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Validating the Software Process Assessment Model for Korean Military Software Industry

Il-Lo Lee[1], SunTae Kim[2,*] and Soojin Park[3]

[1]*Defense Agency for Technology and Quality, Seoul, South Korea*
[2]*Dept. of Computer Engineering, Kangwon National University, SamCheok, Kangwon Do, South Korea*
[3]*Graduate School of Management of Technology Sogang University, Seoul, South Korea*
[1]*215-b@hanmail.net*, [2]*stkim@kangwon.ac.kr*, [3]*psjdream@sogang.ac.kr*

Abstract

This paper presents three-step process for validating the software process assessment model and report the result of each step to check the validity of MND-ESPAM. MND-ESPAM is the software process assessment model invented for evaluating the software process capability of Korean military software organizations, but it is not sufficiently validated so that it cannot be decided to spread it into the military software industry. The three-step process suggested in this paper is composed of 1) the investigation of the state of the Korean military software companies via a questionnaire survey, 2) the software process assessment via a questionnaire survey based on MND-ESPAM, and 3) the experimental software process assessment by the CMMI appraisal team with MND-ESPAM. After the validation, we suggest important improvements of the MND-ESPAM assessment model.

Keywords: *MND-ESPAM, Software Process Assessment Model, Korean Military Software*

1. Introduction

As weapon systems become more complex and intelligent recently, the importance of the software is more emphasized for their advanced abilities. The software in the combat airplane F-4 at 1960, for example, was only in charge of 8% of all functionalities, while the software of F-22 Raptor covers 80% of all functions [1]. Due to high dependency for the software, the internal or external quality issues in developing and maintaining the software have been emerged. In order to handle these issues, SEI (Software Engineering Institute) developed CMMI (Capacity Maturity Model-Integrated) for evaluating the quality of the software development process of an organization [2]. Similarly, the Korean government also has developed the SP (Software Process) certificate for medium and small scale software companies [3].

As the SP certificate is intended for the non-military software, it was hard to directly apply it into the military software industry which must support an embedded system with high reliability, testability, maintainability and longer development & maintenance period [4]. This

* *Corresponding Author: Suntae Kim, Ph.D.*
Dept. of Computer Engineering, Kangwon National University, Sam-Cheok Si, Kangwon Do, South Korea

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motivated DTaQ (Defense Agency for Technology and Quality) to develop the Assessment Model of the Embedded Software Process (MND-ESPAM) for the Korean military software in 2009 [5]. MND-ESPAM is built upon CMMI, SPICE [6, 7] and SP, and simplified for Korean military software industry. It is also tailored by applying MND-TMM [8] and IEC 61508 [9] for the sake of advanced software testing and safety. However, MND-ESPAM does not have enough applications for its validation so that it is difficult to decide to spread the evaluation model into entire military software industry in Korea.

This paper proposes three-step process for validating MND-ESPAM and reports the results of each step to check the validity of the assessment model, and identifies improvements of the assessment model. It starts with diagnosing the current state of the Korean military software companies in terms of its software process quality, which is a mandatory step to examine the subjects for checking the validity of the MND-ESPAM. Then, as the second step, the MND-ESPAM is applied to evaluate the software process capability maturity level by using a questionnaire for the selected subject companies. The result of this step is compared to CMMI maturity level of the subjects for checking the validity of the MND-ESPAM. At last, the CMMI appraisal comprehending the MND-ESPAM assesses two selected companies with the process assessment model, and then we collect the result of checking comprehensiveness and applicability of MND-ESPAM through a survey of appraisal interviewees. Based on the three steps, we discuss the shortcomings of the assessment model and suggest how to improve them. The contributions of this paper are summarized as below:

- *Evaluating the MND-ESPAM assessment model*: the three-step process for validating the process assessment model is worthy of consulting when establishing a new assessment model or software development and maintenance process and checking its validity.
- *Reporting the state of Korean military software industry*: In the three-step process, we report the current state of the Korean military software companies including the organization scale, software process maturity level of each organization.
- *Improving the MND-ESPAM assessment model*: We identify shortcomings of MND-ESPAM compared to the CMMI and suggest improvements of the assess model.

This paper consists of 5 sections. At first, software process assessment models and its technical trend are presented in Section 2. In Section 3, we introduce the MND-ESPAM assessment model developed by DTaQ in 2009. In Section 4, we provide the evaluation result of military software in Korean defense industry, which includes the current state of Korean military software industry, the assessment result of software process capability maturity level for 22 military software companies. In addition, we present the result of experimental software process assessment for two military software companies. In Section 5, we propose the improvements of the assessment model with analyzing the results of Section 4. Finally, we present conclusion in Section 6.

2. Related Work

This section presents representative software process assessment models including CMMI, SPICE and K-Model, each of which is currently used in the military software industry broadly. At first, CMMI (Capability Maturity Model Integration) was initially proposed by SEI (Software Engineering Institute) only for assessing the level of software development of an organization at 1993. In 2002, CMMI v.1.1 was updated into the integrated model for covering software as well as hardware areas. Then, CMMI v.1.3 recently released in 2011 has been widely used to improve the system process including hardware and software

development and maintenance process. CMMI proposes 5 levels as an indicator of the capability maturity of software process consisting of 22 process areas in 4 categories (*e.g.*, Process Management and Engineering).

SPICE (Software Process Improvement and Capability dEtermination) was formed in 1999 as ISO/IEC TR 15504, which is the international standard for assessing software process. However, the number of the SPICE application cases is quite small compared to that of CMMI in Korea, because it takes much time to elicit an internationally consensual assessment. SPICE classifies the software process maturity of an organization into 6 levels composing of 48 process areas in Acquisition, Supply, Engineering, Operation, Management, Process Improvement, Resource and Infrastructure, Reuse, and Support groups.

In Korea, the National IT industry Promotion Agency (NIPA) developed K-Model suitable for Korean software industry based on CMMI, SPICE and so on. Now this model has been used to issue the SP (Software Process) certificate. K-Model classifies the software process maturity into three levels containing 76 detailed assessment items grouped in 17 assessment categories of 5 areas. Recently the Korean Defense Acquisition Program Administration (DAPA) had tried to spread the access model into the military software industry by establishing the regulation that the organizations obtaining SP level 2 or 3 shall get the extra benefit in joining the military research and development (R&D) projects.

In addition to these, there are ISO/IEC20000-2 [10] and CobiT [11] which provides the best practices of software business. However, these commercial software process models are insufficient to apply the R&D project in defense domain, because they just focus on the general software without handling the military specific software attributes such as difficulty of software testing, high reliability and long-term schedule commonly over 2 years.

3. Background: MND-ESPAM

MND-ESPAM is a software process assessment model invented for evaluating the software process capability maturity of Korean military software organizations by Korean DTaQ (Defense Agency for Technology and Quality) in 2009 [5]. It has been created by extracting common process areas from CMMI, SPICE and SP, and incorporating it with the process areas from MND-TMM [7] for enforcing reliable testing into the process, and those from IEC 61508 [8] for guaranteeing software safety. In addition, it is aligned with the Defense Software Development Guideline from DAPA which plays a key role to orchestrate military R&D projects in Korea.

In MND-ESPAM, the capability maturity of the organization is classified into *Amateur* (Level 1), *Managed* (Level 2), *Defined* (Level 3) and *Improved* (Level 4) levels as shown in Table 1. The *Amateur* level indicates the maturity level for an organization which has unpredictable and uncontrolled software process. The *Managed* level is the extent of maturity for an organization that establishes diverse project-specific software processes or sometimes carries out some of the processes after finishing a project, while the *Defined* level is for an organization which defines a standard software process for entire software projects of the organization. The *Improved* level represents the maturity of an organization where most of the processes are quantitatively measured and controlled.

Table 1. Maturity Levels of MND-ESPAM

Process Category	Level1 (Amateur)	Level2 (Managed)	Level3 (Defined)	Level4 (Improved)
Management		- Project Planning - Project Control - Co-worker Management		- Quantitative Project Management
Development		- Requirement Management	- Requirement Analysis - Design - Implementation - Integration - Install and Acceptance Support - Verification - Test Readiness	
Organization			- Organization Process Management - Resource Management - Reuse Management	- Organization Performance Management - Organization Process Innovation
Support		- Measurement and Analysis - Configuration Management - Quality Assurance		

Each level includes the key process area categorized as *Management*, *Organization*, *Development*, and *Support*, each of which contains process areas such as *Requirement Management*, *Quality Assurance* and so on for each level (see Table 1). Each process area is described in the *Objective*, *Major Measurement Metrics* and *Related Process Area*, also it contains sub components including the generic goal, generic activity, output instance and so forth. Figure 1 presents the *Requirements Management* process area of the *Development* category of the Level 2.

After establishing the assessment model, diverse software practitioners in this area have checked its validity in terms of comprehensiveness, applicability and effectiveness. However, it needs to find out various applications where the MND-ESPAM can be applied to enhance it.

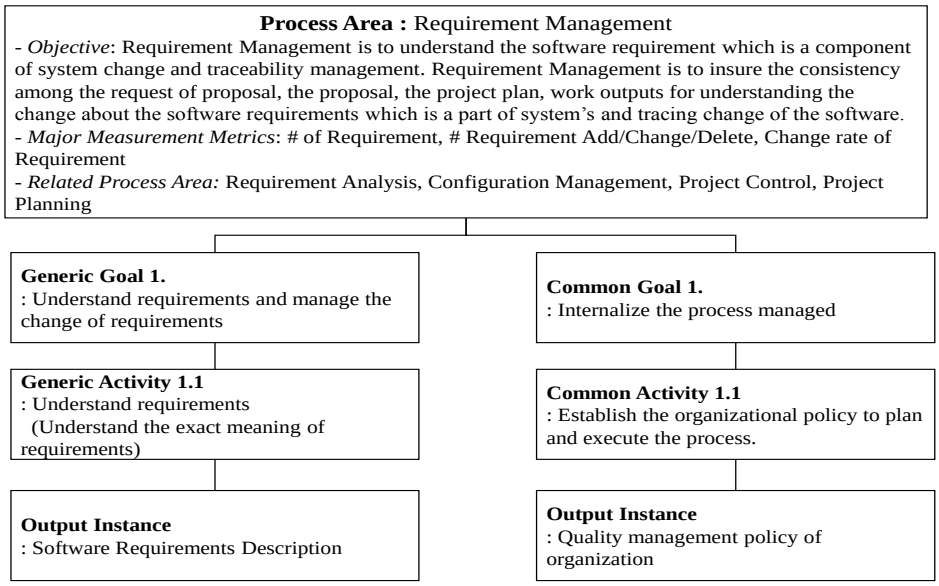

Figure 1. The Structure of the *Requirement Management* Process Area

4. Validating MND-ESPAM

4.1. Overview

In order to check validity MND-ESPAM, this paper proposes the three-step process and reports the results of each step as shown in Figure 2. As the first step, the subject companies for evaluating software process have been selected after inquiring about the software-intensive companies to DTaQ, then sent a questionnaire for investigating their current state for the software development and maintenance process. The second step investigates the capability maturity level of military software process by sending a questionnaire based on MND-ESPAM to the selected companies from the previous step. In the last step, the CMMI appraisal comprehending the MND-ESPAM assesses the selected companies with the process assessment model, and then checks comprehensiveness and applicability of MND-ESPAM by the questionnaire survey. After the validating process, we identify improvements of the MND-ESPAM in Section 5.

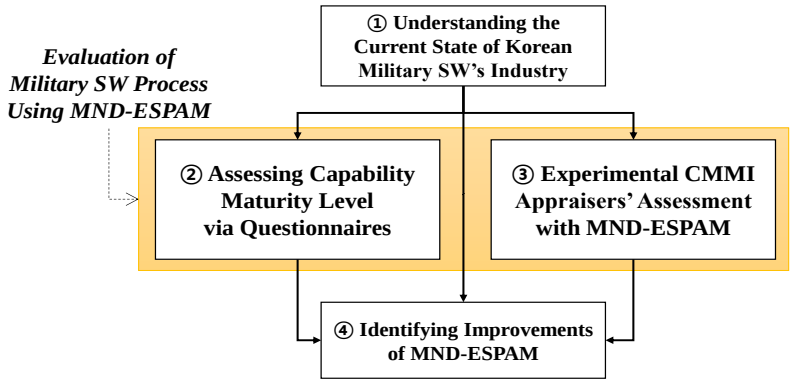

Figure 2. An Overview of the Approach for Validating MND-ESPAM

4.2. Understanding the Current State of Korean Military Software Industry

4.2.1. Survey Subject Scoping and Criteria for Classification

Before directly assessing the capability maturity level of the military software organizations with MND-ESPAM, gathering information on the software companies and selecting the subjects are needed. In order to support this, we first requested DTaQ to search military software companies so that we selected 65 survey candidates from 668 defense companies. Then, we sent the questionnaire to the software organizations for gathering the current state on their software development and maintenance process for a month since Jun. 2011. Specially, we requested the authoritative staffs in charge of software development to respond the questionnaire for the sake of correctness of the survey.

The questionnaire is a set of questions on the extent of the business income of the organization, efforts on software process management and improvement and so forth. For the result analysis, we defined the classification criteria composing of the size of company, the proportion of software, software process certificates as shown in Table 2.

Table 2. Classification Criteria for the Survey Result

<table>
<tr><th>Attribute</th><th>Classification</th><th colspan="4">Criteria for Classification</th></tr>
<tr><td rowspan="3">Scale of Company</td><td>Large Scale</td><td rowspan="3">Sales Figures</td><td>Over 100 (billion won)</td><td rowspan="3">Number of Employees</td><td>Over 300</td></tr>
<tr><td>Medium Scale</td><td>10 ~ 100</td><td>Over 50</td></tr>
<tr><td>Small Scale</td><td>Under 10</td><td>Under 50</td></tr>
<tr><td rowspan="4">Portion of SW</td><td>1 ~ 25%</td><td colspan="4" rowspan="4">Ratio of SW Development expenses against total project expensens</td></tr>
<tr><td>25 ~ 50%</td></tr>
<tr><td>51 ~ 75%</td></tr>
<tr><td>Over 75%</td></tr>
<tr><td rowspan="2">SW process certification</td><td>Certificate</td><td colspan="4" rowspan="2">CMMI, SPICE, SP</td></tr>
<tr><td>Non-certificate</td></tr>
</table>

4.2.2. The Result of the Survey

27 of 65 companies responded to the questionnaire, consisting of 11 large-scale, 11 medium-scale and 5 small-scale companies classified by the criteria as shown in Table 2. About 32% of total employees were engineers where 17 % of them was HW engineers and 15% was SW engineers. Their major products were firepower weapons, ground vehicle weapons, the C4I system, and surveillance and reconnaissance systems in turn according to its frequency.

The proportion of software in project expenses was lower than 50% in 96% of companies as shown in Table 3. The number of the companies which software proportion is under 25% was 55%. Due to the characteristics of this application domain, there was no company that only develops the software system without any hardware support.

Table 3. Proportion of Military Software

Proportion of SW	Large Scale Company	Medium Scale Company	Small Scale Company	Total
Under 25%	6 (22%)	6 (22%)	3 (11%)	15 (55%)
26~50%	4 (15%)	5 (19%)	2 (7%)	11 (41%)
Over 75%	1 (4%)			1 (4%)
Total	11 (41%)	11 (41%)	5 (28%)	

12 companies (44%) obtained the CMMI certificates above level 2 and most companies having the CMMI certificates also acquired other system or software certificates such as Defense Quality Management System [12]. The responds show that as the companies are in charge of larger scale software development, they tend to have more or higher certificates. As the company scale is bigger, the companies held diverse certificates while most of the small scale companies did not have any certificate. As the evidence for this, there ~~are~~ was no CMMI certificated companies among the small scale companies which sales figure is under 10 billion won and the number of employees are under 50.

For the software process improvement, 15% of the respondents thought that the software process improvement is unnecessary, while 85% of them told that software process improvement is necessary as shown in Figure 3. 55% of them said that the process improvement is needed for enhancing the quality of product and productivity. However, some companies have just uitilized software improvement in order to satisfy the request from customers or differentiate them from business competitors.

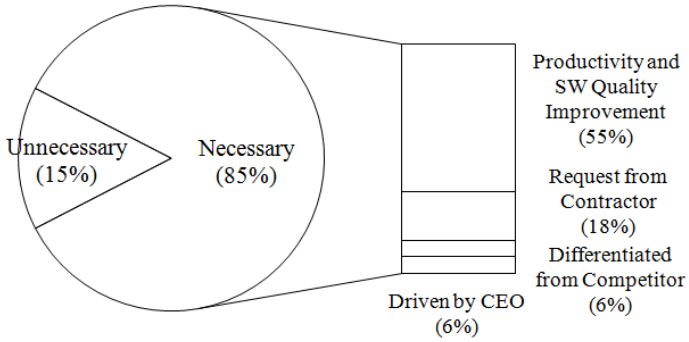

Figure 3. Respond for the Necessity of Software Process Improvement

The respondents said that major expectation for the software process improvement is quality improvement of their released products, because they expected that they can achieve defect decrease, quality and reliability improvements as shown in Figure 4. However, they relatively did not think they can improve their productivity with the software process improvement, because they tend to think of over-workload for executing the improved software process.

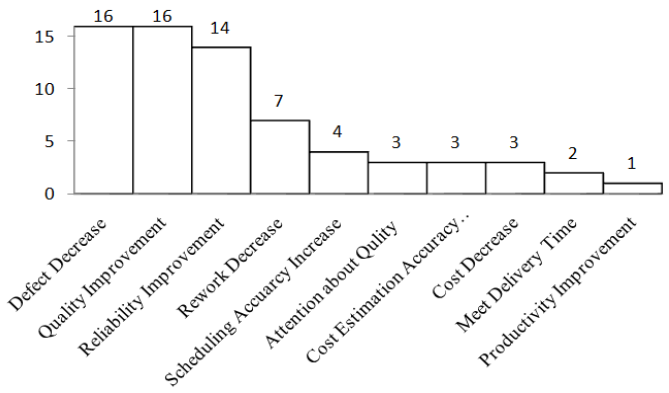

Figure 4. Expected Effect for the Software Process Improvement

For the causes of hindering software process improvement, the lack of the man power or budget were pointed as the major causes. Also, it should be noted that many respondents pointed out the lack of the CEO's willpower for the process improvement. In order to overcome these issues, about 40% of the companies are currently trying to operate training courses for the process improvement. Unfortunately, any of the small scale companies do not try to operate the course during the survey. Compared to the effort for improving software process, 41% of the companies executed the internal quality audit for the system. Particularly, 26% of them have conducted the audit more than once for a project, and 15% have done that annually.

When it comes to the software development step which quality should be improved, the *Requirement Analysis* step was selected to the most important step for developing military products like Figure 5. Subsequently, the diagram says that *Design* and *Coding & Unit Test* are important in turn. Thus, we can infer that the acquirers or contractors for the software system should provide clear requirements to developers in the early stage of the project.

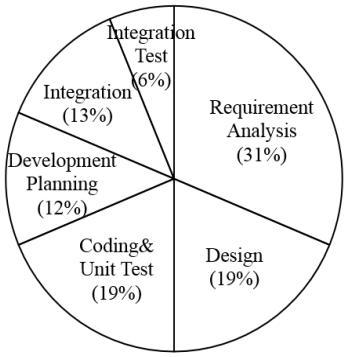

Figure 5. Software Development Steps which Quality should be Improved

For the importance of the software's internal quality, *Reliability* (27%), *Interoperability* (17%), *Safety* (17%), *Functionality* (15%) were considered as the important quality attributes of the military software. The survey results also say that the *Project Management* and *Support* process areas are important for successful project.

4.2.3. Implications of the Survey Result

From the survey results, we could estimate that 60% (16 companies) of the 27 companies were small and medium scale companies. It seemed that the practitioners have been frequently frustrated in improving software process because of the lack of man power, budget and CEO's willpower. Therefore, the government should focus on enhancing the capability level of military software process for small and medium scale companies.

We recognized that the reliability, interoperability and safety are the key quality attributes of the military software system so that the process assessment model should focus on these qualities of the system in assessing the process. In addition, practitioners said that the enforcement of the *Requirement Analysis* process area is strongly required, which means that ambiguous requirements of the customer, and frequent requirements changes during developing the system are critical issues which impact on schedule and software quality.

4.3. Assessing Capability Maturity Level via Questionnaires

As the second step for validating MND-ESPAM, this section presents the assessment result for the military software companies with MND-ESPAM via the questionnaire for checking their process state for developing and maintaining the military software.

4.3.1. Subject Scoping for the Assessment

22 of 27 military software companies presented in the previous subsection were involved in assessing their process maturity level via MND-ESPAM with responding our questionnaire for one month since Oct. 14 at 2011. The companies involved in this assessment consists of 9 large-scale companies (41%) and 13 small/medium scale companies (59%), which had at least 10 year experience in this area. 70% of military software projects took 2 years on average, especially some of the project took over 6 years. It is caused by characteristic of military project having long-term development and testing. Also, 15 companies (68%) obtained software process certificates including 6 companies with CMMI level 2, 2 companies with CMMI level 3, 2 companies with CMMI level 4, and 5 companies GS (Good Software) or ISO9001 certificates respectively as shown in Figure 6.

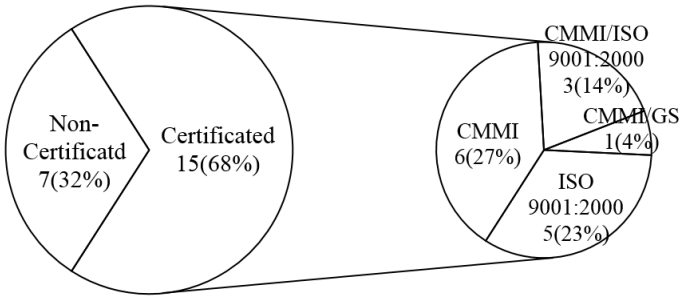

Figure 6. Software Process Certificates Holders in Military Software Industry

4.3.2. Authoring the Questionnaire for the Assessment

The questionnaire is composed of 123 questions for checking the maturity level defined in the Level 2, 155 questions for the Level 3, and 45 questions for the Level 4. Table 4 shows the questions for checking the activity of project scoping in the organization. The responder responses to each question with one of the FI (Fully Implemented), PI (Partly Implemented), NI (Not Implemented), and N/A (not applied to the project). In addition, the output instances

of the process activities are exemplified for understanding the question precisely. The replies FI, PI and NI are quantified into 100, 50 and 0 points respectively. Thus, the organization with over 80 points on average for each process was assessed as 'Sufficient', while the one under 80 points is evaluated as 'Insufficient'. Due to the space limit, a part of the questionnaire is presented in Appendix A.

Table 4. Questions for Checking Project Planning

Process Area	Activity	No.	Inquiry	Reply				Output Instance
				FI	PI	NI	N/A	
Project Planning	Project Scoping	1	Do you define fine-grained tasks after depicting the Work-Breakdown Structure (WBS)?					WBS
		2	Do you define work product of the leaf node of WBS?					WBS
		3	Do you define reusable work product?					List of work product

4.3.3. Result of the Assessment

The survey results say that 11 (50%), 7 (32%), 3 (14%) and 1 (4%) of 22 companies were classified into the Level 1, 2, 3, and 4 respectively. Particularly, all organizations classified as Level 2~4 were turn out to be certificate holders of upper level 2 of CMMI. Two companies having CMMI level 5 satisfy the requirements of process areas in the Level 4 of MND-ESPAM, while most of the companies obtained low points for the Level 4 questions.

When it comes to analyzing the result in terms of company scale, 8 of 9 large-scale companies were evaluated as over Level 2, while 10 of 13 medium and small scale companies were classified into the Level 1. We could know that the one large company for Level 1 has recently started defense business. Consequently, the number of the small and medium scale companies for maturity level was 10 for Level 1, 2 for Level 2, 1 for Level 3 respectively, and no one for Level 4. Particularly, 3 small and medium scale companies have not officially executed software process.

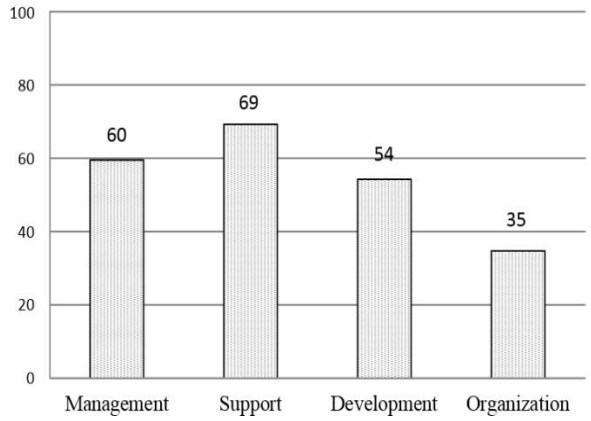

Figure 7. Process Execution Scores for each Process Category

Also, 90% of 10 CMMI certificated companies showed the maturity over Level 2, but most companies (83%) without the CMMI certificate were classified into the *Amateur* level in MND-ESPAM. In the view of process category, the *Support* category composed by process area in Level 2 had the highest points (69) and the *Organization* category composed by process area in Level 3, 4 had the lowest points (35) (see Figure 7).

The average score for all organizations was 70 points out of 100 in the process area of the Level 2, 50 points for those of the Level 3, 21 points for those of the Level 4. Analyzing each process category in more detail indicates that the organizations earned 65.1 and 66.3 in the *Requirement Management*, and *Configuration Management* process area respectively, and also they got 30.1, 47.8 and 49.4 points for the *Reuse Management*, *Verification*, and *Design* process area respectively as shown in Figure 8. On the other hand, the scores for the *Project Control* (72.2) in Level 2 and *Integration* (56.1) in Level 3 were relatively higher than others. Specially, they got very low score for the *Reuse Management* process area.

Figure 8. Scores of Each Software Process Area

4.4. The Experimental CMMI Appraisers' Assessment with MND-ESPAM

4.4.1. An Overview of the Experimental CMMI Appraisal Assessment

This section presents the experimental software process assessment of the CMMI appraisal team for two military software companies with MND-ESPAM. The goal of this experiment is to find out improvements of MND-ESPAM and validates whether we can apply MND-ESPAM adequately into the real software companies or not. After the assessment, we gathered the questionnires on the comprehensiveness and applicability of the assessment model from the appraisal interviewees. In addition, the difference between the actual military software process of the two companies and that of MND-ESPAM is analyzed for improving MND-ESPAM.

The subject consists of two companies: the company *A* certificated by CMMI level 3 and the company *B* with no experience for evaluating their process with the commercial software process assessment model, which is intended to figure out the deviation between MND-ESPAM and CMMI.

4.4.2. Assessment Process Areas

We have applied the Level 3 MND-ESPAM process areas into the company *A*, because the Level 3 of MND-ESPAM is considered as the similar maturity level of the CMMI maturity level 3. Table 5 summaries the subjects of the experimental assessment. Also, the Level 2 MND-ESPAM process areas have been applied into the company *B*. In order to guarantee the reliability of this experiment, the expert groups of embedded software process including CMMI lead apprasiers and software practitioners of the defense domain participated in this assessment. We acquired practice implementation indicator description to finish the assessmet on planned schedule and gathered VOC (Voice of Client) from software practitioners of companies to figure out improvements of MND-ESPAM.

Table 5. Summary of the Experimental Assessment

		Company A	Company B
CMMI level		level 3	None
Organization's Assessment Level MND-ESPAM		Level 3	Level 2
Project phase		System Integration & Testing	Test Development
Assessment period		4 Days	3 Days
Appraisal team	Number of CMMI appraisers	4	3
	Number of Military SW Practitioners	4	3
Assessment Subject of Process Area		16 Process Areas	7 Process Areas
Appraisal Interviewees		10	6

4.4.3. The Result of the Assessment

As the result of the experiment for the two companies, we recognized that the MND-ESPAM accessment model could be properly applied to military software industry. At first, the assessment showed us that the company *A* had properly implemented the process areas of the *Development* category for military software development. However, they were needed to standadize their software process to effectivley excute the project. Also, it must be strengthened that the role and responsibility for each process area should be cleary defined, and the *Monitoring and Control* activity for the process areas was insufficient. Therefore, the company *A* was finally assessed to have capability maturity Level 2.

In the case of the company *B*, they did not prepare the organizational standard for the planning and procedure in order to conduct military software development projects. Their capabiliy for the software process was not considered to achieve the MND-ESPAM Level 2. The company *B* was strongly recommended to establish basic software processes with standadizing processes in the Level 2 of MND-ESPAM. Based on the assessment result, the two companies did not satisfy the expected maturity levels of MND-ESPAM.

4.4.4. Analysis of Comprehensiveness and Applicability of MND-ESPAM

The apprasial interviewees who were in charge of improving software process in their organization evaluated the comprehensiveness and applicability about the process areas of MND-ESPAM Level 2 and 3 on the five scales from 1 (Insufficient) to 5 (Sufficient). The evaluation had been conducted by the questionnaire after the experimental assessment. 6 participants for the company *A* and 4 participants for the company *B* responeded to this questionnaire on the evlauation.

As the result, the comprehensiveness of MND-ESPAM has been evaluated higher than applicability of the Level 2 and 3 process areas respectively as shown in Figure 9. This means that they can easily understand the contents of MND-ESPAM, but it will be slightly difficult to apply MND-ESPAM to the software development field. Specially, the scores of the two evaluation areas of the company *A* certificated by CMMI are almost similar. However, applicability of the comapany *B* with no experience to improve and assess the software process are less than comprehensiveness points about 0.4~0.5.

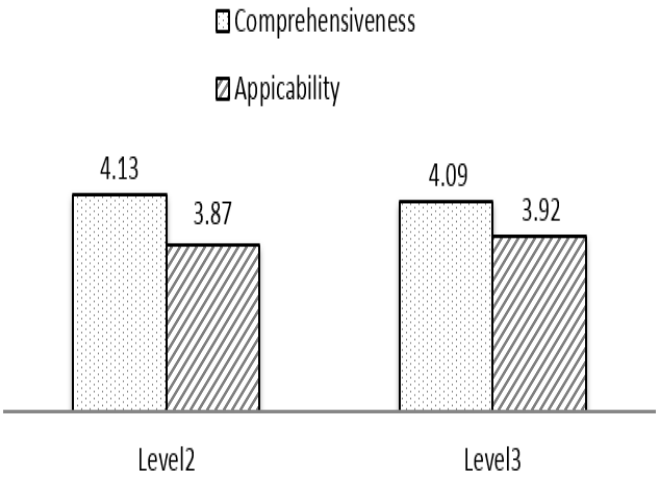

Figure 9. Comprehensiveness and Applicability Measure of Each Capability Maturity Level

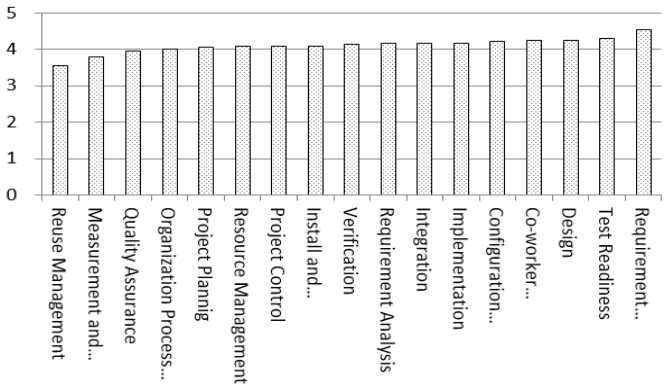

Figure 10. Comprehensiveness Scores for Each Process Area

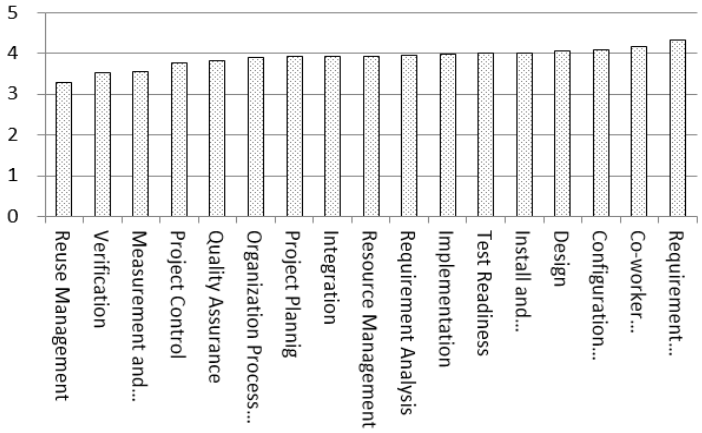

Figure 11. Applicability Scores for Each Process Area

For the scores of each process area in the *Development* category, most of the process areas are evaluated as *Sufficent* as shown in Figure 10 and Figure 11. However, the *Reuse Management*, *Measurement and Analysis*, and *Quality Assurance* process areas got low points than other process areas in terms of comprehensiveness. The respondents replied that it is relatively difficult to apply the *Reuse Management*, *Verification*, and *Measurement and Analysis* process areas in the field. As a result of this survey, we recognized that it is not reasonable to contain *Reuse Management* process area in Level 2 of MND-ESPAM. It is similar to the result of subsection 4.3.3.

5. Improvements of MND-ESPAM

The score of the *Reuse Management* process area in the aforementioned evaluations has been evaluated as very low, which is a similar score with process areas of the Level 4. This causes 5 companies to be evaluated as the Level 2. They might be upgraded into Level 3 or 4 if the *Reuse Management* is relocated into the evaluation criteria of Level 4. After simulating relocation of the process area into the Level 4, 4 organizations can be upgraded into the Level 3 from the Level 2, 1 organization can be moved into the Level 4 from the Level 2. Figure 12 illustrates this change. As a result of this simulation, totally 9 companies can acquire over the Level 3, compared with 4 companies with the original MND-ESPAM. This (9 companies with the over MND-ESPAM Level 3) can be aligned with the result with the commercial certificates (10 companies with the over CMMI level 3).

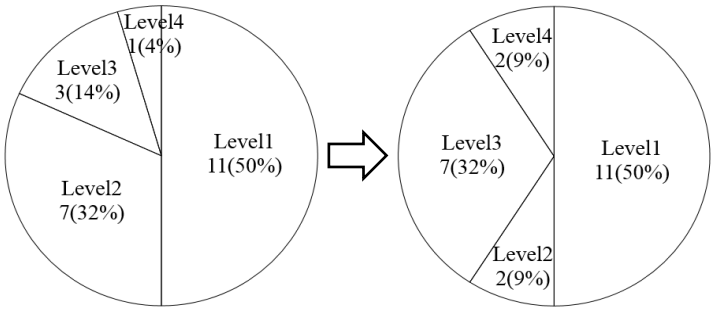

Figure 12. Change of the Maturity Level after Adjusting Reuse Management Process Area

In addition to this, the appraisal team suggested the following improvements for enhancing the MND-ESPAM assessment model.

- First, the *Solution Selection of Software Elements* generic goal in the *Design* process area is already defined in the *Project Proposal* or *Software Development Planning* document on the Korean weapon acquisition procedure[13] that all companies in this domain must observe in Korea. Thus, it is required to remove the redundant process activity.
- Second, the installation activity in the *Install and Acceptance Support* process area should be moved into the *Integration* process area. This is because of the nature of the military software that should be embedded in the hardware during the integration phase for the integration of the hardware and software, and integration testing. Therefore, the *Installation and Acceptance Support* process area should be renamed into *Acceptance Support*, and all installation related activities should be moved into the *Integration* process area.
- At last, in order to clearify the objective and value of each process area, the measurement metrics are required to be clearly redefined for effectiveness.

6. Conclusion

This paper has presented the three-step process for validating the MND-ESPAM assessment model before spreading it into the entire Korean military software industry. First, we investigated the current state on the software development and maintenance process of the 27 Korean military software companies with the questionnaire. Based on the survey, we could realize their military software dependency among their system and the situation on the software process, and read their demands on the assessment model. Second, the capability maturity level of military software process was assessed for 22 of 27 military software companies via responding the questionnaire based on the MND-ESPAM. The result of the second step shows that the MND-ESPAM model evaluated the process capability maturity level of the company appropriately, but it is turned out that the *Reuse Management* process area is not appropriate to be located in Level 3. At last, we executed the experimental assessment for two companies using MND-ESPAM. Through the last real assessment, we found out the gap between MND-ESPAM and real development process of the companies, and identified several improvements of the MND-ESPAM.

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Appendix A: A Part of the Questionnaire for Assessing the Capability Maturity Level with MND-ESPAM.

Table 6. Questions for Process Areas in Level 2

Process Area	Activity	No.	Inquiry	Reply				Output Instance
				FI	PI	NI	N/A	
Project Planning	Project Scoping	1	Do you define fine-grained tasks after depicting the Work-Breakdown Structure (WBS)?					WBS
		2	Do you define work product of the leaf node of WBS?					WBS
		3	Do you define reusable work product?					List of work product
...								

Table 7. Questions for Process Areas in Level 3

Process Area	Activity	No.	Inquiry	Reply				Output Instance
				FI	PI	NI	N/A	
...								
Test Readiness	Test Planning & Design	117	Do you define organization, their roll and scope of testing?					STP(SW Test Plan)
		118	Do you define type, procedure, schedule, method and so on about testing?					STP
		119	Do you select a testing tool of candidates?					STP
		120	Is the testing plan reviewed and agreed by stakeholders responsible for managing project?					STP, Result of STP review
...								

Table 8. Questions for Process Areas in Level 4

Process Area	Activity	No.	Inquiry	Reply				Output Instance
				FI	PI	NI	N/A	
...								
Organization Performance Management	stablishing th criteria and model of performance	1	Are quality, objective and priority of process performance for organization agreed with stakeholder?					Process for analyzing process performance
		2	Are the metrics for analyzing process performance established and managed?					Metrics for analyzing process

								performance
		3	Is the quantitative objective for quality and process performance established and managed?					Objective for quality and process performance
...								

Authors

Il-Lo Lee is a senior researcher of Defense Agency for Technology and Quality (DTaQ), Republic of Korea. He received his B.S. degree from Chonbuk National University in 2001, and the M.S. Degree from Gwangju Institute of Science and Technology in 2003. He worked with DTV Lab. in LG Electronics Co. Ltd., as a senior engineer during 2003-2008. He is currently a Ph.D. candidate in computer science and engineering at Sogang University. His main research interests include software process improvement, requirements engineering and software cost estimation.

Suntae Kim is an assistant professor of the Department of Computer Engineering at Kangwon National University. He received his B.S. degree in computer science and engineering from Chung-Ang University, South Korea in 2003, and the M.S. and Ph.D. Degree in computer science and engineering from Sogang University, South Korea in 2007 and 2010 respectively. He worked in SoftwareCraft Co. Ltd., as a senior consultant for financial enterprise systems during 2002-2004. Also, he developed Android based Smart TV middleware for two years after 2009 at Anypoint Media Group. His research focuses on software architecture, design patterns, requirements engineering and mining software repository.

Soojin Park is an assistant professor of the Graduate School of MOT at Sogang University. She received the Ph.D. in Computer Engineering from Sogang University, Korea, in 2008, the MS in information processing from Sogang University in 2000, and the BS in Computer Engineering from Kyoungbook National University, Korea, in 1995. Her research interests include pattern based software design and adaptive software technology.