# Quality Management Systems in European Industry and the Importance of Modern Technology and Metrology

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***Abstract:*** *Quality management plays together with highly sophisticated metrology a key role in enterprises and factories of modern industry. In the up-to-date world of global competition for the realisation of advanced high quality products quality management is based on collection, transfer and evaluation of measurement data. Besides of the use of modern information technology it is of great importance to apply artificial intelligence and modern measurement technology.*

***Keywords:*** *Quality management, quality assurance, metrology, enterprise integration, factory automation, multi functions products, intelligent metrology*

## 1 Introductory Remarks

Competition and cost consciousness on the one side an increasing demand for quality and reliability on the other side are contrary requirements in present production engineering. This must be considered also from the point of view of the international standards about quality management and quality assurance.

The origins of quality management and quality assurance in a modern sense began in manufacturing organizations at about the beginning of the twentieth century [1], and many of the tools for quality analysis and improvement were developed for manufacturing problems. Through the 1980s, this manufacturing emphasis dominated the profession. In the late 1980s and into the 1990s, business began to recognise the importance of quality service in achieving customer satisfaction and competing in the global marketplace. In the late 1990s also the public domain and governmental departments became aware of the general importance of quality issues. In a very important sense, this recognition has expanded the definition and concept of quality to include nearly any organisational improvement such as the reduction of manufacturing cycle time and improved worker skills. And also the

public sector is now starting to take care of quality management within its structures.

In addition to industrial organisations and the manufacturing industry also service organisations build up quality systems. Ancillary services in manufacturing companies as well as "stand-alone" service organisations such as hospitals and banks are beginning to realise the benefits of a focus on quality.

## 2 International Understanding of Modern Quality Management

Quality is the responsibility of everyone within the organization, from the chief executive officer to the operators on the production floor. People such as machine operators, assembly workers, ticket agents, nurses, and waitresses are the craftspeople who build quality into products and services. First-line supervisors must provide the motivating climate for employees, direct them in proper procedures, work together with them to locate problems, and assist in eliminating sources of error. Middle management must plan, co-ordinate, execute, and monitor quality policy. Finally top management must commit the resources and provide the leadership necessary to set the tone and carry out the requirements of an ongoing, dynamic policy in respect of technical quality.

The modern philosophy of handling quality aspects was created in principal by the work of Frederick W. Taylor, the “Father of Scientific Management” at the beginning of the twentieth century [1]. By decomposing a job in manufacturing industry into individual work tasks, inspection tasks were separated from production tasks, which led to the creation of a separate “quality department” in production factories and therefor to the first steps of developing the modern understanding of quality and the closely related activities of quality control, quality assurance and quality management and especially also to Total Quality Management [2].

In every organisation, effective quality management has to be a total, company-wide effort that is aimed at the avoidance of problems through the
- planning and engineering of processes, methods and products,
- identification of problems that inevitably will arise and the correction of these problems and
- continuous improvement of quality performance.

The International Standards of the "ISO 9000 Family of Quality Management Systems Standards" have been developed [3] in several editions and are still improved [4] to support organisations to rationalise communication and competitiveness in national, regional and world wide international trade. The whole system has several control loops integrated in each other. Improving the

speed and the quality of the information flow, and response characteristic are the main stimuli. With the possibilities of contemporary information technology, data flow management contributes imminent steps against bureaucracy and heavy documentation of the quality management system.

The scope and the structure of quality systems and also of quality management standards should be formed on the basis of an integrated system of quality principles as shown in Figure 1.

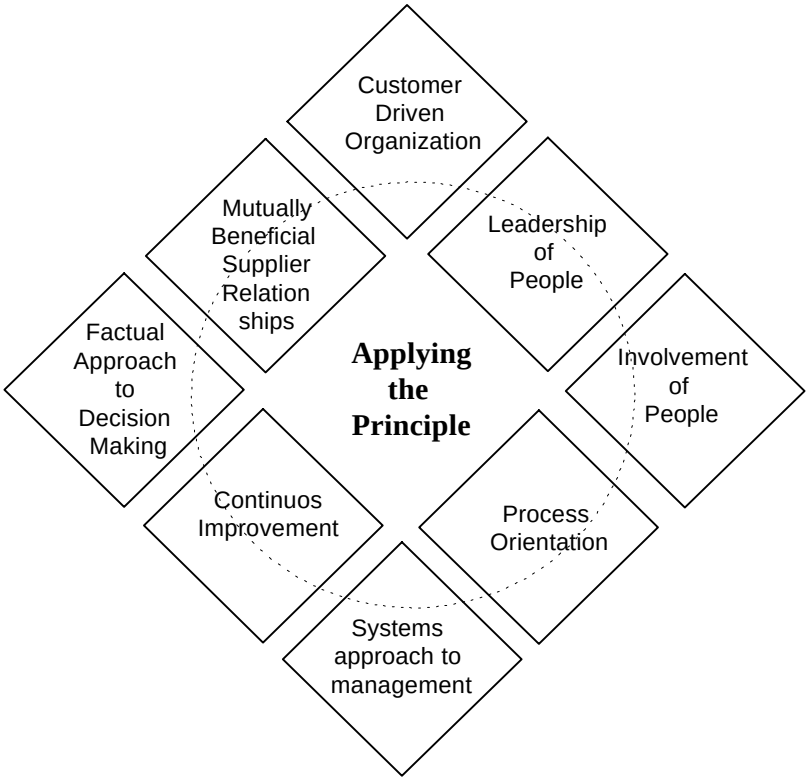


Figure 1: Applying the Quality Management Principles to the Executive Management Area of Strategic Planning

In addition to Figure 1 the general quality management principles are listed as follows giving also some specific information:

Principle 1. Customer-driven organisation: Organisations depend on their customers and therefore should current and future customer needs, meet customer requirements and strive to exceed customer expectations.

Principle 2. Leadership of people: Leaders establish unity of purpose, direction, and the internal environment of the organisation. They create the environment in which people can become fully involved in achieving the organisation's objectives.
Principle 3. Involvement of people: People at all levels are the essence of an organisation and their full commitment enables their abilities to be used for the organisation's benefit.
Principle 4. Process orientation: A desired result is achieved more efficiently when related resources and activities are managed as a process.
Principle 5. Systems approach to management: Identifying, understanding and managing a system of interrelated processes for a given objective contributes to the effectiveness and efficiency of the organisation.
Principal 6. Continuous improvement: Continuous improvement is a permanent objective of the organisation.
Principle 7. Factual approach to decision making: Effective decisions are based on the logical and intuitive analysis of data and information.
Principle 8. Mutually beneficial supplier relationships: Mutually beneficial relationships between the organisation and its supplier enhance the ability of both organisations to create value.

Especially the new ISO 9000 series of international standards with its orientation to processes gave a useful frame for the development of quality management systems. Figure 2 shows the model that can be used for building up a "Process-based Quality Management System" [4].

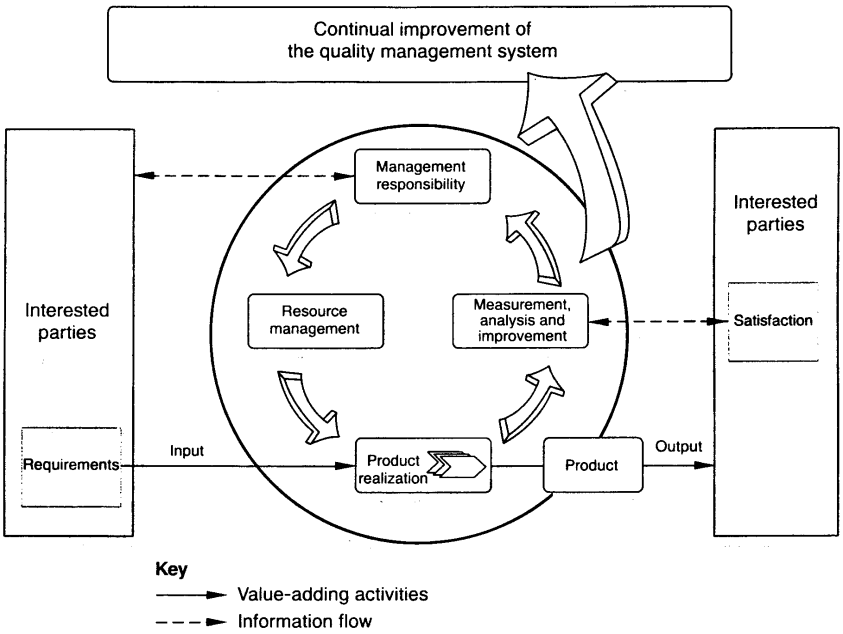


Figure 2: Model of a Process-based Quality Management System [4]

Most important is that a main concern of an organisation's quality management system has to be that the customer's needs and expectations are met. Therefor a quality management system is mainly influenced by the objectives of the organisation and by the practices and processes specific to the organisation.

If this is taken into consideration organisations in all possible areas – industry and economics in general, private and in the public domain – within whole Europe but also world wide are under way to improve the economic situation. Dedication to quality thinking and understanding makes possible to be successful economically in our time of world wide competition. This may help also to create an environment of social welfare, peace and security.

# 3 Quality Management and Metrology in Modern Manufacturing Industry

The automation of quality control and metrology is particularly under the point of view of the productive power of essential meaning whereas flexibility must be considered as an important boundary condition. In an industrial environment of computer integrated and intelligent manufacturing it is necessary that measurement technique can be adjusted flexibly to changing task designations. Appropriate solutions can be found with the help of flexible intelligent measuring cells and their components [5].

To meet high-level demands for comfortable daily life in the future, manufacturing enterprises must be flexible and agile enough to quickly respond to product demand changes, and new models and configurations for future manufacturing systems and enterprises need to be investigated [6].

Multi-Functions Integrated Factory (MFIF) is an innovative concept and model for future enterprises and is initiated with the aim to provide cost-effective, agile and optimum ways to produce customer-driven Multi-Functional Products (MFPs) in the near future, based on intelligent production technology and especially the information highway making possible the application of intelligent metrology at world wide distributed factories on the basis of advanced engineering data exchange techniques.

Figure 3 illustrates in principal how Intelligent Computer Aided Quality Control ICAQ and metrology can be integrated into modern industrial plants.

Automated measurement technique closes quality control loops in production, in that an early recognising possible reasons for rejections together with an analysis results the improvement of manufacturing processes and preventive corrections can be introduced. For the draft and the completion of workpieces experimental values and expert knowledge of geometric deviations facilitate the discovering of

meaningful strategies [7] therefore the demanded workpiece accuracy can be achieved under an economic point of view.

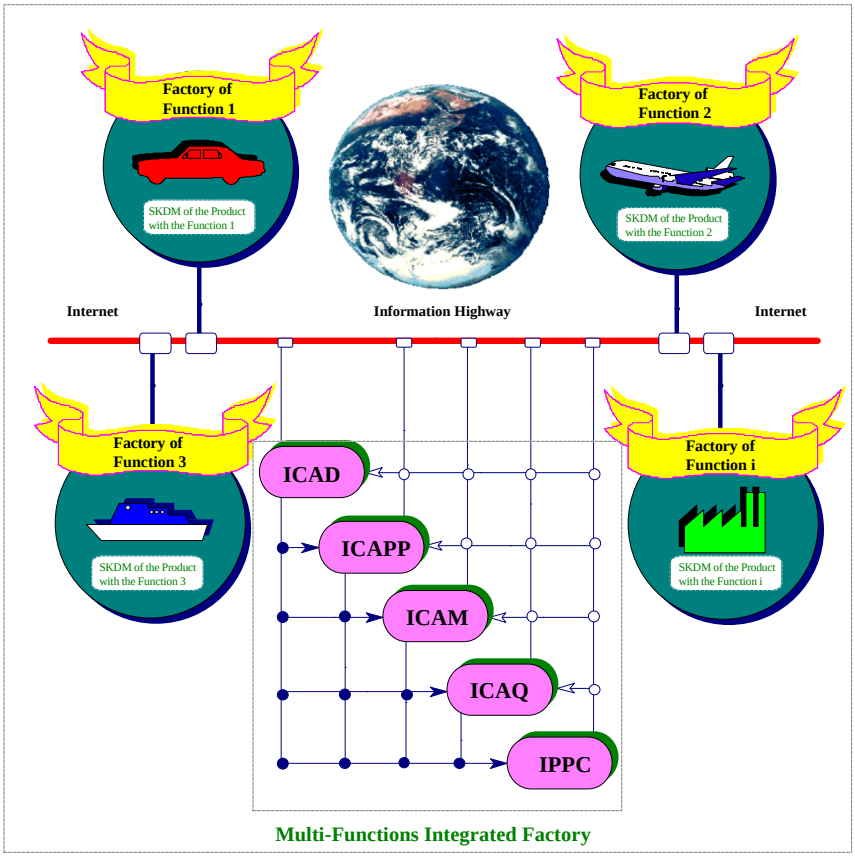


Figure 3: Integration of Intelligent Computer Aided Quality Control ICAQ and metrology into modern industrial structures

# 4 Sophisticated Metrology for Quality Control and Quality Assurance

Quality control and quality assurance in modern manufacturing industry is based on intelligent metrology with e.g. intelligent co-ordinate measuring machines to test the product or to scan and digitise complex product models with freeform surfaces, in order to obtain the digital model of the product and to modify it in a CAD system. On that basis a new modified freeform surface model is created and CNC programs for manufacturing the end product by machine centres in the workshop.

An area with growing importance of co-ordinate metrology in general is for biomedical application. Figure 4 shows as example the carried out measurement of an artificial tooth for implantation in human jawbones.

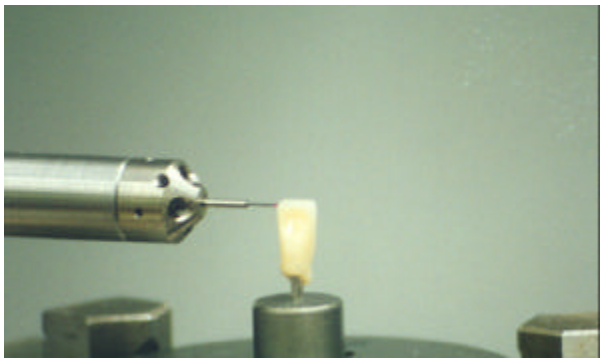

Figure 4: Measurement of an Artificial Tooth for Implantation

The practical application of co-ordinate metrology can be supported by off-line programming systems based on 3D-CAD. By that means the stylus configurations will be chosen automatically or by the operator using an already existing stylus and probe database. The operator can call all regular element measuring functions and the actual data evaluation functions, using main dialogue menue of the programming system. On this basis measuring programs and the probe paths can be simulated, edit and optimised. During the simulation a CNC measuring program is generated in a specific format. Additionally a collision control function is realised through simulating the measuring processes on the computer monitor (Figure 5).

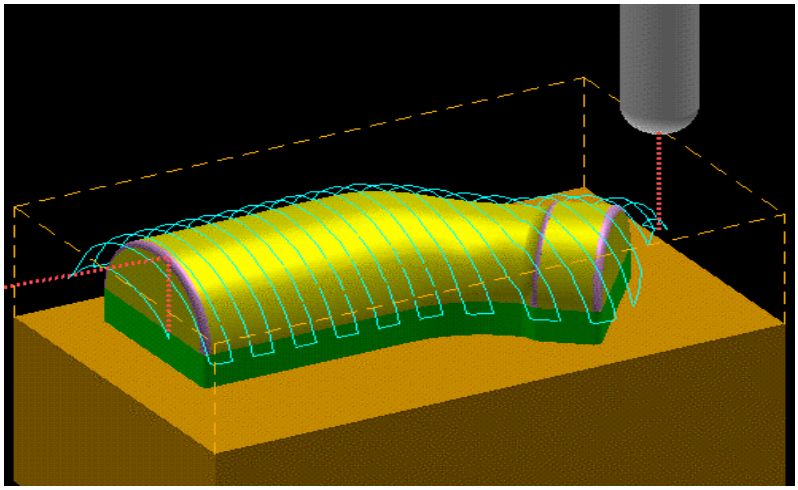

Figure 5: Simulation of CNC measuring process

Intelligent co-ordinate metrology is a very important tool to solve various problems of quality management and quality assurance in modern production especially when high flexibility and high accuracy are demanded. This way of metrology is the up-to-date measuring method for complex dimensional and geometrical measuring problems as there are for instance shoemakers lasts as shown in Figure 6.

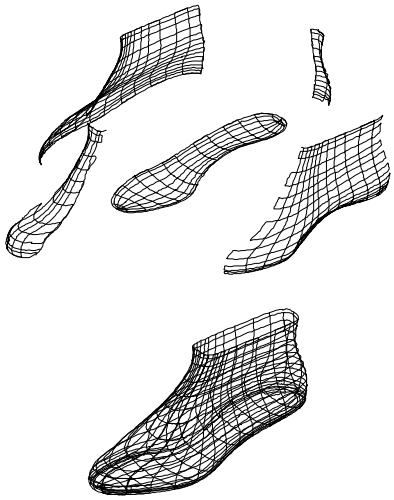

Figure 6: Complex dimensional and geometrical measuring model by using CMM

# 5 Optoelectronic and Nanotopographic Quality Control

Optoelectronic methods are of continuously growing importance as tools in modern computer integrated production plants and also as basic tools for intelligent quality management and quality assurance activities. Their efficient use and correct calibration are crucial requirements for quality management in this environment.

Precise knowledge of the boundary conditions must be presupposed for efficient optoelectronic measurements. Variations in colour, surface finish and cleanliness of the object to be tested show considerable influence on the measurement uncertainty. For calibration and reference measurements contacting methods are necessary.

Optoelectronic methods of quality control are besides co-ordinate metrology very important optical and electronic measurement methods of dimensional and geometrical workpiece metrology.

Nanotechnology describes new innovative manufacturing technologies, finishes, tolerances and measurement technique in the nanometer range [8, 9]. In the field of nanotechnology at the atomic scale there are similar demands for resolution because of the need for information of the shape of small structures and the shape of for instance cells, molecules or atoms. With scanning tunnelling and scanning probe microscopes lateral resolutions up to 10 nm and in vertical direction up to atomic resolution are achieved (Figure 7).

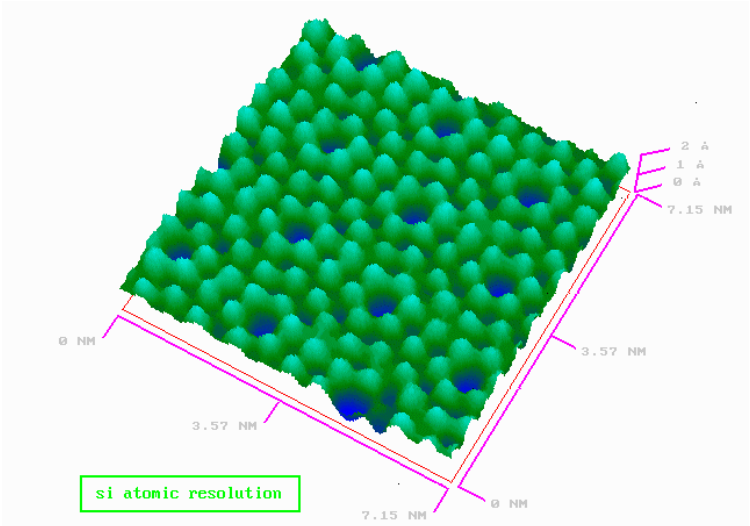


Figure 7: Atomic Structure Topography Obtained by Scanning Probe Microscopy

As additional example the following Figure 8 shows the measurement data of a small part of an integrated electronic circuit.

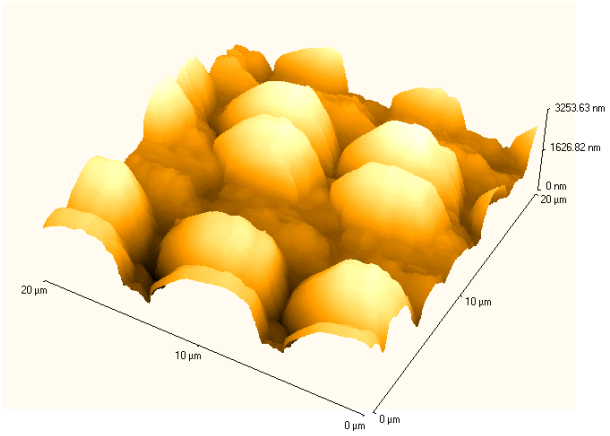


Figure 8: Measurement data of an integrated electronic circuit

# 6 Intelligent Quality Assurance Cell

For the intelligent flexible automation of quality management and assurance, measurement data collection and data evaluation in modern industrial enterprises an intelligent quality assurance cell is proposed as shown in Figure 9.

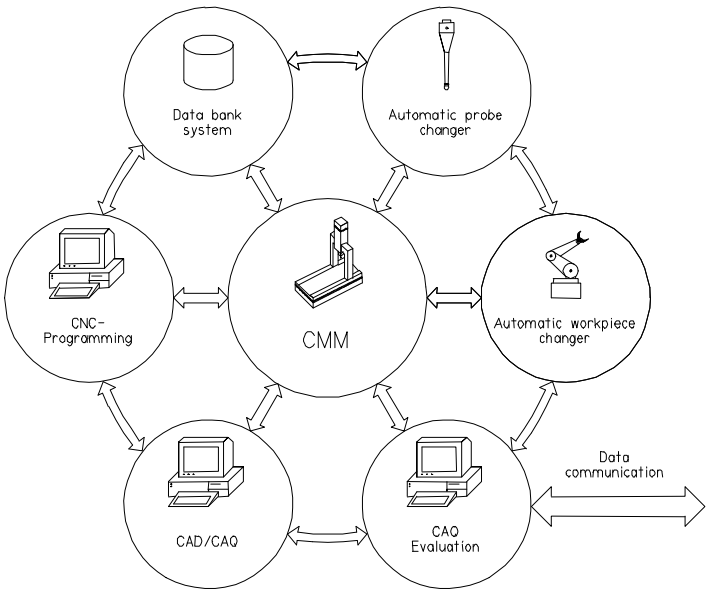


Figure 9: Intelligent Quality Assurance Cell, Scheme

The various tasks to be solved by such a measuring and evaluating system are:
- automatic intelligent measurement by using CNC measurement programs,
- off-line CNC programming of measurement devices,
- automatic changing of workpieces,
- automatic probe changing,
- automated evaluation of measuring results.

An intelligent measuring cell according to the above given definition consists of a series of devices and components:
- a local area network of various PCs especially for CAD, CAE and CAQ evaluation,
- a precision intelligent CNC dimensional measuring equipment with control computer,
- a stylus changer with interface and control computer,
- a robot for workpiece manipulation,
- various measuring instruments, for instance a small CMM and other devices,

- an atomic force microscope to evaluate surfaces in the submicrometer range,
- printers for data and graphic output,
- database systems for construction data, measuring results, quality data etc.

The proposed solution can be seen as a further step with the goal to achieve intelligent and economical manufacturing, inspection and quality management in modern industry, especially in small and medium sized enterprises, and to find flexible solutions for all kinds of measurement and quality management problems in an automated intelligent manufacturing environment.

**Concluding Remarks and Qutlook to Future Developments**

The international standardisation on quality management systems references to the fundamental and general trend to higher expectations on quality. General experience confirms it also again and again that it is only possible through continuous efforts and improvements to achieve high productive power as well as high quality production processes and to receive upright. The dedication to quality can thus be seen thoroughly as fundamental element for just this productive power of industrial enterprises and in general economic organisations.

Quality management is much more than highly sophisticated metrology. But only on the basis of intelligent measurement technique, modern information technology as well as intelligent measurement data collection and data evaluation and supported by the information highway it is possible to achieve high quality production processes and to realise high technology products.

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