Instantiation of an ISO 9000 compliant quality assurance process

Florian Stahl
Master Thesis

Instantiation of an ISO 9000 compliant Quality Assurance Process

Florian Stahl

31\textsuperscript{st} of May 2006

Computer Science Department
Växjö University

Supervisor:

Prof. Dr. Welf Löwe
Rüdiger Lincke, M.Sc.
# Table of contents

Table of contents .............................................................................................................. 4  
List of figures .................................................................................................................... 6  
List of tables ...................................................................................................................... 7  
Glossary ............................................................................................................................... 8  
List of abbreviations ........................................................................................................ 8  
Definitions in terms of the STG ..................................................................................... 8  
1 Introduction .................................................................................................................. 9  
1.1 Context of the thesis ................................................................................................. 9  
1.2 Problem description ............................................................................................... 9  
1.3 Goals and criteria .................................................................................................... 9  
1.4 Motivation ................................................................................................................. 10  
1.5 Outline ...................................................................................................................... 10  
2 Terms and relevant standards .................................................................................... 12  
2.1 Quality in general .................................................................................................... 12  
2.1.1 Quality and quality management ........................................................................ 12  
2.1.2 Software quality .................................................................................................. 13  
2.2 Standards for quality improvement ....................................................................... 13  
2.2.1 ISO 9000 Quality management systems ............................................................... 13  
2.2.1.1 Overview ....................................................................................................... 13  
2.2.1.2 Terms and definitions .................................................................................. 16  
2.2.1.3 ISO 9001 Requirements .............................................................................. 17  
2.2.1.4 Implementation approach .......................................................................... 21  
2.2.1.5 Critical success factors .............................................................................. 23  
2.2.1.6 Evaluation of the standard ........................................................................... 24  
2.2.2 ISO/IEC 15504 Information technology – Process assessment ....................... 26  
2.2.3 CMMI and SCAMPI ......................................................................................... 28  
2.2.4 ISO/IEC 12207 Software lifecycle processes ..................................................... 31  
2.2.5 ISO/IEC 9126 Software Engineering – Product quality ................................... 33  
2.2.6 Comparison of the standards and models ......................................................... 34  
3 Quality management at the Software Technology Group ........................................... 38  
3.1 Description and organization of the STG ............................................................... 38  
3.2 Differences to a common organization ................................................................... 39  
3.3 Arguments for introduction of a standard or model .............................................. 39  
3.4 Reasonable choice of a standard ........................................................................... 39  
4 Instantiation of the ISO 9001 at the STG ................................................................ 41  
4.1 Followed approach ............................................................................................... 41  
4.2 Planning and initial tasks ....................................................................................... 41  
4.2.1 Scope and intention of the introduction ............................................................... 41  
4.2.2 Responsibilities and organisation during initiation ........................................... 42  
4.2.3 Project Plan ....................................................................................................... 42  
4.2.4 Gap assessment ............................................................................................... 43  
4.2.5 Technical infrastructure ................................................................................... 47  
4.2.6 Training and knowledge acquisition ................................................................ 48  
4.3 Design of the quality management system ............................................................ 49  
4.3.1 Structure ........................................................................................................... 49  
4.3.2 Quality policy and quality objectives ............................................................... 50  
4.3.3 Quality manual ............................................................................................... 51  
4.3.4 Procedure documents .................................................................................... 51
4.3.5 Document Control System ................................................................. 52
4.3.6 Records Control System .................................................................. 54
4.4 Implementation of the QMS ................................................................. 55
4.4.1 Documentation implementation ......................................................... 55
4.4.2 Adaptation of processes .................................................................. 56
4.4.3 Ideas for future implementations ....................................................... 57
4.5 Internal audit ....................................................................................... 59
4.5.1 General requirements ..................................................................... 60
4.5.2 Internal quality audit procedure ....................................................... 60
4.5.3 First internal audit at the STG .......................................................... 62
4.5.3.1 Purpose and specifics ................................................................. 62
4.5.3.2 Planning .................................................................................. 62
4.5.3.3 Conduction .......................................................................... 63
4.5.3.4 Results ............................................................................... 64
4.5.3.5 Follow-ups ........................................................................ 72
5 Summary .............................................................................................. 74
5.1 Conclusions ....................................................................................... 74
5.1.1 Problems ..................................................................................... 74
5.1.2 Fulfilment of critical success factors ................................................. 74
5.1.3 Achieved goals ........................................................................... 75
5.2 Expectations and future work .............................................................. 76
Appendix .................................................................................................. 78
A – Mind map of VizzAnalyzer quality meeting in November 2005 ............ 78
B – Initial presentation: ISO 9000 at the Computer Science Department .... 79
C – Quality Manual ................................................................................ 87
D – Templates .......................................................................................... 98
D.1 Procedure documentation template .................................................. 98
D.2 Work instruction template ................................................................. 100
E – Example documentation .................................................................. 102
E.1 Document Control System procedure ............................................. 102
E.2 Document Creation and Change work instruction ............................. 107
F – Libresource platform .......................................................................... 110
F.1 Welcome page ............................................................................... 110
F.2 ISO 9000 Wiki .............................................................................. 111
F.3 Document repository structure ....................................................... 113
G – Internal quality audit ........................................................................ 114
G.1 Internal audit questionnaire ............................................................. 114
G.2 Internal audit interview results ......................................................... 117
References ............................................................................................. 128
List of figures

Figure 1: Model of a process-based quality management system ........................................ 15
Figure 2: Alternate path through the paragraphs ................................................................. 21
Figure 3: Recommended implementation roadmap ............................................................ 22
Figure 4: Interaction between process model and assessment method .............................. 27
Figure 5: Connection of ISO/IEC 15504, CMMI and ISO 12207 ....................................... 28
Figure 6: The CMMI staged model ................................................................................. 29
Figure 7: A process capability profile ............................................................................. 30
Figure 8: The processes of the ISO 12207 ...................................................................... 32
Figure 9: Quality model for external and internal quality .................................................. 33
Figure 10: Quality model for quality in use ..................................................................... 34
Figure 11: Quality in the lifecycle .................................................................................... 34
Figure 12: Connections between standards and models ..................................................... 35
Figure 13: Organization of the Software Technology Group ............................................. 38
Figure 14: Architecture of the LibreSource platform ...................................................... 48
Figure 15: Structure of the QMS at the STG ................................................................. 50
Figure 16: Document creation and change ..................................................................... 53
Figure 17: Creation and distribution of records ............................................................... 54
Figure 18: Use of the document control system .............................................................. 57
Figure 19: Internal quality audit ...................................................................................... 60
List of tables

Table 1: Calculated costs of an ISO 9001 registration .............................................. 26
Table 2: Comparison of relevant standards and models............................................. 37
Table 3: Project Plan.................................................................................................. 43
Table 4: Initial gap analysis at the STG................................................................. 47
Table 5: Planned procedure documents and corresponding priorities.................... 52
Table 6: Proposals for quality records at the STG..................................................... 59
Table 7: Internal audit gap analysis ........................................................................ 72
Glossary

List of abbreviations

- **CMM**: Capability Maturity Model
- **CMMI**: Capability Maturity Model Integration
- **CSD**: Computer Science Department of the Växjö University
- **IEC**: International Electornical Commission
- **ISO**: International Organization for Standardization
- **QMS**: Quality Management System
- **RUP**: Rational Unified Process
- **STG**: Software Technology Group. Group within the Computer Science Department of the Växjö University developing software
- **TQM**: Total quality management
- **UPEDU**: Unified Process for Education

Definitions in terms of the STG

- **Author**: Certain individual from personnel being domain expert realizing document creation and change.
- **Custodian**: Individual assigned by the quality manager for the creation and maintenance of a quality record
- **Customer**: An individual or group of individuals using software or parts of it (product). They receive it as service from the STG and use it for their purpose, having the expectation that the product is fit for their purpose. The customer can on the one hand be external to the STG like project partners, companies, students or other researchers, but on the other hand also internal to the STG, being colleague. The customer is not necessarily a paying customer.
- **Consultant**: Author of this thesis (Florian Stahl) assists acquiring and distributing knowledge about the chosen standard or method and supports its implementation.
- **Developer**: Software developer working on software engineering activities and providing products.
- **Manager**: Head of the STG.
- **Marketing Director**: The marketing director establishes contacts to external customers and mainly represents the organization (STG) in front of them.
- **Personnel**: All members of staff and students that work within the scope of the Quality management system of the Software technology group.
- **Support Personal**: Support Personal assists the Marketing Director to fulfill the needs of external Customers like implementation and support and maintenance tasks.
1 Introduction

Assuring high quality in software engineering and resulting products reduces cost and resources needed during the development and maintenance of a system and increases customer acceptance. However software quality is difficult to measure and construct, and many software projects fail or exceed their budgets. The latest update of the ‘Chaos report’ which examines more than 9,000 software projects was published by the Standish Group International in 2004. It states that still 18% of the projects fail and 52% are over budget, time estimate or do not fulfill the required functionality. [StGr04]

To raise the chance to succeed software projects current approaches aim on implementing software quality by improving and controlling development processes. This can be assisted by applying standards or models for quality and process improvement like the ISO 9000 to the software development process.

1.1 Context of the thesis

The Software Technology Group at the Computer Science Department of Växjö University is currently developing the VizzAnalyzer program. This software is for analyzing and visualizing the quality of source code. The need of establishing a thesis project concerning the software engineering processes at the STG was identified during a meeting about the VizzAnalyzer quality in November 2005 (see mind map in Appendix A). Members of the group detected problems due to mostly bad or undocumented and uncontrolled processes during the development. Also, no methods are established for identifying, reviewing and improving error-prone processes. Consequently quality problems during software development at the STG occur and product quality is not optimal.

1.2 Problem description

Adjusting the SDPs of the STG is not trivial since local constraints and established processes must be respected and the local requirements of the STG have to be met. Furthermore, standards and models for quality and process improvement are mostly quite complex and general. Some of them complement each other or are partially overlapping. Also, conflicts can be expected during an adaptation of processes making compromises necessary. Moreover, feedback about quality is required for improvement as part of the quality management process. However it is not easy to get since quality in software development is difficult to measure.

Thus, the problem addressed by this thesis is:

*Documenting, harmonizing and improving the mostly uncontrolled processes at the STG, especially those for software development and knowledge preservation, and supporting this by introducing a quality standard or model in consideration of local requirements and constraints.*

1.3 Goals and criteria

This problem shall be solved and therefore the following goals are set in the context of this thesis:

- Provide a process environment supporting the development of high-quality software products in a cost-effective way and thereby fulfilling customer requirements. Criterion for that is initiating the introduction of a quality standard or model within the STG.
• Using the advantages of a realized standard or method like process improvement and knowledge gain by the application of associated guidelines, best practices or requirements. Criterion for this is the discussion, comparison and documentation of current standards and models for quality and process improvement applicable to the area of software engineering and the corresponding choice of a suitable one for the STG in consultancy with the persons in charge.

• The subsequent goal is the implementation of the chosen standard or method tailored to the needs of the STG. The outcome and criteria for this is a set of documents and templates providing an overview, guidelines and detailed instructions describing and defining processes related to the software development within the STG. This documentation contains existing and newly established processes and their maintenance. Furthermore it supports the assurance that the identified and improved processes are being followed. Besides this, a technical system supporting the documentation is set up and the members of the STG are trained by presentations and in discussions.

• The success of the taken actions is checked and the compliance with the applied standard or method is evaluated. Criterion for this is a first assessment resulting in a report stating in how far requirements are fulfilled.

An official certification to the standard or model is not in the scope of this thesis and not realistic in such a short time frame, but the fundamentals are set for reaching it as a future goal.

1.4 Motivation

The motivation for the implementation of such a standard is an expected improvement to the quality of produced artifacts, such as research related software and corresponding documentation. The knowledge that is represented in standards and models shall help the STG to improve and define its processes, thus to saving time and improving efficiency.

In addition, this is a formal way to use synergy effects and the staff’s awareness regarding quality is expected to increase.

Furthermore the STG’s research area of software quality also demands gaining knowledge about quality standards and models in general.

In the long term the infrastructure established during the run of the thesis and the defined processes will help to save the STG time in their work, improve the quality of created software and corresponding documentation and to satisfy involved partners.

1.5 Outline

In the following chapters of this thesis, quality related terms are clarified and standards and model for quality improvement are introduced in Chapter 2. Also, the relevant standards ISO 9000, ISO/IEC 15504, ISO/IEC 12207 and ISO/IEC 9126 and the CMMI model are explained and compared.

In Chapter 3 the STG is introduced and one of the discussed standards will be chosen for implementing it within the STG.

The instantiation of the selected standard ISO 9000 within the STG is described in Chapter 4. This includes the planning, design and implementation of a quality management system and the conduction of internal audits.

Finally in Chapter 5, the results of the thesis are summarized, conclusions drawn including the explanation of occurred problems and future work is proposed.
The Appendix contains documents being used and created for the introduction and implementation of the ISO 9000 at the STG. Furthermore, technical support systems are illustrated by screenshots.
2 Terms and relevant standards

This second chapter clarifies the general term quality and software quality in specific. Furthermore standards and models applicable for quality improvement in software development are introduced, discussed and compared to establish a basis for the reasonable choice of one of them for instantiation at the STG. Covered are the standards and models ISO 9000, ISO/IEC 15504, CMMI, ISO/IEC 12207 and ISO/IEC 9126.

2.1 Quality in general

2.1.1 Quality and quality management

The term quality is a frequently used expression in all kinds of businesses. Despite this an exact and accurate definition of the term is not easy.

According to an initial research in Wikipedia “quality refers to the distinctive characteristics or properties of a person, object, process or other thing. Such characteristics may enhance a subject’s distinctiveness, or may denote some degree of achievement or excellence. […] When used in relation to management, the term may be easily defined as ‘reduction of variability’ or ‘compliance with specifications’” [Wiki06a].

This view is also supported by the ISO 9000 standard that defines quality as a “degree to which a set of inherent characteristics fulfills requirements” [Beau00, p 173].

The American Society for Quality defines quality as “the characteristics of a product or service that bear on its ability to satisfy stated or implied needs.” Meaning the quality of a product relates to how well the product serves the needs of the customer. [AmSQ06a]

The German DIN Standard 55350 has a similar description of quality: “Gesamtheit von Eigenschaften oder Merkmalen eines Produkts oder einer Tätigkeit, die sich auf deren Eignung zur Erfüllung gegebener Erfordernisse bezieht.” [Balz98]

This corresponds approximately to the definition of the American Society for Quality if translated into English.

The property of quality can also be used to assess and distinguish products or processes regarding qualitative or quantitative criteria.

These definitions of the term quality give an idea as to what quality is about but no hints on how to implement good quality. It is mostly too late to improve quality when deficits on a product are detected. Quality has to be realized before the product is finished, thus during its design and development.

The process management premise suggests what quality improvement and the more general expression quality management are about:

“The quality of a system is highly influenced by the quality of the process used to acquire, develop and maintain it.” [SEIn05a, p 8]

This premise is also supported by the Total Quality Management (TQM) which is a management strategy that aims at embedding awareness of quality in all organizational processes. The TQM movement was established in the late 1980s in the United States as an answer to the Japanese leadership in automobile and electronic markets. Japanese companies focused earlier on processes improvement and therefore American companies could not compete. [AmSQ06b]

The current quality management movement has matured, especially with the intense focus on customer satisfaction. [AmSQ06c]
2.1.2 Software quality

Regarding the focus on quality improvement in the computer science sector it makes sense to have a look at software quality. Software quality means for some a strict conformance to the requirements, for others it implies that the software fulfils subjectively its practical tasks efficient and satisfying.

The Standard Glossary of Software Engineering Terminology defines “the discipline of software quality [as] a planned and systematic set of activities to ensure quality is built into the software. It consists of software quality assurance, software quality control, and software quality engineering. As an attribute, software quality is (1) the degree to which a system, component, or process meets specified requirements. (2) The degree to which a system, component, or process meets customer or user needs or expectations.” [IEEE90]

A more detailed description of software quality will be given in chapter 2.2.5 when the ISO 9126 standard for Software Engineering Product Quality is introduced.

Software quality assurance became increasingly important with the appearance of the software crisis in the beginning of the late 1960s and continues to be important today. In the past, and nowadays, many software projects exceed their expected time and budget and the products are delivered with an unpredictable error rate. That is the result of developing more and more complex software without using appropriate methods to manage the projects. Therefore a way must be found to control and reduce these risks and to reach satisfactory software quality by improving the development process.

This need results in a number of standards and models, helping to improve quality in software development by applying established approaches.

The most important standards and models that are applicable for improving software quality and quality in general are introduced and compared in the following chapter.

2.2 Standards for quality improvement

Standards for quality improvement are becoming popular. Several of them are applicable or foreseen for use in the area of software engineering. The ISO (International Organization for Standardization) standards ISO 9000, ISO/IEC 15504, ISO/IEC 12207 and ISO/IEC 9126 and the Capability Maturity Model Integration (CMMI) should be the most common ones in this area and are in the interest of this thesis. Therefore they are discussed in this chapter.

2.2.1 ISO 9000 Quality management systems

2.2.1.1 Overview

The most popular standard in the area of general quality improvement and management is the ISO 9000 standard. In the year 2004, 670,399 companies were registered. Nearly one quarter of them were from China (132,926), followed by Italy with 84,485. In Germany 26,654 companies were registered, in Sweden 4,687. [ISOr05]

The standard provides assurance to companies enabling them to offer products or services that meet specific requirements, especially customer and regulatory requirements. These requirements enable to increase customer satisfaction in an orderly and systematic way. [Beau00]

The ISO 9000 is not specifically intended for the use in the area of software development. “All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.” [ISO900, p 13]
The standard is published by the International Standards Organization (ISO) that has its registered office in Geneva, Switzerland. The group responsible for the creation of the standard within the ISO is the Technical Committee 176 (TC 176).

Most industrialized nations adopted harmonized versions of the ISO 9000. They gave the standard their own designations, even though these standards are equal to the ISO 9000 in wording. In Sweden, the corresponding standard is called SS-ISO 9000, in Germany DIN ISO 9000. [John00] In the following only the term ISO 9000 is mentioned, which will refer to the original standard and national versions respectively.

The first release of the ISO 9000 was published in 1987 and described a three-level quality management system (ISO 9001, 9002 and 9003) and contained comprehensive guidelines (ISO 9004). It has its origin in some national standards created in the seventies. More precisely it is the result of the adaptation of the Canadian CSA Z 299 series of standards, the British standard BS 5750 for quality management systems and the Generic guidelines for quality systems ANSI/ASQC Z-1.15 issued by the United States. [Simp06a]

The ISO 9000 was fundamentally revised in 1994 and again in 2000. Since that time the structure has changed and the current ISO 9000 family contains four principal parts [BaDe04]:

- **ISO 9000:2005 Quality management systems – Fundamentals and vocabulary**
  
  Gives a starting point for understanding the standards and defines the fundamental terms and definitions used in the ISO 9000 family which are necessary to avoid misunderstandings in their use. [Simp06a]

- **ISO 9001:2000 Quality management systems – Requirements**
  
  Describes the requirements used to assess how far customer and applicable regulatory requirements can be met by the company. This is the only part of the family against which third-party registration can be carried out and thus the mandatory part when implementing an ISO 9001 compliant quality management system. So correctly an ISO 9000 compliance or registration is not possible, but regardless both terms are often used synonymously.

  This document replaces the ISO 9001-9003 documents of the former 1994 version.

- **ISO 9004:2000 Quality management systems – Guidelines for performance improvement**
  
  This part provides guidelines for continual improvement for companies that “wish to move beyond the requirements of the ISO 9001. […] ISO 9004 gives guidance on a wider range of objectives of a quality management system than does ISO 9001. […] It is not intended for certification or for contractual purposes.” [ISO900, p 11]

- **ISO 90003:2004 Quality management and quality assurance standards**
  
  This additional part provides guidelines for organizations in the application of ISO 9001:2000 to the development, supply, installation and maintenance of computer software and related support services.

There are also a number of guidance documents with the intent to support the ISO 9001:2000. These documents include standards and technical reports.

Furthermore there are some ISO standards which focus on software engineering that are more or less coordinated with the ISO 9001 [BaDe04] and can give some ideas for
the realization of some of the requirements. Two of these are the ISO/IEC 15504 *Information technology – Process assessment* and the ISO/IEC 12207 *Information technology – Software lifecycle processes*, which are described in the sections 2.2.2 and 2.2.4.

But first a more detailed overview over the ISO 9000 shall be given. The standard follows a process approach to reach customer satisfaction. In this approach linked activities are identified and managed to transform inputs into outputs in a way that satisfies quality goals. Process outputs often are the direct input for another process. The model shown in Figure 1 displays the linkage of the processes in a process-based QMS. It illustrates paragraphs 5 to 8 of the ISO 9001 and covers all requirements, but does not show detailed processes. [ISO900] Paragraphs 1 to 3 are only an introduction to the standard. Paragraph 4 provides a framework for the rest of the paragraphs and describes documentation requirements.

The model shows the Management responsibility (Paragraph 5) as a driver of the resources (Paragraph 6), which are needed for product realization (Paragraph 7) processes. The result of the product realization is data and information for measuring, analyzing and improving (Paragraph 8) the organization’s performance. This data is provided to the management to control the business and for the continual improvement of the QMS. The value-adding activities show the provision of the requirements and the receipt of the product by the customer. Furthermore customers communicate with the organization’s management and provide input on satisfaction. [BaDe04]

![Figure 1: Model of a process-based quality management system [ISO900, p 11]](image-url)
2.2.1.2 Terms and definitions

The model gave an abstract overview of the requirements of the ISO 9001 and their interrelation. Before expanding on the requirements further, some specific terms and definitions have to be clarified ensuring a common and clear understanding of the standard. The important ones are listed below. Most of the terms have their origins in the ISO 9000 *Quality management systems – Fundamentals and vocabulary*, some of them in [Beau00].

- **Audit.** Systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled.
- **Audit criteria.** Set of policies, procedures or requirements used as a reference.
- **Certification.** Procedure by which a third party gives written assurance that a product, process or service conforms to specific requirements.
- **Conformity.** Fulfillment of a requirement.
- **Customer.** The paying customer. Organization or person that receives a product. NOTE: A customer can be internal or external to the organization.
- **Customer satisfaction.** Customer’s perception of the degree to which the customer’s requirements have been fulfilled.
- **Document.** Information and its supporting medium.
- **Effectiveness.** Extent to which planned activities are realized and planned results are achieved.
- **Efficiency.** Relationship between the result achieved and the resources used.
- **Management representative.** The person with the defined authority and responsibility to carry out the requirements of ISO 9001.
- **Management system.** System to establish policy and objectives and to achieve those objectives.
- **Organization.** The company or organization seeking ISO 9001 registration.
- **Procedure.** Specified way to carry out an activity or process.
- **Process.** Set of interrelated or interacting activities which transform inputs into outputs.
- **Product.** Result of a process. NOTE: There are four generic product categories, as follows:
  - Services
  - Software
  - Hardware
  - Processed materials
- **Quality assurance.** Part of quality management focused on providing confidence that quality requirements will be fulfilled.
- **Quality audit.** An audit of the quality management system.
- **Quality management.** Coordinated activities to direct and control an organization with regard to quality.
- **Quality management system.** Management system to direct and control an organization with regard to quality.
- **Quality manual.** Document specifying the QMS of an organization.
- **Quality objective.** Something sought, or aimed for, related to quality. NOTE: Quality objectives are generally based on the organization’s quality policy.
- **Quality policy.** Overall intentions and direction of an organization related to quality as formally expressed by top management.
- **Record.** Document stating results achieved or providing evidence of activities performed.
• **Validation.** Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled.

• **Verification.** Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled.

• **Work instructions.** A written description of how to carry out the operations of a particular process.

Furthermore, some terms used in the standard text have a more precise meaning than in common use. These terms are important for the correct interpretation of the requirements and are described in the following:

• **Shall.** You must follow this requirement to comply with the Standard. [Beau00, p 7]

• **Should.** Often used in guidance standards. Indicates a recommendation.

• **May.** Indicates a suggestion. Annotation: notes in ISO standards represent suggestions as well [BaDe04]

2.2.1.3 ISO 9001 Requirements

The ISO 9001 requirements are contained in the paragraphs 4 to 8 of the standard. Previously mentioned, paragraphs 1 to 3 are the introduction and describe the scope of the standard, normative references and terms and definitions shortly.

In the following the most important requirements are listed and briefly explained. For a complete listing of all requirements see the Table 4 in Chapter 4.2.4 (Gap assessment). Describing the standard in detail and interpreting it is not the purpose here. More detailed information about it can be found in [Beau00], [BaDe04] and [John00] on which this chapter is based on, in addition to the original text of the ISO 9001.

The ISO 9001 requirements in an aggregated form are:

4 Quality management system

4.1 General requirements

- A system that ensures product quality within the company has to be designed and created.
- Processes necessary for this system and their sequence shall be identified.

4.2 Documentation requirements

- Documentation of the QMS including the Quality manual, quality policy, procedure documents and records.
- The quality manual shall describe the scope of the system, reference procedures and map the organization’s processes to the requirements.
- Documents shall be created, reviewed, approved and distributed in a controlled manner. They are identifiable, legible and up-to-date.
- Records of the system use shall be kept to demonstrate that the QMS is effectively working in the required way.
- At least 19 different record types and six procedure documents are necessary to fulfill the requirements of the ISO 9001.
- The required record types are marked in Table 4 in chapter 4.2.4 (Gap Assessment) with ‘(R)’ and the mandatory procedure documents are listed in Chapter 4.3.4.
5 Management responsibility

5.1 Management commitment
- The top management shall demonstrate involvement and commitment to effective quality management.
- Communication of the importance in reaching customer satisfaction and requirements.
- Quality policy and quality objectives have to be established and communicated throughout the organization.

5.2 Customer focus
- Top management shall ensure that customer requirements are understood and met to improve customer satisfaction.

5.3 Quality policy
- The quality policy shall express the importance of quality and describe the main goals of the QMS.
- It fits the organization’s purpose and creates a background to establish quality objectives.

5.4 Planning
- Management shall ensure that measurable quality objectives are established that conform to the quality policy.
- The QMS shall be planned so that the quality objectives are met and is maintained so that it continues working when improvements are carried out.

5.5 Responsibility, authority and communication
- Top management shall define responsibilities and authorities and communicate them within the organization.
- A management representative has to be appointed that has the responsibility for the QMS and to ensure conformity to the ISO 9001.
- An effective communication system shall be set up to reach the effectiveness of the QMS.

5.6 Management review
- The top management has to regularly review the QMS to ensure to meet goals and to find ways to improve the QMS.
- The input of the management review includes and requires specific information like internal audit results, customer feedback etc.
- The output results in corresponding actions like the improvement of the QMS or products.

6 Resource management

6.1 Provision of resources
- Provide people, equipment, tools and materials that are necessary to make the QMS working in the required manner.
6.2 Human resources
- People carrying out work that influences product and service quality have to be qualified to perform this work.
- The skills, knowledge and the understanding of their influence on quality of each person shall be identified and assessed and deficits shall be compensated by training or other assistance.

6.3 Infrastructure
- A sufficient infrastructure shall be provided to achieve planned results.

6.4 Work environment
- Sufficient work conditions have to be ensured in order to meet quality requirements.

7 Product realization

7.1 Planning of product realization
- Plan and create the processes needed to develop, manufacture and maintain the product or service in a comprehensive approach to get from the product concept to the finished product. The resulting plan is the so-called quality plan.

7.2 Customer-related processes
- The organization shall determine requirements specified by the customer and other requirements such as internal or regulatory agreements.
- The requirements shall be reviewed if they are understood and if the company is able to meet the requirements.
- Effective customer communication shall be established to discuss product information, contractual question and customer feedback.

7.3 Design and development
- The design and development process of the product shall be planned and controlled effectively.
- The inputs for design and development are reviewed product and other requirements.
- The outputs of the design and development have to meet the product requirements and include sufficient information to verify that.
- The design shall be reviewed and checked to identify and solve problems and to verify that design input requirements are met.
- The design has to be validated to be sure that the product meets the user needs under actual operating conditions.
- Design changes shall be identified, documented, reviewed and approved.

7.4 Purchasing
- The company shall ensure that all purchased products and services that are purchased from suppliers for the inclusion in a product or in any phase of the product realization meet specifications and quality requirements.
- Purchase orders have to describe the purchased product or service clearly.
- Purchased products shall be verified and inspected to meet the expected specifications and if they are adequate for the intended use.

7.5 Production and service provision
- Production, installation and service processes shall be planned and an environment has to be provided in which work can be carried out in an orderly way.
- When quality cannot be verified in a reliable way (e.g., by testing or prolonged use), special attention has to be paid to how the work is carried out.
- Procedures to identify products and its specifications during the manufacturing, delivery and installation process shall be established where appropriate.
- Property of customers handed out for the use within the organization such as material, equipment or proprietary information has to be handled careful and shall be protected.
- The product shall be preserved during handling, storage and delivery.

7.6 Control of monitoring and measuring devices
- Monitoring and measurement equipment shall be sufficient to take correct and accurate measurements and to verify product requirements.

8 Measurement, analysis and improvement
8.1 General
- Inspection, test, measurement, analysis and improvement activities shall be planned and carried out to assure that the product requirements are met and the QMS can be improved and works as planned.

8.2 Monitoring and measurement
- Customer satisfaction shall be monitored.
- The company shall monitor the use of the system by internal audits in which trained auditors verify activities performed to prove conformance with the QMS and the requirements of the ISO 9001.
- The performance of the processes of the QMS has to be measured and corrective action taken when possible.
- The product shall be inspected and measured to assure that its requirements will be met.

8.3 Control of non-conforming product
- Non-conforming products and services have to be identified and corresponding actions taken.
- The usage of non-conforming products has to be avoided.

8.4 Analysis of data
- Data demonstrating the effectiveness and identifying possible improvements of the QMS shall be determined, collected and analyzed.
8.5 Improvement

- The quality policy, quality objectives, audit results, data analysis, corrective and preventive action and management review shall be used to improve the QMS.
- Corrective action has to be taken. This means that the underlying processes have to be fixed when problems occur.
- Preventive action has to be taken. Underlying processes have to be fixed when problems occur in order to prevent similar defects in the future.

All requirements must be fulfilled to become ISO 9001 compliant. Reasonable exclusions are possible but cannot be made arbitrarily. These exclusions are limited to requirements within clause 7 and may not affect product or service quality. [ISO900]

For an easier understanding of the requirements an alternative path through the paragraphs of the ISO 9001 can be chosen regarding dependencies between the requirements. [BaDe04] This path is illustrated in Figure 2 by stepping from the inner to the outer rectangle.

![Figure 2: Alternate path through the paragraphs [BaDe04, p 9]](image)

2.2.1.4 Implementation approach

The implementation of the ISO 9001 in a company is a process that includes many different activities and affects all members of staff. The paragraph 4.1 of the ISO 9001 “contains a slightly disorganized list of steps for an implementation team to follow.” [BaDe05, p 3] These steps are illustrated as a process in Figure 3 beginning with the measurement.
A more detailed implementation approach is given in [Beau00]. It covers all steps from the intention to seek registration until the registration audit and also the required continual improvement of the QMS. The ten steps are listed and briefly explained in the following:

1) **Establish your intention to seek registration**
   - Determine importance and reasons for the instantiation of ISO 9001.
   - Estimation of the effort and schedule.
   - Seek registration or create a QMS without registration.
   - Determine scope of the QMS and create project plan.

2) **Assess the existing quality management system**
   - Determine how close the existing QMS is to conformity.
   - Rate existence of a QMS.

3) **Design the quality management system**
   - Learn the requirements of the standard and evaluate if existing elements conform to them (Gap analysis).
   - Design all elements of the QMS that do not exist.
   - Write a first draft of the quality manual.

4) **Create procedure documents**
   - Assign staff to identify needed processes and write procedure documents and work instructions.
   - Train these writers in the understanding the standard and the QMS.
   - Review and approval of the documents by the management representative.
- Identify and train the people that will conduct internal quality audits.
- Write final draft of the quality manual.

5) **Implement and deploy the quality management system**
- Communicate and deploy the quality manual to all workers and train them in the use of it and the QMS.
- Determine which procedures are relevant to which people and distribute the needed documents.
- Train people to use the procedures.

6) **Conduct internal audits**
- Create internal audit plan and schedule and determine the auditor.
- Conduct the internal audit.
- Take corrective action in case of non-conformities regarding requirements, quality manual and procedure documents and work instructions.
- Arrange a management review and re-audits in the necessary areas.

7) **Conduct pre-assessment**
- Conduct pre-assessment with the registrar.
- Correct identified deficiencies.

8) **Create a history of using the quality management system**
- Offer a history of the use of the QMS, which is required by registration auditors (substantiated by quality records).
- Continue using the QMS, conducting internal audits and taking corrective actions.

9) **Hold the registration audit**
- The registration agency conducts an audit of the entire organization.

10) **Monitor and improve the quality management system**
- Continue holding internal audits to review and improve the QMS.
- Periodic surveillance audits as required by the registration agency.

2.2.1.5 *Critical success factors*

The demonstrated approaches give an overview regarding the tasks and steps which have to be completed in order to establish an ISO 9001 compliant QMS in an organization. Some factors play an important role in processing these steps successfully and efficiently. The following critical success factors shall help to avoid common mistakes during the implementation. They are primarily based on practical experiences and described in [Macf06] and [BaDe04].

- **Planning and project priority**
  Detailed planning and project management is necessary and the “commitment to the ISO project is reflected in its priority relative to all other projects in the organization.” [BaDe04, p 11] The implementation shall be managed as if it were product development. Regular meetings and reports of a steering committee ensure the progress and the fulfillment of goals and schedules.
• **Management involvement and resource availability**
  Management and executives should be strongly involved. “Delegating the responsibility for the success of the ISO 9000 project too low or to an outside consultant is a popular mistake.” [Macf06]
  Furthermore sufficient human resources have to be available in order to carry out necessary tasks.

• **Tight project management and early activities**
  The schedule should be set short to avoid inactivities. Early drafts of documentation such as the quality manual to define the scope, responsibilities and the structure in early stages deliver insight. Establishing success metrics early in the process provides the feeling that the ISO 9000 genuinely improves quality.

• **Early information**
  It is important to collect a large amount of information from a consultant or from other sources at the beginning to get off the ground. But at the same time it is important not to rely on someone else to do the job.

• **Implementation in parts of the organization**
  It is often easier to instantiate the ISO 9001 at first only within a small group or department and then to extend the scope step-by-step.

• **Sufficient training on staff**
  Staff involved in the creation and use of the QMS has to be trained to understand the purpose of the standard and its role and tasks.
  Procedures do not only have to be documented but also understood and implemented by everyone involved in performing them, which should be reached by training.

• **Avoid documentation overload**
  Particularly in software organizations a common error is to write too much. [Macf06] If procedure documents or work instructions get too long or too numerous it will be hard to follow them and confusion will occur.

These factors above aid the successful introduction of the ISO 9001 in common companies. This does not mean that all of them are absolutely essential for a successful realization of the standard, but they will help to avoid problems and increase efficiency.

**2.2.1.6 Evaluation of the standard**

Having given an overview of the content and requirements of the standard, a possible approach for the implementation and critical success factors, and some reasons for introducing the ISO 9001 will be presented. Some criticism of the standard will also be described.

The popularity of the standard itself already implies that there are advantages supporting the implementation of ISO 9001. Conformity to the standard can benefit all people that collaborate with the company like customers, top management, all members of the staff, suppliers and partners.
• Customers are satisfied because their expectations and requirements are understood and met and because they receive products and services that conform to their needs.
• The top management has the information needed to improve the quality and effectiveness of work processes by regular reviews of the system.
• Employees work more confidently and are more cooperative because responsibilities and authorities are defined and understood which leads to fewer conflicts. Work is assigned to competent people so everyone can rely on the results of their co-workers. Also, necessary resources and infrastructure and satisfactory work conditions are provided which leads to a higher morale.
• Rework, defects, delays and scrap is reduced by monitoring processes, products and services at appropriate stages to guarantee effectiveness and quality.
• Operational efficiency increases because business operations are regularly reviewed and thus become more effective. Costs are reduced by reducing rework, defects, delays and scrap and a higher customer satisfaction usually leads to improved market share and profitability.

Figures prove these benefits of standard conformity. Case studies showed that ISO 9001 registrations resulted in a 30% reduction of customer claims, reduction of defects from 3% to 0.5%, a 40% reduction in product cycle time, a 20% increase in on-time delivery and in a higher international acceptance and recognition. [Reso06]

Despite all these facts there are also some points of criticism concerning the ISO 9001. Many companies think the transition to standard conformity is difficult and many do it only because they are forced by their marketplace and do not consider if the ISO 9001 is in fact appropriate to their company.

But there are also some additional and more fundamental points of criticism.

The ISO 9001 is supposed to make processes consistent, but simultaneously makes it more difficult to improve and readapt processes in terms of continual improvement.

Furthermore “it has been argued that it may not be appropriate to apply a process such as ISO 9000 to a field requiring creativity, such as software engineering, which is more analogous to designing factories than to operating a factory.” [Wiki06c]

One of the main critics of the standard, John Seddon, says that mechanisms and processes are just put in place to comply with the standard regardless if whether quality is really improved or not. In his eyes bureaucratization is caused by the various requirements for documentation because the registrar cannot do his work without it. [Sedd98]

Even though there are points of criticism, the ISO 9001 has the potential to improve quality within organizations if it is applied in the correct manner. The standard “describes what a customer- and quality focused organization accomplishes, [but] not how to satisfy those requirements.” [BaDe04, p 25] Therefore the realization of the standard is quite flexible. But the responsibility in how far the implementation of the QMS efficiently improves product quality and customer satisfaction also remains in the hands of the people realizing the ISO 9001.

Economically it is hard to calculate if an ISO 9001 registration pays because quality is often difficult to measure quantitatively. The following calculation gives at least an

---

1 Despite its non-scientific character Wikipedia is sometimes used as a reference throughout this thesis because criticisms about models and standards are often not mentioned by official literature. Furthermore, literature about recently published standards and models is rare, but information and facts about them are mostly available in Wikipedia because it is frequently updated.
idea what the registration itself of a 50-person organization approximately costs based on Figures from [BaDe04]:

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td>One auditor day per 50 employees in scope</td>
<td>$1,000</td>
</tr>
<tr>
<td>Local expenses per auditor day</td>
<td>$190</td>
</tr>
<tr>
<td>Fees</td>
<td>$1,000</td>
</tr>
<tr>
<td>Preparation</td>
<td>$1,000</td>
</tr>
<tr>
<td>Travel per auditor</td>
<td>$500</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$3,690</td>
</tr>
</tbody>
</table>

Table 1: Calculated costs of an ISO 9001 registration [BaDe04]

An estimation of the time it takes to implement the standard is difficult. It could take less than six months for a small organization that already has an acceptable QMS, but it can take three years for a large company with a poor QMS and inflexible structures. [Beau00]

Some more aspects regarding the ISO 9001 and a comparison to other possible standards for quality improvement in software engineering will be given in chapter 2.2.6.

2.2.2 ISO/IEC 15504 Information technology – Process assessment

Another international standard regarding process improvement in the field of software engineering is the ISO/IEC 15504 for Process Assessment. It was first published in 1998 as technical report ISO/IEC TR 15504 and revised and republished as the standard ISO/IEC 15504 from 2003 until March 2006. [ISOS06] The development of ISO/IEC 15504 has taken place in parallel with empirical studies of its use performed by the SPICE project. Therefore, the ISO 15504 is also known as SPICE (Software Process Improvement and Capability dEtermination) because it was developed from this project which is an international initiative that supports the development of an International Standard for Software Process Assessment and also developed a draft for the ISO/IEC TR 15504:1998. [SPIC06]

The standard was inspired by the Software Capability Maturity Model (CMM) and the ISO 9001. Its purpose is to harmonize different models like the CMM, CMMI, ISO 9001, ISO 12207 and Bootstrap and assessment methods such as Bootstrap, SCAMPI and others. [SEIn05b]

The standard is a framework for the assessment of software processes and defines reference models for these processes as well as requirements for assessment methods. Process models define best practices that are usually applied by successful companies. Assessment methods compare processes of a company with a process model including an evaluation and deliver suggestions for improvements. The relation between process models and assessment methods is shown in Figure 4.
The ISO 15504 is based on a two-dimensional model. The first dimension is the process dimension that describes what is done based on the model of the ISO 12207. The second dimension contains capabilities and describes how well the processes are carried out. The capability is measured with attributes for each process from the level 0 to 5 (0 – Incomplete, 1 – Performed, 2 – Managed, 3 – Established, 4 – Predictable and 5 – Optimizing). The standard is often used for supplier evaluation especially in the automotive industry. It contains the following five parts (including the year of publication):

- Part 3 (2004): Guidance on performing an assessment
- Part 4 (2004): Guidance on use for process improvement and process capability determination

The ISO/IEC 15504 standard does not define a specific process model or assessment method. Therefore, different process models and assessment methods can be used to meet the standard as Figure 5 shows. The CMMI process model together with the SCAMPI assessment method fulfills the ISO/IEC 15504 as well as the ISO 12207, from which the ISO/IEC 15504 is derived from, together with SPICE for assessment.
2.2.3 CMMI and SCAMPI

First, an overview of the Capability Maturity Model Integration (CMMI) and its assessment method SCAMPI is given.

A Capability Maturity Model (CMM) is described as “a reference model of mature practices in a specified discipline, used to improve and appraise a group’s capability to perform that discipline” by the editors of the CMMI. [SEIn05a, p 13]

The model has its origin in the Software Capability Maturity Model (SW-CMM) which was developed by the Software Engineering Institute (SEI) at the Carnegie Mellon University. It was sponsored by the U.S. Department of Defense in the mid-1980s when searching for a way to assess the capability of a group to perform software engineering. The latest version of the SW-CMM was published in 1993. It was replaced by the publication of the CMMI in 2000. The CMMI extends the area of software engineering and integrates process improvement for the four disciplines software engineering, systems engineering, integrated product and process development and supplier sourcing. Different releases of the CMMI that cover only one or parts of the four disciplines exist, making an isolated and flexible use possible. The current version 1.1 of the model was published in the year 2002 and is available as a free download on the SEI homepage.¹ The release of version 1.2 is planned for August 2006. [SEIn06]

The model itself says that its “purpose […] is to provide guidance for improving your organization’s processes and your ability to manage the development, acquisition and maintenance of products and services. CMM Integration places proven approaches into a structure that helps your organization appraise its organizational maturity or process area capability, establish priorities for improvement, and implement these improvements.” [SEIn02, p 1]

The model has become established as a de facto standard and is highly popular. It is applicable to companies of all sizes and domains. [ShPh04] Exact numbers of the spreading are not available.

The CMMI is quite complex, thus it can only be explained simplified here. The three main concepts of the model are process areas, goals and practices.

¹ http://www.sei.cmu.edu/cmmi/models/models.html
24 process areas that are relevant to process capability and improvement are described and organized in the four categories process management, project management, engineering and support. Specific goals describe for each of these process areas which desirable state shall be reached by the organization. Generic goals specify common features and are associated with capability or maturity levels (see later). Practices in the CMMI describe how goals can be achieved. For each goal up to seven practices recommend ways to reach it. [Somm04]

The CMMI has two possible representations to choose between. The content of both representations is the same, but there are differences in the organization and presentation. [SEIn05a] The two approaches are called staged and continuous representation and are explained in the following.

The staged version is compatible with the former SW-CMM [Somm04] and provides a defined sequence of improvement steps with each step serving as a foundation for the next. It enables a single rating of the organization as a summary of assessment results and allows comparisons across and among organizations. The rating is expressed by a well-defined maturity-level from 1 to 5. The levels are illustrated in Figure 6.

The different levels are described like following [SEIn05a]:

- Level 1 (Initial): Process unpredictable, poorly controlled and reactive
- Level 2 (Managed): Process characterized for projects and is often reactive
- Level 3 (Defined): Process characterized for the organization and is proactive
- Level 4 (Quantitatively managed): Process measured and controlled
- Level 5 (Optimizing): Focus on continuous process improvement

![Figure 6: The CMMI staged model [Somm04, p 685]](image)

Every maturity level is associated with some of the 24 process areas. The second level for example is associated with the following process areas:

- Requirements management
- Project planning
- Project monitoring and control
- Supplier agreement management
In contrast to the staged representation the continuous representation of the CMMI allows to select the order of improvements that fits best to the business objectives of an organization and mitigates its areas of risk. [SEIn05a] This approach “affords an easy comparison of process improvement to [the] ISO/IEC 15504 because the organization of process areas is similar to ISO/IEC 15504.” [SEIn02, p 2]

The continuous representation makes comparisons of organizations on the process level possible and assesses the maturity of the organization not in a single rating but defines the potential for each process.

Each process area is rated and described in well-defined capability levels from 0 to 5. Every level is the basis for higher capability levels when establishing continuous process improvement. The six capability levels are the following [SEIn05a]:

- Level 0: Incomplete
- Level 1: Performed
- Level 2: Managed
- Level 3: Defined
- Level 4: Quantitatively Managed
- Level 5: Optimized

Usually organizations operate on different capability levels in each process area depending on their business objectives. Therefore the result of a continuous CMMI appraisal can be shown in a chart with the process capability of each process area represented by a bar as partially shown in Figure 7.

![Figure 7: A process capability profile](Somm04, p 686)
Some hints on which representation of the CMMI should be chosen by a company are given in the introduction of the CMMI in the part “Selecting a CMMI model”. [SEIn02]

The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) is the assessment method for CMMI and makes a kind of registration to CMMI possible.

It describes a formalized appraisal process as well as requirements that assessors have to fulfill. It can be used for internal process improvement and external capability determination and supports the conduction of ISO/IEC 15504 assessments. [SEIn01]

The SCAMPI process is divided into the following three phases:

- Plan and prepare for appraisal
- Conduct appraisal
- Report results

An ARC (Appraisal requirement for CMMI) class should be chosen depending on which requirements an organization has to the appraisal. Different intentions such as the generation of ratings or the identification of strengths and weaknesses for process improvement should be considered thereby. The three ARC classes A, B and C are possible in which A is the ‘big’ assessment for an institutionalization of the CMMI in the company including a rating with maturity levels, B is the ‘medium’ appraisal when deploying the method and C the ‘small’ one for evaluating a first approach. [ShPh04] A table with listed requirements assists the company to choose the right appraisal class. (See Appendix D in [SEIn01])

Today more than 1,000 SCAMPI Class A appraisals have been conducted and more than 400 appraisers have been trained and are authorized to lead such appraisals. [SEIn06]

Figures support that the implementation of the CMMI brings benefits. Performance measurements among 25 organizations show an average improvement of productivity by 62%, of quality by 50% and of customer satisfaction by 14%. [SEIn05c]

But there are also critics of the CMMI saying that the intense focus on processes and forms may hinder the organization’s ability to concentrate sufficiently on application development, customer satisfaction and the marketplace. Also compliance with the CMMI does not guarantee successful software development. It may only increase the chances for successful projects. [Wiki06e]

The time for implementing the model is shown by empirical studies. The average time needed to move from one capability level to the next is about 22 months from level 1 to 2, about 21 months from 2 to 3, about 25 from 3 to 4 and about 15 months to move from level 4 to 5. [ShPh04, p 18]

A comparison of the CMMI to other standards will be given in chapter 2.2.6.

### 2.2.4 ISO/IEC 12207 Software lifecycle processes

Another process model besides the CMMI is the ISO/IEC 12207 Information Technology – Software lifecycle processes which is a world-wide accepted standard. It was published in 1995. Amendment 1 (AMD 1) was added in 2002 and Amendment 2 (AMD 2) in 2004. The standard is applicable to internal and external software development. [Free04]

ISO/IEC 12207 defines requirements for acquisition, supply, development, operation and maintenance of software. It describes processes with corresponding activities and tasks and their interrelation but no concrete method on how the development is processed is given. In case of a concrete project, a software development model has to be integrated. [Free04]
The processes defined by the ISO/IEC 12207 are a comprehensive set. The organization applying the standard must choose an appropriate subset appropriate to the organization, project or application. Therefore the standard is a framework made to be tailored for an individual purpose.

The ISO/IEC 12207 itself is organized like following [Sing06]:

- **Section 1 - Scope and field of application**
- **Section 2 - Normative references**
- **Section 3 - Definitions**
- **Section 4 - Top-level overview of the life cycle processes**
- **Section 5 - Activities and tasks of the five primary processes**
- **Section 6 - Activities and tasks of the eight supporting processes**
- **Section 7 - Activities and tasks of the four organizational processes**
- **Annex A - Activities and tasks for tailoring the standard for a software project**
- **Annex B - Brief guidance on tailoring the standard**
- **Annex C - General information on the processes, organizations, and their relationships**
- **Annex D – Bibliography**

The components of the three categories primary, supporting and organizational lifecycle processes are illustrated in Figure 8.

<table>
<thead>
<tr>
<th>5. PRIMARY LIFE CYCLE PROCESSES</th>
<th>6. SUPPORTING LIFE CYCLE PROCESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Acquisition</td>
<td>6.1 Documentation</td>
</tr>
<tr>
<td>5.2 Supply</td>
<td>6.2 Configuration Management</td>
</tr>
<tr>
<td>5.3 Development</td>
<td>6.3 Quality Assurance</td>
</tr>
<tr>
<td>5.4 Operation</td>
<td>6.4 Verification</td>
</tr>
<tr>
<td>5.5 Maintenance</td>
<td>6.5 Joint Review</td>
</tr>
<tr>
<td></td>
<td>6.6 Validation</td>
</tr>
<tr>
<td></td>
<td>6.7 Audit</td>
</tr>
<tr>
<td></td>
<td>6.8 Problem Resolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. ORGANIZATIONAL LIFE CYCLE PROCESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Management</td>
</tr>
<tr>
<td>7.3 Improvement</td>
</tr>
</tbody>
</table>

Figure 8: The processes of the ISO 12207 [Free04]

The assessment method for the ISO/IEC 12207 is SPICE. [RaFB04] Together they fulfill the requirements of the ISO/IEC 15504, which incorporates the model of the ISO/IEC 12207. The term SPICE is a bit dubious as it is an alternative term for the ISO/IEC 15504, but also the assessment method for the ISO/IEC 12207 which is described in the part five of the ISO 15504:2004 as an example of an assessment method. The SPICE method defines one assessment type and does not address different
levels of range or depth like SCAMPI. It also describes the requirements for assessors like training and assessment experience. [RaFB04]

Some aspects concerning the relationship between the ISO 12207, SPICE and ISO 15504 respectively are also covered later in chapter 2.2.6.

2.2.5 ISO/IEC 9126 Software Engineering – Product quality

Unlike the ISO/IEC 12207 and the CMMI, the ISO/IEC 9126 does not address software development processes but the characteristics that represent software quality.

The ISO/IEC 9126 Software Engineering – Product quality standard contains the following four parts (including publication year and a short description):

- **Part 1 (2001): Quality model**
  Classifies software quality in a structured set of factors
- **Part 2 (2003): External metrics**
  Describes measurements during software execution
- **Part 3 (2003): Internal metrics**
  Describes static measures
- **Part 4 (2004): Quality in use metrics**
  Describes measurements (only) applicable for the final system used in real conditions

The first part of the standard specifies functional and non-functional customer and user requirements and a two-part model for software product quality. [ISO901]

The first element of the model represents external and internal quality characteristics. The second part is the model for quality in use. An overview of the content of both models is given in Figures 9 and 10.

![Quality model for external and internal quality](ISO901)

Figure 9: Quality model for external and internal quality [ISO901]
The current sections of the ISO/IEC 9126 are revisions of the version published in 1991. The previous version also contained a part about software evaluation, which is now outsourced to the ISO/IEC 14598 standard for Software Product Evaluation. This gives an overview of the software evaluation process, assists the execution and describes the requirements of the evaluation and should be seen in combination with the ISO/IEC 9126. [SwKo06]

Naturally software development processes influence the software product quality. The interrelation of process quality, internal and external quality and quality in use in the software product lifecycle is illustrated in Figure 11. The process quality which is possibly defined by the lifecycle processes of the ISO/IEC 12207 influences the product quality. Product quality contributes to improve the quality in use. [ISO901]

The ISO/IEC 9126-1 can be used in conjunction with ISO/IEC 15504, ISO/IEC 12207 and ISO 9001 to provide a framework for software product quality and quantitative quality evaluation and to support review, verification and validation activities. [ISO901, p 1 et seq.]

When using the ISO/IEC 9126 in combination with the ISO 9001 specifically, the standard provides “support for setting quality goals [and] support for design review, verification and validation.” [ISO901, p 2]

2.2.6 Comparison of the standards and models

All of the discussed standards and models are potentially applicable to a software developing organization. Except the ISO/IEC 9126 they all have the same structure [Tuev05] and relate to each other so that synergies can be used. Therefore a comparison of the standards is understandable when trying to decide which ones best fit an
An overview of how the standards and models are connected to each other is given in Figure 12. Because of its structure primarily the continuous representation of the CMMI is meant here. [Tuev05]

The numbers labeling the connection arrows do not describe a sequence but are used in the following to explain each association:

(1) The ISO 9001 provides the basis for quality improvement and management to the ISO/IEC 15504. [Sing06]

(2) ISO/IEC 15504 and ISO 9001 harmonize with each other. Capability level 2 (managed) of the ISO/IEC 15504 has an approximately equivalent level of detail as the requirements of the ISO 9001. The ISO 9001 itself demands the use of assessment methods that are defined within ISO/IEC 15504. [FoNR03]

(3) The ISO/IEC 12207 takes the ISO 9001 as a basis for quality assurance. [Sing06]

(4) The ISO/IEC 12207 mentions how requirements of the ISO 9001 in the area of acquisition, supply, development, operation and maintenance of software can be fulfilled in the situations when the ISO 9001 is applied to software developing organizations. [SEPT06]
The ISO/IEC 15504 defines its process dimension based on the process model of the ISO/IEC. [FoNR03]

The ISO/IEC 12207 in conjunction with the assessment method SPICE fulfills the requirements of the ISO/IEC 15504.

The CMMI, along with its assessment method SCAMPI the requirements of the ISO/IEC 15504. The explicit aim of CMMI is to be consistent and compatible with ISO/IEC 15504. [SEIn02, preface]

The development of the ISO/IEC 15504 was inspired by the Software CMM. [SEIn05b]

CMMI (for Software Engineering) and the ISO/IEC 12207 have a similar scope and similar requirements. However the CMMI gives detailed declarations of best practices and defines maturity levels, which the ISO/IEC 12207 does not. [RaFB04]

The synergetic use of CMMI and the ISO 9001 is possible and built on the differences between the two models so that one framework’s strength may help the other framework’s weaknesses. [MuSt03a, p 132] This can be realized by mapping the Generic Practices and the Process Areas of the CMMI to the requirements of the ISO 9001, thus using practices provided from CMMI to interpret and implement the more sparsely described requirements of the ISO standard. [MuSt03a] Such a mapping can be found in [MuSt03b].

The ISO/IEC 9126 supports finding quality goals and supports the design and development review, verification and validation for the ISO 9001 standard if this is applied within the area of software engineering. [ISO901]

The ISO 9126 provides “a framework for software product quality requirements definition in the primary lifecycle processes [and] support for review, verification and validation in the supporting lifecycle processes.” [ISO901, p 2]

ISO/IEC 12207 references ISO/IEC 9126 as a guide for software quality characteristics. [Sing06]

The ISO/IEC 9126 can be used together with the ISO/IEC 15504 and provides in such a case a framework for software product quality definition and support for review, verification, validation and for setting organizational quality goals. [ISO901, p 1]

The synergies and possibilities of a combined use have been stated at present, although the aim and the applicability of the standards and models are not the same. Therefore an organization also has to consider differences between the standards and models when deciding which one fits best to its purposes and should be chosen. Table 2 gives an overview and compares different characteristics to make the decision easier. Some additional issues are described in the following.

As already mentioned no numbers are available about how many organizations use the CMM and CMMI respectively. But according to [Wiki06d] it is wider spread than the ISO/IEC 15504.

The biggest difference between the ISO 9000 and CMMI is that the ISO standard describes a broad direction whereas the CMMI is quite detailed and provides implementation guidance. Furthermore CMMI focuses on process improvement which is only described on a very high level in the ISO 9004:2000. [MuSt03a, p 132]
<table>
<thead>
<tr>
<th>ISO 9000</th>
<th>ISO 15504</th>
<th>CMMI</th>
<th>ISO 12207</th>
<th>ISO 9126</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Standard</td>
<td>Model</td>
<td>Standard</td>
<td>Standard</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>General</td>
<td>Information Technology</td>
<td>Software Engineering, Systems Engineering, Integrated product and process development, Supplier sourcing</td>
<td>Software Engineering</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Quality management</td>
<td>Process improvement, Supplier evaluation</td>
<td>Process improvement</td>
<td>Improvement of software lifecycle processes</td>
</tr>
<tr>
<td><strong>Spreading</strong></td>
<td>&gt; 670,000 registrations to ISO 9001</td>
<td>&gt; 4,000 assessments</td>
<td>High spreading, but “only” 1,000 SCAMPI Class A appraisals</td>
<td>No numbers available</td>
</tr>
<tr>
<td><strong>Level of detail</strong></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Size (pages)</strong></td>
<td>108 (ISO 9000, 9001, 9004), 23 (ISO 9001)</td>
<td>284</td>
<td>639 (Software Engineering, staged model)</td>
<td>118 (including AMD 1 and 2)</td>
</tr>
<tr>
<td><strong>Assessment method</strong></td>
<td>No</td>
<td>Requirements and examples for assessment</td>
<td>Yes (SCAMPI)</td>
<td>Yes (SPICE, in ISO 15504)</td>
</tr>
<tr>
<td><strong>Best practices</strong></td>
<td>No</td>
<td>Yes [RaFB04]</td>
<td>Yes</td>
<td>Yes (in ISO 15504) [RaFB04]</td>
</tr>
<tr>
<td><strong>Maturity levels</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2: Comparison of relevant standards and models

The choice of introducing one or more of these standards at the STG of the Växjö University based on this comparison will be discussed in the following chapter.
3 Quality management at the Software Technology Group

To make a reasonable decision for picking one of the standards or models not only the standards or models themselves have to be known, but also the organization with its specifics for that the standard is applied. Therefore this chapter describes the STG with its structure and specifics compared to a common company. Arguments for the introduction of a standard or model are given and finally a suitable standard is chosen based on the information provided in Chapter 2 and 3.

3.1 Description and organization of the STG

The Software Technology Group (STG) is a group within the Computer Science Department of the Växjö University which itself is part of the School of Mathematics and Systems Engineering. Its tasks include the education of students and research in different areas and projects. To support these activities software is developed being used internally and externally by researchers and students. The group is currently managed by Professor Welf Löwe\(^1\) and concentrates on the development of the VizzAnalyzer Software\(^2\) that has the purpose of inspecting program code and visualizing it based on quality metrics partially contained in the ISO/IEC 9126-3. The VizzAnalyzer tool is freely available for non-commercial purposes, but a license key has to be requested by the user.

Currently the STG has ten members, thereof are three mainly involved with the development and maintenance of the VizzAnalyzer tool and thus also in the introduction of a quality standard or model. Besides this, students contribute to the research in the STG, in particular to the VizzAnalyzer tool, by writing their degree projects. The roles and the organization of the group (in quality assurance relevant terms) are illustrated in the following graph.

![Figure 13: Organization of the Software Technology Group](image)

Each employee represents one or more roles. The roles are defined in the Glossary. Currently the three (for the VizzAnalyzer relevant) local members of the STG have the following roles:
- Welf Löwe: Manager, Marketing director
- Rüdiger Lincke: Developer, Support personal
- Jonas Lundberg: Developer

\(^1\) More information about Welf Löwe at: http://w3.msi.vxu.se/users/wlo/
\(^2\) More information about the VizzAnalyzer at: http://www.arisa.se/
3.2 Differences to a common organization

The character of the STG has some specifics compared to a common company acting on a concurrent marketplace. These differences have to be considered when thinking about introducing a standard or model for quality management or process improvement because these standards and models are mainly prepared for the application in companies dealing on an open market with paying customers. The Computer Science Institute with the STG is not positioned on such a marketplace where the purpose of the companies is to make profit. But still its reputation in the market of research institutes and the fulfillment of expectations from research partners is quite important. Although the STG has hardly any paying customers internal and external partners like other institutes, other universities or companies and also the students have to be satisfied.

A further challenge that complicates creating high software quality within the STG is a quite high fluctuation of staff mainly caused by the employment of Ph.D. students and the collaboration with students writing their Master and Bachelor thesis.

Besides these specifics, the restricted financial and human resources of the STG have to be considered when the decision of introducing a standard or model and its choice are made.

3.3 Arguments for introduction of a standard or model

Some arguments for the introduction of a standard or model for quality and process improvement at the STG were already listed in the introduction and therefore are only mentioned shortly here. The overall goal is to develop high-quality software components and products in an effective way, thereby fulfilling the requirements of external and internal customers like students and researchers and thus supporting reliable, repeatable and high quality education and research results. The information necessary for improving quality and effectiveness of work processes shall be gained by applying a standard and by monitoring processes.

Until now no explicit quality management or process improvement has been established to reach these goals.

But that shall be achieved by choosing one or possibly more standards or models mentioned in Chapter 2 and implementing it or them within the STG.

3.4 Reasonable choice of a standard

The final selection is based on a presentation (see Appendix B) that listed and compared the standards briefly and on the corresponding discussion with people involved. A detailed evaluation process was not conducted because the vision of the decision makers was clear and the scope of the implementation, which is in the beginning the software development within the STG, should be extensible to other areas such as education and teaching. Subsequently the only standard that fulfills this flexibility is the ISO 9000 family. The CMMI covers a wide area as well but is because of its high level of detail and its focus on product development not flexible enough to be applicable in the area of teaching. Other standards such as ISO/IEC 15504, ISO/IEC 12207 and ISO/IEC 9126 focus only on software and software engineering and could only be applied to support the implementation of the ISO 9001 partially. At the moment the support of the design and development review and verification by the ISO/IEC 9126 is foreseen.

One more argument for the ISO 9000 is that it is supposed to be implementable in adequate time and to be the less complex standard (see size in Table 2) and thus seems to fit best to an organization with limited resources. Also the low level of detail of the
standard for quality management is appreciated because it makes a flexible implementation possible.

The ISO 9001 was according to Welf Löwe and to a report on the internet [Mari06] already successfully introduced at some other universities and now it is also implemented at the STG of the Växjö University as described in the following chapter.
4 Instantiation of the ISO 9001 at the STG

This chapter describes all activities that are carried out at the STG regarding the instantiation of the ISO 9000 quality management standard, thus the practical part of the thesis.

First the applied approach for introducing the standard at the STG is illustrated. Initial tasks and planning activities that take place before the actual realization of the ISO 9000 are mentioned. The design of the QMS at the STG including its structure, documentation and essential processes is described and also its implementation. At last the success of the activities is controlled and addressed the conduction of an internal quality audit.

4.1 Followed approach

The organization of the following chapter about the implementation of the ISO 9001 at the STG is based on the approach from [Beau00] which has been introduced in Chapter 2.2.1.4.

As mentioned before the aim of the thesis and of the introduction of the standard at the STG is not an official ISO 9001 registration. Therefore, not all ten steps from the mentioned approach will be performed, but only steps one to six.

Chapter 4.2 contains step one and two about establishing the intention to seek registration, assessing the existing QMS and additionally the gap analysis of step three. The design of the QMS and the creation of procedure documents (steps 3 and 4) are described in Chapter 4.3. The implementation of the QMS (step 5) takes place in Chapter 4.4, the conduction of an internal quality audit in Chapter 4.5.

4.2 Planning and initial tasks

After deciding to introduce the ISO 9001 at the Computer Science Department preparations have to be made for planning and organizing the project. The scope and the intention of the introduction have to be specified, responsible persons named and the organization of the project team defined. A project plan should be created to describe activities and set milestones. Existing processes at the STG have to be identified and assessed and possibly mapped to the requirements of the ISO 9001. Furthermore, an infrastructure has to be established that enables the project team to communicate and to distribute ISO 9000 relevant information in an organized way. Training and knowledge has to be provided that enables the responsible staff to guide the implementation appropriately and the employees to understand the purpose of introducing a quality management standard and their contribution in this context.

4.2.1 Scope and intention of the introduction

As already mentioned the scope of the initial introduction is limited to the software engineering activities concerning the development and maintenance of the VizzAnalyzer tool, thereby affecting in the beginning only these three involved members of the STG. Additional workers such as degree students or external partners enlarge the group temporarily. It is foreseen to extend the scope to other projects and groups within the STG and CSD and other areas of interest such as educating. This shall be done after collecting some experience with the ISO 9000 in this field (VizzAnalyzer project) and after a well working technical platform is established.

A registration and the acquisition of an ISO 9001 certificate is not the goal of the project because no significant advantages are expected yet on the market or for the
reputation as a research institute. If these facts change and when the implementation of the standard is quite advanced a registration could be a future goal.

But the main intention right now is the improvement of the internal quality of software development. More about the motivation for the introduction of a standard like ISO 9000 has been mentioned in the Chapters 1.4 and 3.3.

Important during the implementation of the ISO 9000 is the focus on customer requirements and satisfaction. A customer is defined in the ISO 9000 as “organization or person that receives a product” [Beau00, p 168] and usually a paying customer is meant. [Beau00, p 15] Unlike that the customers of the STG usually are no paying customers, but often internal customers or research partners. Therefore, the STG defines the role of their customers like following:

“An individual or group of individuals using software or parts of it (product). They receive it as service from the STG and use it for their purpose, having the expectation that the product is fit for their purpose. The customer can on the one hand be external to the STG such as project partners, companies, students or other researchers, but on the other hand also internal to the STG, being colleague. The customer is not necessarily a paying customer.” (Cp. Glossary)

4.2.2 Responsibilities and organization during initiation

Besides the customer all members of staff are involved when implementing the standard at the STG. The description of responsibilities and the organization of the project are necessary because the ISO 9001 requires certain responsibility definitions but also to ensure a structured and successful introduction of the standard.

The author of this thesis has the role of a consultant and assists acquiring and distributing knowledge about the ISO 9000 and supports the implementation of the standard.

The manager of the STG is Welf Löwe. He has the authority to define responsibilities and names the ISO 9000 management representative who is referred to as quality manager in the following. This role is represented by Rüdiger Lincke and includes the responsibility and authority for ensuring that processes for an ISO 9001 compliant quality management system are created and implemented and for reporting the performance of the system and the need for improvements to the manager. [ISO900]

All employees have the responsibility to gain adequate knowledge about the standard, to understand its purpose and to support its implementation as instructed by the quality manager.

The planning and the technical and structural framework for the implementation of the ISO 9000 are realized by the consultant in accord and is supported by the quality manager. That includes for example the creation of templates and draft versions of the documentation. The quality manager approves proposals by himself or if necessary after consultation with the manager and also reports important decisions to him. Information regarding the QMS relevant to the staff is transferred to the employees by the quality manager.

The communication between all participants takes place in informal meetings, which is easily possible because staff is located close together, by e-mail or on the technical LibreSource platform that was established for supporting the realization of the QMS and is described more detailed in chapter 4.2.5.

4.2.3 Project Plan

The implementation of the ISO 9001 that is planned to take place within the scope of this thesis is scheduled in a project plan including deadlines and corresponding activities. Further subsequent activities will be necessary to reach complete compliance
to the standard and to ensure continuous improvement of quality. An overview of the project plan is illustrated in Table 3. It was created by the consultant supported by the quality manager approving it. All deadlines take place in 2006. Also the completion date of the milestones is contained in the plan.

<table>
<thead>
<tr>
<th>Deadline</th>
<th>Activity / Milestone</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 14th</td>
<td>Knowledge acquisition about ISO 9000 by literature study and internet research</td>
<td>February 5th</td>
</tr>
<tr>
<td>February 14th</td>
<td>Determine scope and intention of an ISO 9000 implementation</td>
<td>February 10th</td>
</tr>
<tr>
<td>February 14th</td>
<td>Rough assessment of existing QMS</td>
<td>February 6th</td>
</tr>
<tr>
<td>February 21st</td>
<td>Introduce staff to ISO 9000 and discuss it</td>
<td>February 14th</td>
</tr>
<tr>
<td>March 14th</td>
<td>Determine responsibilities and define roles</td>
<td>March 14th</td>
</tr>
<tr>
<td>March 14th</td>
<td>Gap Analysis</td>
<td>March 21st</td>
</tr>
<tr>
<td>March 14th</td>
<td>Establish infrastructure for communication and documentation</td>
<td>March 5th</td>
</tr>
<tr>
<td>March 14th</td>
<td>Draft version of templates and procedure document examples</td>
<td>March 3rd</td>
</tr>
<tr>
<td>March 31st</td>
<td>Publish first version of Quality Manual (QM) including quality policy and objectives</td>
<td>March 28th</td>
</tr>
<tr>
<td>March 31st</td>
<td>Proposal for necessary procedure documents</td>
<td>March 24th</td>
</tr>
<tr>
<td>March 31st</td>
<td>Implementation of Document Control System procedure</td>
<td>March 28th</td>
</tr>
<tr>
<td>April 7th</td>
<td>Publication of the (LibreSource) communication platform and train staff in using it and understanding its purpose</td>
<td>April 19th</td>
</tr>
<tr>
<td>April 7th</td>
<td>Create priority list for procedure documentation and records</td>
<td>April 7th</td>
</tr>
<tr>
<td>April 7th</td>
<td>Creation of Records Control System procedure</td>
<td>April 12th</td>
</tr>
<tr>
<td>April 28th</td>
<td>Create further procedure documents and records according to priority list level one</td>
<td>Open</td>
</tr>
<tr>
<td>May 5th</td>
<td>Implement documented procedures (priority level one)</td>
<td>Open</td>
</tr>
<tr>
<td>May 22nd</td>
<td>Conduction of internal quality audit</td>
<td>May 18th</td>
</tr>
<tr>
<td>May 26th</td>
<td>Communication of audit findings</td>
<td>May 26th</td>
</tr>
</tbody>
</table>

Table 3: Project Plan

4.2.4 Gap assessment

One of the first tasks after the decision of implementing the ISO 9001 in an organization is conducting a gap assessment. It shows the status of the QMS before any activities concerning the implementation of ISO 9001 were processed and contains two phases: the inventory and the analysis phase. [BaDe04] The first phase delivers an overview which processes and activities already occur within the organization. The second phase compares and maps the processes of the STG to the requirements of the ISO 9001 and identifies processes that pertain or already meet the requirements of the standard or that are still missing. [BaDe04]

The gap assessment is the basis for the adaptation of the ISO 9001. It is also the later input to validate if the quality manual is complete.

Table 4 illustrates the result of the gap assessment which represents the status quo at the STG in the beginning of March. Here basically the conformance to the requirements is displayed to set the basis for a later comparison when executing the internal audit.
Due to the focus on that and because many processes and activities of the STG do not fulfill requirements yet or are not even detected, not all of them are listed.

Some of the ISO 9001 requirements are fulfilled partially at the STG but important parts are missing and therefore these lines in the table are marked with ‘×’ anyway, which means ‘Requirement not fulfilled’.

The reasons for deciding about the fulfillment of a requirement in Table 4 state in the positive case which procedures or activities realize the implementation of the requirements and in the negative case which parts of the requirements are not met.

Due to the focus on that and because many processes and activities of the STG do not fulfill requirements yet or are not even detected, not all of them are listed.

Some of the ISO 9001 requirements are fulfilled partially at the STG but important parts are missing and therefore these lines in the table are marked with ‘×’ anyway, which means ‘Requirement not fulfilled’.

The reasons for deciding about the fulfillment of a requirement in Table 4 state in the positive case which procedures or activities realize the implementation of the requirements and in the negative case which parts of the requirements are not met.

<table>
<thead>
<tr>
<th>Status 6</th>
<th>ISO 9001 requirement 6</th>
<th>Reason (Why not? / How realized?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>×</td>
<td>4. Quality management system</td>
<td>Establishment, documentation and implementation of a QMS and its continual improvement is not realized</td>
</tr>
<tr>
<td>×</td>
<td>4.1 General requirements</td>
<td>Quality manual, procedure documents etc. not available</td>
</tr>
<tr>
<td>×</td>
<td>4.2 Documentation requirements</td>
<td>Quality manual not created</td>
</tr>
<tr>
<td>×</td>
<td>4.2.1 General</td>
<td>No document control system established</td>
</tr>
<tr>
<td>×</td>
<td>4.2.2 Quality manual</td>
<td>No records control system established</td>
</tr>
<tr>
<td>×</td>
<td>5. Management responsibility</td>
<td>The importance of quality and meeting customer requirements is not communicated and no quality policy and objectives are established</td>
</tr>
<tr>
<td>×</td>
<td>5.1 Management commitment</td>
<td>No management review of the QMS established</td>
</tr>
<tr>
<td>×</td>
<td>5.2 Customer focus</td>
<td>See requirement 7.2</td>
</tr>
<tr>
<td>×</td>
<td>5.3 Quality policy</td>
<td>No quality policy established</td>
</tr>
<tr>
<td>×</td>
<td>5.4 Planning</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>5.4.1 Quality objectives</td>
<td>No quality objectives established</td>
</tr>
<tr>
<td>×</td>
<td>5.4.2 Quality management system planning</td>
<td>No QMS is planned to reach the requirements of 4.1 and the quality objectives</td>
</tr>
<tr>
<td>×</td>
<td>5.5 Responsibility, authority and communication</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>5.5.1 Responsibility and authority</td>
<td>Roles and responsibilities of people in regard to quality are not defined and communicated within the STG</td>
</tr>
<tr>
<td>×</td>
<td>5.5.2 Management representative</td>
<td>No management representative appointed</td>
</tr>
<tr>
<td>×</td>
<td>5.5.3 Internal communication</td>
<td>No effective communication regarding product and service quality established</td>
</tr>
<tr>
<td>×</td>
<td>5.6 Management review</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>5.6.1 General (R)</td>
<td>No management review of the QMS established</td>
</tr>
</tbody>
</table>

5 Red shade and × : Requirement not fulfilled; Green shade and ✓ : Requirement fulfilled
6 (R) means: Record(s) is (are) required for this requirement
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6.2 Review input</td>
<td>See requirement 5.6.1</td>
</tr>
<tr>
<td>5.6.3 Review output</td>
<td>See requirement 5.6.1</td>
</tr>
<tr>
<td>6. Resource management</td>
<td></td>
</tr>
<tr>
<td>6.1 Provision of resources</td>
<td>No sufficient information and trained people are available to implement the ISO 9001. Other resources are available.</td>
</tr>
<tr>
<td>6.2 Human resources</td>
<td></td>
</tr>
<tr>
<td>6.2.1 General</td>
<td>People have sufficient education, training, skills and experience for carrying out work affecting software quality.</td>
</tr>
<tr>
<td>6.2.2 Competence, Awareness and training (R)</td>
<td>Competencies are not identified and assessed in all cases and awareness regarding quality is not sufficient. Training is performed by literature study, but not sufficiently assisted and recorded.</td>
</tr>
<tr>
<td>6.3 Infrastructure</td>
<td>Infrastructure, facilities, hard- and software and communication services are sufficient to reach product requirements.</td>
</tr>
<tr>
<td>6.4 Work environment</td>
<td>Work conditions are adequate to achieve conformity to product requirements.</td>
</tr>
<tr>
<td>7. Product Realization</td>
<td></td>
</tr>
<tr>
<td>7.1 Planning of product realization (R)</td>
<td>Plans for software development at the STG do not incorporate appropriate information such as product requirements, quality objectives and necessary processes sufficiently and do not ensure product quality by verification, validation, monitoring and test activities and by identifying records.</td>
</tr>
<tr>
<td>7.2 Customer-related processes</td>
<td></td>
</tr>
<tr>
<td>7.2.1 Determination of requirements related to the product</td>
<td>Functional and non-functional requirements provided from internal customers are only partially documented and determined in an unorganized way. Requirements from external customers are not determined sufficiently.</td>
</tr>
<tr>
<td>7.2.2 Review of requirements related to the product (R)</td>
<td>Requirements are not sufficiently verified if they are known and understood and if the STG is able to meet them.</td>
</tr>
<tr>
<td>7.2.3 Customer communication</td>
<td>Effective customer communication channels especially to external customers are not sufficiently put in place to clarify questions and handle feedback and complaints. Internal communication channels are satisfactory.</td>
</tr>
<tr>
<td>7.3 Design and development</td>
<td></td>
</tr>
<tr>
<td>7.3.1 Design and development planning</td>
<td>No software life cycle is defined and project plans for design and development are not sufficiently documented and maintained.</td>
</tr>
<tr>
<td>7.3.2 Design and development inputs (R)</td>
<td>No requirement documents are recorded and used as input for design and development.</td>
</tr>
<tr>
<td></td>
<td>7.3.3 Design and development outputs</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
<td>7.3.4 Design and development review (R)</td>
</tr>
<tr>
<td></td>
<td>7.3.5 Design and development verification (R)</td>
</tr>
<tr>
<td></td>
<td>7.3.6 Design and development validation (R)</td>
</tr>
<tr>
<td></td>
<td>7.3.7 Control of design and development changes (R)</td>
</tr>
<tr>
<td></td>
<td>7.4 Purchasing</td>
</tr>
<tr>
<td></td>
<td>7.4.1 Purchasing process (R)</td>
</tr>
<tr>
<td></td>
<td>7.4.2 Purchasing information</td>
</tr>
<tr>
<td></td>
<td>7.4.3 Verification of purchased product</td>
</tr>
<tr>
<td></td>
<td>7.5 Production and service provision</td>
</tr>
<tr>
<td></td>
<td>7.5.1 Control of production and service provision</td>
</tr>
<tr>
<td></td>
<td>7.5.2 Validation of processes for production and service provision (R)</td>
</tr>
<tr>
<td></td>
<td>7.5.3 Identification and traceability (R)</td>
</tr>
<tr>
<td></td>
<td>7.5.4 Customer property protection (R)</td>
</tr>
<tr>
<td></td>
<td>7.5.5 Preservation of product</td>
</tr>
<tr>
<td></td>
<td>8. Measurement, analysis and improvement</td>
</tr>
<tr>
<td></td>
<td>8.2.1 Customer satisfaction</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>8.2.2 Internal audit (R)</td>
</tr>
<tr>
<td></td>
<td>8.2.3 Monitoring and measurement of processes</td>
</tr>
<tr>
<td></td>
<td>8.2.4 Monitoring and measurement of products (R)</td>
</tr>
<tr>
<td></td>
<td>8.3 Control of nonconforming product (R)</td>
</tr>
<tr>
<td></td>
<td>8.4 Analysis of Data</td>
</tr>
<tr>
<td></td>
<td>8.5 Improvement</td>
</tr>
<tr>
<td></td>
<td>8.5.1 Continual improvement</td>
</tr>
<tr>
<td></td>
<td>8.5.2 Corrective action (R)</td>
</tr>
<tr>
<td></td>
<td>8.5.3 Preventive action (R)</td>
</tr>
</tbody>
</table>

Table 4: Initial gap analysis at the STG

4.2.5 Technical infrastructure

Despite most of the requirements of the ISO 9000 are not technical and the awareness of employees concerning quality is much more important than organizing everything in a computer system, the support especially of the documentation requirements by a technical system is essential. It eases documentation processes and provides a central portal for the publication of issues of all kinds regarding the standard.

Within the STG a LibreSource platform was established for this purpose. Such a system was already before the implementation of the ISO 9000 in use at the CSD for different purposes such as the communication between teachers and students and for project groups.

LibreSource is a web-based open source software platform dedicated to the software development and management of distributed communities. “[It] offers advanced functionalities for configuration management with its generic synchronization module So6. […] The creation of development chains, validation processes and quality control processes can be done through the interconnection of synchronizers. LibreSource includes numerous tools dealing with projects and users management, such as bug trackers, forums, Wiki pages, mailing lists, etc… The search engine indexes all the data hosted in the platform, as well as uploaded files (including Word, PDF, OpenOffice).” [Libr06]

The architecture of the platform is illustrated in Figure 14.
Many functionalities of LibreSource are helpful to support the implementation of the ISO 9001 and are deployed within the STG’s Quality Management platform. For example documents corresponding to the standard are stored and published in a file repository in MS Word format. Further application of LibreSource functionalities for ISO 9001 issues at the STG is described in the next chapter about training and in later parts of the thesis.

4.2.6 Training and knowledge acquisition

Although the ISO 9001 is a comparable simple standard considering its size it is not trivial to implement and knowledge and training is necessary for all people involved in and affected by its realization.

The author of the thesis acquired his knowledge for consulting the implementation by literature study and internet research. Mainly the approaches and guidelines of [Beau00] and [BaDe04] are followed, supported by numerous other articles and examples from the internet.

Not all standards of the ISO 9000 family were available completely due to cost reasons and because secondary literature and interpretations often contain the content of the standard partially or completely plus additive information for interpreting the standards and thus are even more helpful than the standard itself. The current text of the requirements part (ISO 9001) is included in [Beau00] and therefore was completely available.

The consultant’s knowledge was transferred to the quality manager and other people involved.

---

7 [http://cs.msi.vxu.se:9001/projects/administration](http://cs.msi.vxu.se:9001/projects/administration) (see also Appendix E)
Regular meetings and discussions with the quality manager enabled him to gain appropriate knowledge and an adaptation of the standard to the specifications of the STG could be guaranteed.

Further training of all members of the STG was realized by the initial presentation about ISO 9000 including important critical success factors (see Chapter 2.2.1.5) and other models and standards (see Appendix B), by informal meetings, for instance, for introducing the LibreSource platform and by information offered on the platform itself. Especially the ISO 9000 Wiki in LibreSource (see Appendix F) offers information and links for gaining knowledge about the standard and gives an overview of its implementation at the STG. Furthermore a discussion forum supports the clarification of questions.

4.3 Design of the quality management system

4.3.1 Structure

The quality management system at the STG is designed to conform to the ISO 9001 and to fulfill the intention to develop high-quality software in an effective way regarding local requirements.

It is structured in three levels as illustrated in Figure 15. The levels are briefly described in the following.

- **Quality manual:** The quality manual is a rather abstract document to allow its flexible use with different products. It contains the quality policy and objectives, describes the structure of the STG and references appropriate procedure documents. Its content is detailed in Chapter 4.3.3.
- **Procedure documents:** The procedure documents describe the desired processes for the STG and apply controls more detailed and specific. They focus on the activities needed to attain quality assured services and products and to comply with the quality policy and objectives. Work instructions are referenced within these documents. Procedure documents are specified in Chapter 4.3.4.
- **Work instructions:** Work instructions are documents describing certain activities detailed and tailored to a specific product or service. They are only applied to activities that are critical regarding quality and if exact repeatability is an aim.

The members of the STG decided that work instructions are used to refer to a concrete software project like the development of the VizzAnalyzer. Procedure documents are more general and applicable to all software engineering projects within the STG. To illustrate the difference between a work instruction and a procedure document one example for each is contained in Appendix E.
Furthermore, records are created to prove the performance of consequent activities and a proper implementation of the quality management system in all levels.

### 4.3.2 Quality policy and quality objectives

Quality policy and quality objectives establish the frame for deriving further steps and for setting priorities for corresponding actions in order to reach the objectives.

The quality policy gives a high-level description of the goal that shall be reached by implementing the QMS. Usually it is a short meaningful proclamation that states the importance of the quality within the company. To communicate it within the STG it is discussed with all its members and printed on the title page of the quality manual and on the welcome page of the ISO 9000 LibreSource platform. As required it is developed in cooperation with the manager Welf Löwe. The quality policy of the STG is the following:

*The overall goal is to develop high-quality software components and products in a cost-effective way (time, resources), thereby fulfilling the requirements of external and internal customers (students and researchers) thus supporting reliable, repeatable and high quality education and research results.*

The quality objectives support business objectives [BaDe04] and the quality policy by setting targets of how well processes, products, etc. shall fulfill their requirements. Their effectiveness depends on in how far the achievement of objectives can be determined. Therefore they should be measurable as far as possible. The quality objectives have been developed in cooperation with the quality manager as well. As the quality policy they are also contained in the quality manual. Quality objectives of the STG are the following:

- Minimum number of non-conforming software components and products
- Maintenance and steady improvement of software quality and structure based on a quality model measures derived using the VizzAnalyzer
- Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students
- Active risk reduction by increasing process maturity and documentation
• Knowledge preservation in form of work instructions and procedure documents to deal with changing staff
• Compliance to legal contracts when using 3rd party components
• Save time through central information storage

4.3.3 Quality manual

The quality manual describes the quality management system on a high level and explains how the requirements of the ISO 9001:2000 are fulfilled within the STG. It defines the scope and excludes explicitly parts of the standard that are not applicable to the organization. It is also used as a kind of handbook to make new employees familiar with the QMS. The quality manual gives an overview about the procedure documents and their scope and references them. It also describes how procedures interact with each other.

Since the quality manual gives a good introduction to the quality management system of the STG it is recommended to read in this place for a better understanding of the thesis. It is contained in Appendix C.

4.3.4 Procedure documents

The quality manual is a high-level description of the QMS. Its sections are detailed in the procedure documents. These documents are more in-depth, but they are still independent from the actual software project and generally applicable within the STG.

As mentioned before at least six procedures have to be documented according to ISO 9001. They are the following:
• Internal audit
• Document Control System
• Non-conforming products
• Preventive action
• Corrective action
• Records control system

Further procedure documents should be written if an area of interest requires more detailed instructions than given in the quality manual to reach quality objectives and conform to the quality policy.

The additional procedure documents that shall be created at the STG are consequently mainly derived from the quality objectives. Table 5 lists all procedure documents planned so far and associates priority numbers from zero to three (lower number means higher priority). They represent the order in which procedures should be created and implemented. A priority of zero means that this procedure is a precondition for the creation of others. The priorities were chosen in order to reach quality objectives and are approved by the quality manager.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Document control system</td>
</tr>
<tr>
<td>0</td>
<td>Records control system</td>
</tr>
<tr>
<td>1</td>
<td>Internal quality audit</td>
</tr>
<tr>
<td>1</td>
<td>Project management</td>
</tr>
<tr>
<td>1</td>
<td>Inspection and testing</td>
</tr>
<tr>
<td>1</td>
<td>Customer property and licensing</td>
</tr>
<tr>
<td>1</td>
<td>Non-conforming products</td>
</tr>
<tr>
<td>1</td>
<td>Training and competence</td>
</tr>
</tbody>
</table>
The creation process of procedure and other documents is detailed in Chapter 4.3.5 including responsibilities. Templates are provided for documenting procedures and work instructions (see Appendix D). General ideas about the implementation are already contained in the quality manual and should be used as guidelines and be detailed in the procedure documents.

Besides this, understanding the requirements of the ISO 9001 before proceeding the documentation, using existing documentation as much as possible and creating a draft of the procedure in form of a flowchart with assigned responsibilities are helpful for a successful procedure documentation. Furthermore, the level of detail should be appropriate to the knowledge of the document users, a clear and simple writing style should be used and details should only be added if accurate. [Beau00]

### 4.3.5 Document Control System

The document control system procedure (see also Appendix E) is detailed in the context of the thesis because it is essential for the creation and maintenance of all documents related to the QMS. In other words it is a procedure describing how to document other procedures and activities.

The ISO 9001 requires that certain documents are created, reviewed and approved. Changes and the current revision status have to be identifiable and the documents shall be easily available at all work locations. Furthermore obsolete documents have to be identified and possibly discarded. [Beau00]

The document control system procedure at the STG contains the Use of the document control system, which is more about the implementation and therefore detailed in Chapter 4.4.2 and the Document creation and change. The latter activity is the core of this procedure and illustrated by a flowchart in Figure 16. The interpretation of the chart is quite intuitive. Its implementation is supported by the LibreSource platform and detailed in Chapter 4.4.1.
Figure 16: Document creation and change

Concrete activities describing the process of document creation and change are contained in the homonymous work instruction. It lists precise steps how the documentation is carried out by detailing issues such as communication channels, naming conventions and versioning of documents (see Appendix E).
4.3.6 Records Control System

A further requirement of the ISO 9001 is the identification and protected storage of records that demonstrate the conformance to the requirements and the effective operation of the QMS. Records have to be easily identifiable and retrievable but there is no review or approval required. [Beau00]

How records are created and distributed at the STG is illustrated in another flowchart in Figure 17.

The procedure begins with the identification of a need for a record by the quality manager. He derives required records from the quality objectives and the mandatory record list and determines and contacts a custodian. This one checks if a potential record is already available and has to create it if not. The quality manager references the record in the appropriate procedure document and publishes it on the LibreSource platform by uploading it or referencing it in a list. Finally the retrievability of the record is controlled by the custodian.

Furthermore, the quality manager checks regularly if all mandatory record types are available and up-to-date regarding the retention time which is one year by default. It can
be shortened for each record if appropriate. Records are only valid if they are updated within the defined period.

As previously mentioned are 19 record types required. Ideas how to realize them at the STG and already available records are listed in Table 6 in Chapter 4.4.3.

4.4 Implementation of the QMS

The implementation of the QMS is the realization of the documented and planned processes and of the requirements of the ISO 9001 within the STG. The quality manual is deployed to all employees and its use has to be trained. Documented target processes are distributed and communicated through the LibreSource platform. The relevant procedure and work instruction descriptions have to be learned and followed in the daily work by everybody collaborating with the STG in the area of software engineering.

4.4.1 Documentation implementation

Due to the quality objectives a focus on documentation and knowledge preservation is required when implementing the QMS at the STG. Therefore a platform for central storage of procedure documents and work instructions is provided to prevent the loss of knowledge because of personal fluctuation and to enable temporary workers such as degree students gaining knowledge about the daily work at the STG.

Some components of this LibreSource platform were already mentioned. A more detailed description of its use and functionality is given in this chapter. Screenshots in Appendix F show the most important parts of the system.

The five main sections of the platform, which also represent the first level of navigation, are:

- **Discussion Forum** for posting news and clarifying questions.
- **ISO 9000 Wiki** to give an introduction to the ISO 9001 and to the application of the QMS at the STG including LibreSource for all people using it. The current content of this section is shown in Appendix F.
- **Responsibilities** section maps the roles used in the documentation to the current employees of the STG because roles have not been defined within the STG before. Roles are used to keep the documentation flexible in case of staff fluctuation. Furthermore, rather abstract responsibilities described in the quality manual are clarified in the responsibilities section if necessary.
- **Creation and change requests** bug-tracker for the organization of document creation, changes, reviews and approvals and the association of responsible persons. The quality manager is the default assignee. Documents worked on are uploaded and comments describe corresponding tasks.
- **Document repository** containing all documents relevant or required for the introduction and documentation of the quality management system. Its current structure and an overview of all documents are illustrated by the tree in Appendix F. The content and its use are described more detailed in the following.

Currently all documents in the repository are provided in MS Word format which is compatible to all work stations in the STG. A replacement by the Latex format is considered in case of an extension of the QMS to other groups or departments of the CSD.

The document repository is hierarchically structured. On the highest level documents concerning the whole QMS are provided. Those are the **Quality Manual** in its current version, the **Gap Analysis** describing the current status of the implementation of ISO 9001 requirements at the STG, the **Glossary** containing relevant definitions and abbreviations to have a common base of understanding terms, a list of **Mandatory**
Record types including ideas how to fulfill them, the Procedure Priority List and the Project Plan.

Furthermore the following subsections of the document repository are linked:

- **Procedure documents** section containing approved procedure documents
- **Work instructions** section containing approved work instructions
- **Records** section containing the records themselves or an entry with its location in the records reference list, which is realized as a forum if the record is not available as an uploadable document (e.g., if the record is a log-file or a part of another system like a bug-tracker)
- **Templates** section containing templates for procedure documentation and for work instructions
- **Document archive** containing obsolete documents to be able to reproduce changes

Sought documents are retrieved by browsing the repository or by using the integrated LibreSource search engine.

In all sections of the platform individual filters can be setup to retrieve e-mail notification in case of events such as newly uploaded documents or assigned tasks.

An example how LibreSource is applied to assist the implementation of procedures is given in the following. Document creation and change is supported by the platform’s creation and change request bug-tracker and the document repository. The quality manager posts a documentation need in the bug-tracker and assigns the bug to a specific member of the STG (the author) who is automatically informed by e-mail. After the creation or change request is carried out by the author, he uploads the draft of the document in the bug-tracker and changes the assignee of the task to the quality manager for approval. If the approval is successful the task is fixed and the document is uploaded to the document repository. A possibly available obsolete document is removed by the quality manager and stored in the document archive. For newly revised or changed documents tasks in the bug-tracker are reopened and reassigned.

### 4.4.2 Adaptation of processes

The documentation of the QMS such as procedure documents or work instructions does not only have to be created and published as supported by the LibreSource platform. The documents also have to be understood and applied. Work processes and activities have to be adopted and carried out according to them. All concerned members of the STG have to be aware of that. Therefore the importance of being conform to the target procedures is communicated by the quality manager supported by the manager. If necessary, additional training will be provided for understanding and realizing the QMS documentation.

Until now not all parts of the QMS at the STG are documented and only some few parts are implemented because the ISO 9000 project is still in an early phase. Therefore wide experiences of how processes are changed or created are quite rare, but some like the implementation of the document creation and change are promising. In this case the procedure was learned by simply applying it until it became routine.

The formal way how daily work should be carried out to conform to the QMS documentation is illustrated in Figure 18. The flowchart describes the use of the **Document control system** and is also part of the homonymous procedure document.
When applying this part of the procedure the person first has to reflect if the task is trivial, does not influence the product quality in a significant way or is well remembered. Is that the case, the task is just performed.

If the task is not trivial and the exact procedure is not well known and has significant impact on the product quality, the corresponding document describing it has to be looked up on the LibreSource platform. If a suitable document describing the task can be found, the task is performed according to this. If not, a document creation or change is performed as described in Chapter 4.3.5.

4.4.3 Ideas for future implementations

As previously mentioned is the implementation of the QMS at the STG still in an early phase. Therefore not all requirements are realized yet. But for many of them exist ideas on how they could be implemented. These ideas are described in this chapter to show further planning and approaches for implementation. Some of them are also contained in the quality manual. The number of the corresponding ISO 9001 requirement (see Table 4) that is addressed by the idea is mentioned in parenthesis.

- Management review (5.6) shall be realized by quarterly review meetings involving at least the manager and the quality manager to discuss and solve problems that were detected in internal audits or reported from customers for example.
- Competence and training (6.2.2) shall be provided between colleagues. Each employee describes his skills and area of expertise on a personal page on the
Libresource platform. Other colleagues browse and search in these pages and can contact and ask the corresponding competent person for help if they have a need of knowledge in a specific area.

- External customer feedback will be handled in a bug-tracker that is accessible on a website or possibly by e-mail to ensure satisfactory customer communication (7.2.3) and to reach customer focus (5.2)
- A system for configuration management and version control will be established to ensure product identification and traceability (7.5.3). It includes a definition of the build process including a description of how releases are created and which content and requirements they have. The Debian subversion (SVN) repository will be used for version control.
- Preservation of product (7.5.5) will be realized by regular scripted backups and the deployment of adequate security mechanisms and is supported by the configuration management.
- Non-conforming products (8.3) and internal customer (colleague) feedback are reported and controlled in bug-trackers. Some are already setup but not adjusted to the latest program modularization and not consequently used.
- Monitoring and measurement of products (8.2.4) is done by different test mechanisms and constant software monitoring will be implemented by VizzAnalyzer code inspection based on the ISO/IEC 9126.
- The software development process will follow the UPEDU (Unified Process for Education)\(^8\) which is also taught by members of the STG. This software engineering process is derived from the RUP (Rational Unified Process) and is a disciplined method to support the production of high-quality software. The UPEDU follows an iterative and incremental approach and assists all phases of the software development by providing documentation templates. It includes the six disciplines Requirements, Analysis and Design, Implementation, Test, Configuration and change management and Project management and sets milestones for process monitoring. [KrRo03] Significantly improved quality in product realization (7.1, 7.2, 7.3 and 7.5) can be expected by applying this method.

The listed ideas are planned as the next implementation steps and intended to be finished in the end of the summer. They do not fulfill all requirements of the ISO 9001, but are important steps for reaching the quality objectives.

As previously mentioned 19 record types are mandatory in the terms of the standard. A list of proposed records that would fulfill this demand at the STG is illustrated in Table 6. It was created by the consultant in accordance with the quality manager. The table also connects the Procedure documents to the records and shows which records currently exist. That is rather part of the internal audit of the next chapter but also shown here to avoid the repetition of all possible records.

---

\(^8\) [http://www.upedu.org/upedu/](http://www.upedu.org/upedu/)
<table>
<thead>
<tr>
<th>Procedure</th>
<th>Corresponding records (proposals)</th>
<th>Exists&lt;sup&gt;9&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal quality audit</td>
<td>Audit report</td>
<td>✓</td>
</tr>
<tr>
<td>Project management</td>
<td>P roject Plan</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Software Development Plan (includes Measurement plan, Iteration plan, Risk list)</td>
<td>✗</td>
</tr>
<tr>
<td>Inspection and Testing</td>
<td>Verification report</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Test report (Supported by VizzAnalyzer reports)</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Customer acceptance report</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Controlled handling of test tools report</td>
<td>✗</td>
</tr>
<tr>
<td>Customer property and licensing</td>
<td>List of received (and removed) customer data</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>List for administrating received licenses</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>VizzAnalyzer license list (issued licenses)</td>
<td>✓</td>
</tr>
<tr>
<td>Non-conforming products</td>
<td>Bug-Trackers for software development (VizzAnalyzer) and customer complaints</td>
<td>✗</td>
</tr>
<tr>
<td>Training and competence</td>
<td>Skill description in LibreSource (Knowledge base)</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>List of ordered books</td>
<td>✗</td>
</tr>
<tr>
<td>Preventive and corrective action</td>
<td>Documentation of preventive actions and solutions (partially in bug-trackers)</td>
<td>✗</td>
</tr>
<tr>
<td>Configuration &amp; change management</td>
<td>Configuration management log files</td>
<td>✗</td>
</tr>
<tr>
<td>Management review</td>
<td>Minutes or protocol from review meeting</td>
<td>✗</td>
</tr>
<tr>
<td>Design and development planning</td>
<td>Requirements documentation</td>
<td>✗</td>
</tr>
<tr>
<td>Customer requirements review</td>
<td>Protocol of review meeting</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Verification list with evaluation criteria</td>
<td>✗</td>
</tr>
<tr>
<td>Design control</td>
<td>Protocol results of design review</td>
<td>✗</td>
</tr>
<tr>
<td>Development guidance</td>
<td>Protocol results of design review</td>
<td>✗</td>
</tr>
<tr>
<td>Product preservation</td>
<td>Configuration management log files</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Backup report</td>
<td>✗</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Supplier evaluation list</td>
<td>✗</td>
</tr>
</tbody>
</table>

Table 6: Proposals for quality records at the STG

4.5 Internal audit

The purpose of the quality audit is to analyze the QMS of the STG to determine if quality activities and related results comply with the planned arrangements. Unconformities and efficiency problems shall be detected. [Beau00] The audit is as far as possible conducted by a competent and independent auditor. The fulfillment or non-fulfillment of the ISO 9001 requirements is documented. Audit findings are discussed and reported to the members of the STG who are responsible for solving them and result in improvements of the QMS. They also give an idea about the current implementation status of the standard and if a registration audit would be promising.

This chapter first states the ISO 9001 requirements for an internal audit based on [Beau00], then it describes the internal audit procedure defined for the STG and finally

<sup>9</sup> Red shade and ✗: Record not existing; Green shade and ✓: Record existing
specifies the planning, conduction and the results of the first internal audit carried out at the STG.

4.5.1 General requirements

The ISO 9001 requires the organization to have auditors verifying that work activities in all areas concerning the quality management system are planned and performed. The activities have to meet the requirements of the standard, of the quality plan that describes the product realization (ISO 9001 requirement 7.1) and other requirements (e.g., customer commitments or quality objectives). Furthermore, it has to be determined if the QMS is being used and maintained effectively.

Reasonable time intervals for conducting such audits have to be chosen finding a trade-off between the necessity and cost of audits. A plan has to be created specifying the scope and frequency and methods to be used for the audit.

Auditors are not allowed to audit their own work because objective results shall be achieved. A procedure document has to be written defining the responsibilities for the activities described above. The manager is responsible for solving the found problems and the corresponding corrective actions should be verified.

4.5.2 Internal quality audit procedure

How these requirements for an internal audit shall be implemented at the STG is described in the internal quality audit procedure document. The procedure was created by the consultant and the quality manager. The flowchart in Figure 19 gives a high-level overview of how the need for an internal audit is detected and how it is planned.

Figure 19: Internal quality audit
Audits are initiated if a regular planned audit is required, which is periodically scheduled in the project plan available on LibreSource or if the quality manager considers an internal audit as necessary. In case of the mandatory periodic audit the scope is always the whole QMS. Otherwise the quality manager can limit the scope to the areas where circumstances require it and to the activities that highly influence product quality.

After fixing the scope the quality manager appoints an independent auditor, who is defined like following in the terms of the STG: “Person with the competence to conduct an internal audit. The auditor can also be an audit team to increase objectiveness.”

Due to the restricted resources at the STG the quality manager decided that if an adequate person is not available, he will conduct the audit himself being aware of that this does not comply to the requirements of the ISO 9001 because the quality manager is not independent. For a sought registration this clause and practice would have to be changed. An alternative would be the conduction of internal audits by one or more trained students in the scope of a project work or lecture.

After being appointed, the auditor plans and schedules together with the quality manager the steps for conducting the audit, which are described in the following.

The conduction of the audit includes the analysis of documents and technical support systems, interviews with the members of the STG and the analysis, documentation and communication of the results.

At first the auditor has to get familiar with the QMS of the STG. The quality manager introduces him to the QMS including the LibreSource platform and gives the auditor access to all relevant documentation.

The auditor considers reports of previous quality audits if available to focus on former deficiencies and to track the success of improvements. Documents describing the QMS like the quality manual, procedure documents and as necessary also work instructions are read and understood by the auditor. He analyzes if the documented QMS would fulfill the requirements of the ISO 9001 when implemented. For this purpose he uses checklists from ‘The ISO 9001 Standard Interpretation’ [equals Beau00] for assistance. The book contains questions for each requirement of the ISO 9001 that ease the evaluation of the compliance to the standard. Exemplary are some checklist questions for the requirement 8.2.2 ‘Internal Audit’ shown:

- Does a written procedure exist for conducting internal audits?
- Are there records showing that audits have been performed throughout all areas making up the registration scope?
- Do these audits cover all paragraphs of the Standard over an appropriate time period?
- Are the auditors trained to conduct audits?
- Are the auditors independent of the work being audited?
- Are audit results kept as records?
- Is corrective action taken promptly on every deficiency found by the audit?
- Do the audits adequately evaluate the effectiveness of the QMS?

After this assessment the auditor examines the records to check if processes are carried out as described in the documentation but also to see if all mandatory records are created and available. Furthermore, technical support systems like the LibreSource platform and their efficiency and use are inspected to control if the Document Control System procedure and other technical supported procedures are implemented satisfactory and if the systems are accepted and used by the members of the STG.
Based on the knowledge acquired from the previous audit steps the auditor derives questionnaires for individual interviews. Depending on the role of the interviewee (manager, quality manager, developer, etc.), the questions are adjusted and thus differ partially. Their main purpose is to control the consequent implementation of the documented procedures. The auditor prepares the interviews and makes individual appointments with the members of the STG. The personal interviews are conducted on the basis of the questionnaires and results are analyzed by the auditor. He summarizes the compliance to the ISO 9001 requirements in a gap analysis derived from the knowledge gained in the previous audit activities and if necessary assisted by the earlier mentioned checklists again. This gap analysis is part of the audit report which is created by the auditor and also lists problems and findings. The audit report is stored as a record and discussed with the quality manager and the manager, who consequently create a plan for improvements.

Finally the audit report is discussed with the members of the STG and the improvement plan is realized under supervision of and verified by the manager.

4.5.3 First internal audit at the STG

The first internal audit at the STG is carried out in the context of this thesis and not because a time period has elapsed or specific circumstances really require it. The scope of this audit is the whole QMS of the STG as far as designed and implemented. Due to the restricted resources of the STG only one person, the consultant conducts the audit. The chosen auditor is competent regarding the ISO 9001 because he gained sufficient knowledge about the standard in the context of his thesis project. He also can be considered as an independent and objective auditor because his main interest is to write a good and reasonable thesis and to present this also at another research institute\(^{10}\), rather than to describe project results better than they are. Furthermore he assisted introducing the ISO 9001 at the STG, but he does not directly audit his own work activities.

4.5.3.1 Purpose and specifics

The early phase of the realization of the QMS at the STG makes it problematic to follow the exact approach described in the internal quality audit procedure because this is rather intended for assessing a mostly complete QMS which is not the case at the STG. Therefore there are some specifics and differences to the documented internal quality audit procedure described above.

Besides finding out which ISO 9001 requirements are already completely or partially realized the purpose of this audit is to evaluate the people’s knowledge about the QMS in general and the awareness towards quality and the ISO 9001 standard to be able to assess if the project is on a good way and promising.

A further aim of the interviews of the audit is that the members of the STG are confronted to questions about the QMS and therefore have to recapitulate and find answers which is an implicit training and shall further increase the awareness towards the quality standard.

4.5.3.2 Planning

The first internal audit at the STG takes place from the 8\(^{th}\) until the 19\(^{th}\) of May 2006. The planning of most of its steps like document and system analysis and an assessment of their ISO 9001 conformity is not too complex for the auditor because he already has

\(^{10}\) Presentation as diploma thesis at Regensburg University in Germany
a quite good knowledge about the QMS of the STG because he assisted creating most of its components.

Therefore the focus in this chapter is mainly on the planning of the questionnaire-based interviews. As mentioned before the purpose of the audit including the interviews is not only to evaluate the compliance to the standard’s requirements and to detect problems but also to judge the attitude and awareness of the members of the STG regarding quality management and the ISO 9000. Doing this and analyzing the fulfillment of critical success factors (cp. Chapter 2.2.1.5) shall enable the auditor to estimate the project expectations. For these reasons the auditor considers to extend the scope of the interview questions from the issues described in the internal quality audit procedure. Also questions that give hints about the awareness and about the critical success factors will be asked in the interviews.

The questionnaires are independently created by the auditor. The questions are of different difficulty and not known by the staff before the survey. They are adjusted for the different members of the STG, thus for the manager and marketing director (Welf Löwe), the quality manager (Rüdiger Lincke) and for the pure developer (Jonas Lundberg). The interviews will approximately take half an hour and are scheduled in the week from the 15th until 19th of May.

Another adaptation of the internal quality audit procedure is that the use of the mentioned checklist questions in this first audit will be limited to the procedures and parts of the QMS that are already created. Thus useless work overload shall be avoided by only assessing the fulfillment of promising requirements.

4.5.3.3 Conduction

After the completion of the planning, the audit is conducted as described in the internal quality audit procedure in consideration of the mentioned modifications and exceptions. The corresponding steps are carried out like following:

1) Introduction of the auditor to the QMS is not necessary because the auditor is already familiar with it.

2) No previous audits have been considered, therefore no former reports can be considered, but the initial gap assessment will be used.

3) Documents are mostly already known by the auditor. The following relevant documents currently exist in an approved version:
   - Quality manual
   - Three procedure documents:
     - Document Control System
     - Records control system
     - Internal quality audit
   - Two work instructions:
     - Document creation and change
     - Issue VizzAnalyzer-Vizz3D license

The three mandatory procedure documents Non-conforming products, Corrective action and Preventive action are still missing and also twelve further planned procedure documents that are contained in Table 5.

4) The three existing procedure documents are assessed if they would fulfill the relevant checklist questions when completely implemented:
   - Document Control System (12 of 13 questions potentially fulfilled; documents written outside of the organization are not identified yet, but irrelevant because no such documents exist at the moment)
   - Records Control System (10 of 10 questions potentially fulfilled)
• **Internal audit procedure** (11 of 12 questions potentially fulfilled; as already mentioned is the auditor at the STG not necessarily independent of the audited work)

5) Two records will be created at the end of this audit. The existing *VizzAnalyzer license* list record proves that the *Issue VizzAnalyzer-Vizz3D license* work instruction is implemented as described and the *Audit report* record will show the conduction of this quality audit.

6) The procedures whose realization should be assisted by a technical system (currently *Document Control System* and *Records Control system* procedure) are supported satisfactory by the LibreSource platform as described in Chapter 4.4.1. The use of the platform will be checked by adequate questioning in the interviews.

7) Questionnaires for interviewing are created including the proposed answers or a scale if adequate for the question (see Appendix G). The questions aim to find out about the following different issues. The numbers of the corresponding questions are listed in parenthesis:
   - Importance and expectations of the ISO 9000 project at the STG (1, 2, 3, 17)
   - Awareness of staff regarding quality including own responsibilities (5, 6, 7, 18, 19, 20)
   - Sufficient training of staff
     - General training about the ISO 9000 at the STG (4, 8, 13, 16, 22, 33)
     - Reading and understanding the quality manual (14, 15, 23, 25)
     - Understanding and implementation of created procedures (12, 14, 32)
   - Use of the LibreSource platform (9, 10, 11)
   - Compliance to the specific ISO 9001 requirement annotated at the question (21, 24, 26, 27, 28, 29, 30)
   - Quality objectives of the STG (31)

8) The interviews with the members of the STG will take place like following:
   - Welf Löwe: 15<sup>th</sup> of May, 11 a.m.
   - Rüdiger Lincke: 15<sup>th</sup> of May, 10 a.m.
   - Jonas Lundberg: 16<sup>th</sup> of May, 1 p.m.

9) Interviews are carried out as scheduled

**4.5.3.4 Results**

The results of the former steps are listed and analyzed in the audit report which is published as a record on the LibreSource platform. The report is created by the auditor and summarizes audit results in a complete and well-organized form to ease follow-up actions. It contains besides audit findings and problems the questionnaire including the answers from all members of the STG in its Appendix (see also Appendix G of the thesis). Furthermore a gap analysis shows which ISO 9001 requirements are currently fulfilled at the STG.

Most parts of the audit report are content of this chapter. To avoid redundancies some facts mentioned in this thesis before are skipped and a reference to the corresponding paragraph is given. The sections of the audit report are specified like following:

1) **Documentation evaluation**

   In this part of the report the results of the evaluation of documents concerning the ISO 9001 and the QMS of the STG are shown.
a. **Quality manual**  
The quality manual describes all parts of the QMS of the STG and maps the requirements of the ISO 9001 sufficiently. Quality policy and quality objectives are contained and procedure documents are referenced within the manual as desired. Also relations between the procedures are described.  
Many good approaches for quality improvement are listed in the quality manual but only few of them are implemented yet.

b. **Procedure documents**  
The procedure documents created at the moment and the mandatory ones that are still missing were already listed in the previous chapter. Furthermore, the creation of the following procedure documents is planned at the STG, but not realized yet (the priority number is given in parenthesis, 1 is highest, 3 lowest):

- Project management (1)
- Inspection and testing (1)
- Non-conforming products (1)
- Training and competence (1)
- Preventive and corrective action (2)
- Configuration & change management (2)
- Management review (2)
- Design and development planning (3)
- Customer requirements review (3)
- Design control (3)
- Development guidance (3)
- Product preservation (3)
- Purchasing (3)

A summary of the planned content and scope of the procedure documents is contained in the quality manual.  
An analysis evaluating if the already written procedures would fulfill the ISO 9001 requirements *when* they are completely implemented is also part of the audit report. Its results are shown in ‘Step 4’ in Chapter 4.5.3.3 of the thesis.

c. **Work instructions**  
Work instructions are not mandatory in the terms of ISO 9001, but an important part of the QMS of the STG because repeatability and knowledge preservation are main objectives and shall be supported and realized by the creation of written work instructions. Until now two work instructions are created (see Chapter 4.5.3.3). Further work instructions are necessary to reach the mentioned objectives.

d. **Records**  
Two of the mandatory records are created until now (including this audit report). According to the procedures that are currently created and implemented no further records are required yet.

---

11 See procedure priority list in Table 5
But the ISO 9001 requires 19 different record types that could be realized within the STG with the proposals of Table 6. Existing records are marked in the table. The two created records represent the mandatory record types for the ISO 9001 requirement 8.2.2 and partially for requirement 7.5.4.

2) Efficiency of technical support systems

a. Realization of technical supported procedures

The ISO 9000 LibreSource platform provides an introduction to and some training about ISO 9000. It supports the implementation of all available documentation focused procedures like ‘Document control system’ and ‘Records control system’. The realization of these procedures is adequately technical assisted by a bug-tracker with e-mail notification and document upload for approving. Furthermore, the document repository provides all relevant documents in a satisfactory way. Up-to-date documents are available on all work locations and current and old versions of the documents are identifiable by the user. LibreSource provides the flexibility to support the implementation of further procedures like ‘Non-conforming product’ and ‘Corrective and preventive action’ with a bug-tracker or ‘Project management’ with a new section in the document repository for the project documents.

b. Use of the system by the members of the STG

An evaluation of the use of the LibreSource platform is based on the number of entries in the different sections of the system and on the answers of the questions 9, 10 and 11 from the personal interviews. (See questionnaires in Appendix G)

The platform at this time is only used by the consultant (Florian Stahl) and the quality manager (Rüdiger Lincke) who both regularly apply the functionalities for document creation and changes and update and improve the ISO 9000 platform.

Other members of the STG only tested the platform or did not use it at all. That shows also the rare use of the discussion forum. Currently it is only used to post news. Also the use of the ‘Creation and change requests’ section could be expanded to all members of the STG by assigning further tasks for creating procedure documents and work instructions. At this time only the ‘Project management’ procedure is assigned for creation.

Summing up is the use of the LibreSource platform by members of the STG still insufficient.

3) Interview results

In this part of the report the most interesting and meaningful interview results and answers and some interpretation are contained. The complete questionnaire and the answers of the members of the STG is contained in Appendix G. Questions about the LibreSource platform (questions 9, 10, 11) and about the fulfillment of specific ISO 9001 requirements (questions 21, 24, 26, 27, 28, 29, 30) are barely addressed in this section because they are covered in the sections 2b and 4 of the audit report.
The main conclusions derived from the answers of the remaining questions are:

- Quality problems in software development are mainly caused by undocumented and not standardized processes. Therefore process and quality improvement shall be realized by implementing the ISO 9000.
- The focus of the project is on quality improvement and knowledge preservation by documenting procedures. This shall improve the repeatability of processes and thus help to save time and ease introducing new staff to the work activities at the STG.
- The project has a high priority because quality improvement and product consolidation is most important for the VizzAnalyzer at the moment, more important than the extension of functionality. The ISO 9000 project is the basis for improving quality.
- Resources at the STG are according to the manager not sufficient to produce high quality software because the main business for the members of the STG is educating students and doing research, but not to develop software. Thus there is not enough time and energy for perfect software development, but anyway the goal is best possible software quality.
- Customer focus as the major demand of the ISO 9001 is not the main intention of the QMS at the STG. Especially pro-active communication with external customers is not established and the satisfaction of their requirements has a low priority.
- Instruments for measuring internal or external customer feedback are not established. Therefore no assessment of customer satisfaction is possible.
- An extensive use of the VizzAnalyzer software of external customers is not assumed because otherwise customer feedback and questions could be expected.
- The awareness of staff regarding the importance of quality and of the project is mostly available.
- Knowledge about the quality standard within the STG has increased since the beginning of the ISO 9000 project but is still mostly only basic.
- Sufficient training of all members of the STG for an efficient use of the QMS is not given yet.
- Responsibilities regarding the quality management are well defined but not exactly known by the members of the STG, which can cause misunderstandings.
- The quality manual is not fairly known by all members of the STG. Some important definitions like of the term ‘customer’ are understood inconsistent.
- The three created procedure documents are implemented and known partially. Documentation procedures (Documentation control system, Records control system) are mostly well understood.
- The manager does not plan any consequent improvements after the publication of the audit report as foreseen in the internal quality audit procedure.
- The fulfillment of quality objectives was rated by the manager and quality manager on a scale from 0 (not reached), 1 (partially reached or methods implemented) until 2 (reached). The average results are the following:
  - Minimum number of non-conforming software components and products: 0
- Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer: 0
- Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students: 0.5
- Active risk reduction by increasing process maturity and documentation: 1
- Knowledge preservation in form of work instructions and procedure documents to deal with changing staff: 1
- Compliance to legal contracts when using 3rd party components: 0
- Save time through central information storage: 1.25

4) Fulfillment of ISO 9001 requirements

The following table shows in a gap analysis which requirements of the ISO 9001 are fulfilled at the time of the audit and which ones not. It also includes reasons for the assessment. The evaluation considers amongst others the answers to the interview questions 21, 24, 26, 27, 28, 29 and 30. In some cases checklist questions from [Beau00] were considered to ease the decision. Some of the ISO 9001 requirements are fulfilled partially at the STG but important parts are missing and therefore these lines in the table are shaded red and marked with ‘×’ anyway, which means ‘Requirement not fulfilled’. Requirements for that only minor parts are missing are shaded yellow instead.

<table>
<thead>
<tr>
<th>Status¹²</th>
<th>ISO 9001 requirement¹³</th>
<th>Reason (Why not? / How realized?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>×</td>
<td>4. Quality management system</td>
<td>Establishment, documentation and implementation of a QMS and its continual improvement is not completely realized</td>
</tr>
<tr>
<td>×</td>
<td>4.1 General requirements</td>
<td>Not all mandatory procedure documents and records are available (See Documentation evaluation)</td>
</tr>
<tr>
<td>×</td>
<td>4.2 Documentation requirements</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>4.2.1 General</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>4.2.2 Quality manual</td>
<td>Quality manual published in complete and satisfactory version</td>
</tr>
<tr>
<td>✓</td>
<td>4.2.3 Control of documents</td>
<td>Document Control procedure implemented in LibreSource; identification of external documents irrelevant at the STG</td>
</tr>
<tr>
<td>×</td>
<td>4.2.4 Control of records</td>
<td>Records control system established, but not all required records created</td>
</tr>
<tr>
<td>×</td>
<td>5. Management responsibility</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>5.1 Management commitment</td>
<td>Quality policy and objectives are established Importance of meeting customer</td>
</tr>
</tbody>
</table>

¹² Green shade and ✓: Requirement fulfilled; Red shade and ×: Requirement not fulfilled; Yellow shade and ×: Requirement nearly fulfilled
¹³ (R) means: Record(s) is (are) required for this requirement
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2 Customer focus</td>
<td>×</td>
<td>The determination and meeting of customer requirements is not ensured</td>
</tr>
<tr>
<td>5.3 Quality policy</td>
<td>✓</td>
<td>Contained in the quality manual</td>
</tr>
<tr>
<td>5.4 Planning</td>
<td>✓</td>
<td>Contained in the quality manual</td>
</tr>
<tr>
<td>5.4.1 Quality objectives</td>
<td>×</td>
<td>QMS is not sufficient yet to reach the requirements of 4.1 and the quality objectives</td>
</tr>
<tr>
<td>5.4.2 Quality management system planning</td>
<td>×</td>
<td>QMS is not sufficient yet to reach the requirements of 4.1 and the quality objectives</td>
</tr>
<tr>
<td>5.5 Responsibility, authority and communication</td>
<td>×</td>
<td>Roles and responsibilities of people in regard to quality are defined But not sufficiently communicated to and understood of all members of the STG yet</td>
</tr>
<tr>
<td>5.5.1 Responsibility and authority</td>
<td>×</td>
<td>No sufficient communication between the members of the STG regarding product quality and the effectiveness of the QMS is established</td>
</tr>
<tr>
<td>5.5.2 Management representative</td>
<td>✓</td>
<td>Determined (Rüdiger Lincke)</td>
</tr>
<tr>
<td>5.6 Management review</td>
<td>×</td>
<td>No management review of the QMS established</td>
</tr>
<tr>
<td>5.6.1 General (R)</td>
<td>×</td>
<td>No management review of the QMS established</td>
</tr>
<tr>
<td>5.6.2 Review input</td>
<td>×</td>
<td>See requirement 5.6.1</td>
</tr>
<tr>
<td>5.6.3 Review output</td>
<td>×</td>
<td>See requirement 5.6.1</td>
</tr>
<tr>
<td>6. Resource management</td>
<td>×</td>
<td>Sufficient time is not available to produce perfect software quality because main business is education and research Other resources are available</td>
</tr>
<tr>
<td>6.1 Provision of resources</td>
<td>×</td>
<td>People have sufficient education, training, skills and experience for carrying out work affecting software quality</td>
</tr>
<tr>
<td>6.2 Human resources</td>
<td>×</td>
<td>Competencies are not identified and assessed consequently Training is performed by literature study, but not sufficiently assisted and recorded</td>
</tr>
<tr>
<td>6.2.1 General</td>
<td>✓</td>
<td>Infrastructure, facilities, hard- and software and communication services are sufficient to reach product requirements</td>
</tr>
<tr>
<td>6.2.2 Competence, Awareness and training (R)</td>
<td>×</td>
<td>Infrastructure, facilities, hard- and software and communication services are sufficient to reach product requirements</td>
</tr>
<tr>
<td>6.3 Infrastructure</td>
<td>✓</td>
<td>Work conditions are adequate to achieve conformity to product requirements</td>
</tr>
<tr>
<td>6.4 Work environment</td>
<td>×</td>
<td>Plans for software development at the STG do not incorporate appropriate information such as product requirements, quality</td>
</tr>
<tr>
<td>7. Product Realization</td>
<td>×</td>
<td>Plans for software development at the STG do not incorporate appropriate information such as product requirements, quality</td>
</tr>
<tr>
<td>Objective</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>7.2 Customer-related processes</td>
<td>Functional and non-functional requirements provided from internal customers are only orally discussed but not documented and determined in an organized way. Requirements from external customers are not determined at all.</td>
<td></td>
</tr>
<tr>
<td>7.2.1 Determination of requirements related to the product</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.2.2 Review of requirements related to the product (R)</td>
<td>Requirements are not sufficiently verified if they are known and understood and if the STG is able to meet them.</td>
<td></td>
</tr>
<tr>
<td>7.2.3 Customer communication</td>
<td>Effective customer communication channels to external customers are not put in place to clarify questions and handle feedback and complaints. Internal communication channels are satisfactory.</td>
<td></td>
</tr>
<tr>
<td>7.3 Design and development</td>
<td>A software development method is defined (UPEDU). But project plans for design and development are not documented and maintained yet.</td>
<td></td>
</tr>
<tr>
<td>7.3.1 Design and development planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3.2 Design and development inputs (R)</td>
<td>No requirement documents are recorded and used as input for design and development.</td>
<td></td>
</tr>
<tr>
<td>7.3.3 Design and development outputs</td>
<td>No sufficient information is available to verify that the design output meets design input requirements.</td>
<td></td>
</tr>
<tr>
<td>7.3.4 Design and development review (R)</td>
<td>Formal reviews of project and design and development artifacts are not conducted.</td>
<td></td>
</tr>
<tr>
<td>7.3.5 Design and development verification (R)</td>
<td>The design is not sufficiently checked and it is not verified if the output meets input requirements.</td>
<td></td>
</tr>
<tr>
<td>7.3.6 Design and development validation (R)</td>
<td>Only informal and internal checks if the system meets the user needs (not sufficient).</td>
<td></td>
</tr>
<tr>
<td>7.3.7 Control of design and development changes (R)</td>
<td>No sufficient configuration management established.</td>
<td></td>
</tr>
<tr>
<td>7.4 Purchasing</td>
<td>Selection and evaluation of suppliers to meet quality requirements are not defined and recorded.</td>
<td></td>
</tr>
<tr>
<td>7.4.1 Purchasing process (R)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.4.2 Purchasing information</td>
<td>No clear specifications of products or services that are purchased for use in the SDP are described.</td>
<td></td>
</tr>
<tr>
<td>7.4.3 Verification of purchased product</td>
<td>No process is defined that verifies products and services of externals that influence the...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SDPs of the STG</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.5 Production and service provision</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Monitoring and measuring processes and tools, product specifications and work instructions are not sufficiently applied for the product (VizzAnalyzer).</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.5.2 Validation of processes for production and service provision (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Not necessary within the STG because no such processes exist</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.5.3 Identification and traceability (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Version and status control is not sufficiently applied and recorded</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.5.4 Customer property protection (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Tracking and proper handling of intellectual customer property (especially software for code inspection) is not ensured and recorded</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.5.5 Preservation of product</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Backups are individually created, but not in an organized way Configuration management and security mechanisms are not sufficiently applied</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>7.6 Control of monitoring and measuring devices (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Measurement equipment like the VizzAnalyzer is not run in a controlled environment and protected from invalidate changes or from damage during handling or maintenance</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8. Measurement, analysis and improvement</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.1 General</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Measurements and corresponding analysis to ensure that product requirements are met and to improve the QMS are not performed</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.2 Monitor and Measure</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.2.1 Customer satisfaction</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Methods for monitoring customer feedback (e.g., from colleagues, research partners, students, etc.) and how to use this information are not sufficiently defined</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.2.2 Internal audit (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>The internal audit is defined and conducted and a report is created But the required realization of the improvement plan is not reliable yet</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.2.3 Monitoring and measurement of processes</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>The performance of the QMS is not monitored and measured</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.2.4 Monitoring and measurement of products (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Some unit tests performed, but software not inspected sufficiently and in an organized way. No integration and acceptance tests performed and recorded</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.3 Control of nonconforming product (R)</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Users are not sufficiently protected from failed products by establishing procedures to identify nonconforming products and to avoid their accidental use</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>8.4 Analysis of Data</td>
<td></td>
</tr>
<tr>
<td>×</td>
<td>Data about customer satisfaction and software conformity is not sufficiently analyzed</td>
<td></td>
</tr>
</tbody>
</table>
analyzed and it is not learned from it

|   | 8.5 Improvement | Organizational learning from audit results, analyzed data, etc. is not implemented yet
|   | 8.5.1 Continual improvement | No written procedures are established to solve known problems by satisfying customer complaints, identifying the cause of unconformities and ensuring corrective actions. E.g., no bug-trackers are consequently used.
|   | 8.5.2 Corrective action (R) | No procedures for preventive actions are written and implemented to avoid the occurrence of similar problems in the future.

|   | 8.5.3 Preventive action (R) | No procedures for preventive actions are written and implemented to avoid the occurrence of similar problems in the future.

Table 7: Internal audit gap analysis

5) Comparison to earlier audits

This is the first internal quality audit conducted at the STG. Therefore the control of the realization of improvements based on former audit reports is not possible. But a comparison to the initial gap analysis (see table 4 in Chapter 4.2.4) that assessed the situation at the STG before the project started is given. The following ISO 9001 requirements have been fulfilled since that time:

- 4.2.2 Quality manual
- 4.2.3 Control of documents
- 5.3 Quality policy
- 5.4.1 Quality objectives
- 5.5.2 Management representative

Nearly fulfilled are currently the requirements:

- 4.2.4 Control of records
- 5.5.1 Responsibility and authority
- 8.2.2 Internal audit

6) Project progress

The ISO 9000 project at the STG is still in an early stage. Therefore the audit report also contains a brief section about the progress of the implementation of the standard. The results reached until now are satisfactory considering the limited resources due to lecturing and research activities during the semester time. But anyway, two important milestones set in the project plan (see Table 3 in Chapter 4.2.3) could not be reached yet:

- Create further procedure documents and records according to priority list level one (see missing procedure documents with priority (1) in the first section of this audit report)
- Implement the documented procedures (according to priority level one)

4.5.3.5 Follow-ups

In the seventh and last section of the audit report, the auditor added some recommendations how the implementation of the ISO 9001 at the STG should be
continued. These suggestions and other consequent actions after the conduction of the audit are described in this chapter.

As defined in the ‘Internal quality audit’ procedure the audit report is discussed in meetings with the quality manager and the manager in the week from the 22\textsuperscript{nd} until the 26\textsuperscript{th} of May.

To solve the audit findings and problems an improvement plan is created and discussed and implemented with the members of the STG. This plan is written by the quality manager and the manager. Milestones should be set to enforce the realization of the following recommended activities:

- The open tasks from the project plan should be aspired to fulfillment.
- Thereby on the first place is the focus on the ‘Project management’ and the ‘Inspection and testing’ procedures because they are most important in the eyes of the members of the STG and also realizable with restricted resources.
- Furthermore the mandatory procedures ‘Corrective and preventive action’ and ‘Nonconforming products’ should be covered.
- The creation of records should be continued corresponding to the created procedure documents and work instructions. The relation between possible records and procedure documents is shown in Table 6.
- Enforce the use of the ‘Creation and change requests’ section in the LibreSource platform. Create tasks for each member of the STG with the previously mentioned procedure documents or with quality affecting work instructions. Every member should at least solve one documentation task per month.
- Further training and appeals for the use of the LibreSource platform should be communicated. Also an ISO 9000 workshop or additional ISO 9000 training would be helpful to improve the basic knowledge.

The realization of the improvement plan until the end of summer is controlled by the manager. The milestones are added to the quality management project plan in the LibreSource document repository. Also the date for the next internal audit will be scheduled there to assess the realization of the improvement plan.

The results of the internal audit should also be input for the management review and result in corrective and preventive actions, but the corresponding procedures are not created and implemented yet.
5 Summary

In the summary as the last part of the thesis conclusions about the instantiation of ISO 9000 compliant processes at the STG and about the realization of the objectives of the project are drawn.

That includes the listing of problems and the evaluation of the fulfillment of critical success factors to reason difficulties. Moreover it is stated in how far the goals of the thesis are achieved by examining the reaching of criteria.

Finally, a reflection of the project expectations is stated by the author and necessary future work is mentioned.

5.1 Conclusions

5.1.1 Problems

During the introduction of the ISO 9000 at the STG in the context of this thesis some problems occurred. Most of them have its origin in the relatively short time frame and the limited resources of the STG. Especially during the semester time (middle of January until beginning of June) much effort has to be put in teaching activities.

Anyway, the project has according to the interview results a high priority. But therefore the resource allocation is despite the restrictions of resources quite low and some more time and effort should be spent for the project during the summer when no teaching activities take place. Some more activities than until now will be necessary of all members of the STG to establish a quite complete QMS in the next time. An improvement of efficiency and saving time will be the results of the effort in later stages of the project.

Another difficulty was the lack of training and knowledge of the members of the STG about the ISO 9000 before its introduction. According to interview answers there was no or only poor knowledge about the standard available. This complicated the description of the subject and the knowledge acquisition took much time in the initial project phase.

Later the different knowledge bases of the consultant and of members of the STG resulted in different project expectations and caused some misunderstandings. The main goal of the QMS in the eyes of the members of the STG is to reach a better quality by supporting repeatability of processes and knowledge preservation. This could be part of an ISO 9001 compliant QMS, but the superior goal of the standard is customer satisfaction.

Another issue is the focus on technical implementation and on documentation at the STG. Both are necessary for an effective and conforming QMS, but should not be overestimated because the psychological aspects and the employee awareness also play an important role when implementing the ISO 9000 as Dr. Wallace Carlson of the University of Wisconsin-Stout confirms in [John00, p. 27]: “ISO 9000 to me is 80 percent technology and 20 percent technique.” Therefore the training of staff and the communication of quality improvement are really important.

5.1.2 Fulfillment of critical success factors

To show that some of the mentioned issues are really problems that hinder the introduction of the ISO 9001 standard at the STG, the fulfillment of the critical success factors that were listed in Chapter 2.2.1.5 is evaluated. This is done based on the results of the internal audit, but also on experiences made by the author of the thesis during the consultation of the project at the STG. In the following the critical success factors are
marked with ‘✓’ if they are satisfied, with ‘✗’ if they are not satisfied and with ‘○’ if they are partially satisfied or no reasonable decision can be made.

- **Planning and project priority ✗**
  - Fulfillment of schedules is not controlled by the quality manager or manager
  - Introduction of the ISO 9000 has in the eyes of the author a lower priority than product development

- **Management involvement and resource availability ✗**
  - Management is only involved in some decisions
  - Responsibilities are delegated too low because planning and implementation tasks are mainly done by the quality manager (Ph.D. student) and the consultant (Master thesis student)
  - Sufficient human resources are difficult to provide for the reasons mentioned before

- **Tight project management and early activities ✓**
  - Project plan was quite ambitious
  - Early activities like the creation of early draft documents and a presentation for training were carried out

- **Early information ○**
  - Early information was collected by the consultant
  - But the knowledge could not be completely transferred to the members of the STG mainly because of lack of time

- **Implementation in parts of the organization ✓**
  - The ISO 9000 standard is only implemented in a small group of three people at the Computer Science Department

- **Sufficient training on staff ○**
  - Staff is trained by presentations, in meetings and by information provided on LibreSource
  - But probably not sufficient yet for using and improving the QMS efficiently and independently

- **Avoid documentation overload ○**
  - Certain risk for documentation overload is given because of the focus on knowledge preservation, but the restricted resources argue against it
  - Anyway, this is hard to evaluate in this early project phase

5.1.3 Achieved goals

Despite not all critical success factors for the implementation of the ISO 9000 are satisfied the main goals that were set for the thesis project are achieved. This can be shown by examining the fulfillment of corresponding criteria. Goals and criteria were also mentioned in the introduction (see Chapter 1.3).

- A process environment that supports the development of high-quality software is provided by the initiation of the introduction of the ISO 9000 quality standard.
- Standards and models for quality and process improvement applicable to the area of software engineering have been discussed and compared. The ISO 9000 standard has been chosen as a suitable one for the STG (see Chapter 3.4) to use its requirements and guidelines for process improvement and knowledge gain.
- The ISO 9000 has been implemented adapted to the needs of the STG. Documentation templates were created. The quality manual and created procedure documents and work instructions give an overview, guidelines and detailed instructions that describe and define the software development processes
at the STG. But some more documentation is necessary for detailing all processes. Furthermore, the LibreSource platform supports documentation tasks (cp. Chapter 4.2.5) and the members of the STG were trained by presentations and discussions (cp. Chapter 4.2.6).

- The success of the taken actions and the compliance to the ISO 9001 was evaluated in a first internal quality audit. The results of this assessment were documented in an audit report.

Besides the achievement of the main goals of the thesis, good approaches for reaching some of the ISO 9001 quality objectives and at least the partial fulfillment of some of them show that the implementation of the standard itself is on a promising way at the STG considering the early project stage (cp. interview results in Chapter 4.5.3.4). Furthermore, many good ideas for realizing requirements exist as contained in the quality manual and in Chapter 4.4.3 but the implementation is often still missing and therefore a challenge for the future.

5.2 Expectations and future work

The last chapter of the thesis states some reflections of the author, approaches for possible improvements and future work. Not all the initial expectations of the author could be fulfilled by the project because limited resources made compromises necessary. But as mentioned in the previous chapter the main goals of the thesis are reached and also some good approaches for realizing the quality objectives of the STG exist.

Possibly the ISO 9001 standard is an overload if only repeatability and knowledge preservation is the goal at the STG as often mentioned by the decision makers. Then a simple system for process documentation realized on a LibreSource platform would have been sufficient to fulfill this goal. On the other hand is the ISO 9001 a flexible standard with the “recommendation to focus on development practices that suit the organization.” [BaDe04, p 9] And this was done at the STG, even though finding suitable practices was a big challenge. And a bit more recapitulation and a deeper look into the standard and possible alternatives before the choice of the ISO 9000 by members of the STG would have given a deeper understanding of its main purpose.

To realize the complete implementation of the standard still some future work is necessary. The recommendations from chapter 4.5.3.5 should be realized and a realistic time frame for them such as until the beginning of the autumn semester in September should be set. Essential for the future success of the project is that the manager plans milestones and communicates and controls their realization. Until now milestones were set but no pressure to reach them was made and no real control mechanisms established. This pressure and support by the management includes being an example and carrying out documentation tasks oneself and also demanding activities of the colleagues. Such an approach is promising in the author’s opinion because otherwise there is a certain risk that the ISO 9000 project at the STG will not be consequently continued after the completion of the thesis project.

The extension of the ISO 9000 project to other groups at the CSD or to other areas of interest such as education or research activities as considered when initiating the project is not recommendable in the near future. But if the implementation of the standard is more progressed and the establishment of the QMS consolidated an extension especially to other software developing groups at the CSD makes sense because their processes could be easily adapted and thus synergies used.

Seeing this ISO 9000 project at the STG as an example for other computer science departments is only conditionally recommendable. Software development should be a
primary activity at the institute. Otherwise the ISO 9000 could also be applied, but not by following the specific approach described in this thesis.
Appendix

A – Mind map of VizzAnalyzer quality meeting in November 2005
B – Initial presentation: ISO 9000 at the Computer Science Department

ISO 9000
at the Computer Science Department

Initial presentation for Master Thesis:
*Instantiation of an ISO 9000 compliant quality assurance process*

1. Outline
   * Context
   * ISO 9000 Overview
   * Alternative models
   * Why ISO 9000?
   * ISO 9001 Requirements
   * Project Plan
   * Initial Tasks
   * Discussion

2. Context of the Master Thesis
   * Background and Problem:
     - Certain processes of the STG are not documented or not accessible
     - Loss of time, efficiency and quality
     - Detected during the development of the VizzAnalyzer (Welf, Rüdiger, Jonas and Thomas)
     - Research in Software Quality also demands gaining knowledge in Quality Standards
2. Context of the Master Thesis

- Motivation and aims:
  - Defined processes help to save time
  - Implementing a formal way allowing to use synergy
  - Process quality improvement shall lead to a better VizzAnalyzer quality (no loss of time and code)
  - Overall awareness of quality and processes
  - Instantiation of a quality standard like ISO 9000 in the STG (Maybe step-by-step extension)

Result:

- Outcome
  - Improved efficiency and saving of time and costs
  - Awareness of processes and quality

- My contribution
  - ISO 9000 infrastructure (documents)
  - Internal audit

- Our contribution
  - Use of infrastructure, creation of content
  - Support in creation of infrastructure
  - Continuation of process quality improvement

3. ISO 9000 – Overview

- ISO 9000:2005
  - Fundamentals and vocabulary

- ISO 9001:2000
  - Requirements (Registration)

- ISO 9004:2000
  - Guidelines for performance improvement

- ISO 9000-3:2000
  - Guidelines for the Application of ISO 9001:2000 to Computer Software
Critical Success Factors

- Responsibility at management level
  → Do not delegate responsibility too low
- Train staff to understand ISO 9000
- Every employee has to be involved
- Tight project management (e.g. Early drafts)
- Documentation by involved people

"Complete, but make it short!"

Source: http://www.simply-quality.org/case01.htm

---

4. Alternative Models

- ISO 12207 – Software lifecycle processes
- ISO 9126 – Software Quality metrics
- CMMI – Capability Maturity Model Integration
  - CMMI is a de facto standard
  - Extends the former CMM for Software Engineering (SW)
  - Integrates the four disciplines SW, Systems Engineering, Integrated Process and Product Development and Supplier Sourcing
  - Many similarities with ISO 9001, also differences

---

Comparison

<table>
<thead>
<tr>
<th>ISO 9001:2000</th>
<th>CMMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Model</td>
</tr>
<tr>
<td>Broad direction</td>
<td>Detailed</td>
</tr>
<tr>
<td>One set of requirements to be satisfied</td>
<td>Progressive steps (levels from 1-5)</td>
</tr>
<tr>
<td>15 pages</td>
<td>At least 89 pages required</td>
</tr>
</tbody>
</table>

→ ISO 9001 more flexible, but demands higher responsibility
5. Why ISO 9000?

- Work procedures change
- Additional work is required
- Does this effort pay?

Backup: Quality management

- Process management premise:
  "The quality of a system is highly influenced by the quality of the processes used to acquire, develop and maintain it."
- Belief in this premise is visible worldwide in quality movements in manufacturing and service industries (e.g. in ISO standards)

Facts and Figures

- 670,000 companies worldwide are registered to ISO 9000 (2004)
- 85% of them report external benefits like
  - Higher perceived quality
  - Greater customer demand
- 95% report internal benefits
  - Greater employee awareness
  - Increased operational efficiency
6. ISO 9001 Requirements – Overview

1) Scope  
2) Normative reference  
3) Terms and definitions  
Introduction
4) Quality management system  
5) Management responsibility  
6) Resource management  
7) Product realization  
8) Measurement, analysis and improvement
7. Generic project plan (1)

1) Establish intention to seek registration ✓
   • Proposal for the Master Thesis ✓
   • Intention of ISO 9001 initiative ✓

2) Assess the existing quality management system ✓
   • No existing quality management system ✓

7. Generic project plan (2)

3) Design the quality management system ✗
   • Determine responsibilities, quality policy and objectives ✗
   • Determine scope of implementation ✗
   • Documentation in a quality manual ✗
   • Document control system for administration ✗

4) Create procedure documents ✗
   • Procedure documentation template and example ✓
   • Proposal for necessary procedure documents ✓
   • Create procedure documents ✓

7. Generic project plan (3)

5) Implement and deploy the quality management system (QMS) ✗

6) Conduct internal audits (Milestone for May) ✗

7) Conduct a pre-assessment
8) Create a history of using the QMS
9) Hold the registration audit
10) Monitor and improve the QMS
8. Initial tasks (1)

- Management's commitment to quality
- Train staff in ISO 9000
- Clarify responsibilities
  - ISO 9001 conformity manager
  - Steering team
  - My role (consulting?)

8. Initial tasks (2)

- Determine scope of implementation
  - Which parts of the Computer Science Department?
  - What are our customers (students, companies, other research institutes, colleagues)?
- Design the quality management system
  - Draft of the quality manual
  - Design Document Control System

Document Control System

- Shared web space with e-mail notification?
- Platform independent system?
- Metamodel for process documentation (Ha.)
- Which procedures shall be documented?
  - Proposals mapped to requirements (Handout)
  - Procedure documentation template (Handout)
  - Staff training as example procedure (Handout)
  - Procedures conforming to quality policy/objectives!
9. Discussion

- Discuss intention of ISO 9000 initiation?
- How shall the staff be trained?
- How are responsibilities delegated?
- Scope of the quality system (Which customers)?
- Implementation of a Document Control System
- Who creates quality policy and manual?
- Responsibility for procedure documents?
- Flowcharting with MS Word
- Further planning (Next meeting – Jour Fixe?)

References (1)

- FAQs at Simplyquality.org [http://www.simplyquality.org]
- Seeing the elephant one bite at a time – Effective implementation of ISO 9001/Ticket [http://www.simplyquality.org/case01.html]

References (2)

- Example quality manual (Network Systems) [http://www.quality.co.uk/example/manual.htm]
QUALITY POLICY:

Our overall goal is to develop high-quality software components and products in a cost-effective way (time, resources), thereby fulfilling the requirements of external and internal customers (students and researchers) thus supporting reliable, repeatable and high quality education and research results.
## REVISION HISTORY

<table>
<thead>
<tr>
<th>Rev #</th>
<th>Description of Change</th>
<th>Author</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Created incomplete draft version</td>
<td>Florian Stahl</td>
<td>2006-02-13</td>
</tr>
<tr>
<td>0.2</td>
<td>Improved draft after meeting with Rüdiger Lincke</td>
<td>Florian Stahl</td>
<td>2006-03-04</td>
</tr>
<tr>
<td>0.3</td>
<td>Reviewed: introduction, Policy and Objectives; minor text corrections</td>
<td>Rüdiger Lincke</td>
<td>2006-03-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2006-03-17</td>
</tr>
<tr>
<td>0.4</td>
<td>Summarized chapter 10-14 to chapter 10, removed chapter 15, Purchasing</td>
<td>Rüdiger Lincke</td>
<td>2006-03-20</td>
</tr>
<tr>
<td>0.5</td>
<td>Reviewed, minor changes and comments</td>
<td>Welf Löwe</td>
<td>2006-03-22</td>
</tr>
<tr>
<td>0.6</td>
<td>Reviewed, if all ISO 9001 requirements contained</td>
<td>Florian Stahl</td>
<td>2006-03-23</td>
</tr>
<tr>
<td>0.7</td>
<td>Reviewed, changed quality policy, added purchasing, minor changes, formatting</td>
<td>Florian Stahl, Rüdiger Lincke</td>
<td>2006-03-24</td>
</tr>
<tr>
<td>1.0</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-03-28</td>
</tr>
<tr>
<td>1.1</td>
<td>Added customer licensing and relations under 11</td>
<td>Florian Stahl</td>
<td>2006-04-04</td>
</tr>
<tr>
<td>1.2</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-04-12</td>
</tr>
<tr>
<td>1.3</td>
<td>Reviewed, if the interaction of the procedures is described; some consequent changes; added internal quality audit, added first page</td>
<td>Florian Stahl</td>
<td>2006-04-17</td>
</tr>
<tr>
<td>1.4</td>
<td>Reviewed, minor changes in layout, approved</td>
<td>Rüdiger Lincke</td>
<td>2006-04-19</td>
</tr>
<tr>
<td>1.5</td>
<td>Reviewed generality, use of term VizzAnalyzer</td>
<td>Florian Stahl</td>
<td>2006-04-19</td>
</tr>
<tr>
<td>1.5</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-04-25</td>
</tr>
<tr>
<td>1.6</td>
<td>Updated internal audit (auditor description)</td>
<td>Florian Stahl</td>
<td>2006-05-04</td>
</tr>
<tr>
<td>1.6</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-05-09</td>
</tr>
</tbody>
</table>
## CONTENT

<table>
<thead>
<tr>
<th>Section title</th>
<th>Related procedure document(s) ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction</td>
<td></td>
</tr>
<tr>
<td>2. Policy and Objectives</td>
<td></td>
</tr>
<tr>
<td>3. Definitions</td>
<td></td>
</tr>
<tr>
<td>4. Quality management system</td>
<td></td>
</tr>
<tr>
<td>5. ISO 9001 compliance</td>
<td></td>
</tr>
<tr>
<td>6. Organization</td>
<td></td>
</tr>
<tr>
<td>7. Authority and responsibilities</td>
<td></td>
</tr>
<tr>
<td>8. Management review and internal audit</td>
<td>Management review</td>
</tr>
<tr>
<td></td>
<td>Internal quality audit (M)</td>
</tr>
<tr>
<td>9. Document control system</td>
<td>Document control system (M)</td>
</tr>
<tr>
<td>10. Software Engineering Process</td>
<td>Design and development planning</td>
</tr>
<tr>
<td></td>
<td>Project management</td>
</tr>
<tr>
<td></td>
<td>Customer requirements review</td>
</tr>
<tr>
<td></td>
<td>Design control</td>
</tr>
<tr>
<td></td>
<td>Development guidance</td>
</tr>
<tr>
<td></td>
<td>Inspection and testing</td>
</tr>
<tr>
<td></td>
<td>Configuration &amp; change management</td>
</tr>
<tr>
<td></td>
<td>Product preservation</td>
</tr>
<tr>
<td>11. Customer relations</td>
<td>Customer property and licensing</td>
</tr>
<tr>
<td>12. Purchasing</td>
<td>Purchasing</td>
</tr>
<tr>
<td>13. Production and measurement equipment</td>
<td></td>
</tr>
<tr>
<td>14. Non-conforming products, preventive and</td>
<td>Non-conforming products (M)</td>
</tr>
<tr>
<td>corrective action</td>
<td>Preventive and corrective action (M)</td>
</tr>
<tr>
<td>15. Records</td>
<td>Records control system (M)</td>
</tr>
<tr>
<td>16. Training and competence</td>
<td>Training and competence</td>
</tr>
</tbody>
</table>

### 1. INTRODUCTION

The Software Technology Group (STG) is part of the Computer Science Department of the Växjö University. Its tasks include the education of students and research in different areas and projects. To support these activities software is developed being used internally and externally by researchers and students. An ISO 9001 compliant quality management system shall be implemented covering all activities related to software development within the STG.

To reduce the complexity of introducing a new, non-trivial process into an existing environment the central focus of the process introduction are software development, management and administration processes. Once this is successfully introduced, it may extend to other areas.

¹ The procedure documents are current proposals and not completely available yet. Mandatory procedure documents are marked with an M.
2. POLICY AND OBJECTIVES

QUALITY POLICY:
Our overall goal is to develop high-quality software components and products in a cost-effective way (time, resources), thereby fulfilling the requirements of external and internal customers (students and researchers) thus supporting reliable, repeatable and high quality education and research results.

QUALITY OBJECTIVES:
Our quality objectives in particular are:

- minimum number of non-conforming software components and products
- maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer
- continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students
- active risk reduction by increasing process maturity and documentation
- knowledge preservation in form of work instructions and procedure documents to deal with changing staff
- compliance to legal contracts when using 3rd party components
- save time through central information storage

3. DEFINITIONS

The terms and descriptions used in this manual are generally defined within ISO 9000 Quality Management Systems – Fundamentals and vocabulary. Important ones can also be found in the Glossary document.

Roles for individuals involved in and concerned by the quality management system are defined as following:

- **Customer**: An individual or group of individuals using software or parts of it (product). They receive it as service from the STG and use it for their purpose, having the expectation that the product is fit for their purpose. The customer can on the one hand be external to the STG like project partners, companies, students or other researchers, but on the other hand also internal to the STG, being colleague. The customer is not necessarily a paying customer as in the terms of ISO 9000.

- **Manager**: Head of the STG supporting the quality management system, standing behind the Quality Manager giving him authority towards the other members in the STG.

- **Quality Manager**: Management representative with the defined authority and responsibility to carry out the requirements of ISO 9001.

- **Developer**: Software developer working on software engineering activities and providing products. He has to improve the product according to the feedback.

- **Marketing Director**: The marketing director establishes contacts to external customers and mainly represents the organization (STG) in front of them.

- **Support Personal**: Support Personal assists the Marketing Director to fulfill the needs of external Customers like implementation and support and maintenance
tasks. Further he receives feedback from the customers related to the fitness for purpose feeding it into the Quality Management System for improvement of the products.

4. QUALITY MANAGEMENT SYSTEM

The quality management system applies to all software developing activities in the STG and has been developed in accordance with ISO 9001. The quality management system is structured in three levels:

Level 1: Quality Manual
This document details the corporate quality policy and objectives and structure of the STG and references appropriate procedure documents. It is rather abstract to allow for generic use with different products. It therefore uses terms like software and product, which have to be substituted in the particular case.

Level 2: Procedure documents
These documents describe in a more detailed, customized and specific way the actual process, and controls applied. They focus on all activities concerned with the attainment of quality assured services and products and how they interact to comply with the quality policy and objectives. Work instructions are referenced within these documents.

Level 3: Work instructions
These documents describe detailed work instructions for a certain activity and are tailored to a specific product or service. They are owned and managed by a level 2 process.

Quality Planning
Customer satisfaction and quality are achieved by operation in accordance with the documented quality management system. Specific customer requirements are identified and documented during the commitment or contract review process, allowing these requirements to be communicated and achieved, ensuring satisfaction of all customers declared needs.

5. ISO 9001 COMPLIANCE

This quality management system is structured to fulfill the requirements of the ISO 9001:2000.

The following items of ISO 9001 are not addressed within the operating procedures, as they are not applicable to this company:

- Validation of processes for production and service provision (requirement 7.5.2)
  Rationale: No special processes that could not be verified are applied in the STG
6. ORGANIZATION

The following diagram shows the organization in roles of the STG.

![Organization Diagram]

A mapping of the roles to persons is documented on the ISO 9000 LibreSource platform. Gaining access to this platform is documented in the chapter “Document Control System” of this quality manual.

7. AUTHORITY AND RESPONSIBILITIES

Authorities and responsibilities are defined to make all employees understand and fulfill their tasks for establishing and continually improving the quality management system.

7.1. Authority

- All staff is allocated with authority to perform their allocated responsibilities. The following provides a summary of the principal responsibilities of each role, and these are clarified in greater detail within the Procedure Documents and Work Instructions.

- All staff shares the authority and responsibility of identifying non-compliances or possible improvements, and recording these instances such that corrective action can be taken, both to rectify the immediate situation and to prevent recurrence.

- The Manager continually reviews the company's resources to ensure that adequate staff, equipment and materials are available to meet customer requirements.

7.2. Responsibilities

All members of staff have to perform their allocated responsibilities. The mentioned responsibilities also give references to other chapters of this quality manual relevant to the specific role.

Responsibilities are defined as following:

- The Manager role has the responsibility to:
  - assign roles and responsibilities to individuals
  - define responsibilities for roles
o define quality policy and objectives
o approve the quality management system and changes to it
o perform a management review
o provide resources and training
o assure the internal communication of quality policy and objectives
o decide which products are managed by the quality management system
o demand and authorize individuals to follow and fulfill their roles and the involved responsibilities
o review, order, assign or provide resources required by the staff for complying with the demands of the quality management system and answering customer needs and requirements
o control that the roles and responsibilities are understood, accepted and performed by the individual staff members

• The Quality Manager role has the responsibility to:
o perform internal audits
o control and maintain the quality management system
o perform documentation and change control (Quality system documents)
o review and approve new and changed documents (drafts)
o make final documents available in the quality management system
o resolve quality management system discrepancies

• The Marketing Director role has the responsibility to:
o monitor external Customer satisfaction
o perform project management
o control of contract documentation
o review contracts

• The Developer role has the responsibility to:
o review Customer requirements
o control the Design
o develop the Product
o inspect and test the product
o perform configuration and change management
o participate in project management
o purchasing required resources

• The Support role has the responsibility to:
o review Customer requirements
o assist in external Customer satisfaction

8. MANAGEMENT REVIEW AND INTERNAL AUDIT

8.1. Management review

A management review of the Quality Management System takes place every 3 months to check the suitability, adequacy and effectiveness of the Quality Management System and to find opportunities to improve it.

The management review meeting includes at least the Manager and the Quality manager and covers the following input areas:
• Quality policy and objectives
• Internal audit results
• Non-conforming products
• Status of corrective and preventive actions
• Inspection and testing
• Customer feedback
• Identified quality and efficiency problems
• Recommendations for improvements
• Status of previously implemented improvements

The review results in decisions to improve the quality management system and the product and possibly in the need for additional resources.

8.2. Internal quality audit

The internal quality audit at the STG is a documented process to determine if the activities at the STG are carried out as specified in the procedure documents and if the quality management system conforms to the requirements of the ISO 9001. It evaluates the efficiency of processes and detects opportunities for improvement considering results of previous audits.

It is carried out by an independent auditor or group of auditors (or possibly by the quality manager of the STG because of restricted resources) at least once a year. The quality manager determines the auditor and may increase the frequency of audits if appropriate.

The audit is planned defining its criteria, the scope and methods. It includes a review of documents and systems connected to the ISO 9001 and records are inspected. Scheduled individual interviews based on a questionnaire take place with all members of the STG to ensure a systematic approach.

Written findings that document problems including a description of the problem and where it was found are communicated to the person responsible for solving it and are also reported to the manager. The findings are recorded in the audit report. Corrective and preventive actions are subsequently taken.

9. DOCUMENT CONTROL SYSTEM

A document control system is provided supporting the creation, change, version management and provision of the quality management system related documents. The documents provided are up-to-date, clearly written and understandable for everyone. They are reviewed and approved before their publication and changes and revision levels are identified.

The system is realized on the LibreSource platform as collection of Wiki pages and file upload areas (http://cs.msi.vxu.se:9001/projects/administration). An account to this platform can be received from the Quality manager (Rüdiger Lincke, rudiger.lincke@msi.vxu.se). The use of the system is explained in the "ISO 9000" Wiki.

10. SOFTWARE ENGINEERING PROCESS

The STG shall use the UPEDU (Unified Process for Education, http://www.upedu.org/upedu/) as its software engineering process providing a disciplined approach to assigning tasks and responsibilities within the STG. The goals are to ensure the production of high-quality software, meeting the needs of the end users within a predictable schedule and budget.

UPEDU is a use-case centric, iterative, and incremental software development process defining disciplines, role set and artifact set. It is supported by a rich set of defined concepts, guidelines, case studies and templates thereby easing the improvement of product quality in the software engineering process. This process shall be adapted for the use in the development of products being concerned by the quality management process.
The UPEDU defines six disciplines in the software engineering process having all impact on the quality of the developed products. They are all supported by defined concepts, workflows, activities, artifacts and guidelines.

The *Project Management* discipline provides a framework for planning, managing and controlling a project and dealing with risks. A project plan includes the software development plan, risk list, quality assurance plan and measurement plan. Review activities are part of the process. It has impact on all other disciplines defined in the process providing the framework whereby a project is created and managed.

The *Requirements* discipline establishes and maintains an agreement with the customers on what the system should do. Further it provides the system developers with a better understanding of the requirements and it defines the boundaries of the product. Requirements review is integral part of the requirements workflow of the requirements discipline. Reviews of the requirements are performed in a review session to make sure that the customer and the developer understands them and the STG is able to meet them. The reviewed requirements are:

- Clear
- Verifiable
- Design independent
- Correct
- Traceable
- Complete
- Consistent
- Feasible

The customer is involved in the requirements elicitation and reviews. Functional requirements are described as actors, use-cases, use-case models in the software requirements specification and non-functional are documented in the supplementary requirements specification together with constrains. This discipline provides input to the analysis and design and test discipline.

The *Analysis & Design* discipline deals with the transformation of the requirements into a design of the system-to-be. It receives input from the requirements discipline in form of software and supplementary requirements specifications. The design is controlled by frequent reviews of the architecture & design assuring the adherence to the design, satisfaction of requirements, and identification of reuse opportunities. The design output is verified to make sure that it meets the input requirements. The analysis & design discipline provides input to the implementation and test discipline.

The *Implementation* discipline deals with the definition of the organization of the code, the implementation of the classes and components, unit tests, and the integration and build of an executable system. It is strongly influenced by development guidelines containing code and documentation conventions being used to reduce complexity and to simplify product understanding for internal customers and to ease maintenance. This discipline provides input to the test discipline.

The *Test* discipline deals with finding and documenting defects in software quality, generally advising about perceived software quality, providing validity of the assumptions made in design and requirements specifications through concrete demonstration, validation of product functions as designed, and validation that the requirements have been implemented appropriately. Unit testing is part of the implementation discipline. Testing is supported by scripted test cases. If a bug is encountered, it needs to be scripted to test if it has been repaired, and to assure, that it is not reintroduced. A test script library needs to be maintained. The final product is tested by integration tests and acceptance test in
accordance with the customer and the internal software quality is assessed using a suitable quality model such as ISO/IEC 9126. All tests are recorded in protocols. Software quality is additionally measured and recorded by VizzAnalyzer reports. The product is verified to meet the product requirements and the customer validates its intended use. Non-conformities are reported and corrective action is taken in this case.

The Configuration & Change Management discipline helps to deal with simultaneous updates, limited notifications and multiple versions in a common project. The main purposes are to maintain integrity, completeness and correctness of the product, a stable development environment, restriction on changes to artifacts according to policies, and an audit trail.

Product preservation is of central concern; it includes the configuration and change management, but additionally defines frequent backups of the product and development artifacts, and security methods like use of firewall and antivirus.

11. CUSTOMER RELATIONS

11.1. Customer property

Customer property like intellectual property contained in software and systems that is given to the STG for quality analyzing or some other reason is handled confidentially yet respecting the public principle of the Växjö University. It is assured to external customers that his property is not given to third parties or anybody that is not involved in the analyzing process.

Applied methods to support confidentiality:
• Storage only on the hard disk where the analysis is processed
• Encryption of confidential customer software and files
• No access to computers with confidential data for unauthorized personnel
• Deletion of confidential data after completion of analysis

Further it needs to be ensured, that no third party products or parts of them are contained in the product against their license regulations.

11.2. Customer licensing

Customers demanding licenses for the use of software developed by the STG receive the license fast and reliable. The issued licenses are recorded and controlled to ensure traceability.

12. PURCHASING

Individual evaluations ensure that everything that is purchased or used for the inclusion in the product or in any phase of the product realization that influences the quality of the product conforms to the requirements.

(The description above does not fulfill the purchasing requirements (like managing suppliers or inspection of materials and services) completely, but seems sufficient for the initial stage of quality improvement.)
13. PRODUCTION AND MEASURING EQUIPMENT

The entire infrastructure for developing software is provided so that the development process can be carried out in an appropriate way to reach the quality objectives.

It is recommended that all developers in a project have the same development environment, and that central resources are for the development and communication are available.

Measuring and monitoring equipment as the VizzAnalyzer, a bug-tracker or a configuration management system is managed in a way so that the availability and correctness of the tool is assured and the current version is available at all locations where its use is necessary.

14. NON-CONFORMING PRODUCTS, PREVENTIVE AND CORRECTIVE ACTION

Once non-conforming items have been noticed they are identified by location, associated documents, or specific markings to prevent their inadvertent use. All non-conforming items and customer complaints or complaints by colleagues are subject to review and correction by nominated personnel. The type and extent of non-conformity is documented in a bug-tracker or in a customer complaints document in order to establish trends and identify possible areas for improvement.

Corrective action is the consequence of non-conforming products or processes, audit findings or customer complaints. It is required to prevent recurrence and is evaluated, documented, and its effective implementation is monitored. All corrective actions are subsequently re-inspected to ensure complete customer satisfaction. Preventive action is similar, but is taken when potential non-conformities are detected to prevent their occurrence.

All employees are encouraged to suggest improvements in methods and materials.

15. RECORDS

Records are taken to monitor and measure the conformance to the requirements and the effective operation of the quality management system. Records are organized by a records control system. They are identified in the LibreSource platform and are retrieved either as a document stored in LibreSource or via a reference to the path or location where they can be found. Records are always retrievable, they are protected from unauthorized access and they have a defined retention time.

16. TRAINING AND COMPETENCE

Skill and knowledge of the staff is identified and documented on LibreSource or the public homepage of each staff member. Information should inform about education, training, special skills, projects, publications, teaching areas and contact data. This information allows all members of the STG in case of knowledge lack to find fast a colleague with the appropriate knowledge for knowledge and experience exchange. The knowledge stored in the work instructions supports knowledge preservation and members of the STG can read up on tasks.

If knowledge cannot be acquired from colleagues, self-training is done by studying literature. Not available literature is ordered if appropriate.
D – Templates

D.1 Procedure documentation template

ISO 9001 – Computer Science Department Växjö University

Rüdiger Lincke (Quality manager)

<Document Title (Procedure name)>  Rev. <Number>

<table>
<thead>
<tr>
<th>Rev #</th>
<th>Description of Change</th>
<th>Author</th>
<th>Effective Date</th>
</tr>
</thead>
</table>

<IMPORTANT NOTE>

<All parts of this document that are written in cursive gray letters are for explanation reasons or signaling that a part is optional. In the second case the item is not mandatory if the procedure can be documented understandable and completely without the corresponding section. All notes of this kind have to be deleted before publication.>

1. PURPOSE

<List of the key value added reasons for executing this procedure>

2. SCOPE

<Describe situations in which this procedure is applied and executed>

3. DEFINITIONS AND ACRONYMS

<Optional>

4. FLOWCHART

<Optional>

<In case of complex work flows it often makes sense to illustrate this by a flow chart diagram. This should be done if an only written procedure description would be hard to understand>

5. RESPONSIBILITIES

<Description of involved roles in this procedure and the responsibility of these roles>
6. PROCEDURE DESCRIPTION

<If flowchart available: Describe procedure either based on the flowchart and explain each task and corresponding responsibilities shown in the flowchart>

<If no flowchart available: Give a detailed description of the procedure that makes it easy for others to completely reconstruct the procedure>

7. REFERENCES

7.1. Records

<Partially optional, see required records, ISO 9001>

<How can the quality objective of this procedure be measured and proven>

The following Quality Records shall be generated and managed in accordance with this document:

<table>
<thead>
<tr>
<th>Required record</th>
<th>Custodian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.2. Work instructions

<Work instructions are optional and describe the exact way how this procedure is carried out>

The following documents contain work instructions connected to this procedure:

<table>
<thead>
<tr>
<th>Work instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
1. PURPOSE

<List of the key value added reasons for executing this work instruction>

2. SCOPE

<Describe situations in which this work instruction is applied and executed>

3. DEFINITIONS AND ACRONYMS

<Optional>

4. PRECONDITIONS

<Optional>

<Describe conditions or other work instructions that have to be fulfilled or completed before this work instruction can begin>

5. FLOWCHART
In case of complex work flows it often makes sense to illustrate this by a flow chart diagram. This should be done if an only written work instruction description would be hard to understand.

6. RESPONSIBILITIES

<Description of involved roles in this work instruction and the responsibility of these roles>

7. WORK INSTRUCTION DESCRIPTION

<If flowchart available: Describe work instruction based on the flowchart and explain each task and corresponding responsibilities shown in the flowchart>

<If no flowchart available: Give a detailed description of the work instruction that makes it easy for others to completely reconstruct the work instruction>

8. POSTCONDITIONS

<Optional>

<List possibly measurable conditions or deliverables (documents, updated data, etc.) that have to be fulfilled when the work instruction is successfully finished>

9. QUALITY RECORDS

<Optional>

<How can the quality objective of this work instruction be measured and proven>

The following Quality Records shall be generated and managed in accordance with this document:

<table>
<thead>
<tr>
<th>Required record</th>
<th>Custodian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
E – Example documentation

E.1  Document Control System procedure

ISO 9001 – Computer Science Department Växjö University

Rüdiger Lincke (Quality manager)

Document Control System

---

<table>
<thead>
<tr>
<th>Rev #</th>
<th>Description of Change</th>
<th>Author</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Creation</td>
<td>Florian Stahl</td>
<td>2006-03-09</td>
</tr>
<tr>
<td>0.2</td>
<td>Included students in Personnel, minor language corrections, modified workflow in 4.2 (no goes to end, not start),</td>
<td>Rüdiger Lincke</td>
<td>2006-03-10</td>
</tr>
<tr>
<td>0.3</td>
<td>Added issues to scope and definitions, added flowchart 4.1, changed 6.1</td>
<td>Florian Stahl</td>
<td>2006-03-13</td>
</tr>
<tr>
<td>0.4</td>
<td>Shifted definitions to Glossary</td>
<td>Florian Stahl</td>
<td>2006-03-13</td>
</tr>
<tr>
<td>0.5</td>
<td>Changes to workflow chart and procedure description, not finished</td>
<td>Rüdiger Lincke</td>
<td>2006-03-15</td>
</tr>
<tr>
<td>0.6</td>
<td>Final reviews, pre-approval, reformatting is needed</td>
<td>Rüdiger Lincke</td>
<td>2006-03-24</td>
</tr>
<tr>
<td>0.7</td>
<td>Reformatted</td>
<td>Florian Stahl</td>
<td>2006-03-27</td>
</tr>
<tr>
<td>1.0</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-03-28</td>
</tr>
<tr>
<td>1.1</td>
<td>Detected inconsistency in flowchart 4.1</td>
<td>Florian Stahl</td>
<td>2006-04-27</td>
</tr>
<tr>
<td>1.1</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-05-09</td>
</tr>
</tbody>
</table>

---

1. PURPOSE

This procedure describes the implementation of a document control system. It defines the methods for preparing, reviewing, approving, maintaining and changing documents identified for use within the quality management system of the Software Technology Group.

2. SCOPE

This procedure covers all necessary actions and processes that are necessary to identify, create, review, publish and maintain documents within the quality management system. It defines responsibilities and tasks for making relevant documents available at all work locations in a proper way.

Documentation shall be used when procedures or work instructions are not trivial or influence the product quality in a significant way and thus shall be carried out in an exactly defined way.

The handling of records is covered in a separate procedure.
3. DEFINITIONS AND ACRONYMS

See Glossary.

4. FLOWCHART

4.1. Use of the document control system

Start

Tap is trivial, doesn't influence product quality significantly or is well remembered

- no
  - no
    - Perform task
  - yes
    - Suitable document available in LibreSource?

- yes
  - yes
    - Perform task according to documentation

End
4.2. Document creation or change

Start

Need for creation or change of document identified, report to Quality Manager

Review of need by quality manager (Creation or change appropriate?)

Determination of author for creation or change

Not ok, modification needed

Documentation template (LibreSource)

Author creates or changes document content

Review and approval of document by quality manager

Publication of document (Document Control System (LibreSource))

End
4.3. Administration

No flowchart available.

5. RESPONSIBILITIES

Personnel
- Check document availability and validity

Author
- Create or change document content

Quality manager
- Review of the need of the creation or change of a document
- Determination of an appropriate author for the document
- Review and approve the document
- Publication of the document
- Administration of documents

6. PROCEDURE DESCRIPTION

6.1. Use of the document control system

When performing a task which is trivial, does not influence the product quality in a significant way or is well remembered, do not consult the document control system.

If the task is not trivial, the exact procedure is not well known, it has significant impact on the product quality consult the document control system.

If a suitable document describing the task can be found, perform the task according to it. While you are doing this check, if the work instruction is still up-to-date, or if requires change. If it requires change, submit a change request.

If no suitable document can be found, create a new one, while performing the task. Submit a document creation request.

6.2. Document creation or change

1. Personnel identifies the need of the creation or change of a document and reports it to the quality manager.
2. The quality manager evaluates the creation or change request and accepts it or not after consultation with the reporter.
3. If the creation or change request is accepted the quality manager shall determine a suitable author for the document which has to create or change the content of the document.
4. The author creates or changes the document as far as possible by applying a document template and sends it to the quality manager.
5. The quality manager reviews and approves the document.
6. If the document is approved it is published in the document repository of the ISO 9001 LibreSource platform by the quality manager.
6.3. Administration

The Quality manager assures regularly that:
1. All documents corresponding to the quality management system are available in the LibreSource Document repository
2. Obsolete or unnecessary documents are removed from the LibreSource platform
3. Documents are easily identifiable in the LibreSource platform

7. REFERENCES

7.1. Records

Quality records are not required for this document.

7.2. Work instructions

The following documents contain work instructions connected to this procedure:

<table>
<thead>
<tr>
<th>Work instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document creation or change</td>
</tr>
</tbody>
</table>
E.2 Document Creation and Change work instruction

ISO 9001 – Computer Science Department Växjö University
Rüdiger Lincke (Quality manager)

| Document creation or change | 1.1 |

**REVISION HISTORY**

<table>
<thead>
<tr>
<th>Rev #</th>
<th>Description of Change</th>
<th>Author</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Creation</td>
<td>Florian Stahl</td>
<td>2006-03-10</td>
</tr>
<tr>
<td>1.0</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-03-10</td>
</tr>
<tr>
<td>1.1</td>
<td>Updated creation and change request in 7.</td>
<td>Florian Stahl</td>
<td>2006-04-20</td>
</tr>
<tr>
<td>1.1</td>
<td>Approved</td>
<td>Rüdiger Lincke</td>
<td>2006-04-25</td>
</tr>
</tbody>
</table>

1. **PURPOSE**

This work instruction defines how procedure and work instruction documents shall be created and changed.

2. **SCOPE**

This work instruction is relevant to all actions performed in the scope of the quality management system.

3. **DEFINITIONS AND ACRONYMS**

Refer to glossary document.

4. **PRECONDITIONS**

A non-trivial task or process influencing the quality of products has been identified. It is not documented at all, or the documentation is outdated. Appropriate documentation in form of a procedure document or work instruction needs to be created or updated in the necessary detail.

5. **FLOWCHART**

No flowchart available.
6. RESPONSIBILITIES

Personnel
- Identification of lacking or outdated procedure or work instruction documents.

Author
- Creation or change of document
- Consultation with quality manager

Quality manager
- Review of need of document creation or change
- Determination of author
- Review and approval of document
- Publication of document

7. WORK INSTRUCTION DESCRIPTION

1. A lacking or outdated procedure or work instruction document is identified
   a. Add new “Creation and change request (issue)” in LibreSource if no issue for
      the document exists, otherwise re-open the old issue corresponding to the
      document
   b. Describe need of creation or change (summary in the format
      “<prefix>:<name>” whereas the prefix describes the type of document (e.g.
      PD or WI); more details in body).
   c. If necessary: discuss obscurities with quality manager

2. Review of need by quality manager
   a. Evaluate relevance of creation or change considering the quality objectives
   b. If necessary: consultation with reporter by e-mail or personally
   c. Approve creation or change or disapprove it

3. Determine author
   a. Identify possible authors maybe by consultation with the reporter or other
      qualified personnel
   b. Determine author
   c. Add creation or change request in LibreSource and assign the responsible
      author to the request

4. Creation or change of document by author
   4.1 Creation of procedure or work instruction document
      a. Download corresponding template from Document repository →
         Templates
      b. Enter declarative document title in the document header (which is also
         the procedure or work instruction name)
      c. Enter revision number in header and in the review history (0.1 for
         initial creation)
      d. Enter description of change (here: creation), the author’s name and
         the current date in the revision history
      e. Fill in all mandatory sections of the document
      f. Fill in the optional sections of the document if necessary. If not, write a
         short note like “None” or “Not necessary or available” in the
         corresponding section.
      g. Enter related records in the reference sections. (This is mandatory if
         records are required for this procedure or work instruction
         corresponding to ISO 9001.)
h. Only for procedure documents: Enter related work instructions in the
   references sections.

i. Remove all annotations of the template (written in cursive grey letters)

j. Save document as (PD) <ProcedureName>, rX.X.doc or (WI)
   <WorkInstructionName>, rX.X.doc (e.g. if the procedure name is
   “Document control system” in the revision 1.0, the corresponding file’s
   name is (PD) Document Control System, r1.0.doc)

k. Upload the file together with the request for approval

4.2 Change of procedure or work instruction document
   a. Download existing document from Document repository
   b. Update revision number in header (e.g. 1.1 instead of 1.0)
   c. Enter new revision number, description of change, the author’s name
      and the and the current date in the revision history
   d. Perform changes in the document updating description of change in
      change history
   e. Upload the new document in LibreSource together with the request for
      approval

5. Review and approval of document by quality manager
   a. Review of the document in form and content
      i. Check fulfillment of the instructions of 4.
      ii. Check content for correctness
   b. If necessary: Contact author for consultation and make improvements
   c. Approve document by new entry in the revision history
      i. Revision number 1.0 after initial creation (e.g. 1.2 or 2.0 after update)
      ii. Description of change: Document approved
      iii. Author: Name of quality manager

6. Publish document
   a. Upload document to the Procedure or Work instruction section of the
      Document repository in the LibreSource platform
   b. For document changes only: The old version of the document is moved from
      the active Document repository to the archive.

8. POSTCONDITIONS

An appropriate procedure or work instruction document has been created or updated and is
available in the Document repository of the LibreSource platform.

9. QUALITY RECORDS

There are no quality records required for this document.
F – Libresource platform
Source: http://cs.msi.vxu.se:9001/projects/administration

F.1 Welcome page
Captured: 2006-05-18

Quality management with ISO 9000
This platform contains relevant information and documentation about the ISO 9000 project at the Software Technology Group (STG).

Overview
The quality policy of the STG
The overall goal is to develop high-quality software components and products in a cost-effective way (time, resources), thereby fulfilling the requirements of internal and external customers (students and researchers) thus supporting reliable, repeatable and high quality education and research results.

Sections of this platform
- Discussion forum to clarify questions
- ISO 9000 wiki with an introduction
- Document repository for storing relevant documents
- Responsibilities section to detail roles and responsibilities
- Creation and change requests for the organization of documentation tasks

Human resources
- Jonas Lundberg
- Roger Lindh
- Fred Love

Other resources
- Libresource online collaboration platform

News
May, 17 2006 - Audit report published: The report stating the internal quality audit results is published in the Records section.
March, 30 2006 - Responsibilities section created: Tasks and roles are detailed in the responsibilities section.
March, 27 2006 - Records reference list created: Creation of the Records reference list forum to specify the location of not downloadable records.
March, 17 2006 - Mail service advanced: From now on Fibumuse will send emails to users.
F.2  ISO 9000 Wiki

Content of the ISO 9000 Wiki (accessed 2006-05-09):

ISO 9001 within the Software Technology Group

A project based on the Master Thesis of Florian Stahl to improve quality in software development. This Wiki describes briefly the ISO 9001 and gives some links to enable everyone to achieve knowledge about the standard. Furthermore the structure of the Quality Management System (QMS) and the aim of the document repository are explained here. In the last part some guidelines for the application of this platform are given considering different user types.

ISO 9001 briefly

Requirements overview:

- Quality management system
- Management responsibility
- Resource management
- Product realization
- Measurement, analysis and improvement

A more detailed overview can be found at [http://www.simplyquality.org/whatr2000.htm](http://www.simplyquality.org/whatr2000.htm)

Additional helpful literature for understanding the purpose and structure of the ISO 9001 implementation at the STG can be received from Rüdiger Lincke or Florian Stahl. Also feel free to post in the discussion forum.

Quality management system

The documents describing the quality management system are stored in the Document repository. Document creation and change is described by the procedure Document Control System. The QMS documentation is structured in three levels:

Level 1: Quality manual

Gives an overview of the quality management system and describes the quality policy and objectives and the structure of the STG and references appropriate procedure documents. It is rather abstract to allow for generic use with different products. The Quality manual can be downloaded in the Document repository.

Level 2: Procedure documents

These documents describe in a more detailed, customized and specific way the actual process, and controls applied. They focus on all activities concerned with the attainment of quality assured services and products and how they interact to comply with the quality policy and objectives.

Work instructions are referenced within procedure documents and also Records that confirm meeting the objectives and requirements. 19 records are mandatory to conform to the standard. They are described in the MandatoryRecords.doc in the document repository.

Level 3: Work instructions
These documents describe detailed work instructions for a certain activity and are tailored to a specific product or service. They are owned and managed by a level 2 process. Their application is voluntarily and makes sense to make specific processes more efficient and repeatable.

Furthermore Templates are provided for the documentation of procedures and work instructions.

**Application guidelines**

Different user types of this platform have different needs and responsibilities. Therefore in the following a short instruction for using the system is given.

**Members of the Software Technology Group**

Members of the STG shall fulfil the following tasks for a responsible use of the system:

- Acquire general knowledge about the requirements and the aim of the ISO 9001 (requirements part of the ISO 9000) for understanding the purpose of the system
- Read and understand the quality manual, especially the quality policy and objectives
- Fulfil their responsibilities as described in the quality manual and personified in the Responsibilities section of this platform
- Carry out non-trivial tasks of their daily work according to relevant procedure and work instruction documents available in the Document repository
- Identify the need of new or updated procedure and work instruction documents and handle them as described in the Document control system procedure
- Carry out document creation and updates as assigned in the Creation and change requests section
- Identify possible improvements of the whole system and report them to the quality manager

**Students and external workers**

Students and externals that support the software development of the STG do not need a complete understanding of the quality management system including quality policy and objectives. But they have to work conforming to the requirements of the standard that are documented in the document repository. Therefore they can pick single Procedure documents or Work instructions from there and carry out their work according to them.
F.3 Document repository structure

Captured: 2006-05-18

Children List:

- (QM) Quality Manual, r1.6.doc
- Document archive
  - (PD) Document_Control_System_r1.0.doc
  - (QM) Quality Manual, r1.4.doc
  - (QM) Quality Manual, r1.5.doc
  - (QM) Quality_Manual_r1.0.doc
  - (QM) Quality_Manual_r1.2.doc
  - (WI) Document Creation or Change, r1.0.doc
  - (WI) Issue_VizzAnalyzer_Vizz3D_license_r0.1.doc
  - (WI) Issue_VizzAnalyzer_Vizz3D_license_r1.0.doc
- GapAnalysis.doc
- Glossary.doc
- MandatoryRecords.doc
- Procedure documents
  - (PD) Document Control System_r1.1.doc
  - (PD) Internal Quality Audit_r1.0.doc
  - (PD) Records_Control_System_r1.0.doc
- ProcedurePriorityList.doc
- ProjectPlan.doc
- Records
  - AuditReport.doc
  - Records reference list
    - Customer contact and license list
    - Customer contact and license list
- Templates
  - ProcedureDocTemplate.doc
  - WorkInstructionDocTemplate.doc
- Work instructions
  - (WI) Document Creation or Change_r1.1.doc
  - (WI) Issue_VizzAnalyzer_Vizz3D_license_r1.2.doc
G – Internal quality audit

G.1 Internal audit questionnaire

The answers to this questionnaire shall provide information in how far ISO 9001 requirements are already implemented within the STG and how the employee awareness concerning the quality standard is. Possible correct answers are written in grey letters if available.

Date: 

Time: 

Auditor: Florian Stahl 

Interviewee: <Name>, <Role(s)> 

Questions: 1 

1) Why do you think does it make sense to introduce the ISO 9000 standard at the STG? 

2) What is the overall goal of the ISO 9001 compliant QMS at the STG? (5.3) 

QUALITY POLICY: 
Our overall goal is to develop high-quality software components and products in a cost-effective way (time, resources), thereby fulfilling the requirements of external and internal customers (students and researchers) thus supporting reliable, repeatable and high quality education and research results.

3) What are (further) objectives that shall be reached by introducing the ISO 9001? (5.4.1) 

- Minimum number of non-conforming software components and products 
- Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer 
- Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students 
- Active risk reduction by increasing process maturity and documentation 
- Knowledge preservation in form of work instructions and procedure documents to deal with changing staff 
- Compliance to legal contracts when using 3rd party components 
- Save time through central information storage 

4) Who is the Quality manager at the STG? (5.5.2) 

5) What is (are) your role(s) in the STG according to ISO 9000 documentation? 

1 Italic numbers in (parenthesis) show if the question is related to (a) specific ISO 9001 requirement(s) and if yes to which one(s). Bold letters before the question describe the role to which this question is addressed to. If no role is given, the question is addressed to everybody. Roles are abbreviated like following. M: Manager, Q: Quality manager, C: Marketing director (Customer relation), S: Support personal Questions not addressed to the role(s) of the interviewee are skipped by crossing them out.
6) What is your responsibility regarding the implementation of the ISO 9000 at the STG or where can you check it up? (5.5.1, 5.5.3)

   Contained in the quality manual and in the LibreSource Responsibilities section

7) Who is responsible for identifying problems or possible improvements related to the QMS?

   Everybody

8) Describe the structure of the QMS using the terms quality manual, work instructions and procedure documents.

   Tree structure

9) Where can ISO 9001 relevant documentation be found and get from?

   LibreSource → Document repository

10) Did you make yourself familiar with the ISO 9000 LibreSource platform? If yes, how much time did you spend with it? Did you read the ISO 9000 Wiki?

11) Where on the LibreSource platform can you check your current documentation tasks?

   Document creation and change request section

12) What is the first step that is done if you detect the need of a document creation or change? (4.2.3)

   Contact quality manager (Determine author in case of QM)

13) What is a record?

   One possible answer: Document stating results achieved or providing evidence of activities performed.

14) How can you receive available records?

   Via LibreSource → Document repository → Records

15) Who are the customers in regard of the QMS of the STG? (5.2)

   Internal (colleague) or external customer (company, research partner, student)

16) M: Does customer orientation play an important role when implementing the ISO 9000 standard at the STG? (5.2)

   (Yes, undecided, no)

17) M: Do you see the ISO 9000 project as an important step for the success of the VizzAnalyzer software and why? (5.1)

   (Yes, undecided, no)

18) M: What should be regularly reviewed and controlled by the manager? (5.6)

   Resource allocation, Inputs for management review (audit reports, quality policy and objectives, non-conforming products, customer feedback, corrective action, etc)

19) Q: What should be reviewed and controlled by the quality manager? (5.5.2)

   Documentation, establishment and implementation of required processes, efficiency of the QMS
20) Q: How do you ensure that QMS processes are established and that mandatory documents will be created? (5.5.2)

21) M: Do you think the resources at the STG are sufficient to produce high quality software? (6.1)
   (Yes, undecided, no)

22) M, Q: How do you communicate the importance of quality and the introduction of the ISO 9000 to your team? (5.5.3)

23) Which approach / method shall be applied to the software development process of the STG for future improvements? (7.3)

24) Are you discussing and documenting customer requirements with external and internal customers (companies, research partners, students; colleagues)? (7.2.1)
   (Yes, no, sometimes)

25) How will developed software be inspected and tested at the STG? (7.3.4, 7.3.5, 8.2.4)
   See quality manual.

26) Do you use backup or security mechanisms and if yes, which ones? (7.5.5)

27) Do you consequentially use bug-trackers during the VizzAnalyzer development process? (8.5)

28) If yes, for what do you use it? Are only bugs in the program code reported or also missing functionality or insufficient non-functional requirements? (8.5)

29) C, S: How do you regularly communicate with external customers? (7.2.3)

30) C, S: Which action is taken after external customer feedback and complaints? (8.5)

31) M, Q: Are the following objectives reached or methods to reach them established?
   Scale: 0 – not reached, 1 – partially reached or methods implemented, 2 – reached
   
   - Minimum number of non-conforming software components and products
   - Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer
   - Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students
   - Active risk reduction by increasing process maturity and documentation
   - Knowledge preservation in form of work instructions and procedure documents to deal with changing staff
   - Compliance to legal contracts when using 3rd party components
   - Save time through central information storage

32) M, Q: What will be done with the results of this audit (audit report)? (5.6)

33) How do you estimate your current knowledge about the ISO 9000 and how was your knowledge before this project?
   Scale: 0-4, 0: no knowledge, 1: poor ~, 2: basic ~, 3: good ~, 4: excellent ~.
   Before:
   Now:
The answers to this questionnaire shall provide information in how far ISO 9001 requirements are already implemented within the STG and how the employee awareness concerning the quality standard is. Answers are written in cursive letters. Partially they are summarized.

Date: 2006-05-15
Time: 10 a.m.
Auditor: Florian Stahl
Interviewee: Rüdiger Lincke (quality manager, developer, support personal)

Questions: ¹

1) Why do you think does it make sense to introduce the ISO 9000 standard at the STG?
   
   Increase software quality and the awareness for the importance of quality

2) What is the overall goal of the ISO 9001 compliant QMS at the STG? (5.3)
   
   Development of high-quality software components, especially improve the quality of the VizzAnalyzer
   Saving time and reach better research results

3) What are (further) objectives that shall be reached by introducing the ISO 9001? (5.4.1)
   
   • Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer
   • Knowledge preservation in form of work instructions and procedure documents to deal with changing staff
   • Save time through central information storage
   • Distribute and define responsibilities in a better way

4) Who is the Quality manager at the STG? (5.5.2)
   
   Rüdiger Lincke

5) What is (are) your role(s) in the STG according to ISO 9000 documentation?
   
   Quality manager

6) What is your responsibility regarding the implementation of the ISO 9000 at the STG or where can you check it up? (5.5.1, 5.5.3)

¹ Italic numbers in (parenthesis) show if the question is related to (a) specific ISO 9001 requirement(s) and if yes to which one(s).
Bold letters before the question describe the role to which this question is addressed to. If no role is given, the question is addressed to everybody. Roles are abbreviated like following, M: Manager, Q: Quality manager, C: Marketing director (Customer relation), S: Support personal
Questions not addressed to the role(s) of the interviewee are skipped by crossing them out
- Supervise the use of the QMS
- Help and train colleagues
- Enforce the use of the system
- Approve documents
- Detect need for procedure documentation and work instructions

7) Who is responsible for identifying problems or possible improvements related to the QMS?
   Everybody

8) Describe the structure of the QMS using the terms quality manual, work instructions and procedure documents.
   Tree hierarchy (1st level quality manual, 2nd level procedure documents, 3rd level work instructions)

9) Where can ISO 9001 relevant documentation be found and get from?
   Annotation of the auditor: Questions about LibreSource skipped because Rüdiger Lincke assisted the implementation and establishment of the platform and therefore knows it really good

10) Did you make yourself familiar with the ISO 9000 LibreSource platform? If yes, how much time did you spend with it? Did you read the ISO 9000 Wiki?

11) Where on the LibreSource platform can you check your current documentation tasks?

12) What is the first step that is done if you detect the need of a document creation or change? (4.2.3)
   Decide if the task is trivial or not. Look the task up in the procedure document or work instruction

13) What is a record?
   Document that proves that a procedure documentation or work instruction is carried out as described and that the QMS is used.

14) How can you receive available records?
   Work instruction contains reference
   Overview document on LibreSource platform listing all records

15) Who are the customers in regard of the QMS of the STG? (5.2)
   Internal (colleague) or external customer (company, research partner, students)

16) M: Does customer orientation play an important role when implementing the ISO 9000 standard at the STG? (5.2)

17) M: Do you see the ISO 9000 project as an important step for the success of the VizzAnalyzer software and why? (5.1)

18) M: What should be regularly reviewed and controlled by the manager? (5.6)

19) Q: What should be reviewed and controlled by the quality manager? (5.5.2)
   Usage of the QMS, creation of documentation, records, audit reports, product itself if improvements are realized
20) Q: How do you ensure that QMS processes are established and that mandatory documents will be created? (5.5.2)
   
   Train colleagues in the use of the document management system (LibreSource)
   Logging functionality for controlling the use of Libresource.
   Assign documentation tasks to colleagues

21) M: Do you think the resources at the STG are sufficient to produce high-quality software? (6.4)

22) M, Q: How do you communicate the importance of quality and the introduction of the ISO 9000 to your team? (5.5.3)
   
   Personal meetings and presentation about ISO 9000
   General understanding of quality already existing
   Motivate staff to use the system, if necessary ask for support of the manager (pressure)

23) Which approach / method shall be applied to the software development process of the STG for future improvements? (7.3)
   
   UPEDU

24) Are you discussing and documenting customer requirements with external and internal customers (companies, research partners, students; colleagues)? (7.2.1)
   
   Not with external customers yet, but planned by e-mail
   Internally just informal, but here the formal way of bug-trackers and the use of the UPEDU planned.

25) How will developed software be inspected and tested at the STG? (7.3.4, 7.3.5, 8.2.4)
   
   Extensive JUnit tests and scripted testing as part of the test plan and the use of the VizzAnalyzer

26) Do you use backup or security mechanisms and if yes, which ones? (7.5.5)
   
   Personal backups and backups of the home folders,
   But methods and definitions for that are missing

27) Do you consequentially use bug-trackers during the VizzAnalyzer development process? (8.5)
   
   Yes

28) If yes, for what do you use it? Are only bugs in the program code reported or also missing functionality or insufficient non-functional requirements? (8.5)
   
   Bugs, new features, task distribution, but not for non-functional requirements yet

29) C, S: How do you regularly communicate with external customers? (7.2.3)
   
   No regular external customer communication

30) C, S: Which action is taken after external customer feedback and complaints? (8.5)
   
   No feedback or complaints existing. Probably no extensive use of VizzAnalyzer because otherwise feedback or questions could be expected

31) M, Q: Are the following objectives reached or methods to reach them established?
   
   Scale: 0 – not reached, 1 – partially reached or methods implemented, 2 – reached
• Minimum number of non-conforming software components and products: 0
• Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer: 0
• Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students: 0
• Active risk reduction by increasing process maturity and documentation: 1
• Knowledge preservation in form of work instructions and procedure documents to deal with changing staff: 1
• Compliance to legal contracts when using 3rd party components: 0
• Save time through central information storage: 1-2

32) M, Q: What will be done with the results of this audit (audit report)? (5.6)

Presented in front of staff and a plan for improvements will be derived

33) How do you estimate your current knowledge about the ISO 9000 and how was your knowledge before this project?

Scale: 0-4, 0: no knowledge, 1: poor ~, 2: basic ~, 3: good ~, 4: excellent ~.

Before: 1

Now: 2-3
The answers to this questionnaire shall provide information in how far ISO 9001 requirements are already implemented within the STG and how the employee awareness concerning the quality standard is. Answers are written in cursive letters. Partially they are summarized.

Date: 2006-05-15

Time: 11 a.m.

Auditor: Florian Stahl

Interviewee: Welf Löwe (Manager, marketing director, developer)

Questions: ¹

1) Why do you think does it make sense to introduce the ISO 9000 standard at the STG?

   To solve quality problems in software development which are mainly caused by undocumented and not standardized processes.

2) What is the overall goal of the ISO 9001 compliant QMS at the STG? (5.3)

   Increase product quality of VizzAnalyzer by defining processes. Former experiences of tasks carried out shall be preserved.

3) What are (further) objectives that shall be reached by introducing the ISO 9001? (5.4.1)

   • Knowledge preservation in form of work instructions and procedure documents to deal with changing staff
   • Save time through central information storage
   • Remember infrequent carried out tasks (infrastructure tasks)

4) Who is the Quality manager at the STG? (5.5.2)

   Rüdiger Lincke

5) What is (are) your role(s) in the STG according to ISO 9000 documentation?

   Manager, Developer

6) What is your responsibility regarding the implementation of the ISO 9000 at the STG or where can you check it up? (5.5.1, 5.5.3)

   Pushing and controlling the implementation, but also development tasks

7) Who is responsible for identifying problems or possible improvements related to the QMS?

¹ Italic numbers in (parenthesis) show if the question is related to (a) specific ISO 9001 requirement(s) and if yes to which one(s).

Bold letters before the question describe the role to which this question is addressed to. If no role is given, the question is addressed to everybody. Roles are abbreviated like following. **M**: Manager, **Q**: Quality manager, **C**: Marketing director (Customer relation), **S**: Support personal

Questions not addressed to the role(s) of the interviewee are skipped by crossing them out
Mainly the quality manager, but everybody has to report problems to him

8) Describe the structure of the QMS using the terms quality manual, work instructions and procedure documents.
   Quality manual: general objectives of the group
   Procedure documents: contain single work processes
   Work instructions: refine procedure documents and describe detailed tasks

9) Where can ISO 9001 relevant documentation be found and get from?
   Intranet platform LibreSource

10) Did you make yourself familiar with the ISO 9000 LibreSource platform? If yes, how much time did you spend with it? Did you read the ISO 9000 Wiki?
    Test use done, but not used as a daily tool yet. There is still some training necessary.
    ISO 9000 Wiki read.

11) Where on the LibreSource platform can you check your current documentation tasks?
    No answer.

12) What is the first step that is done if you detect the need of a document creation or change? (4.2.3)
    If the document is available, contact the document owner
    If not, contact the quality manager and determine the responsible person for creation

13) What is a record?
    Documentation stating that processes are carried out as defined.

14) How can you receive available records?
    On the LibreSource platform

15) Who are the customers in regard of the QMS of the STG? (5.2)
    Internal customers (colleague)
    External customers possible but not foreseen

16) M: Does customer orientation play an important role when implementing the ISO 9000 standard at the STG? (5.2)
    Internal yes, external not

17) M: Do you see the ISO 9000 project as an important step for the success of the VizzAnalyzer software and why? (5.1)
    Yes, because quality improvement and product consolidation is most important for the VizzAnalyzer now, more important than extension of functionality. And the ISO 9000 project is the basis for this.

18) M: What should be regularly reviewed and controlled by the manager? (5.6)
    If a satisfactory version of the quality manual is available.
    If all necessary processes are documented and implemented.

19) Q: What should be reviewed and controlled by the quality manager? (5.5.2)
20) Q: How do you ensure that QMS processes are established and that mandatory documents will be created? (5.5.2)

21) M: Do you think the resources at the STG are sufficient to produce high quality software? (6.1)

   No, because the main business is to educate students and doing research, but not to develop software. Thus there is not enough time and energy for perfect software developing, but anyway the goal is high quality software.

22) M, Q: How do you communicate the importance of quality and the introduction of the ISO 9000 to your team? (5.5.3)

   Oral, team meetings, research activities in the area of quality

23) Which approach / method shall be applied to the software development process of the STG for future improvements? (7.3)

   UPEDU with a special focus on testing

24) Are you discussing and documenting customer requirements with external and internal customers (companies, research partners, students; colleagues)? (7.2.1)

   Discussions with internal customers and students, but no documentation
   No discussion of requirements with externals

25) How will developed software be inspected and tested at the STG? (7.3.4, 7.3.5, 8.2.4)

   Code inspection with VizzAnalyzer with an implemented quality model; Unit tests, Integration test and scripting

26) Do you use backup or security mechanisms and if yes, which ones? (7.5.5)

   Zipped files on server

27) Do you consequentially use bug-trackers during the VizzAnalyzer development process? (8.5)

   No, because I am rarely developing

28) If yes, for what do you use it? Are only bugs in the program code reported or also missing functionality or insufficient non-functional requirements? (8.5)

29) C, S: How do you regularly communicate with external customers? (7.2.3)

   No communication with external customers

30) C, S: Which action is taken after external customer feedback and complaints? (8.5)

31) M, Q: Are the following objectives reached or methods to reach them established?

   Scale: 0 – not reached, 1 – partially reached or methods implemented, 2 – reached

   - Minimum number of non-conforming software components and products: 0
   - Maintenance and steady improvement of software quality and structure based on a quality model measures derived using adequate tools like the VizzAnalyzer: 0
   - Continuous and organized development of software guaranteeing its quality in spite of frequently changing staff and contributions by students: 1
   - Active risk reduction by increasing process maturity and documentation: 1
   - Knowledge preservation in form of work instructions and procedure documents to deal with changing staff: 1
• Compliance to legal contracts when using 3rd party components: 0
• Save time through central information storage: 1

32) M, Q: What will be done with the results of this audit (audit report)? (5.6)

Published on LibreSource

33) How do you estimate your current knowledge about the ISO 9000 and how was your knowledge before this project?

Scale: 0-4, 0: no knowledge, 1: poor ~, 2: basic ~, 3: good ~, 4: excellent ~.

Before: 1

Now: 2
Internal audit questionnaire

The answers to this questionnaire shall provide information in how far ISO 9001 requirements are already implemented within the STG and how the employee awareness concerning the quality standard is. Answers are written in cursive letters. Partially they are summarized.

Date: 2006-05-16

Time: 2 p.m.

Auditor: Florian Stahl

Interviewee: Jonas Lundberg (Developer)

Questions: 1

1) Why do you think does it make sense to introduce the ISO 9000 standard at the STG?
   To improve quality

2) What is the overall goal of the ISO 9001 compliant QMS at the STG? (5.3)
   List some items and processes such as testing that are required to fulfil

3) What are (further) objectives that shall be reached by introducing the ISO 9001? (5.4.1)
   • Knowledge preservation to introduce new people
   • Improve cooperation in the group to avoid mistakes when putting software components together (code should match each other)

4) Who is the Quality manager at the STG? (5.5.2)
   Welf Löwe (guessed)

5) What is (are) your role(s) in the STG according to ISO 9000 documentation?
   Responsible for testing procedures

6) What is your responsibility regarding the implementation of the ISO 9000 at the STG or where can you check it up? (5.5.1, 5.5.3)
   Can check it on the VizzAnalyzer project homepage

7) Who is responsible for identifying problems or possible improvements related to the QMS?
   Everybody

1 Italic numbers in (parenthesis) show if the question is related to (a) specific ISO 9001 requirement(s) and if yes to which one(s).
Bold letters before the question describe the role to which this question is addressed to. If no role is given, the question is addressed to everybody. Roles are abbreviated like following. M: Manager, Q: Quality manager, C: Marketing director (Customer relation), S: Support personal
Questions not addressed to the role(s) of the interviewee are skipped by crossing them out
8) Describe the structure of the QMS using the terms quality manual, work instructions and procedure documents.
   Not remembered.

9) Where can ISO 9001 relevant documentation be found and get from?
   Internet

10) Did you make yourself familiar with the ISO 9000 LibreSource platform? If yes, how much time did you spend with it? Did you read the ISO 9000 Wiki?
   No

11) Where on the LibreSource platform can you check your current documentation tasks?
   No answer

12) What is the first step that is done if you detect the need of a document creation or change? (4.2.3)
   No answer

13) What is a record?
   No answer

14) How can you receive available records?
   No answer

15) Who are the customers in regard of the QMS of the STG? (5.2)
   Everyone involved in the software development processes and the users of the future products

16) M: Does customer orientation play an important role when implementing the ISO 9000 standard at the STG? (5.2)

17) M: Do you see the ISO 9000 project as an important step for the success of the VizzAnalyzer software and why? (5.1)

18) M: What should be regularly reviewed and controlled by the manager? (5.6)

19) Q: What should be reviewed and controlled by the quality manager? (5.5.2)

20) Q: How do you ensure that QMS processes are established and that mandatory documents will be created? (5.5.2)

21) M: Do you think the resources at the STG are sufficient to produce high-quality software? (6.1)

22) M, Q: How do you communicate the importance of quality and the introduction of the ISO 9000 to your team? (5.5.3)

23) Which approach / method shall be applied to the software development process of the STG for future improvements? (7.3)
   Do not remember

24) Are you discussing and documenting customer requirements with external and internal customers (companies, research partners, students; colleagues)? (7.2.1)
Discussing yes, but not documenting

25) How will developed software be inspected and tested at the STG? (7.3.4, 7.3.5, 8.2.4)
   Individual package (unit) testing; Final test for releases

26) Do you use backup or security mechanisms and if yes, which ones? (7.5.5)
   Backup system on UNIX machine (data stored on server)

27) Do you consequentially use bug-trackers during the VizzAnalyzer development process? (8.5)
   Not consequently, began last months, but more planned in the future for the next versions of the programs

28) If yes, for what do you use it? Are only bugs in the program code reported or also missing functionality or insufficient non-functional requirements? (8.5)
   No real use

29) C, S: How do you regularly communicate with external customers? (7.2.3)

30) C, S: Which action is taken after external customer feedback and complaints? (8.5)

31) M, Q: Are the following objectives reached or methods to reach them established?

32) M, Q: What will be done with the results of this audit (audit report)? (5.6)

33) How do you estimate your current knowledge about the ISO 9000 and how was your knowledge before this project?
   Scale: 0-4, 0: no knowledge, 1: poor ~, 2: basic ~, 3: good ~, 4: excellent ~.
   Before: 0
   Now: 1
References

- [DuSi06] van der Duin, Louwarnoud; Sinnema, Marco: Quality assurance. (Lecture slides), University of Groningen.
- [FoNR03] Foegen, Malte; Nössler, Oliver; Raak, Claudia: Einführung in ISO 15504 / SPICE. (German), http://www.wibas.de/download/iso15504spice.pdf, 2003, accessed 2006-03-28


