teams should focus on real opportunities for quality and cost improvement; not just "moving the water cooler to a better location." If done correctly, the assessment will have identified priority areas for improvement. These areas may require further investigation by teams before the project scope and objectives can be defined. Teams can also identify potential improvement projects based on their first-hand experience. **In all cases, they should have approval from management for their plans, including project scope, objectives, resources, methods and timetables.**

Some characteristics of successful teamwork, as well as some obstacles to achieving it, are listed on the next page.

It is difficult to implement TQM throughout the company simultaneously. Departments tend to undergo change "in single file." This results from bottlenecks in key services (e.g. training, assessments, etc.), and because the level of readiness typically varies among departments. Conducting one or a series of pilot projects will not, therefore, slow the process down appreciably.

The pilot project approach has several advantages, including:

- maximizing the opportunity to learn from early mistakes without repeating them;
- generating support by demonstrating success; and
- progressively building up the resources and skills needed for company-wide implementation.

CHARACTERISTICS OF SUCCESSFUL TEAMWORK

- CLEAR GOALS
- A PROJECT PLAN
- CLEARLY DEFINED ROLES
- CLEAR COMMUNICATIONS
- AWARENESS OF BENEFICIAL BEHAVIOURS
- CLEARLY DEFINED DECISION PROCEDURES
- BALANCED PARTICIPATION
- ESTABLISHED GROUND RULES
- AWARENESS OF GROUP DYNAMICS
- SCIENTIFIC APPROACH

OBSTACLES TO EFFECTIVE TEAMWORK

- FLOUNDERING
- OVERBEARING, DOMINATING PARTICIPANTS
- RELUCTANT PARTICIPANTS
- ACCEPTING OPINIONS AS FACT
- QUICK REJECTION OF MEMBERS' IDEAS DURING MEETINGS
- FAILURE TO ACKNOWLEDGE & DISCUSS MEMBERS' IDEAS DURING MEETINGS
- DIGRESSION
- FEUDING MEMBERS

Martin Marietta's process improvement teams reduce costs and delays on Nasa's Space Shuttle. Teams of staff and hourly workers have developed ideas for process improvements that save tax payer dollars and reduce delays in launch preparations. One notable improvement involved protecting the insulating foam that covers the surface of the space shuttle external tank. This soft foam layer is extremely delicate and one slip of a wrench can mean hours of work repairing the insulation. Assemblers suggested a number of ways to prevent damage, including placement of plastic shields to protect the insulation at points where hardware had to be attached, taping segments to protect exposed primer paint on metal areas from scratches, and the use of styrofoam wedges, protective mats and plastic bubble wrap to shield large sections of the tank.

Another improvement involved modifying a tool for working on the interface between external tank and shuttle. The original tool was not rigid enough and had to be constantly realigned. A team involving assemblers and tooling department employees devised a new, rigid model that maintained its alignment. The result: an operation that formerly took two shifts about 40 days was reduced to one shift and 14 days. These and other worker-initiated improvements have added up to a 38% improvement in productivity, a process time reduction from 90 to 70 days, and elimination of backlog.

(based on *Manned Space Systems Experts Lead the Way to Quality*, Martin Marietta Today, TQM Special Report, Number One 1990)

The pilot project should be reviewed on a regular basis and the results used to modify the approach and methods being used. This learning phase will save a great deal of time and resources when the TQM initiative is expanded throughout the company. While one, or a small number of pilot projects, are being undertaken, other employees can be receiving introductory training. They should also be kept informed about the pilot projects. When other employees are ready, team operations can be expanded by having members of the pilot team join them as team leaders or facilitators.

It is useful for senior managers themselves to tackle some projects during the early stages of TQM implementation. This will demonstrate their commitment and help them understand what they are asking their employees to do. One way to do this is for senior managers to serve on some project teams to gain first-hand experience. The Executive Steering Committee can also function as a team for at least one initial improvement effort.

Implementing the results of process improvement efforts is critical. In order to obtain the maximum benefit from process improvement efforts, care should be taken to ensure that the results are utilized by all relevant groups and that the gains made will be long-lasting. Teams should keep in mind that the groups who adopt their improvements, or are otherwise affected, are their clients. Good communications are needed throughout the improvement effort, starting with obtaining input from client groups during the analysis stage. When the desired process changes have been identified, it is vital to explain them to everyone involved. They will want to know why they are being asked to change procedures, how to do it and what benefits to expect. An example process improvement checklist is included at the end of this chapter.

Evaluation of team performance should be used to assist teams in improving their operations. Evaluation categories could include: 1) meeting effectiveness; 2) process improvement results; 3) effectiveness of management's support; and 4) overall performance (done annually). Teams can evaluate themselves in the first three categories, under the guidance of a special Evaluation Team. The fourth category should be done by a management team or TQM support staff team and be part of a company-wide assessment of TQM progress. Typical criteria include: customer satisfaction, number of processes analyzed and improved, number and types of improvements and percent productivity improvement. A list of questions which could be included within a team self-evaluation appears at the end of this chapter.

Self-Directed Work Teams: Some companies have taken the team concept further to include self-directed work teams – groups of employees who have day-to-day responsibilities for managing themselves and their work. Members of self-directed teams (SDTs) conduct process improvement activities in the same way as the Quality Improvement Teams. However, their scope is broader. Typically they handle job assignments, plan and schedule work, make production-related decisions, and take action on problems – all with a minimum of supervision. Team members assume, to varying degrees, the responsibilities usually reserved for an organization's leaders and managers. They may select new team members, appraise performance, and make team compensation decisions.

SDTs normally have two types of leader: 1) a "group leader," outside the team, whose role is analogous to that of a supervisor or manager, but with more emphasis on coaching and facilitating than on directing and controlling; 2) a "team leader," within the team, who may be appointed or elected or on a rotational basis. Tasks such as performance problems and appraisals are often handled by the outside group leader. According to some TQM practitioners, "shared direction" rather than "self-directed" is probably a more accurate term to describe SDTs.

> **Self-directed teams are being used in Canadian aerospace companies** such as GE Aircraft Engines' airfoil manufacturing plant in Bromont, Quebec and Bell Helicopter Textron in Mirabel, Quebec. In both these cases, the concept was introduced during the design of new plants. See Chapter 10 for a discussion of Bell Helicopter Textron's experience with self-directed teams.

BUILDING MANAGEMENT SYSTEMS WHICH SUPPORT TQM

TQM involves continuous improvement of all business processes – not only manufacturing and administrative processes but also management processes. The need to change management processes will be particularly great during the TQM implementation period, since existing processes (including policies and procedures) may be inconsistent with a TQM environment. These high priority changes, and further ongoing improvements, can be accomplished using process improvement methods such as those discussed in Chapter 4.

Some management processes which are critical to successful implementation of TQM include:

- communications;
- performance management;
- compensation;
- information management;
- recognition and reward;
- promotion and selection;
- job design and rotation;
- training;
- career and development planning; and
- operational policies and procedures.

MEASURING PROGRESS

Ongoing measurement of progress in implementing the TQM plan and achieving the intended results is a vital part of TQM. This includes regularly asking the questions:

"Have we carried out the activities in the TQM implementation plan?"

"Have we achieved the intended changes in management style and organizational culture?"

"Have we improved our understanding of customer needs?"

"Have we improved the level of customer satisfaction?"

"Have we achieved the improvements in quality and productivity that we expected?"

"Is our bid win/loss ratio improving?"

"Are profit margins improving?"

The answers to these questions will provide an indication of your company's progress in TQM, identify problem areas and assist in devising solutions. They provide a "reality check" and can also be used to motivate people, however, careful consideration must be given to how this is done. Where an adversarial relationship has existed between management and workers, the latter group may view measurement as a weapon in the hands of management. **TQM requires even more measurement; therefore, it is important for everyone to understand how to use the results.** They are needed by everyone to figure out where changes are required and how to make them – not to assign blame or target anyone for negative consequences.

Providing enthusiastic, positive feedback when the results are good is important but it is only one part of the answer. The other part is dealing with disappointing results. Using diplomacy and creating a "team-like atmosphere" to discuss negative results is important but the results themselves should provide a basis for useful discussion. They should be useful for fixing problems, not just indicating that there is a problem. To summarize, the type of measurements made, as well as the way they are used, will determine the success of your measurement system.

> **Using the Baldrige Criteria as a basis for TQM assessments.** Paramax Systems Canada is one of several aerospace organizations that use these criteria for measuring TQM progress. See the case study in Chapter 10 for a discussion of the advantages and disadvantages of this approach.

What types of measurements should be made, and when? Your system for measuring progress in TQM can make use of the measurement techniques and activities discussed in earlier chapters. **Periodic assessments should be undertaken**, which are similar to the initial assessment which was done at the beginning of planning the TQM initiative. You will want to update the scope to address the activities and intended results identified in the TQM implementation plan.

A list of questions which could be included in an annual assessment, as well as an example assessment summary, provided by Haley Industries Ltd., are provided at the end of this chapter.

The methods in Chapter 5, dealing with quality and productivity measurement at the process level, can be used to determine the extent to which improvements are successfully implemented. Employees working throughout the company should be using the methods for process control, and a roll-up of these results will provide a company-wide picture.

Your measurement system will allow the company to continuously improve its overall TQM process, along the lines of the PDCA Cycle – by measuring progress against the plan; identifying areas where changes should be made; modifying the plan; and communicating the changes to all employees.

SUSTAINING MOMENTUM

"TQM is a direction not a destination." Although some initial pay-offs can be achieved within the first year, the major pay-off will come from cumulative improvements over time. On the down-side, there is a very real risk that TQM implementation could falter. Old ways of doing things have a habit of resurfacing, particularly if the TQM "buy-in" throughout the company is not high. External business conditions can also exert tremendous pressure to switch back to the old "fire fighting" mode.

There are no guarantees of success, however there are some actions that will increase the likelihood of sustaining momentum and receiving that major pay-off.

Some of these are listed:

- Management should remain interested and involved in the effort; e.g., participate in team meetings, respond promptly to quality issues brought to their attention; regularly visit OEMs and airline customers;

- Establish regular reviews with external and internal customers and agree on improvements; ensure that customers are kept informed and involved in improvement efforts;

- Don't let the necessity of "putting out fires" allow you to gradually abandon the TQM plan and switch back to conventional management techniques;

- Regularly examine the policies, procedures, business decisions, management style and practices that are being used to see if they are consistent with the quality goals and values;

- Continue to reinforce the idea that TQM is not a program, it is an approach to doing business; and

- Keeping tabs on performance relative to international aerospace competitors.

Your management team will be able to improve upon and add to this list.

Haley Industries uses a seven-step process to implement TQM. The seven-steps are: 1) Assess; 2) Organize; 3) Plan; 4) Educate; 5) Involve; 6) Execute; and 7) Review. The case study in Chapter 10 discusses these steps in more detail, as well as some results which have been achieved.

Example Assessment Summary

Senior Management commitment To TQM	SPC Steering Team	Company Wide Implementation Plan	Procedures & Documentation	SPC Control Planning	SPC Training	Measurement Process Capability	Control Charts	Process Analysis	Designed Experimentation	Supplier SPC Project
Management provides resources for solving process capability problems	Steering team consistently looks for other areas where SPC can be applied	A company wide implementation plan is on schedule with each milestone	Procedures that define methods for continuous process improvement are in place and working	Control plans define the appropriate stabilical methods for the process	Advanced training in SPC and design of experiments	Gage capability studies have been performed and documented when necessary	Appropriate statistical charts are used in all departments. In the company	These are documented process improvements to a Cpk of > 1.33	D.O.E. results are used for continuous improvement of processes	Statistical methods are used on suppliers product at receiving inspection
BLANK	BLANK	The SPC plan has been formally approved by senior management	Procedure define the method for reaction to incapable processes	BLANK	All employees using SPC have been trained at appropriate levels prior to application	BLANK	Significant characteristics are in control and others are being monitored	Process capabilities are communicated to customers and affected departments	BLANK	BLANK
Management meets regularly with the TQM and learn to discuss progress	Goals for SPC results have been established and are tracked	The SPC plan is being reviewed by senior management	Procedures define methods for reaction to out-of-control processes	Control plans reflect the significant characteristics and/or process parameters	BLANK	BLANK	Charts are used as a process control tool, out-of-control conditions are annotated	BLANK	BLANK	SPC impacts the suppliers quality rating and/or P.O. awards
Senior managers have completed awareness training on TQM	The steering team holds regularly scheduled strategy meetings	A form of SPC implementation plan has been prepared in draft form	Procedures or other work inspections define specific statistical methods used	Control plans are in place and is an integral part of the SPC system in the company	Specific work teams and technical support people are trained	BLANK	Charts are used on predetermined significant characteristics	Process capability is determined, Cp & Cpk	Procedures document when D.O.E. is necessary	SPC analysis is received with suppliers shipments and control is demonstrated
A TQM facilitator has been appointed	The steering team has been trained in statistical methods	At minimum a milestone chart for SPC implementation exists	BLANK	BLANK	A formal training program and schedule is in place	Measurement methods/gages are selected prior to the data collection activity	Control limits were derived from data and plotted by the operator	Analysis is performed on pre-determined significant processes	BLANK	Assistance is provided to suppliers in starting their SPC project
A written policy statement at management level exists supporting TQM	Each major functional department is represented on the team	Management objectives have been defined and performance measurements established	There is a procedure or other document which defines organizational responsibility in SPC	Procedures for use of control plans has been drafted	SPC training for employees has been scheduled	Gages used are based upon the 10% rule of discrimination	Charts used either have no control limits, pre-control limits	Processes are defined	Specific work teams are being trained in D.O.E.	SPC has been communicated to key suppliers
Senior management has communicated their support for implementating TQM	A management level steering team has been formed for implementation of SPC	Implementation strategy meetings are underway with management	SPC procedures have been prepared in draft form for review	BLANK	A training program has been documented and outlined	Necessary measuring equipment for process control exists	Charts used for process control are visible in all areas where applied	BLANK	Awareness training of design of experiments is underway	A supplier SPC facilitator has been established
No activity	None	No plan	Non-existent	No plans	No training	Not equipped for process control	No charts	Process definition does not exist	No activity	No activity

Date _____ Supplier _____ Evaluator _____ Interviewed _____ Total Score _____

c/o Haley Industries

SUPPLEMENTARY MATERIAL FOR CHAPTER 7

TEAM MEETING EVALUATION CHECKLIST

Administration:

- ☐ Meeting had a specific purpose
- ☐ Meeting held as scheduled
- ☐ Meeting followed written agenda
- ☐ Minutes of last meeting were read
- ☐ Written agenda for next meeting was prepared

Resources:

- ☐ Meeting location suitable for the work at hand, e.g. room size, furniture, lighting, quiet, etc.
- ☐ Required information, equipment, supplies were available
- ☐ Resource people were present as scheduled

Role of Team Leader:

- ☐ Involved all team members
- ☐ Kept the focus on process improvement
- ☐ Acted to create positive atmosphere

TEAM MEETING EVALUATION CHECKLIST (continued)

Participation of Team Members:

- ☐ Participated in discussions
- ☐ Showed positive attitude and responsibility
- ☐ Showed good inter-personal skills
- ☐ Utilized problem-solving techniques

Results Achieved:

- ☐ Progress was made on identifying or characterizing the process or problem at hand
- ☐ Progress was made toward achieving a solution to the problem at hand or improving the process
- ☐ Obstacles were identified and overcome

PROCESS IMPROVEMENT CHECKLIST

Initial Steps:

- ☐ Project selected based on needs analysis or overall improvement strategy
- ☐ Project has Management Sponsor
- ☐ Process Owner identified and is a team member
- ☐ Objectives of process improvement project have been agreed on by Management Sponsor, Process Owner and Team Leader
- ☐ Plan,. resources

Process Analysis:

- ☐ Customers of process have been identified
- ☐ Customers' needs identified and verified
- ☐ Customer needs translated to required process outputs
- ☐ Process flow charts have been completed
- ☐ Overall cost of process and cost of poor quality have been measured
- ☐ Process steps evaluated for value-added
- ☐ Sources of variation have been identified
- ☐ Cause and effect relationships have been established
- ☐ Measurement systems have been assessed
- ☐ Process control has been assessed

PROCESS IMPROVEMENT CHECKLIST (continued)

Process Analysis: (continued)

- ☐ Process capability has been assessed
- ☐ PDCA Cycle or other process improvement strategy used to identify and test potential improvements

Results:

- ☐ Process simplified by eliminating non value-added steps and combining other steps where applicable
- ☐ Process capability has been improved to target level

Implementation:

- ☐ Process changes and benefits have been documented
- ☐ Management has been informed of project outcome and has approved changes
- ☐ Those working in the process have necessary information and resources to implement changes
- ☐ Process owner has implemented improvements permanently
- ☐ Customers have been informed of project outcome, changes and benefits
- ☐ Plans for continuous improvement have been made

EVALUATING PROGRESS:
SOME QUESTIONS FOR PROCESS IMPROVEMENT TEAMS

How many process improvement projects were undertaken at management's request?

How many were: completed/on-schedule/stalled/discontinued?

How may process improvement projects were suggested by us and undertaken with management approval?

How many were: completed/on-schedule/stalled/discontinued?

What processes have been analyzed (where applicable):
- to determine if in-control and capable?
- for cost of poor quality (scrap, re-work and inspection)?
- to identify and eliminate non-value added steps?

What improvements have been accomplished in terms of:
- process control and capability?
- eliminating non value-added from processes?
- reducing cost of poor quality?

What other improvements have been made (environmental, health, safety, working environment and employee relations, etc.)?

What feedback has been received from our customers, in terms of:
- improved satisfaction?
- reduced complaints?

What training objectives were identified for the team during the last year?

Which of the above training objectives were met?

EVALUATING PROGRESS: SOME QUESTIONS FOR MANAGEMENT

How often do we measure customer satisfaction?

How often do we update our knowledge of customer needs?

Have we established a quality vision, values and goals?

Is TQM a formal part of the company's strategic plan?

How (and how often) have we communicated the quality vision, goals and values throughout the company?

How many process improvement teams have been operating?

What percent of our employees have received:

- General TQM awareness training?
- Training in teamwork?
- Training in TQM problem-solving techniques?

How many process improvement projects were undertaken at our request? How many were completed/on-schedule/stalled/discontinued?

How may process improvement projects were suggested by teams and undertaken with our approval? How many were completed/on-schedule/stalled/discontinued?

How many requests/recommendations have we received from process improvement teams?

What percentage of these requests/recommendations have been acted on?

Have managers at all levels participated in Process Improvement Teams?

What percentage of the company's processes have been analyzed:

- to determine (where applicable) if in-control and capable?
- for cost of poor quality (scrap, re-work and inspection)?
- to identify and eliminate (where applicable) non-value added steps?

What improvements have been accomplished in terms of:

- process control and capability?
- eliminating non value-added from processes?
- reducing cost of poor quality?

What other improvements have been made (environmental, health, safety, working environment, employee relations, etc.)?

What actions have we taken to recognize/reward employee activities and accomplishments in support of TQM?

Chapter 8

THE SMALL BUSINESS PERSPECTIVE

The trend toward TQM is impacting all sizes of companies within the aerospace industry, including small businesses. These companies have the potential to reap the same benefits from TQM as larger companies and, in some ways, they are better positioned to do so. However, they also face some obstacles due to their smaller size. This chapter discusses the relative advantages and disadvantages associated with implementing TQM in small businesses and how the implementation plan can be tailored to this environment.

ADVANTAGES AND DISADVANTAGES

Small businesses have some advantages with respect to TQM. They have less organizational inertia, so resistance to change is often more easily overcome. The time period required to establish an effective TQM program is normally the same as for a larger business. In a small business, however, a larger proportion of this time can be spent training employees rather than "selling" them on the concept.

The size of the workforce offers other unique advantages. First, internal communications tend to be easier. Communications are a vital aspect of TQM both when establishing and maintaining the program. Second, the logistics of the training component can be easier to handle when dealing with a smaller group of people.

After the program is established, employees in small businesses tend to develop a better understanding of the whole operation, rather than just their own area of responsibility. This leads to healthier relationships between departmental teams – placing more emphasis on cooperation than competition – than might be experienced in a larger business where team goals may be more diverse.

Finally, successes in TQM tend to be more visible in a small business. These successes can then be used to promote or support the TQM philosophy.

There are also some disadvantages which must be overcome. In a small business, the role model responsibility of senior management tends to be more closely scrutinized by the workforce. Management behaviours perceived to be inconsistent with the TQM philosophy tend to have a more harmful impact on the TQM effort. This type of error, on the part of senior management, will be relatively more costly than in a larger business where senior management is often less visible.

Setbacks in the implementation process are at least as visible as successes. As a result, they can cause greater harm to TQM implementation than might be experienced in a larger business.

Implementation of TQM in any business normally begins on a small scale, with selected individuals undergoing preliminary training and forming pilot teams. In a small workforce, some employees may feel left out or envious of those who have been selected for initial participation. The smaller workforce can also mean that the responsibility for maintaining the momentum of TQM implementation, in its early stages, rests on too few individuals.

Many small businesses choose to implement TQM upon the insistence of their larger customers. Indeed, some prime contractors even insist that full implementation by a vendor of the prime's own Total Quality system be a condition of doing business. Small businesses serving a variety of larger primes can then be subject to differing demands on the implementation of the same components of TQM. This can create confusion, add redundancies and add cost.

IMPLEMENTING TQM IN SMALL BUSINESSES

While the long-term rewards of TQM are numerous, the costs associated with getting started can be substantial. Making the move to TQM requires employee time and funding that are not always readily available to small businesses.

Fortunately, small businesses can often take advantage of the experience gained by larger companies that are well-established in TQM. Many large prime contractors offer no-cost assistance in TQM training to their small business vendors. The benefits of such assistance are mutual: the vendor has access to proven TQM methods without making a substantial financial investment; and the prime contractor develops a vendor that is more reliable and better able to meet its requirements.

Comprehensive TQM implementation programs for small businesses can be created by selecting appropriate methods and concepts that have already proven effective in larger companies. It is useful to assess a variety of established methods, particularly those developed by customers or suppliers. While many aspects of TQM are applicable across a wide range of industries, specific industries (such as aerospace) do have special needs. At least the first implementation programs to be assessed should be selected from within the small business's own industry. Adapting the concepts or methods best suited to the small business's own circumstances can then yield a TQM approach fully tailored to meet each unique set of needs.

Despite the free assistance that may be available from customers or suppliers, some amount of financial investment is unavoidable when implementing TQM. Training is normally the most expensive direct cost associated with getting started. However, allowances should be made for indirect costs that arise, such as losses in production efficiency during the initial training and set-up stages.

If financial considerations are not a primary determining factor in TQM planning, it is worthwhile to investigate training and implementation packages offered by other sources. Many consultants, educational institutions and trade associations have generic training packages that cover the various aspects of TQM. Consultants are also available to assist in the design of Total Quality systems specifically suited to the small business, as well as assisting in set-up, implementation and maintenance. The costs for these complete services are often beyond the means of many small businesses. However, they normally provide the benefit of establishing an effective implementation program in a shorter time period.

There may be government programs available to your company which will share the cost of employee training and diagnostic assessments. There are also regionally-based TQM initiatives which companies from all sectors can join to exchange TQM information and resources.

Few small businesses have the luxury of a human resources, training or TQM resource department that can be relied upon to establish TQM and maintain its momentum. In most cases, these important tasks will be the responsibility of senior management or perhaps a few key designates. In the initial stages, implementing TQM often means taking people away from their normal duties for short periods of time at the expense of some loss in productivity.

Fortunately, there are actions that can be taken to minimize disruption. For example, involving the right employees from the start increases the likelihood of making progress and sustaining momentum. The selection of pilot team members from employees who have demonstrated a commitment to quality through their work ethic, initiative and cooperation is often a better method than choosing people who have strong technical or academic qualifications, but lack these former characteristics. Peer pressure tends to be a larger influence within small business workforces, so selection at the outset of the right TQM "pioneers" can play a major role in the long-term success of the effort.

The role of senior management in supporting and promoting TQM is probably even more important in small businesses than in large organizations. Small businesses tend to have fewer layers of management. Because of this, senior management will be more actively involved in all facets of TQM. The perception by the workforce of senior management's commitment to TQM tends to have a much bigger influence in small businesses. Participation, rather than delegation, becomes the key to success.

To summarize, here are five key activities that small businesses will want to emphasize in their TQM implementation plan:

1. Develop a general understanding of TQM concepts by having management and key employees attend introductory seminars.

2. Assess a variety of well-established implementation programs, particularly those implemented by large customers or suppliers.

3. Review available training packages and implementation systems offered by consultants, educational institutions and trade associations.

4. Create an implementation plan that is best suited for the unique needs of your own small business.

5. Prepare a budget for this plan, considering that the amount of financial resources devoted to TQM implementation will have some bearing on the length of time it will take to complete.

TQM investment pays off quickly for small aerospace company. The All-Power Manufacturing Company, of Santa Fe Springs, CA, manufactures hardware and machined components for the aircraft industry. With 95 employees working in 40 000 sq ft, and sales of $7 million/year, the firm is part of the highly competitive sub-sector of small firms supplying aircraft manufacturers. Like many companies in the aerospace business, All-Power has always had high standards for the quality of the product it ships to customers. The trouble was, that this high quality was being achieved through emphasis on inspection, and this was very expensive.

With the help of an external consultant, the company has implemented TQM. Company management were involved in customizing the implementation program, which included training everyone in SPC. This training has paid off, enabling employees to better understand and control the processes they work on and to make significant process improvements. For example, total throughput time has been reduced by half, set-up time has been reduced from 46 to 26 minutes and equipment utilization has increased from 70% to 86%. Inspection costs are about 30% of what they were before TQM. Better understanding of processes has led to simplification such as eliminating unnecessary secondary machining operations after heat treating.

All-Power's investment in TQM has yielded returns within a short timeframe. According to President Jim Rankin, "While quality improvement goes on forever, a large portion of the benefits are achievable in the first few months."

(based on *TQM Keys Job Shop Profitability, Survival*, Steve Wernick, Quality, May 1991)

Chapter 9

APPLYING TOTAL QUALITY MANAGEMENT TO BUSINESS PROCESSES

Prior to the emergence of TQM, quality management issues dealt primarily with manufacturing operations. As discussed in earlier chapters, TQM extends the scope of quality management to include all of a company's products, services and business processes. In this chapter, we discuss the application of TQM to the following areas: 1) strategic planning; 2) product development; 3) production; 4) marketing and purchasing; 5) administration; and 6) corporate citizenship. While these areas are not all-inclusive, they cover a wide range of business processes, illustrating the applicability of TQM.

STRATEGIC PLANNING

In Chapter 7, we introduced planning for TQM and made the point that it should be part of your company's overall strategic plan, not a stand-alone process. In this section, we discuss the broader aspects of strategic planning and how TQM principles can be applied to this key business process.

Strategic planning helps companies determine their objectives, define a path to realize them, and allocate resources to achieve them in the most effective way. At the core of this process, is matching the company's capabilities with customers' needs. Without this, a company may provide defect free, "high quality" products that nobody wants!

Elements of a Strategic Plan: Much has been written on how to do strategic planning. We do not cover the subject in detail here, however, we will briefly describe its basic elements. Strategic planning can be approached by asking a number of questions and then answering them objectively. These questions should include:

"What business are we in?"
(markets, segments addressed, products, services,)

"Where do we stand?"
(market characteristics, customer characteristics, competitive position, internal and external environment)

"Where do we wish to go?"
(mission and objectives, incorporating quality vision, values and goals)

"How do we get there?"
(strategy, issues to be resolved, action plans)

In an ideal world, these questions would be answered in detail – in a highly structured document including supporting data and analysis. In practice, a strategic plan can be an informal narrative, a few pages in length. However, the contents of the plan should be based on fact, not supposition. It should concentrate on ideas, rather than being numbers driven.

Applying TQM to Strategic Planning:

The strategic plan is usually developed by a relatively small team of senior mangers. However, this team must not work in isolation! They will need to obtain input from throughout the organization, its customers and suppliers. The process of thinking about and debating the issues is a very valuable exercise in understanding the business and also in team building. Some of the TQM methods, such as brainstorming and Pareto analysis, which were discussed in Chapter 4, can be used here. The written expression of the plan is a valuable management tool because it will keep all parts of the business in step and provide a benchmark against which decisions can be made.

Once the plan is prepared, the major challenge is implementation. Often, well written plans do not succeed. There is often a reluctance, at various levels in the organization, to consider change and fresh approaches. Successful implementation involves "deploying" the plan throughout the organization through specific detailed action plans developed at each management level and with a "buy-in" at all levels. The action plans at each level of the company are linked to the objectives of the level above. A formalized version of this process, known as Policy Deployment, has been used by advanced TQM companies in Japan. It provides a disciplined approach to continuous improvement that focuses all employees on a manageable number of goals identified by senior management.

All policies, procedures and activities within the company should be consistent with the strategic plan. If not, either there is something wrong with the plan or the policy/procedure! Improvement initiatives focusing on management processes should therefore begin by considering how the process supports the strategic plan. The strategic plan is not just for senior management. Every employee should have a basic understanding of it and understand how their jobs contribute to its successful implementation.

Finally, do not leave the plan on a shelf to be dusted off when strategic planning time comes around next year. Make it a living document that evolves as circumstances change.

PRODUCT DEVELOPMENT

When most people first think of quality, producing products that have few, if any, defects often comes to mind. Quality is certainly an important production issue, but it is just as important in product development. Product development itself is a process, having customer needs as inputs, and product designs as outputs. By using TQM methods to improve this process, your company can produce products which satisfy customer requirements more effectively and have shorter development times, as well as fewer defects. This is called "designing for quality" – taking steps to ensure quality even before production starts.

A systematic process improvement strategy (see Chapter 4) such as the Shewhart (PDCA) Cycle, can be applied to developing and improving products. This involves collecting and utilizing accurate and up-to-date information on customer needs and requirements; and involving every function in the business to meet these requirements. The process involves close cooperation between several departments, including research, design, production and sales. The application of the PDCA Cycle to product development is shown, in general terms, below:

Plan: Plan for the product design, incorporating market research and production capabilities information.

Do: Produce a prototype and test it.

Check: Evaluate test results and identify changes needed.

Act: Modify the design of the product, based on the evaluation.

Quality Function Deployment (QFD) is another technique for product development which is gaining acceptance. QFD enables product designers to determine customers' requirements and translate them into product specifications. Rather than being an alternative to the PDCA Cycle described above (or similar strategies), it is a tool which can be used within the cycle.

Figure 21 shows a QFD matrix, sometimes called a "House of Quality" because of its characteristic shape. In the QFD matrix, customer requirements are written along the vertical axis of the array, and product characteristics are written across the top. The matrix is used to identify and evaluate the strength of relationships between product features and market requirements, and among the product features themselves. These relationships are used to establish priorities for product features and, subsequently, to establish the detailed design parameters for the product and manufacturing process.

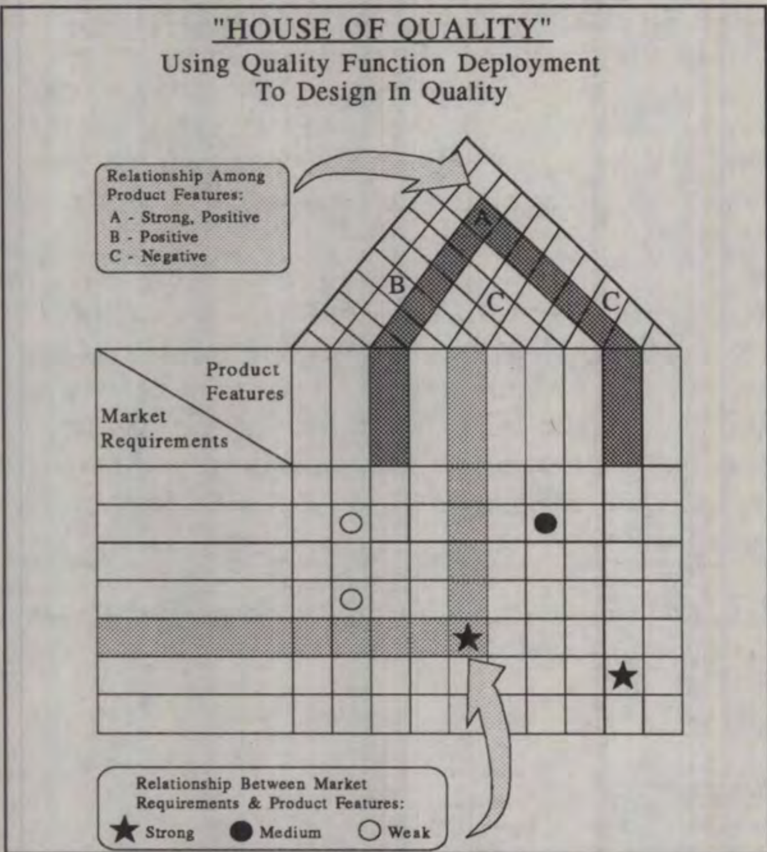


Figure 21 — House of Quality

QFD can be used by cross-functional teams with members from product development, production and marketing. It is fully compatible with concurrent engineering, described on the following page.

Concurrent engineering, also known as Simultaneous Engineering and Design-Build Teams, is a process where the traditional engineering design function is performed concurrently with inputs from all other functions affecting the end product. This means the involvement in the design process of customers, users, suppliers and internal functions such as manufacturing, quality assurance, industrial engineering, test engineering, customer support, etc. The teams consider factors such as: meeting specified requirements, reliability, producibility, procurability, inspectability, and serviceability. Based on this analysis, they design the product, production processes and tooling. Benefits of the method include shorter development times, lower costs and fewer changes.

> **AlliedSignal Aerospace Canada uses Design-Build Teams to improve competitive position.** As part of its commitment to continuous improvement, the company's Engineering and Operations departments have partnered to introduce the Design-Build Team concept on the Boeing 777 Air Supply Control System (ASCS). In implementing this concept, also called Concurrent Engineering, AlliedSignal has incorporated ideas from a similar program at Boeing as well as drawing upon a long-time AlliedSignal tradition of Working Together.
>
> The Design-Build Teams involve representatives from each company function working together to develop the design, the build, and the support of each part of the Boeing 777 ASCS. During the development of the product design and production processes, the teams consider such factors as: meeting specified requirements, reliability, producibility, procurability, inspectability and serviceability.
>
> Design-Build teams ensure that the company's products and the required production processes are designed right the first time, with minimal change after drawings are released. Having fewer changes means that the company improves its competitive position by having a more producible, lower-cost product which is delivered to the customer in a faster time.
>
> (from *Commitment to Excellence*, AlliedSignal Aerospace Canada)

SOFTWARE DEVELOPMENT

The overall objective of TQM in software development is no different than in other environments: to satisfy the customer. What makes software unique are the changed balances over the development life-cycle. Software is essentially a one-time design activity, with negligible recurring production costs. The quality of the design alone determines the quality of the product. Hardware quality, by contrast, is determined equally by design and production. This distinction influences the planning and execution of a TQM program, including the continuous improvement tools to be used.

There are three major elements which determine the cost, schedule and quality of a software product: **process, people and technology**. The relation between these three is quite simple. Software as a profession has moved from a craft-like approach to an engineering approach that follows a disciplined, step-by-step process. It is widely accepted that the quality of a software product stems, in large part, from the quality of the process used to create it. This process is implemented by people with the use of technology (including tools and methods).

Process: The software engineering process is the sequence of steps used to produce a finished software product, in effect, a road map for software development. A clearly identified process should be documented and executed on every project, and it should also be measured, managed and improved over time. This improvement should be reflected in a more effective execution of a project, defect prevention instead of defect correction and higher product quality, including increased reliability and maintainability.

A clear development **life-cycle model** (waterfall, spiral, etc.) should be defined and followed. In addition to being suitable for the nature and criticality of the application, it should be well-accepted by the developing organization and its customer. Life-cycle models include detailed definitions of the following: 1) gates/milestones that separate the life-cycle phases, along with their passing criteria; 2) an overall development methodology (e.g. object-oriented); 3) methods (e.g. Ward-Mellor for requirements modelling) and standards for each development phase; and 4) detailed **inputs, activities and outputs** for each development stage.

Project oversight is an important element of the development process. Formal procedures should be in existence for management reviews prior to contract award, followed by periodic status reviews during development. Peer reviews, in the form of structured inspections and walk-throughs, should be defined. Independent audits and reviews, such as Independent Verification & Validation (IV&V), should be built in for highly critical applications.

Procedures and metrics for estimating software size, schedules and cost should be utilized. Management procedures and tools should also be in place for tracking compliance with cost and schedules. To the extent possible, the engineering process should be quantified and measured. Typical metrics concern software quality, the amount of code developed, resources used, and progress indicators such as review coverage, test coverage and test completion.

Several other practices contribute to the quality of the software development process. Reuse should be encouraged on all new applications, and this should not be restricted to code reuse only. Design, test specifications, test procedures, test scripts and test tools are all candidates for reuse. Risk management, in the form of assessment and mitigation, contingency planning, risk planning and reporting, should be practised.

Formal change control and configuration control processes should be in place to control all software artifacts: requirements, design, code test cases and scripts, documentation and software tools. Lessons-learned documents, analysis of metrics, interpretation of the process-related causes of errors, and a process change mechanism designed to prevent errors can all contribute to a continuously improving software development process.

People: Given that software is logical rather than physical, and that it is engineered rather than manufactured in the classical sense, software development is typically more labour-intensive than other human endeavours. Consequently, people considerations are central to software development in a TQM environment. The aim is to move from an environment characterized by "fire-fighting," low effectiveness, high frustration and adversarial relationships across disciplines, toward one with an emphasis on "fire-prevention," and teamwork.

The principle issues related to people, and the means of achieving improvement in these areas are: 1) training; 2) people management and motivation; and 3) organizational structure.

Training in software engineering fundamentals, and the software development process, is important in order to emphasize the need for discipline and rigour, and to discourage the old craft-like approach to software development. Training in methods and tools should be carried out continuously in order to keep up with the rapid advances in the field. Training in problem solving and teamwork is equally important, considering the ever-increasing size, complexity and criticality of modern software applications.

The TQM principles and methods concerning employee involvement, discussed in Chapter 6, should be employed in order to stimulate and maintain enthusiasm, encourage creativity and initiative, and promote teamwork and cooperation with other skill groups. Elements of these participatory management techniques are: the frequent articulation of a vision, managing by fact and by principle, developing successful subordinates, trusting people, giving accountability with responsibility, establishing high standards and giving lots of performance feedback.

Software managers should be placed in charge of software development projects. Software engineers should participate in the system engineering effort. Software Quality Assurance should have its own reporting channel to the program office, separate from that of the developers. Software Configuration Control should be executed on each project. A separate Software Process Group should be established to continuously refine (define, measure, optimize) the development process. A rotating system amongst projects and this group would have the double benefit of bringing practical experience into the group, and keeping developers up-to-date with the latest software development processes.

Customer Involvement: The involvement of the customer in all phases of software development is extremely important. During requirements definition, it eliminates the possibility of misunderstanding, thus ensuring that the "right product is developed." During design reviews and audits, it gives the customer evidence that a rigorous process is being followed to build quality in at every stage. During testing, it ensures that the customer witnesses the absence of defects as well as the collection and evaluation of quality metrics on the product. The ultimate effect of this intense customer involvement is a greatly enhanced level of customer satisfaction.

Technology: Effective use of technology is an important quality objective since it provides the means for process automation, increased rigour and quality. The aim of an organization should be to move from a culture where new technology is resisted as being risky, to an organizational culture that has first a qualitative, and later a quantitative basis for applying technology effectively.

The key factors of technology are tools and methods. Automated tools should be employed both in project management and software development. All life-cycle phases could benefit from CASE environments that support graphic modelling of requirements and design, requirements analysis, design and test traceability, configuration management, metrics collection, etc. Methods such as modern design notation, graphic modelling, testing and metrics collection and analysis methods should be employed. Their use will enhance productivity and product quality (particularly reliability and long-term maintainability).

Conclusion: Process is central to TQM in software development. To be effective, the development process must be clearly defined, stable, and subject to continuous improvement. It must enjoy the support of metrics, product assurance, configuration management, etc., and often, at least on highly critical applications, it has to be certified.

In turn, process improvement is conditioned by the following principles:

- major changes must start at the top;
- if a fix is necessary, the process should be fixed, not the people;
- the change should be regarded as continuous;
- improvement requires investment; and
- retaining improvement requires periodic reinforcement.

The payback from applying these principles and practices will be reduced development times, significant cost savings and high product performance and reliability.

PRODUCTION

One of the most widespread uses of TQM involves the application of statistical methods (often called SPC) to monitor, understand and improve production processes. Quality depends not only on shop floor activities but also on material handling, production planning and inventory control. TQM methods can be applied to improve all of these processes. SPC principles and methods were discussed in Chapter 4. They emphasize controlling production process inputs, and the processes themselves, rather than relying mainly on inspection to control quality. Production workers can play a significant role in applying these methods. This requires that: 1) they have sufficient training; and 2) the production environment is conducive to employee involvement.

There are a number of manufacturing practices which, while not strictly part of TQM, are consistent with TQM principles and are particularly effective when implemented within a TQM environment. These include: Just-in-Time (JIT), Computer Integrated Manufacturing (CIM) and Cellular Manufacturing. TQM methods for analyzing existing processes, planning changes, and measuring the effectiveness of the changes should be used when adopting these and other new manufacturing techniques. We do not have the space to discuss the techniques in detail, however, we will provide a brief description of one of the most important methods which is closely linked to TQM: JIT manufacturing and inventory control.

JIT is a system of inventory and production control, in which each employee performs his or her task just-in-time for the next person to perform theirs. All activities are demand-driven — they are initiated in response to requests received directly from customers (external or internal). The system reduces inventory dramatically (resulting in lower holding and financing costs), cuts lead times, and makes the work process more responsive to customer needs. In order for the process to operate, underlying causes of quality problems, which produce delays, defects and scrap, have to be eliminated.

JIT enables companies to be more competitive through reduced lead times, increased on-time delivery and greater schedule flexibility. Suppliers of aircraft components and subsystems face increasing customer expectations in this area from aircraft manufacturers such as Boeing, Aerospatiale and Fokker.

Israel Aircraft Industries, Technologies Division (Servo Hydraulics Lod) uses TQM methods to strengthen its position in the global civil aviation market. This Israeli firm is a world-class aerospace competitor, producing hydraulic actuators for the Boeing 737, 747, 757, and 767. It has recently been designated a supplier for the 777.

By organizing production cells that group together machines to make specific types of parts, and training personnel in teamwork, the company has achieved significant cycle time and product quality improvements. For example, the production cycle time for pistons used in the firm's hydraulic systems has been reduced from 150 to 125 days, with 90 days being the target. The percentage of pistons requiring re-work has been reduced from 40-50% to 8%.

(based on *Israeli Military Spending Decline Spurs TQM-based Cost, Production Improvements in AI*, J.M. Lenorovitz, Aviation and Space Technology, Dec. 9, 1991)

There are similarities between TQM and JIT. For example, they both emphasize cost-of-quality reduction, employee empowerment, striving for continuous improvement and close cooperation between customers and suppliers. The essential difference between TQM and JIT, is that TQM is an overall quality philosophy, applicable to all functions in the organization, whereas JIT is a specific method of optimizing work processes. They are complementary, rather than alternative approaches.

MARKETING, PURCHASING AND CUSTOMER-SUPPLIER RELATIONSHIPS

Aerospace companies are in business-to-business marketing – supplying products and services to other companies who produce or use aerospace equipment. Very often, a company has a small number of customers, with each customer representing a major share of the firm's business. Compared to most industries, customer-supplier relationships are more complex, and less likely to be based solely on price competition. As the industry progresses with TQM, these characteristics will become even more pronounced.

One of J. Edwards Deming's 14 Points is to: "End the practice of awarding business on price tag alone. Instead, minimize total cost by working with a single supplier" (for each category of supply item). The TQM approach, with its focus on building-in quality at each step, necessitates bringing suppliers into the quality management process. This cannot be done with a large group of suppliers who compete on price. Moreover, the use of JIT and other techniques, closely related to TQM, favours minimizing the number of suppliers and increasing mutual commitments.

Many companies are now reducing their supplier lists using systematic approaches to evaluate suppliers' capabilities for contributing quality and value. They can then work more closely with their remaining suppliers to jointly manage quality. These arrangements can vary in level of complexity, commitment and formality.

Examples of activities being increasingly undertaken include:

- placing emphasis on more open communications and a non-adversarial environment;
- sharing of resources, strategic information, and joint planning;
- concurrent engineering;
- training in topics such as SPC;
- quality improvement teams to deal with processes at the interface between the two companies, (e.g. joint master scheduling plans, improving supplier packing slip formats to reduce the number of errors made by receiving personnel); and
- reduction or elimination of inspection of incoming materials, replaced by reliance on the supplier to prevent quality problems.

It is possible to use surveys as an instrument for assessing relationships with suppliers. On the next page, is an extract from a questionnaire mailed to 5 000 suppliers of Spar Aerospace. The questions covered the products or services provided, an assessment of Spar's procurement practices, and attitudes towards industry practices such as the establishment of preferred supplier lists. Spar is using the responses as a tool to enhance its subcontract and purchasing performance.

The influence of TQM on customer-supplier relationships is having a profound effect on how marketing and purchasing is done. There is renewed emphasis on marketing, rather than just selling. Progressive marketing people have, for many years, succeeded by: 1) working with customers to understand their needs and product requirements; and 2) working with product development and production to plan how these needs can best be met – and make a reasonable profit. This applies not only to established customer-supplier relationships but also to new business. The marketing approach is completely consistent with TQM. What TQM brings to the table is: 1) it creates an environment which demands this approach; and 2) it provides additional methods for accomplishing marketing objectives.

An Excerpt from SPAR's Supplier Survey:

g. SPAR always adheres to the terms and conditions laid out in the PO or contract.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

h. SPAR always pays its bills as per terms agreed.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

i. Feedback and evaluation of supplier performance is rarely provided by SPAR.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

j. SPAR works hard to develop an ongoing relationship with its suppliers, emphasizing teamwork.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

k. SPAR is not receptive to supplier suggestions in areas such as new technology and cost saving initiatives.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

l. Overall, SPAR's purchasing practices demonstrate a high degree of professionalism.
5 ——— 4 ——— 3 ——— 2 ——— 1
Agree Neither Agree nor Disagree Disagree

Section C: Industry Practices

5. Have you had any orientation visits to SPAR?

Yes .... 1 → Did you find it helpful?
No 2
Don't Know ... 3

Yes 1
No 2
Don't Know 3

6. Have you had any visits by SPAR to your facility?

Yes .... 1 →	Did you find it helpful?
No 2	
Don't Know ... 3	Yes 1
	No 2
	Don't Know 3

As the price-oriented, somewhat adversarial, relationship between customers and suppliers is replaced by a cooperative approach, the responsibilities of marketing and purchasing personnel are changing. The output of successful marketing and purchasing processes will be much more than one, or a series of orders. Instead, it will be a strategic partnership or alliance.

Marketing and purchasing people will play important roles in establishing and managing these relationships, however, the effort will involve multidisciplinary teams, including people from R&D, Production and Quality Assurance as well. Senior management will be more directly involved in establishing and maintaining these relationships.

More complex customer-supplier relationships represent both an opportunity and a challenge to your company as a supplier. If things go well, they are the best way to guarantee future business. They will also allow your firm to utilize its full capabilities to produce innovative, high quality products and services – not just competing on price alone. Strong relationships with customers is a well-established positive factor in financial performance. According to a study by Forum Corp, keeping a customer typically costs about 20% as much as finding a new one. (See *Managing for Global Excellence: Building the Total Quality Company*, Business International Corporation, 1990, p.105). Furthermore, established customers are responsible for twice the revenue of new ones.

On the other hand, customer-supplier alliances require significant commitments – which can only be made to a limited number of firms. For example, potential difficulties could arise in meeting several suppliers' requirements concerning quality assurance procedures. A company may have to reduce its number of customers to accommodate growing commitments to the important ones. Finally, there is an element of risk in these alliances since the return on investment will be closely tied to the customer's success in the marketplace.

Canadian aerospace companies extend TQM approach to working with customers and suppliers. An AlliedSignal Aerospace Canada team, including customer representation, used TQM methods to improve the design of a product for a major customer. To get its suppliers involved in TQM, Pratt & Whitney Canada has assisted them in introducing SPC. These stories are told in two case studies in Chapter 10.

Harris Corporation's Electronic Systems Sector extends its Total Quality system to its suppliers. Between 1987 and 1990, this firm made major changes to its supplier base. The company had found that it did not know enough about most of its 5 000 suppliers, nor they about Harris, to form the lasting partnerships needed for TQM. The supplier base was subsequently reduced to 278, while still retaining at least three sources of supply in each product category.

The initial step was to focus on a base of 2 500 major suppliers. These companies were then evaluated using a list of 14 attributes of preferred suppliers which had been identified. According to a company official, "We realized that to become a great company, we would have to go beyond fixing problems we were causing and integrate our suppliers into the value-added chain."

(based on a report in Commitment Plus: A product of the Quality and Productivity Management Association, Vol. 6, No. 1, November 1990)

ADMINISTRATIVE PROCESSES

There is a tendency for technology-based companies to initially focus their quality improvement efforts on production and development since the link to customer satisfaction is most readily apparent. In fact, all of a company's processes affect the quality of goods and services delivered to customers. Shipping the wrong part, incorrect invoicing, and late deliveries are quality problems – failures to meet customers' requirements.

During a Keynote Address at the 31st semi-annual conference of the QPMA (Toronto, October 1991), Ken Kivenko, President of AlliedSignal Aerospace Canada, described the situation in many companies: "Many business processes were not designed at all; they just happened. The general manager one day recognized that he didn't have time to handle a chore, so he delegated to Jones. Jones improvised. Time passed, the business grew, and Jones hired more people to cope with the increased work load. They all improvised. The hodge-podge of special cases and quick fixes was passed from one generation of workers to the next."

> **Process improvement team streamlines Gruman's hiring process.** After analyzing their hiring process, Gruman discovered it took 60 days and 17 signatures to bring a new employee into the company. A process improvement team streamlined this process to use two individuals and take ten working days.
>
> The team found, however, that the improvement began to disappear once it was implemented. The required time gradually lengthened to 60 days. When the team re-examined this new process they found the root of the problem: the form still contained signature space for two individuals, with another page stapled to the first with the other 15 names on it. Further effort, focusing on the people involved, allowed the improvement to be regained. The lesson learned was that improvements must be monitored if they are to be maintained.
>
> (based on *Extending the Boundaries of Total Quality Management*, J.R. Jarrett, Journal for Quality and Participation, Jan/Feb. 1992)

Many existing processes originated before the advent of modern computers and communications technology. In some cases, they were automated before being redesigned to be optimized with automation. This is analogous to what happened when robotics were introduced into some production operations in the 1970s, without considering the design of the processes themselves. The key phrase to remember is "Simplify, Integrate, Automate" – in that order.

Clearly, there are significant opportunities for process improvement within the office as well as the plant. In improving these processes, employees working in the process should identify their customers. Processes can be redesigned to take advantage of new technology; not only making data collection and storage more efficient, but also enabling the use of information for decision-making as close as possible to where the decision applies.

BUSINESS PROCESS REENGINEERING

Since *Reengineering the Corporation* by Michael Hammer and James Champy was published in 1993, there has been significant interest in the methodologies proposed. According to the authors, "reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as cost, quality, service and speed."

Reengineering focuses on the core business processes including such items as product development, order-to-delivery systems, after sales service, and so on.

It has been said that "reengineering goes beyond TQM" or that "reengineering characterises a new wave." However, closer analysis has shown that reengineering is a performance improvement methodology within TQM. It usually comprises a one or two year program of very intense effort that needs to be put within the context of ongoing continuous improvement. It is a "Breakthrough" approach to TQM.

CORPORATE CITIZENSHIP

Much of our discussion on TQM so far has focused on how companies can meet the needs of their customers. In dealing with employee involvement, we have also addressed one of the most important needs of employees: being part of a team, and making a meaningful contribution. Employees have other important needs which companies need to consider, both financial and non-financial. Companies also face the challenge of achieving and maintaining good relationships with a much wider group of stakeholders (anyone who is affected by the company's business). These stakeholders include government regulators, shareholders, special interest groups and the general public.

The aerospace industry has always been a leader in corporate citizenship. Aerospace companies have been good places to work and have benefitted the communities in which they are located. They have also had close relationships with governments. In the future, the industry will want to maintain this position and respond to the continuous changes in society which test even good relationships between companies and their stakeholders. TQM can play an important role here. It is fairly straightforward to extend the concept of the customer to include these other stakeholders. The TQM approach and methods for continuous improvement can be applied to satisfying the needs of this broader group of customers. As with a company's external customers, partnering with unions, schools, community and government agencies can be effective and is consistent with TQM.

Chapter 10

CASE STUDIES IN TOTAL QUALITY MANAGEMENT

INTRODUCTION

Throughout this handbook, reference has been made to the application of TQM within the aerospace industry. The case studies in this chapter report, in greater detail, on the successful application of TQM principles and techniques by Canadian aerospace companies. Several of the cases discuss the application of Statistical Process Control (SPC). Others deal with teamwork and the TQM implementation process. Not all of the companies represented here have programs called "Total Quality Management." However, the case studies demonstrate the TQM principles which form the basis of this handbook: Focus on the Customer, Management Leadership, Employee Involvement and Continuous Improvement.

In Chapter 4, we discussed process improvement methods. Two of the case studies in this chapter describe applications of SPC to manufacturing operations. Charlie Mason tells how Menasco Aerospace used SPC to improve its shot peening operation (for increasing the fatigue life of metal components). Ian Leishman, of Hawker Siddeley Canada (Orenda Division), describes how SPC was used to improve drilling and grinding operations. The techniques covered in these two papers include: histograms, control charts, process capability calculations and statistical design of experiments.

Employee involvement and the role of teamwork were discussed in Chapters 6 and 7. René Deland and Elizabeth Busse tell how Bell Helicopter Textron has implemented self-directed work teams in Bell's new plant in Quebec. Magued Iskander, of Spar Aerospace, relates how teamwork was used to design and develop a robotic joint for Space Station Freedom "right the first time." The role of team facilitators, and how Litton Systems Canada went about building a facilitator staff, is discussed by Steven Petgrave.

In Chapter 7, we discussed planning and implementing company-wide TQM initiatives. Larry McHenry and Lennox Vaillancourt discuss how Haley Industries uses a seven-step process for introducing SPC and other process improvement methods within the company. Brian Lanoway, of Standard Aero, describes how a company-wide approach to productivity and quality improvement was accomplished, with specific examples in process re-design. Measuring progress in TQM is an essential element of any TQM implementation plan. Peter Holt describes how Paramax Systems Canada utilizes the Baldrige criteria to measure its TQM progress.

TQM involves developing closer, more sophisticated customer-supplier relationships—an issue which was introduced in Chapter 9. Bill Beckett, of Pratt & Whitney Canada, explains how the engine manufacturer worked with one of its key suppliers, Sider-Tech, to implement quality procedures and coordinate them with P&WC. Ken Kivenko, of AlliedSignal Aerospace Canada, describes how an AlliedSignal team, including customer representation, used TQM methods to improve the design of a product for a major customer.

THE IMPLEMENTATION OF SPC TO THE SHOT PEENING PROCESS

CHARLIE MASON
MENASCO AEROSPACE LIMITED

Menasco Aerospace Ltd., a wholly-owned subsidiary of Coltec Industries, is a leading manufacturer of landing gear assemblies, parts and components for medium-to-heavy commercial and military aircraft and provides spare parts and overhaul services for these products. Menasco also supplies aircraft flight control actuation systems and other engineered and machine products, primarily for the aircraft industry. The company is also involved, as team leader, in a flight control systems Research & Development program directed toward the design, validation and implementation of very advanced "fly-by-wire/fly-by-light" flight control technology.

Landing gear of high-performance aircraft require a large number of precision parts: cylinders, pistons, axles, bogie beams, drag braces and torque arms, to name a few. These systems incorporate both hydraulic and electrical components and their structural requirements vary depending upon weight, speed and landing characteristics of the aircraft, as well as the expected landing surface. Consequently, Menasco's design and engineering proficiency significantly compliments its production capability.

Menasco's Continuous Improvement Program began in 1991 and has resulted in significant quality improvements. Key elements of the program are Statistical Process Control (SPC) and Process Improvement Teams. This case study discusses how a Process Improvement Team introduced SPC to Menasco's Shot Peening process.

The Shot Peening process is used extensively throughout the aircraft and automotive industry to increase fatigue life and reduce stress cracking corrosion of metal components. The process involves bombarding the part with shot which are propelled by centrifugal force, generated by a rotating "blast wheel," or by compressed air. Process parameters include air pressure, wheel speed, shot size and hardness.

Before we could start our SPC program, we needed to identify the main measurable output variables directly related to the process. After a brainstorming session, our team determined intensity (thickness of the compressive peened layer on the part) to be the main measurable output variable. Intensity is determined by holding a flat Almen test strip in a fixture and peening it to saturation. The Almen strip is then removed from the holder and the arc or bend in the strip is measured. This arc height is referred to as the intensity. Shot peen specifications and engineering drawings call out the required intensity ranges, which vary depending on the type of material, hardness, thickness, etc.

Our first step was to use a standard SPC rule: "Centre The Process." This was accomplished when developing Shot Peening techniques (wheel speed, air pressure, shot flow, peening time and cycle settings, etc.). We focused on achieving the nominal intensity and consuming a minimal amount of the engineering tolerance. Intensities near the outer limits were not accepted as these may drift out of specification during production runs.

The histogram in **Figure 1** illustrates the variation in intensities in an old technique used to process the outer cylinder for the 737 Main Landing Gear. The intensities consume all the lower end of the engineering tolerance and the C_p and C_{pk} had very low values of 0.66 and 0.53 respectively. Our present 737 outer cylinder technique is shown in **Figure 2**. Through the application of standard SPC rules, the intensities are now centred around the nominal, as well as consuming much less of the engineering tolerance. The success of this exercise is reflected in the improved C_p and C_{pk} values of 1.3 and 1.26.

The above results, demonstrating an improved process, were achieved under test conditions. The histogram in **Figure 3** illustrates the intensities achieved for the new process during actual production runs. The intensities consume more of the engineering tolerance, resulting in lower C_p and C_{pk} values (1.24 and 1.04 respectively). Variation during actual production, using our old technique, would presumably have been worse. Our next step was to identify and eliminate the causes which were responsible for the higher process variation observed in actual production runs.

We began by plotting the intensities for each lot of parts processed. Individual control charts (X charts) were used to examine the extent of variation and to calculate control limits. After the control limits were established, special cause variation was identified and corrective actions such as nozzle break-in cycles and daily visual checks were incorporated to reduce variation. Operators were advised about the importance of plotting all results obtained, including out-of-specification values. Once the problems were identified, corrective action was taken.

As time progressed, we noticed a consistent upward trend on all intensities charted. Something in the machine was changing and we had no control over it. The team conducted further brainstorming and concluded that the blast pattern was changing due to wear on the blast wheel components. This forced us to take a step backward and establish basic machine set-up standards.

Blast pattern intensity charts, test run procedures and control limits were implemented. Almen intensity test strips were strategically located across the peening (working) zone and standards were determined for each wheel separately (see **Figure 4**). Variable control charts with control limits were developed for each test strip and regular verification runs were performed to detect changes in the blast pattern. These standards enabled us to replace worn components and maintain consistent operating conditions. This was a major step in reducing variation in our process. In the past, whenever maintenance was performed on the machine, peening conditions would alter drastically and techniques would have to be changed.

Having established basic machine standards, we then looked at our key process parameters. Again, a brainstorming session was conducted and the following key process parameters were identified: shot flow, wheel speed, air pressure, shot quality and blast pattern. We felt that these parameters had the greatest impact on the main output variable, intensity. To date, we have established control limits on our wheel speeds, shot flow and shot quality based on SPC calculations. Programmable alarms have been installed on the machines to warn us immediately of out-of-control situations.

A recent study involved charting the defective or deformed shot count. We found that the shot in the machine did not meet quality standards, the upper control limit being above the specification. Adjustments were made to the shot separators and a daily maintenance program was incorporated, with very little success. At this point, management approved a request to upgrade our present separation system. A spiral separator was installed and our defective shot count is now in control. New data were then collected and the control limits were recalculated (see **Figure 5**). The daily maintenance program was also retained as it helps to control defective shot count.

An Almen Gauge repeatability and reproducibility study (Gauge R & R) was performed to ensure our measurement system was not a source of excessive variation. The maximum percentage of variation found in the gauge was 9.4%. We concluded this was acceptable as it does not consume more than 10% of the engineering tolerance.

To further understand the parameters of our process, a statistically designed experiment was performed. Our goal was to determine the optimum settings to achieve an intensity of .016 A, the nominal intensity required to peen Boeing's new 777 Nose Landing Gear (actual tolerance .014 - .018 A). The process parameters (input factors) selected were shot flow, wheel speed, time, and table rotation. The process output variable measured was intensity. Based on the goals and factors used in this experiment, we selected a Two Level Full Factorial Design (2_4), with 2 replicates and 2 centre points, as the most likely accurate and practical experiment. Using Boeing's SQC software, a tally sheet was produced consisting of 34 randomized test runs.

After conducting the experiment, the resulting data were analyzed for accuracy, interactions, and responses using the SQC software. Charts and graphs illustrating the impact of the individual parameters on the output variable were produced.
The Scree Plot (**Figure 6**) and Main Effects Plot (**Figure 7**) indicate that the wheel rotation speed has the greatest effect on the intensity with the table rotation speed having no effect at all.

The software also allowed us to determine the optimum settings for the process parameters to achieve the required intensity. Using the Main Effects Plot, we determined that a wheel speed of 1 600 RPM, shot flow of 75% and a peening time of 4 minutes would yield an intensity of .016A. Our conclusions were justified with four verification runs producing the following intensity results, .0164A, .0163A, .0163A, .0162A. ***Success:*** **We had achieved our goal.** The results also indicated that we required tight control limits on our wheel speeds and shot flow, as well as a simple warning light to monitor the table drive. This brief overview has covered only a small portion of the analysis performed.

Once we have gathered all the necessary information, we plan to produce a Process Control Document (PCD) that demonstrates our Shot Peen process is in control. This document will contain a procedure to monitor the machine's capability instead of verifying individual set-ups for each lot of parts. When we are only required to verify the machine's capability on a periodic basis, the number of test runs during production will be notably reduced. This PCD was initiated by Boeing's Shot Peen Specification BAC-5730.

At Menasco Aerospace Ltd., shop floor personnel are not only involved in organizing and running quality improvement programs, they are also directly involved in problem-solving and corrective actions. Menasco's team approach to SPC has resulted in extremely high operator participation and motivation levels. The continuing challenge to optimize our processes provides an exciting outlook for the future.

Menasco's Shot Peen Process Improvement Team, of which the author is Team Leader, received the 1992 International Shot Peener's Award for its expertise in SPC and statistical design of experiments (DOE). This award was achieved through the commitment of both top management and shop floor personnel to continuous quality improvement.

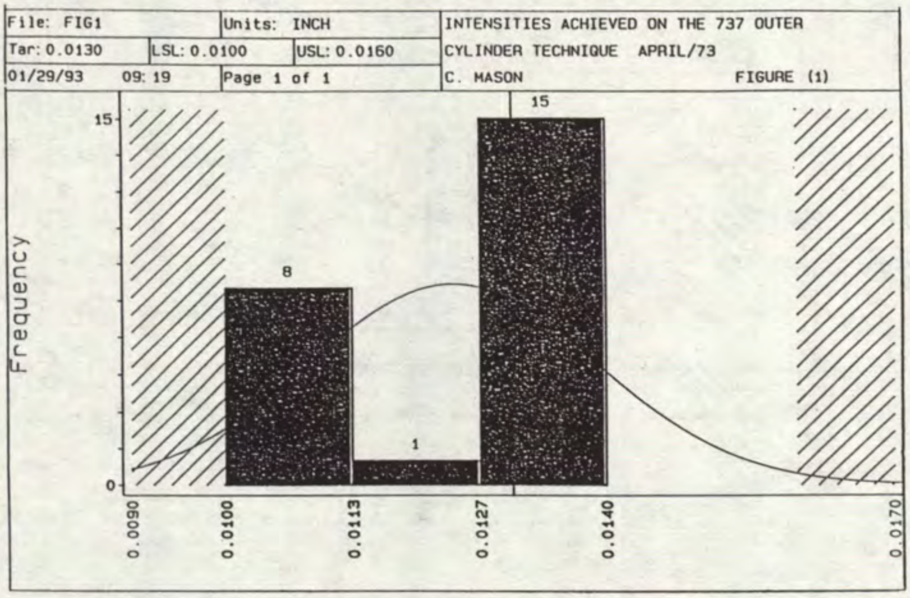


Figure 1
Variation in Shot Peen Intensity: Old Process, Test Conditions
$C_p = 0.66$ $C_{pk} = 0.53$

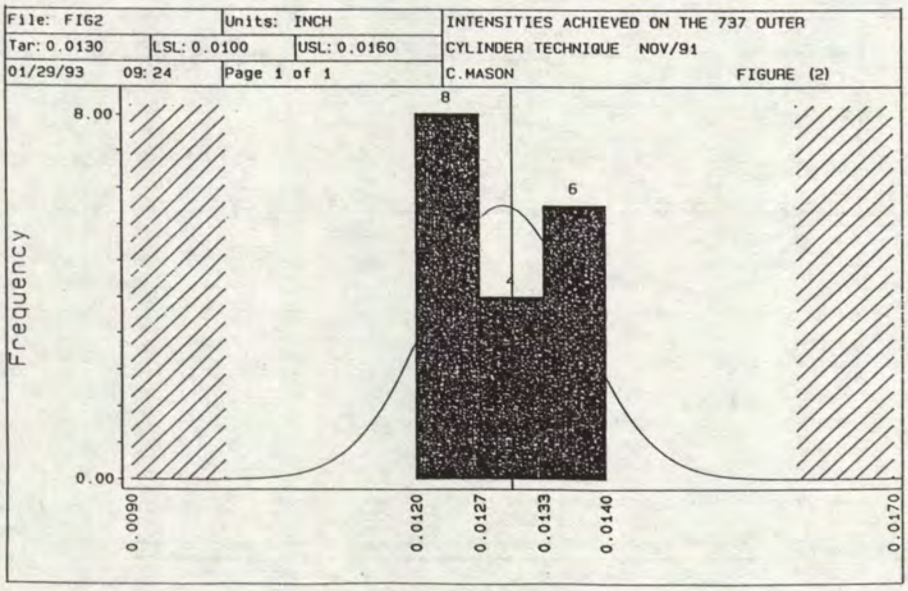


Figure 2
Variation in Shot Peen Intensity: New Process, Test Conditions
$C_p = 1.3$ $C_{pk} = 1.26$

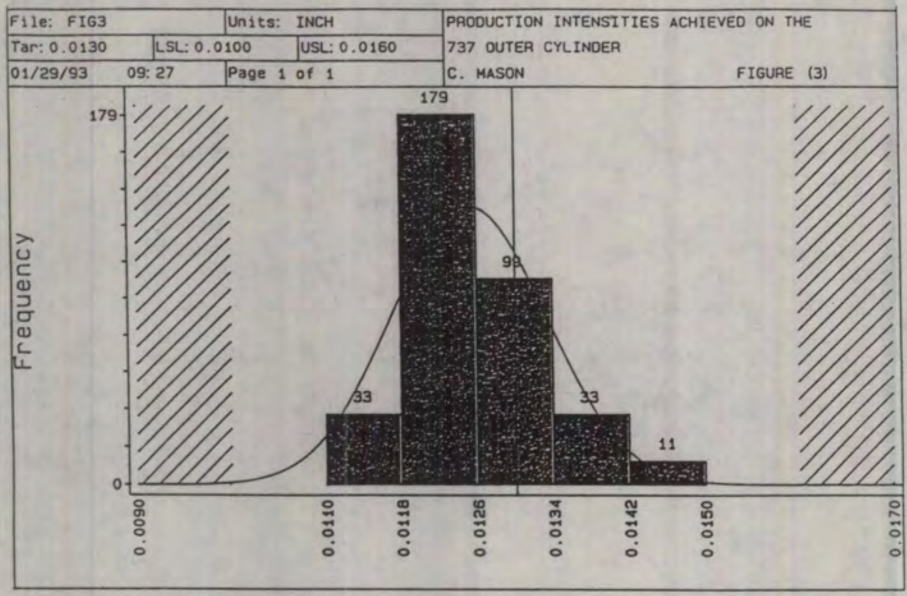


Figure 3
Variation in Shot Peen Intensity: New Process, Actual Production
$C_p = 1.24$ $C_{pk} = 1.04$

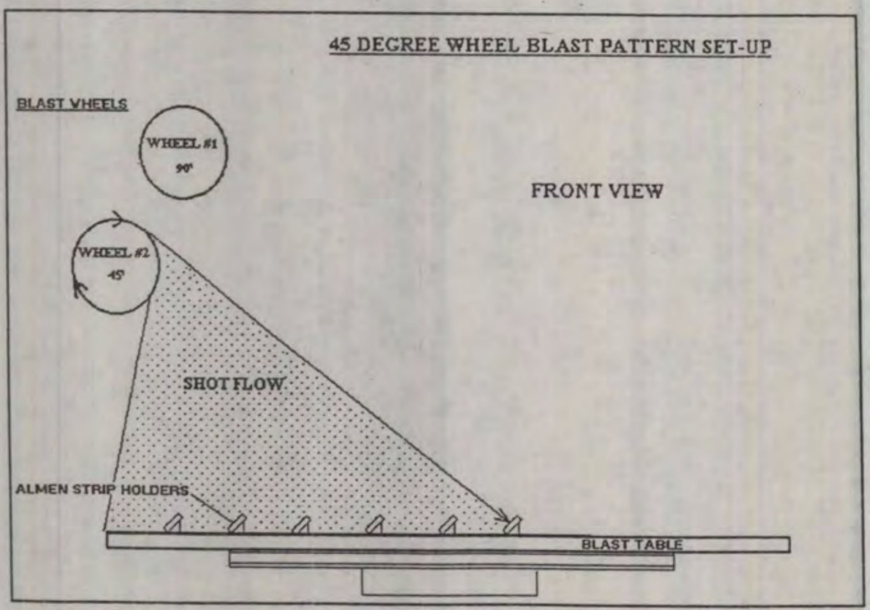


Figure 4
Shot Peening Process Configuration

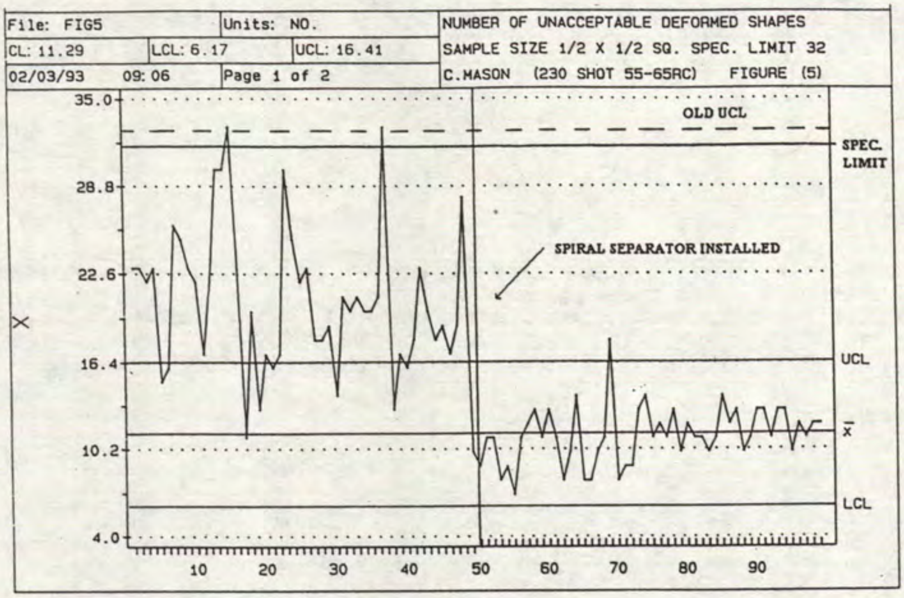


Figure 5
Control Chart Showing Effect of Spiral Separator on Defective Shot Count

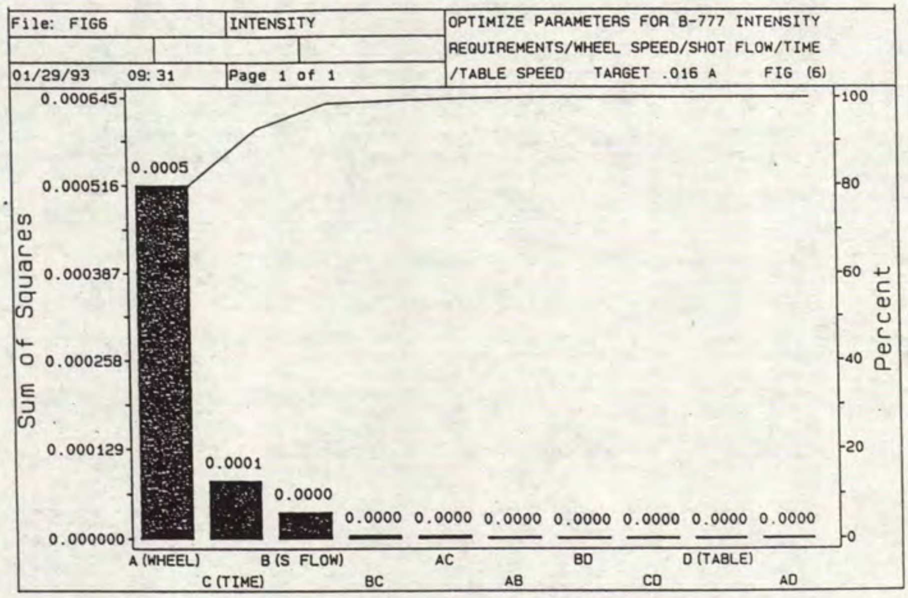


Figure 6
Statistical Design of Experiments
Scree Plot Showing Effect of Shot Peen Process Parameters

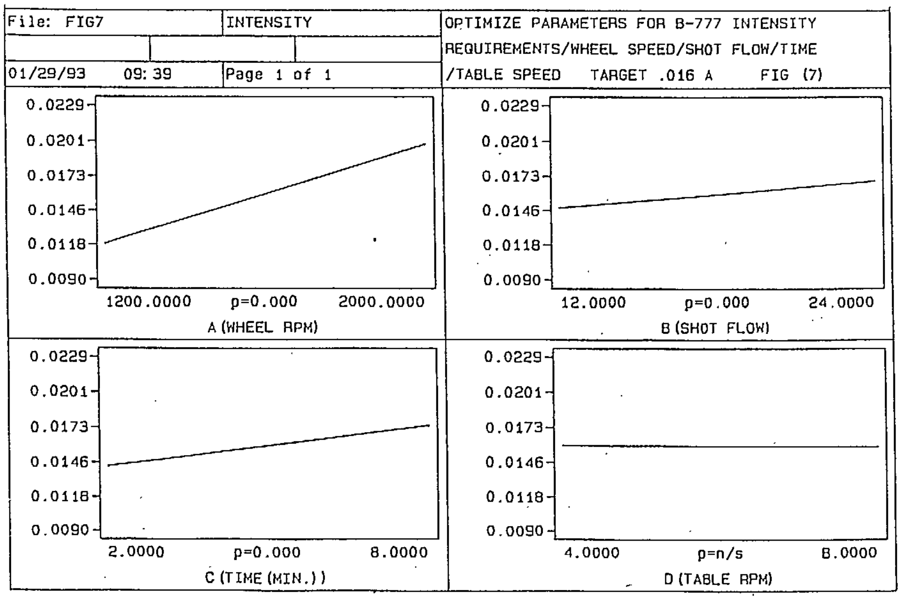


Figure 7
Statistical Design of Experiments
Main Effects Plot of Shot Peen Process Parameters

USE OF STATISTICAL METHODS FOR PROCESS IMPROVEMENT IN MANUFACTURING

IAN LEISHMAN
HAWKER SIDDELEY CANADA INC. ORENDA DIVISION

Introduction

Orenda Division has been the leading manufacturing and overhaul centre for Canadian Forces' high performance gas turbines since 1946. More recently, Orenda has built up a significant subcontract component manufacturing activity, producing high quality parts for a number of other aerospace manufacturers in Canada and internationally. The company currently employs approximately 500 people at its modern, climate-controlled facility located close to Toronto's International Airport. Orenda's comprehensive manufacturing and overhaul capabilities are complemented by extensive supporting activities such as R&D, design engineering, manufacturing and process engineering, government-qualified laboratories, computerized data processing and a modern graphics department.

Objectives of Orenda's Quality Assurance Initiative

In the past, like most major manufacturers in North America, we attempted to quickly adopt and implement some of the successful Japanese quality improvement techniques and tools. SPC was one of the tools identified as being a possible solution to a number of quality problems. In 1989, we hired a full time SPC Coordinator and gave all employees a basic, two-hour training course on what SPC was and how to generate SPC charts. This was unsuccessful because the training was limited and, with one SPC Coordinator shared among 500 employees, it was not possible to spend a lot of time with each employee analyzing data and solving problems.

Our second attempt at implementing SPC involved selecting a few key components and performing in-depth training sessions for all of the employees involved in their manufacture, including operators, supervisors and engineers. The training session was a 20 hour program of video, demonstrations, hands-on exercises and lots of examples of successful SPC applications. The result was a well informed work force, ready to apply their newly acquired knowledge.

Using control charts, the operators quickly identified various out-of-control characteristics. This allowed them to quantify problems they had been aware of for years. The SPC charts provided a useful picture of the process. Action teams were formed for the various programmes and weekly meetings were held involving operators, inspectors, manufacturing and quality engineers to review the results, brainstorm potential solutions and set priorities and ownership for corrective actions. Below we describe how SPC methods were used to improve manufacturing processes for a Combustion Liner Assembly which Orenda supplies to a major North American jet engine manufacturer.

The Combustion Liner Assembly

The Combustion Liner Assembly consists of an inner and outer wrapper, connected by a nose cone. Dimensions and tolerances for each component are critical to ensure a good fit up at the final assembly stage without having "fit" the parts to meet final drawing requirements. The outer wrapper is basically a formed sheet metal cylinder, .025" thick, with a series of punched holes around the perimeter.

Two of the key dimensional characteristics to ensure a good fit up at assembly are the overall length of the outer wrapper and the distance from the edge of the wrapper to the .389 diameter holes. These holes are used for various fixture locations on both the piece part and the assembly. (See **Figure 1**.)

The 2.200/2.220 Dimension

The 2.220 dimension is the distance from the .389 diameter holes to datum "A." It is generated by locating the part in a holding fixture on a punch press and piercing a number of different diameter holes as shown in **Figure 2-A** ("Before"). Problems were being experienced at the assembly stage since we locate from these holes. Data was collected to determine the variation on the dimension from the .389 diameter hole to datum face "A." The initial condition indicated a fairly wide spread across the tolerance band, located toward the lower end of the scale, with a C_{pk} value of 0.79 (see **Figure 3**). Investigation into the root cause of the problem revealed that, during the piercing operation, the part was located on datum "A" by dropping it into the fixture. Because there was no restraining device to hold the part firmly against the datum during piercing, the punch for the smaller holes would actually push the wrapper up the slope of the fixture and raise it off the locator for datum "A" before piercing the .389 diameter hole. This caused the 2.200/2.220 dimension to be on the low side of the tolerance band.

The corrective action involved modifying the die fixture to add a locating plate and spring to hold the part tight against datum face "A" during the piercing operation (see **Figure 2-B**, ("After")). This resulted in a significant improvement and a highly capable process as reflected by a C_{pk} value of 2.72 (see **Figure 4**).

The 4.665/4.705 Dimension

The final operation is to trim the wrapper to length. This is achieved by mounting the wrapper in a Trimmer, on a holding fixture located on the .389 diameter holes. The Trimmer consists of two drive heads, whose axes are parallel. The part is mounted on one head and rotates clockwise. The cutter is mounted on the other head and rotates anticlockwise. Trimming is accomplished by feeding the cutter head towards the part thereby shearing the end of the wrapper parallel to datum "A" (see **Figure 5**).

Data was gathered on this characteristic and plotted. Analysis of the data revealed that the curve was fairly widespread and targeted towards the top end of the tolerance band (see **Figure 6**). C_p and C_{pk} values were 1.38 and 0.42 respectively. Initial corrective action was taken to shim the cutter up enough to raise it to the height of the nominal dimension. This improved the C_{pk} value from 0.42 to 1.698 (see **Figure 7**). Further investigation revealed that the bearings were worn on the cutter side of the Trimmer. The bearings were replaced, resulting in a highly capable process with a C_{pk} value of 2.10 (see **Figure 8**).

In each of these cases, the corrective actions were carried out through regular meetings among operators, inspectors, manufacturing and quality engineers, facilitated by a full-time SPC Coordinator. The Operator's input, both in identifying the root cause of the problems and the potential corrective actions, was invaluable. With highly capable processes and dimensions targeted on nominal on these components, the final assembly of the liner has been vastly improved, with considerably less fitting of components and a significant reduction in scrap and rework.

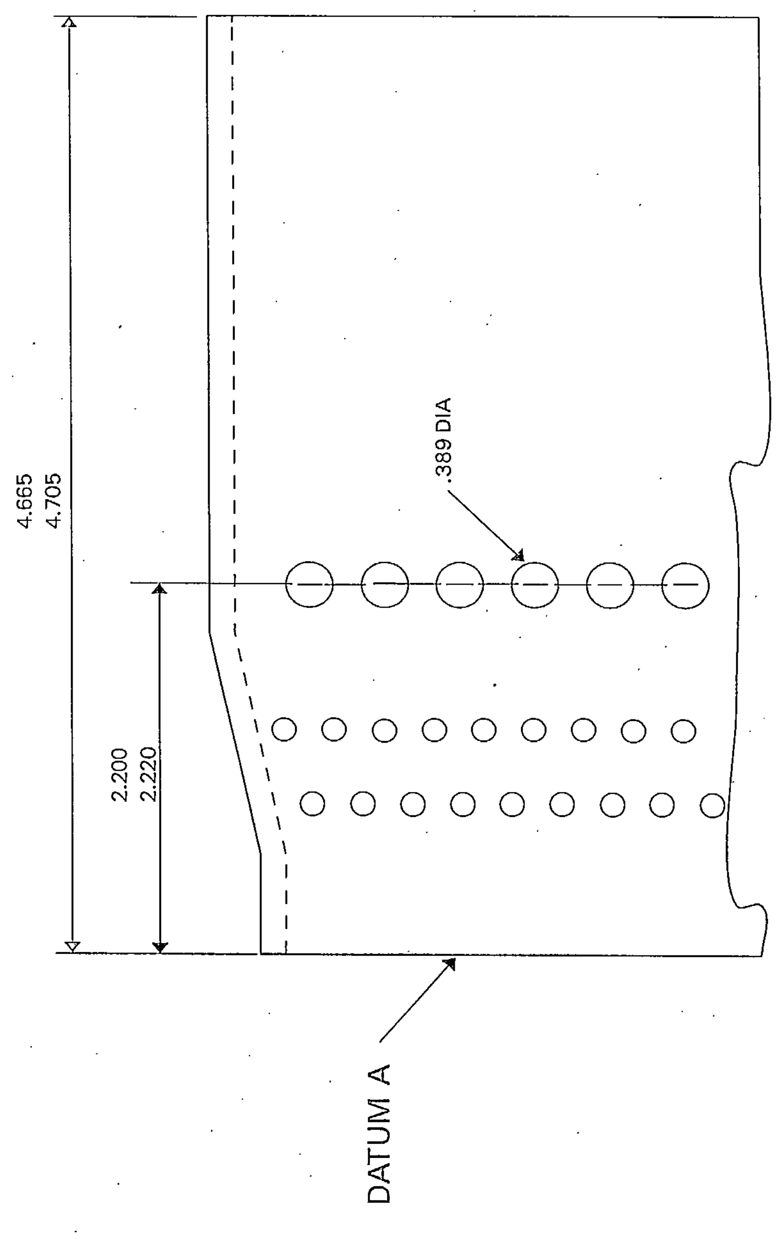


Figure 1
Location of Holes in Combustion Liner Outer Wrapper

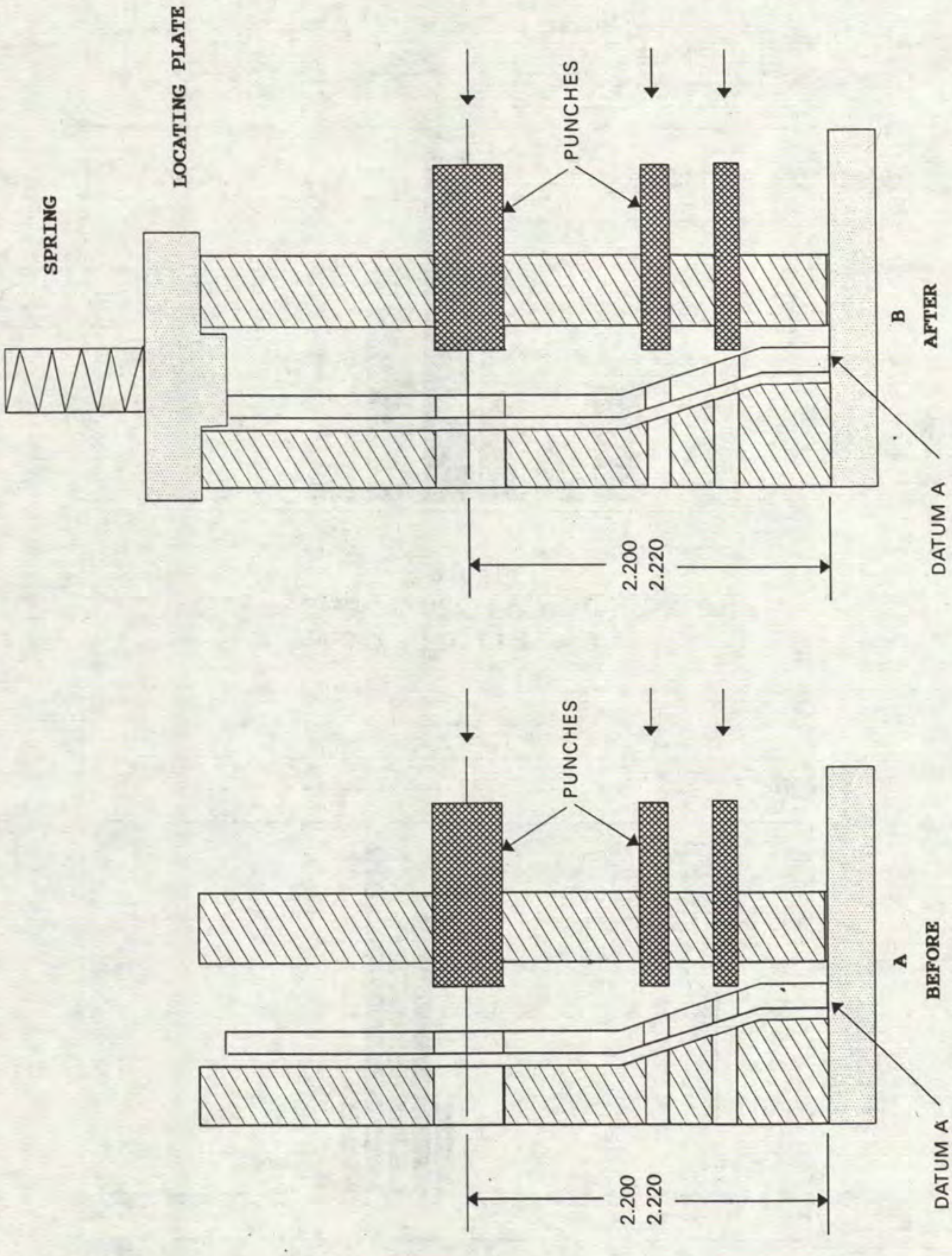


Figure 2
Part and Holding Fixture on Punch Press

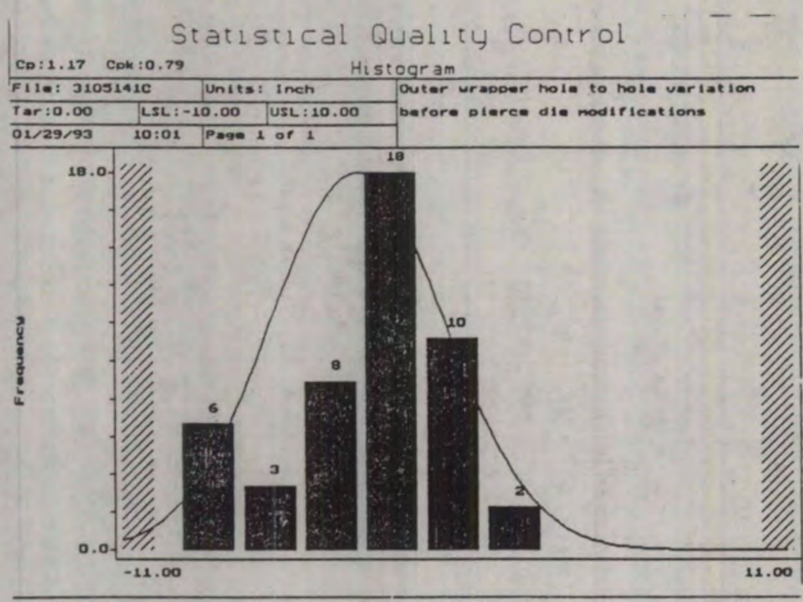


Figure 3
Initial Variation in 2.220/2.200 Dimension
$C_p = 1.17$ $C_{pk} = 0.79$

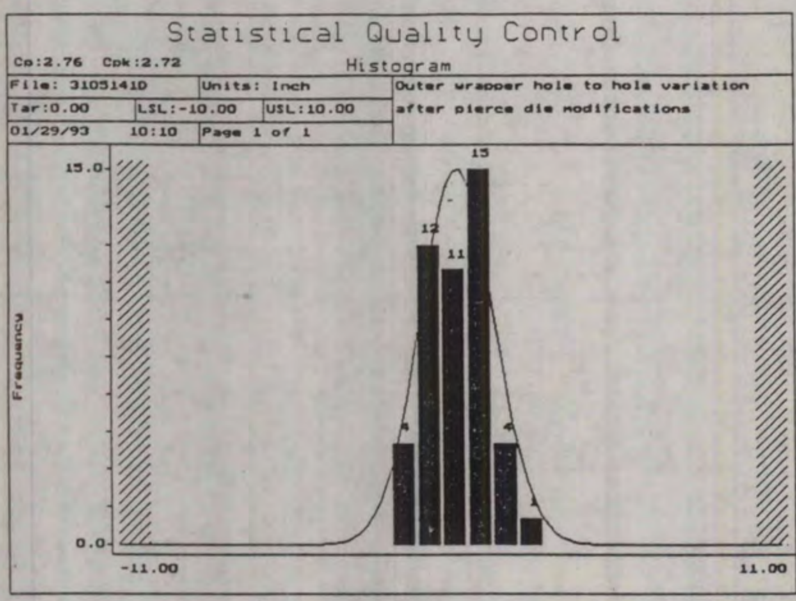


Figure 4
Hole to Hole Variation After Pierce Die Modification
$C_p = 2.76$ $C_{pk} = 2.72$

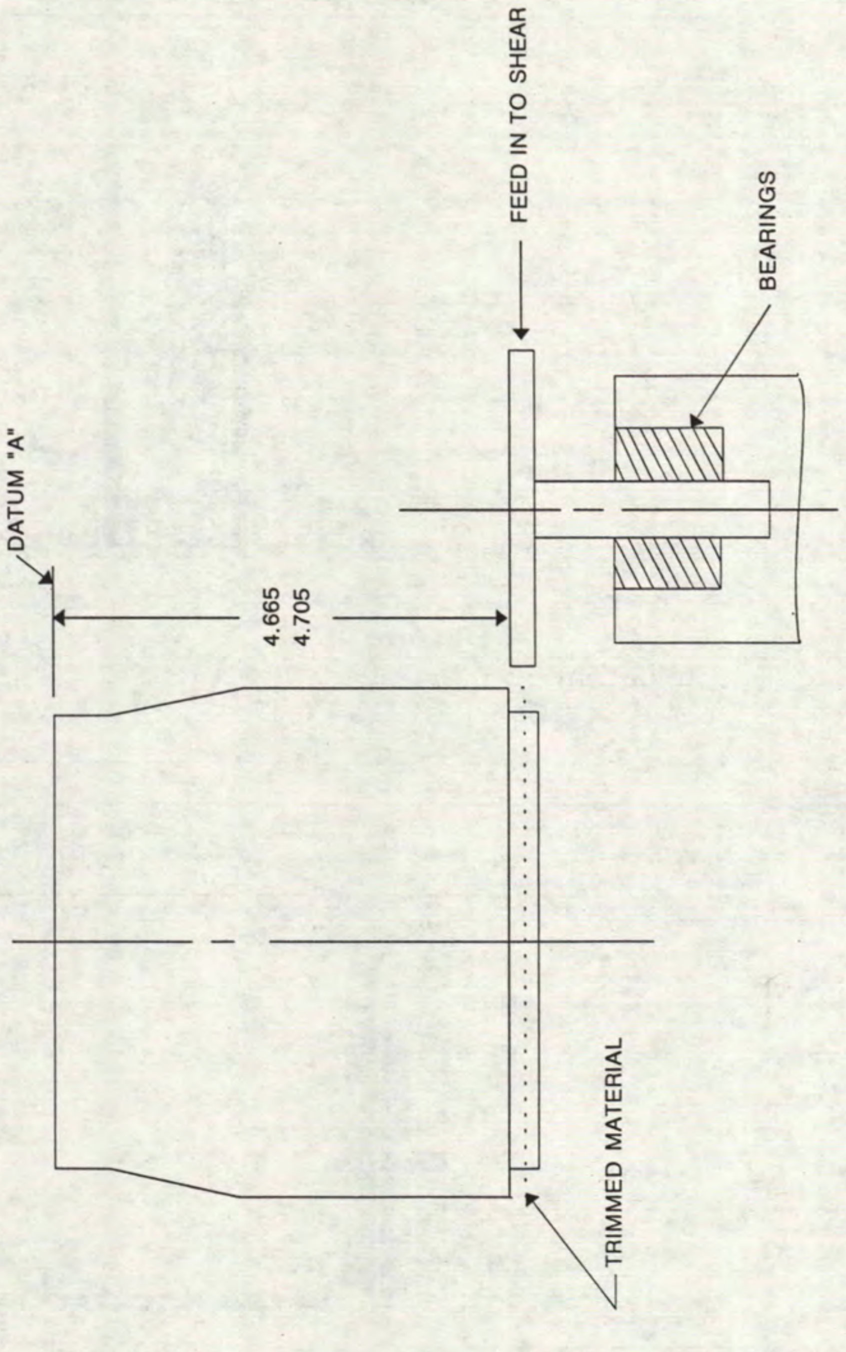


Figure 5
Configuration of Part and Cutter Head for Trimming Operation

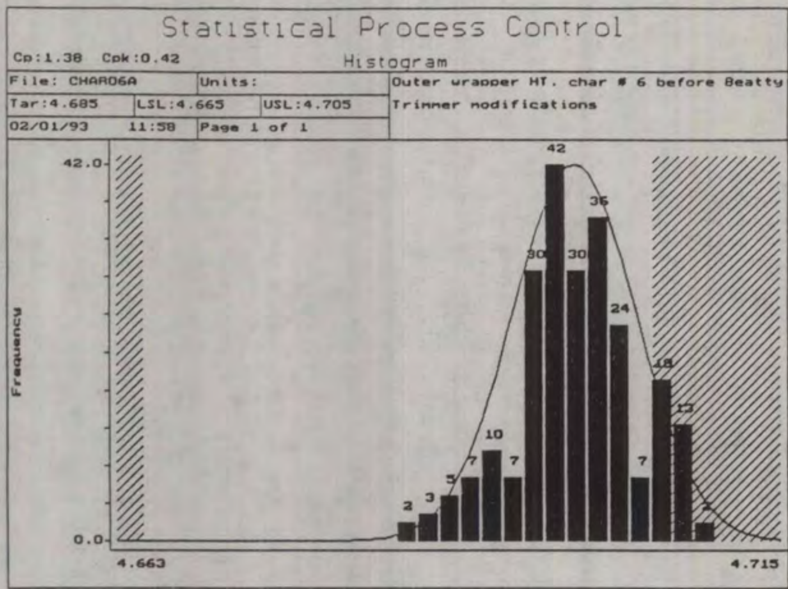


Figure 6
Initial Variation in Outer Wrapper Height
$C_p = 1.38$ $C_{pk} = 0.42$

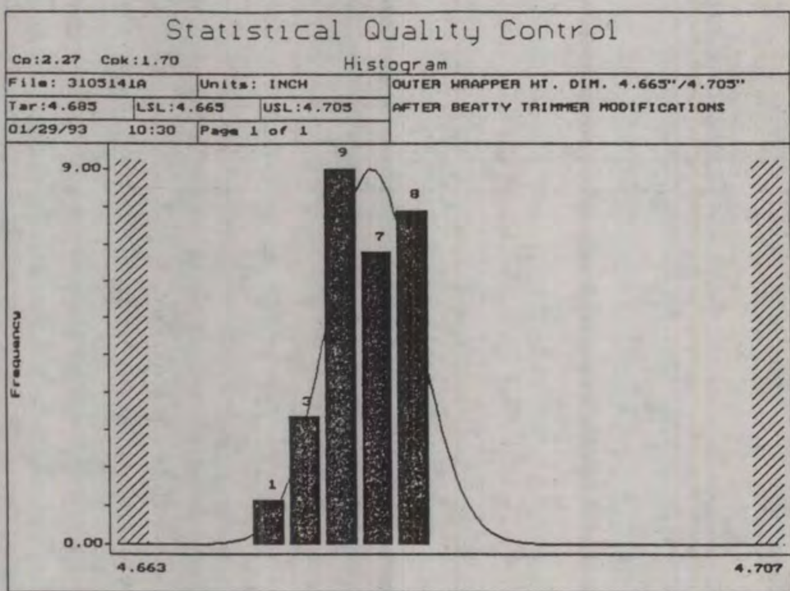


Figure 7
Outer Wrapper Height Variation After Trimmer Modification
$C_p = 2.257$ $C_{pk} = 1.698$

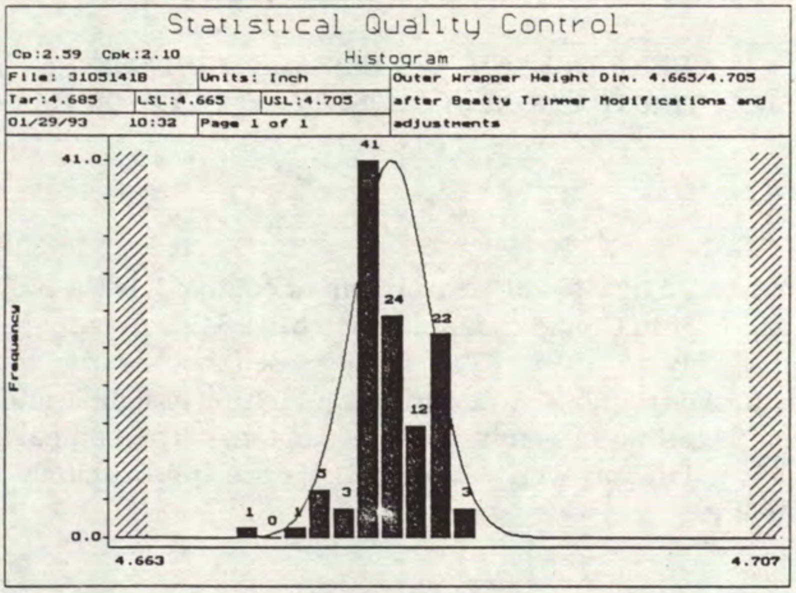


Figure 8
Outer Wrapper Height Variation After Further Adjustments
$C_p = 2.59 \quad C_{pk} = 2.10$

QUALITY - THE NON TRADITIONAL WAY

RÉNE DELAND AND ELIZABETH BUSSE
BELL HELICOPTER TEXTRON (A DIVISION OF TEXTRON CANADA LTD.)

Company Profile

Bell Helicopter Textron, a division of Textron Canada Limited, is the only fully integrated helicopter manufacturer in Canada. Established in 1984, the company inaugurated its Mirabel, Quebec facility in 1986. The facility itself houses the human resources, technology and materials required to design, manufacture, assemble and provide product support for a complete line of commercial helicopters. The company's international headquarters is located in Fort Worth, Texas. There are approximately 1 150 employees at our Mirabel facility.

Our Product Line

Bell Helicopter Textron manufactures five commercial helicopter models: the Jet Ranger 206B, a light, five-place, single engine aircraft; the Long Ranger 206L, a seven-place stretch version of the Jet Ranger; the Bell 212, a medium, fifteen-place, twin engine; and the Bell 412, a four blade version of the 212. In 1991, the company extended its product line by developing the Bell 230, a corporate, nine-place, twin engine aircraft. Worthwhile mentioning is that 60% of the helicopters flying in the world today are Bell products. Bell Helicopter Textron's reputation is built on the production of a high quality, safe and reliable product with an after-sales service second to none. In fact, the Jet Ranger is statistically the safest single engine aircraft flying today.

Company Mission and Management Philosophy

Bell Helicopter Textron's mission is to produce quality commercial helicopters and spare parts on schedule to meet customer requirements by utilizing a total team concept and a continuous improvement philosophy. The company's management philosophy supports this mission and is based on a non-traditional approach towards employee relations which includes teamwork, multi-skilling, participation in decision-making, effective communication and a dedication to continuous improvement at all levels of the organization.

Creation of Semi-Autonomous Work Teams

Bell Helicopter Textron wanted to start up its operations according to the "socio-technical" system by creating functional work teams grouped by production business units, that is, sub-sections of the total production process. The goal was to create an organization functioning with small, semi-autonomous teams, enhanced by integrated support systems to encourage employee participation, teamwork and a commitment to the fabrication of a high quality product.

In more concrete terms, employees, as part of these semi-autonomous teams, are responsible for and manage most of their own work. Team meetings occur on a daily basis to discuss supply, production or quality problems encountered the previous day and how these problems were or should be resolved. In addition, representatives from each of these teams meet weekly for a Business Meeting where common issues, relating to efficiency, productivity and quality, are discussed.

Where quality is concerned, all employees at Bell Helicopter Textron are involved. The role of quality assurance is therefore quite distinct:

- the inspector is part of the production team;
- the production employee completes and verifies his/her own work;
- when a problem occurs, the employee consults the inspector before submitting his/her work;
- the responsibility of the inspector is to monitor the work in process; and
- the inspector has the responsibility to recommend the immediate corrective measure to take.

Training — A Key to Our Success

At Bell Helicopter Textron, quality is **everyone's** responsibility. In order to build on this commitment to quality, the company invests heavily in the training and development of its employees. As part of the company's non-traditional philosophy, production employees are remunerated on a pay-for-knowledge basis: the more skills and knowledge acquired and mastered, the more the employee will be paid. Training is therefore an integral and essential part of this philosophy.

The majority of our manufacturing employees have participated in a three-day Team Building session. This program provides them with information on the concept of teamwork and the tools necessary to function effectively within a team environment.

When Bell Helicopter Textron opened its Mirabel facility in 1986, the company faced a significant challenge in finding skilled employees since there was a nationwide shortage of aircraft assemblers — a critical position in the production process. Bell therefore chose to invest in its employees and started a basic assembly techniques program to train employees to its particular needs and quality requirements. This program was a fourteen-week, intensive course consisting of eight weeks of theory and six weeks of practice.

As the company has matured, so has the level of ability and skills of its employees, but we continue to invest in the development of our workforce. For example, in 1992, a total of 50 000 person-hours of training were given during the course of the year. This training included advanced assembly courses to further increase the technical skills of our employees and improve the quality of our products.

Creation of the Corrective Action Centre

As part of its continuous efforts to improve the quality of its products, Bell Helicopter implemented the Corrective Action Centre in April 1992. This centre is made up of representatives from the engineering, manufacturing engineering, quality assurance, production and other departments, as required. Located in a central area in the plant, the group is easily accessible to manufacturing employees. The Corrective Action Centre's role is to identify the source of quality problems and coordinate efforts to immediately rectify them. This team approach has greatly improved the response and process times required to look at quality issues, e.g. reducing the time necessary to repair a non-conformity or to take the appropriate measures to ensure that the problem does not reoccur.

The Corrective Action Centre is also directly linked to Bell Helicopter Textron's external suppliers as well as its product support team. This interaction encourages a more direct and efficient communication process and ensures a more rapid response time to customer requirements.

Total Quality Results

Our management philosophy, based on open communication and participation, implementation of semi-autonomous work teams, major investments in training and the implementation of the Corrective Action Centre, has had a major impact on quality at Bell Helicopter Textron. Between 1990 and 1992, the Company was able to reduce the cost of non-conforming parts by 25% (see **Figure 1**). Much effort has also been put into developing a partnership with Bell Helicopter Textron's direct suppliers in order to contribute to the quality effort. Bell Helicopter's training courses have been offered directly to some suppliers on their own premises. Such endeavours have contributed to reducing the cost of non-conformity from our own suppliers by approximately 70% (see **Figure 2**).

Conclusion

What is quality at Bell Helicopter Textron Canada? It is the combination of the following elements:

- a firm and sincere commitment from management;
- open and honest communication at all levels;
- sharing of responsibility and decision-making authority with employees;
- careful appreciation of the expectations and requirements of the customer;
- team work; and
- training at all levels of the organization.

The key to Bell Helicopter Textron's success has been a Total Quality Management approach right from the start.

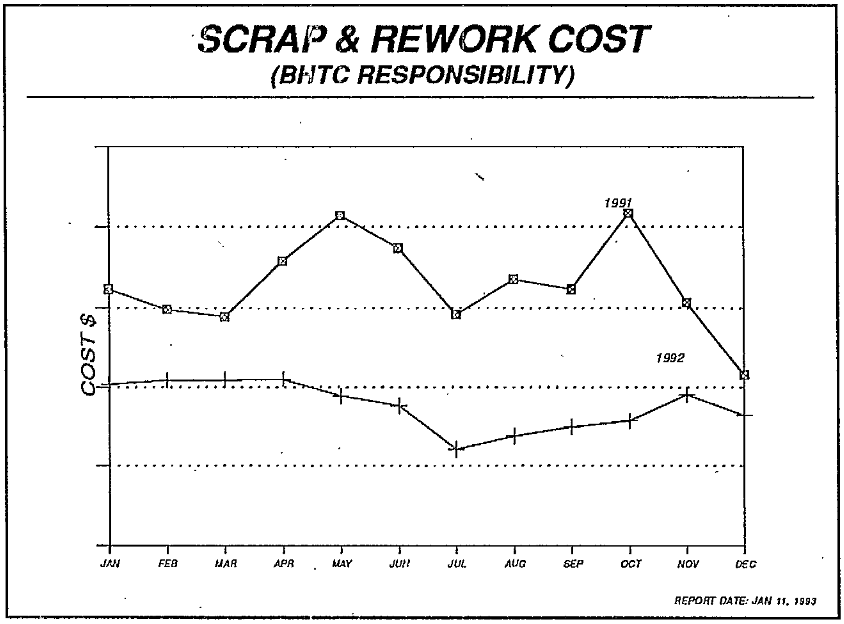


Figure 1

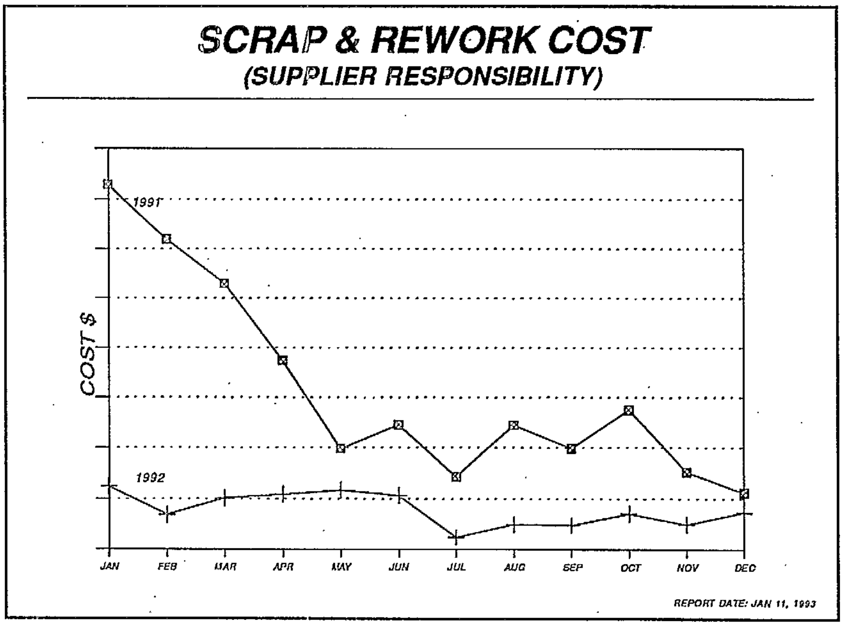


Figure 2

TEAMWORK IN THE DEVELOPMENT OF A ROBOTIC JOINT FOR SPACE STATION FREEDOM REMOTE MANIPULATOR SYSTEM

MAGUED ISKANDER
SPAR AEROSPACE LIMITED

Introduction

Spar Aerospace built the "Canadarm" remote manipulator for the NASA Space Shuttle and delivered four systems between April 1981 and March 1985. Three are still in service, one was destroyed in the Challenger accident.

The arm has been characterised by very highly reliable, trouble free operation. It has met all its design goals and surpassed all expectations of its versatility in dealing with unexpected requirements. The arm loosened a jammed solar panel array and freed a clogged waste-water vent by knocking off an icicle that might have endangered the shuttle on reentry. In addition, the arm rescued two drifting communications satellites from orbit and, with a "swatter" made of briefing manual covers, attempted to switch into action a satellite that had failed to go into its proper orbit. The Canadarm's most spectacular feat was the rescue and repair of "Solar Max," a $250 million solar observatory satellite.

Spar is now developing two manipulators for Space Station Freedom. This case study describes how Spar's Satellite Systems Division (SSD) in Ste-Anne de Bellevue, Quebec successfully employed Total Quality Management principles to manufacture, assemble and pre-test a highly complex robotic joint for that program. The robotic joint was produced "right the first time" in almost half the time initially planned.

The Challenge

SSD's sister division, the Advanced Technology Systems Group (ATSG) of Brampton, Ontario, requested us to build a prototype of the complex robotic joint used as part of the Space Station Freedom in much less time than we had thought possible. Since this was a new design, it would be the first time such a device were built, and several things could conceivably cause problems. For example, the high-precision mechanical elements or special tooling might not fit properly, or assembly procedures and plans might not be adequate and need modification as we went through the process. After all, the purpose of this prototype was to help us shake out any teething problems. And yet we were being challenged to assemble it in 3½ months, almost half of the originally planned duration.

An additional challenge was that parts for the joint were procured from companies across Canada in accordance with a regional distribution policy; from Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia.

The Response

Our response was to focus on the basics of Total Quality Management: make sure we know what the customer needs, plan properly, involve both the customer and suppliers, constantly monitor progress, encourage everyone on the team to participate actively, ensure open and immediate communications and do everything possible to "do it right the first time."

The project team was formed and went through, step-by-step, what needed to be done. A day-by-day plan was then established with all the members participating. The plan included three weeks allowance to deal with major reworks.

A launch meeting was held mid-March 1992. The goals were explained clearly: "*to deliver a robotic joint by early July 1992, one which meets all the technical requirements, and within the cost constraints.*"

We started on 23 March 1992. The detailed plan of daily events was posted, and we began a daily half-hour get-together to make sure everyone knew what was happening and how we would approach the day ahead. The meetings were held in a "War Room." Charts showing parts status were posted. Assignments were reviewed. Quality issues were addressed. Weekend and overtime work was planned ahead. Feedback was given to everyone. Each person on the twenty-member team had a clear role, though as time went on, team members helped each other out, irrespective of their basic skill or function. The team included representation from the customer and one major supplier (IMP of Nova Scotia).

We soon ran into the problems we had anticipated: shortages of parts, technical problems, design questions; in short, all of the typical events which slow the pace of progress in a first effort with new technology. This was where good communications, both within our team and with our customer and suppliers, paid off. We were jointly able to find work-around solutions. Problems were solved through special meetings with the relevant representation. Everyone participated, from managers through to assembly operators. Our customer and suppliers joined in the problem-solving process and in suggesting better ways of doing things.

By early April 1992 (about half way in the schedule) a "morale-booster" meeting was held to highlight the success to date and reinforce the team spirit. We kept focused on our efforts, and saw our level of energy and pro-activity build as our solutions led to success. We finished on 6 July 1992, right on time.

The Joint has since been completely tested and accepted by the customer. The key to success was the open communications, continuous feedback, parallel activities and the clarity of goals and expectations. These in turn created the team atmosphere, high level of commitment and positive attitudes.

The Canadarm

In 1974 Spar formally started work, under contract to the National Research Council of Canada, on a Remote Manipulator System for the U.S. Space Transportation System (the Space Shuttle). The system is comprised of a 50 foot long arm, an astronaut display and control work-station, and control electronics and software. To keep weight to an absolute minimum (it costs approximately $50 000 per pound to launch) the arm is incapable of supporting it's own weight on the ground but can be used to deploy and capture satellites with a mass up to 65 000 lbs, manoeuvre payloads for maintenance and assist the astronauts with a variety of tasks.

Spar was faced with a tremendous series of challenges in design and development. Not least of these was to provide evidence so that NASA, NRCC and ourselves could certify the system, which we couldn't fully test on the ground, as being fit and safe to fly. Consider the severe launch vibration shaking a cantilevered assembly which is just one inch away from the mission critical payload doors.

Well we did it! Through a massive teamwork exercise, we planned our engineering and our analyses, tests and simulations and then slowly and deliberately worked our way step by step until all was complete to everyone's entire satisfaction. Our team involved engineering, manufacturing and quality staff at NRCC and NASA, at three Spar divisions, CAE, DSMA and a number of companies in the U.S. from Little Rock to San Diego. Communication, empowerment (although it wasn't called that then) and productivity and continuous process improvement has all been key ingredients. We received NASA team awards for our efforts from both the Johnson Spaceflight Center in Houston and the Kennedy Space Center at Cape Canaveral.

The Canadarm, or SRMS in NASA acronymese, proudly displayed the Canadian flag to the world on its first mission in 1981 and has continued to do so ever since. After 12 years in service, every SRMS task has been successfully completed.

SELECTION OF FACILITATORS - A STRATEGIC PROCESS

STEVEN PETGRAVE
LITTON SYSTEMS CANADA LIMITED

Litton Systems Canada Limited is a Canadian company with over thirty successful years as a producer of highly sophisticated airborne, land-based and maritime electronic equipment. Litton's inertial guidance systems are used by approximately half of the world's intercontinental, commercial airlines as well as scientific, military and corporate aircraft. Other product lines include: self-contained flight inspection systems, automated test equipment for avionic systems, airborne search radar and flat panel displays. Litton Systems Canada Limited, a division of Litton Industries, currently employs over 1 200 scientists, engineers and technologists at its engineering and manufacturing facilities in Ontario and Nova Scotia.

In the fall of 1986, Litton Systems Canada began to experience world-wide competitive pressures at a level we had not been accustomed to. Our President, Thomas Mcguigan, expressed in an address to his employees that in order to survive as a company, we would have to be able to compete in the world marketplace. He also stated that it was apparent that our high technology market is putting three major demands on us as a company:

1. Our products and systems are getting more complex and sophisticated.

2. The quality and performance demands are becoming much more stringent every year.

3. We have to be able to deliver to the market faster and at a lower price than the competition.

Tom Mcguigan said, "These requirements will challenge us to use all our resources, knowledge and skills if we are to be successful. It will require everyone in the company to think about their job and how it can be done more efficiently and effectively."

As an organization, Litton Systems had grown significantly over the years, with increasingly more people and more buildings further apart. There was a feeling that we had lost some of the close communication of days gone by. We knew that this situation must be resolved in order to achieve the flow of new ideas, the early warning of problems, and the benefit of input from our employees who are directly responsible for production.

To resolve this situation, senior management recommended a solution called **Smarter Work Action Teams (SWAT)**. The concept itself was straightforward: Of the 40 hours in the standard work week, a compulsory one hour was assigned to participation in a team environment, to study specific work-related manufacturing problems or, as we like to refer to them, "opportunities for improvement." These teams were small by design: approximately 10 to 15 people, who shared reasonably common work activities. Problem-solving, meeting discipline and group participation training was provided to every team member. They were led by a team leader who received further training in conducting meetings, team-building processes and leadership skills.

The principal player in this participative style of management is the facilitator. These individuals are responsible for the ultimate development of the team, by providing team member and leadership training, supplying guidance and direction for the team and coaching support for the leader.

This brings us to the focal point of this study: selection of facilitators. At Litton, we realized that this process was one of the most important keys to success (along with management commitment and commitment to training) when instituting a participative style of management.

Characteristics of an effective facilitator

The facilitator's job has been described as being that of a change agent, responsible for transforming the organization from a set of individuals into a set of informed, well trained and mutually supportive teams. Facilitators must have the innate ability to replace tension with trust and disbelief with understanding, while providing the organization with a sense of common purpose. The individuals empowered with this responsibility must be trusted by the organization. They must possess first-class skills in group development, problem-solving, decision-making and communication.

We made a conscious effort to strategically select facilitators having the following characteristics:

1. Strongly committed to employee involvement and inspiring change;

2. Experience in working in teams and utilizing problem-solving techniques;

3. Organization behaviour, training design and development experience;

4. Strong verbal/written communication skills, including the ability and willingness to listen;

5. History of positive interaction with people while possessing the ability to handle conflict;

6. Potential for positively influencing and the ability to teach others;

7. Leadership qualities;

8. Credibility in the workplace – recognized by peers and/or management as having facilitator qualities; and

9. Willingness to take risks and make tough decisions.

Where to recruit facilitators: from within the organization or from outside?

When searching for facilitators, we had two options: we could recruit facilitators from within the organization or hire new employees specifically to be become full-time facilitators. Below, we discuss the factors which we considered in making this decision:

i) Selecting facilitators from within the organization:

Advantages: Employees who are currently in the organization may require more upfront training in facilitator skills, but these individuals know the company culture, which helps them to understand the inevitable barriers and consequences of planned change. In most cases, these individuals can get more accomplished because they know who to contact and how to "work the informal organization."

Disadvantages: In-house candidates can sometimes be blinded by the organizational culture, causing them to be negatively influenced by existing organizational biases. This is why it is important that the candidate be willing to take risks and instigate change.

A word of caution is important here: organizations have a tendency to select employees that they are not sure what to do with or that don't seem to fit anywhere else. This is a mistake. Select some of your best employees. This will send a strong message to everyone in the organization that you are serious about, and committed to, employee involvement.

ii) Selecting facilitators from outside the organization:

Advantages: Selecting external candidates provides you with the opportunity to add to your pool of in-house skills. Bringing in outside talent imports fresh ideas and new perspectives as to how things are accomplished in organizations. They can often see opportunities and flaws in the organization and its teams that an insider may miss. With previous experience in the field, they should be able to get up to speed quickly.

Disadvantages: The down side of hiring external candidates is the necessary progression up the learning curve. They will need some time to get to know the culture and the employees. On occasion, however, being naive can help them to be effective. In some instances, people will tend to open up to outsiders more easily because they do not have any previous history with the individual. However, for many employees, an outsider will be perceived as an unproven commodity until they prove themselves.

Given the advantages and disadvantages discussed above, its clear that the decision on whether to recruit facilitators from within or outside one's organization should take into consideration the organization's particular needs and circumstances. In our case, the decision was to recruit facilitators from within our organization.

Should facilitators be generalists or specialists?

At Litton Systems, we assumed, when staffing the facilitator positions, that generalists were best. Generalists tend to have a full complement of communication and group development skills. As the process developed and the number of teams began to grow, we considered hiring a few key specialists: individuals skilled in one area such as, training, statistical process control (SPC) or assessment, etc. These specialists could have been hired to provide skills that the generalists did not have or did not have time to concentrate on.

Our approach has been to develop our facilitator staff as broadly trained generalists. Our facilitators attended in-house seminars on SPC, provided by our resident expert, and attended university courses to develop their skills in areas such as: training & development, organization & management, human resource planning and organization design. Few organizations are fortunate enough to have people on staff with the ability to train facilitators in all the required areas. We found that a combination of in-house and external training was effective in providing facilitators with the required skill set.

The initial task assigned to newly trained facilitators was to train employees in problem-solving and teamwork skills. Once they received this training, employees were organized into teams to which facilitators were assigned.

We have found that each facilitator, when fully occupied, can handle between ten and fifteen teams. As the initiative has progressed, some facilitators have specialized in training.

Using the above approach, we have been able to successfully involve about 1 000 Litton employees in teams, with relatively little outside training assistance. Over the last five years, Litton's SWAT teams have made measurable improvements, including: productivity increases of 45 to 50%; inventory reduction of greater than 50%; product lead time improvements of from 27% to greater than 80%; and quality improvements of from 37 to 98%. The development of a capable in-house facilitator staff was crucial to achieving this success.

In conclusion, top management and individuals working with teams should continually be looking for team members who exhibit the potential to become future facilitators. Under no circumstances should the companies' leadership underestimate the critical importance of the facilitator's function and qualifications. To "make do" with less-than-capable facilitators, simply to avoid cost, is to undermine the change process from the start.

PROCESS IMPROVEMENT VIA SPC AND EMPLOYEE EMPOWERMENT

LARRY McHENRY AND LENNOX VAILLANCOURT
HALEY INDUSTRIES LIMITED

Haley Industries Limited, located in Renfrew, Ontario west of Ottawa, produces complex magnesium and aluminum aerospace castings for military and civilian fixed wing aircraft and helicopters. Haley is recognized as a world leader in the production of high grade, critical application castings whose quality and reliability are without question.

In an industry which continues to be decimated by reductions in military and commercial aircraft purchases, it is essential that Haley personnel maintain absolute control over the processes in which they work. This execution of process control was initiated by management in late 1990 through a partnership with the company's greatest asset, it's employees. Haley employees play a major role in our continuous improvement process, including the use of statistical process control (SPC) techniques to control and improve our processes.

In 1991, the TQM implementation team, composed of hourly and staff personnel, formulated a continuous improvement process plan based upon the earlier success of Haley's Health and Safety Committee. This committee, managed by unionized personnel, had successfully completed a plan to reduce lost time compensable accidents by 50%. Without such success, Haley would have been double assessed by workman's compensation due to the previous high incidence of accidents at the Haley facility.

Haley TQM principles include customer focus (both internal and external customers), quality, and continuous process improvement through employee empowerment. The TQM team developed and executed a seven-step process, shown below, to target our problem areas and eventually eliminate them. Particular emphasis was placed upon defective material reduction through process control application to key process variables.

Haley's seven-step process is outlined below.

Haley's Seven Step TQM Process

1. Assess - Utilize Pareto principles to segregate the largest problems from the trivial many.

2. Organize - Target largest to smallest categories and solicit help from employees and staff.

3. Plan - TQM committee and management develop a corporate plan for quality improvement.

4. Educate - Provide extensive training in problem-solving, team dynamics and statistical methods.

5. Involve - Organize natural work cells and self-directed work-teams. Eliminate unnecessary supervision.

6. Execute - Allow teams to utilize the seven-step process and advanced quality tools to improve target areas.

7. Review - Analyze success areas and failures and initiate the seven-step process again.

Using the above seven-step process, Haley organized process improvement teams and natural work teams in the manufacturing and engineering sectors. A combination of hourly and staff personnel worked cohesively to improve key process variables in areas of metal processing, refractory control assembly, test and finishing. Industrial problem-solving (brainstorming) and SPC methods provided the tools to improve these processes and to reduce defective material rates.

The successes achieved by these groups have removed barriers between staff, hourly and management employees, and have helped achieve an overall reduction in the rejection rate by 30% since 1991. Our facility continues to see improvement in the critical process areas with the majority now running in statistical control and exhibiting process capabilities in excess of 1.33. Areas lower than 1.33 are still under examination.

The astounding success of our work cells has prompted Haley management to eliminate supervisory tasks in several key areas where work teams have been achieving great gains without the need for constant supervision. Furthermore, Haley's internal customer – supplier relationships have been substantially improved via communication, cross training and involvement between work teams.

In December of 1991, Haley's efforts in the areas of Advanced Quality systems and teamwork resulted in D1-9000 approval from Boeing Commercial Airplane Company. The D1-9000 approval recognizes Haley's efforts and allows our facility to engage in production of structural castings for the 777 program, as well as meeting D1-9000 flowdown requirements from numerous Boeing sub-contractors.

The principles of our TQM process will continue to chart Haley's course through the treacherous business climate which all aerospace companies are now experiencing. To re-state our commitment: **we will continue to grow and challenge our employees in an effort to maintain a process of continuous improvement**.

GAINING A COMPETITIVE ADVANTAGE THROUGH BUSINESS PROCESS REDESIGN

BRIAN J. LANOWAY *

STANDARD AERO LIMITED

Introduction

Standard Aero is the largest independent aviation gas turbine repair and overhaul facility in Canada. The company has 630 employees at its Winnipeg location and also operates remote sales and service centres throughout North America and Europe.

In 1989, Standard Aero undertook a competitive initiative known as its World Best Project. The initiative was first applied to our largest business unit, the T56 engine line. Over the next three years, this was followed by subsequent redesigns of our component remanufacturing facility, computer systems and Allison 250 helicopter engine line. Since May, 1990, Standard Aero has implemented 17 production cells, 3 material handling cells and 3 support or office cells. These redesigns represent an investment of over $9.4 million for capital additions, internal expenses and external consulting fees.

During this initiative, we utilized the training and on-site support services of Lucas Engineering and Systems (LE&S), whose systems redesign methodology has proven capable of handling the wide variety of design situations that we have encountered.

The Redesign Process

To prepare for the business process redesign, company management received training from LE&S. A T56 redesign Task Force, including full-time team members from engineering, the shop-floor, accounting and management, was then formed. Part-time members, who would serve as gateways to various support areas, were also identified and trained. The project was launched immediately after training.

In order to understand our current performance in the T56 repair and overhaul marketplace, a baseline analysis was conducted. Over a two-week period, task force members visited 16 current, past and potential customers from Anchorage to Miami.

* *currently with Motor Coach Industries*

During these visits, customers were asked to rate Standard Aero on: quality, price, turn time, customer support, customs/traffic, engineering support and rework innovation. The ratings included comparisons with customers' needs and competitors' performance, resulting in a wealth of information on our perceived strengths and weaknesses. Analysis of the results led to a series of targets for the T56 redesign, based on the following strategy:

While maintaining existing quality and with a decrease in price, Standard Aero will endeavour to produce turn times 50% better than our best competition.

The next step was a detailed analysis of existing work flow and component travel, including: 1) the roles of all relevant departments; 2) machines and processes used; 3) common characteristics of all components; and 4) functional performance. The results provided a clear definition of the inputs required to produce a T56 engine repair or overhaul and served as a basis for future comparisons.

The Task Force identified non value-added activities and waste that could be eliminated, and determined that several functions provided by central support areas should be decentralized. These functions were combined into team-based natural groupings, or cells, to provide maximum process ownership and minimal waste.

Details of the redesign, including personnel, equipment and process requirements, were then worked out, based on current average workloads and those forecast over the next three years (using information received during the customer visits). Potential bottlenecks were pinpointed and the design was stressed to determine how robust it would be under real world workload variations. The output was a detailed cell lay-out, with a list of assignments, control systems, performance measures, training needs and capital equipment. This process was repeated for each cell to redesign the entire T56 engine line.

Sophisticated production planning and control systems were essential to achieving the proposed improvements. Before the redesign, our control systems were a combination of manual and computerized MRPII systems, neither of which provided the coordination and control required for the targeted turn times. To resolve this, a Control Systems Project Team was formed to refine our existing systems and integrate them fully with cell operations. Emphasis was placed on the shared production areas: component repair and engine test, where choreography was critical to achieving the redesign turn time targets.

The Management of Change

Early in the T56 redesign, we realized that successful implementation requires much more than a comprehensive design. A good design will fail if it isn't followed by a well-coordinated construction process, an intensive period of post-implementation support and finally, some means of driving the design toward improved performance – the goal of the redesign process.

Standard Aero's organizational structure was ill-equipped to manage the cross-functional redesign process, therefore, a change management structure was created which featured: 1) a "Change Council" (composed of senior managers); 2) a full-time Change Program Manager (reporting to the Change Council); and 3) several Task Force Leaders (reporting to the Change Program Manager). The Change Council met weekly and was responsible for allocating resources required by the redesign initiative. The Change Program Manager was responsible for managing day-to-day operations and maintaining momentum.

Standard Aero learned that it was necessary to maintain a clear distinction between regular operations and the redesign initiative – primarily to keep the enthusiasm of the latter from overwhelming our normal business. Each task force was, therefore, governed by detailed terms of reference and a comprehensive "sign-off" process.

Redesign Approval and Implementation

The restructuring process included three major milestones:

a) **Design Launch:** presentation by the Task Force of the design plan and resource requirements to the Change Council. This publicly committed the Task Force to the plan and prevented management misconceptions about the results.

b) **Interim Design Review:** provided a detailed examination of progress at the half-way point as well as educating the business unit manager in the redesign process – the result of which he or she would eventually assume ownership of.

c) **Final Design Review:** a detailed review to prove the design prior to its presentation to senior management. Final approval did not occur at the management presentation, but at a subsequent presentation to the Change Council of the implementation plan and budget.

Once approved, cell implementation was handled on a "turnkey" basis by a multi-disciplinary Facilities Team. This team was only released from its responsibility once the cell was commissioned. A detailed sign-off was used to ensure that equipment was functional and calibrated and that all basic systems, such as inner-cell control systems and measures of performance, were in place.

Post-Implementation Support of the Redesign

Once the cell was commissioned, its ownership reverted back to the redesign Task Force Leader, until it was mature enough to be handed over to operations. Post-implementation support was carried out by a Cell Implementer, who completed the design details and trained cell members. Additional training was provided by a full-time trainer, assigned to the cell for 4 to 6 weeks, and through a training seminar and tours of existing cells.

The post-implementation support process was driven by an Implementation Audit that was designed to ensure that the final result matched the original design intent. When a 60% audit score was reached, ownership of the cell passed to Operations.

Driving the Redesign Toward Improved Performance

The Implementation Audit ensured that the cell design intent was carried out – that the systems were in place and operational. It did not, however, drive the cell toward the ultimate objective of the redesign: improved performance. To provide this incentive, the Change Council developed an Operations Audit to: 1) trigger continuous improvement; 2) document improvements; and 3) maintain the standards set by the Implementation Audit. Besides tracking improvements in cell performance, the operations audit tries to focus the cell on where these improvements are likely to come from.

Conclusion

Standard Aero has found that a successful business restructuring process entails not only a comprehensive design process, but the development of systems and allocation of resources to support the redesign until the intended performance improvements are actually achieved. Some "lessons learned" during the redesign process are summarized below:

1. Top management support is essential.

2. A thorough design process alone does not guarantee success.
3. Traditional business structures are ill-equipped to handle the magnitude of change involved in process redesign.
4. Implementation and post-implementation support can result in a significant drain on company resources.
5. The post-implementation audit process is crucial to achieving success.
6. Success is directly proportional to the degree of involvement of cell members.

Despite these "lessons learned," the results achieved have made the redesign process more than worthwhile. The cellular design has resulted in drastically simplified work flow, clear ownership of work processes and benefits from a team approach to continuous improvement. The cells implemented to date have demonstrated a "step change" in performance, achieving remarkable improvements in cycle time and due date compliance. The ultimate measure of the success has been the high return on investment – **with payback occurring in less than two years.**

IMPLEMENTING AN IMPROVEMENT METHODOLOGY

PETER HOLT
PARAMAX SYSTEMS CANADA INC.

Paramax Systems Canada's primary activity is systems management – an intricate science involving the design, integration and testing of complex, computer-based electronic systems. Established in 1982, the company has locations in Montreal, Winnipeg and Ottawa and a workforce of approximately 1 500. This case study describes Paramax Systems Canada's experience within the Unisys Group in implementing an improvement methodology based on national awards criteria.

Building in the basics and maximizing your chances of success

The need for new ways of improving overall business performance is well recognized and ever present. Translating the need into a successful and well planned improvement program, however, is a challenge that few organizations manage well and most fail to address at all. The challenge that must be met is how to plan and implement a sustained improvement program.

To start quickly, and to maintain the organization's enthusiasm and momentum, it is essential that the program is not developed in an "ad hoc" manner. The program must be able to be understood and communicated to all levels of the organization and must have clear objectives right from the start. It must also be credible, consistent and maintainable. Quite a challenge.

In 1988, Paramax's parent corporation, Unisys, looked for a program that could be "seeded" in the whole organization and would improve everything the organization did. This program also had to help the whole organization work together. Unisys decided to adopt a quality program based on a common quality improvement methodology. The difficult decisions concerned, of course, how much to invest in the program, how to make it credible and how to maintain it. Consultant-generated programs had merit and often appeared to offer a quick fix. National initiatives sometimes appeared to be more for the benefit of government than industry. The following describes some of the background and the key decisions that have lead Unisys, and particularly Paramax Systems Canada, to believe in the use of a structured improvement methodology.

Unisys decided to adopt an improvement methodology in 1988 and, with the help of consultants, developed a client-oriented Total Quality process. This process was deployed throughout the corporation during 1989 and 1990. In March 1991, Jim Unruh, Unisys Chairman and CEO, instigated the Unisys Chairman's Total Quality Award (UCTQA), as part of an overall strategy to obtain world-class levels of quality and customer satisfaction. The UCTQA is derived from the United States' Malcolm Baldrige National Quality Award (MBNQA). (See Note at end of article.)

The combination of a well defined Total Quality process and the Award Criteria further lead to increased co-operation between internal Unisys sites and, in 1992, fostered the development of a "UCTQA Best Practices Symposium" where different sites shared their best ideas and methods of implementation with other sites. The UCTQA was first awarded in 1992. The site that won the award was selected by Unisys to submit an application for the 1993 MBNQA and has been selected as a finalist – a very unusual honour for a first-time applicant. Whether the Unisys site will be a Baldrige Award recipient is as yet unknown, but the indications that we are achieving some of our goals are unquestionable.

Unisys – The Key Decisions and Events

- 1988 - Unisys develops a common approach to Total Quality.
- 1989/90 - The common approach is taught to all operating units.
- 1989 - Units implement the approach themselves.
- 1991 - UCTQA criteria developed and deployed.
- 1991 - No applicant meets the exacting standards of the award. No winner from 19 applicants.
- 1992 - First Best Practices Symposium.
- 1992 - Paramax Space Systems (Houston) declared the winner from 42 applicants.
- 1992 - Corporate Benchmarking Initiative.
- 1993 - Best Practices Symposium allows high performing organizations to share their successful practices with other sites.
- 1993 - Malcolm Baldrige NQA finalist, increased participation in the UCTQA, further Best Practices Symposium, increase in benchmarking with other organizations.

The Hidden Benefits – Hindsight

- The common approach continues to be deployed consistently throughout the organization. This is a powerful message to the whole workforce.

- By utilizing the nationally controlled MBNQA criteria in the UCTQA, the rules of the game were credible and "tamper-proof." Linking the UCTQA process to the changes in the MBNQA dramatically reduced the cost of the whole UCTQA process.
- Employees were willing to invest their time in understanding improvement concepts and ideas that were tied to consistent and credible criteria. They could also read about the criteria in professional journals and in national publications.
- Sceptics were reassured from the fact that senior management were not in control of the criteria but instead are themselves being influenced by it.
- Specific corporate-wide initiatives, such as adoption of the Software Engineering Institute's Capability Maturity Model and associated work with the Canadian Applied Software Engineering Centre, have benefited greatly from Paramax's knowledge of the fundamental principles of Total Quality.
- The organization has learned to communicate using the common values and language of the criteria.

The Hidden Challenges – Hindsight

- The organization must be focused on those parts of the criteria that are important to their business goals.
- Improvement objectives must be relevant, clear and well communicated. Changes often take longer than anticipated. Persistence pays off. Never give in before reaching the objective.
- Improvement methodologies have a significant subjective element in the assessment process. Organizations that are geared to the objective measurement of everything may not gain the full benefits.

Organizations can rarely meet the requirements of the criteria quickly. It may take years, depending on the cycle times. It is important to communicate progress against the criteria and overall goal without embarking on unachievable levels of improvement.

What effect has this approach had in Paramax Systems Canada?

As in all quality programs, "the jury is out." However there are some clear benefits in a number of unexpected areas. I have listed the ones that are most important to the current success of the program here in Canada, below. There are many others.

- Substantial savings have been achieved by small groups applying the methodology to basic activities.

- The approach to training throughout the organization has become more consistent.
- The organization carried out three self-assessments by submitting applications for the Unisys Chairman's Total Quality Award (1991 & 1992) and the Canada Awards for Business Excellence (1992 only).
- Addressing the model's criteria and writing the application proved to be one of the best practical training exercises undertaken to date.
- The organization, including the senior managers, believe the model is credible. This is continuously reinforced by the Leadership.
- We've discovered we have measurements that are able to be compared with other organizations using the same model. Other organizations are also able to help us much more easily.
- The individuals who participate closely in the self-assessment against the model gain in confidence and begin to take leading roles on improvement issues.

There were also some unexpected disappointments:

- It has taken longer than we expected to measure improvements.
- The details of the UCTQA feedback report received from the award examiners were not easily sold to all senior and middle management.

The choice of the MBNQA criteria was driven by the Unisys initiative. Other national quality awards have many characteristics similar to the MBNQA. The advantages of using national awards include: 1) cost of maintaining the criteria are borne by an outside organization; and 2) the publicity generated by such awards help to increase interest.

Many of the Unisys sites that have applied the criteria to their operations are small organizations of 50 or 100 people. The benefits do not appear to be limited to large organizations.

> **NOTE:** Responsibility for **the Malcolm Baldrige National Quality Award** (MBNQA) rests with the United States Department of Commerce which manages the program through the National Institute of Standards and Technology (NIST). The American Society for Quality Control (ASQC) assists in the administration of the program. MBNQA publishes an updated Award Criteria document each year, reflecting changes in global business conditions and technology. Unisys flows these changes into it's own UCTQA so that the approaches used accurately reflect current business factors.

SPC DRAMATICALLY IMPROVES SUPPLIER'S PERFORMANCE

BILL BECKETT
PRATT & WHITNEY CANADA

Pratt & Whitney Canada, a subsidiary of United Technologies Corporation, is the world's leading manufacturer of small gas turbine engines for the general aviation and regional/commuter markets. Known for their outstanding reliability, P&WC engines have accumulated nearly 215 million flying hours on some 17 000 aircraft in 150 countries around the world.

Since the quality of P&WC engines depends in large part on the quality of their parts, the company works very closely with its 330 parts suppliers to ensure that its exacting standards are maintained. The example below, involving Sider-Tech, of Longueil, Quebec, demonstrates how collaboration between P&WC and its suppliers promotes and enhances product quality. Sider-Tech manufactures mechanical parts for most Pratt & Whitney Canada (P&WC) engine models.

P&WC has adopted a number of strategies under the Total Quality Management (TQM) umbrella over the past few years to improve the quality of its products and enhance its competitive position in the increasingly global marketplace. One such strategy, Integrated Product Development (IPD), requires the cooperation of several departments within the company — and of the company's suppliers — in the development of products and processes.

To get its suppliers involved in implementing TQM techniques, P&WC has encouraged them to begin introducing Statistical Process Control (SPC). Sider-Tech adopted SPC after receiving a letter from P&WC's Materials & Procurement organization in June, 1992. The letter introduced a new specification requiring the implementation of **Process Control** by all the company's producers (including its own manufacturing units) in order to improve product quality and eliminate deviations. "It is essential that we work together in a spirit of partnership and focus on customer satisfaction if we are to survive the challenges posed by competitors.", said the letter.

The key elements of P&WC's Process Control are:

- mapping the selected process;
- identifying the key characteristics of the product and process; and

- controlling the key characteristics (particularly by using SPC).

Sider-Tech responded quickly to P&WC's invitation. By late August, it had chosen the parts to be used for an SPC pilot project, based on two criteria:

1. The parts were from repetitive orders consisting of several different batches, enabling comparisons to be made from one batch to another.

2. The parts received a non-acceptable quality rating from P&WC during the first eight months of 1992.

In September, Sider-Tech appointed one of its employees, Guy Plouffe, as SPC Coordinator. Guy was trained in SPC techniques during a three-day seminar organized by P&WC for its suppliers. He subsequently trained all the Sider-Tech employees who are involved in product manufacturing.

Sider-Tech also purchased two personal computers to help employees collect and monitor data for the SPC project. In consultation with Jean-Pierre Camus of P&WC's Procurement Quality Control organization, the supplier also prepared an SPC Procedures Manual that documents the standard methods and techniques used at Sider-Tech.

Within months of adopting Process Control, Sider-Tech posted significant improvements in the level of non-conformance of its products. As shown on the accompanying chart, the relative reduction in defects at production was dramatic. From a relative level of 1.0 for the five months before SPC was implemented, the defects index dropped to just .25 for April 1993.

The success of its pilot project and the enthusiasm of its employees have prompted Sider-Tech to begin implementing SPC techniques on all its other parts. "We expect a major improvement," notes Guy, with less rework, fewer rejects, and a reduced need for corrective actions -- "all of which", points out P&WC's Jean-Pierre Camus, "has already made this supplier more competitive".

Sider-Tech's next step, Guy says, is to calculate the cost of rework, rejects, and scrap in order to evaluate the real benefit of SPC. "In the future," he adds, "we will target the most costly problems to be solved by SPC."

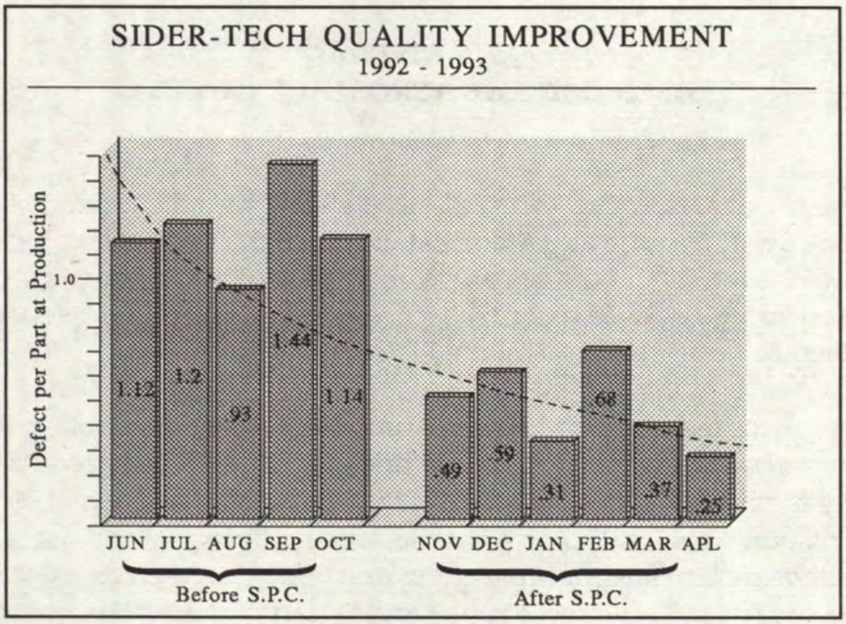

SIDER-TECH QUALITY IMPROVEMENT
1992 - 1993
Defect per Part at Production
1.0
1.12
1.2
.93
1.44
1.14
.49
.59
.31
.68
.37
.25
JUN JUL AUG SEP OCT
NOV DEC JAN FEB MAR APL
Before S.P.C.
After S.P.C.

Figure 1

THE TOTAL QUALITY TEAM APPROACH TO CUSTOMER SATISFACTION

KEN KIVENKO
ALLIEDSIGNAL AEROSPACE CANADA

AlliedSignal Aerospace Canada (ASACa), a division of AlliedSignal Aerospace, with production facilities in Toronto and Montreal, is one of the world's leading manufacturers of aircraft control systems. Our products include electronic temperature and engine bleed air controllers, window heat controllers, temperature and flow sensors, engine fuel controls and electro optics (night vision goggles).

ASACa Toronto has manufactured a Pneumatic System Controller (PSC), used on A300/A310 commercial aircraft, for two decades. Although the product was reliable, it was excessively labour intensive to build (early '70s design) and expensive. In 1991, we entered into discussions with Aerospatiale, the world's second largest commercial airplane manufacturer, regarding upgrading and reducing the cost of the existing PSC. Aerospatiale is located in Toulouse, France and is part of the Airbus consortium. It is an aggressive, fast-paced, global company which has adopted Just-In-Time procedures and is extremely cost-conscious.

In late 1991, ASACa and Aerospatiale agreed to an Engineering Change Proposal (ECP) for the PSC, and a Process Improvement Team was formed. In line with the AlliedSignal Vision, Commitment and Values, team members undertook the project with the following key considerations in mind: 1) Customer Satisfaction; 2) Speed; 3) Teamwork; and 4) Innovation.

Customer satisfaction would be increased by: reduced price, weight and lead time; improved reliability; a single configuration, instead of two, for use with two different aircraft engines (General Electric and Pratt & Whitney); and enhanced engineering features such as: enhanced system fault detection, user friendly display and closed box software download capability.

Once the team had accepted this major responsibility, it did not take long for them to realize that there were some significant barriers to overcome:

1. This was the first design and development program undertaken with Aerospatiale since the 1970s for ASACa – there was a need to quickly establish a closer working relationship.

2. Language and geographical distance barriers had to be overcome.

3. An 18-month schedule had to be compressed to 12 months.

4. Specifications for the new PSC were demanding: it had to interface with the older technology components without compromising requirements, and be interchangeable with configurations of the old PSC.

The project involved full utilization of AlliedSignal's Process Improvement/Problem Solving (PIPS) model, based on the following steps: 1) Identify Opportunities; 2) Form Team and Scope Project; 3) Analyze Current Process; 4) Define Desired Outcome for Improved Process; 5) Identify Root Causes and Proposed Solutions; 6) Prioritize, Plan and Test Proposed Solutions; and 7) Measure Progress and Hold Gains.

Essential to the strategy was the principle that the customer was the key team member and should be involved in all phases of the project. Effective communications were established through a single point of contact with the customer's engineering department. Needless to say, choosing the right person from the customer's organization was important. Most of the work was undertaken at ASACa, however, key meetings and tests were conducted at the customer's Toulouse facilities.

Members of the team received training in Total Quality methods, which were applied during the project. These included: Flow Charting, Pareto Charts, Cause and Effect Diagrams, Brainstorming and Force Field Analysis.

The project was completed on time, culminating with successful ground and flight tests in November, 1992. The first production delivery followed in January 1993.

Some notable "firsts" were achieved during this project. For example, the new PSC passed burn-in and Qualification tests the first time. New software test methods, using the VXI Station (PC based automatic reconfigurable test station), were used. The new PSC meets the Joint Airworthiness Authority (JAA) lightning specification, which is the most severe ever imposed on ASACa.

The results achieved by the Process Improvement Team went beyond customer satisfaction to include customer delight. These results included: a 35% price reduction; 33% weight reduction (from 15 to 10 pounds); 150% increased reliability (mean time between failures increased from 10 000 hours to 25 000 hours); development lead time reduced by 33% (from 18 to 12 months), production lead time reduced by 45% (from 48 to 26 weeks); and number of configurations reduced from two to one.

Aerospatiale is now receiving a lower priced, lighter weight PSC. In turn, ASACa has secured its future position as supplier of PSCs for the A300/A310 and has drastically reduced the factory build time. The new design also eliminated a major problem of procuring certain components of the old design which were becoming obsolete. This was a "Win-Win" program for both companies.

Chapter 11

FAMOUS NAMES IN TOTAL QUALITY MANAGEMENT

This chapter discusses some of the most well known experts on Total Quality Management. In particular, W. Edwards Deming, Joseph M. Juran and Philip B. Crosby are generally recognized as the Big Three in Total Quality in North America. Their approaches to TQM, and those of other high profile quality experts, differ to some extent but have much in common. For example, they all place a high importance on: 1) focus on the customer; 2) management leadership and commitment; 3) employee involvement; and 4) continuous improvement. (Shown in Figure 1 of Chapter 1, as four "Pillars of Quality.")

Below, we briefly outline the major TQM contributions and ideas of some of the most well known TQM experts.

W. Edwards Deming, the world's best known "quality guru," was born in 1900 and grew up on a farm in Wyoming. Deming was introduced to statistical methods in quality control by Walter Shewhart (of Bell Labs) while working at the U.S. Department of Agriculture. He taught statistical quality control to companies involved in the Allied war effort during the Second World War. This approach served the Allies well during the war but was pretty much ignored in North America following the war.

Deming is credited with pioneering TQM in the late 1940s and early 1950s. In 1947, he was asked by General Douglas MacArthur to help Japan prepare for the 1951 census. While in Japan, he gave a series of lectures on statistical methods to Japanese industry leaders and advocated their use, as well as other aspects of what we now call TQM. They apparently listened to what he had to say, and the rest is history.

Some experts disagree on the magnitude of Deming's role in helping the Japanese adopt TQM. They maintain that it's not clear to what extent he was providing new information or reinforcing a change which had already begun. Nevertheless, Deming is held in very high regard by Japanese industry. The prestigious Deming Prize is awarded annually by the Japanese Union of Scientists and Engineers (JUSE) to companies and individuals that have achieved excellence in quality.

Deming was relatively unknown in North America until 1980 when the broadcast of a television documentary entitled: "If Japan can, Why Can't We?" initiated a rapid rise in his notoriety. He has since been a consultant to some of North America's largest and most dynamic corporations.

Deming's 14 point program for managing productivity and quality is set forth in detail in his book, *Out of the Crisis* (MIT Press, 1966). The 14 points are summarized below:

1. Create constancy of purpose for improvement of products and service.

2. Adopt the new philosophy.

3. Cease dependence on inspection to achieve quality.

4. End the practice of awarding business on the basis of price tag alone. Instead, minimize total cost by working with a single supplier.

5. Improve, constantly and forever, every process for planning, production and service.

6. Institute training on the job.

7. Adopt and institute leadership.

8. Drive out fear.

9. Break down barriers between staff areas.

10. Eliminate slogans, exhortations and targets for the workforce.

11. Eliminate numerical quotas for the workforce and numerical goals for management.

12. Remove barriers that rob people of pride of workmanship. Eliminate the annual rating or merit system.

13. Institute a vigourous program of education and self-improvement for everybody.

14. Put everybody in the company to work to accomplish the transformation.

Joseph Juran also has a background in statistics, although he emphasizes quality as a "discipline of management, analogous to finance." In the 1920s, he worked at Bell Laboratories' Hawthorne Works and was part of the team that developed the first SPC system to be used in a factory. Like Deming, he was also invited to Japan (1954) where his ideas received an enthusiastic response.

In 1979, Juran founded the Juran Institute which offers consulting and training services, educational products, conferences and seminars. His major contributions to the TQM literature include: the *Quality Control Handbook* (4th ed., McGraw-Hill, 1988) and *Juran on Planning for Quality* (The Free Press, Division of Macmillan, Inc., 1988).

Juran is a strong advocate of employee involvement and contends that management is responsible for 80% of all quality problems (Deming puts the figure at 85% or higher). To assist management with change, Juran developed his "Quality Trilogy" which consists of three areas of quality management:

- **Quality Control** (meeting quality goals during operations – analogous to financial control);
- **Quality Planning** (preparing to meet quality goals – analogous to financial planning); and
- **Quality Improvement** (achieving superior, unprecedented levels of performance – analogous to cost reduction).

Some other TQM ideas which are emphasized in Juran's approach include:

- Quality is "fitness for use" (by the customer);
- To develop quality products, customer needs must be systematically translated into product and process features;
- Chronic waste must be identified and eliminated;
- Pareto Analysis is useful to identify priority opportunities for quality improvement by separating the "vital few" from the "useful many"; and
- Cost of Quality is useful, as an attention-getting tool and for measuring improvement.

Juran believes that the Zero Defects ideal advocated by Philip Crosby (see below) may not be a practical goal because rising appraisal and prevention costs could begin to dominate over decreasing costs of failure, i.e. the Cost of Quality function would reach a minimum before zero defects is attained.

Philip Crosby

"Zero Defects" is Philip Crosby's battle cry. Crosby places less emphasis on statistical methods than either Deming or Juran. He claims that "the problem with statisticians is that there's no zero in statistics." Crosby had a very successful corporate career before starting his own consulting firm and was among the first quality professionals to hold a senior management position: Vice President for Quality at ITT from 1965 to 1979. He created the Zero Defects movement at Martin Marietta in the 1960s (this included offering workers incentives for defect reduction) and popularized the "Do it right the first time" concept which was first used in the 1930s at Western Electric.

Crosby is a formidable speaker who places more emphasis on management approach and organizational culture than on quantitative methods. His four "Absolutes of Quality Management" and 14-step approach to implementation are detailed in his books *Quality is Free* (Penguin Books, USA, Inc. 1979), and *Quality without Tears* (1979). These principles are summarized below:

Crosby's "four absolutes of quality management":

1. Quality is defined as conformance to requirements;
2. The system for causing quality is prevention;
3. The performance standard is zero defects; and
4. The measurement of quality is the price of non-conformance.

Crosby's fourteen-step approach to quality improvement:

1. Management Commitment;
2. Quality improvement teams;
3. Measurement;
4. Cost of Quality;
5. Awareness;

6. Corrective Action;
7. Zero Defects Planning;
8. Employee Education;
9. Zero Defects Day;
10. Goal Setting;
11. Error Cause Removal;
12. Recognition;
13. Quality Councils; and
14. Do it all again.

Armand V. Feigenbaum

Armand Feigenbaum, a former manager of manufacturing operations and top quality expert at General Electric, is a leading author and quality consultant. While at GE, he was involved in reliability engineering on the world's first jet engines. He is noted for, among other things, inventing the Cost-of-Quality concept. Feigenbaum coined the term: **"Total Quality Control"** in an article in the Harvard Business Review in 1956. He published a classic text of the same name in 1961.

Feigenbaum believes that "Quality has become crucial to the industrial strength of the United States" and, although gains are being made, there is still a long way to go. According to Feigenbaum, accelerating the rate of quality improvement is the single most important competitive challenge facing industry in North America.

Feigenbaum's basic premise is that **quality relates to all functions within a company**, including production, engineering and administration. Management must support both the quality work of employees and quality teamwork among these departments. However, quality is defined by the customer, not by the engineer, marketer or general manager. He emphasizes that modern quality improvements require the application of new technology – its not a matter of dusting off a few traditional quality control techniques.

Some of Feigenbaum's other principles are:

- Make quality a full equal partner with innovation from the onset of quality development;

- Emphasize getting high-quality product design and process matches upstream – before design freezes the quality alternatives; and

- Make the acceleration of new product introduction a primary measure of the effectiveness of a quality program.

Kaoru Ishikawa

Kaoru Ishikawa was one of the pioneers of the quality revolution in Japan which started in the 1940s. Prior to his death in 1988, he was President of Musashi Institute of Technology in Tokyo and a professor at University of Tokyo.

Whereas most North American managers began focusing on the customer in the 1980s, Ishikawa's approach to quality had a customer focus thirty years earlier. He has made major contributions to promoting and facilitating the use of statistical methods by employees other than quality control experts.

In particular, he promoted the **Seven Tools of Quality**, (methods based on his ideas and those of others), which can be learned and applied, with a reasonable level of effort, by all employees. The seven tools are: Pareto charts, cause-and-effect diagrams, stratification, check sheets, histograms, scatter diagrams, and control charts.

Ishikawa has contributed much to education on quality. He was instrumental in developing a quality control correspondence course which was broadcast over radio in Japan. This course was the forerunner of educational television courses available to Japanese viewers. His Guide to Quality Control, originally published in Japanese, is one of the most widely read books in North America on statistical methods in quality management. For his many achievements in quality, Ishikawa has won the Deming Prize and the ASQC's Shewhart medal.

According to Ishikawa, the goal of quality is to "develop, design, produce and service a quality product which is most economical, most useful and always satisfactory to the consumer." He defines quality to include: "quality of work, quality of service, quality of information, quality of division, quality of process, quality of people, including workers, engineers, managers and executives, quality of company, quality of objectives, etc."

Some additional concepts which Ishikawa has emphasized include:

- Emphasize quality, not short-term profit.

- Adopt a consumer rather than producer orientation.
- The next process is your customer.
- Manage by facts: use statistical methods.
- Respect for humanity should be a central element of management philosophy.

Genichi Taguchi

Genichi Taguchi is one of the most well known Japanese quality experts in North America. In fact, his methods are more widely used in North America than in Japan. In particular, the American Supplier Institute (a spin-off of Ford Motor Company) has made his methods a major part of its approach. Taguchi is largely self-taught and comes from a small business family background. In spite of limited acceptance of his quality methods in Japan, he has received official recognition in the form of the Deming prize and an award from the emperor for his work in statistical theory.

Taguchi's approach focuses on improving both product development and manufacturing. It emphasizes achieving "optimum targets" and developing "robust" products capable of resisting forces that can degrade quality. He has developed procedures for conducting engineering experiments to identify the ideal combination of product characteristics to meet customer requirements and minimize susceptibility to variation.

Another unique contribution of Taguchi to TQM is his Total Loss Function (discussed in Chapter 4) — which illustrates the concept that any deviation of important variables from their optimum values, even if the variable remains within tolerance limits, results in some loss to the customer.

Taiichi Ohno

Taiichi Ohno is not well known outside Japan but his accomplishments have had a profound effect on manufacturing quality and productivity throughout the world. Ohno is a self-taught engineer who has had a brilliant career with Toyota. His basic principle is to eliminate all waste (from inventory, defects, time, plant capacity, labour), resulting in lower costs and higher quality.

During his career with Toyota, **Ohno developed the basis of what is now called Lean Production and Flexible Manufacturing**. These techniques are closely aligned with TQM since they incorporate continuous improvement and employee involvement. His accomplishments include: 1) inventing and implementing the Just-in-Time (JIT) system; 2) redesigning changeover processes to take much less time (and to be accomplished by the production workers rather than specialists); and 3) designing machines which stop automatically when a defective part is produced (thus allowing unattended operation, with resultant labour cost decrease).

In addition to his technical achievements, Ohno has been instrumental in increasing worker training and participation. For example, he pioneered the use of teams of workers to carry out production, support tasks and quality improvement at Toyota. He also advocated giving workers the ability to stop the production line if it is systematically producing defects. He has trained workers to find root cause of errors using a method known as the "**Five Whys**" (similar to causal - chain analysis discussed in Chapter 4).

APPENDIX A

QUALITY AWARDS AND ASSESSMENT CRITERIA

This appendix discusses some of the major national Quality Award programs. By providing national recognition for achievement in the field of quality, these programs play an important role in raising the profile of quality throughout industry.

The **Canada Awards for Business Excellence (CABE)** were created in 1984 by the Government of Canada to honour businesses in all industry sectors for their outstanding achievements. The program is operated by Industry Canada in cooperation with the National Quality Institute (NQI), a joint government-industry organization. Private sector experts perform the assessments of award applicants. Awards are given in eight categories. These include Total Quality and seven others, including: Entrepreneurship, Environment, Industrial Design, Innovation, Invention, Marketing and Small Business. The criteria for the Quality Award are organized into four categories:

i. Quality Improvement Policy and Plan;

ii. Implementation of Policy and Plan;

iii. Results Achieved; and

iv. Future Planning.

In the U.S., the **Malcolm Baldrige National Quality Award** is designed to recognize firms with outstanding records of quality performance. Since 1987, the Baldrige Award has been a major symbol for improvement in American business. The number of requests for applications exceeded a quarter of a million in its first three years. While the number of actual applications has averaged only 77 per year, thousands of companies are using the criteria, in one form or another, for internal self-assessment.

Preparing to apply for the award involves developing and documenting a wide range of quality management practices. This is a major undertaking and can take from three to five years. The Baldrige criteria cover the following categories: Leadership, Information and Analysis, Strategic Quality Planning, Human Resources Utilization, Quality Assurance of Products and Services, Quality Results and Customer Satisfaction.

The **Deming Award**, overseen by the Japanese Union of Scientists and Engineers (JUSE), is given annually to organizations that, according to the award guidelines, have successfully applied company-wide quality control based on statistical quality control and will keep up with it in the future. Although the award is named in honour of W. Edwards Deming, its criteria are not specifically related to Deming's methods.

The Deming Award has categories for Japanese companies, individuals and non-Japanese companies.

RELATIONSHIP BETWEEN QUALITY AWARDS AND QUALITY STANDARDS

In Appendix B, we discuss quality standards such as ISO 9000 and AQAP. There are similarities between these standards and the quality awards. They both assess a company's quality management system using standard criteria, some of which are overlapping. For example, the Baldrige Award includes a category for Quality Assurance of Products and Services which covers the same issues dealt with in ISO 9000. Quality awards and standards criteria also share some limitations. In particular, they are not intended to provide a guarantee of high quality products and services, or of financial success for the firm.

There are also significant differences between quality standards and awards. Quality standards are designed to provide assurance that a company's quality procedures meet certain minimum requirements. The quality awards, which are designed to recognize excellence, use broader criteria than the quality standards (e.g. leadership, strategic quality planning and customer satisfaction). The awards criteria deal as much with the quality of management as with the management of quality – they are TQM-oriented. In contrast, the quality standards deal with procedures and documents to control and assure quality.

In the future, the scope of quality standards may expand to incorporate additional elements of TQM. In particular, the strategic plan for ISO 9000, Vision 2000, identifies a long-range goal of having a single Total Quality Management Standard by the year 2000.

YOUR COMPANY'S STRATEGY WITH RESPECT TO QUALITY AWARDS, STANDARDS AND ASSESSMENT CRITERIA

As discussed in Chapter 7, TQM implementation should include regular measurement of progress. This involves assessing all the managerial practices within the firm from a quality viewpoint. The assessments may be performed by in-house staff or an external consultant. Many companies use the assessment criteria and methodologies associated with an awards program as the basis for measuring progress in TQM. In their view, the awards criteria provide a solid basis for measuring Total Quality.

Some TQM practitioners, however, have reservations about reliance on awards-based criteria to assess overall progress in TQM. (See, for example, *Beyond Quality: How 50 Winning Companies Use Continuous Improvement*—J. Bowles, and J. Hammond, G.P. Putnam & sons, 1991; p. 15). They believe that these criteria miss some essential elements of business success, including: innovation, financial performance and long-term planning. Others have expressed concern that too much effort is required to prepare for some awards and that this effort results in the creation of a "quality bureaucracy." They also caution about the danger of discouragement if, after much preparation, the company does not win.

The increased emphasis on quality, throughout industry, is generating more interest in quality assessments, audits and registration to quality standards. At the same time that management is determining its own needs in this area, the firm is likely to face new requirements from its customers.

Resources are needed in order to: 1) develop procedures and documentation to meet quality standards; 2) perform quality assessment/audits; and 3) be assessed/audited. To optimize use of these resources, companies should take a strategic approach to deciding which quality standards, quality awards and other assessment practices are relevant to their needs (both internally and with respect to customer needs and expectations). The following issues should be considered:

i. What company-specific, industry-specific, technical, national and international standards are currently necessary to do business with our customers?

ii. What other measures of effective quality management, beyond minimum requirements, are important to our customers?

iii. What Quality standards and criteria would be necessary to meet in order to gain additional customers?

iv. How will the situation change within our time-frame for business planning?

v. How can we optimize our use of resources for addressing the above issues, considering our quality management and marketing objectives?

Appendix B

QUALITY STANDARDS

Quality standards have always played an important role in quality management and will continue to do so. These standards define minimum requirements for effective **quality systems** (defined as the process, organizational structure, procedures and resources that manufacturers and suppliers use to produce a product of consistent quality meeting defined specifications). While quality standards existed before the emergence of TQM, they should not be considered separately from TQM, nor does TQM diminish their importance. Rather, the evolution of quality standards is being influenced by TQM.

Quality standards define minimum requirements for quality systems in two principle areas:

i. **Procedures** for ensuring quality roles and responsibilities of personnel (documents used, requirements for reviews and audits, use of flow charts for problem solving, etc.)

ii. **Records** which document adherence to procedures and quality results (inspections, tests, contract-related procedures, records retention, etc.)

Quality standards cover all processes which impact on quality: procurement, inventory, production, discrepancy controls/resolution, training, drawings, digital media/specifications, designs, test equipment, inspection methods, functional tests, tooling, shipping, etc.

Quality Systems Registration involves assessment and periodic auditing of a company's quality system by an independent, accredited auditor using standard criteria to ensure its adequacy. Registration does not mean that the company's products meet any particular quality requirements since it is the quality system, rather than products, that is assessed. Quality systems may also be audited by customers, or a company may perform self-audits. It is important to distinguish between audits for quality systems registrations **(procedural audits)** and audits to verify product quality **(product audits)**.

Internationalization of Standards:

Several quality standards are currently in use within the Aerospace Sector, including the Allied Quality Assurance Publications (AQAP), for military procurement, and company-specific standards, such as Boeing Corporation's DI-9000, within the civilian market. Since the late 1980s, however, there has been growing use of the ISO 9000 series of standards, developed by the International Organization for Standardization (ISO). These standards, which first gained widespread acceptance in Europe, are now becoming more influential in North America and Asia, partly due to increasing globalization of industry and markets.

The ISO standards are applicable to all industry sectors. They were originally intended to be advisory in nature and were developed primarily for use in contractual situations or for self-audits. However, the standards are now being applied under a broader range of circumstances.

Four categories of product are covered by ISO 9000: i) hardware; ii) software; iii) raw materials; and iv) services. The standards cover twenty basic quality system elements, which are listed at the end of this appendix. They represent the minimum requirements for a quality system in a well-run company — they do not require excellence in quality management or in the quality of products produced.

The five ISO 9000 standards are:

ISO 9000: Describes the series of standards and provides guidelines for selection and use.

ISO 9001: A model for quality assurance in the design, development, production, installation, servicing and supply of products or services (most comprehensive).

ISO 9002: A model for quality assurance in production and installation.

ISO 9003: A model for quality assurance when only final inspection and testing are required.

ISO 9004: Guidelines for applying internal quality management elements and activities.

The accreditation body for ISO in Canada is the Quality Management Institute (QMI), a subsidiary of the Canadian Standards Association. In the USA, the Registrar Accreditation Board, an affiliate of the ASQC, has been formed to license domestic registrars. The Board is also linked to the American National Standards Institute (U.S. representative to ISO) and the National Institute of Standards and Technology.

The ultimate objective of ISO 9000 is international standardization, and international support has been growing. However, the standards have been interpreted, applied, administered, and even titled differently from one country to the next. Country-specific and industry-specific adaptations of the standards have appeared, resulting in concern about the true extent of standardization that will be achieved.

The ISO is working on a strategy which will lead to evolution of the standards to meet the needs of diverse user groups — with elimination of the need for sector-specific supplementary or derived standards. For the time being, however, support for other quality standards will probably continue to a varying extent. They will most likely use the ISO series as a "baseline" and specify additional sector-specific or national requirements.

A further area of divergence involves technical quality requirements. The ISO Ad Hoc Task Force has stated that product-specific standards, containing technical requirements for specific products or processes or describing specific test methods, are necessary and should be developed within industry sectors.

Acceptance of a company's registration in international markets depends on there being reciprocal recognition arrangements between accreditation bodies in different countries. This reciprocal recognition is not universal, although it is increasing. **Before choosing an accreditation body (registrar) to work with, a company should consult with its customers.**

Despite the uncertainties concerning the ISO 9000 series, the move towards ISO registration is rapidly gaining momentum in North America. Of particular note is a 1989 memo, issued by the U.S. Department of Defense, stating that ISO 9000 will be adopted, and an April 1991 report indicating Canadian Department of Defence support for the adoption of the ISO standards.

ELEMENTS OF THE ISO 9000 QUALITY SYSTEM

1. Management Responsibility
2. Quality System
3. Contract Review
4. Design Control
5. Document Control
6. Purchasing
7. Purchaser-supplied Product
8. Product Identification and Traceability
9. Process Control
10. Inspection and Testing
11. Inspection, Measuring and Test Equipment
12. Inspection and Test Status
13. Control of Non-conforming Product
14. Corrective Action
15. Handling, Storage, Packaging and Delivery
16. Quality Records
17. Internal Quality Audits
18. Training
19. Servicing
20. Statistical Techniques

APPENDIX C

TQM GLOSSARY

Acceptance Sampling: inspection of a lot by sampling, used in determining the acceptability of lot as a whole.

Benchmarking: the continuous process of measuring products, services and practices against the toughest competitors or industry leaders. Information gained is used to improve performance.

Big Q: term used to indicate a broad concept of quality management, spanning all business processes and products.

Brainstorming: a technique used for thought generation. A meeting of multiple participants, set out to generate as many ideas as possible.

Cause and Effect Diagram: also known as Isikawa or Fish-bone diagram. Visual aid, used in analyzing quality problems. Diagram relates cause and effect and allows for group analysis of entire process.

Cellular Manufacturing: manufacturing process in which production is organized into families of parts within a single line or cell of machines. Machinists operate within specific lines or cells.

Check Sheets: (data recording device), custom-designed form used to record quality data. Allows for the interpretation of results. One of seven basic tools.

Common Cause: sources of variation inherent to a process, that affects individual results.

Continuous Improvement: refers to the ongoing improvement of products, processes and services.

Control Chart: chart for the recording of some statistical measure for a series of samples. Chart usually shows a centre line, upper and lower control limits to help detect trends. Quality control tool.

Cost Of Quality: refers to the cost of poor quality. Represents the sum of the cost of prevention, appraisal, internal and external failure.

Cross-Functional Team: a group of people performing different functions (i.e., design, planning, manufacturing, etc.) assembled and charged with a task of planning and implementing specific quality improvements.

Customer Delight: product or service exceeding customer expectations.

Customer Orientation: the planning, production and marketing of products according to the customers' true requirements.

Customer Satisfaction: result of product or service meeting customer expectations.

Design of Experiments: a branch of applied statistics, dealing with planning, conducting, analyzing and interpreting controlled tests to evaluate the factors that control the value of a parameter or group of parameters.

Empowerment: refers to the involvement of employees in the decision-making process. Employees are able to make decisions and take actions without prior authorization. They have the power to stop the process in order to make improvements or correct problems.

External Customers: refers to customers that are not within an organization, i.e., those traditionally thought of as customers.

External Failure: failures in a product that are detected after delivery to the customer.

Flow charting: (visual aid), process is mapped out using symbols representing different production stages. Aids in locating problems and helps in improving process.

Force Field Analysis: a technique for the identification of driving and restraining forces that will aid or hinder an organization in achieving a given objective.

Frequency Distribution: graphical and mathematical representation of the relationship between the value of a variable and the relative frequency with which the value occurs.

Histogram: graphical display of variance. Used to display tabulated data in a graphical format, allowing for the easy detection of patterns. One of seven basic tools.

Hoshin Planning: system to control the direction of an organization by identifying key targets for improvement efforts. Use of tools for continuous improvement, breakthroughs, and implementation, allows for total (top-down and bottom-up) strategic planning.

In-Control Process: a process in which the statistical measure being evaluated is in a state of statistical control, i.e. the variations among the observed sampling results can be attributed to common causes.

Inspection: measuring, examining, testing or gauging one or more characteristics of a product or service and comparing the results with specific requirements to determine whether conformity is achieved for each characteristic.

Internal Customers: refers to customers within an organization. Person or department receiving service or product from other persons or departments, all within an organization.

Internal Failure: failures in a product that are detected before delivery to the customer.

Kaizen: Japanese term made famous by Masaaki Imai meaning, "Little things better," gradual unending improvement, i.e. Continuous Improvement. Guides in setting and achieving higher standards.

Key Characteristic: a feature whose variation has the greatest impact on the fit, form, performance, or service life of a finished part from the perspective of the customer. Key characteristics are a tool to help decide where to focus limited resources. They are intended to be used for manufacturing purposes only and should not be confused with flight safety or design features which are sometimes called critical characteristics in the aircraft industry. Key characteristics may or may not also be categorized as critical characteristics.

Key Process Parameters: process parameters which contribute to variation of a key characteristic. These are used most effectively in designed experiments.

Loss Function: a term describing monetary loss due to variation; exact loss is rarely known, but the greater the deviation from nominal, the greater the loss. Also called total loss function, quadratic loss function, and Taguchi loss function.

Little Q: term used to indicate a concept of quality management, limited to factory goods and processes.

Lot: the whole of a quantity or number of product considered uniform for sampling purposes.

Mean Time Between Failures (MTBF): refers to average time interval between successive failures of a given repairable product.

Material Requirements Planning (MRP): set of techniques which use inventory data, production schedules and bills of material to determine material requirements. Time phased approach facilitates replenishment orders and recommendations to reschedule open orders, when due dates and need dates are not in phase.

Nominal Group Technique: a technique used for the generation of ideas on particular subjects. Ideas are collected and prioritized in a group environment.

Out-of-Control Process: a process in which the statistical measure being evaluated is not in a state of statistical control; i.e. the variations among the observed sampling results can be attributed to special causes.

Pareto Chart: a graphical tool, ranks causes from most to least significant. Helps in the identification of most significant cause of problems. One of seven basic tools.

PDCA Cycle (Plan, Do, Check, Act): sometimes referred to as the Shewhart or Deming Cycle, is the scientific methodology in which improvements are planned, tried, and checked to determine merit for implementation or abandonment.

Process Control: control and management focusing on the process to achieve quality improvement.

Process Improvement Team: also called Quality Improvement Team, a group of people charged with the task of planning and implementing quality improvement. The three major roles are team leader, team facilitator and team member.

Process Parameter: controllable factors of a process that affect its output. Examples include feed rate, router RPM, and temperature.

Quality: (a subjective term), the degree and consistency to which a service or product conforms to a specified standard or requirement; fitness for use; cause of customer satisfaction.

Quality Assurance: activities organized systematically, to provide confidence of quality to customers.

Quality Audit: an independent investigation and review of quality activities. Used to determine whether quality activities are effectively implemented to produce desired results.

Quality Circle: small study groups that work on quality improvement, also provides a team approach to work on quality related problems.

Quality First: places top priority on quality in management improvement and business strategy.

Quality Function Deployment (QFD): system for the translation of customer requirements into appropriate technical requirements through all stages of the deployment process – from R&D/manufacturing to marketing, sales and distribution. A disciplined approach to solving quality related problems before the design phase.

Random Sampling: sampling technique, in which units are selected such that all combinations of units have an equal probability of selection within a lot.

Reliability: the probability that a product will perform its intended function under stated conditions, without failure, for a given period of time.

Rework: reprocessing end results (products) to conform to originally specified requirements.

Scatter Diagram: graphical technique used to analyze the relationship between two variables; gives indication of possible relationships.

Scrap: product unfit and non-salvageable for use; may have scrap value.

Set-up Time: time required to convert from the production of one specific item to another. e.g. time to set up machine, line or work centre to perform different task or produce different product.

Standard Deviation: a statistical measure of variability used in describing the spread of process output.

Statistical Process Control (SPC)/Statistical Quality Control (SQC): quality control methodology focusing on the process and use of statistical techniques, in the desire for well-aimed and uniform levels of operation.

Tampering: over adjustment. Assuming a problem or source of variation results from a special cause (when it is actually a natural result of the system producing it) and adjusting something in hopes of fixing it. This may actually cause more variation.

Total Quality Management (TQM): is both a philosophy and a set of guiding principles that represents the foundation of a continuously improving organization. TQM is the application of quantitative methods and human resources to improve processes, products and services for the benefit of the customer, members of the organization and society. TQM incorporates management leadership and commitment, employee involvement, focus on the customer and continuous improvement.

Variation: change or deviation from a usual state or assumed standard or mean. In quality management, any non-conformance to specifications.

THE CALF PATH

One day, through the primeval wood,
A calf walked home, as good calves should;
But made a trail all bent askew,
A crooked trail as all calves do.

Since then two hundred years have fled,
And, I infer, the calf is dead.
But still he left behind his trail,
And thereby hangs my moral tale.

The trail was taken up next day
By a lone dog that passed that way;
And then a wise bell-wether sheep
Pursued the trail o'er vale and steep,
And drew the flock behind him, too,
As good bell-wethers always do.

And from that day, o'er hill and glade,
Through those old woods a path was made;
And many men wound in and out,
And dodged, and turned, and bent about
And uttered words of righteous wrath
Because 'twas such a crooked path.

But still they followed—do not laugh—
The first migrations of that calf,
And through this winding wood-way stalked,
Because he wobbled when he walked.

The forest path became a lane,
That bent, and turned, and turned again;
This crooked lane became a road;
Where many a poor horse with his load
Toiled on beneath the burning sun,
And traveled some three miles in one.
And thus a century and a half
They trod the footsteps of that calf.

The years passed on in swiftness fleet,
The road became a village street;
And this, before men were aware,
A city's crowded thoroughfare;
And soon the central street was this
Of a renowned metropolis;
And men two centuries and a half
Trod in the footsteps of that calf.

Each day a hundred thousand rout
Followed the zigzag calf about;
And o'er his crooked journey went
The traffic of a continent.
A hundred thousand men were led
By one calf near three centuries dead.
They followed still his crooked way,
And lost one hundred years a day;
For thus such reverence is lent
To well-established precedent.

A moral lesson this might teach,
Were I ordained and called to preach;
For men are prone to go it blind
Along the calf-paths of the mind,
And work away from sun to sun
To do what other men have done.

They follow in the beaten track,
And out and in, and forth and back,
And still their devious course pursue,
To keep the path that others do.

But how the wise old wood-gods laugh,
Who saw the first primeval calf!
Ah! Many things this tale might teach—
But I am not ordained to preach.

Sam Walter Foss
1858-1911