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Quality Management Systems and Information Systems: Getting More than the Sum of the Parts

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ABSTRACT

Companies are increasingly concerned with quality management of their products and services. Holding a quality certification, such as ISO 9001:2000, is becoming a compulsory requirement to play in selected markets. Designing a quality management system requires the extensive involvement of staff and managers and the analysis and redesign of business procedures. Interestingly enough, very similar requisites and tasks characterize enterprise systems design. However, the two endeavors are systematically conducted as separate projects, which are handled by different teams, equipped with unconnected methodologies. We present the first results of an approach we are developing to simultaneously address the design of the Quality Management System and of the Enterprise System. We identify the important synergies between the two initiatives, with the ultimate goal of creating a streamlined match between business processes and information system support, so that, when the project is finished, we can get both a fully operational information system and an officially certified quality audit for the whole enterprise.

Keywords

Information Systems, Quality Management Systems, Synergies

INTRODUCTION

Quality Management of products, services and business processes is, today, a key issue in the success of most companies operating in global contexts. In fact, quality certification, such as established by ISO 9000 standards, is becoming a basic requirement for companies to play in some international markets.

On the other hand, the development, implementation and deployment of enterprise architectures, and of the underlying information systems infrastructures, is another critical aspect. It is quite surprising, thus, that in spite of the fact that both quality management and enterprise architecting require intensive strategic analysis and requirements engineering, the two processes tend to be looked as completely distinct. In some organizations, they are even carried out in succession with no interaction between the corresponding teams taking place.

Note that we are not referring to the need of having information systems designed with their intrinsic quality in mind, nor to the localized use of software to support some quality issues (such as statistical control). Those are completely different issues. We are referring to a deep integration between the organization's Quality Management System and Information System, in a manner that they depend on, support, and reinforce each other.

The likelihood of synergy between quality management and IT infrastructure has already been suggested by a few authors, such as Fok and Hartman (2001), Ahamed and Ravichandran (1999), Chou, Yen and Chen (1998) and Woodall, Rebuck and Voehl (1997). However, no systematic processes for leveraging those apparent synergies could be found in the literature.

What if, after developing, implementing, and deploying the broader enterprise architecture (including the information system component), the corresponding business processes immediately became ready for Quality audit by a certification authority? What if a quality management system could quickly be derived from the existing enterprise architecture? What if the organization, after being officially certified for Quality, could more easily derive an enterprise architecture and underlying information system?

This paper presents the first results of a research project aimed at creating a methodology capable of simultaneously designing the Quality Management System and the Information System, tightly intertwining the two to achieve more than the sum of the parts.

In the next section we briefly describe our research approach. Then, we move on to introduce the key concepts in the design of a quality management system for an organization. In section 4 we briefly outline the methodology we use to establish the enterprise architecture of an organization and its supporting information system blueprint. This serves as a common ground to explain, in section 5, how this methodology is being extended to encompass the simultaneous design of quality management systems. We close the paper with a discussion and several indications of future developments.

RESEARCH APPROACH

Creating a new systems development methodology, or making changes to an existing one, is impossible from a socio-organizational viewpoint without intervening in the real word to test it (Baskerville, 1999; Baskerville and Wood-Harper, 1996). Moreover, a responsive and flexible posture is vital during such interventions, to ensure that the knowledge built through practice shapes the methodology. Few research approaches can be legitimately employed in such a context, since the principles on which most of them base their rigor and validity – problem decomposition, standardization of procedures and collection of rigorous quantitative measures under the control of independent researchers – become unfeasible. As argued by (Baskerville and Wood-Harper, 1996), action-research can meet this challenge.

The cyclic nature of action-research is one of its main pillars of rigor and validity (Dick and Swepson, 1994; Baskerville and Wood-Harper 1996; Dick 1997; Lau 1999). The theory under development is tested and refined iteratively, in various field situations. In each cycle the researcher systematically tries to disprove it by deliberately seeking divergent data and focusing on disagreements with previous cycles. At the end of each cycle, a critical reflection on the process is carried out, leading to insights and adjustments that feed the subsequent cycles, and expectedly strengthen the theory.

As discussed in (Cunha and Figueiredo, 2002) these characteristics make action-research a privileged instrument for inquiry within the epistemological framework of critical rationalism (Lecomte, 2000). Karl Popper, the modern founder of critical rationalism, claimed that for a theory to be scientifically valid, it needs to be simultaneously falsifiable (lending itself to verification or confrontation with facts that may eventually show it as illegitimate) and not yet falsified. It is, thus, of essence to use a research approach that systematically tries to disprove the emerging theory. According to Popper, scientific progress stems from the rejection of less satisfying theories and their replacement by others that resist best the criterion of falsifiability (Popper, 1982).

Since our aim is to create a methodology for the simultaneous design of the Quality Management System and the Information System, we organized our work as a series of action-research cycles. It is our intention to use the various iterations, in diversified client settings, to refine the initial set of ideas and practices into a coherent body. So far, a first, cruder, cycle has been completed, and the findings are described in section five of this paper. Meanwhile, two new cycles have been initiated, in parallel, in two different organizations, as illustrated in Figure 1.

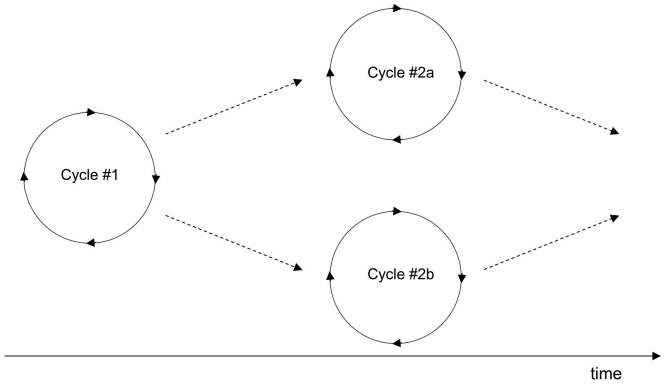

Figure 1. Organization of action-research cycles in the study, so far

QUALITY MANAGEMENT IN ORGANIZATIONS

Manufacturing a product or providing a service involves a series of activities that must be carried out in an organized manner. However, many companies are unable to exhibit any document describing those steps. Even worse, if asked to write one down they will probably face much hesitation and disagreement when trying to consolidate the views of the different people involved. An after sales process of "servicing a faulty product", for example, might reveal several discrepancies, from the moment of the first contact by the customer (e.g., in the degree of collected diagnostic information and the format of the

document used for that effect), through solving the problem (e.g., in judging the pertinence of contacting the customer), to conclusion (e.g., to inform the client or to wait for his/her call).

A quality management system ensures that products or services are always consistently supplied, meeting customer and applicable regulatory requirements and seeking to enhance customer satisfaction. It can be set up by following guidelines provided in standards, such as the ISO 9000 family. Conformance with the standard can then be audited and certified by independent authorities, providing recognition from customers, business partners and the general public.

In a simplistic way, setting up a quality management system is about: writing down how things are to be done; doing things the way they were written; and providing evidence of both.

More specifically, when adopting the ISO 9001:2000 standard, the following documents must exist:

An explicit statement regarding the company's Quality Policy and Objectives, used for overall orientation of the quality management effort. This is usually closely tied with the strategic definition of the company's mission and aims (Ward and Griffiths, 1996).

The Quality Manual, a central document that states which company processes are considered under quality management (e.g. "procurement", "sales", "after sales service"), the interactions between these processes, and the procedures that make them up (e.g. "receive faulty product", "repair faulty product", "deliver serviced product"). For the detailed description of each procedure, a flowchart of activities and a textual description is used. Responsibilities for the various activities are clearly assigned. The procedure descriptions can be moved to separate documents, as long as a reference to those documents is kept in the Quality Manual.

Also required, to comply with the standards, are the Models of all the documents used by the procedures, to ensure that the information flows in the organization use standard, consistent, templates.

Finally, the last kind of documents required by ISO 9000 is Records – filled-in Models that result from the normal operation of the procedures, according to the descriptions that were written down. Records are of key importance, since they represent evidence, to the auditors, that the procedures are, in fact, being followed.

Since the quality management system relies on these various documents, strict control is exerted upon them throughout their lifetime. Clear procedures for approval, versioning, reviewing, updating, distributing and retiring a document are required by the standard.

Although a company can exercise judgment on whether to put some areas of its business under the control of the quality management system, some other areas are mandatory, and result from international consensus on the good management practices built into the ISO 9000 family. Figure 2 shows how these mandatory areas fit into the overall quality management system (IPQ, 2000).

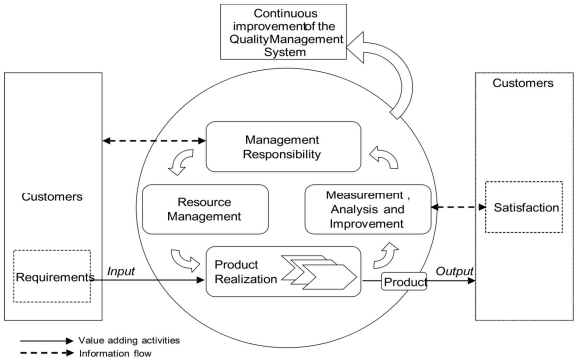

Figure 2. Model of a process-based Quality Management System (adapted from (IPQ, 2000))

Management Responsibility defines their role in the quality management system. Resource Management lists requirements for dealing with personnel, training, the facility and work environment. Product Realization addresses the manufacturing of the product or the delivery of service, including planning, customer related processes, design, purchasing and process control. Measurement, Analysis and Improvement accounts for the requirements of monitoring and improving processes.

It should be noted that, although ISO 9000 standards are often said to inhibit the organization's flexibility to change, that judgment usually results from a static interpretation of quality management, ignoring that continuous improvement is an

integral part of the standards. In fact, the underlying philosophy of ISO 9000 is the "plan-do-check-act" cycle – Figure 3 – originally proposed by Shewhart (1939), and later popularized by Edwards Deming. Quality Management is, thus, a continuous and evolutionary process.

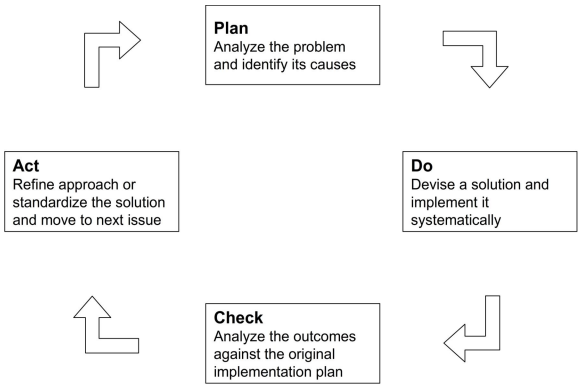

Figure 3. Shewhart/Deming plan-do-check-act cyclic model

Another common criticism to ISO 9000 is that it causes a significant increase in bureaucracy, namely in the amount of documents generated by the quality management system (Seddon, 1997). A considerable part of these documents are records, the filled-in models that must be created for evidence. Additionally, some overhead is introduced when paper-based solutions are used, as some excerpts of information that could otherwise be retrieved from a database have to be written by the user for every instance of a record. This reliance on paper-filling results, however, from a misinterpretation of the standard, which is clear in stating that all documents can exist in electronic format as long as they are legible, identifiable and retrievable.

ENTERPRISE ARCHITECTURE AND INFORMATION SYSTEMS

Our description of how quality management systems and information systems can be designed simultaneously, in an integrated manner, requires a brief description of our approach to establish the enterprise architecture and define its supporting information system, which is summarized in Figure 4 (Cunha and Figueiredo, 2000, 2001). It starts with the Strategic Analysis of the business, from which the business model and corresponding Business Architecture are derived. The Business Architecture is then used to build the Information Architecture, which, in turn, leads to the Enterprise Wide Technical Architecture & Application Portfolio. Feedback paths between the first three stages make possible the tuning and refinement of their outputs. The whole cycle closes to enable new cycles of Strategic Analysis, Business Architecture, Information Architecture, and Technical Architecture & Application Portfolio to be repeated continuously, in a permanent effort to achieve continuous improvement. Some such runs may take months of serious development, implementation and deployment, but others may take no more than a couple of hours, in a quick brainstorming session to carry out some organizational tuning.

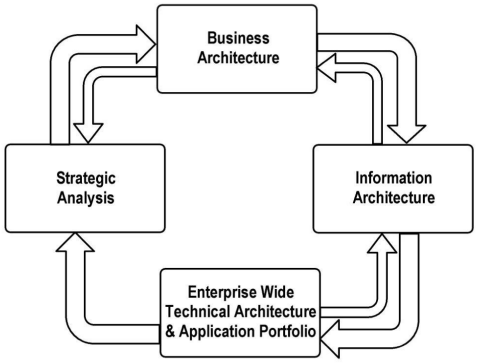

Figure 4. Cycle for establishing the enterprise architecture and underlying information system

With most organizations now developing their information systems solutions for a wired economy, business modeling is becoming a most central part of project development, with model-based technologies actively sought to develop faster and in a controlled manner (Kruchten, 2000). In this new approach, CEOs and marketing directors are expected to be deeply involved in developing the models, rather than just giving broad instructions to "'business domain experts' that might have

known how business is run but were not empowered to make decisions about changing it" (Kruchten, 2000). Indeed, business development is becoming more and more a reflection about the nature of the business and the way it should be run, involving "people from the various parts of the organization, from executives with the power to make decisions, to 'grass roots' and end users who feel the consequences of those decisions" (Kruchten, 2000). This is the major concern of the Business Architecture phase of our cycle. Although, to keep text within manageable proportions, we will not enter into the details of the cycle, it is essential to stress the critical importance of basing upon simple concepts and natural language tools the dialog that occurs between experts, executives, "grass roots" and end users.

Two additional factors played a decisive role in shaping our approach. On one hand, present day information systems have been mutating from fairly homogeneous software solutions into heterogeneous portfolios of applications, where systems of various ages, from different vendors, and based on different technologies coexist to support the diverse business needs. On the other hand, intranets and extranets have become increasingly important dimensions of the information system, as they leverage the information held by heterogeneous systems and enable it to be exchanged, both internally and with other stakeholders in the organization's value network.

This reality calls for high granularity "blueprints" for the information systems architecture, so we have centered our approach on two key concepts: "business entities", and the "responsibilities" for which those entities are accountable. "Business entities" can represent several realities, ranging from clearly defined "divisions", typical of more mechanist organizations, to versatile configurations, or functions, or teams, or even individuals, characteristic of more organic companies. The "responsibilities" are the major "services" that business entities provide to their environment. To use such services, client entities must follow predetermined interaction protocols. For a simple illustration of the use of the two concepts, we can think of the accounting division of an enterprise as being a business entity, and the services it provides – such as "refund travel expenses" – as examples of responsibilities. The inner workings of a responsibility may be supported by full-scale applications, or ERP modules, such as financials, human resources or employee relationship management. By systematically identifying and documenting all business entities and their interactions via responsibilities, this modeling approach affords an organizational model that blends in the information system.

To ensure field instruments are accessible to executives, "grass roots" and end users, inspiration was sought on CRC cards (Beck and Cunningham, 1989; Cunningham, 1994; Taylor, 1995; Wilkinson, 1995), recognized for their pedagogic and conversational qualities and their usefulness in framing natural language descriptions of use cases (Fowler, 1997):

- Business entity cards are used to document each business entity: name, a list of its responsibilities, and its client entities.
- Responsibility cards are used to detail information about each such services: name, purpose, importance, main rules, exchanged data, business procedure to carry it out, and available information systems support (e.g. applications in use). For the last two items, both current situation and intended changes are identified, in order to facilitate the definition of alternative evolution roadmaps for different scenarios. Additionally, simple intranet/extranet prototypes can be drafted to further clarify the interaction between the responsibility and its environment.

It should be noted that even responsibilities for which no information systems support exists are documented, as their inclusion in the model affords a better understanding of the overall functioning of the organization.

The main deliverable of this approach is a report, made up of the various entity and responsibility cards. A compact disc is used to supply the intranet and extranet prototypes. The final document provides a holistic, yet manageable, view over the "whole" organization: the way it works and planned changes, both in terms of business procedures and information systems support. Open discussions about possible evolutions can take place on a permanent basis, by simple sketching new views and reflecting upon them, thus turning the design process into a light, shared, continuous endeavor.

INVESTIGATING SYNERGIES BETWEEN IS AND QUALITY – FIRST LESSONS FROM A REAL CASE

The methodology described in the previous section has been applied to several real cases since 2000, to model organizations and design their information systems. One of those cases, however, has drawn our attention to its previously unnoticed potential to simultaneously encompass the design of the quality management system. We have decided to initiate a series of action-research cycles to progressively identify the modifications and additions that should be introduced in the methodology to achieve that objective.

So far, a first, cruder, cycle has been completed in an organization that, concurrently with the information system design project we were leading, had a second team in charge of setting up an ISO 9000 quality management system.

Meetings with the quality team revealed that our information systems design methodology and their conventional approaches to the design of the quality management system had many shared activities and information requirements. Also, both projects required the sponsoring and involvement of top management and the participation of end users.

Setting up a quality management system begins with the definition of the organization's Quality Policy and Objectives. This explicit statement, where top executives describe the expected role of quality management and its contribution to the success of the organization, has very close ties with the strategic analysis of our cycle for establishing the enterprise architecture and underlying information system. The high-level directives emerging from this process then influence subsequent options and activities.

Various other intersections have been identified. Both projects needed to:

- identify how responsibilities were assigned inside the organization;
- identify and describe in detail how business processes were to be carried out;
- identify what document models were in use or needed to be defined;
- identify information flows and the business entities involved in those flows.

Some additional quality management requirements included:

- generating a Quality Manual describing all business processes under quality management control;
- generating Work Instructions: autonomous documents detailing employee activities for specific situations in more complex business processes;
- ensuring that records (filled-in document models) that provide evidence of procedure compliance were maintained;
- ensuring that relevant data was collected, to enable measurement, analysis and improvement.

As we deepened our understanding of the issues at stake, not only we realized that they could be addressed in our methodology, but it also became clear that unifying the design of both projects would lead to a tighter fit between the resulting information system and quality management system. For instance, document models – traditionally paper-based – could be smoothly replaced by their web form equivalents; in addition, authentication could be used to identify the user, retrieve contextual information and, thus, minimize the amount of data to be typed in; records would become database entries of information introduced in the web forms. Auditing would become easier if we created custom "auditor views" of the database, for inspection by internal teams and external certification authorities. Work instructions, traditionally kept in paper files, could be embedded into more comprehensive on-line context-sensitive help, weaving together application support and the business process itself.

These and other synergies are summarized on table 1.

Quality management requirement	**IS design synergy**	**Comments**
Quality Policy and Objectives	Strategic Analysis, namely mission and aims, critical success factors and strengths, weaknesses, opportunities and threats analysis.	The organization strategy and its plans for quality have direct impact on the information systems components required to support those options.
Quality Manual	New deliverable can be derived from the existing final report, produced with the methodology of section 4, provided additional data are gathered during requirements analysis.	The current report is a systems design deliverable, while the Quality Manual will be a document to be made available to the organization stakeholders.
Work Instructions	Work instructions can be derived from the methodology's responsibility cards, namely: main rules and business procedure.	In addition, the traditional paper documents can be transformed into context-sensitive on-line help that guides the user, not only in using the application, but also in carrying out

		the business process.
Document models	Web forms have several advantages over paper-based equivalents, by leveraging the advantages of having the information in digital format.	In addition, the application can handle relevant contextual information, such as user identification, date, and process history, thus minimizing the amount of data required from the user at any moment.
Records	Database records of information inserted in web forms are the digital equivalents of filled-in paper documents.	Auditing and other analysis become much easier, due to the digital nature of the data. Specific views of the databases can be customized for different purposes.
Measurement, Analysis and Improvement	Current responsibility cards can be expanded to include a section on relevant business indicators.	The indicators can be collected by the information system, either explicitly or transparently. Data warehousing and data mining components can be included in the design to enable effective analysis of those indicators.

Table 1. Summary of synergies between information systems and quality management systems design

Other possibilities afforded by the information system are of a more horizontal nature. For instance, the degree of rigidity in the execution of a task supported by the information system can be enforced in the way its workflow is designed. Document management becomes easier, since on-line web forms always represent the latest version of documents, thus minimizing the burden involved in approving, versioning, reviewing, updating, distributing and removing documents, as required by the ISO 9000 standard.

Given these apparent synergies between information system and quality management system design, close coordination of the two teams has been arranged in our first action-research cycle. Unfortunately, since the organization was going through a particularly intensive period of its life, calling for sustained attention from management, they eventually became unavailable for the quality management system project, which had to be postponed. Scarce management time was then directed toward the information system project, which had to proceed autonomously. Nevertheless, the identification of synergies with quality management was kept in our agenda.

The entity and responsibility cards of our methodology were filled in during our routine interviews with business entity heads and their appointed collaborators. As we expected from our previous experience, putting in writing some business procedures turned out to be a challenging chore. Hesitations and disagreement emerged, sometimes raising issues all the way up to top management. For part of them, the effort eventually narrowed down to clarification, while others ended up completely reengineered. Process description also involved revising, streamlining and standardizing documents in use. However, instead of paper-based models, intranet forms were sketched and the information flows between business entities was derived from the use they made of each other's responsibilities. Our process was clearly addressing some of the concerns in setting up a quality management system, namely ensuring that consistent business procedures and documents were used.

As the enterprise architecture was concluded and validated by users and top management, our initial conviction of the enormous potential of designing the information system and quality management system together had become even deeper. Stronger evidence, however, was yet to reveal itself: due to the world-wide economic slowdown, the deployment of the information system was delayed. In reaction to this setback, the users, themselves, without any specific directions from management, decided to translate the intranet web forms prototypes into more rudimentary paper-based models and started using them as described in the "business procedure" section of the corresponding responsibility definition. As a consequence, those processes became repeatable and supported on standardized documents, even before computer support was provided, and they became consistent, by quality management standards. Today, a fully operational information system brings efficiency gains to those already consistent and effective processes. Apart from the fact that digital information circulates much more quickly, the ability to integrate and cross-reference data eases up the user's role, by enabling automatic handling of relevant contextual information, such as identification, custom configuration of the form fields to fill, time-stamping, and

activity history tracking. This contextual information (e.g. name, position, department, phone, email, date…) can represent an excess of 70% of the overhead information required from the user in typical paper-based quality management systems.

We currently envision the prospect of returning to the organization where this first action-research cycle took place. Our plans include the exploration of the similarities between our cycle for establishing the enterprise architecture and underlying information system (depicted in figure 4) and the ISO 9000 plan-do-check-act cycle (depicted in figure 3). Our process has already proven its flexibility and lightness, so we expect to bring those assets to the design and evolution of the quality management system, to address the common concern that these initiatives often freeze the organization and inhibit further progress.

Two new cycles of action-research are currently in progress, in two distinct organizations, offering additional opportunities to make the methodology evolve toward an approach capable of addressing the design of both systems simultaneously. Our aim is to challenge our current conviction that, after the design process is finished and translated into an operational information system, the underlying business processes becomes immediately ready for a full audit by an ISO 9000 quality certification authority. This means that the scope of our current practice will be adjusted to encompass additional requirements of the quality standard, such as, for instance, covering specific business areas and audits.

CONCLUSION

We have presented the first results of an action-research project aimed at developing a methodology for jointly designing the quality management system and information system of an organization.

In the initial cycle we were able to see how an existing methodology for modeling an enterprise architecture and the underlying information system could address some of the key issues of quality certification. We have explored this line of research and identified a promising variety of potential synergies. The field instruments of our existing methodology have been modified to accommodate these synergies, so that they can now be put to test in future cases. Two additional cases, started recently, in two distinct organizations, are now fulfilling this aim and bringing in many additional insights.

In spite of achieving a quality certification, some companies complain that the additional bureaucracy of the quality management system decreases efficiency, mainly due to the much increased production and handling of paper. One of our main additional objectives is to overcome this drawback by designing the information system closely aligned to the quality management system.

Another common complaint is that companies become “frozen” on the first version of their quality management systems. This is mainly due to the extensive effort required to make them evolve when they are mainly supported by paper artifacts. We are particularly interested in studying how the much lighter processes and simpler field instruments of our approach fit ISO’s underlying plan-do-check-act philosophy, to effectively turn the design of the overarching enterprise architecture, in all its dimensions, including IS and quality, into a natural and permanent endeavor.

Finally, we are collecting requirements to develop a software tool to support field work. Besides helping throughout the modeling phase, that tool is likely to make possible the automated production of the documents required by the ISO 9000 standard, such as the Quality Manual of the organization.

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