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ISO Roadmap for Software Products

School of Applied Science

Master Thesis

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ISO Roadmap for Software Products

A.M. Ihrig*

Abstract

The complex nature of ISO 9001 standards has been an obvious limitation for implementation. ISO 9001 accreditation provides external and internal advantages. The external benefits include increased market access and customer confidence. The internal advantages include quality improvements in both the product and process. However, this research demonstrates that the current ISO guideline for software products has not completely fulfilled the expectations in its implementation within the software organisation. Numerous companies are experiencing difficulties with ISO implementation and maintenance. Based on the analysis provided by this research, poor communication and an unsystematic approach were identified as the main current problems associated with ISO implementation. In addition, it also shows that the organisations often underestimate internal organisation factors, such as resistance to change. The existing difficulties in maintaining applied quality systems have resulted in a lack of control and monitoring. This thesis introduces an ISO Roadmap and corresponding Checklist for software products. The main goal of this ISO Roadmap is to provide enhanced transparency and assistance in the application of ISO 90003:2004 in order to make ISO implementation more manageable, visible and understandable for all people involved within the organisation. The result of this research provides the software industry with an initial step towards better systematisation and control for ISO implementations. This should help the software industry to better navigate through the 'ISO jungle' and facilitate an improved approach for implementation and maintenance activities. This research relied heavily on the development of the literature review, ISO 90003 standards, and knowledge from interviewees. Through this comprehensive approach, the executed experiment on the ISO Roadmap and Checklist was able to elicit satisfaction in its application within the

Keywords: ISO Roadmap; ISO 90003 Checklist; ISO 90003 implementation; Quality management systems; Software products

1. Introduction

In the past, the software industry has often exhibited a lack of high quality and productivity levels. This can be attributed to a lack of quality control systems being properly applied by software companies. In the software industry, companies use 60% their time to detect and solve software defects [12]. This wasted time and energy can be attributed primarily to poor quality control in software development. In fact, 94% of the software companies do not possess a quality system to assure consistency and effectiveness in design and development [12]. Nowadays, software systems are of primary importance to business advancement in a variety of industry sectors. Therefore, software functions are significant, and often critical, factor for business success. Many software companies have implemented software quality assurance to ensure that their products meet their customers' needs. There are several models for software quality assurance, such as the ISO/IEC 90003 and the capability maturity model integration (CMMI). However, the adequate implementation of these models remains often a difficult and expensive task for numerous software companies.

1.1 ISO standard

The International Organisation for Standardization (ISO) has developed a number of ISO 9000 standards for quality management and quality assurance.

These standards are designed to help organisations to achieve quality and assure that the product or service is adequate for both the organisation itself and its customers.

As more organisations worldwide are getting accredited through ISO standards, the formalisation process is becoming more and more essential [1]. This process has become increasingly popular and stimulated the interest of many companies. Its accreditation provides a competitive advantage to improve customer confidence and market access [3].

The principle of ISO 9000 is directed at process quality standards, not product quality. It focuses on the examination of the process used to develop a product, but not the product itself. As such, it implies that a good product is the result of an effective development process [2]. The ISO 9001:2000 section is the most relevant standard for the application of quality assurance in the software industry.

1.2 ISO/IEC 90003:2004

In order to facilitate the implementation of ISO 9001:2000 in the software industry, ISO/IEC 90003:2004 was developed [3]. It was published on 15 February, 2004 to replace the ISO 9000-3:1997 version and to better match the ISO 9001 requirement.

The ISO 90003:2004 was developed to assist companies with the application of ISO 9001:2000 in terms of procurement, supply, development, operation and maintenance of computer software and associated support services. ISO/IEC 90003:2004 covers all phases of software development. Software engineering is defined as activities of requirement analysis, design, coding, integration, testing, installation and support for the acceptance of software products.

1.3 Problem Statement

The literature describes the approach in the application of ISO 9001:2004 as formal procedures that often seem rigid, repetitive and overly bureaucratic. The structure of ISO 9001:2000 and its guideline ISO/IEC 90003:2004 is generally unsystematic, non-formal and short-term oriented [5].

The technical and management tasks, as well as the quality functions are not clearly outlined by the guideline. This is also the case within the documents [6]. These issues prevent the approach of the ISO to be understood and implemented by the industry.

The ISO 9001:2004 is a generic framework that can be applied to any organisation; as such, it is not specific to, or relevant for, information technology [6]. While the ISO guideline illustrates the aspects of a quality assurance system in general, it fails to explain how an organisation should apply it [7]. The objectives are not clearly outlined by the guideline.

The industry statements collected from two companies in different industry sectors (Mechanical Engineering and Software Engineering) have defined the ISO standard as disorganised and unsystematic. As a result, ISO implementation and maintenance is often overly strenuous [8]. Additional information, attained from industry informants, illustrates the difficulty in managing, communicating and monitoring the ISO approach within the organisation [9].

This makes it difficult for senior management to encourage the commitment for ISO standards within the organisation.

Management commitment and employee involvement are the key factors for successfully implementing a quality management system [5].

2. Research aim & objectives

This paper intends to fill a gap in the literature by addressing the aforementioned challenges with ISO implementation, and by providing industry with a systematic roadmap to assist the ISO implementation for software products. In doing so, this paper aims to support other activities such as the planning and monitoring procedures. The result of this research should help the software industry to better navigate through the 'ISO jungle' and facilitate an improved approach for implementation and maintenance activities.

The main goal of this roadmap is to provide enhanced transparency and assistance in the application of ISO 90003:2004, in order to make ISO implementation more manageable, visible and understandable for all people involved within the organisation.

The specific objectives to be achieved throughout this research project have been identified as the following:

Carry out a literature review to better understand the existing ISO standard guidelines used for the application of ISO 9001.
Identify the standard stages and activities related to the software development.
Determine the main factors affecting the implementation and maintenance of ISO 9001 through the literature review and interviews with industry experts.
Develop a roadmap that will enable the implementation and maintenance of ISO 9001 within the software industry.
Arrange for the roadmap to be reviewed and revised by experts in the field.

The paper is structured as follows:

In Section 3 and 4, the research methods and ISO 9001 content is defined and discussed. Section 5 investigates ISO implementation while section 6 discusses the findings in earlier and related works. This is followed by section 7 which summaries the conducted industry interviews and section 8 analyses and evaluates collected data. Section 9 identifies the research gap and

section 10 explains the development and evaluation approach used for the ISO Roadmap and Checklist. Section 11 discusses the experiment results, and finally, the conclusion and results are presented.

3. Research Methods

The topic investigated by this thesis is complex due to the intangible nature of the research factors such as tacit knowledge. Furthermore, there is a lack of publications and research examining ISO 9001 implementation.

The conducted literature review identifies the need to study the field of ISO implementation for software products. For this purpose, an exploratory approach based on qualitative research techniques has been applied in this thesis. Data collection was conducted using key-informant interviews in order to elicit industry viewpoints and experience regarding ISO implementation.

Both qualitative and quantitative research methods were considered for this study. The resulting research design is illustrated in the following figure (Fig.1):

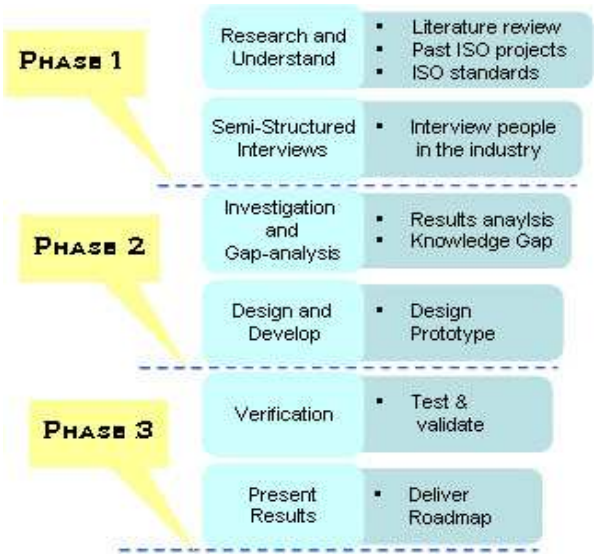


Fig. 1 Research approach

The research design was divided into three major phases:

Phase 1: Literature review of ISO standards

Phase 2: Data analysis & roadmap development

Phase 3: Roadmap verification & delivery

The first stage of Phase 1 consisted of conducting an extensive literature review and investigating related works to gain a clear understanding of the areas to be covered in this thesis. The literature review incorporated a variety of sources including: journal articles, books and online sources. This provided a comprehensive understanding of varying ISO standards and the key issues relating to implementation and maintenance procedures. The second stage involved assessing expert reviews and their experience with ISO 9001 through interviews and industry cooperation.

Phase 2 involved analysing and evaluating data collected to identify the knowledge gap in this field. Based on Phase 1, an initial roadmap design was developed for the test the next phase.

In Phase 3, the design was tested within the software department of the sponsor. Feedback was collected, necessary modifications were identified, and additional requirements were observed and documented. These requirements were adopted, reviewed and presented.

4. Research review: ISO 9001

ISO 9001 is the most well known of the ISO 9000 series of international standards for quality management, and provides the requirements for a quality management system. Standard 9001 does not provide requirements for certain products or services; rather it provides a set of generic requirements relating to the processes of development and production. In addition, it suggests how these processes should be managed, reviewed and improved, in order to meet customer satisfaction [19].

Basically, ISO requirements entail the documentation of all involved processes and procedures starting from the acquisition phase up to the delivery and training phase. Each phase has to be verified and reviewed by the assigned and authorised personnel to ensure that the requested changes to the product are made in accordance with protocol.

The accreditation of an ISO 9001 certificate confirms the ability of a company to provide high quality products. Its certification lasts three years, with annual surveillance audits being part of maintaining certification throughout the three-year period [21].

4.1 ISO 9001 Chapters Content

The main goal of ISO 9001 is to assure customer quality requirements are met. This requires the application of regulatory requirements to the process are used, in order to enhance customer satisfaction. The ISO 9001:2004 is divided into eight chapters. The first three chapters apply to the scope, terminology and the normative reference of the standard [18].

The fourth chapter addresses the requirements for the quality management system. This section discusses the quality standards and their requirements for documentation. This involves the structure and processes of the quality management system. In addition, it includes the contents of the documentation (quality policy, objectives and quality manual) [18].

The fifth chapter illustrates the senior management's commitment to quality. This chapter explores the relationship between ISO and the responsibilities of senior management in terms of quality management. Specifically, it recommends that senior management should strive to establish clear responsibilities and authorities within the organisation, and ensure the availability of necessary resources for the development and a quality management approach [19].

ISO 9001 considers the responsibility of the management as an inherent part of customer orientation. With this in mind, it outlines methods to identify customer needs. The standard requires that the management establishes a quality policy, and even defines how such a quality policy should be implemented. The assignment of quality representatives and their tasks also falls under the management's responsibilities. In addition, the management should develop methods to encourage the flow of information and communication within the organisation.

The sixth chapter presents the requirements for effective resource management (staff, infrastructure and working environment). For instance, the company should provide the right staff, and prepare well in advance for the required trainings in order to adhere to the quality management system and improve customer satisfaction [18]. The ISO 9001 refers to infrastructure not only as buildings and rooms, but also, hardware, software and several other tools.

The seventh chapter discusses the requirements and planning procedures for product development. It recommends that organizations must ensure the efficiency of their selected process early on, in order to achieve the quality objectives for both products and services [19]. The ISO 9001 not only deals with development requirements, but also explains the requirements for inputs and results.

The ISO requires that the organisation performs verification and validation activities throughout the design and development processes. The verification process is essential for a number of reasons. First, it ensures that design and development are performed according to the requirements. Second, it ensures that a defined method is followed and that the product results are controlled. Third, it reviews the product function to ensure that the product meets the expected requirements. The organisation is required to validate all processes and procedures that are related to the development process before approval [19]. This also includes the process of reviewing and closing nonconformities. The documentation of these activities in this phase is essential, especially with regards to the occurrence of nonconformities and the steps taken to eliminate the detected cause(s) [19].

The eighth chapter provides an overview of measurement, analysis and process improvement. ISO 9001 considers customer satisfaction a key indicator for measuring the performance of a quality management system. As such, ISO is an extremely useful instrument for monitoring both the process and product, and identifying failure to meet expectations. This supports the organisation to determine potential improvements within the quality system.

4.1 ISO 90003:2004 guideline for Software Products

ISO 90003:2004 is used as a guideline for the application of ISO 9001 and supports the application throughout the entire process of software product development and related support services (Acquisition, Supply, Development, Operation, and Maintenance). It is an authorised guidance for the application of ISO 9001 to software audits. The use of this guideline should make ISO 9001 more adaptable [24]. The guideline consists of five categories.

The inputs need to be defined and checked for completeness and accuracy. They should be provided in a form that enables verification against the design and development. This section also requires validation, control, and testing of the results to ensure product requirements are met [20]. The ISO guideline for software products makes everyone involved responsible for quality. This makes it difficult to define the roles, responsibility and authorities engaged in the implementation of ISO [29].

Reviews should be performed regularly and in accordance to the predetermined methods in order to evaluate the ability of the design and development. This allows for any required changes to be determined and recorded. The following figure (Fig. 2) outlines the stages one must go through in order to implement a design and development change.

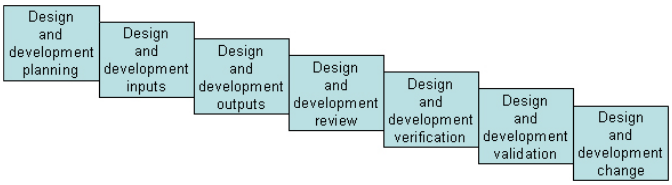


Fig. 2 Design and development activities 90003:2004

The literature review defines three key themes that make up the ISO guideline for software products. The first theme is purchaser and supplier management. Supplier management is responsible for enhancing product quality, while purchaser management helps ensure that product requirements are met. The second theme is the engineering process used for the software development. The third theme is the support activities (Configuration management) for the engineering development process [29].

5. ISO implementation advantages and disadvantages

An increasing number of companies are beginning to consider implementing ISO due to external factors such as marketing advantages. Further examples of such external factors include: consumer demand and government regulations that require a quality management system to be in place [11]. For instance, ISO provides a competitive advantage by improving market access.

The previous literature review showed that customers often prefer purchasing from ISO certified suppliers. Furthermore, many companies that have adopted ISO require that their suppliers are also ISO certified. These are two examples of important factors driving many companies toward ISO standard adoption. Other benefits obtained through the implementation of ISO 9001 are internal and include indicators such as improvements in quality, productivity and organisational structure [11]. These benefits are mainly the result of more streamlined and efficient internal processes based on the quality structure. The motivation of the senior management in this approach is imperative.

In order for ISO implementation to succeed, the senior management must remain committed during the entire implementation process. Moreover, the management should display long-term commitment to maintaining ISO 9001 in order to sustain the aforementioned benefits [26]. The application of the ISO quality standard and its documentation require extensive managerial resources and a considerable, sustained effort.

G. E. Thaller (1996) stated that the implementation of a quality management system for software products does not only depend on the fulfilment of ISO standards requirements [30]. Rather, the success of ISO implementation requires the additional important elements: customer needs and requirements, product-specific conditions, staff involvement, specific know-how and expertise, management commitment and specific literature. These sources play an important role for an effective and successful implementation (see Fig.3).

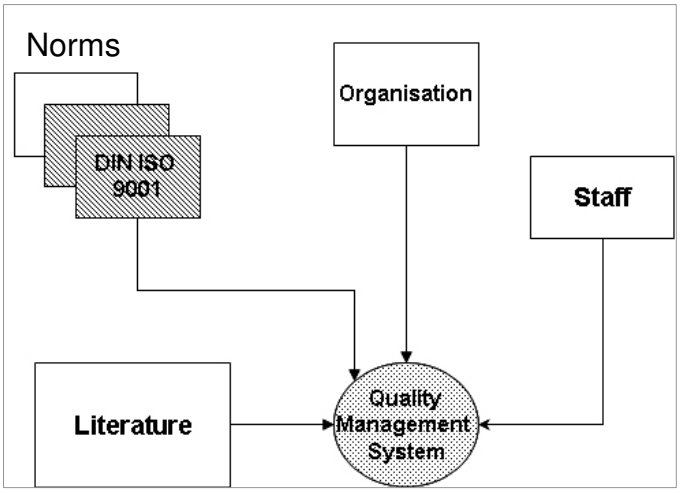


Fig. 3 Factors of influence on Quality Management System

The maintenance of the ISO system often requires that regular upgrades and progress control be properly documented [22]. Often, failure to comply with ISO 90003 can lead to business disadvantages [23].

Between 1995 and 2001, the number of companies with ISO 9000 certifications has increased from 127,349 to 510,616 worldwide. Currently, ISO 9000 is recognised in more than 161 countries. The rapid adoption of this standard has increased the pressure on many companies to consider ISO implementation [25].

6. Related works

Only a few studies have tackled the implementation of ISO 9001:2000. Chanwoo Yoo et al. (2006) developed a unified model to help ISO certified companies implement CMMI. This model applies the structure of ISO organisation to explain the application of CMMI [13]. Beschid Behkamal (2007) customised the ISO 9126 quality model in accordance to the individual characteristics of B2B applications and web applications, which were then weighted from the viewpoints of developers and users. This model was used as a quality model for evaluating B2B applications [14].

Wen-Kui Chang et al. (2006) proposed a roadmap for software process improvement to emphasise the verification and validation of software during the capability and integrity stages. The development was supported through practical resources in the industry. The developed roadmap supports ISO 9001 registered organisations to complete the gap analysis and maintain their quality manual without any complications [15].

Large companies in India have used the model from Srivastav to manage a resistance to change. This has enabled them to develop more comprehensive work designs for higher organisational effectiveness while completing certifications for ISO 9000 [16].

Walker developed a checklist to provide a common framework for assessments and auditing in software development [17]. The aim of this checklist is to enhance customer confidence and improve the effectiveness of audit assessments. This checklist should fill the large gap between the ISO 9001 clauses and their interpretation for the field of software. This checklist can easily be adjusted for the application in the ISO audit domain [17].

In his 2005 study, Bricoe (2005) introduced a conceptual process model to enable managers in small companies to effectively implement ISO 9000. His model suggests that there are four stages for effective implementation. First, the company must assure that there is a real need for change. Second, it has to establish a quality culture. Third, the company should perform a compelling and thorough analysis of the ISO support infrastructure. Finally, to involve ISO practice as a part of the company's quality routine, it should assist the managers to evaluate the implementation process prior to starting it [17].

7. Summary of Industry Interviews

In order to determine the main factors and issues affecting ISO 9001 implementation and maintenance procedures, key informants from the industry were selected to participate in semi-structured interviews. These interviews were conducted with representatives from two Swiss companies: *RUAG Electronics* and *Sulzer Innotec.*

RUAG Electronics, Software Development for Live Simulation Software, went through the implementation of ISO 9001 two years ago and is currently preparing for its 9001 annual auditing period. In total, five people were interviewed at *RUAG Electronics*. Four persons were from the software development team (as well as the head of the department) and one person from the quality department. *RUAG Electronics*, also provided the experiment field for this research. The second company, *Sulzer Innotec* is an engineering, R&D, and Management company that deals with certifications and accreditations and offers ISO auditing services for the industry sector. The interview at *Sulzer Innotec* was conduct with an expert for ISO Audit.

The following section discusses and summarizes the key findings from these interviews:

- A lack of visibility and correlation in the ISO guideline for software products is one of the most crucial challenges for its implementation. It requires excessive time and effort to understand and familiarise oneself with all the details [8]. This impairs the planning procedures in terms of resource planning and preparation activities. The complex structure and lack of clearity in the guideline 90003:2004 makes it difficult to apply.

- The guideline does not clearly show the link to the concerned organisation's structure. There is no explanation in terms of ISO implementation approach [9]. This complicates the communication of the approach between the involved groups and divisions. A lack of communication between senior management and development has been identified, particularly with respect to ISO standards and regulation.

- The complex nature of the guideline becomes noticeable when attempting to introduce the ISO 9001. Its approach is generally seen as disorganised, informal and short-term oriented [9]. The guideline does not specify or explain how to implement ISO standard to software products.

The guideline fails to convey the required steps in a clear and concise manner [8]. Additional statements were made regarding how to monitor ISO compliance in the process after implementation. The expert in this field suggests a well-defined formal procedure should be used to review the process on a regular basis. This will help ensuring the effectiveness of the process and support annual audits.

Furthermore, documentation is one of the major problems that ISO certified companies often deal with. Frequently, documentation is not continuously maintained. This is due to a lack of control and monitoring of configuration management procedures [9]. ISO 9001 is considered to be bureaucratic and documentation can become excessive.

The key informant interviewees considered the documentation issue to be a neglected problem that has been mostly overlooked. In most cases the documentation was completed after the creation of a project; however, it is most effective to generate the documentation during data creation. The documentation is compulsory for all kinds of quality management implementation. Therefore, it is highly recommended to ensure that documentation is comprehensive and of good quality. This should not only pertain to the applied systems (e.g the Quality Center), but also motivate the people to use it on a regular basis. The management should assign someone the responsibility of overseeing the documentation process [9].

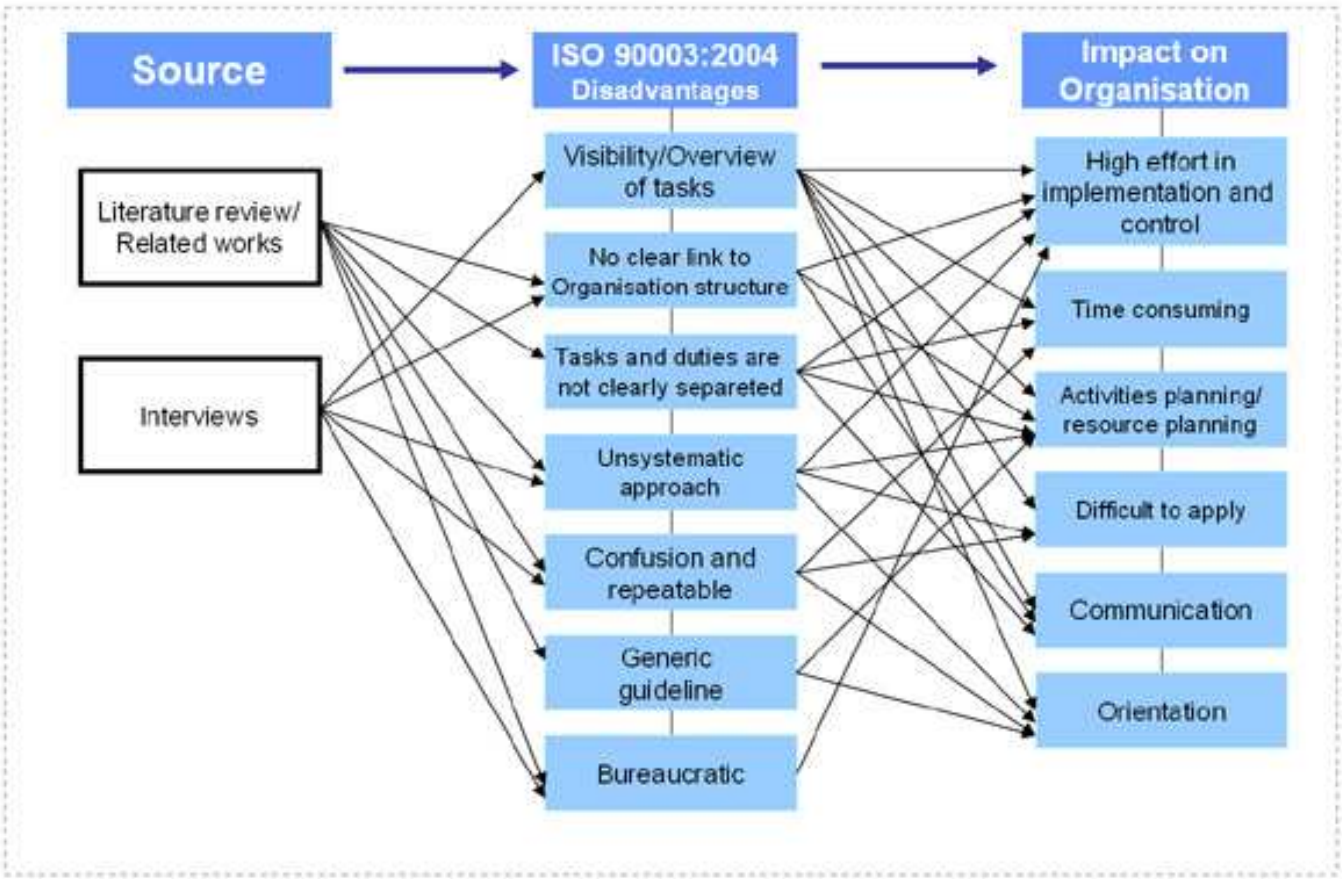


Fig. 4 Disadvantages and their impacts

8. Data analysis

In this section, data collected through the literature review and interviews were analysed, structured and presented. The result of the data analysis does not show any major critiques of the ISO 90003:2004 itself, but rather reveals shortcomings in the ISO's organisational structure and layout.

The above figure (Fig. 4) mapped, structured and presented the conduct data. The graph identified key disadvantages of the ISO 90003:2004 guideline and their impacts on the ISO approach within the organisation. In total, seven fundamental negative factors were determined and linked to the six concerned areas within the organisation. The result of the analysis states that nearly all disadvantages influence more than one activity in the approach of ISO. The reason for this lies in the existing dependency and correlation within the concerned activities and the ISO implementation. The similarities between the findings in the literature and those in the industry, demonstrate the need for investigating the ISO implementation approach for software products. The visibility in the ISO approach was not mentioned in the literature. However, according to the analysis, the impacts of visibility are significant in the ISO application. In addition, the analysis also determined several important issues related to the ISO implementation as shown in the above figure (Fig. 4).

In order to narrow the focus of this research, the disadvantages were divided into two main categories as shown in Fig. 5. The analysis considered the following as the core reasons in the application of ISO 90003 standards to the software products within the organisation:

1. Communication
2. Unsystematic approach

The core piece of an internal communication is controlled by the management's leadership style. Good communication is the key means of control and development [27].

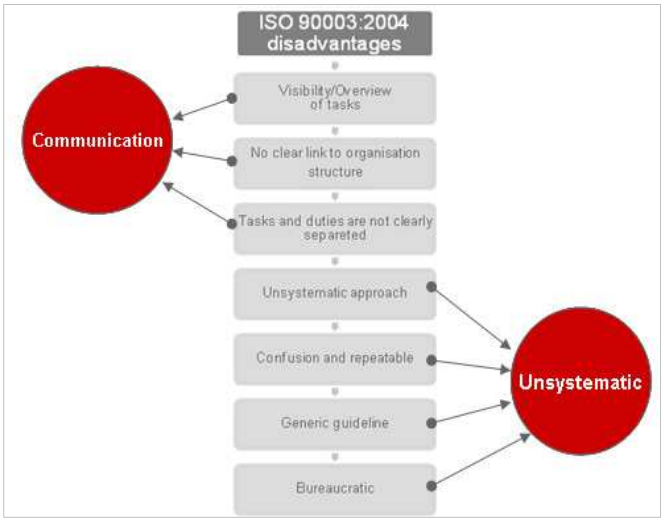


Fig. 5 Main problems

Communication refers to the exchange of information by expression and perception of symbols. It is the requirement for team development to encourage collaboration and co-operation [28]. The complex nature of the ISO guideline was explicitly addressed by both sources (literature and interviews). The guideline fails to provide a clear orientation and guidance in the implementation or audit procedures. This results in confusion when attempting to understand the ISO guideline and how to apply it to the organisation. Moreover, bureaucracy in ISO standards requires a high degree of documentation. This slows down the approach and requires more effort.

The analysis results provided detailed insight into the current problems associated with ISO implementation and highlighted the impact of poor communication and an unsystematic approach.

9. Research gap

Based on the intensive literature review and the study carried out on ISO standards, supported by the industry statements, the research gap was determined.

The literature has shown some related works in this area, but they are not specific to ISO 90003 implementation. These works focus more on issues related to the adoption of specific software assurance quality systems, with the frameworks of ISO standards. The research materials were extremely useful in identifying the benefits gained through ISO 9001 standards. Moreover, the literature also highlighted the problems of implementation and addressed the affected areas by ISO 9001. However, during the course of the research, a lack of material available on the application of ISO 9001 within the IT industry was identified. There is no overarching best practice framework available that provides systematic structure to ISO implementation. This has been achieved through the use of individual tools, such as checklists, that support the implementation.

9.1 Problem definition

This section briefly summarises the major difficulties in the ISO implementation. The research on this topic identified that the existing ISO guideline for software products does not fulfil expectations in its implementation within in the organisation. The literature emphasises the importance of considering the additional relevant factors discussed in Section 5. The ISO guideline itself should not be the only source for such an approach.

10. Development approach

The purpose of this section is to report how the ISO Roadmap and the corresponding Checklist were developed. As shown in Figure 6, the step process has been utilized for ISO Roadmap development. This process covers Phase 2 and Phase 3 of the research methodology. The selected literature for this purpose provided a solid background understanding and useful introduction to ISO implementation for the software development process. This first step demonstrates the sources used for the ISO Roadmap development. It refers to the literature review and semi-structured interviews.

Step 2 involved the analysis and identification of the outputs generated through sections 4 and 5 and the analysis shown in section 8.

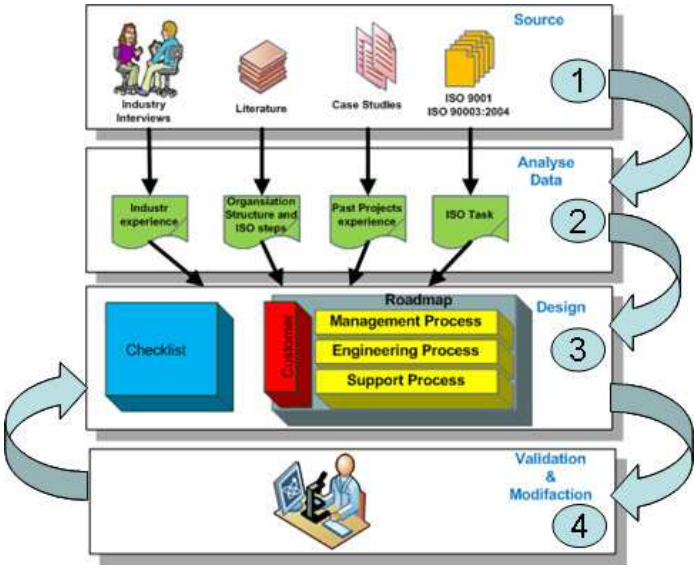


Fig. 6 Development approach

10.1 Roadmap development

10.1.1 Layout design

The literature review provided three themes as discussed in section 3. These were considered in the development of the roadmap. These themes were integrated into a generic organisation process landscape to design the roadmap structure.

The roadmap structure is divided into three phases. The first phase includes two functions, “Marketing” and “Supplier”, which show the direct link to the customer. This is intended to illustrate the consumer focus required by ISO 90003 standards. The second level represents “Operation”. This level is responsible for all engineering processes relating to the roadmap. The link between the engineering process and the customers exists at this level as well. This should improve customer relations and ensure that software requirements are properly understood and communicated. The interview has shown that it is essential to involve the customer early on in the engineering process. The last phase involves the supporting processes for the operation and management level. This level deals with documentation, configuration management and quality control.

ISO representatives are placed at all three levels to ensure that ISO processes are monitored and followed, particularly the support activities at Level 3. The research identified documentation as a major issue with respect to quality control and maintenance. As such, the additional control is aimed at improving maintenance and documentation procedures. In addition, the roadmap uses arrows to identify the information and workflow in the roadmap. Furthermore, it applies a black bold border or cut line to individual ISO tasks to indicate the necessity for co-operation and involvement see appendix B.

10.1.2 ISO 9001 Tasks

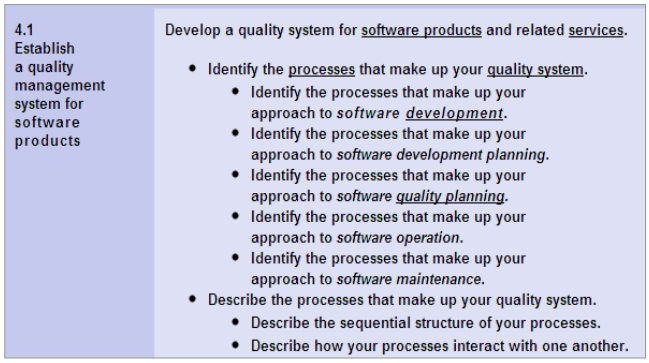
The ISO tasks were assigned in accordance with the roadmap layout referred to in the literature review (Section 4.1). The confusion and repetitive nature of the ISO guideline was seen to be disadvantageous. In order to mitigate this issue, the tasks were carefully investigated and assigned to the corresponding organisation level, as outlined in the literature review. This also required that smaller tasks to be incorporated into larger ones. These tasks were then defined as steps in the checklist to ensure their execution.

10.2 Checklist design

The development of the Checklist went through the same process used for the ISO Roadmap (see Figure 6). In order to systematise this approach, a set of steps was defined for each task in the roadmap. The definitions of these steps were support by the literature review.

It used simplistic language to understand and develop a step-by-step approach. The following figure (Fig.7) shows a section taken from the ISO guideline for software products.

It does not show any systematic or dependency approaches (see Appendix A). It is not specific, as was determined from literature and interviews. The following figure (Fig.8) demonstrates the difference between current ISO guideline and the developed Checklist.



4.1 Establish a quality management system for software products	Develop a quality system for software products and related services.
	• Identify the processes that make up your quality system.
	  • Identify the processes that make up your approach to *software development*.
	  • Identify the processes that make up your approach to *software development planning*.
	  • Identify the processes that make up your approach to *software quality planning*.
	  • Identify the processes that make up your approach to *software operation*.
	  • Identify the processes that make up your approach to *software maintenance*.
	• Describe the processes that make up your quality system.
	  • Describe the sequential structure of your processes.
	  • Describe how your processes interact with one another.

Fig. 7 Section 4.1 Quality System ISO 90003 guideline for software products

The Checklist clearly shows the systematic nature of this approach, which is directly linked to the tasks in the ISO Roadmap (see Appendix B). Furthermore, it shows each level and phase involved in the task. The connection is realised through a well-structured and organised ISO Roadmap and Checklist. Both the checklist and roadmap use the same definition and structure to highlight the linkages between them and to avoid misunderstandings. The overview is straightforward and easy to understand.

1. Phase	Management					
4	Quality System	Requried Completed Task	Objectives	Status		Note
		Engineering enviroment	Quality management system	If none	Red	Not fullfilled
1	Ensure the existence of a documented quality system, to support the quality right from the development phase		Quality system documentation	If less than 7 checked	Yellow	Partly fullfilled
			Awarenes and competence of people	If all checked	Green	Fullfilled
			Regular review of quality system			
2	Ensure the quality system elements are documented in a systematic and orderly manner		Consider audit in the quality plan			
			Control of quality system			
			Review by management at least once a year			
3	Ensure the review of the quality system by management and adaption of change when required					
4	Ensure changes are docuemented in orderly manner					
5	Ensure the eixstance of a quality plan for each project that identifies the activities, shedule and resources need to ensure the software development and implementation					
6	Ensure the exist of enough resources with right skills to assist, improve quality system to meet customer needs					
7	Ensure the control of the quality system at all organisation levels through ISO representative					

Fig. 8 Example for the task "Quality System "checklist

The seven specific steps are numerically controlled, allowing for the effort required for these steps to be measured in this way. Moreover, it encourages a more systematic approach. The row "Required Completed Task" indicates the dependency between the tasks. In this example, the task "Engineering Environment" must be completed prior to "Quality System" in order to progress with this step. This ensures that the individuals involved are aware of other tasks and how they could affect each other. The next row shows the objectives that should be fulfilled by completing this task.

Clear objectives help the staff to understand what is expected by the task and provide a self-control mechanism. The existing confusion in the guideline could be reduced if objectives were better communicated and the progress of each task were individually controlled and monitored.

The checklist applies three colours to indicate the status of progress. This application tracks the progress and makes it more visible.

The combination of both the ISO Roadmap and Checklist provide structure, systematization and visibility in the approach. This fusion of characteristics sustains the communication and transparency required for the successful application of ISO standards.

10.2 Evaluation

In Step 4, the method expert review is introduced for assessment. This provides an evaluation of the ISO Roadmap and Checklist through an external ISO 9001 auditor supported by Sulzer Innotec [9]. The individual provided is highly skilled in quality issues and an expert in the execution of ISO audits for the industry sector. Since the evaluation of one person is not seen to be sufficient, additional reviews are arranged. This process considers the involvement of persons in different roles, such as users and developers. For this purpose a structured interview is used (see Appendix C). The overall evaluation was expressed through a combination of different views. The review with the expert key informant was achieved through formal interviews.

This evaluation resulted in the collection of useful feedback. For instance, the expert key informant highlighted the importance of ensuring a control's feedback culture within the organisation. Other gathered feedback recommended the use of legends. The modifications were then adapted and evaluated again with the expert. This evaluation of the ISO Roadmap and Checklist, provided useful insights for the next stage of the research: the experiment.

11. Experiment

The purpose of this section is to perform an experiment and to analyse the applicability of the ISO Roadmap within the software environment sponsored by RUAG. The result of the experiment will be treated confidently. The idea of the experiment is to gain insight into how to better support ISO 9001 implementation procedures. At the time of this experiment, the sponsor company was preparing for its annual 9001 audit. This provided a great opportunity to test the competence of ISO Roadmap. The period of this experiment was short, due to limited resources and personnel availability. The experiment took place within the management organisation. Usually, the person responsible for the ISO 9001 prepares for the audit by relying on the results of the pervious audit documentation. However, for this experiment, the ISO Roadmap was used as the guiding instrument for this process. Due to time constraints, the experiment was based only on the inspection of one task. In this case "Requirement Specification" was selected and was evaluated according to the ISO Roadmap guideline. First, it evaluated the delegation of responsibilities and personnel for the task. The ISO Roadmap suggests that at this stage, co-operation between the customer, marketing and supplier management should be evident. According to the Checklist, the task "Contract review" was selected as a required completed task. This required further documentation, such as a contract. The next step required the examination of the task in relation to the defined steps in the Checklist. This was conducted systematically, according to the numerical steps. This approach provided a focused and directed approach (see Appendix D). The field objectives in the Checklist helped to keep the experiment focused and enhanced the proposed activity.

According to the completion of the required steps in the checklist, the status of the "Requirement Specification" was identified and linked to the ISO Roadmap. In this case, some of the steps were incomplete, and thus the status was yellow; the colour yellow indicates that they were "Partly fulfilled". These had to be investigated to ensure all required steps were fulfilled, thus switching the status to green. Green indicates that the status is "Fulfilled".

11.1 Experiment Result

The result of the experiment was satisfactory; even though only one task had been used for this experiment, the experiment showed a systematic approach. It led directly to the task and illustrated clearly what to do. It ensured that the focus remained on the task at all times and that effective inspection was achieved by following the defined steps in the checklist. It delivered good orientation and supported the understanding of the required steps. In addition, the inspection of this task was efficient and goal-oriented. It allowed for progress to be monitored and for the status statement to be delivered. The status notification is highly useful in terms of performance and progress measurement. The ISO Roadmap provided clear guidance that reduced the organization's time and effort.

The people involved in this experiment agreed that the ISO Roadmap was systematic and transparent. This encouraged the sponsor to accept it as an assistance tool for the maintenance and control procedures for ISO 9001 standards.

12. Conclusion

12.1 Discussion

The research topic relied heavily on the literature, ISO standards and knowledge from the interviewees. The literature provided overall materials related to the benefits gained by ISO standards. The complexity of ISO standards in its structure and layout was the most challenging aspect of this study. The research has clearly shown the need for research in this area. Despite this necessity, there was a lack of material available related to ISO implementation for software products. For this reason, the research needed to capture tacit knowledge that is present in only in the minds of the experts. This also included the collection of feedback from non-experts during the evaluation phase.

The experiment with the ISO Roadmap delivered significant results in terms of its effective application in control and inspection with ISO 9001 standards for software products. The results of this research are represented in the form of a roadmap and checklist for all relevant tasks needed to acquire ISO 9001 accreditation for software products.

This roadmap and checklist reduce the ISO guideline's complexity and provide a visually-oriented approach.

12.2 Main benefits

The study provides an ISO Roadmap and Checklist for software products. This roadmap presents ISO 90003 standards in the form of a generic organisation structure. It provides a clear overview and structure combined with a checklist to ensure a systematic approach. It also contributes to the following additional benefits:

- Well-structured presentation of ISO standards tasks for software product
- Clear dependency and tasks arrangement
- Systematic approach driven by a clear set of steps and objectives
- Control and monitor functions
- Mechanisms for providing feedback

The main benefit in this approach is to provide the software industry with an initial step towards better systematisation for ISO implementation. Until now there has been no framework available to assist in the application of ISO standards. According to the experiment and experts' insights, this roadmap shows the ability to support ISO standard implementation. Moreover, it will facilitate and support the planning and preparation procedures related to ISO standards implementation and audit activities. Additionally, a review of the existing ISO tasks could potentially support the necessary preparation procedures.

12.3 Research limitations

This study concentrated on the statements gathered from the literature analysis and industry statements.

Due to the lack of the material available for ISO software implementation, it was necessary to conduct additional qualitative research. Unfortunately, due to time constraints, it was not possible to carry out further qualitative research and experiments. For this kind of research, it is important to collect tacit expert knowledge related to ISO implementation for software products. Another limitation of this study was the absence of any logical algorithms models that progress the connection between the ISO Roadmap and Checklist.

12.4 Findings

Several software organisations are seeking the accreditation of ISO standards due to potential external and internal benefits. The high demand for, and complexity of, the recent software requires rapid reaction and high quality. As such, many organisations have recognised the need for improved quality obtained through quality management systems. Often, this kind of implementation fail due to a lack of effort, time and involvement with external and internal factors. The internal factors include issues such as: resistance to change, lengthy implementation processes, and failure to select the appropriate tools and methodologies. These factors have often been underestimated by several software organisations. The external factors are: customers' quality expectations and the importance of rapid adaption in new technologies. The need for the application of a quality system such as ISO standards is obvious. However, software organisations suspect that the slow internal processes are due to limitations such as quality regulation, documentation, resources, time and bureaucracy. Furthermore, organisations that have already implemented ISO standards are facing major difficulties in maintaining their quality systems. The research identified a lack of control and monitoring as the main reasons for these inefficiencies.

The results from this research have shown that the ISO Roadmap provided a more systematic approach and visible structure. The experiment performed on the ISO Roadmap, within the software environment, demonstrated an impressive step toward a systematic approach for ISO implementation. The combination of a generic ISO Roadmap and corresponding Checklist for software products, proved beneficial. Furthermore, the generated ISO Roadmap provides a reliable set of requirements that can be used for the development of specific software to assist the ISO implementation.

12.5 Recommendations

The findings in this research prove the necessity of conducting an internal evaluation to investigate the real need, resistance and resources (Jason, A. Bricoe et al., 2005) before initiating such an approach. This enables the management to obtain better insight into the organisation to support decision-making and the evaluation of the internal resources and needs. In this way, organisations gain a big picture from all potentially involved factors that tend to affect the ISO standards implementation.

As suggested by the literature, it is important to consider all sources of knowledge (literature review, specific know-how or expertise) when developing an approach for ISO implementation. The ISO Roadmap approach has done just that, by relying on a solid literature review, expert reviews, user involvement and an experiment.

Due to the current needs relating to ISO standards and implementation for software products, further research is needed to gain more experience with, and in-depth understanding of, ISO standard application for software products.

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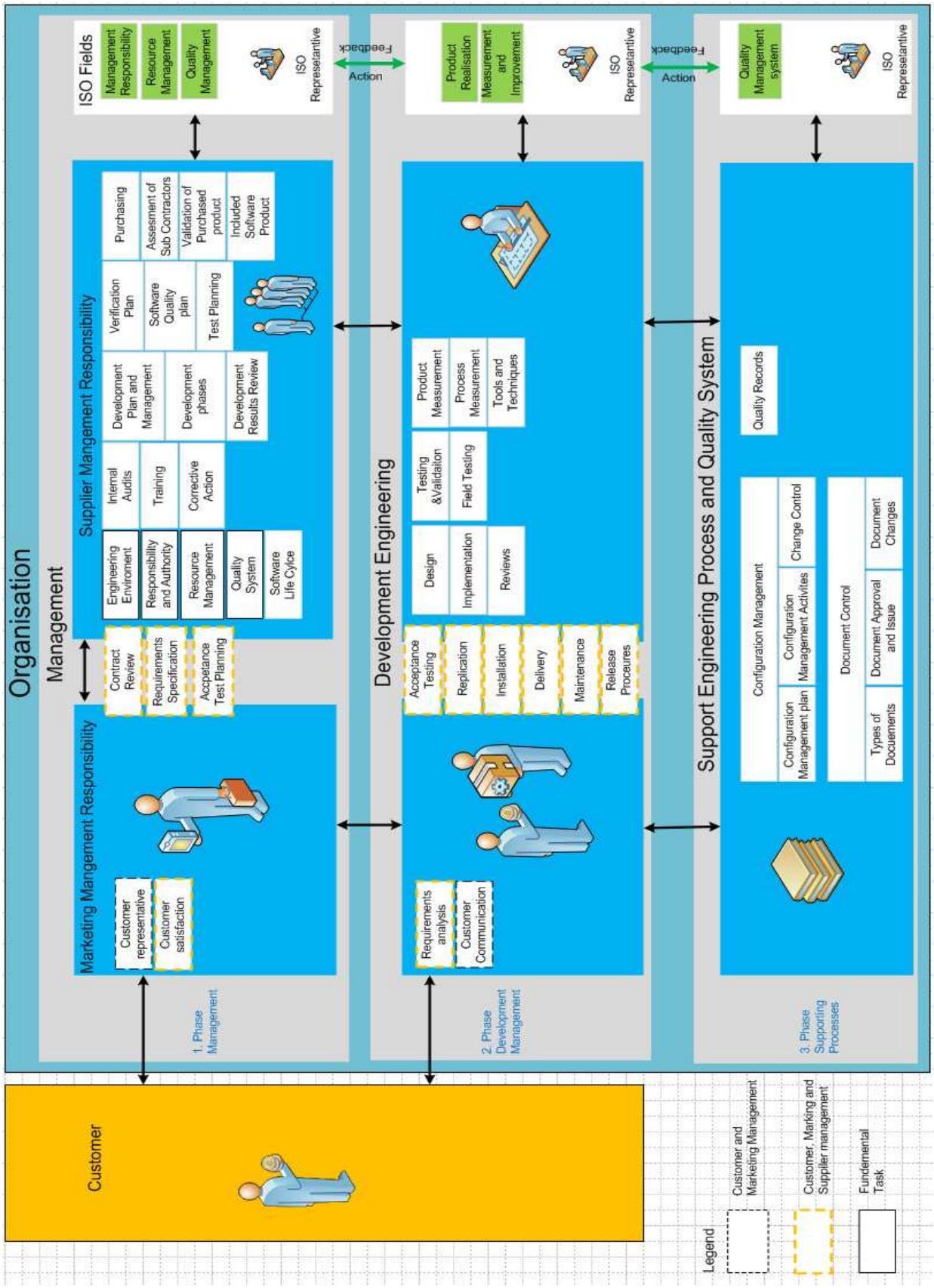
Appendix A

ISO 90003	4. Systemic Requirements and Guidelines

4.1 Establish a quality management system for software products	Develop a quality system for software products and related services.
	• Identify the processes that make up your quality system.
	  • Identify the processes that make up your approach to *software development*.
	  • Identify the processes that make up your approach to *software development planning*.
	  • Identify the processes that make up your approach to *software quality planning*.
	  • Identify the processes that make up your approach to *software operation*.
	  • Identify the processes that make up your approach to *software maintenance*.
	• Describe the processes that make up your quality system.
	  • Describe the sequential structure of your processes.
	  • Describe how your processes interact with one another.
	
	Implement a quality system for software products and services.
	• Use your quality management system processes.
	• Manage the effectiveness of your processes.
	• Support the effectiveness of your processes.
	
	Improve your software oriented quality management system.
	• *Monitor* the effectiveness of your processes.
	• *Measure* the effectiveness of your processes.
	• *Improve* the effectiveness of your processes.

4.2 Document your software oriented quality system	4.2.1 Develop quality management system documents. • Develop documents to implement your quality system. • Develop documents that describe your software processes. • Develop documents that describe your life cycle models.

Appendix B: ISO Roadmap



Appendix C: Interviews questionnaire

Interview zur ISO Roadmap Evaluation

Datum	
Name	
Fachbereich	
Position	
Datum	
Version	1.0

1. Feedback zur Roadmap und Checklist

Um die Qualität meines Interviews zu verbessern, bin ich auf Ihr Feedback angewiesen. Deshalb bitte ich Sie folgende Fragen mit dem zutreffenden anzukreuzen.

1. **Wie beurteilen Sie allgemein der ISO Roadmap und die entsprechende Checkliste?**

☐ ausgezeichnet ☐ sehr gut ☐ gut ☐ befriedigend ☐ ausreichend

☐ nicht gut

Bemerkung: _____

_____

2. **Wie beurteilen Sie die Übersichtlichkeit der Tasks im Roadmap und Checkliste?**

☐ ausgezeichnet ☐ sehr gut ☐ gut ☐ befriedigend ☐ ausreichend

☐ nicht gut

3. **Wie beurteilen Sie die Komplexität?**

☐ sehr kompliziert ☐ kompliziert ☐ einfach ☐ sehr einfach ☐ keine aussage

Bemerkung: _____

_____

4. **Wie wird die Abhängigkeit der einzelnen Tasks dargestellt?**

☐ vollständig ☐ grosses Teil ☐ teilweise ☐ wenig ☐ keine

5. **Könnte diese Methode Ihrer Meinung nach alle notwendigen und relevanten ISO?**

☐ vollständig ☐ grosses Teil ☐ teilweise ☐ wenig ☐ keine

5.a Wenn nein was fällt Ihrer Meinung nach?

_____

2

6. Wie beurteilen sie die Struktur und Inhalte der Checkliste?

☐ ausgezeichnet ☐ sehr gut ☐ gut ☐ befriedigend ☐ ausreichend

☐ nicht gut

Bemerkung: _____

_____

7. Wie bewerten Sie die Vorgehensweise?

☐ ausgezeichnet ☐ sehr gut ☐ gut ☐ befriedigend ☐ ausreichend

☐ nicht gut

8. Wie beurteilen Sie die Sprache in der Checklist?

☐ ausgezeichnet ☐ sehr gut ☐ gut ☐ befriedigend ☐ ausreichend

☐ nicht gut

9. Was kann man besser machen?

_____

_____

10. Wie finden Sie den Link mit dem Roadmap?

☐ sehr gut ☐ gut ☐ befriedigend ☐ nicht ausreichend

Bemerkung: _____

_____

Appendix D: ISO Checklist, Task “Requirements Specification

	11	Requirements Specification	Requried Completed Task	Objectives	Status		Note
			Contract review	Identificaton the functional and technical	If none	Red	Not fullfilled
	1	Ensure requirements have been developed in close cooperation for both parties		requirements of a product	If less than 7 checked	Yellow	Partly fullfilled
					If all checked	Green	Fullfilled
				Cooperation in developing the requirements			
	2	Ensure requirments cover the following aspects: performance, saftey, reliability, security and privacy		Requirements are completed and quantifiable			
	3	Ensure the identification of persons responsible for developing requirements specification on both side					
	4	Ensure the agreement to the scope and costs of change					
	5	Ensure the use of a specification template to be used to request changes to requirements					
	6	Ensure the support from supplier to write the product specification					
	7	Ensure to document and review the resuls of the regular meeting to discuss requirements					