Digital Capability Maturity Improvement Strategy Design: A Case Study of a Mobile Phone Manufacturing Company

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Abstract

PT. XYZ is a company engaged in the telecommunications technology industry that produces cellular telephones and sells cellular telephones under its own trademark. The company runs its manufacturing processes using a combination of labor and the use of assembly machines, testing machines, packaging machines, and is integrated with manufacturing software. PT. XYZ uses Manufacturing Execution System (MES) manufacturing software in its manufacturing processes. MES is a comprehensive manufacturing software system for monitoring, tracking, documenting and controlling the process of manufacturing goods from raw materials to finished products. Manufacturing software must always be developed and its performance improved. Companies need to carry out approaches and assessments to increase the capability and maturity of digital manufacturing processes. Thus, the Capability Maturity Model (CMM) is used as the basis for the manufacturing software maturity measurement model used in the manufacturing process. The capability maturity model determines the company's current level of digital maturity. Then based on the gap analysis, design a strategy to increase digital maturity in the manufacturing process. At level 2 repeatable, PT. XYZ reaches a maturity level of 2.23, then at level 3 defined it reaches a maturity level of 2.18. Based on the current maturity level, KPA profiling, gap analysis, and strategy development are made to increase the company's digital maturity level.

Keywords
Capability Maturity Model, Manufacturing Software, Capability Maturity Improvement Strategy.

1. Introduction
PT. XYZ is a company engaged in the telecommunications technology industry that manufactures smart cellular telephones and sells these cellular telephones under its own trademark. This XYZ company is a foreign company that opened a factory in Indonesia. PT. XYZ has met the government's domestic content requirement standards with scores above 30% of the assessment parameters for the aspects of manufacture, development and mobile software. Cell phone products manufactured by PT. XYZ ranges from low-end, mid-range, high-end, and flagship-class phones to meet the needs of the Indonesian mobile phone market.

As a company engaged in the telecommunication technology industry, PT. XYZ runs its manufacturing processes using a combination of labor and the use of assembly machines, testing machines, packaging machines, and is integrated with manufacturing software. More specifically on the cell phone production process, from the raw materials arriving at the warehouse, the materials entering the factory, the assembly line, the test line, the packaging line, finished goods sent to the warehouse, until the finished goods are sent to market, processing and process control are assisted by the use of Manufacturing Execution System (MES) software. MES is a comprehensive manufacturing software system for monitoring, tracking, documenting and controlling the process of manufacturing goods from raw materials to finished products.

The manufacturing process must always be able to develop and improve its performance, especially since the manufacturing process also involves the use of manufacturing software. Companies need to carry out approaches and assessments to improve the capabilities and maturity of digital manufacturing processes. The Capability Maturity Model (CMM) helps companies to assess, position digital processes, and company internal resources to determine the current level of maturity and describe it to improve digital processes in production activities (Titov et al. 2016). The capability maturity model describes the path of evolutionary improvement from immature formed processes to mature

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disciplinary processes (DGoksen Y et al. 2015). It includes practices for planning, engineering and managing software development and maintenance. These key practices enhance an organization's ability to meet cost, schedule, functionality, and product quality objectives. The digital capabilities maturity framework is widely applied in process improvement programs for quality and productivity. One of the most well-known models of derived maturity is for software engineering. The framework has had a significant impact on software engineering practice and has helped improve software quality, lower costs, and reduce the high probability of product defects (Ngai et al. 2013). Maturity capability models can be used to facilitate companies in assessing and improving process quality to reduce quality risks that may occur in the manufacturing process (Doss et al. 2017). Companies need to carry out approaches and assessments to improve the capabilities and maturity of digital manufacturing processes. Before making improvements, companies must first identify gaps in the digital processes that are currently implemented. After that, the company needs to make a strategy to increase its maturity.

1.1 Objectives

This study aims to create a CMM digital capability maturity model as the basis for a manufacturing software maturity measurement model used in the manufacturing process, then identify a digital capability maturity model to determine the company's current digital maturity level. Based on the gap analysis, a strategy is designed to increase digital maturity in manufacturing processes using MES.

2. Literature Review

Manufacturing is the process of converting raw materials into finished goods that have a sale value through the use of tools, human labor, machines and other processes. Manufacturing strategy has focused extensively on competitive priorities that act as strategic capabilities that can help companies create, develop, and maintain competitive advantage (Thun 2008). Competitive priority is defined as the dimension that a company's production system must have to support market demand in which the company wants to compete (Nurcahyo and Wibowo 2015). Six criteria that act as competitive priorities are: uality, cost, delivery, flexibility, customer focus, and knowledge.

To remain competitive, companies need to increase efficiency by ensuring high quality product standards, managing costs, and reducing lead times. so that companies can fulfill customer demands with excellence (Filz et al. 2021). Currently, technology is the most important capability in supporting growth plans and improving the quality of the manufacturing industry. Many manufacturing processes involve various forms of technology combined with human labor to improve the production process. Forms of technology in manufacturing can include the use of information technology, automation, computing, software, sensing, and networks (Kronberger et al. 2020). One form of technology used in the manufacturing process is manufacturing software. Manufacturing software is a type of software that helps companies manage production processes. There are different types of manufacturing software, each designed to assist businesses with different aspects of the manufacturing process, such as tracking inventory, managing production schedules, tracking production processes, controlling quality, and so on.

Manufacturing Execution System (MES) provides real-time information about production processes to optimize manufacturing operations. MES offers a number of benefits to manufacturers, including improved visibility and control over production processes, increased productivity and efficiency, and better decision-making based on real-time data. MES is used in a wide range of industries and applications, and as technology continues to evolve, new trends are emerging in MES that offer even greater flexibility and efficiency. One area of research on MES is its integration with other manufacturing systems. For example, Kusiak et al. (2017) proposed a framework for integrating MES with enterprise resource planning (ERP) systems to improve manufacturing performance. They highlighted the importance of data integration and analysis in enabling real-time decision-making. Another area of research is the use of MES to improve quality control. Ren et al. (2020) conducted a systematic literature review on MES for quality control in manufacturing. They found that MES can improve quality control by providing real-time monitoring and analysis of production processes, enabling manufacturers to detect and address quality issues quickly. MES can also be used to optimize production scheduling and resource allocation. Gao et al. (2019) conducted a review of MES-based scheduling and control approaches. They discussed various approaches to production scheduling, such as genetic algorithms and mathematical programming, which can help optimize production efficiency and reduce lead times.

The Capability Maturity Model (CMM) is a framework developed by the Software Engineering Institute (SEI) at Carnegie Mellon University to improve the software development processes of organizations. The CMM is used to

evaluate the maturity level of an organization's processes and identify areas for improvement (Aguiar et al. 2019). The CMM was first developed in the 1980s by the SEI as a response to the growing need for standardized software development processes. The initial version of the CMM was published in 1987, and subsequent versions were released in 1991, 1993, and 1997. The CMM provides several benefits to organizations, including:

1. A standardized framework for evaluating and improving software development processes
2. A common language for discussing process improvement
3. Identification of areas for improvement and opportunities for optimization
4. Improved efficiency and productivity
5. Better control over software development processes
6. Improved quality and reliability of software products

The CMM is used in software development to evaluate an organization's processes and identify areas for improvement. The CMM provides a five-level maturity model, with each level representing a different stage in the organization's software development processes. The five levels of the CMM are:

1. Initial - Processes are ad hoc and chaotic
2. Repeatable - Processes are documented and repeatable
3. Defined - Processes are standardized and integrated
4. Managed - Processes are measured and controlled
5. Optimized - Processes are continuously improved

Organizations can use the CMM to evaluate their current maturity level and develop a plan to improve their processes to reach a higher maturity level. One area of research on CMM is its impact on software development processes. For example, Paulk et al. (1993) presented the initial CMM framework and its application in software development organizations. They found that CMM can help organizations to improve their processes and reduce development time and costs.

3. Methods

This study will measure the maturity level of companies in using MES as manufacturing software. The research method is divided into 5 stages:

1. CMM model creation.
2. Conducted interviews with 4 respondents at manager and expert levels with questions based on 18 KPA.
3. Document review.
4. Perform maturity level calculations.
5. Perform gap analysis.
6. Formulation of maturity capability improvement strategy.

Based on Table 1, the study will only cover level 2 and 3 measurements with a total of 18 KPA. The minimum target for process capability at level 2 is KPA level 2 and the recommendation target for process capability at level 3 is KPA level 2 and level 3.

Table 1. Maturity level and KPA

Level	Focus	KPA
1 : Initial	HR competence	
2 : Repeatable	Project management process	Requirements Management
		Software Project Planning
		Software Project Tracking and Oversight
		Software Subcontract Management
		Software Quality Assurance
		Software Configuration Management
3 : Defined	Process engineering and organizational support	Organizational Process Focus
		Organizational Process Definition
		Training Program
		Integrated Software Management

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		Software Product Engineering
		Intergroup Coordination
		Peer Reviews
4 : Managed	Product and Process Quality	Quantitative Process Management
		Software Quality Management
5 : Optimized	Continuous process improvement	Defect Prevention
		Technology Change Management
		Process Change Management

The interviews included 18 KPA with a total of 124 questions and each question had a choice of 0-5 which describes achievement with the following index on table 2:

Table 2. Index and its maturity level

Index	**Level**
0 – 0.5	0 : Non Existent
0.51 – 1.5	1 : Initial / Ad Hoc
1.51 – 2.5	2 : Repeatable
2.51 – 3.5	3 : Defined Process
3.51 – 4.5	4 : Managed
4.51 – 5	5 : Optimized

(10 font)

4. Data Collection

In table 3, a capability maturity model is created as a reference for measuring manufacturing processes and the use of manufacturing software.

Table 3. Maturity of the manufacturing process in the use of manufacturing software

Level	1 : Initial	2: Repeatable	3: Defined
KPA achievements	/	1. System requirements are allocated to controlled software to establish the basis for software engineering and usage management. 2. Software project activities and commitments are planned and documented. 3. Actual results and	1.Software process development and improvement activities are coordinated throughout the organization. 2. Standard software processes for the organization are developed and maintained. 3. Training to develop the skills and knowledge required to operate the software is provided and executed. 4.Project defined software processes are customized versions of the organization's standard software

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		performance are tracked against the software plan. 4. Main contractor selects qualified software subcontractors 5. SQA activities are planned. 6. Planned SCM activities.	processes. 5. Software engineering tasks are defined, integrated, and consistently performed to produce software. 6. Commitments between engineering groups are agreed upon by the affected groups. 7. Engineering identifies, tracks, and resolves intergroup problems. 8 Defects in software work products are identified and eliminated

Based on the interview results and response calculations, the maturity measurement results were obtained as shown in Table 4.

Table 4. Results of KPA maturity measurement, focus, and overall

Focus	CMM KPA	Maturity Level		
		KPA Maturity	Focus Maturity	Overal Maturity
Project management process	Requirements Management	2.54	2.23	2.21
	Software Project Planning	2.14		
	Software Project Tracking and Oversight	2.39		
	Software Subcontract Management	1.69		
	Software Quality Assurance	2.43		
	Software Configuration Management	2.19		
Process engineering and organizational support	Organizational Process Focus	1.86	2.18	
	Organizational Process Definition	1.79		
	Training Program	2.64		
	Integrated Software Management	2.04		
	Software Product Engineering	2.50		
	Intergroup Coordination	2.57		
	Peer Reviews	1.88		

5. Results and Discussion

Based on table 4, it is found that the maturity level of the company's ability to use the current MES manufacturing software as a whole is at maturity level 2: repeatable with a value of 2.21. For the maturity focus of the project management process at level 2, maturity level 2 is obtained: repatable with a value of 2.23. For maturity focus process

engineering and organizational support at level 3, maturity level 2 is obtained: repeatable with a value of 2.18. So with these results, it is known that the company is quite good at carrying out the manufacturing process by using MES as its manufacturing software.

In the assessment of maturity level per KPA, the average score obtained has reached maturity level 2. The lowest 3 KPAs are in KPA Software Subcontract Management, Organizational Process Definition, and Organizational Process Focus with respective values of 1.69, 1.79, and 1.86.

In-depth study of the 3 KPA found that in the subcontract management software process the selection and qualification of the subcontractor had been carried out properly, as well as the commitments and agreements made, but the communication between the company and the subcontractor had not been carried out properly so that there were several obstacles caused by a lack of maintaining communication. As a result of not properly maintaining communication, this also has an impact on obstacles for tracking results and the subcontractor's actual performance. Companies and subcontractors must comply with the commitments made, it is required to establish a communication system between the company and subcontractors so that tracking results and actual performance of subcontractors can be ensured according to commitments. The communication platform needs to be supervised so that communication is more directed and in accordance with the portion of the project that should be.

Then in the KPA Organizational Process Definition, actually standard software processes for organizations have been developed and maintained, but sometimes there is information related to standard use of software at the organizational level that has not been properly reviewed and socialized to all lines in the relevant departments. At the organizational level with various departments, socialization and supervision of the use of the software must be made clear structure. So that the standard operation of the use of software can be carried out correctly and avoid skip processes and software operations that deviate when executed.

Furthermore, in the KPA Organizational Process Focus, the strengths and weaknesses of the software processes used are identified relative to a standard process, but the software process development and improvement activities have not been well coordinated at the organizational level, this is due to process development and improvement on an organizational scale not well planned. Because basically if software improvement activities are carried out without a mature plan coordinated with the relevant departments, this actually risks creating new problems that can be detrimental to the company. For example, there is a trial activity for the latest MES version and requires the MES system to restart on all lines without clear planning and coordination during working hours, then the manufacturing process can stop and cause losses.

6. Conclusion

In overall, the maturity level of PT. XYZ's ability to carry out the manufacturing process using MES as manufacturing software is quite good with a score of 2.21 with a maturity level of 2.21. Companies need to make improvements in all KPA at levels 2 and 3 so that the capability maturity level can rise to level 3 starting with the lowest 3 KPA Software Subcontract Management, Organization Process Definition, and Organizational Process Focus.

So, to increase the maturity level of manufacturing capabilities in using MES, companies need:

1. Maintain good communication with subcontractors, so that tracking results and actual performance of subcontractors can be known with certainty so that they always follow commitments. Each meeting is made with a meeting resolution which is reviewed by the relevant department manager so that the results of the discussions and development directions can be monitored.
2. Information for the organizational level must be ensured that it is available and accessible, if there are changes, repairs, and improvements to software that need to be known at the organizational level must be informed in advance.
3. Process software activity plans at the organizational level must be carefully prepared and coordinated in an integrated manner, so that cross-organizational activities can be carried out properly.

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