PRINCIPLES AND TOOLS OF TOTAL QUALITY MANAGEMENT

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Summary

Quality improvement and cycle time reduction are no longer fads or slogans but have become the survival issues of the 21st century. Companies that have adopted quality management practices have experienced an overall improvement in corporate performance including better employee relations, higher productivity, greater customer satisfaction, increased market share, and improved profitability. While each company developed its practices in a unique environment with its own opportunities and problems, there were common features in their quality management systems. These features included corporate focus on meeting customer needs, management that led the way, the empowerment of employees to seek continuous process improvement, a flexible and responsive corporate culture, fact-based decision making, and partnerships with suppliers. It is important to note that many different kinds of companies benefited from putting specific TQM practices in place; however, none of these companies reaped those benefits immediately. Allowing sufficient time for results to be achieved was as important as initiating a quality management program.

Often when people talk about how they truly embraced the TQM strategy, they talk about a *compelling event*. This is often driven by a crisis such as the massive lost of business to major competitors or a significant drop in profitability. Companies such as

Motorola and Xerox adopted the TQM journey after experiencing sharp competition from several Japanese companies. The big-three automakers in the United States began to embrace TQM after they had lost significant market share to Honda and Toyota.

Others have embraced the TQM philosophy based on a motivating vision. For example, Disney has used the vision: "The Happiest Place on the Earth," to motivate employees to new heights of customer satisfaction. While a crisis creates stress, a motivating vision creates opportunity or romance. In either case, the most important issue for success is to have *a resolve to make things be different.*

In summary, there is no magic formula to success in the quality journey. The work needed to implement TQM may, in many cases, seem unnatural in the sense that it is very different than anything that one has been led to believe is true. One will have to begin doing some new things, and, perhaps even more importantly, stop doing some old things. It is clear that one must allow sufficient time for results to be achieved. Don't expect instantaneous results, although there is always some "low-hanging fruit" that will give positive reinforcement. It is important to allow sufficient time for results to be achieved. This is a journey of unending length, but it is critical to start immediately. This article provides a summary of total quality management for systems engineering and management.

1. Introduction

Quality is a very misunderstood concept. To many, improved quality means that there must be more inspection. Others believe that the only important quality issues have to do with manufacturing operations. There has been a strongly held belief that quality costs both time and money. Some organizations would argue that if one wants a higher quality product, it will take longer to design and manufacture and it will cost more. Interestingly, all of these beliefs have been proven to be wrong. Inspection does not improve quality, and it turns out that real quality issues pervade the entire organization. Finally, many companies are now demonstrating that high-quality products can be produced more rapidly and at a lower cost.

A study of the Profit Impact of Market Strategies (PIMS) Data Base [The PIMS Letter on Business Strategy, 1986], which contains financial and strategic information for around 3000 businesses over a twenty year period, indicates that in the long run, the most important single factor affecting a business unit's performance is the quality of its products and services relative to those of its competitors. The study goes on to point out that:

- Businesses that offer premium quality products and services usually have large market shares and are early entrants into their markets. The clear conclusion is that quality does not cost time!
- Quality is positively and significantly related to a higher return on investment for almost all kinds of products and market situations. Companies with superior relative quality receive almost three times the return on investment (ROI) as compared with those companies with inferior relative quality (7% vs. 20%).

- Product quality is an important determinant of business profitability. High quality producers can usually charge premium prices for their products. As we will see later, by using the right processes, quality products can, in fact, be made at a lower cost. As a result, it is clear that quality does not cost money!

A 2002 study done by the National Institute of Standards and Technology (NIST) [NIST, 2002], the governmental agency responsible for the Malcolm Baldrige National Quality Award (MBNQA) award program, shows that quality management can result in impressive financial returns. NIST "invested" a hypothetical sum of money in the Standard & Poor's (S&P) 500 and in each of the publicly traded companies (two whole companies and 18 parent companies of subsidiaries) who have won the MBNQA since 1991. The investment was tracked from the first business day in April of the year the Baldrige winner received the award, or the date they began publicly trading, through to December 3, 2001. As a group, the companies outperformed the S&P 500 by greater than 3 to 1. NIST also reports [NIST 2003] that Baldrige winners exhibit such attributes as higher growth rates, better customers and employee satisfaction, and increased market share and repeat business.

Total quality management involves both quantitative methods and human resources. Total quality management integrates fundamental management techniques, existing improvement efforts, and technical tools. It is important to understand this duality of tools (quantitative and decision-making methods) and philosophy (people issues). Doing one without the other will not be successful. The integration of tools and techniques is critical if TQM is to be something other than an overlay program. The next two sections of this article elaborate on these two interrelated concepts – tools and philosophy.

2. Total Quality Management Tools

There are a wide range of TQM tools; the size of this article does not permit a detailed discussion of them along with appropriate examples. The following is a list of widely used tools. There is no tool that is best for every application; the knowledgeable practitioner is aware of a rich variety of tools and uses the appropriate one(s).

- **Process maps:** One of the important keys to understanding how to improve a process is to map the process. While there are several different approaches to process mapping, the key is to determine who does what at each step of the process. Often, the simple drawing of a process map is sufficient to solve many quality problems because the map makes it so obvious where defects can be introduced.
- **"Poke-A-Yoke":** This concept of the Japanese management philosophy is to make a process foolproof. The idea is to design the process in such a way that it is self-checking or incorporates process steps that cause immediate detection and possible correction of any defect. Simple examples include color-coding and special keying of parts to ensure that they are assembled the correct way.
- **Statistical Tools:** One of Deming's major contributions to the quality movement was the introduction of statistically grounded approaches to the analysis of defects. Without the use of these tools, one can often make incorrect decisions regarding the

cause of a problem. This can often lead to exactly the opposite effect of that being sought. Included in this set of tools are statistical process control (SPC) charts, Pareto Charts, and histograms.

- **Force Field Analysis:** This tool asks one to diagram the forces (policies, culture, and so forth) that are resisting a desired change and the forces that support the change. This assists one in clearly determining the degree of difficulty of making change and exactly where effort will be needed. The supporting forces are places where assistance can be expected.

- **Root Cause Analysis (Five Whys):** The Japanese popularized this tool. It consists of asking a series of questions (whys) until one uncovers the root cause of a defective product. The objective is to determine why a defective product was produced; this is to be contrasted with the usual approach of just fixing the defective product or replacing it.

- **Fishbone Diagram (Ishakawa Diagram):** This tool is also called a cause-and-effect diagram. It is used in a brainstorming session to examine factors that may influence a given situation or outcome. The causes are often grouped into categories such as people, material, method or process, and equipment. The resulting diagram takes the shape of a fishbone, hence the name.

- **Loss Functions:** In many manufacturing situations, one creates tolerance limits for a product. Products that fall outside of the limits are defective and those that are inside the limits are deemed good. Several difficulties arise with this approach. First, there is always the temptation to reclassify products that are just outside the limits into the acceptable category, especially if there is a great push for quantity. Second, and perhaps more important, the accumulative effect of several parts which are all on the extreme limits of acceptability, may lead to defective performance. The loss function tool is used to recognize that there is a cost associated with any deviation from the ideal value.

- **The Plan-Do-Check-Act (PDCA) Cycle:** This tool is also known as the Shewhart Cycle. Deming popularized it in Japan; as a result the Japanese refer to it as the Deming Cycle. The tool emphasizes a new plan for change. It carries out tests to make the change on a small scale, observes the effects, and finally, studies the results to determine what has been learned. The cycle is repeated as needed.

- **Brainstorming:** This process has become a staple of the TQM movement. The concept is to invite participants to suggest "solutions" to a problem without any evaluation of the usefulness or correctness of their ideas. Several approaches are possible, including open suggestions, rotating suggestions, or blind suggestions. There are several computer tools that have been developed to assist in this process. After a fixed period of time, or after all suggestions have been made, there is discussion of the "value" of the suggestions.

- **Affinity Diagram:** The affinity diagram tool is used to organize large amounts of non-quantitative (ideas, opinions, issues, *etc*.) information into groupings based on natural relationships between the items. It is largely a creative rather than a logical process. In a very loose sense, the affinity diagram does for ideas what statistics does for numbers, *viz.* extract meaning from raw data. The affinity diagram process is often used with the results of a brainstorming session to organize the resulting ideas.

- **Interrelation Digraph:** This tool takes complex, multi-variable problems, or

desired outcomes, and explores and displays all of the interrelated factors involved. It graphically shows the logical and often causal relationship between factors. It is often used in conjunction with the results of an affinity diagram exercise to seek causes and effects in order to determine why corrective action needs to be applied.

- **Tree Diagram:** This tool is used to systematically map out, in increasing detail, the full range of paths and tasks that need to be accomplished to achieve a primary goal and every related sub goal. Graphically, it resembles an organization chart or family tree.

- **Prioritization Matrices:** Prioritization matrices are one of a group of decision-making tools that help to prioritize tasks, issues, or possible actions on the basis of agreed upon criteria. While these tools cannot make decisions, they can help to ensure that all factors are evaluated and that logical decisions are reached.

- **Activity Network Diagram:** This class of tools includes a wide range of project management tools used to plan the most appropriate schedule for a complex project. Typical examples are Gantt Charts and PERT charts. These tools project likely completion time and associated effects and provide a method for judging compliance with a plan. Several excellent computer programs exist for automating the work associated with this class of tools.

3. Total Quality Management Philosophies

The core values and concepts of the Criteria for Performance Excellence of the Baldrige National Quality Program [NIST, 2006] form an excellent framework for understanding the philosophies of Total Quality Management.

In addition, the Criteria provide an excellent tool for measuring an organization's performance against a well-calibrated standard. As outlined in the Criteria, the TQM philosophy involves eleven interrelated concepts:

1. Visionary Leadership
2. Customer-Driven Excellence
3. Agility
4. Organizational and Personal Learning
5. Management by Fact
6. Valuing Employees and Partners
7. Focus on the Future
8. Managing for Innovation
9. Social Responsibility
10. Focus on Results and Creating Value
11. Systems Perspective

The following eleven sub-sections explain each of these items in more detail.

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Biographical Sketch

James l. Melsa, Dean Emeritus of the College of Engineering at Iowa State University, is a distinguished scholar, an award-winning educator, and a visionary corporate leader. Dr. James L. Melsa served as dean of the Iowa State University College of Engineering from 1995 to 2004. Previously, he spent 11 years at Tellabs Inc., Lisle, Ill., including appointments as vice president of strategic planning and advanced technology, vice president of research and development, and vice president of strategic quality and process management.

Melsa also was on the faculty at the University of Notre Dame for 11 years, serving as professor and chair of the electrical engineering department. He also has worked on the faculties at Southern Methodist University, Dallas, and the University of Arizona, Tucson. During his years as an academic, Melsa conducted significant research on control and estimation theory, speech encoding, and digital signal processing; directed 20 masters theses and 16 Ph.D. dissertations; earned recognition as one of the nation's outstanding electrical engineering professors; and authored or co-authored 116 publications and 12 books, including *Linear Control Systems*, a classic text used around the world.

He was named a fellow of the Institute of Electrical and Electronic Engineers in 1978 and received that group's Third Millennium Medal in 2000. He was named a fellow of the American Society for Engineering Education in 2006. He has previously served as President of the IEEE Control Systems

Society and President of Eta Kappa Nu, the national electrical and computer engineering honorary and is currently President Elect of ASEE He has an extensive record of service to national and international groups, including the Herbert Hoover Presidential Library Association (past trustee), the Iowa Business Council (past deputy), and the Malcolm Baldrige National Quality Award (past member of the Board of Examiners and the Board of Overseers). Melsa received his B.S. degree in electrical engineering from Iowa State (1960) and his M.S. (1962), and Ph.D. (1965) degrees from the University of Arizona, Tucson.