QUALITY MANAGEMENT
FOR MOBILE COMMUNICATION SOFTWARE

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Abstract: This paper describes the content and form of quality that is needed to apply the development processes in accordance with controlling tasks and the continuous improvement process. The software Product Line Process for Mobile Communication Product is divided into the phases that end up with milestones, and represents the Waterfall Model. The V-Model defines the product and the appropriate antiproduct - this parallel development leads to a better Know How of the testing objects. The goal of Risk Management in projects is to control the risks that could ensue from the course of a project so that the success of the project is not endangered. Quality Management & Quality Assurance Plan ensures standards for achieving the quality goals.

KEYWORDS: Quality Management, mobile communications, quality, software, process

INTRODUCTION

Throughout long-term experience on the wide field of technical development, Quality Management became the major idea and philosophy of modern approach to quality. Business strategies based on Quality Management are representing today one of the strongest arms in abstention of existing customers and getting new ones.

Quality Management is the new philosophy and approach to quality at which base is the satisfaction of customers, whose implementation asks for changes of organizational culture in a way that every individual is recognizing itself as creator of quality for one's own customer, without difference between internal and external customer [1]. It includes concept and principles based on a new role of management and all employed and also designs a lot of procedures and techniques for implementation and use of modern quality system.

It is possible to observe Quality Management as process, which is starting with identification of customer needs and expectations, and ends not only with product delivery, but also with monitoring and measuring the customer satisfaction and undertaking appropriate actions for continuous improvement [2]. Quality Management by software evolution and its methodical evolution are caused by the following factors: very complex software, high requests on reliability and stability of software, maintenance and modular and decentralized development.

In order to satisfy high quality requirements several models are used in software development – waterfall, evolutionary development, prototyping, incremental delivery and spiral model [5]. This paper considers Quality Management Process used in the Waterfall model with the goal of optimizing mobile communication software development.
1. PROJECT MANAGEMENT PROCESS

Complete project planning and consequent project controlling, based on a consistent metric system, additional analysis of problems and elaboration of measures within the teams, are the basis for successful projects. This chapter describes the process of Project Management for the development of “common SW products”. The way from the first market request up to the realization of the product for a customer is the basis for the product development process. The Project Management Process is responsible that the customer will get a product with all the given requirements, as good as possible. Therefore, for each product there is a defined project, which will be managed by the Project Management Process. Goal of this process is to:

- Run the projects with as less cost as necessary,
- Release products with a high quality,
- Deliver products until the negotiated date.

![Figure 1: “Magic triangle” of the general project requirements](image)

The main team of a project is the Project Control Team. This team is appointed by the management and is in charge of controlling the “own” project. The members of the Project Control Team are:

- Project Leader,
- Project Leader - Development,
- Project Leader - Test,
- Project Manager,
- Project Quality Manager.

The number of the Subproject Leaders depends on the size and the requirements of the project and will be defined by the Project Leader. The organization of the project overlaps the organization of the line as a matrix. The task and the responsibilities of the Project Control Team member are defined by the Project Leader and have to be agreed by the Resource Management.

2. WATERFALL MODEL

This chapter describes the Product Line Process (PLP) for the common SW product development. The following pages contain a definition of the processes involved in product planning with reference to the baselines of the process plan illustrated below (Fig. 2). The Mobile Communication Product is created upon the Waterfall Model. All planning tasks during the individual phases are shown. The whole process is divided into the phases, which end up with milestones. For reaching each of the milestones there is a number of criteria’s that have to be fulfilled. A definition is also given of the necessary input and subsequent output upon completion of baselines in each of the steps involved.
**Figure 2: Product Life Cycle - Waterfall Model**

**Business Opportunity Proposal (BO)**
Business Opportunity Proposal (BO) is defined as a point for gathering new service & product ideas and registration of individual BO ideas. Market analysis based on target market, market price, time frame and priority is needed for evaluation, review and update and for presentation of all these information. The output of this process phase is: the brief description of the BO idea, the qualitative benefits for the customer and the company/division itself, the strategic and tactical significance of the BO on the market, estimated potential market and sales, target costs, target development budgeting and disadvantages/costs of non-implementation [3].

**Feasibility Study (FSY)**
Feasibility Study (FSY) has for input the BO Specification. The phase is started with evaluation of feasibility for some products with information on impacts to interfaces and systems and further detailing of requirements. The FSY must be sent for review to all responsible persons and updated with their comments. The Feasibility Study output is positive/negative result for individual BO’s and reasons for decision. For positive decisions BO Specification must be completed and stored into CM system. Next step is to define features and R&D effort pro features and to clarify areas of responsibility. Major output of study is to create business plan with explanations and prerequisites and key values as revenue, profit margin, development effort and target costs. Also, the market parameters must be taken into consideration: target customers, strategic considerations and list of competitors.

**Pre-analysis**
The Pre-analysis phase is based on documents from BO Specification and Feasibility Study result. Responsible person for Pre-analysis needs to be defined. This person defines then a Pre-analysis team, sets up the Pre-analysis planning and provides this planning to the Project Manager. This phase describes features in more details, evaluates influences to interfaces and system entities and improves cost and effort estimations.

At review start a first effort estimation sheet is provided by responsible person for Pre-Analysis, i.e. subject of review are the Feature Sheet (definition part), Pre-analysis documents and effort estimation sheet. During Pre-analysis phase the following documents must be created: BO packaging list (version packaging list), draft business and resource plan, frame schedule, roadmap and cost and budget framework. For this it is necessary to define resources and process supervisors, and also budgets for market introduction, service introduction and production introduction [3]. At the end of phase there is a list of all features and main document of Pre-analysis - Feature Specification Level 1 with estimated development efforts completed for each feature. At review end the agreed effort estimation sheet has to be provided to Project Manager, the review result has to be transmitted to database and the Pre-analysis documents have to be set in their final version into the CM system.
Analysis
After the Pre-analysis has been completed the Project Control Team decides on Analysis start. The decision is based on available Analysis/Implementation capacity and market priority. In case of Analysis start Feature Coordinator provides Analysis planning and the Analysis documents are referenced on Feature Specification Level 1. In the early Analysis phase an Analysis Workshop has to be planned for know how transfer to Analysis team and to discuss the concept in order to ensure focus on feature requirement. The purpose of Analysis is to describe features completely, evaluate influences to interfaces and system entities in details and improve cost and effort estimations in each phase, each subfunctionality and each development department [3].

At start of review a detailed effort estimation sheet is provided by Feature Coordinator, i.e. subjects to review are Feature Sheet (analysis data), Analysis documents and effort estimation sheet. At the end of review Feature Sheet is set to “completed”, Analysis documents have been set to “completed”, review result has been transmitted to database and agreed effort estimation sheet has been provided to Project Manager. Feature Coordinator sets “Analysis complete” after the Analysis has been completed.

The Analysis phase ends with the following: CM and QM/QA plan both completed and stored into CM system; Feature Specification Level 2, with defined detailed development efforts, must be completed and all database and hardware implications must be defined. In this early phase, Test Strategy and Test Requirement Plan must be defined. As a point of consideration, target value for the faults in field up to one year after Market Release will be taken. Therefore, all risks and counter-measures will here be defined.

Design
The referencing input for Design phase is the Feature Specification Level 2. The Analysis results are designed up to quality suitable for implementation a detailed evaluation of all necessary changes and also the verification of interfaces are being made. As a result of Design phase, the Design Specification document has to be completed and stored into the CM system, to be available for further actions (phases). At this point the proper test equipment should be defined, and also all interfaces should be verified. This phase ends with completed database design.

Implementation - Phase 1 – Coding
Design Specification, created in Design phase is the fundamental document for the Implementation phase, Coding part. This phase consists of pure coding the source code up to completion, and defining the Offline Test scenarios. Preparation for further step, Offline Test, is made. The results of this phase are: a) source code completed and stored into the software pool, and; b) Offline Test Parts and Test Cases defined and stored into the CM system, through adequate tools.

Implementation - Phase 2 – Offline Test
The result of the previous phase (Coding), the source code itself, is the input for Offline Test in Implementation phase. The Offline Tests are performed on the simulator, and those “white box tests” will define the Online Test scenario. Offline Tests (which can consist of feature and regression tests) should be completed here, with results stored into the CM system. Online Test Parts and Test Cases should also be defined and stored into CM system. Special care must be taken for the First Call tests - the Online Tests of basic functionalities, which have to be completed before other tests. With completion of customer documentation, the Offline Test in Implementation phase ends.

Integration
Integration phase evaluation goes through performing Online Tests on the test equipment, so called “black box tests”. During this phase, Online Tests (feature and regression tests) have to be completed, and results stored into the CM system. System-test Test Parts and Test Cases must also be defined and stored into the CM system. At the end of Integration phase, first version of the product is completed.

System Test
Before starting of System Test, Online Tests should be completed. Then the Load and Stress Tests will be performed. They consist of Product Stability Test, Network Integration Test, and also the Interoperability Tests. The Final Report on development project must be made and “Ready for Acceptance” declared. Also, release of all production documents, as well as release of all installation, operation and maintenance documentation must be completed. As result of this phase the product is released to the market.

Acceptance Test
Finally, the product is released and sold to the customer. Now it goes through country specific and customer specific adaptation, various Acceptance Tests will be performed on the customer real equipment, “live” one - this is the moment of true attesting the product. The test backward information is integrated into the correction version or into new BO's. Real weak points should be identified, and service requests defined. Acceptance Test ends when the Acceptance by customer is completed and PAC (Provisional Acceptance Certificate) signed. Now, the product implementation in the live network can start.

Maintenance
After Acceptance, the Maintenance phase begins. The technical support in maintaining the product is given to customer. The Phase-out time has now to be defined. During this phase, customer fault reports should be solved. All BO ideas from customer implementation should now be gathered for new versions and change requests. At the end, the Phase-out time frame must be agreed between sales, service, development and management.

Phase-out
The Phase-out phase begins with the Maintenance expiry, which comes simultaneously with the end of marketing. Further Maintenance is done only for critical functionalities until the Phase-out end, which is the end of Product Life Cycle.

3. V-MODEL

Target of V-Model is better Know How of the testing staff about the features and better distribution of test effort curve. The verification scenarios are discussed already as part of the Analysis and Design, with better coordination and most effective split of test scenarios to the test phases.

3.1. Advantages of the V-Model

The V-Model defines the appropriate antiproduct, i.e. test objects to the product - HW/SW objects. In principal Acceptance tests can be defined already during Pre-analysis. Online Test scenarios can be defined within Analysis phase, i.e. the Online Test Coordinator must participate in the Analysis. During Design of a feature the appropriate Offline Tests can be defined. Module Tests are defined based on the SW Coding.
The parallel development of the product and the antiproduct in the earliest possible phases leads to a better Know How of the testing staff about the new features. A portion of the effort is shifted to an earlier phase, smoothening the effort curve.

The common analysis of the functional verification scenarios gives a better coordination and the most effective split of these scenarios to functionality test phases. At this early stage of product development, the “real” test environment does not “automatically” influence the decision for certain test scenarios. If the test environment does not allow the intended tests, the requirement for an enhancement of the test environment can still be defined.

The definition of test scenarios during the Analysis is based on functional aspects of the new feature. The implemented solution should not influence the scope. The early start of the development of the antiproduct leads to a better quality and better preparation of the test scripts at the beginning of the actual test phases.

3.2. Disadvantages of the V-Model

Because of the overlapping of the Offline Test phase of the former version with the Analysis phase of the next version, the V-Model leads to conflicts and problems in the resource planning at the Introduction time of the V-Model. Activities for product creation and verification are intermingled; it becomes more difficult to plan personnel deployment, especially where the same staff is responsible both for the product and the antiproduct.

4. QUALITY MEASURES

The non-phase related quality measures are considered in this chapter.

4.1. Risk Management

Risk Management is a planned, systematic administration of risks. Risk Management consists of identifying and analyzing risks, quantifying and assessing them, formulating measures for handling the risks and then, monitoring and controlling these preventive measures.

The goal of Risk Management in projects is to control the risks that could ensue from the course of a project so that the success of the project is not endangered. Risk Management helps to identify risks in advance so that preventive measures can be defined before the risks develop into problems or loss occurs. Risk Management also fosters risk-consciousness in projects. Risk Management permits possible conflicts to be considered before the project begins, i.e. when
adequate freedom of action still exists. Actions for avoiding risks or minimizing the effects of risks are explicitly planned as work packages to be included in Project Planning. The Risk Plan is refined (new risks and their appropriate preventive measures are added) and updated (costs, completion dates, probability estimates, implementation statistics) during the entire development process [4].

Risks are classified into risk categories as soon as the Risk Gauge (probability of risk occurring effect of the risk within the project) attains a certain percentage of the total project costs. The Project Manager is responsible for implementing Risk Management from the beginning of the project, when development begins till the end of development. Primarily the Project Control Team performs the tasks associated with Risk Identification. If necessary, other experts are included in these deliberations.

For each high-categorized risk a special Risk Coordinator is pointed out. The Risk Coordinator analyses a risk and takes measures to minimize the damage it may cause the project. The Coordinator is usually accountable for certain areas in which he has proved to be highly competent. The Risk Coordinator’s success is a measure of the extent to which damages could be reduced (Risk Gauge minus the remaining losses minus the costs of the preventive measures). The individual designated to deal with the most critical risk situations must be carefully selected. To analyze the risk properly it may be necessary to involve additional people to form a team to deal with Risk Analysis.

The Risk Plan, consisting of a Risk Action List together with the Risk Analysis Sheets, provides comprehensive Risk Analysis documentation:

- A Risk Action List furnishes a survey of all risks involved and their state.
- A Risk Analysis Sheet (RAS) exists for each risk, which was analyzed. It presents a detailed description of the risk, its effects, and procedures for reducing its damage.

4.2. QM/QA Plan (Quality Management & Quality Assurance Plan)

The QM/QA Plan ensures standards for achieving the quality goals. The work on QM/QA Plan begins in the Pre-analysis phase and has to be finished by the end of the Analysis phase. The phases Analysis, Implementation (Design, Coding, Offline Test) and Integration start simultaneously in all development centers throughout the world via the Kick Off meetings. In the Kick Off document there is an overall information about the next phase. The content of this document consists of Configuration Management information, project organization, time schedule, tools, templates, naming conventions, effort estimation, quality aspects and criterias, planning, controlling and process information.

The QM/QA Plan must include the reference to the international standards (GSM/UMTS), as well as to the basic documents and tool versions.

For certain phases there is an obligatory review. The responsible Project Leaders decide which kind of review will take place for particular occasion (meeting, commentary…). The Root Cause Analysis (RCA) must be applied to all faults in order to recognize clusters of faults. The RCA is also an input for improvement measures in the next release. The Error Finding Rate is defined as Quality Gate (number of errors divided by effort) for the phases Analysis, Design, Coding and Offline Test. If the Quality Gate is not reached for specific feature, the Feature Coordinator has to investigate weak areas and to define appropriate measures. On the basis of experience from the previous versions the new/improved tools are introduced in each version [4].

Test Strategy meetings must be carried out until a certain period defined in the QM/QA Plan. For each Subproject a Test Strategy has to be defined for all new features within the Subproject. The work split for functional Offline Test, Online Test and Load & Stress Test needs to be agreed between the affected and responsible.
For all Test Cases where it is possible an Automatic Test List has to be written. This effort enables easier test handling in the next releases. After feature implementation not only the new functionality has to be tested but also previous functionality. This is done with Automatic Tests. A link to the relevant Configuration Management items must be provided in the QM/QA Plan.

The detailed Metric Process enables the Project/Multiproject control mechanism. The main metrics are carried out for: planning quality for cumulative revenue, feature stability, development cycle time, development effort, faults in the field and status of market introduction.

CONCLUSION

Quality Management is the major idea and experience of modern approach to quality. The development of mobile communications software product is among the most complex, work intensive and error-prone technologies. The Quality Management System provides a unique system of processes, methods and regulations. That supports development activities to achieve products with high quality and efficiency. Complete project planning and consequent project controlling, based on a consistent metric system additional analysis of problems and elaboration of measures within the teams, are the basis for successful projects.

Benefits of the Product Line Process of Mobile Communication Software Development are in separation and concentration of quality engineering and process descriptions. It is the guideline for continuous qualities work in the project. All quality assurance measures, target values and project specific issues are fixed in this plan. Therefore, the quality criteria should be defined to describe the level of quality, which satisfy the process in order to reach the high quality product.

The Waterfall model presented in this paper is a classical life cycle approach of software development. The advantage of Waterfall model and its improvement V-model is better Time to Market orientation. The other known development models are used for different purposes - evolutionary development is used for version development, prototyping for customer specific requirements, incremental delivery for specific SW requirements & subprojects and spiral model is similar to Waterfall but used for very large projects. The Waterfall model improved by V-model and additional quality measures provides optimal quality and is concerned as the most suitable for the mobile communication SW development.

REFERENCES