Usage of Multiple Process Assessment Models

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Abstract. Organizations seek to obtain benefit from different process capability frameworks - the most popular ones as ISO/IEC 15504 and CMMI and the new ones as Enterprise SPICE – but every assessment is expensive both financially and time-wise. Furthermore, new assessment is required when a new process assessment model's version is released. In order to define and/or improve their software process, organizations choose different Software Development Methodologies. It is important for the organization to know what capability/maturity of the process a chosen methodology could ensure. In order to solve these problems, Transitional Process Assessment Model (TPAM) [1] has been proposed. It should enable the transformation of assessment results according to one Process Assessment Model to other models and determines what capability/maturity according to different Process Assessment Models a chosen methodology could ensure. The requirements for TPAM and its implementation principles have been introduced in [1]. This article presents the development of TPAM and supporting tool. The ideas of Enterprise SPICE integration into TPAM are outlined also.

Keywords: CMMI, ISO/IEC 15504, Enterprise SPICE, Agile methodologies, models mapping, transitional process assessment model.

1 Introduction

Investigations in software process maturity provide a deep insight into software activities and introduce various process capability frameworks which help assess and improve both software process capability, and the maturity of organizations producing software. The research achievements are noticeable but the problems related to software projects are very real. Organizations seek to obtain benefit from different process capability frameworks that stimulate harmonization of the process assessment models (PAMs) and investigation of process improvement in multi-model environments [2, 3, 4, 5, 6, and 7]. The most popular Process Capability Frameworks worldwide are ISO/IEC 15504 and CMMI. It is desirable for organizations to have assessments according to PAMs of both these frameworks but every assessment is expensive both financially and time-wise.

In order for organizations to improve their software process, they should choose from one of the many different Software Development Methodologies, for example,

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XP, Scrum, DSDM, and RUP. There are many and various methodologies, so it is important for the organization to know how it could benefit from their chosen methodology. The choice of methodology should depend on what it can achieve for the organization. It is desirable to determine software process capability/maturity according to different PAMs. When a new version of the PAM is released the organizations needs to know their capability/maturity according the newest version preferably without making the new assessment.

We propose the Transitional Process Assessment Model (TPAM) [1], which would help organizations to tackle problems related to multiple process assessment models and the evaluation of software development methodologies. The implementation of TPAM and supporting tool is discussed in this article.

2 Background and Related Works

This chapter provides the motivation for the mapping between the process assessment models and development methodologies assessment. The research performed is presented and explained in the following chapters. A process assessment model defines the standard process that provides the basis for an organization's process assessment and improvement. It should ensure the usage of the same concepts and maintain relevance with the best software engineering practices and compatibility with internationally accepted standards.

All process assessment models summarize the best practices of software development and services worldwide. But although the source is almost the same, the resulting models are different. Therefore, organizations face the double problem of selection in that they need to choose both the process assessment model and the software development methodology that is most suitable for their business goals. The solution is made further complicated because organizations want the benefit of the advantages of different models, but they do not know what methodology can achieve these advantages. Therefore, research that establishes the relationships between process assessment models and software development methodologies is important. That is why mappings between the models and methodologies, which help to solve this problem, are developed.

Fundamental ideas of CMMI and ISO/IEC 15504 mapping have been proposed in [8]. Mappings of the CMMI-DEV V1.2 and ISO/IEC 15504-5:2005 models are presented in [9]. They show how CMMI-DEV maturity levels can be expressed by ISO/IEC 15504-5 Processes capability profiles and vice versa. Mappings show what is common in the models and how they differ. These mappings are used as the basis for TPAM development but the latest versions of models CMMI-DEV V1.3 and ISO/IEC 15504-5:2012 are employed.

Also, it is important to track the changes in different versions of the same process assessment model. An approach for the control of model evolution and compliance maintenance is proposed in [10]. The organization may want to have assessments by several models in the hope of achieving the respective benefits of each model. It is important for organizations to efficiently implement and assess multiple reference

models and benefit from synergy effects [11]. It is significant for organizations to have assessments according both CMMI and ISO/IEC 15504. For example, many organizations drive their process improvement on the basis of CMMI. However, their customers require process capability ratings determined on the basis of ISO/IEC 15504. An approach that enables organizations performing internal process improvement on the basis of CMMI to survive SPICE assessments with relatively small efforts is presented in [6]. As it is important for organizations to be aware of their process capability, it has become important for methodologies to determine what capability they could ensure. There are many articles published that analyse what capability/ maturity could ensure popular Agile methodologies [12, 13, and 14]. It is important to emphasize that all these works investigate CMMI only.

3 Transitional Process Assessment Model

The Transitional Process Assessment Model (TPAM) enables the transformation of results of an assessment according to one process assessment model (PAM) to other models and also deals with the transition to a new version of the model. Also, it provides the means to determine what capability/maturity according to different PAMs software engineering methodologies could ensure. Furthermore, the methodology showing how to extend the transitional model is provided. It covers the following cases: inclusion of a new process assessment model, transition to a new version of existing process assessment model, and addition of a software development methodology.

An organization's assessment according to TPAM and/or transformation of existing assessment's results through TPAM provides the capability profiles and maturity levels according to CMMI-DEV and ISO/IEC 15504-5, as well as other process assessment models included in TPAM. The transformation results should provide enough good understanding of the situation.

All the models must be transcribed according to the defined ontology so they become structurally equal and this facilitates the mapping between them. Table 1 shows the ontology of TPAM. Further in the article, the terms listed in the table 1 are used; otherwise, it would be unclear what is meant because the same concepts are referred differently in ISO/IEC 15504 and CMMI.

Table 1. The ontology of TPAM

TPAM	ISO/IEC 15504	CMMI
Organizational Process	-	Process
Named Process	Process	Process Area
Process Purpose	Purpose Statement	Process Purpose
Outcome	Process Outcome	Specific Goal
Practice	Base Practice	Specific Practice
Generic Property	Process Attribute	Generic Goal
Generic Practice	Generic Practice	Generic Practice

TPAM requirements were defined in [1]. This paper presents how these requirements were implemented in practice. TPAM have only continuous representation. The continuous representation of the model is intended for the assessment of the capability of each Named Process. The assessment result for the organization is the Processes capability profile that consists of capability levels for each Named Process. This approach allows selecting a set of Named Processes to be improved and the order of improvements that best meets an organization's business objectives.

TPAM consists of 2 levels: Visualisation level; and Assessment level. The purpose of the Visualisation level is providing possibility visually to examine TPAM, its Named Processes and practices, as well as relationships with included PAMs (e.g. ISO/IEC 15504-5, CMMI-DEV). Software & Systems Process Engineering Meta-Model (SPEM) [15, 16] has been chosen for the definition of TPAM. Presentation of TPAM in SPEM has been discussed more detailed in [1]. It is elaborated using the EPF tool but for the viewing of TPAM it is enough to have any web browser. Excerpt of TPAM visualisation is provided in Fig. 1.

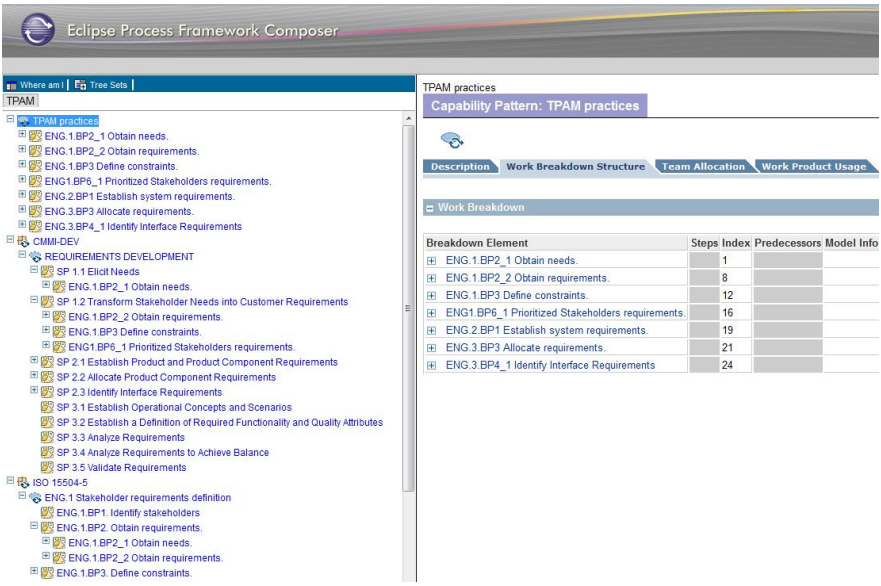

Fig. 1. Visualisation level of TPAM

However, to ensure transformation of assessment results, a more complex data structures are needed. For this purpose TPAM Assessment level has been developed. It ensures possibility to collect assessment results according TPAM or some PAM, then to choose the process assessment model and its version into which the results are to be transformed. Further sections of this chapter analyse the assessment level, present its database schema and algorithms for transformation of an assessment results.

3.1 TPAM Assessment Level

TPAM assessment level consists of three parts. The first part stores TPAM itself: Named Processes, their outcomes and practices. This part will be constantly modified, upgraded and updated when a new version of the integrated PAM is released or a new PAM is to be integrated. The second part consists of TPAM source models, i.e. process assessment models integrated into TPAM. As described in [1], TPAM practices are derived from source models. It is important to emphasize that the Full Coverage rule as shown in Fig. 2 should always be fulfilled: each TPAM practice should be covered fully by one or more practices of integrated models. Transformation of the assessment results should be performed automatically. Therefore, assessment level contains relationships between TPAM practices and corresponding practices of integrated PAMs. These relationships are supplemented by percentage of PAM practice coverage by TPAM practice.

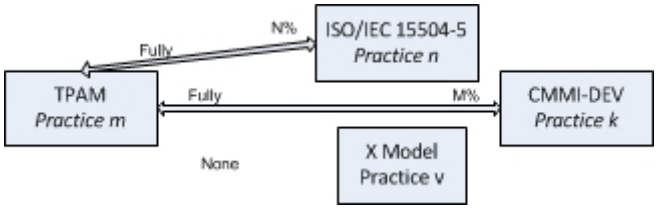

Fig. 2. Relationships between practices of the Models (Full Coverage rule)

The third part serves for the entry of assessment results. The following approaches are supported (as presented in Fig. 3):

- The assessment results according to TPAM are entered and they are transformed into CMMI-DEV, ISO/IEC 15504-5, and other integrated models and/or versions.
- The assessment results according to some integrated PAM are entered. In this case first they are transformed into TPAM assessment. Then transformation to any other integrated PAM become possible.

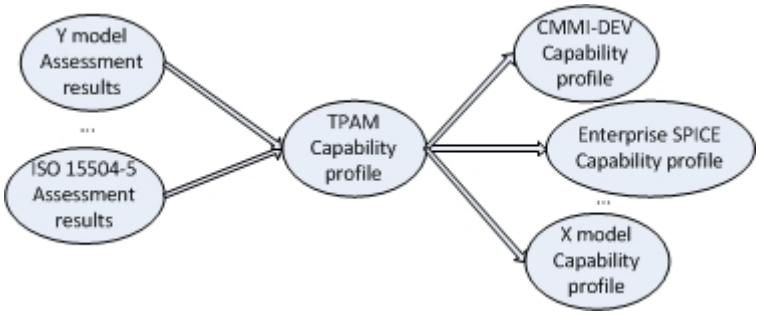

Fig. 3. Transformation of Assessment Results

For example, assessment results of an organization according to ISO/IEC 15504-5 could be transformed into capability profile according to CMMI-DEV through the intermediate transformation into TPAM.

The same approach as for an organization could be applied for the assessment of Agile or other software development methodology, i.e. assessment results according TPAM or some PAM could be entered. It could be noted that in the case of methodology additional possibilities could be useful for the companies implementing it. It is desirable to know how the practices of the chosen methodology influence the assessment results and what capability profile will be ensured after implementation of the selected practices. Therefore, relations between practices of the methodology could be established also. ISO/IEC 15504-5 has been chosen as the key starting model for TPAM. So first, TPAM has been filled by ISO/IEC 15504-5 practices. The second step was integration of CMMI-DEV into TPAM. As a result TPAM practices have been adjusted to meet the Full Coverage rule. The experience of CMMI-DEV integration is discussed in the chapter 4.

3.2 Version Control

It is of utmost importance to control newly released versions. A new model version often has Named Processes that are the same as in the older version. Therefore, TPAM assessment tool involves version tracking techniques. As a result, only new practices should be mapped into TPAM, which saves a lot of time. Changes in the versions are checked at the level of Named Processes. So, assessment results could be transformed to new version of the same model. If we have assessment results according to CMMI-DEV V.1.2 the version control allows getting capability profile according to CMMI-DEV V.1.3 in uncomplicated and not very time consuming way.

The same approach would be applied when releasing new versions of TPAM itself. After the integration of a new model into TPAM, a new version should be released because TPAM practices change: some of them can be separated and new practices appear. So, without tracking TPAM versions, old assessment results could not be transformed into new models without complete remapping of new TPAM to all previously integrated PAMs.

3.3 Database Schema

Visualisation level of TPAM has been implemented in SPEM using EPF. Assessment level is more complicated so relational database has been chosen for its implementation. The database schema is shown in Fig. 4. It is divided into three logical parts: *Transitional Process Assessment Model, TPAM source models* and *Assessment results*. The first part *Transitional Process Assessment Model* stores TPAM Named Processes and their practices. The table *TpamPractices* stores Generic Practices also; they are used for the assessment of capability levels higher than the first. Generic Practices have been integrated following the same approach as base/specific practices. The Generic Practice also has the links to its source and Named Process. Named Processes have been introduced into TPAM because

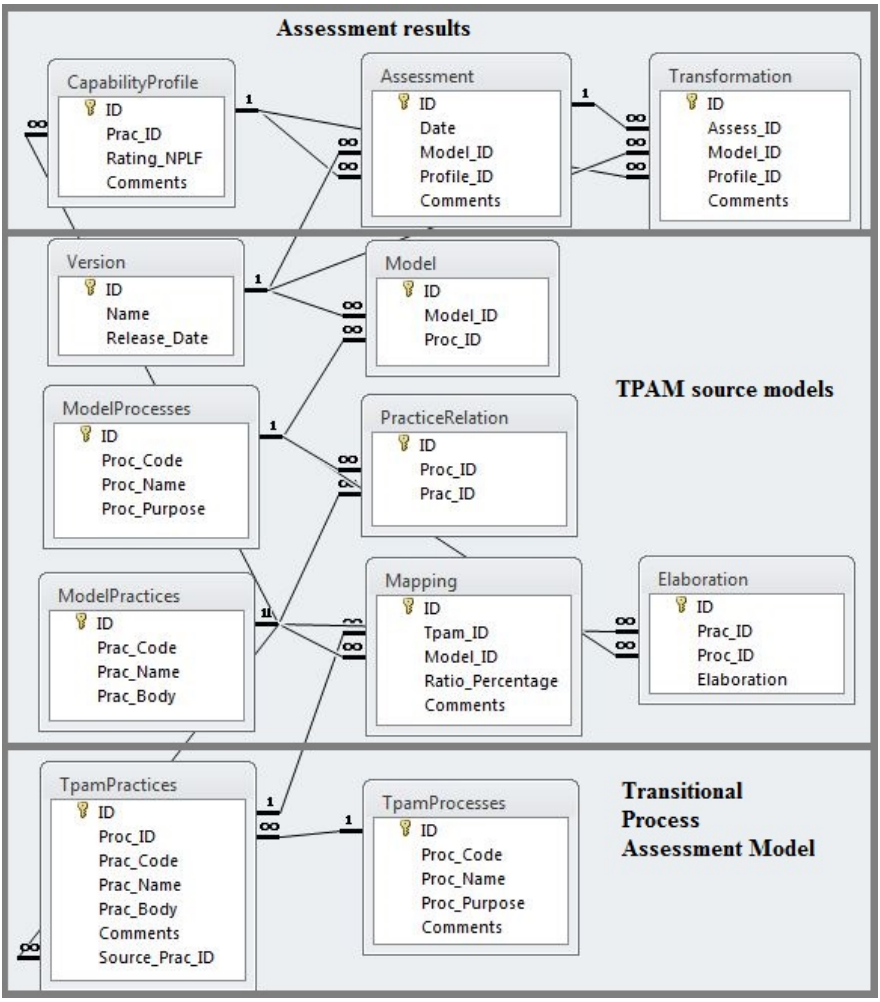

Fig. 4. TPAM assessment level database schema

ISO/IEC 15504-2:2003 states such requirement for PAMs and they allow getting TPAM capability profiles. It should be noted that for the transformation into other PAMs Named Processes are not needed. TPAM capability levels are coinciding with capability levels of ISO/IEC 15504-2:2003.

The second part *TPAM source models* is used to store both: integrated PAMs and mapping between them and TPAM. Model versions are stored in the table *Version*, and the *Model* table links the version to corresponding Named Processes. If a Named Processes is the same as in the old version, only the link to the old Named Process is indicated. The most important is the table *Mapping* keeping the links between TPAM practices and practices of integrated models. It is a one-way link – from TPAM practice to integrated model's practice – because TPAM practices are constructed so

that they satisfy Full Coverage rule. The percentage of PAM practice coverage by TPAM practice is kept in the field *Ratio_Percentage*. The sums of *Ratio_Percentage* for all integrated PAM practices should be 100%; otherwise, it means that some practices are missed in TPAM or there is a mistake in percentage assignments. If certain TPAM practice is completely uncovered by all practices of certain integrated PAM, this TPAM practice is not linked to such PAM. The table *Elaboration* is used to store Generic Practices examples of Named Process related experiences. Such information is provided in CMMI-DEV V.1.3 only but is very useful when performing an assessment so it has been included into TPAM.

In the third part *Assessment results*, assessment results and transformation data are stored. If an organization aims to assess what advantages it could get by using a certain Agile or other methodology, it simply assess this methodology directly according TPAM practices and then the results are transformed into desired models (e.g. CMMI-DEV). If a company already has assessment results according to some PAM (e.g. CMMI-DEV), these results are entered into the table *CapabilityProfile*. Then they are automatically transformed into chosen models. The desired transformations should be indicated in the *Transformation* table. Transformations are also possible into different versions of the same model.

3.4 Rating Scale

The assessment results of the practice could be entered into TPAM as a percentage and as a standard rating in NPLF scale as described in Table 2 (further NPLF rating). This rating scale is based on the ratings of ISO/IEC 15504 and Standard CMMI Appraisal Method for Process Improvement (SCAMPI). The SCAMPI rating do not provide percentage scale but the descriptions basically coincide.

Table 2. Standard rating scale

Value	Percentage scale of achievement	Description
N – Not achieved	0 to 15 %	Insufficient objective evidence exists to state that the practice is implemented.
P – Partially achieved	>15 % to 50 %	Some artefacts are absent or judged to be inadequate. One or more weaknesses are noted.
L – Largely achieved	>50 % to 85 %	Sufficient artefacts are present and judged to be adequate. One or more weaknesses are noted.
F – Fully achieved	>85 % to 100 %	Sufficient artefacts are present and judged to be adequate. No weaknesses are noted.

The intermediate calculations during transformation are performed in percentage but the results of transformation are provided additionally as NPLF rating because ISO/IEC 15504 expresses requirements for capability levels in terms of NPLF rating.

For example, a Named Process gets the capability level 1 if assessments of all its practices are L or F.

More accuracy would be ensured by assessing the practices in percentage, and it is recommended to apply such approach when performing a new assessment. But it is more likely that already existing capability assessment of an organization will be in NPLF rating than in percentage.

Two types of transformations are employed in TPAM assessment tool: X model assessment results to TPAM; and TPAM assessment results to Y model. It is important to emphasize that transformation of the assessment results according to X model to TPAM are performed precisely even they are provided as NPLF rating because of Full Coverage rule. For example, the practice of CMMI-DEV RD SP 1.2 *Transform Stakeholder Needs into Customer Requirements* covered completely by 3 TPAM practices: *Obtain requirements*, *Define constraints*, and *Prioritize Stakeholders requirements*. Thus, if CMMI-DEV RD SP 1.2 practice is assessed as Largely achieved, all 3 corresponding TPAM practices get rating Largely achieved.

Unfortunately, precise transformation of the assessment results provided as NPLF rating from TPAM to Y model is not possible. Therefore, transformation algorithms have several options for interpretation of the assessment results provided as NPLF rating:

- Lowest values: N – 1%, P – 16%, L – 51%, F – 86%;
- Mean values: N – 8%, P – 33%, L – 68%, F – 93%;
- Highest values: N – 15%, P – 50%, L – 85%, F – 100%.

Because the capability profile of a company should not increase after the transformation, the lower bound is taken by default. For example, the same 3 practices of TPAM – *Obtain requirements*, *Define constraints*, and *Prioritize Stakeholders requirements* – are assessed as Largely achieved (by default the lowest value 51% is taken for calculations). Then CMMI-DEV RD SP 1.2 gets rating: (51*50+51*40+51*10)/100=51 → Largely achieved. Suppose one of TPAM practices *Obtain requirements* is assessed Fully achieved, then CMMI-DEV RD SP 1.2 gets rating: (86*50+51*40+51*10)/100=68,5→Largely achieved. It should be noted that TPAM assessment tool provides the possibilities to select other 2 options as well as to compare transformation results got using different options. So, enough thorough analysis of the capability according to the destination PAM could be carried out.

4 Integration of CMMI-DEV into TPAM

ISO/IEC 15504 is de jure international standard so ISO/IEC 15504-5 has been chosen as the key starting model for TPAM. First, TPAM has been filled by the practices of ISO/IEC 15504-5. Then CMMI-DEV practices one by one have been integrated into TPAM. This has caused adjustments of TPAM practices in the following four ways:

1. If CMMI-DEV practice is not addressed in TPAM yet it has been included into TPAM.
2. If CMMI-DEV practice is essentially the same as some TPAM practice, no changes have been made.
3. If CMMI-DEV practice is more detailed than existing TPAM practice, the corresponding TPAM practice should be adjusted even if some CMMI-DEV practices together match one practice of TPAM. Therefore, the existing TPAM practice is replaced by 2 new practices: CMMI-DEV practice and the rest part of TPAM practice. The description of new TPAM practice derived from CMMI-DEV is modified in order to correspond the terms used in TPAM (e.g. change stakeholder into customer where it means the same). So, the integrity of TPAM is preserved and the Full Coverage rule is fulfilled.
4. The last case is when the CMMI-DEV practice partially covers the existing TPAM practice and no one is a subset of another. It should be noted that this case is the most common and complicated. In this case, both practices (CMMI-DEV and TPAM) are divided. The existing TPAM practice is replaced by 2 new practices: common part of CMMI-DEV and TPAM practice, and the rest part of TPAM practice. The rest part of CMMI-DEV practice is further investigated according to all four rules.

It should be emphasized that these four rules are enough for integration of all practices of CMMI-DEV or any other process assessment model. Practices of TPAM always have a priority versus other models, because ISO/IEC 15504-5 is the primary source of these practices. When including CMMI into TPAM the following problem has occurred: one model has superficial-abstract practices and they correspond to several more detail practices in other model. In this way, a specific requirement is separated from superficial practice and the abstractness is left in the new practice. For example, TPAM practice **ENG.1.BP5: Identify critical requirements.** *Specify health, safety, security, environment and other stakeholder requirements and functions that relate to critical qualities and shall address possible adverse effects of use of the system on human health and safety.* As there is no such practice in CMMI, where specific listed requirements should be identified, this practice should be divided into two: **ENG.1.BP5_1: Identify critical requirements.** *Specify stakeholder requirements and functions that relate to critical qualities and shall address possible adverse effects of use of the system on human health and safety.* and **ENG.1.BP5_2: Identify health and safety requirements.** *Specify health, safety, security and environment stakeholder requirements and functions.* In this way, a model which does not list the requirements and demands to identify the requirements will satisfy **ENG.1.BP5_1** practice, but will not cover **ENG.1.BP5_2** practice, as it is not clear whether the assessed company really distinguishes these requirements.

It is also very important to draw attention to the terms of the model to be integrated. TPAM uses the terms of ISO/IEC 15504-5; therefore, when including the new practices or Processes, their descriptions should be adapted according to the terms of ISO/IEC 15504-5, as it is necessary to maintain the integrity of TPAM practices and Named Processes. Some examples of differences are presented in Table 3. Of course, these terms are not perfect synonyms, but in the scope of CMMI-DEV process area *Requirements development* and ISO/IEC 15504-5 process *Stakeholder requirements definition* these terms have been matched and changed into TPAM concepts.

Table 3. The relationships between TPAM and CMMI-DEV concepts

CMMI-DEV	TPAM (ISO/IEC 15504-5)
Customer requirements	Stakeholder requirements
Product Requirements	System requirements
Product component requirements	Software requirements

5 Approach for Enterprise SPICE Integration

After integration of CMMI-DEV the third model to be integrated into TPAM is Enterprise SPICE, which is currently being actively developed and becoming popular. Enterprise SPICE aims to establish an integrated model for enterprise-wide assessment and improvement for use with international standard ISO/IEC 15504 (SPICE) [17]. Enterprise SPICE is appropriate to assess the capability/maturity of the company operating any business. TPAM is appropriate only for software development capability assessment. Therefore, Enterprise SPICE will be approached from the perspective of software development only. Enterprise SPICE has a specific element Special Applications (Safety and Security) that is not presented in ISO/IEC 15504-5 and CMMI-DEV. After investigation it has been decided that Special Application will be included into TPAM as Named Process with special flag because they are structurally similar. As Special Application's practices are derived from practices of other Named Processes, TPAM structure will be slightly adjusted by adding the links between these practices. So, it can be stated that TPAM fits for the models of Enterprise SPICE type.

6 Conclusions

The proposed Transitional Process Assessment Model (TPAM) ensures the possibility to deal with multiple Process Assessment Models (PAMs) by the transformations of an assessment results to all integrated PAMs. The proposed construction principals have been testing by developing TPAM that integrates ISO/IEC 15504-5 and CMMI-DEV V1.3. Enterprise SPICE integration into TPAM has been investigated and very minor additions in TPAM assessment level have been determined. So, it could be stated that TPAM ideas could be applied to different PAMs, including ones under development (e.g. ISO/IEC 330xx series). It is obvious that this model will never replace lively assessment process of the company. However, it lets with some margin of error convert assessment results to other models cheaply and quickly. Verification of the correctness of resulting capability profiles and more precise determination of the margin is in progress. Agile software development methodology – DSDM Atern – has been assessed directly according to CMMI-DEV. Method for the assessment of Agile methodologies according to TPAM has been developed. Now DSDM Atern assessment according to TPAM is performed. Then the results of both assessments will be transformed using TPAM and compared.

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