ON THE COSTS OF QUALITY ASSURANCE

Sorin Ionescu, Ph.D, Politehnica University of Bucharest, Romania

Abstract

There are several models of cost management, most notably PAF model. But this model has been questioned in the recent years. This article proposes a different view of quality costs. It is therefore necessary to consider the cost of investment in the quality system and the cost of procedures, depending on the time needed.

The analysis necessary to quality assurance activities, adopted by different companies or suggested by some papers, lead to distinguish the following functions: build of quality, quality inspection, quality improvement, guarantee of quality and staff training. To determine the costs related to quality, we should take into consideration two types of costs: costs for system implementation (design and implementation), which can be viewed as an investment. and costs related to the use of systems, to the procedures necessary to achieve a batch of products.

Keywords*:cost management, quality system, build of quality, quality inspection, quality improvement, guarantee of quality*

INTRODUCTION

An important managerial issue for quality assurance is to find out the cost of quality. But the cost by itself does not give the real measure, unless we also study the effects obtained by applying the quality assurance activities. For this reason a new paradigm appeared in quality management: the so-called “economy of quality”. Economy of quality [1] means a quality management activity that examines the economic aspects, such as the cost of quality and its effects.

After more than fifty years of studies, the problem of Economy of Quality is still open, although some progress has been made about quality costs, and successive methods used have led to a better understanding of them. Since 1946, the costs of quality have been studied by General Electric [2]. But current models still cannot be used to manage quality activities in practice. The problem of project quality costs has been even less studied.

Today the economy of quality is a modern tool for the company management [3] used by large corporations, as well as by SMEs. J Juran said [4] that the language of a manager should be an economic and not a technical language.

THE CURRENT LEVEL OF RESEARCH

Referring to the cost of quality, J. Juran proposed including the costs for market research, for research and development, design, manufacturing planning, maintaining the precision of equipment, employees training, sales of products and products testing, defect prevention, replacing defects, search of information.

Ph. Crosby [5] introduced the concepts of conformity and non-conformity, and consequently the costs for conformity (prevention and evaluation) and for non-conformity (internal and external defects). R. Tricker [7] noted that British standards introduce the notion of "economic quality" (the break even point at which costs exceed benefits). This expression is more acceptable than that of "optimal quality". Taguchi’s concepts [8] can be summarized in the fact that a poor quality is a loss for the society, the loss incresing with the square of the error magnitude. In 1967 A.S.Q.C. published the "Quality Cost" document followed by a guide to "Quality Cost Reduction" and another on "Cost Management". Industry reacted in different ways to these concepts starting with 1980.

There have been issued many solutions for management of quality cost, but they are still not universally accepted. This is mainly because in quality some expenses are, actually, investments (for example the training costs).

Other experts [10] are even more categorical, considering that quality assurance as a whole should be seen as an investment and not as an expense, because it affects the reduction of loss (scrap), reduces the inventory (assets in stocks), increases efficiency and productivity, improves the company image and ensures its competitiveness.

Therefore costs should be managed and not recorded. But current accounting used by enterprises does not contribute to identifying quality costs and, consequently, to its increase.

The PAF Model is the most used model for determining the cost of quality. Masser defined in 1957 the PAF model which records the costs for prevention, testing, defects replacing. Similarly, John Groocock [11] used these three cost categories: prevention of damage, identification of defects, and replacement of defects. Feugenbaum added to this that there are both internal and external defects.

As it can be seen, this concept refers to the products conformity quality and not to the quality as perceived by the customer. Further it is missing a clear definition of what is meant bz these cost, so that in practice it is necessary to provide various examples of expenses that are part of these categories.

Method of survey points [14] no longer seeks the cost split by articles of calculation, but looks at some issues called "the survey points". For example, the time of interruption of manufacturing is one such point. The method points out that the base of current calculation is a direct labor, but this is only about 15% of total spending, too little to estimate the cost from it. Furthermore, some manual operations require a very short time, but registration may require more time than that, hence accounting costs increase. Also some costs do not require a precise knowledge, but a good approximation, which in current accounting cannot exist. Many activities in quality assurance have an intellectual character in which time is not important, but necessary knowledge is.

M. Porter suggested [15] that in each activity are three types of cost: direct costs to create value, indirect costs to ensure performance of work and quality costs necessary for quality assurance and quality control.

SYSTEMIC APPROACH TO QUALITY MANAGEMENT

Quality system

Quality assurance is achieved through a quality system. This is because quality management is a transfunctional management. J. Forrester noted [16]: "Until now, much of the practice and management training deals only with activities. Accounting, production, finance, human relations are taught as separate subjects. Industrial system is so complex, that knowledge of its parts is not enough. In management, the interconnections and interactions between the components are more important than the components separately". This explains the interest in industrial systems.

Although in the General Theory of Systems, the notion of "system" was made clear a long time ago, in the theory of quality, things have evolved slowly and some uncertainties still exist. The I.S.O. 9000 standard defines the quality system (Q.S.) "the organizational structure, responsibilities, procedures, processes and resources for implementing quality management". Notes accompanying the definition add that Q.S. must be extended so as to

achieve the objectives for quality. The standard is designed essentially to meet internal management requirements of the organization and is more general than the requirements of a particular beneficiary, who only evaluates the system part that interests him. This definition corresponds with the G.T.S concepts.

The quality system appeared [19] as a consequence of profound changes in science and technology, changes that took place initially within high technology: military, nuclear, aerospace, but now widespread in electronics, computers, vehicles, machine tools etc. The quality system is in turn a "High Product", a macro technology used to introduce technical progress in businesses. With its help, taking minimal and controllable risks, high quality products are made.

A definition encountered in the literature [21] about the quality system, which is consistent with G.T.S, states that it is a "combination of equipment, software specialists and procedures in such a structure chosen, that one can achieve the objectives derived from quality policy". Other authors define quality system as a group of man-machine elements, driven by information, acting on the material, information, energy, people, to pursue a specific purpose. QS is a network of administrative procedures and techniques required to manage quality, i.e. design, production and produc support.

Below we will try to define the quality system's elements. The aim of identifying its elements is encountered in many works [22], which try to find the basic "bricks" of the system. The Q.S. definition of ISO puts particular emphasis on the procedure. Applying a procedure involves the existence of experts, information and equipment that can define a basic system (arhema), the smallest subsystem of quality, the "brick" of which we spoke earlier.

Literature devoted to systems presents different types of structures, industrial management studies leaning more towards hierarchical structures. Also, in works related to quality system several possible structures are presented, but it should be noted that they refer to industrial activities that determine quality and not to the quality system elements. For example, ISO 9004 defines in this regard the "quality curve" while previous works refer to the "spiral of quality", "fan work", "waterfall of activities". All these structures are simple, involving a sequence of activities. Recent works advance the idea that the structure is more complex, with parallel or hierarchical activities. Industrial activities considered for these structures have some differences, but their analysis shows that these are not fundamental.

The procedures that form the quality system are classified according to their quality assurance functions.

Quality assurance functions

Quality assurance (QA) contains all the measures that are adopted to constantly achieve a certain quality level of products. These measures must be planned and systematic, to ensure the producer and the customer that the desired quality will be obtained and all requirements satisfied. It should be noted that:

- the measures are adopted within some activities conducted in the company;
- the measures must ensure customer satisfaction;
- the measures should ensure a repetitive activity;
- the measures are translated into procedures, in other words in documents to be followed by the entire company.

In ISO standards the quality assurance is considered to be a set of actions planned and systematic, which are able to give confidence that the product meets the specified requirements. It is judged [23] that the ISO 9001 standard gives a guarantee to the customer and that it has a horizontal dimension (outwards expansion), while TQM is oriented towards the development of the company's capacity of satisfying the client an that it has a vertical dimension (expansion inside of company). The role of QA is to ensure all links between the two dimensions.

Some other opinions on quality assurance are also interesting. Thus, W.E. Erickson found that quality is always obtained as a result of a huge effort, and A. Toynbee stated that "good quality is obtained through a hard work". Actually, quality is desired by everybody, as long as they do not have to do anything.

To understand the essence of quality assurance one should appeal to its functional approach. In management, the functional approach is used for making analyses, while the systematic approach is used for designing the processes. The explanation of functional approach can be found in the fact that the management processes and its activities are part of the company, which is a complex organism continually transforming itself and evolving. Thus it can be compared to a live, biological, organism, whose existence is ensured by performing its functions [4].

The function is an abstract theoretical concept used to put in order complex and varied actions, thus having the purpose of describing the role of an activity. The functions describe activities with a high degree of similarity. In addition to functional approach to enterprises or functional approach to products (used in value analysis), quality management also began to address functionally the quality assurance.

The enterprises activities that contribute to quality assurance are very different. The chain of activities within an enterprise can be represented as a "spiral of quality", which shows how activities succeed. ISO 9000 uses, in the same purpose, the term of „quality loop". The spiral shows the enterprise activities that participate to quality assurance.

The measures necessary for Q.A. of a process can be applied prior to the process, in the same time or after the process. This observation allows definition of classes with such measures that lead to quality assurance, called quality assurance functions.

The analysis necessary to quality assurance activities, adopted by different companies or suggested by some papers, lead to distinguish the following functions: build of quality, quality inspection, quality improvement, guarantee of quality and staff training. Grouping activities by functions is made after their homogeneity and time of application [17].

- Build of quality includes measures to be adopted initially to achieve quality in an industrial activity;
- Quality inspection includes the achievement comparison activities with their specifications;
- Quality improvement includes measures to be taken to improve quality, after the verification activities;
- Guarantee of quality includes measures which confirm and guarantee the systems, processes, products or services;
- Staff training includes training measures and improvement of personnel for quality.

Quality engineering

Nowadays systems engineering notions are used to design systems, including their quality. Systems Engineering is a discipline which studies the creation and optimization of systems, meaning the design, implementation and exploitation (including the setting up of maintenance and security assuring procedures) [27].

The term "quality engineering" is already used in the literature [28], but with limited and incomplete meanings, referring, for instance, to a range of activities such as professional training, technical assistance, research activities (for product development, logistics, etc.). In Japanese literature [29], it is considered that "quality engineering" is the activity performed by the quality engineer, and its purpose is to collect information about the product, determining the quality characteristics, to establish procedures for quality in all activities including relations with suppliers and customers, training and development of systems for quality assurance. A recognized expert in quality, G. Taguchi, names his statistical method as "quality engineering".

Further on, we will use the quality engineering term to describe the design, implementation and usage of quality systems.

THE SYSTEMIC MODEL OF COSTS

To determine the costs related to quality, we should take into consideration two types of costs [30]:

- Costs for system implementation (design and implementation), which can be viewed as an investment.
- Costs related to the use of systems, to the procedures necessary to achieve a batch of products.

The first ones are fixed costs, which are paid back pro-rata from each product. The other costs are variable costs for each product made. Fixed costs are allocated to each product using the distribution key, which involves the ABC method. Total cost of quality of a product is the cost of access to quality system, plus the costs of using the procedures.

$$CQ = Cas + Cup \qquad (1)$$

where:

CQ - total cost of quality (a lot)of a product;

Cas - cost of access to quality system;

Cup - costs of using the procedures.

Cost of access to quality system. The design and implementation of the system is an investment that is recovered by each resulting product, using the quality management system. The cost is related to staff training, implementation of the quality system, system certification, and studies to define and write procedures. There are costs for creating a Department of Quality Assurance, for testing procedures, quality manual development, for the purchase and testing of equipment, etc. Thus, it exist a necessary investment to implement the system, which has several components:

$$C_{as} = I = I_1 + I_2 + ... + I_n \qquad (2)$$

This investment is a cost that has to be distributed to the lifespan of the quality system, on each batch and each product, using the distribution key. A distribution key is a measure of a type of cost. If a quality system is used to achieve more products, the resulting cost is smaller.

A product receives a variable percentage of each component of the investment according to the degree in which it was necessary. Distribution key can be: the percentage of procedures used, the time of use of the information system, product complexity, requests to change of quality plan, the number of hours required for training, of how much of the system capacity was actually used. The smaller the volume of products resulting from the project, the higher the access costs. If the distribution would depend on the volume of products, for a small volume we would have low associated costs. In this case, some products would support other products.

Determination of investment distribution key must be made carefully. The fundament of management accounting is direct labor. This seemed natural, because in the early twentieth century, labor represented the highest cost. But today it represents only a low percentage. In 1970 labor costs represented 40% and nowadays it is only 5%. Many costs have causes other than manual labor.

To simplify, a repartition key of investment in the quality system may be given by the time of use of the system [33].

$$K = \frac{Taq}{DCV.Zl.L} \tag{3}$$

where:

T_{aq} - Time of use of the quality system for a batch of products (days);
DCV - Lifecycle of the quality system (about 15 years);
Zl - Working days per year (about 260);
L - Number of batches that are simultaneously working.

Supporters of the ABC Method [32] say that the arbitrary allocation of costs not related to production, depending on labor costs, is not representative for the resource use. Usually information about costs is distorted and wrong decisions may be made [33].

For correct calculations we must update the investment. The pro-rata cost of using the system for a product is given by:

$$Cas = I \cdot K \tag{4}$$

The Costs of using the procedures (Direct costs of quality assurance) for a batch of products is based on recording the total times for using the procedures (for each batch of products) (Table 1). In the table is shown the record of the time for using the procedures, equipment, employee training, information seeking. Time is then converted into money. Costs are then centralized at the sector level (cost centers) (Table 2).

Table 1 - *Expediture on use procedures*

Quality assurance functions	PRODUCT						Salary schedule	Total
	A	B	C	D	E	F		
Building								
Inspection								
Improvement								
Guaranty								
Training								
Direct costs (CD)								

Table 2 - *Quality costs in enterprise*

Center	Buiding	Inspection	Improvement	Guaranty	Training	TOTAL
C						
C_2						
C_3						
C_4						
Total						

Registration is facilitated if there are product directors. Each worker doing an activity based on a procedure has to declare the time spent. This time is then converted into money. Certainly these statements would contain errors and therefore there is a tendency for them to be filled by direct supervisors.

Some costs can be directly determined because they are recorded in primary documents, but others are determined based on a distribution algorithm. Similarly, one can identify the costs for the improvement, assurance and training activities. It should be noted that for guarantee we consider the money spent on product certification, while for training we consider the money spent on the employees training.

The costs associated with defects must be considered in the fabrication cost. The training cost and the guarantee cost include the money spent to train the people involved in the actual execution (to clarify the modus operanda), as well as the costs associated with the product certification. The training of quality system and quality system certification are investments.

Thus, the cost of a product quality is:

$$CQ_p = CQ / n \qquad (5)$$

where n is the size of the batch.

CONCLUSIONS

There is some similarity between the PAF model and the systemic model. One may argue that prevention means implementing quality, identification means inspection, fixing defects means improving. However, the difference lies in the prevention costs that include the investments for the quality system and for training.

There are also some differences. Implementing a quality system is considered an investment that has to be paid back by the products, while the use of procedures represents

direct costs. This way the costs have a clearer meaning, and we can better measure up the improvement activities. Finally, we must stress that cost has no meaning by itself, that is we cannot say it is big or small, unless we take into consideration the benefits of applying quality assurance.

REFERENCES

[1] Conti T. , *Come costruire la qualita totale*, Ed. Sperling & Kupfer, Milano, 1992.
[2] Di Cristofano G., *Il ritorno degli investimenti*, Rev. Sistemi & Impresa no. 2/1992.
[3] *** , *Programme Detroit Diesel Allison*, Automative Engineering SUA, Jun. 1982.
[4] Juran J., *Leadership for Quality,* Ed. The Free Press, New York 1989.
[5] Crosby Ph., *Quality is Free*, Ed. McGraw Hill Book, New York, 1986.
[6] Hsiang T., *Zero Defect,* Rev. I.E.E. Communication in Statistics, no. 11/1995.
[7] Tricker R., *ISO 9000 pentru intreprinderi mici,* Ed. All Beck Bucuresti 1999.
[8] Ealy L., *Les methods Taguchi,* Ed. D'Organization, Paris 1990.
[9] Oakland J., *Total Quality Management*, Ed. Butterworth Oxford, 1995.
[10] Logomorsimo B., *La Qualita in Azienda*, Sistemi & Impresa febr. 1991.
[11] Schonberger R., *Building a Chain of Customer,* Ed. The Free Press, New York 1990.
[12] Feigenbaum A., *Total Quality Control*, Ed. McGraw Hill International, New York, 1991.
[13] Parker G., *Achieving Cost, Efficient Quality,* Ed. Gower Publishing, England 1995.
[14] Dale B., *Quality Costing,* Ed. Chapman Hall, Londra 1991.
[15] Porter M., *L`Avantage Concurrential,* Ed. Intereditions Paris 1985.
[16] Forrester J., *Dinamica industrială,* Ed. Tehnică, Bucureşti, 1981.
[17] Ionescu S., *Excelenta Industriala,* Ed. Economica, Bucuresti 1997.
[18] Mallia R., *I costi e benefici della qualita.* Ed. C. I. Lecco nov. 1992
[19] De Pari R., *Il Manuale della Qualita,* Ed. Camera Comercio Lombardia, Lecco, 1991.
[20] *** *Glosar EOQ,* Ed. EOQC Berna 1985.
[21] Kelada J., *Is Reengineering Replacing Total Quality ?* Rev. Quality Progress, Dec. 1994.
[22] Galgano A., *La qualita Totale,* Ed. Il Sole 24 Ore Milano 1990.
[23] Ranzanici M., *Garanzia della Qualita.* Ed. Nuova Magrini Galileo Bergamo 1990.
[24] Dembour M., *La spiral de qualite.* Rev Industrie, march 1992.
[25] Rogerson W., *Quality vs. Quantity,* The American Economic Review, March 1990.
[26] Ishikawa K., *What is Total Quality Control*, Ed. Prentice Hall Inc. Englewood Cliffs 1985.
[27] Gheorghe A., *Ingineria sistemelor,* Ed. Academiei, Bucureşti, 1979.
[28] Vigier M., *Ingineria calităţii*, Ed. O.S.C. Bucureşti, 1990.
[29] Mizuno S., *Fare Qualita,* Ed. I.S.E.D. Torino, 1992.
[30] Gray J., *Quality Cost,* Rev. Quality Progress, April 1995.
[31] Ionescu S., *Les couts de la qualite,* Romanian Journal of Technical Sciences. Ed. Academiei Bucuresti 2002.
[32] Barnes F., *Activity Based Costing,* Industrial Engineering, Sept. 1991.
[33] Hergert M., *Accounting Data for Value Chain Analysis,* Strategic Management Journal nr. 10 / 1989.