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Measurement of Capability Maturity Model Integration Implementation Impact for Application Development Process Improvement in Telkomsigma

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Abstract

The objective of writing this thesis is to measure the impact of Capability Maturity Model Integration (CMMI) for application development process improvement in Telkomsigma. The method used is by comparing samples of application development projects before Telkomsigma implemented CMMI and after implemented CMMI. In gathering projects information, author observed documentations related to sample projects, organization policies and procedures and discussions with related parties.The data that has been received, is analysed with CMMI practice to measure its maturity levels. The result of the measurement is comparison of CMMI practice goals achievement before and after Telkomsigma's CMMI implementation from measured samples projects.The conclusion that the author can get is, CMMI implementation can improve Telkomsigma's application development process.

Keywords: *CMMI, Process Area, Practice, Application Development*

1. Introduction

Established in 1987, PT Sigma Cipta Caraka (Telkomsigma) is a company that provides end-to-end ICT Solutions. Employs more than 1200 employees including IT professionals who have international certifications. IT services provided by telkomsigma includes consulting services, IT service management, application development services, and integrated data center operations for companies engaged in the banking sector (conventional and Islamic), finance, telecommunications, manufacturing, distribution and other sectors.

Portfolio solutions offered includes: Managed Services (international certified data center, cloud computing, e-transaction, telco managed services, dan edutaintment media and communication services), Financial & Banking Development Services, Consulting dan System Integrator.

Currently Telkomsigma service has been used by more than 350 clients from various industries in Indonesia. In early 2008, Telkomsigma acquired by a subsidiary of the telecommunications and information service provider in Indonesia, TELKOM. As part of the Telkom Group, telkomsigma provide support in accordance with TELKOM's portfolio: TIMES (Telecommunication, Information, Media & Edutaintment dan Services).

Telkomsigma vision is "to be a leading Information Technology and Communication Solution Company in its territory". While the mission of Telkomsigma is "to become the most

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trusted partner in providing and implementing the benefits of ICT solutions to accelerate the improvement of the customer's business".

Currently Telkomsigma organizational structure consists of several units that focuses on functions and certain services. The structure is set up so that each unit can be more easily manage the responsibilities and authority of its unit. Telkomsigma organizational structure outlined in the picture shown below:

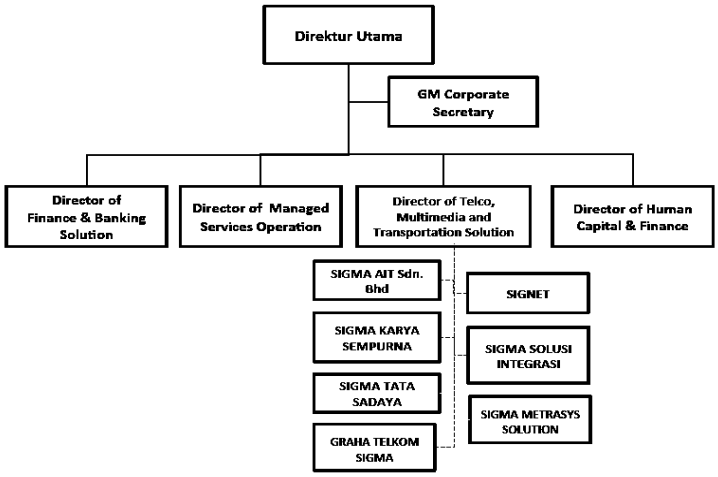


Figure 1. Telkomsigma Organizational Structure Overall Diagram (2013)

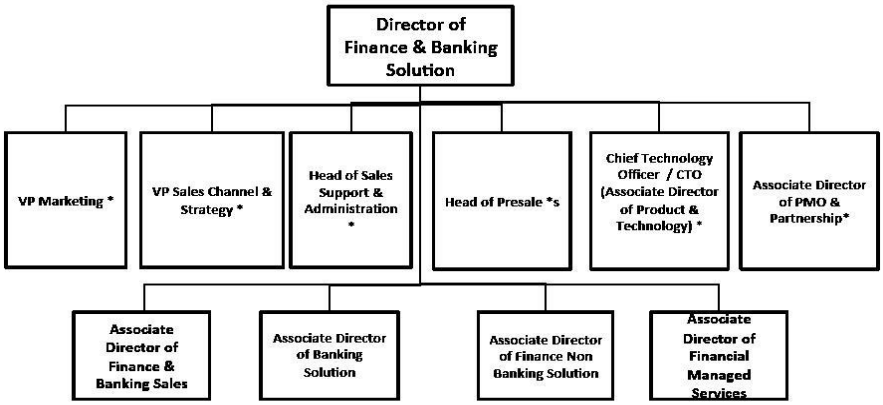


Figure 2. Finance & Banking Solution Organizational Structure Diagram (2013)

Industrial enterprise application developers are currently experiencing increasingly rapid development, along with advances in technology and the needs of an increasingly complex business. Enterprise application developers are required to provide application solutions according to specification, on time and in accordance with a predetermined budget. To be able to optimize the delivery of products to consumers, it is required to have a standardized and thorough process within the organization, understood and used by all parties involved (senior management, project manager, system analyst, programmer, *etc.*,), and adequately documented.

One of the frameworks that can be used to help the company improve the application development process is the Capability Maturity Model Integration (CMMI). CMMI was

developed by the Software Engineering Institute (SEI) - Carnegie Mellon University, which is a set of practices (best practices) to assist organizations in improving their processes (Chrissis, Mary B., Konrad, Mike., Shrum, Sandy., 2011). With CMMI, companies can simultaneously make decisions about how much range improvement process that they want to achieve. This pushes the overall process improvement initiatives within the company as well as helping to develop and measure the processes within the company.

As published on the CMMI Institute's website, CMMI implementation can provide several benefits for companies, namely; increase on-time delivery, increased productivity, improved quality, increased customer satisfaction, and so forth.

There are five maturity levels in the CMMI, the "Initial", "Managed", "Defined", "Quantitatively managed" and "Optimize". To know the process weaknesses and maturity level of a company, the process maturity level mapping using the CMMI framework need to be performed. Once the company knows the weakness of the process and their maturity level. The Company may use the information as a basis and guide for improving their future application development process

In April 2012 to August 2013, Telkomsigma collaborated with an IT consultancy company to conducted CMMI model implementation in three business units in order to improve the application development process as the followings:

1. Financial and Non Banking Business Unit. Focuses on the development of applications for the financial industry, securities, finance companies, trading, and other related applications
2. Banking Solution Business Unit. Focused in application development for the banking industry.
3. Product and Technology Business Unit. Focuses on application development for Arium product family.

The project also aims to assist in taking Telkomsigma assessment process (appraisal) to be performed by a CMMI Lead Appraiser for CMMI maturity level to know the maturity level position of the Company.

On September 18, 2013, Telkomsigma has officially passed appraisal on the CMMI maturity level 3 that conducted by CMMI Lead Appraiser and the result has been published in CMMI Institute website. Attainment of maturity level 3 indicates that the organization has reached a "Defined" level in the CMMI framework, which at this level of the process has been running and the requirements of the process has been fairly well understood and realized in the form of standards, procedures, tools - tools and methods – methods.

The discussion conducted in this paper aims to determine the impact of the implementation of the CMMI model in the Telkomsigma application development process. The analysis is done by evaluating the condition of the application development process before Telkomsigma applying CMMI maturity level 3 and the condition of the application development process after Telkomsigma applying CMMI maturity level 3.

Analysis performed is expected to provide information on the extent to which the increase in process development applications received by Telkomsigma. In addition, this information can be a reference for similar companies wishing to implement CMMI models in the company. This study seeks to answer the question that includes the following:

1. Is the implementation of CMMI models give effect to the increase in the application development process within the organization?
2. Which Telkomsigma application development process increased after applying CMMI?

3. What things need to be taken into consideration to ensure that the Company can maintain and improve the application development process in the future?

2. Research Method

To be able to analyze the impact of the implementation of the CMMI process improvement application development on Telkomsigma, few several stages of activity required which starts from the definition of the problem, the projects sample selection, evaluation of compliance associated with each process area of CMMI approach, the application development process improvement analysis, and discussion of the analysis results. The following are the stages of the research methodology that will be used:

1. Problem Definition

Is the initial phase as a beginning step to learn in depth how the application development process runs in each relevant project within the Company. It aims to determine the purpose of this paper. Problem definition is useful as a cornerstone for the methodology of this paper.

2. Project Sampling Method

To make the selection of the sample application development projects in Telkomsigma, the first step that needs to be done is to map existing application development projects within the sampling factor telkomsigma below (SCAMPI Upgrade Team, 2011):

a. Location (*e.g.*, headquarters, branch offices)

b. Customer (*e.g.*, government, private / commercial)

c. Size (*e.g.*, short term, medium term, long term)

d. Organization structure (*e.g.*, unit, department)

e. Type of work (*e.g.*, application development, maintenance)

Sampling factor provides an overview of the various ways that the work done in the company. For each sampling factor, needs to be ascertained whether the different settings on the factors affecting the workings of the company. If yes, then the sampling of the relevant factors to be used. However, if not, then the sampling factor is not relevant for use.

Mapping application development projects to the sampling factor is useful to obtain information on the number of existing subgroups. Subgroup is a cluster of interconnected projects have the same sampling rate factor and demonstrate the application of the same process (O'Toole, Pat., 2012).

The next process after knowing the number of subgroups is to enter the related variables into the sampling formula below to find out how the minimum number of samples required to perform the project evaluation.

The mapping results will then be grouped into subgroups (clusters) that will be used in determining the minimum number of samples of research projects.

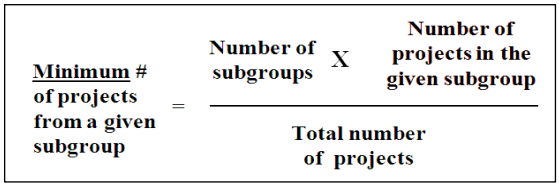


Figure 3. Sampling Formula (2011)

After getting the minimum amount of sample, the next step is the selection of a sample project that will be used in research. Things to note at the time of sampling in the research project is:

a. Identification of the sample application development projects that will be selected is conducted for project that has been mapped into the sampling factor (location, customer, size, etc).

b. One or more samples of application development projects have been done before / without Telkomsigma implementing CMMI.

c. One or more samples of application development projects have been carried out after applying CMMI telkomsigma.

The first point is to ensure that the sample application development projects used in the research equivalent / comparable in order to support the move to the next point is to compare the sample application development projects before Telkomsigma implementing CMMI and after applying CMMI Telkomsigma. This is done to allow for a comparison between the application development process that carried out in the project before Telkomsigma applying CMMI and application development process undertaken in the project when Telkomsigma already implementing CMMI. So that it can be seen the impact of the application of CMMI to the application development process within Telkomsigma.

3. Measurement of Compliance of Each Related Process Area at Project Selected Samples with CMMI Approach

Measurement of compliance of each process area related to the sample application development project was conducted to determine how far the compliance of each process area. An assessment process area can be said to be satisfactory if the purpose of each process area are met.

Measurement of compliance of each process area related to the sample application development projects in Telkomsigma is using CMMI specific practices. CMMI has defined best practices required for each process area in order to meet the goals of the process area concerned. Measurement of compliance of each of the CMMI process areas can be done by reviewing the implementation of the application development process that carried out by an organization with the best practices (best practices) that are defined in the CMMI. A process area can be said to be satisfactory if the purpose of each process area are met.

Measurement criteria used for each process application development in this paper using the SCAMPI (Standard CMMI Appraisal Method for Process Improvement) criteria as shown in the table below:

Table 1. Measurement Criteria (2011)

Criteria	Description
NY: not yet	a. One or more direct artifacts are present and judged to be adequate, b. at least one indirect artifact and/or affirmation exists to confirm the implementation, and c. no weaknesses are noted.
NI: not implemented	a. One or more direct artifacts are present and judged to be adequate, b. at least one indirect artifact and/or affirmation exists to confirm the implementation, and c. one or more weaknesses are noted.
PI: partially implemented	a. Direct artifacts are absent or judged to be inadequate, b. one or more indirect artifacts or affirmations suggest that some aspects of the practice are implemented, and c. one or more weaknesses are noted. OR a. One or more direct artifacts are present and judged to be adequate, b. no other evidence (indirect artifacts, affirmations) support the direct artifact(s), and c. one or more weaknesses are noted.
LI: largely implemented	a. Direct artifacts are absent or judged to be inadequate, b. no other evidence (indirect artifacts, affirmation) supports the practice implementation, and c. one or more weaknesses are noted.
FI: fully implemented	The project or support group has not yet reached the stage in the lifecycle to have implemented the practice.

Measurement of compliance of each process area in this research is performed until maturity level 3. This is because in CMMI, process maturity level of each area must meet the objective process before going up to a higher level, so that the level can not be bypassed / skip. Based on the achievement of CMMI Telkomsigma appraisal issued by the CMMI Institute on 18 September 2013, Telkomsigma currently appraised in a maturity level 3. Thus, based on the achievement of the current level, the authors limit the evaluation to maturity level 3. The following are the list of the CMMI process areas evaluated in this paper:

Table 2. List of Process Area Evaluated in the Research

4. Application Development Process Improvement Analysis

The next step is to conduct an analysis of the improvement in the application development process that occurs in Telkomsigma based on the fulfillment of compliance of each process area corresponding process area goals. The results of this analysis can provide information on the extent to which the impact of an improvement in the application development process after applying CMMI Telkomsigma.

5. Discussion

The discussion is based on the results of the steps taken by the compliance measurement and analysis of process improvement on previous research stages. The discussion aims to confirm between the researcher and the Telkomsigma party based on the compliance measurement and analysis of the improvement conducted in this paper.

6. Conclusion and Suggestion

It is the last step in which the conclusions of analysis and advice will be given as a conclusion of this paper.

3. Result and Discussion

The measurements activity performed and the results are as follows:

1. Project Sampling

In order to determine the sample project that will be used in research, first it is necessary to confirm on what relevant sampling factors to be used. Based on the discussion, it is known that several sampling factors, namely the location, the customer and the project size is not relevant for use. While the sampling of other factors such as organizational structure and the type of work relevant for use in research. Here below is an explanation for the confirmation sampling factor research.

Table 3. List of Relevant Sampling Factor

No	Sampling Factor	Description
1	Location	Not relevant. There is only one location (head office).
2	Customer	Not relevant. The way the work is done is not differ by type of customer (e.g. banks, insurance companies, etc.).
3	Project Size	Not relevant. The way the work is done is not differ based on the size of the project.
4	Organization Structure	Relevant. Finance and Non Banking Solution Business Unit (FNBS), Banking Solution Business Unit (BAS), Product and Technology Business (PT) Unit depicted on the Telkomsigma organizational structure. Application development projects derived from these three business units. CMMI process areas that are affected are the Engineering process areas.
5	Type of Work	Relevant. The way the work is done differently based on the type of work, i.e. project development, change request (CR), and maintenance. CMMI process areas that are affected are the Project Management and Engineering process areas.

1.1Mapping Project Samples to Sampling Factor

The next step after knowing the sampling factor to be used is to map the list of existing projects in Telkomsigma into the sampling factor. There are a total of 67 projects undertaken by the three business units in the period April 2012 - August 2013 (during project implementation CMMI). Based on the mapping done, the information of project subgroups (clusters) or projects that show similarities can be gathered. Due to the structure of the organization and type of work are the relevant sampling factors that can be used, then the possibilitties of subgroups exist in the project are as follows:

Table 4. Possible Project Subgroup

No	Sampling Factor	Possible Subgroup	Amount
1	Organization Structure	FNBS / BAS / PT	3 (i)
2	Type of Work	Project development / CR / maintenance	3 (ii)
		Total (i x ii)	9

Based on Table 4, it is known that there are 9 possible projects subgroups. To be able to know the number of subgroups actual / actual project, the first step taken is to combine the projects that have been mapped in the sampling factor (refer Appendix 1) with the subgroup that is possible, as shown in Table 5.

Table 5. The Combination of the Project Subgroup that has been Mapped into the Sampling Factor

No	*Subgroup*	Number of Projects in Subgroup
1	BAS, Project	52
2	BAS, CR	1
3	BAS, Maintenance	1
4	FNBS, Project	5
5	FNBS, CR	0
6	FNBS, Maintenance	0
7	PT, Project	6
8	PT, CR	1
9	PT, Maintenance	1

The next step is to identify subgroups that do not have a project (project number with a value equal to zero) in Table 5 to determine the actual subgroups. As shown in the table, there are two subgroups that do not have a project. So the actual subgroups number are 7 subgroups.

1.2Determination of Minimum Number of Sample Projects

Previously, it is known that the total number of projects are 67 and the number of subgroups project are 7 subgroups. So that calculations can be carried out using the sampling formula as shown in Table 6 below:

Table 6. Minimum Sample Calculation

No	*Subgroup*	Number of Projects in Subgroup	Calculation of Minimum Number (#) of Samples Using Formula	The Minimum Sample Required
1	BAS, Project (BP)	52	#minimum BP = (7x52)/67 = 5.43	5
2	BAS, CR (BC)	1	# minimum BC = (7x1)/67 = 0.10	1
3	BAS, Maintenance (BM)	1	# minimum BM = (7x1)/67 = 0.10	1
4	FNBS, Project (FP)	5	# minimum FP = (7x5)/67 = 0.52	1
5	PT, Project (PP)	6	# minimum PP = (7x6)/67 = 0.60	1
6	PT, CR (PC)	1	# minimum PC = (7x1)/67 = 0.10	1
7	PT, Maintenance (PM)	1	# minimum PM = (7x1)/67 = 0.10	1

The values obtained from calculations using the formulas are rounded, so that the minimum number of samples required for the study can be found as listed in the table above.

1.3Selected Sample Project

To be able to evaluate the impact of the implementation of CMMI in Telkomsigma, comparison between samples of application development projects before and after the CMMI applied are carried out, so that change in application development process can be identified. Based on discussions with the company, it is known that there are 2 pieces sample project that fits the criteria. The sample are:

a. Project A – ATM Interaction application development projects.
b. Project B – ATM Simulator application development projects.

Projects above were undertaken by Finance and Non Banking Solution (FNBS) business units, and categorized as application development type of work.

2. CMMI Maturity Level 2 Process Area Measurement

2.1REQM – Requirement Management Process Area

Requirement Management (REQM) process area purpose is to manage the project work products and product components requirements and to ensure alignment between requirements, project plans and work products. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 7. REQM Process Area Measurement Results

Process Area: Requirement Management (REQM)			
No	Practice Description	Project A	Project B
1	Develop an understanding with the requirements providers on the meaning of the requirements.	FI	FI
2	Obtain commitment to the requirements from the project participants.	FI	FI
3	Manage changes to the requirements as they evolve during the project.	FI	FI
4	Maintain bidirectional traceability among the requirements and work products.	LI	FI
5	Ensure alignment between Project work and Requirements.	FI	FI

2.2PP – Project Planning Process Area

Project Planning (PP) process area purpose is to establish and maintain plans that define project activities. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 8. PP Process Area Measurement Results

Process Area: Project Planning (PP)			
No	Practice Description	Project A	Project B
1	Establish a top-level work breakdown structure (WBS) to estimate the scope of the project.	PI	FI
2	Establish estimates of Work product and Task attributes.	PI	FI
3	Define the project lifecycle phases on which to scope the planning effort.	FI	FI
4	Estimate the project effort and cost for the work products and tasks based on estimation rationale.	NI	FI
5	Establish and maintain the project's budget and schedule.	NI	LI
6	Identify and analyze project risks.	NI	LI
7	Plan for the management of project data.	NI	FI
8	Plan for resources to perform the project.	FI	FI
9	Plan for knowledge and skills needed to perform the project.	NI	FI
10	Plan the involvement of identified stakeholders.	PI	FI
11	Establish and maintain the overall project plan content.	PI	FI
12	Review all plans that affect the project to understand project commitments.	PI	FI
13	Adjust the project plan to reconcile available and estimated resources.	FI	FI
14	Obtain commitment from relevant stakeholders responsible for performing and supporting plan execution.	FI	FI

2.3PMC – Project Monitoring and Control Process Area

PMC (Project Monitoring and Control) process area purpose is to provide an understanding of the project's progress so that appropriate corrective action can be taken when the project's performance deviates significantly from the plan. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 9. PMC Process Area Measurement Results

Process Area: Project Monitoring and Control (PMC)			
No	Practice Description	Project A	Project B
1	Monitor the actual values of the project planning parameters against the project plan.	FI	FI
2	Monitor commitments against those identified in the project plan.	FI	FI
3	Monitor risks against those identified in the project plan.	PI	FI
4	Monitor the management of project data against the project plan.	NI	FI
5	Monitor stakeholder involvement against the project plan.	FI	FI
6	Periodically review the project's progress, performance, and issues.	FI	FI

Process Area: Project Monitoring and Control (PMC)			
No	Practice Description	Project A	Project B
7	Review the project's accomplishments and results of the project at selected project milestones.	FI	FI
8	Collect and analyze the issues and determine the corrective actions necessary to address the issues.	FI	FI
9	Take corrective action on identified issues.	FI	FI
10	Manage corrective actions to closure.	FI	FI

2.4SAM – Supplier Agreement Management Process Area

The purpose of Supplier Agreement Management (SAM) is to manage the acquisition of products and services from suppliers. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 10. SAM Process Area Measurement Results

Process Area: Supplier Agreement Management (SAM)			
No	Practice Description	Project A	Project B
1	Determine the type of acquisition for each product or product component to be acquired.	FI	FI
2	Select suppliers based on an evaluation of their ability to meet the specified requirements and established criteria.	FI	FI
3	Establish and maintain supplier agreements	FI	FI
4	Perform activities with the supplier as specified in the supplier agreement.	FI	FI
5	Ensure that the supplier agreement is satisfied before accepting the acquired product.	FI	FI
6	Select and evaluate work products from the supplier of custom made products.	FI	FI

2.5M&A – Measurement and Analysis Process Area

The purpose of Measurement and Analysis (MA) is to develop and sustain a measurement capability used to support management information needs. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 11. M&A Process Area Measurement Results

Process Area: Measurement and Analysis (M&A)			
No	Practice Description	Project A	Project B
1	Establish and maintain measurement objectives that are derived from identified information needs and objectives.	PI	FI
2	Specify measures to address the measurement objectives.	NI	FI
3	Specify how measurement data will be obtained and stored.	NI	FI
4	Specify how measurement data will be analyzed and communicated	NI	FI
5	Obtain specified measurement data.	FI	FI
6	Analyze and interpret measurement data.	FI	FI
7	Manage and store measurement data, measurement specifications, and	FI	FI

Process Area: Measurement and Analysis (M&A)			
No	Practice Description	Project A	Project B
	analysis results.		
8	Communicate results of measurement and analysis activities to all relevant stakeholders.	FI	FI

2.6PPQA – Process and Product Quality Assurance Process Area

The purpose of Process and Product Quality Assurance (PPQA) is to provide staff and management with objective insight into processes and associated work products. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 12. PPQA Process Area Measurement Results

Process Area: Process and Product Quality Assurance (PPQA)			
No	Practice Description	Project A	Project B
1	Objectively evaluate selected performed processes against the applicable process descriptions, standards, and procedures.	NI	FI
2	Objectively evaluate selected work products and services against the applicable process descriptions, standards, and procedures.	PI	FI
3	Communicate quality issues and ensure resolution of noncompliance issues with the staff and managers.	FI	FI
4	Establish and maintain records of the quality assurance activities.	FI	FI

2.7CM – Configuration Management Process Area

The purpose of Configuration Management (CM) is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 13. CM Process Area Measurement Results

Process Area: Configuration Management (CM)			
No	Practice Description	Project A	Project B
1	Identify the configuration items, components, and related work products that will be placed under configuration management.	NY	FI
2	Establish and maintain a configuration management and change management system for controlling work products.	NY	FI
3	Create or release baselines for internal use and for delivery to the customer.	NY	FI
4	Track change requests for the configuration items.	NY	FI
5	Control changes to the configuration items.	NY	FI
6	Establish and maintain records describing configuration items.	NY	FI
7	Perform configuration audits to maintain integrity of the configuration baselines.	NY	FI

3. CMMI Maturity Level 3 Process Area Measurement

2.8 RD – Requirement Development Process Area

The purpose of Requirements Development (RD) is to acquire, analyze, and build customer, product, and product component requirements. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 14. RD Process Area Measurement Results

Process Area: Requirement Development (RD)			
No	Practice Description	Project A	Project B
1	Elicit stakeholder needs, expectations, constraints, and interfaces for all phases of the product lifecycle.	FI	FI
2	Transform stakeholder needs, expectations, constraints, and interfaces into customer requirements.	FI	FI
3	Establish and maintain product and product component requirements, which are based on the customer requirements.	FI	FI
4	Allocate the requirements for each product component.	FI	FI
5	Identify interface requirements.	FI	FI
6	Establish and maintain operational concepts and associated scenarios.	FI	FI
7	Establish and maintain a definition of required functionality and quality attributes	FI	FI
8	Analyze requirements to ensure that they are necessary and sufficient.	FI	FI
9	Analyze requirements to balance stakeholder needs and constraints.	FI	FI
10	Validate requirements to ensure the resulting product will perform as intended in the user's environment.	FI	FI

2.9 TS – Technical Solution Process Area

The purpose of Technical Solution (TS) is to select, design, and implement solutions to requirements. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 15. TS Process Area Measurement Results

Process Area: Technical Solution (TS)			
No	Practice Description	Project A	Project B
1	Develop alternative solutions and selection criteria.	FI	FI
2	Select the product component solutions based on selection criteria.	FI	FI
3	Develop a design for the product or product component.	FI	FI
4	Establish and maintain a technical data package.	FI	FI
5	Design product component interfaces using established criteria.	FI	FI
6	Evaluate whether the product components should be developed, purchased, or reused based on established criteria.	FI	FI
7	Implement the designs of the product components.	FI	FI
8	Develop and maintain the end-use documentation.	FI	FI

2.10 PI – Product Integration Process Area

The purpose of Product Integration (PI) is to assemble the product from the product components, ensure that the products are integrated, providing good performance (*i.e.*, has the functionality and quality attributes are required), and ship the product as expected. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 16. PI Process Area Measurement Results

Process Area: Product Integration (PI)			
No	Practice Description	Project A	Project B
1	Establish and maintain product integration strategy.	FI	FI
2	Establish and maintain the environment needed to support the integration of the product components.	FI	FI
3	Establish and maintain procedures and criteria for integration of the product components.	FI	FI
4	Review interface descriptions for coverage and completeness.	FI	FI
5	Manage internal and external interface definitions, designs, and changes for products and product components.	FI	FI
6	Confirm, prior to assembly, that each product component required to assemble the product has been properly identified, behaves according to its description, and that the product component interfaces comply with the interface descriptions.	FI	FI
7	Assemble product components according to the product integration strategy and procedures.	FI	FI
8	Evaluate assembled product components for interface compatibility.	FI	FI
9	Package the assembled product or product component and deliver it to the customer.	FI	FI

2.11 VER – Verification Process Area

The purpose of Verification (VER) is to ensure that selected work products meet their specified requirements. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 17. VER Process Area Measurement Results

Process Area: Verification (VER)			
No	Practice Description	Project A	Project B
1	Select the work products to be verified and the verification methods to be used.	FI	FI
2	Establish and maintain the environment needed to support verification.	FI	FI
3	Establish and maintain verification procedures and criteria for the selected work products.	FI	FI
4	Prepare for peer reviews of selected work products.	FI	FI
5	Conduct peer reviews on selected work products and identify issues resulting from the peer review.	PI	FI
6	Analyze data about preparation, conduct, and results of the peer reviews.	FI	FI
7	Perform verification on the selected work products.	FI	FI

Process Area: Verification (VER)			
No	Practice Description	Project A	Project B
8	Analyze the results of all verification activities.	FI	FI

2.12 VAL – Validation Process Area

The purpose of Validation (VAL) is to demonstrate that a product or product component meets for use when placed in an environment that is intended. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 18. VAL Process Area Measurement Results

Process Area: Validation (VAL)			
No	Practice Description	Project A	Project B
1	Select products and product components to be validated and the validation methods that will be used for each.	FI	FI
2	Establish and maintain the environment needed to support validation.	FI	FI
3	Establish and maintain procedures and criteria for validation.	FI	FI
4	Perform validation on the selected products and product components.	FI	FI
5	Analyze the results of the validation activities.	FI	FI

2.13 OPF – Organizational Process Focus Process Area

The purpose of Organizational Process Focus (OPF) is to plan, implement, and use the organizational process improvement based on a thorough understanding of the strengths and weaknesses of the organization's processes and process assets. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 19. OPF Process Area Measurement Results

Process Area: Organization Process Focus (OPF)			
No	Practice Description	Project A	Project B
1	Establish and maintain the description of the process needs and objectives for the organization.	NI	FI
2	Appraise the organization's processes periodically and as needed to maintain an understanding of their strengths and weaknesses.	NI	FI
3	Identify improvements to the organization's processes and process assets.	FI	FI
4	Establish and maintain process action plans to address improvements to the organization's processes and process assets.	FI	FI
5	Implement process action plans.	PI	FI
6	Deploy organizational process assets across the organization.	FI	FI
7	Deploy the organization’s set of standard processes to projects at their startup and deploy changes to them as appropriate throughout the life of each project.	FI	FI
8	Monitor the implementation of the organization’s set of standard processes and use of process assets on all projects.	FI	FI

Process Area: Organization Process Focus (OPF)			
No	Practice Description	Project A	Project B
9	Incorporate process-related work products, measures, and improvement information derived from planning and performing the process into the organizational process assets.	FI	FI

2.14 OPD – Organizational Process Definition Process Area

The purpose of Organizational Process Definition (OPD) is to establish and maintain a set and can be used as an organizational process assets, work environment standards, and rules and guidelines for the organization. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 20. OPD Process Area Measurement Results

Process Area: Organization Process Definition (OPD)			
No	Practice Description	Project A	Project B
1	Establish and maintain the organization's set of standard processes.	FI	FI
2	Establish and maintain descriptions of the lifecycle models approved for use in the organization.	FI	FI
3	Establish and maintain the tailoring criteria and guidelines for the organization's set of standard processes.	FI	FI
4	Establish and maintain the organization’s measurement repository.	FI	FI
5	Establish and maintain the organization's process asset library.	FI	FI
6	Establish and maintain work environment standards.	FI	FI

2.15 OT – Organizational Training Process Area

The purpose of Organizational Training (OT) is to develop the skills and knowledge of people so they can perform their roles effectively and efficiently. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 21. OT Process Area Measurement Results

Process Area: Organizational Training (OT)			
No	Practice Description	Project A	Project B
1	Establish and maintain strategic training needs of the organization.	FI	FI
2	Determine which training needs are the responsibility of the organization and which are left to the individual project or support group.	FI	FI
3	Establish and maintain an organizational training tactical plan.	FI	FI
4	Establish and maintain a training capability to address organizational training needs.	FI	FI
5	Deliver training following the organizational training tactical plan.	FI	FI
6	Establish and maintain records of organizational training.	FI	FI
7	Assess the effectiveness of the organization’s training program.	FI	FI

2.16 IPM – Integrated Project Management Process Area

The purpose of Integrated Project Management (IPM) is to establish and manage the project and the involvement of relevant stakeholders according to an integrated and defined process that is tailored from the organization's set of standard processes. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 22. IPM Process Area Measurement Results

Process Area: Integrated Project Management (IPM)			
No	Practice Description	Project A	Project B
1	Establish and maintain the project's defined process from project startup through the life of the project.	PI	FI
2	Use the organizational process assets and measurement repository for estimating and planning the project activities.	NI	FI
3	Establish and maintain the project's work environment based on the organization's work environment standards.	FI	FI
4	Integrate the project plan and the other plans that affect the project to describe the project's defined process.	FI	FI
5	Manage the project using the project plan, the other plans that affect the project, and the project's defined process.	FI	FI
6	Establish and maintain teams.	FI	FI
7	Contribute process related experiences to organizational process assets.	FI	FI
8	Manage the involvement of the relevant stakeholders in the project.	NI	FI
9	Participate with relevant stakeholders to identify, negotiate, and track critical dependencies.	NI	FI
10	Resolve issues with relevant stakeholders.	NI	FI

2.17 RSKM – Risk Management Process Area

The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk handling activities can be planned and invoked as needed in the life of the product or project to mitigate adverse impacts on achieving objectives. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 23. RSKM Process Area Measurement Results

Process Area: Risk Management (RSKM)			
No	Practice Description	Project A	Project B
1	Determine risk sources and categories.	FI	FI
2	Define the parameters used to analyze and categorize risks, and the parameters used to control the risk management effort.	FI	FI
3	Establish and maintain the strategy to be used for risk management.	NI	FI
4	Identify and document the risks.	NI	FI
5	Evaluate and categorize each identified risk using the defined risk categories and parameters, and determine its relative priority.	NI	FI
6	Develop a risk mitigation plan in accordance with risk management strategy.	NI	FI

Process Area: Risk Management (RSKM)			
No	Practice Description	Project A	Project B
7	Monitor the status of each risk periodically and implement the risk mitigation plan as appropriate.	FI	LI

2.18 DAR – Decision Analysis and Resolution Process Area

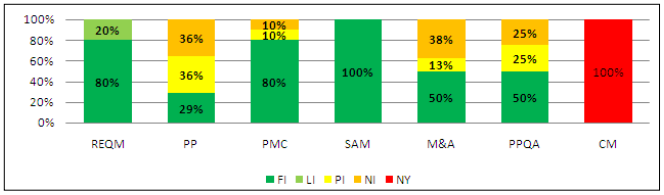
The purpose of Decision Analysis and Resolution (DAR) is to analyze possible decisions using a formal evaluation process to evaluate alternatives identified by the criteria established. A summary of the measurement results for both sample projects based on CMMI measurement criteria are as follows:

Table 24. DAR Process Area Measurement Results

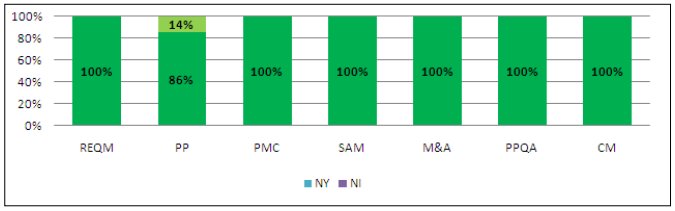
Process Area: Risk Management (DAR)			
No	Practice Description	Project A	Project B
1	Establish and maintain guidelines to determine which issues are subject to a formal evaluation process.	NY	FI
2	Establish and maintain the criteria for evaluating alternatives, and the relative ranking of these criteria.	NY	FI
3	Identify alternative solutions to address issues.	NY	FI
4	Select evaluation methods.	NY	FI
5	Evaluate alternative solutions using the established criteria and methods.	NY	FI
6	Select solutions from the alternatives based on the evaluation criteria.	NY	FI

4. Summary of Results of CMMI Process Area Measurement

Based on measurements made on the impact of the application of CMMI on projects A and B, it can be seen that there is an increase in the application development process that occurs after applying CMMI organization. The results of 17 measurements in the CMMI process areas Telkomsigma, described in the following figure:



(a)

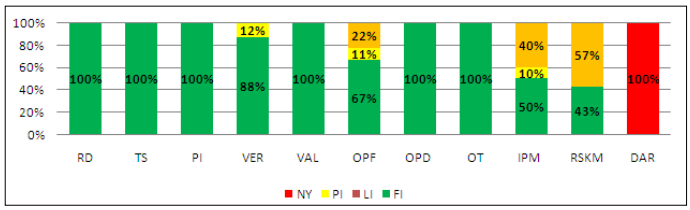


(b)

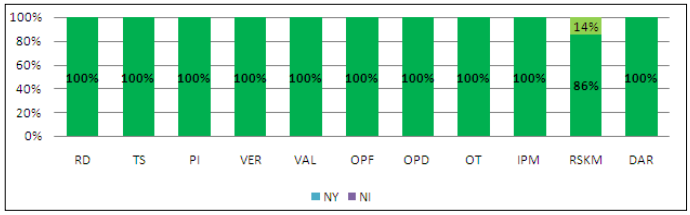
Figure 4. Measurement Results on Maturity Level 2

As shown in Figure 4 (a), some process areas at Maturity Level 2 as REQM, PP, M & A, PPQA and CM has some major drawbacks before Telkomsigma implementing CMMI. This is because in those areas there are some processes that have not been performed correctly. For example in REQM process, yet there is no bidirectional traceability between requirements identification to determine the association between the needs of one another when the IT staff needs to make Requirement Verification Matrix (RVM).

Meanwhile, in other processes such as PP, there is lack of planning on the project audit activity, no identification of the relevant stakeholders, and no review of the project planning. Similar things happen in other areas of the application development process. However, after Telkomsigma implement CMMI, the majority of the area at Maturity Level 2 has increased as shown in Figure 4 (b).



(a)



(b)

Figure 5. Measurement Results on Maturity Level 3

In Figure 5 (a) above, before Telkomsigma implementing CMMI, we identified some Maturity Level 3 process areas such as VER, OPF, HDI, RSKM and DAR has a major weaknesses. Similar to the Maturity Level 2, there are some processes that are not conducted in accordance with best practices. On VER process, we found no documentation of peer review reports. Then in OPF, there is lack of process requirement description , organization objective and audit planning process. Process improvement after Telkomsigma implementing CMMI can be seen in Figure 5 (b) above, in which almost all the area has not had a major weakness.

4. Conclusions

After measuring the impact of the implementation of CMMI in Telkomsigma, the conclusion that can be drawn is as follows

1. Implementation of CMMI gives effect to an increase in the application development process telkomsigma. This can be seen with the improvement on the previous application development process weaknesses such as those found in Project A, but has been corrected in Project B.
2. As shown in Figure 4 and Figure 5, some of the Telkomsigma's application development process has increased / improved after applying CMMI like the followings:
   a. *Requirement Management* (REQM);

b. *Project Planning* (PP);
c. *Measurement and Analysis* (M&A);
d. *Process and Product Quality Assurance* (PPQA);
e. *Configuration Management* (CM);
f. *Verification* (VER);
g. *Organization Process Focus* (OPF);
h. *Integrated Project Management* (IPM);
i. *Risk Management* (RSKM);
j. *Decision analysis and Resolution* (DAR).

Improved processes can be occured because Telkomsigma has implemented a follow-up is needed such as: identification of bidirectional traceability between requirements, project planning for the audit activity, identification of the involvement of relevant stakeholders, a review of the project planning, estimation of effort, time and cost required, budget, identification project risk, data management plans, competency identification, configuration management (configuration management), implementation of the action plan process, and the existence of a formal evaluation procedure.

3. Some of the application development process has been done properly and consistently related to the supervision of the project, reporting to senior management on the performance of the project, the design of products and product components, as well as validation of products and product components.

Suggestions given to a consideration for telkomsigma in order to maintain and improve the application development process in the future, ie:

1. Needs a commitment from senior management consistently over the application development process within the organization.
2. Conduct periodic training and socialization to the individual level, especially against a team that recently joined the project. training provided related to application development process within the organization so that the individual concerned can contribute to the application development process.
3. Perform resource management carefully in order to ensure the availability of resources required in the application development process.
4. Conduct periodic monitoring of the process, it can be reached through a process of review and audit, as well as performance review.

Conduct periodic communications to the stakeholders involved in the process of application development for performance as well as milestones that have been achieved

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