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PROCESSUS - Methodology for Quality System Improvement and Assessment

The PROCESSUS methodology was developed to assist the software organizations with quality system establishment and improvement. It covers the assessment of software organizations and training and consulting procedures during the establishment or improvement of their quality systems. The methodology is based on two best known software quality improvement models, SEI CMM and ISO standards. In the paper special attention is given to the method of integration of both models. The integrated model also forms the basis for the PROCESSUS methodology.

Key words: software process, software process improvement, quality system (QS), ISO model (ISO 9001 and ISO 9000-3), SEI CMM

1. Introduction

The software process is the subject of intensive studies and research trying to define its unique characteristics and bring it closer to other manufacturing processes by using some of the already proved and appropriate concepts [1]. Many new methods, models and supporting tools have been introduced to guide software organizations towards efficient software process management. Due to the complexity of the software process (and, admittedly, to be honest, software market interests) these methods, models and tools still do not cover all issues needed. Some of the Slovenian software organizations that were interested in the improvement of their software process and the achievement of its compliance with the required standards confronted this problem and the idea of the PROCESSUS project arose. The main goal of the project is to define a model that would help the organizations to introduce, assess and maintain their quality systems.

2. The PROCESSUS project

The PROCESSUS Project (Assessment and Introduction of a Quality System) was initiated in 1994 through the cooperation between the research group Laboratory for Information Systems and by Slovenian local industry. The financial support of the Ministry of Science and Technology of Slovenia gives the project national

significance. Partners from the local industry can be divided in three groups (see Table 1).

In the project two issues are intertwined:

- the ***research issue*** involving the development of methodology which can be applied for the wide range of potential organizations searching for quality of the software process
- the ***implementation issue*** involving the use of methodology to introduce and maintain quality systems in participating organizations.

Goals and activities needed to achieve these goals, as well as the results of the activities are listed in Table 2.

The basis of the project is the first research goal which also serves as the rationale of the whole project. Therefore, the greatest effort was put into setting up the PROCESSUS methodology. In spite of the multidimensional aspect of methodology its nucleus is the comparison and integration of both the *Capability Maturity Model* (CMM) [2] [3] and *ISO standards 9001, 9000-3* [4], [5] into a unique quality model.

Table 1. *Types of organizations participating in the PROCESSUS project.*

Type	Description	Characteristics
A	Large information organizations	• extensive software development activities, • consulting and training activities • interest for selling of the PROCESSUS methodology
B	Internal information centers	• software support of main activities of organization (eg. pharmacy, insurance, banking, etc.) • interest for certification only within the entire organization
C	Small software organizations	• software development activities • small organizations(approx. 20 employees) • interest for certification

3. Comparison and integration of CMM and ISO models

The purpose of the comparison of models was not to determine which model is better, but to define areas that are equally covered in both models and those that are discussed only in particular model. Due to substantial differences in formality of both models we were mainly confronted with two problems. The first problem of the comparison to be observed is the fact that starting-points of both models are different:

Table 2: *The scope of the PROCESSUS project*

A) Research Goals	Activities	Results
1. Setting-up the PROCESSUS methodology		• PROCESSUS methodology
• definition of usability of existing models	• studies of the existing models and requirements of the SW market	• chosen models: ISO and CMM
• unification of ISO and CMM in the PROCESSUS model	• comparison of ISO and CMM • unification of ISO and CMM	• common/specific areas of both models • unified PROCESSUS model
• definition of required documentation	• studies of required documentation of ISO and CMM • definition of the list and content of required documents of the unified model	• prototype of the Quality Manual • prototype of the documentation structure for QS (quality manual, standard procedures, standard documents, etc.)
• definition of the assessment methodology	• definition of a questionnaire • definition of analysis methods	• PROCESSUS questionnaire
• definition of education/training activities	• studies of needed areas (eg. SW engineering, communications, information system technologies, etc.)	• list and content of seminars • list and content of workshops • consultation methods
• software support for PROCESSUS methodology	• QS assessment support • QS documentation support • QS establishment support	• PROCESSUS Tool
2. Assisting organizations to improve their quality systems		• improved QS
	• implementation of PROCESSUS methodology	• improved QS • metrics of PROCESSUS methodology efficiency
B) Implementation Goals	**Activities**	**Results**
1. Improvement of the quality system		• improved QS
• to define the present state ("where are we?")	• assessment of the software process	• report of PROCESSUS questionnaire analysis
• to obtain a plan of activities needed for process improvement	• definition of major improvement activities together with consultant activities • cooperation with the PROCESSUS team • education/training activities	• plan of improvement activities and methods for their achievement
• to achieve inner staff motivation	• education/training activities • involvement of personnel in QS establishment	• improved QS
• to prepare for certification	• internal assessment of the software process	• report of PROCESSUS questionnaire analysis

- *ISO model*: The basic importance of ISO model is in the fact that it provides organizations with guidance as to **what to include in their quality** to achieve compliance with the demands of ISO standard 9001. The model states nothing about which methods organizations should use to meet these demands - choosing the method for setting up a quality system is left completely to the particular organization.
- *CMM*: Besides giving a definition of what the standard process in an organization should look like it also provides good assistance as to how the improvement in the organization be should conducted. The maturity levels and key process areas for transition between maturity levels largely facilitate the course of setting up a standard process and its maintenance.

It needs to be pointed out that ISO model deals with the quality management system while *CMM* deals only with the process of software development.

Another problem already considered at the beginning of the comparison of both models is that two models with completely different structure are being compared.

- *ISO model*: It is written in form of a text in which both explanation of the meaning of a particular area and the objectives, procedures and documents that are to be included in a particular area are intertwined.
- *CMM*: It is defined quite formally, so that all the key process areas are precisely defined by their common features (goals, commitment to perform, ability to perform, activities performed, measurement and analysis, verifying implementation). In the operating manual for CMM each of the common features is presented more precisely and additionally explained with several examples.

Due to its nonformality ISO model allows various interpretations of individual items. To avoid difficulties brought about by such an interpretation of ISO model our comparison is based on the assumption that the organization's basic intention is to improve the process (and not merely get the certificate). In cases where a particular demand takes several different interpretations we decided on strict interpretation of ISO model.

The comparison between CMM and ISO models is made in two steps:

1. *CMM-ISO directed comparison.* In this part CMM was taken as the basis. For each KPA and for all common features within KPA those items or respective chapters from ISO model were looked for that refer to or even precisely overlap with the content of a particular common feature. During the comparison the degree of overlapping was defined. A detailed description and results of the comparison are given later on in this paper.

2. *ISO-CMM directed comparison.* In CMM-ISO directed comparison some chapters from ISO model remain "untouched" - these chapters are not related strongly enough to any KPA, for which reason they are not included in CMM-ISO directed comparison. These chapters are defined only in ISO model or can be only partially

related to a particular common feature of an individual KPA. These chapters become very important later when models are joined.

3.1. CMM-ISO directed comparison

Due to large differences in form of both models, from the very beginning there has been a need to avoid checking all common features in the same form. In common features, such as *Goals, Commitment to perform, Ability to perform, Measurement and analysis, Verifying implementation*, it becomes evident that the content of ISO model is by no means as formal as to allow sensible comparison of each item separately. A detailed comparison was made for the common feature *Activities performed* (henceforward *Activities)* which in fact represent the core of each KPA. A discussion about activities will be presented in the following pages.

Activities were compared in such a way that for each activity from individual KPA a corresponding content from ISO model was looked for. This means that, for example, for each activity from a particular KPA corresponding sentences, paragraphs or chapters were looked for in ISO 9000-3 guidelines, which was followed by a comparison of consistency of both items. The value given to this comparison is called ***consistency degree***. These values are listed in Table 3.

Table 3. *List of values for consistency degree*

Value	Meaning
2	Activity is defined **only in CMM.**
1	Activity is defined **in both models although CMM is more extensive.**
0	Activity is **equally defined in both models.**
-1	Activity is defined **in both models but ISO adds new aspects.**
-2	Activity is **defined only in ISO model.**

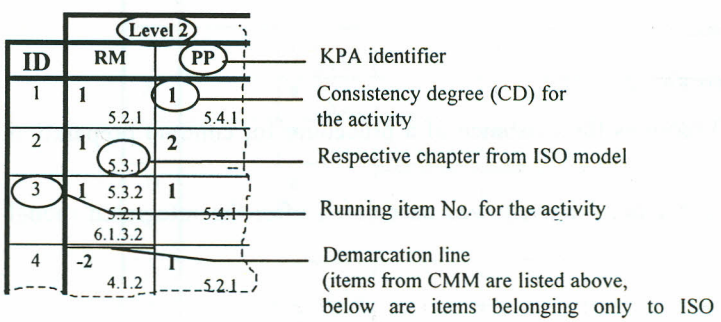

Figure 1. *Explanation of the comparative table*

The results of the comparison of the common feature *Activities* are given in a so-called **comparative table** (Table 4). The original comparison table is designed in such a way to include all KPAs defined in CMM and, simultaneously, all activities that need to be performed within a particular KPA. Figure 1 illustrates in more detail the form of the table and the meaning of individual cells in it.

In the first line of the table demarcations of levels for CMM (from level 2 to level 5) are defined. In the second line all 18 key process areas are listed. In the following lines values obtained by comparing individual items are given. In the first column of the table running numbers of individual activities from particular KPAs are given. Each cell in the table, therefore, belongs to a precisely defined activity from a precisely defined KPA. When we refer to a particular activity we mark it in the text with the following identifier:

<KPA>-A<running No. of activity in KPA>

Example:

RM-A2 is used to mark the second activity in KPA Requirements Management. Abbreviations for KPAs are created from the two most meaningful words in each KPA´s name.

In each column of the comparative table the activities listed upside down to the double line are those included in the KPA to which the column belongs. Below the double line the activities are also added which ISO model presupposes for this KPA but that are not included in CMM. If there are no such activities in ISO model then no values are listed below the double line. Demarcation with a double line was used to make the number of activities included in KPA easily evident.

Table 4 on the following page presents the results of comparison for level 2 KPAs*.

For each activity with consistency degree -1 or -2 a detailed explanation why such value was assigned is given.

Example:

Activity: RM-5

Consistency degree: -2

Comment: ISO requires the existence of a procedure for contract preparation and review.

Comment given for each activity was used later, after the integrated model has been created.

* Detailed results for all KPAs and their explanation are available from the authors.

3.1.2. ISO-CMM directed comparison

While comparing the common feature *Activities* we checked which activities from ISO refer to a particular KPA from CMM. Results of this overlapping were shown in Table 4 and the degree of overlapping of these KPAs was analyzed. It can be very easily understood from Table 4 which areas belong only to CMM, whereas the table says very little about which areas are included only in ISO model. Namely, the values -1 and -2 were given only to items from ISO model which thematically belong to a particular area of CMM resp. they are closely related to it. ISO model still contains items which could not be placed in any KPA. In Table 5 only those chapters of ISO model are presented which are not discussed in enough detail or not discussed at all in CMM. Therefore, Table 4 includes data which, from the ISO viewpoint, are needed for integrating both models.

Table 4. *Comparison of CMM and ISO models for Activities of Level 2 KPAs.*

	Level 2					
ID	**RM**	**PP**	**PT**	**SM**	**QA**	**CM**
1	**1** 5.2.1	**1** 5.4.1	**0** 5.4.3	**1** 6.7.1,2	**-1** 5.5.1,2	**-1** 6.1.2
2	**1** 5.3.1	**2** --	**0** 5.4.1 5.4.3	**0** 6.7.2	**1** 5.5.1	**0** 6.1.2
3	**1** 5.2.1 5.3.2 6.1.3.2	**1** 5.4.1	**2** --	**1** 6.7.3	**1** 5.5.1	**0** 6.1.1 6.1.3.1
4	**-2** 4.1.2	**1** 5.2.1	**2** --	**1** 6.7.3	**1** 5.5.2	**0** 6.1.1 6.1.2
5	**-2** 5.2.1	**0** 5.4.1	**2** --	**1** 6.7.3	**1** 5.4.6 5.5.2	**0** 6.1.3.2
6	**-2** 5.2.2	**0** 5.4.1	**1** 5.4.3	**2** --	**2** --	**0** 6.1.3.2
7		**-1** 5.4.2	**1** 5.4.3	**1** 6.7.2	**1** 5.4.6	**0** 6.1.3.1
8		**-1** 5.4.2.2	**1** 5.4.3	**0** 6.7.3	**2** --	**0** 6.1.3.3
9		**1** 5.4.1	**1** 5.4.6	**1** 6.7.2,3	--	**1** 6.1.2
10		**1** 5.4.1	**1** 5.4.3	**1** 6.7.2		**1** 6.1.2
11		**1** 5.4.2.1	**2** --	**1** 6.7.2		--
12		**0** 5.4.1	**1** 5.5	**0** 6.7.3		
13		**0** 5.4.2.1	**1** 5.5	**0** 6.7.2		
14		**0** 5.4.2.3	--	--		
15		**2** --				
16		**-2** 5.4.6				
17		**-2** 5.4.1				
18		**-2** 5.4.1				
19		**-2** 5.4.4 5.4.5				

3.2. Integration of models

Results of the comparison of both models provide basis for their integration. By integrating both models we aimed to establish the simplest possible method for setting-up a quality system in an organization. **As a target form we adopted such a quality system as required by ISO standard, together with advantages offered by CMM.** The method for setting up a quality system in our integrated model resumes the form of CMM because of the advantages of this model already proved. In the framework of CMM we, therefore, added those activities and those areas that are required by ISO model but have yet not been included in CMM.

When integrating the models we set the following goal: *The integrated model should to the largest possible extent keep the identity of each individual model.* For this reason we tried, as much as possible, not to change individual activities and KPAs of CMM. In cases where too many activities in an individual KPA would be changed or, respectively, where the content of a KPA would expand too much if these new activities were added, we opted for introducing a new KPA. This also contributes to the increased transparency of the integrated model, since references to individual activities and also changes of individual activities are kept to the minimum. Namely, all considerable novelties are integrated in new KPAs. Despite of all this, we cannot avoid for some existing activities to be enhanced.

Table 5. *Specifics of ISO model.*

CHAPTER FROM ISO 9000-3
4 Quality System - Framework
4.1 Management responsibility
4.1.1 Supplier's management responsibility
5 Quality System - Life-cycle activities
5.1 General
5.9 Replication, delivery and installation
6 Quality System - Supporting Activities
6.3 Quality records
6.8 Included software product

3.3. Method of integrating the models

When comparing the models we classified the activities belonging to ISO model into two categories: activities acting as a supplement to an existing activity from CMM (CD = -1) and activities that are completely new as regards the content of CMM (CD = -2). The method of integrating both models comprises three groups of activities or, respectively, three stages of integrating the models:

1. ***enhancement of an existing activity from CMM*** - for all activities with CD = -1;

2. ***adding of new activities to existing KPAs*** - for activities with CD = -2, when these activities are closely related to other activities in the existing KPA;

3. ***adding of a new KPA*** - for activities with CD = -2, when these activities introduce a new issue, defined only by ISO standard.

3.4. Integrated model

By adding new KPAs to CMM structure we obtain the form of the integrated model shown in Figure 2. In the figure new KPAs are placed on transition between respective CMM levels. They are written in bold type. At the same time we defined the succession of establishing KPAs on transition between respective areas, where the direction is bottom-up, as with CMM (see Figure 2 on the following page).

Figure 2 shows only the first three levels of the integrated model and transitions between them. On higher levels we neither added new KPAs nor changed the existing KPAs. The structure of the integrated model from level three upwards is completely identical to CMM.

In the figure the information about changes of existing activities in activities in KPA is also added. A -1 mark is added to the identifiers of all KPAs in which the existing activities were changed. Those KPAs in which new activities were added are marked with value -2.

The content of new KPAs that are added to the integrated model is as follows:

1. Quality System Management - QS

The Quality System Management area focuses on defining quality policy in an organization and its presentation to all working staff. It also takes up defining the quality manager's tasks related to the quality policy. It describes basic principles of quality system documentation. The above requirements are crucial for setting up or improving a quality system. KPA QS is, therefore, an area that needs to be established already on transition between levels 1 and 2. On higher levels, however, KPA loses its intensiveness, as it is primarily aimed at initiating the improvement of the process in the organization and introductory activities aimed at achieving understanding and acceptance of quality policy by all working staff within the organization.

2. Organizational Structure Management - OS

The key process area Organizational Structure Management focuses on definition or adjustment of the organizational structure, the roles in organization and all authorizations, responsibilities, required qualifications and commitments related to a particular role. Besides, it covers procedures for creating groups, choosing their members, their authorizations, tasks and required qualifications. It is therefore sensible to establish KPA Organizational Structure Management already on transition from level 1 to level 2. Since the need for many roles and groups becomes evident later, when establishing individual KPAs, the KPA OS is also influenced during transitions between higher levels.

3. Contract Management - CT

This KPA is thematically closely related to KPA Rmof CMM. Namely, both KPAs deal with the definition of requirements for the product (system) that needs to be developed in a particular project. If all issues introduced by ISO model were included in KPA RM this area would change too much with regard to the content. However, the KPA CT deals with all the details of contract management. The KPA CT is a simple KPA, which returns its results in short time. It is sensible to place KPA CT among KPAs that are needed for transition between levels 1 and 2. In Figure 2, which presents the framework of the integrated model, thematic connection between areas RM and CT is illustrated by a broken line between both areas.

4. Product Delivery Management - DM

The Product delivery management KPA deals with the quality of delivery, which includes taking over the product, placing and testing in the target environment, completing of all copies and ensuring correctness of installation. The KPA DM is a rather simple KPA with great influence on the end-user's satisfaction and, consequently, on the effectiveness of the organization. This KPA should also be placed on the transition between levels 1 and 2.

5. Document Control - DC

The KPA Document Control deals with procedures for maintaining all existing documents in organizations, issuing valid documents, changing the existing documents, etc. DC is an extensive KPA which needs, at least at the beginning, a lot of administrative work with results of KPA showing much later - when by using these procedures we actually control all documents in the whole quality system. For this reason it is sensible to place KPA DC on a higher level - on transition between the second and the third level. KPA DC is to a considerable extent related to KPA PD (Process definition). In Figure 2 thematic connection between PD and DC areas is illustrated by a broken line between both areas.

6. Included Product Management - IP

This area deals with the procedures for managing the products that need to be included in the end product and are provided by the customer. The customer and organization's responsibilities, procedures of testing and including the product as well as conditions regarding its maintenance should be emphasized. This area is placed on transition between level 2 and level 3.

When compared to the original form of CMM the integrated model seemingly becomes very extensive. However, we should not forget that some new areas can be easily included in the quality system (e.g. *Contract Management, Product Delivery Management, Included Product Management*). Setting up of these areas does not essentially increase the amount of time needed for transition on a higher level but, on the other hand, brings several advantages - mainly those regarding working with customers. The time needed for transition between the first and the second level is slightly longer because of KPA *Quality System Management* and *Organizational Structure Management*, where we are faced with effectively more extensive work.

However, these KPAs provide an organizational basis which can be well used when establishing areas on higher levels. In this way time needed for transition between higher levels is reduced. Besides, these areas need to be established if the organization is to be in accordance with ISO model. By placing areas on transitions between individual levels choosing methods for establishing and maintenance of a quality system is made easier for the organization that will establish it.

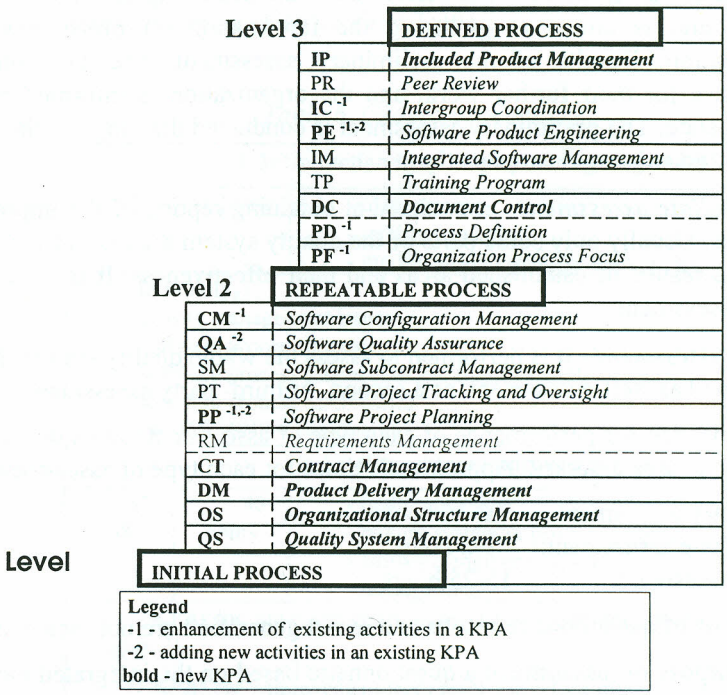

Figure 2. *Integrated CMM-ISO model.*

4. Improvement Methodology

Methodology consists of three major parts:

- introduction of the organization,
- assessment of the organization,
- improvement activities (training and consulting)

All parts are supported by a PROCESSUS Tool and are based on the described integrated model.

The first part is rather informal and is aimed at restoring the contacts and knowledge about organization and methodology. By using the introductory questionnaire the information about software organization is acquired. The methodology, together with other important issues (like the need for time, resources, finances, human resources, etc.), is presented to the organization's management and

personnel. This step is important, since at the beginning of the quality establishment many organizations do not completely realize the complexity of the effort to be made.

Other parts are more complex and will be described in more detail.

4.1. Assessment

In methodology implementation three types of assessment are anticipated:

- ***preliminary assessment*** - it is performed at the beginning of the improvement project and is aimed at gathering the information on procedures in the organization. Results of the preliminary assessment give the consultants guidelines for their further work, and the organization is informed about its present state. The preliminary assessment is conducted drawing on the existing project and existing documentation.
- ***intermediate assessment*** - it is aimed at obtaining reports of the improvement progress. Usually only some parts of the quality system are assessed in order to gain the results of established areas and their effectiveness. It is performed as aself-assessment.
- ***global assessment*** - it is performed to assess the whole quality system. It can be performed as self-assessment, as a second- or third- party assessment.

The time needed for performance of each type of assessment varies depending on complexity of the area assessed. Approximate times for each type of assessment are:

- preliminary assessment: 8-16 hours
- intermediate assessment: 3-6 hours
- global assessment: 15-25 hours

The analysis of questionnaire results and report generation are not included.

For the purpose of assessment a questionnaire based on the integrated model was defined. It is implemented within the PROCESSUS Tool, which supports assessment of the organization (answering the questionnaire) and also provides automation of questionnaire analysis (generating reports, data exports to other applications, archiving)

The questionnaire provides the assessor with further help:

- *question* - text of the question that should be answered;
- *explanations* - additional subquestions and further explanations of specific issues;
- *list of documents* - list of all documents needed to prove the given answer;
- *terminology explanation* - specific terms prepared to help to explain the questions to assessors and personnel representatives.

4.2. Improvement activities

Improvement activities are set according to the concept of methodology and the experience with cooperating organizations. Activities are divided into:

- ***seminars***

The purpose of seminars is to educate the organization's personnel about aspects of the quality system improvement and also the software engineering activities improvement. According to the methodology ten seminars are provided, each as a one-day lecture and discussion of problems involved.

Seminars are divided into three thematically related groups which are presented in Table 6. The length of seminars, desired participants and global topics discussed within each seminar group are also given in Table 6.

Table 6. *Groups of seminars*

1. Introduction to quality system management		
S1, S2	16 hours	- management - quality manager - quality system improvement group
- terminology, - quality management issues, - software process issues, - software process assessment and improvement - software process certification - PROCESSUS methodology		
2. Quality system improvement		
S3-S8	48 hours	- quality manager - quality system improvement group - software engineering personnel - management
- KPAs for improvement from level 1 to 2 (see integrated model, Figure 2) - KPAs for improvement from level 2 to 3 (see integrated model, Figure 2) - software engineering activities improvement (detailed discussion of each software engineering activity and presentation of available and appropriate methods and tools)		
3. Up-to date technologies		
S9, S10	16 hours	- quality manager - quality system improvement group - software engineering personnel
- communication methodologies - OO technologies		

- ***workshops***

They are aimed for personnel working on the preparation of a quality manual and other types of quality system documentation. During the first workshop the attendance of a management representative is recommended, because the global issues (quality policy and organization structure) are discussed.

There are four workshops included the improvement methodology (altogether 32 hours).

In workshops only guidelines for the quality manual and other documents are given. For that purpose the *prototypes of the quality manual together with the structure and content of other documents* are prepared. Preparation of concrete documents whose content would suit the procedures in the organization is much too extensive to be performed within 32 hours of workshops. It is included in consultation activities.

In workshops common problems of participating organizations are also discussed and solutions are proposed.

- ***consultations***

In addition to seminars and workshops individual consultations for each organization are provided. These activities are the most flexible and detailed part of improvement activities. Namely, all actual questions and problems occurring during the quality system improvement should be solved consultations. Therefore, the content of each consultation is completely related to these problems. In addition, the correctness and appropriateness of defined procedures and respective documentation have to be assured.

For each organization a group of trained and experienced consultants is assigned. Apart from the assignments already described, consultants are also responsible for coordination between the organization and the consulting organization in all issues. Reports of improvement of the quality system are prepared on a regular basis and the personnel involved informed about the achievements.

Time needed for consultations is hard to predict in advance because of its considerable dependency on the size of the organization, complexity of procedures in the organization and skills of personnel involved in quality system improvement. Experience has shown that in small organizations (up to 20 employees) 40-60 consultation hours are needed.

5. Conclusion

The development of PROCESSUS methodology was primarily based on the need that became evident in our cooperation with software organizations. As the basis of the methodology the two best- known and widespread models for software process improvement, the SEI CMM and ISO standards, were chosen. Described comparison

and integration of both models offers theoretical knowledge needed for quality system improvement.

Presented methodology provides application of this knowledge in organizations. It has already been used in cooperating organizations. The improvement of their quality systems is based on assessment and improvement activities, defined within the methodology. The first organizations have already improved their quality system on level-three compliance and are already prepared for ISO certification. Even in organizations which have not achieved the defined level the efficiency of the methodology has been proved. Namely, the results of established key process areas provide the organizations with better work procedures and better efficiency of projects performed.

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Rozman I., Horvat V. R., Györkös J., Heričko M. PROCESSUS - metodologija za uspostavljanje sustava za poboljšanje kvalitete

Sažetak

Metoda PROCESSUS razvijena je za pomoć softverskim organizacijama u uspostavljanju sustava za poboljšanje kvalitete. Ona omogućuje procjenu razine kvalitete softverske organizacije i definiranje postupaka za vježbanje i savjetovanje tijekom uspostavljanja sustava za poboljšanje kvalitete.

Metoda se temelji na dva najpoznatija modela za poboljšanje kvalitete softvera, SEI CMM i ISO standarda.

U ovom radu posebna pažnja posvećena je načinu na koji su povezana oba modela, a integrirani model čini osnovu za PROCESSUS metodu.