Defence Science Journal, Vol. 56, No. 1, January 2006, pp. 53-59

Quality Management System–Some Reflections

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ABSTRACT

With the increasing demand for high quality products in every field, the demand for a good quality management system (QMS) in every organisation is increasing. This has since been well-appreciated by many organisations who have adopted QMS like ISO 9000, which has standardised the requirements for QMS. A well-organised QMS benefits the organisation in achieving its goals and sucess in its missions.

In this paper, author's experiences in QMS and its implementation during his long tenure at ISRO, are briefly described. The author recalls a few incidents he faced during working on the projects of ISRO and DRDO, highlighting issues wrt quality and reliability, QMS, and ISO 9000 implementation. A few guidelines for effective QMS implementation are also suggested.

Keywords: Quality management system, ISO 9000, quality system, QMS FMECA, FTA, quality assurance, reliability, fault tree analysis, failure mode effects and critical analysis

1. INTRODUCTION

Quality of a product refers to its conformance to the specifications. The better is the quality of the product, the better is the chance of its operating satisfactorily during its usage or the better is its reliability. Quality requirements for products in a production organisation in USA and other western countries had been well-understood since 1930s when quality control methods were implemented in an organised and systematic manner. Since then, quality control and statistical quality control methods as disciplines have grown tremendously[1]. During 1950s, the concept of quality system was introduced by Deming[2], who considered all aspects of the organisation comprising planning, manufacturing, management, and quality control. This is a systems approach to quality.

Requirements and necessity for a good quality system has been well-understood by all aerospace companies from the beginning of 1950s. The fact that a large number of successful satellite launches and space missions have taken place since 1960s in USA, USSR, China, Europe, Japan, and India, shows that there has been a good quality system existing in the aerospace companies in these countries. Comprehensive design/process documentations also exist.

2. CONCEPT OF STANDARDISATION OF QUALITY

The concept of standardisation of quality and quality management system (QMS) was found essential to facilitate international trade that people everywhere would recognise and respect. International Standards

Received 04 October 2005

Organisation (ISO), established in 1947 and located in Switzerland, developed common international standards to meet this objective. Its members come from over 120 national standards bodies. ISO 9000 refers to a set of quality management standards. ISO 9001:2000 presents requirements, while ISO 9000:2000 and ISO 9004:2000 present guidelines. ISO 9000 has now been widely accepted as a quality management standard by many companies, including aerospace companies.

3. CONCEPT OF RELIABILITY

Another important issue is the concept of reliability and the relationship between quality and reliability. Of course, the reliability is closely associated with the quality, and the high quality system generally has higher reliability. The reliability of a product/ system conveys the concept of dependability, successful operation or performance, and absence of any failure. The failure or mechanism of failure in a system is associated with the quality of a product. Quality, on one hand, denotes conformance to the specifications, whereas reliability denotes absence of failure during operational phase of the product. The reliability is a statistical parameter based on failure rates, etc, which predicts the probability that the system will work without failure in the given environment.

There are many methods to improve the reliability of the product, like reliability by design, reliability by testing. Reliability analysis tools are available to identify weak links, which can be corrected to improve the design. The reliability modelling of the system can be carried out through techniques like failure mode effects and critical analysis (FMECA) and fault tree analysis (FTA), which can be used to estimate the reliability of the system. Reliability engineering discipline has found applications in areas like warranties and guaranties in various industries[3].

4. CONCEPT OF QUALITY

Quality describes the inherent characteristics of the system. It characterises the system as it is manufactured. Any deviations in dimensional details (physical characteristics) or the performance characteristics are reflected directly in the quality of the product. If the system (product) is demonstrated to work, say in a rocket flight, with the given design, then the design is proven and if the quality of the product during its manufacturing for the next flight is very good (ie, there are no unacceptable deviations), then one can definitely conclude that the system will work satisfactorily in the next rocket flight.

In this paper, some aspects of quality and reliability, quality system and quality management system (QAS), and the relevance of ISO 9000 for research and development organisations like Indian Space Research Organisation (ISRO) and Defence Research and Development Organisation (DRDO) are presented. A few incidents which the author faced during his tenure at the ISRO are given to highlight these aspects.

5. QUALITY & RELIABILITY–SOME REFLECTIONS

One of the person working as Head of Quality Division in a defence R&D laboratory in India was being asked about the reliability of the missile, being readied for launch. The reliability of the missile was required to be assessed before being cleared for the launch by the board constituted for this purpose. The figure worked out based on the available data was 0.50 and input like failure rates were taken from DATA handbooks or from the available literature. The input data was reviewed by a committee and it was recommended that the input used should be revised based on additional tests done and quality control records of the components/ subsystems. Also, the details of non-conformances, failures were revisited, which were found to be lower. The fact that the missile comprised many systems already proven in similar flights earlier, was also considered. The revised figure was worked out to be 0.62. The missile flight, after the clearance by the board, was successful.

The following inferences can be drawn from the above incident:

- The reliability figure is based and solely dependent on the input used. Hence, it is necessary that the correct and updated data are used in the reliability prediction. This should cover track

record, usage of subsystems in earlier similar flights, and updated failure rates based on all the field data and not only based on the DATA handbooks.

- The reliability is higher if the failure rates or non-conformances are low. Hence, quality of components, subsystems and systems, including their performance deviations, directly affects the mission success.

- The reliability figure gives the confidence on the success of the mission (flight).

Once the design is tested in similar flights, as mentioned earlier, what is needed in subsequent flights is the need to strictly adhere to the process and to see that there are no deviations, either in manufacturing or testing. If there is any deviation, this should be properly analysed and accepted or rejected (known as non-conformance management). The environment in which the system is required to work during flight should be checked and the system should be tested for that environment. If these are carried out and proper analysis for their acceptance for the flight is undertaken, then one will have more confidence on the success of the flight. Also, it is necessary that the quality culture be built in all the organisations involved in the development/production processes and not only in the core team/quality assurance (QA) team. It should be a closed-loop system with feedback received from the customers and also an open system wrt all reports needed for scrutiny. This assures success.

6. QUALITY MANAGEMENT SYSTEM

To introduce the ISO 9000 at the Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, there were many questions raised about its relevance to ISRO. One important aspect of ISO is the need to have a quality management system (QMS). ISO 9001:2000 stipulates the requirements of QMS. Question frequently asked would be–what is real meaning of quality management system? Does it mean management aspect of the quality of the organisation or the quality management as a system? The answer is important, since if it is the management of quality, then ISO has no business to tell the organisation how to run an organisation wrt quality and how to organise quality in an organisation. The answer is that ISO does not, in anyway, manage the quality system of an organisation.

A quality system, as mentioned earlier, consists of not only quality control but all aspects of the organisation affecting the quality of the product. This includes management aspects, planning, review, and quality assurance, and quality improvement. It is the total system with all limbs of the organisation as elements or states, and the output being the product meeting the customer's requirements. The feedback in the system is the customer's feedback wrt the quality of the product (for example: Its specifications meeting the customer's expectations). The system needs to continually (dynamically) changing (improving) to meet the customer's requirements. In this context, quality has two meanings[1]:

(i) Quality means those features of the products which meet customer's needs, and thereby, provide customer's satisfaction.

(ii) Quality means freedom from deficiencies–freedom from errors that require rework, or that result in field failures, customer's dissatisfaction, customer claims, and so on.

A quality management system is the organisational structure or managerial processes which enables the organisation to produce a quality product. Managing for quality makes extensive use of the three such managerial processes–quality planning, quality control, and quality improvement. These processes are known as Juran trilogy[1].

However, in the context of ISO, there is a fourth element, namely the quality assurance, which is focussed on providing confidence that quality requirements will be fulfilled. These four elements along with quality policy and quality objectives form the basic requirements of the QMS. The QMS approach* encourages the organisation to analyse the customer's requirements, define the processes that contribute to the realisation of a product which is acceptable to the customer, and keep the process under control. The QMS can provide the framework for continual product

* A pamtop handbook on ISO 9001:2000, concept and clauses, designed and compiled by ISO 9000 Cell, Systems Reliability, VSSC, Thiruvananthapuram, 2002. (for internal circulation only).

improvement, which in turn gives confidence to the customers that the organisation is able to provide products that consistently fulfil their requirements. Implementation of a QMS in an organisation involves determining the needs and expectations of the customers, determining the processes and responsibilities to attain the objectives, providing resources, measuring effectiveness and efficiency of each process, preventing non-conformances, and establishing and applying a process for the continual improvement of the QMS. How the continual improvement of the QMS is achieved in a dynamic organisation is represented in Fig. 1.

7. ISO CERTIFICATION

How ISO certification is granted to R&D organisations like ISRO and DRDO in having successful missions? ISO 9000 stipulates that the organisation should document the QMS followed in the organisation. This document is called quality manual. ISO 9000 also stipulates that the organisation structure, interaction among divisions and groups, the process details, and the review and acceptance criteria in producing the product/products, and the procedure for evaluation and continual improvements, are detailed in the quality manual. This type of quality manual with well-documented processes helps in realising the

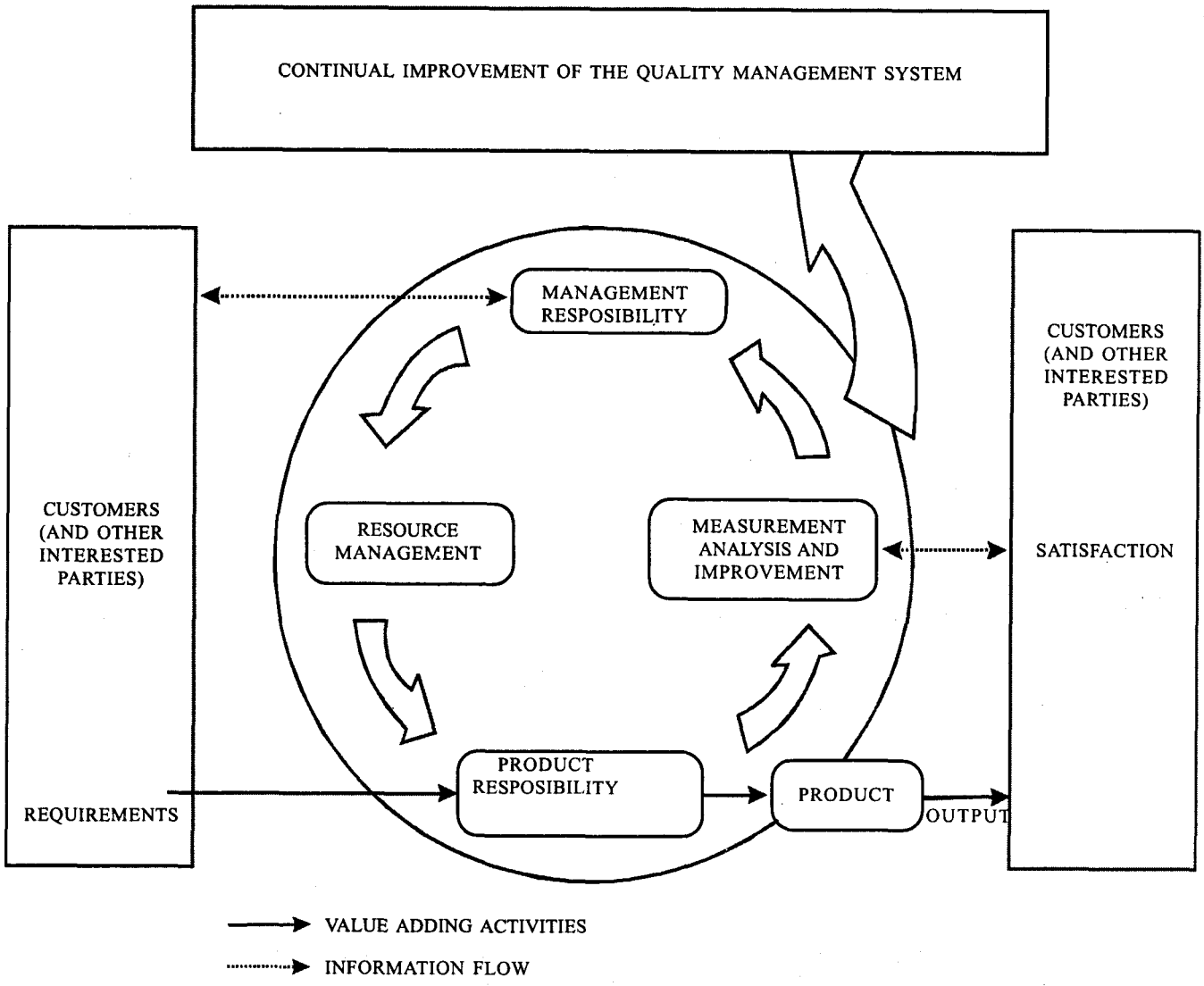

Figure 1. Closed-loop system of a QMS

product without much personality problems. Once this culture is developed, the products will have the specified quality. ISO 9000 also helps in checking these requirements in the organisation (once it is properly documented in the quality manual of the organisation) in realising the product. The required quality attitude is achieved through this approach for producing the quality product.

As per personal experience of the author, the change in the organisational perspective was felt with the introduction of ISO 9001:2000/QMS at the VSSC, Thiruvananthapuram. It is a matter of pride that VSSC, the leading R&D centre for rockets and launch vehicles, has a number of successive successful launches since the last eleven years. The changes were slow with the initial reaction being more bureaucratic than technical. It involved a lot of additional paperwork which engineers started doing reluctantly initially. After initial hiccups, it was found useful in generating better technical process documents, detailed test plans, review documents, process drawings, closure of failures and non-conformances. A few improvements in these areas were visibly seen during the tenure of the author as Dy Director, Systems Reliability Entity.

8. QUALITY IS OUR MANTRA

The author happened to visit a private software company in Bangalore in connection with a job interview for someone about three years back. After initial introduction, the lady receptionist wanted the person to be interviewed to go to the examination hall. She called the watchman loudly saying 'Watchman No. 2, take this person to room number 101'. A man with *khaki* dress appeared and saluted the person and asked the person to follow him. After the examination, the author asked the person about the examination. The person was almost in tears and told him that the test was very bad and the person could not answer many questions. The question paper was cyclostyled and cyclostyling was so bad that he could neither read the questions nor the multiple choice answers properly. There was nobody nearby to clarify. The test was a total fiasco. When they were about to leave, the author saw a slogan written in capital letters behind the receptionist's desk, under the company's logo: 'QUALITY IS OUR MANTRA'.

The author has narrated a personal incident and has inferred the following:

- Quality system encompasses everybody involved in the organisation, from CEO to the watchman. Deming's 14 point mantra[2] stipulates this requirement. It should be practised. It is necessary that the watchman be called by his name and not as 'Watchman No.2'.
- Quality is not displaying slogans, but practising these by providing quality question paper, service, etc.
- Quality should be reflected in organisational management by having a competent human resource management system.
- Quality is not getting ISO certification, but planning engineer's growth, their road map, and practising principles of good governance in addition to software quality assurance requirements.

The author commented on few good things about quality system of many software companies in Bangalore or elsewhere in India. Those companies, which have survived, have improved a lot wrt quality and established a quality system in their organisations. Many have taken up quality improvement programmes and total quality management (TQM), and have established themselves as good companies in terms of human resources and technical competence.

9. RECOMMENDATIONS

Based on the experience at the ISRO, the author has suggested the organisations to follow the guidelines given below in introducing and managing QMS:

- A thorough and comprehensive quality manual should be prepared, by the organisation, whether it needs ISO certificate or not. The manual should reflect the process, management aspects, quality control/quality assurance aspects, and

quality improvement methodology, among other things.

- The top management should review QMS periodically and ensure its implementation in true spirit.
- ISO 9000 is a tool which ensures better QMS in the organisation which will be accepted by pier organisations, resulting in wider acceptability of the company's products.
- The customers, quality assurance people, and others associated with the product should be encouraged to provide feedback to the organisation and the analysed feedback should be used to improve the quality system.
- QMS should reflect the culture of the organisation.
- QMS has to involve everybody in the organisation
- ISO 9000 does not manage the quality. It provides a certification that quality system, as stipulated in the quality manual, is followed in the organisation and continual improvement is taking place in the organisation.

10. CONCLUSIONS

A few aspects of QMS have been highlighted. It emphasises the fact that quality system in an organisation should cover all aspects of the organisation affecting the quality of the product it develops like management, process, persons, reviews, and the continual improvement methodology. ISO 9000 helps the organisation to ensure that such a QMS is followed in realising the product. ISO does not and will not manage quality system in the organisation. Quality of the product depends on the design robustness, process, and deviations in its specifications. Once the design is proven in the development flights, successful mission can be achieved by maintaining the quality and adhering to the process. Reliability tools are required to be used in the design, and later, to gain confidence in the launch success. Quality of the product cannot be achieved through slogans, but through rigorous implementation of QMS. One can conquer through competitiveness, and the competitiveness comes only through quality.

ACKNOWLEDGEMENTS

The work reported here is based on the experience of the author during his tenure at the ISRO, Thiruvananthapuram. He wishes to thank Shri G. Madhavan Nair, presently, Chairman ISRO, who was the Director, VSSC when the author was Dy Director, Systems Reliability Entity at the VSSC. The author also wishes to thank Shri Sojan Thomas, GD, QSMG, SR, VSSC for his useful comments on the draft copy of the paper. He wishes to acknowledge support given by the authorities of Narvik University College, Narvik where he is presently a Visiting Professor, for enabling him to prepare this paper.

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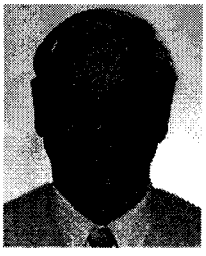

Dr Sudhakara Rao after getting his PhD (Systems Science and Engineering) from Washington University, USA, joined Control, Guidance and Instrumentation Division of Indian Space Research Organisation (ISRO) in 1971. Subsequently, he was made Head, Control and Guidance Division of ISRO. During this period, he carried out significant research work in the development of fin tip control system, autopilot electronics, inertial sensors and systems for the first satellite launch vehicle, SLV-3. In 1981, he was promoted to Dy Project Director of PSLV project and made responsible for mission analysis and synthesis, guidance and control systems, and simulations. The developmental efforts in these areas called for systems approach, which he effectively applied in the successful development of PSLV. PSLV launches were successful in 1994 and 1996 under his able guidance.

In 1996, Dr Rao was made Associate Project Director of GSLV project designed to launch satellites in geo-stationary transfer orbit (GTO). He was responsible for the realisation of GSLV vehicle and mission. He successfully integrated the efforts in the multidisciplinary areas of navigation, guidance and control, mission analysis and simulations, cryo systems, and project management in realising the PSLV vehicle. He was the Vehicle Director for GSLV-D1 mission launched successfully in 2001.

From 2001 till his superannuation in 2003, he was Dy Director, Systems Reliability Entity of Vikram Sarabhai Space Centre (VSSC). He directed R&D in systems reliability and provided reliability and quality assurance (R&QA) support to various projects. He was also instrumental in the implementation of ISO 9000:2001system at the VSSC.

Dr Rao is INAE Distinguished Visiting Professor at the Indian Institute of Technology Bombay, Mumbai and Anna University. He has presented/ published about 20 papers in national/international conferences and journals. He was awarded *Dr Biren Roy Space Science/Design Award* (2001)by the Aeronautical Society of India. He was presented with *Significant Contribution Award* (2003) by the Society for Aerospace Quality and Reliability, for his significant contributions in systems engineering and R&QA. He is a fellow of the Aeronautical Society of India, a life member of the Astronautical Society of India, the Systems Society of India, and Society for Aerospace Quality and Reliability.

Dr Rao was re-employed by ISRO as Visiting Scientist at ISRO Satellite Centre, Bangalore, during 2003-04. He was engaged in the review of launch vehicle systems at VSSC, R&QA at ISAC, and assisting ISREL Office at ISRO Hqrs in generating standards.

Since September 2004, he is employed as Visiting Professor in the Department of Aerospace Technology in Narvik University College, Narvik, Norway.