A critical look at ISO 9000 for software quality management

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Received 26 November 1996

A considerable number of software suppliers report improvements in product and service quality, development costs and time to market achieved with the help of the ISO 9000 standards. Nevertheless, the ISO 9000 family has received unfavourable criticism in journals, textbooks and at software quality conferences. The paper summarizes, discusses and reviews eleven of the most popular arguments against the ISO 9000 standards. The review of the criticism is based on findings of two empirical surveys among European software suppliers that have implemented an ISO 9000 quality system. The paper concludes with suggestions and guidelines for advances in software quality management concepts, such as the ISO 9000 family, CMM, BOOT-STRAP and the emerging SPICE standard.

Keywords: software quality management, ISO 9000, criticism, ISO 9001, ISO 9000–3, ISO 9004, certification, quality management, quality systems, software process improvement, CMM, SPICE

1. ISO 9000 and software quality management

The ISO 9000 family is one of the most important standards in the field of software quality management in Europe. ISO 9000 consists of various standards:

- ISO 9000-1 provides guidelines for selection and use of the ISO 9000 standards. It describes the spirit of the standards and the key assumptions of the authors of the ISO 9000 family. It has the role of a ‘road map for the ISO 9000 family’.
- The ISO 9004 series provide guidance for quality management, i.e. for the design, implementation and improvement of a quality system. A quality system is a set of ‘organizational structures, procedures, processes and resources needed to implement quality management’ [1]. A major purpose of quality management is to improve quality systems so that continuous quality improvements can be achieved. The standards are based on the assumption that all work is accomplished by a process. Accordingly, quality management means managing all processes in an organization.
- ISO 9001, 9002 and 9003 are models for external quality assurance [2–4]. They specify a set of requirements. The demonstration of conformance to these requirements is called certification or registration. The key objective of quality assurance is to provide confidence to customers and other stakeholders that specified quality requirements will be met.
- ISO 9000-2 [5] is a guideline for the application of ISO 9001, 9002 and 9003. ISO 9000-3 [6] is a guideline for the application of ISO 9001 to the development, supply and maintenance of software.
The authors of ISO 9000 strongly recommend taking the following route: a company should first use ISO 9004-1 [7] and other applicable parts of ISO 9004 to design and to implement a quality system. Once the quality system has been installed, the company may use the quality assurance models of ISO 9001, 9002 or 9003 to demonstrate the adequacy of the quality system. Software suppliers usually choose the ISO 9001 as a basis for certification.

2. Findings of two empirical surveys

We have conducted two empirical surveys among software suppliers that have gathered experience with the implementation of ISO 9000 based quality systems. Objectives, research methodology, and findings of the surveys have already been described in detail in other papers [8–10]. The following paragraphs summarize the findings of our surveys. This will help the reader to better understand the discussion of arguments on ISO 9000 in Section 4.

From June to September 1994, we conducted a survey among the first twenty German software houses that had received an ISO 9001 certificate [8, 10]. One of the objectives of the study was to assess the value of an ISO 9001 certificate for buyers of software and software–related services. Major findings of our study are:

- Some companies, and the respective certification agencies, have interpreted the clauses of the standards very strictly. Others have put a wide interpretation on the clauses of ISO 9001.
- The certificate usually does not point out deviations from the requirements of the standards. Scope and nature of the interpretation are not documented in detail.
- A third party is not able to distinguish between a certificate that is based on a restrictive interpretation and a certificate that is based on an extensive interpretation of the wording of ISO 9001. A certificate does also not distinguish between organizations that only fulfil the letter of ISO 9001 and other organizations that have implemented quality systems according to the entire ISO 9000 family.
- A certificate does not guarantee that the certified quality system fulfils all requirements specified in ISO 9001.
- An ISO 9001 certificate is no indicator of the quality of the products, the processes, or the quality system.

Another objective of our study was to find out whether companies have achieved software process improvements with the help of ISO 9000. Our survey concentrated on five elements of an ISO 9000 quality system: code reviews and inspections, software testing, product and process measurements, measurement of quality costs, demonstration of quality improvements.

- Forty per cent of the software houses did not change any of the five quality system elements considered in our study. In other words, these companies have not achieved any improvements in any of the five elements. Thus, it seemed that ISO 9000 had not led to substantial improvements in many software houses.
- This result is in sharp contrast to another finding of our study: not a single respondent of our survey said that the implementation of the quality system had ended in failure. Forty-seven per cent of the respondents said that their expectations were met. Fifty-three per cent of the respondents answered that the quality system had only partially come up to their expectations.

Obviously, the results of our study did not reflect the value of ISO 9000 for software houses correctly. Therefore, we decided to take a closer look at software process improvements achieved via ISO 9000.
Between October 1994 and May 1995 we carried out a second study [10]. We conducted various interviews with representatives of companies that had recently sought certification. Furthermore, we examined progress reports and case studies of software houses. The findings of our study are based on interviews and reports from a total of 36 European software houses. The study also draws on interviews with ISO 9000 auditors and consultants working in the software industry, and on the authors’ experience gathered by consulting software houses that are currently implementing an ISO 9000 quality system.

We identified ten key success factors that the respondents of our study considered to be the most helpful when implementing an ISO 9000 quality system:

1. Definition and documentation of the status quo revealed weaknesses in the software process.
2. Identification of best practices improved internal knowledge transfer.
3. Identification of business processes helped to focus on business objectives.
4. Simplification of routine procedures reduced rework.
5. Internal quality audits are a helpful activity to support a continuous improvement initiative.
6. Implementation and certification of an ISO 9000 quality system is an enormous impetus for most staff members.
7. Implementation of a quality system creates a team spirit among management and employees.
8. Workshops and regular meetings are an efficient way to identify weaknesses and to discuss options for improving software development processes.
9. Definition of a common language helps to prevent misunderstandings.
10. Top management and change agents play an essential role in implementing software quality systems.

The findings of our second study indicate that it is not the technical contents of the ISO 9000 family that makes it specifically appropriate for software process improvement. The culture created by a company-wide improvement programme seems to be more important. Implementing an ISO 9000 quality system is a helpful impetus for a cultural change.

Our second study also revealed that most software houses have not made intensive use of ISO 9004-1 and 9004-4 [7, 11]. They gather information directly from ISO 9001. Consequently, software companies do not apply the suggestions of ISO 9004. For example, they do not follow the advice to control cost of quality, to conduct continuous quality improvement and to implement a metrics programme to analyse the correlation of process and product quality.

Surprisingly, also ISO 9000-3 is not of great help for software houses. Most quality managers ignore it and use ISO 9001 instead.

3. Some prerequisites for a constructive discussion

The ISO 9000 family has received unfavourable criticism in various journals, textbooks and at software quality conferences. The arguments might be used as a basis for advances in software quality standards. However, many criticisms cannot be used directly for constructive recommendations. Some authors neither disclose their basic assumptions, nor do they clarify which of the objectives, aspects or contexts of the ISO 9000 family they address. A constructive discussion has to take into account the following facts:

- The spirit and the letter of the ISO 9000 family should be distinguished from inadequate use of the standards, and also from the current practice of certification. Some critical arguments are fair and reasonable when reviewing the practice of implementing and certifying quality
systems but they are not quite in place when discussing the standards.

- The ISO 9000 standards pursue two objectives [1]: first, they provide guidance for quality management, that is for designing and implementing quality systems. Second, they describe general requirements for quality assurance, that is for demonstrating the adequacy of the quality system. Some critics do not distinguish between the two objectives. Consequently, some of their arguments are inadequate.

- As already mentioned, the ISO 9000 family comprises various standards. Nobody will be able to understand ISO 9001 and ISO 9000-3 correctly, unless he has read and understood at least ISO 9000-1, ISO 9000-2 and ISO 9004-1. Another misunderstanding is that ISO 9001 provides guidelines for the implementation of quality systems. The standard describes a model for demonstrating that specified requirements of quality systems are fulfilled. Likewise, ISO 9000-3 is not a guideline for the design or implementation of quality systems for software development. ISO 9004-1 provides guidance for the design and implementation of quality systems. The objective of ISO 9004-4 is to ‘facilitate and promote continuous quality improvement’. Unfortunately, most critics focus on ISO 9001 and ISO 9000-3 and ignore other important standards. Furthermore, they confuse the objectives of various standards of the ISO 9000 family.

- ISO 9001 consists of 20 quality system elements. Each of these elements is composed of various different requirements. If a company decides to use ISO 9001 as a guideline to implementing a quality system, each of these requirements has to be interpreted, tailored and implemented according to the specific needs of the organization. Furthermore, some of the requirements may be implemented differently in different organizational units of a company. Some of the implemented quality elements may have positive effects on achieving business objectives. Other elements may hinder an organization’s success. As a consequence, it is difficult to assess the impact of the ISO 9000 standards on achieving business objectives in toto.

The following section structures, summarizes, and discusses eleven of the most popular arguments against the ISO 9000 standards. It reveals fundamental assumptions underlying the arguments. Where necessary, the arguments will be explained, reframed and put in a larger context, so that they can be easily understood and evaluated. Each argument will be examined thoroughly by considering pros and cons from different points of view. Table 1 at the end of Section 4 summarizes the eleven arguments and selected pros and cons.

4. A critical look at the critics’ arguments

**Argument 1.** The implementation of an ISO 9000 quality system does not necessarily lead to better software products, to a reduction of time-to-market, and to improved return on investment [12].

**Pro:** The suggestions of ISO 9000 are a result of various working group meetings of international experts in quality management. However, although international experts developed the standards, no empirical evidence, no theory, and no explicit model have been given that justify or explain the relation between the suggestions of the ISO 9000 family and the accomplishment of the objectives mentioned above. Other concepts for software process improvement, such as the Capability Maturity Model (CMM), have similar weaknesses. Experts investigating the state of the payoff when applying the CMM draw the following conclusion: ‘We need to learn how, when, why, and for whom process improvement pays off. ... We need to achieve an understanding of the critical factors that cause success and failure’ [13]. Obviously the lack of a solid understanding and of an explicit model explaining causes and
effects is not a weakness of the ISO 9000 family only.

Pro: Our surveys have shown that only very few managers are able to quantify the benefits of an ISO 9000 quality system [10]. Most respondents are not sure to what extent the implementation of the ISO 9000 quality system has led to a reduction of cycle time, working effort or product failures. They have not collected data, and they have not produced documented records of success. Therefore, the impact of ISO 9000 on productivity, cycle time and product quality is unclear in most organizations.

Con: The key objective of the ISO 9000 family is to provide guidance to quality management and to quality assurance [1]. Depending on the objectives an organization pursues and on the specific activities it implements, quality management may, or may not, lead to increases in productivity and product quality and to reductions in costs and time to market. Further investigations are needed to examine under which circumstances which of the suggestions of the ISO 9000 standards are helpful to accomplish superior software quality management and to provide confidence that the requirements for software product quality can be met.

Argument 2. ‘ISO 9000-3 may be effective for promoting an organization’s quality level from third class to second class, but it may not be effective for first-class organizations’ [14]. Implementing an ISO 9001/9000-3 quality system does not pay off for mature organizations [15].

Con: The objective of ISO 9001 is to specify quality system requirements that can be used to demonstrate a supplier’s capability to provide adequate products [1]. The objective of ISO 9000-3 is to specify guidelines for the application of ISO 9001 to the development, supply and maintenance of software. ISO 9001 and ISO 9000-3 must not be used for ‘promoting an organization’s quality level’ from one class to another class. ISO 9001 and ISO 9000-3 are not meant to help an organization involved in software development to improve its software process.

Con: The essential question is whether ISO 9004-1 and 9004-4 are helpful for mature organizations involved in software development. ISO 9004-1 and -4 suggest a Total Quality Management (TQM) approach that emphasizes continuous process improvement, tracking of quality costs, motivation of staff, quality in marketing, leadership, etc. Applying these aspects will probably also pay off for excellent companies. Reading the standards carefully, it seems that ISO 9004-1 and 9004-4 are mainly helpful to support evolutionary ‘grass-roots improvements’. However, the standards do not seem to be adequate to support revolutionary ‘breakthrough improvements’. Unfortunately, there is no empirical evidence to verify this opinion because most companies in the software field do not apply ISO 9004-1 and 9004-4 [10].

Pro: Our empirical findings indicate that a significant number of software companies have indeed ignored ISO 9004-1 and ISO 9004-4. They have misunderstood the objectives of ISO 9001 and used it as a guideline to design and implement a software quality system. Given the objectives of ISO 9001, it is obvious that the standard only states minimal requirements. These requirements should be obvious for mature organizations.

Con: However, the assessments of the Software Engineering Institute have shown that the majority of software-producing organizations are not excellent companies [16]. They have not achieved mature software processes. They do not have complete command of software testing strategies, configuration management and other basic software engineering techniques. Although software process improvement is neither the objective of ISO 9001 nor of ISO 9000-3, the standards might nevertheless help second- and third-class companies (i.e. the majority of software companies) to improve their software development capabilities.
**Argument 3.** The application of ISO 9000 may be adequate in large software development companies but it may not be adequate for small companies [12].

**Con:** The findings of our surveys indicate the contrary: large software companies often had established formalized processes long before the implementation and certification of an ISO 9000 quality system was planned. When preparing for the certification audits, some large companies only adapted the quality system to the requirements of ISO 9001 and documented the status quo. These companies did not achieve major improvements. A significant number of smaller software companies (with approximately 20 to 100 employees) had not implemented stable processes, explicit organizational structures, etc. before they started to implement an ISO 9000 quality system. ISO 9000 helped them to accomplish substantial improvements during the implementation of the quality system.

**Con:** The previous counterargument shows that the size of the company is not the most important aspect when considering the potential benefits of implementing an ISO 9000 quality system. The existence, effectiveness and efficiency of organizational structures and procedures are much more important. Companies that suffered from a lack of organizational structures and clearly defined procedures seem to have the largest benefits from quality management. Investing in an ISO 9000 quality system usually pays off in these companies.

**Argument 4.** ‘In ISO 9001, support for continuous improvement is almost absent’ [15]. ISO 9001 ‘... is based on conformance rather than effectiveness of an organization’ [17].

**Pro:** The statements are correct. ISO 9001 does not support continuous improvement. Likewise, ISO 9000-3 does not support continuous software process improvement.

**Pro:** Our empirical findings indicate that many companies focus on conformity rather than on effectiveness and efficiency. A significant number of quality systems in the software industry are stakeholder-motivated, which means that a company implements a quality system in response to demands by customers or other stakeholders but not primarily to achieve quality improvements [10].

**Con:** The authors of the ISO 9000 standards prefer the management-motivated approach in which the company’s own management initiates the effort to install a quality system. As already mentioned, ISO 9000-1 and ISO 9004-1 emphasize the need for continuous improvement of processes and products. ISO 9004-1 emphasizes that it is ‘a business need to attain and to maintain the desired quality at an optimum cost’ [7]. The arguments quoted above adequately criticize the current practices of some software companies and certification bodies. However, the statements are not valid to criticize the ISO 9000 standards. It is not adequate to pick out only one standard of the ISO 9000 family and to ignore other essential standards.

**Argument 5.** ‘The quality system stipulated in ISO 9001 and ISO 9000-3 depends heavily on top-down and centralized quality management. ... It will not work and may even be counterproductive in software development. Top-down, centralized management may depress programmes’ morale and spoil their cult of quality’ [14].

**Pro:** ISO 9004-1 and ISO 9001 suggest that required skills and qualifications of personnel should be assessed. Furthermore, training and motivation should be provided. The ISO 9000 standards mention that ‘motivation of personnel begins with their understanding of the tasks’ and that ‘efforts to encourage personnel towards quality’ should be undertaken [7]. However, the responsibility of each employee for quality is not emphasized in the ISO 9000 standards. Leading experts in TQM for software development have pointed out that the responsibility and active participation of all members of a company are essential for a
successful quality system [18]. ISO 9004-1, and similarly ISO 9001, point out that ‘the responsibility for and commitment to a quality policy belongs to the highest level of management’ [7]. This may lead to a false approach to implementing a quality system. An organization in which top management defines a quality policy and ensures that the policy is implemented by the employees has a Tayloristic approach to achieving quality. This might indeed be counterproductive in a software development context.

**Con:** Reading the texts of the standards carefully, however, it becomes clear that it is not necessary to take the Tayloristic approach. The ISO 9000 family is compatible with a TQM approach in which employees are responsible for the quality of the products and services. ISO 9000 does not prevent a bottom-up strategy when developing a quality policy. The standards do not prohibit active participation of employees, provided that top management takes the responsibility and shows strong commitment to quality. Some of the organizations included in our study definitely do not depend on top-down and centralized quality management. Still, they have implemented an ISO 9000 quality system, they have received an ISO 9001 certificate and they are highly competitive and successful companies.

**Argument 6.** ‘ISO 9000-3 implicitly requires huge volumes of paperwork, because the only way to show evidence of quality management to third persons ... is by providing documents and keeping records’ [14].

**Pro:** It is correct that ISO 9000 promotes documentation. Documents are highly important elements of an ISO 9000 quality system. A quality auditor pointed out that ‘any aspect that has not been documented virtually does not exist in an ISO 9000 environment’. We have to admit that many companies produce an inflexible and bureaucratic documentation overhead. A third of all companies included in our study regarded the efforts to produce, maintain and update documents required by the ISO 9000 standards as a serious problem [8].

**Con:** ISO 9004-1 points out that it is ‘a business need to attain and to maintain the desired quality at an optimum cost’ and that it is ‘important that the effectiveness of a quality system be measured in financial terms’ [7]. Of course, these suggestions must also be applied to documentation. ISO 9000-1 specifies the intention of documentation in the context of the ISO 9000 family ‘to be a dynamic high-value-adding activity’ [1]. Some organizations involved in software development have understood this idea. They have designed and installed IT-systems that support documentation in a very flexible and efficient way [19]. If many companies do not implement cost-effective documentation this may be due to a misunderstanding of the standards, or to inadequate advice given by consultants. The authors of ISO 9000 should probably warn readers more clearly of the pitfalls of inadequate documentation.

**Argument 7.** ISO 9001 only partially supports assets like leadership, human resources, marketing and processes. ‘ISO 9001 also does not address total-quality-management issues, like morale and motivation’ [15].

**Pro:** As already mentioned before, the objective of ISO 9001 is to specify quality system requirements that can be used to demonstrate a supplier’s capability to provide adequate products [2]. Providing support for designing and implementing quality systems is not within the scope of ISO 9001. We will have to examine whether the elements mentioned above are adequately dealt with in ISO 9004-1 and ISO 9004-4.

**Con:** ISO 9004-4 emphasizes the importance of the top management’s leadership, commitment for quality, and responsibility for creating an environment that supports continuous improvements. Managers should empower employees to improve work processes. Quality awareness
and motivation are mentioned in ISO 9004-1 and ISO 9004-4. Clause 7 of ISO 9004-1 ‘Quality in Marketing’ suggests market research, market-driven product improvement, definition and communication of customer requirements within the organization, and establishment of a feedback system on customer satisfaction. ISO 9000-1 points out that ‘a major purpose of quality management is to improve the systems and processes so that continual improvement of quality can be achieved’. ISO 9004-1 and 9004-4 specify how continuous improvement of processes can be achieved.

Pro: We agree with Coallier’s statement with regard to the fact that TQM, change management, marketing, and leadership are not strengths of ISO 9000. The standards should be improved in these aspects. However, one should keep in mind that the ISO 9000 family comprises standards on quality management and quality assurance. The application of ISO 9000 is no substitute for adequate general management practices.

Argument 8. The ISO 9000 standards were designed for quality systems for production of tangible manufacturing products. Software is an intangible design-intensive product. The most important and fundamental problems with ISO 9001 stem from the fact that its quality systems are designed for tangible products [12, 14, 15, 17].

Pro: It is correct that the authors of the ISO 9000 standards emphasize some aspects that are typical for production. For example, handling, storage, packaging, preservation and delivery are not of great importance in the software field. Also, the authors seem to underestimate typical problems of software development, such as elicitation of customer requirements or difficulties in defect detection. The findings of our empirical surveys show that ISO 9000 is not helpful to overcoming weaknesses in software engineering techniques. Problems that distinguish software development from a manufacturing environment are usually not reduced when implementing an ISO 9000 quality system [10].

Con: However, software development suffers from many problems that are common to most industries: inadequate communication, poor documentation, lack of management commitment for quality, insufficient organizational structures, missing process improvement activities, etc. Software companies have achieved substantial improvements in these aspects during the implementation of ISO 9000 quality systems [10]. ISO 9000 emphasizes process management, defect prevention, satisfaction of customer requirements, maintenance of quality at optimum cost, planning for quality, auditing, continuous improvement of the quality system. Most of the basic assumptions of the ISO 9000 family are applicable to tangible as well as to intangible products. They are helpful for manufacturing as well as for design-intensive environments.

Argument 9. The software industry should develop standards specific for software and replace ISO 9000-3 with them [14].

Con: Software development usually is an element of various services such as organizational analysis and design, business process re-engineering, consulting, maintenance, etc. Similarly, software products are usually embedded in complex IT systems consisting of hardware, services, people, organizational structures, and business processes. It might be helpful to have common standards that are applicable to all elements of an IT system. The ISO 9000 family is such a baseline. The software quality community should not try to erect barriers that might impede co-operation with other disciplines that are essential for developing effective and efficient IT systems.
Pro: Of course the ISO 9000 family has to be complemented by more specific standards and guidelines. However, this is not typical for the software industry. The chemical, the pharmaceutical, the automotive and the construction industry apply the ISO 9000 standards and they have established standards that go beyond the requirements of ISO 9000. These standards are not part of ISO 9000 and we do not see any reason why standards specifying software quality management should be part of ISO 9000.

**Argument 10.** The focus on certification is the most important weakness of the ISO 9000 family [14].

Con: The statement should read: the focus on certification is the most important weakness and strength of the ISO 9000 family. The certification process has been a strong impetus for staff members in many software companies [10]. Undoubtedly the world-wide trend to certify quality systems has empowered the idea of software quality management. Certification has given the necessary momentum to the ISO 9000 standards. The ISO 9000 initiative has improved quality awareness in the software community, at least in Europe.

Pro: Unfortunately, certification has also turned out to be a weakness of the ISO 9000 family. Often, customers and official bodies oblige software companies to implement quality systems and obtain a certificate no matter how unreasonable this might be. Software suppliers assume that they will rapidly lose market share if they do not receive an ISO 9001 certificate. They regard an ISO 9001 certificate as a prerequisite for maintaining sales figures. Consequently, they implement a quality system and seek certification although they might not be convinced of positive internal effects. Another unfavourable side effect of the focus on certification is that most companies concentrate on ISO 9001 and 9000-3 and ignore other important standards.

Pro: The current practice of some certification bodies seems to enforce the negative trend. As shown in one of our studies [9] a certificate does not necessarily indicate the quality of a quality system. A certificate does not distinguish between organizations that only fulfil the letters of ISO 9001 and other organizations that accomplish the spirit of the entire ISO 9000 family.

Pro: ISO 9001 suggests various measures, such as contract review, design control, control of quality records, etc. These measures can be regarded as abstract solutions to potential problems in a specific organization. However, nobody knows whether the set of solutions suggested by ISO 9001 adequately reflects the problems in a specific organization. An ISO 9001 certificate requires that all measures are implemented, no matter how adequate they might be. Perhaps, in some companies sensible implementation of only one or two elements of ISO 9001 might bring about more substantial improvements than cursory implementation of all elements.

**Argument 11.** ISO 9001 does not provide a framework that can be tailored to meet business needs. Tailorability is relegated to the audit process [14].

Con: As already mentioned, ISO 9001 is not a guideline for the implementation of quality systems. ISO 9004-1 and ISO 9004-4 provide guidance to implementing quality management. The suggestions of these standards can be tailored to meet business needs. ‘The International Standards in the ISO 9000 family describe what elements quality systems should encompass but not how a specific organization implements these elements. It is not the purpose of these International Standards to enforce uniformity of quality systems’ [1].
ISO 9001 and ISO 9000-3 are open to various interpretations. ISO 9001 does not specify the limits of admissible interpretation and tailorability. The investigation whether a quality system is compatible to the requirements of ISO 9001 is left to the discretion of the auditor. The ISO 9001 certificate does neither specify the nature nor the scope of interpretation. A third party has no chance to reproduce interpretation and tailoring in order to analyse whether the quality system is acceptable. Various initiatives have been started to overcome these problems. For example, the TickIT-Guide [20] specifies the requirements of ISO 9001 and the suggestions of ISO 9000-3. ITQS, the agreement group for assessment and certification of quality systems in information technology and telecommunication [21], promotes harmonized assessment and certification services in the IT sector. These are helpful steps. However, they still suffer from two weak points: first, the initiatives are not recognized world-wide. TickIT for example, does not matter in Germany. Second, the guidelines do not specify the limits of admissible interpretation and tailorability.

Table 1 summarizes the eleven arguments and selected pros and cons.

**Table 1. Summary of the discussion**

**Argument 1. ISO 9000 does not necessarily lead to improved productivity, cycle time and product quality.**

**Pro:** No empirical evidence, no theory, and no explicit model justify the relation between ISO 9000 and improved productivity, cycle time and product quality.

**Con:** Improvements in productivity, cycle time and product quality are not the key objectives of the ISO 9000 family.

**Argument 2. Implementing and ISO 9001/9000-3 quality system does not pay off for mature organizations.**

**Con:** ISO 9004-1 and 9004-4 provide guidelines to implementing quality systems. Implementing these guidelines should also pay off for mature organizations.

**Con:** Although software process improvement is not the objective of ISO 9001/9003, the standards might nevertheless help the majority of software companies.

**Argument 3. The application of ISO 9000 may be adequate for large but not for small companies.**

**Con:** The findings of our surveys indicate the contrary.

**Con:** Size is not the most important aspect; companies suffering from poor organizational structures seem to have the largest benefits from quality management.

**Argument 4. ISO 9001 does neither support continuous improvement nor effectiveness of an organization.**

**Pro:** Supporting continuous improvement and improving organizational effectiveness is not within the scope of ISO 9001.

**Con:** ISO 9004-1 and 9004-4 emphasize the need for continuous improvement and for improving organizational effectiveness.

**Argument 5. ISO 9001 and 9000-3 depend on top-down, centralized quality management.**

**Pro:** ISO 9001 and 9000-3 may indeed lead to a top-down approach and to centralized quality systems.

**Con:** However, ISO 9000 does neither prevent a bottom-up strategy nor does it prohibit active participation of all employees.

**Argument 6. ISO 9000-3 requires huge volumes of paperwork.**

**Pro:** ISO 9000 promotes documentation and many companies produce an inflexible and bureaucratic documentation overhead.
Con: The fact that many companies do not implement cost-effective documentation is probably due to a misunderstanding of the standards.

**Argument 7. ISO 9001 only partially supports TQM issues.**
Pro: Providing support for TQM is not within the scope of ISO 9001.
Con: ISO 9004-1 and 9004-4 emphasize the importance of various TQM issues.

**Argument 8. The ISO 9000 standards are not adequate for intangible design-intensive products such as software.**
Pro: The ISO 9000 standards emphasize some aspects that are typical for the manufacturing industry and underestimate other typical problems of software development.
Con: Most of the basic assumptions of the ISO 9000 family are applicable to manufacturing as well as to design-intensive environments.

**Argument 9. The software industry should develop standards specific for software and replace ISO 9000-3 with them.**
Con: Software development is usually embedded in various services. It is an advantage of the ISO 9000 standards that they are applicable to all elements of IT system development.
Pro: The ISO 9000 family has to be complemented by more specific standards and guidelines. However, this is also true for other industries.

**Argument 10. The focus on certification is the most important weakness of the ISO 9000 family.**
Con: Certification has empowered the idea of software quality management and has given the necessary momentum to the ISO 9000 standards.
Pro: Many software suppliers focus on certification. They only fulfil the letter of ISO 9001 and do not accomplish the spirit of the entire ISO 9000 family.
Pro: In some companies sensible implementation of only one or two elements of ISO 9001 might bring about more substantial improvements than cursory implementation of all elements.

**Argument 11. ISO 9001 does not provide a framework that can be tailored to meet business needs.**
Con: The suggestions of ISO 9004-1 and 9004-4 can be tailored to meet business needs when implementing quality systems.
Pro: ISO 9001 does not specify the limits of admissible interpretation and tailorable.

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5. Synthesis of the discussion

In the following paragraphs we summarize key aspects of the discussion outlined in the previous section. We do this by addressing three questions:

- Does the current discussion adequately reflect the benefits of ISO 9000 for software quality management?
- How can software organizations gain maximum benefit of ISO 9000 based quality systems?
- How can the ISO 9000 family be improved to support software quality management more effectively?

**Does the current discussion adequately reflect the benefits of ISO 9000 for software quality management?**
Most of the critics’ arguments do not adequately reflect the benefits of ISO 9000 for software quality management. This is mainly due to two facts: (1) some critics focus on ISO 9001/9000-3 only instead of taking into account the entire ISO 9000 family; (2) some arguments are fair and
reasonable when reviewing the practice of implementing and certifying quality systems but they are not quite in place when discussing the letter and the spirit of the standards.

*How can software organizations gain maximum benefit of ISO 9000 based quality systems?*

Most misunderstandings and inadequate implementations of the suggestions of the ISO 9000 family obviously result from the fact, that software organizations focus on ISO 9001 when implementing a quality system.

Software suppliers suffering from poor organizational structures usually benefit from implementing the requirements of ISO 9001/9000-3. However, software quality systems could probably be improved more effectively if they were based on the suggestions of the entire ISO 9000 family, particularly on ISO 9004-1 and 9004-4, rather than on ISO 9001/9000-3 only.

ISO 9004-1/-4 based quality systems would not focus on conformity to the standards but on enhancing business success by improving productivity, cycle time, product quality, etc. ISO 9004-1 and -4 suggest a Total Quality Management (TQM) approach that emphasizes continuous improvement, tracking of quality costs, motivation of staff, quality in marketing, leadership, etc.

*How can the ISO 9000 family be improved to support software quality management more effectively?*

The ISO 9000 standards could probably support software quality management more effectively if the authors of the standards described an explicit model that explains the assumed relations between the suggestions of the ISO 9000 family and the accomplishment of the objectives of the standards, and if the standardization bodies specified the limits of admissible interpretation and tailorability of the standards.

On this basis further research work should be conducted to examine under which circumstances which of the suggestions of the ISO 9000 standards are helpful to accomplish superior software quality management and to provide confidence that the requirements for software product quality can be met. In particular, empirical research work is needed to assess potential benefits and pitfalls of implementing ISO 9004-1/-4 based software quality systems.

Although ISO 9004-1 and 9004-4 emphasize many important aspects of TQM the standards could be improved in the following aspects: the responsibility and active participation of all members of an organization in implementing a quality system should be emphasized more clearly. Furthermore, leadership, change management, and marketing should be supported more effectively.

Most inadequate arguments and inefficient implementations of the suggestions of the standards obviously result from misunderstandings of the standards. Standardization bodies should therefore carefully monitor the current practice of interpreting and implementing the suggestions of the standards. If common misunderstandings and significant pitfalls are detected standardization bodies should probably warn readers more explicitly of these problems.

6. Suggestions for advances in software quality management concepts

Leading experts in the software community agree that we must achieve advances in quality management. In the following paragraphs we describe suggestions and guidelines for the development of the ISO 9000 family. The recommendations might also be helpful for advances in other software
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quality concepts and software process improvement initiatives, such as CMM, BOOTSTRAP, and the emerging SPICE standard. These software quality management concepts will be described by the word ‘concept’ in the following paragraphs. From the findings of our empirical surveys and from the discussion of ISO 9000 outlined in Section 4 we deduce the following recommendations for advances in software quality management concepts:

- **Focus on business success.** A significant part of the unfavourable criticism the ISO 9000 family has received results from the fact that many companies focus on conformity to the standards rather than on enhancing business success when implementing quality systems. Concepts for software quality management should therefore aim at business success first. Meeting customer requirements, creating value for the customer, cutting costs, reducing time-to-market, and improving return on investment should be key objectives of any concept in the field of software improvement.

- **Make sure that the purpose of the concept is clearly understood and communicated.** Most misunderstandings and inadequate implementations of the suggestions of the ISO 9000 family obviously result from the fact that software organizations focus on ISO 9001 and 9000-3 rather than on the entire ISO 9000 family when implementing a quality system. Other software quality management concepts have suffered from similar problems. For example, the maturity questionnaire of the Capability Maturity Model has often been confused with the CMM itself [22]. It is therefore essential that the authors of a concept take precautions to ensure that a concept is understood entirely.

- **Discuss and communicate objectives that will not necessarily be achieved when applying the concept.** Some critics have argued that the application of the ISO 9000 family does not lead to better software products, to a reduction of time-to-market, and to improved return on investment. However, these targets are not the key objectives of the ISO 9000 standards. It is important that the limits of a concept that will not necessarily be achieved when applying the concept are clearly communicated.

- **Identify and publish key assumptions of the concept.** The ISO 9000 family is based on various assumptions. However, most of these assumptions are implicit and it is not easy to identify them. Various critics have based their arguments on assumptions that are different from the assumptions of ISO 9000. This has led to misunderstandings and hindered a constructive discussion. Key assumptions of software quality management concepts should therefore be identified, described and published.

- **Construct and publish an explicit model that explains assumed relations between causes and effects.** Each quality management concept is based on assumptions explaining the relations between the recommendations of the concept (causes) and the objectives pursued when applying the concept (effects). However, these assumptions are not always obvious or explicit. For example, the ISO 9000 standards do not explicitly describe the relations between the suggestions and the objectives of the standards. This has led to misunderstandings, false interpretations, and inadequate implementation of the concept. Documentation and publication of the assumed cause-effect relations could prevent misunderstandings and facilitate constructive discussions and improvements of the concept.

- **Promote a constructive discussion about strengths and weaknesses of the concept.** Software quality management concepts should be subject to continuous improvement. Fortunately, there are various conflicting views, different perspectives and approaches to software quality management. Discussing these perspectives provides a great opportunity to improving quality concepts for software development. A constructive discussion may help to identify and to challenge critical assumptions, to discuss weaknesses and strengths and to assess options for
improving the concept. For example, the publication of critical arguments in ISO 9000 may help to gain a better understanding of key assumptions, and of difficulties and opportunities when implementing the standards. However, the critical arguments on ISO 9000 are dispersed in textbooks, journals, and conference proceedings. It is very difficult for the users of the standards to gain a complete understanding of the discussion. Therefore, it would be helpful to establish a public forum in which the concept could be discussed effectively. This would imply to invite proponents and opponents of the concept. Standardization bodies or the initiating organizations that published a concept would probably be the most appropriate institutions to host such a forum.

- **Encourage organizations to gather and publish experience with the concept.** Experience reports and case studies may help to clarify strengths and weaknesses of the concept. They may point out opportunities and common pitfalls when implementing the concept. Experience reports will also be helpful for preparing empirical evaluations of the concept. Unfortunately, only few software companies have published experience reports that address benefits and problems when implementing ISO 9000 based quality systems. Standardization bodies should therefore encourage organizations to publish experience with the concept.

- **Evaluate key assumptions and suggestions of the concept by empirical studies.** The lack of empirical evidence justifying key assumptions and suggestions of ISO 9000 for software development is probably one of the most important weaknesses of the standards. Software quality management concepts should be based on empirical evidence, whenever possible. Standardization bodies would probably be the most appropriate institutions to initiate, to support, and to co-ordinate empirical research work.

- **Provide guidelines explaining the most common pitfalls and potential drawbacks when implementing the concept.** Putting software quality management concepts into practice usually reveals difficulties and pitfalls of the concepts. Inadequate documentation, for example, is a common pitfall when implementing an ISO 9000 quality system. Many software companies have suffered losses when applying ISO 9000 because they made mistakes that other companies had already made. Software quality management concepts should therefore be supplemented by guidelines explaining the most common pitfalls and potential drawbacks when implementing the concept. This might help to prevent unnecessary losses.

- **Point out the importance of change management for the success of software quality management concepts.** Implementing ISO 9000 based software quality systems or CMM based software process improvement initiatives, for example, requires various changes to the organization of the software supplier. Our empirical surveys have shown that many software organizations have underestimated the efforts needed to accomplish the change process. Software companies that successfully applied ISO 9000 or the CMM have stressed that effective change management is essential. However, change management is not emphasized sufficiently in the ISO 9000 family. Change management should therefore be a central element of future concepts for software improvement.

- **Provide a framework that specifies the limits of admissible interpretation and tailorability of the concept.** The limits of admissible interpretation and tailorability are not clarified in ISO 9001. This seems to be one of the most important problems when certifying software quality systems. This weakness might also be the reason for the bad reputation that the ISO 9000 standards have gained among some software specialists. The authors of software quality management concepts should therefore provide a framework that specifies the limits of admissible interpretation and tailorability of the concept.
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References