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ISO 9001:2015 and Capability Maturity Model Integration 3.0 in Software Development Project

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Abstract

Integration between Capability Maturity Model Integration (CMMI) 3.0 and ISO 9001 can provide several significant benefits to organizations seeking to improve the quality, efficiency, and maturity of their processes. CMMI and ISO 9001 can be integrated framework as guidance and evaluation. ISO 9001 promotes a risk-based approach, while CMMI helps in measuring process capability. Literature review conducted between 2018-2023 that indicates five researches regarding ISO 9001 and CMMI for software development. This study aims to integrate the ISO 9001:2015 standard with the CMMI 3.0 model. Selected CMMI 3.0 Practice Area PLAN, EST, CM, RDM, SAM, PQA, and MC are mapped in clause 8, while only RSK is mapped in clause 6. This study can be developed by mapping other Practice Area of CMMI and other standard.

A. Introduction

Information Technology industry sector have been certified of a quality management system based on ISO 9001:2015. Based on a survey conducted by the ISO Standards Organization in 2022[1], the number of organizations that have been certified to ISO 9001:2015 is 48,593 organizations. The adoption of ISO standards for quality management systems is currently widely applied by organizations engaged in the Information Technology segment.

The ISO 9001:2015 management system standard [2]adheres to the Plan-Do-Check-Act (PDCA) principle. The PDCA cycle consists of planning, implementing, evaluating, and improving phases. The requirements in ISO 9001:2015 require organizations to carry out performance evaluations on the implementation of quality management systems. Methods for assessing the quality management system need to be established so that the management system can run optimally.

A quality management system is needed for organizations to improve the business processes they run. Likewise, with software development organizations, it is necessary to implement standards and models to improve the processes and products produced. The adopted quality management system and the CMMI model can be integrated as an organizational framework.

This study aims to integrate the ISO 9001:2015 standard with the CMMI model. The integration that is applied is not only ISO 9001:2015 but other ISO standards applied by organizations such as service management systems or other management systems. This research uses a quality management system based on ISO 9001:2015 due to widely applied in organizations and is the basis for management systems. The research questions posed in this research are :

RQ1: What is correlation between ISO 9001:2015 and CMMI 3.0 in project improvement of software development?
RQ2: How is the integration of the ISO 9001:2015 standard and the CMMI 3.0 model in the organization?

The paper is organized as follows: Section A describes introduction and literature review; Section B provides a thorough overview of the research methodology; Section C discusses and analyses the findings; Section D conclusion of research the paper.

A.1.Quality Management System Standard

Standard for quality management systems (QMS) for this research is using ISO 9001:2015. The standard required risk-based thnking and process approach to implement [2] for an effective quality management system, which can be applied to many types of organizations, including software development. Guidlines software development in ISO 9001:2015 is defined in ISO/IEC/IEEE 90003:2018[3]. Both standard have PDCA structure that stands for Plan-Do-Check-Act. The PDCA cycle consists of :

- Plan: The first stage in the PDCA cycle is planning. At this stage, the goals and targets to be achieved are set. Planning also involves identifying problems, analyzing situations, and formulating strategies and action plans.

- Do: The second stage is implementing the plan that has been formulated. The planned steps are implemented in accordance with the established strategy. This involves executing actions, collecting data, and measuring and gathering process-related information.
- Check: At this stage, the results and data collected are evaluated to check whether the goals that have been set are achieved or not. Analysis is performed to compare actual performance with the expected target. If there are deviations or discrepancies, the problems that arise are identified.
- Act: The last stage is to act based on the results of the evaluation in the previous stage. If problems or irregularities are detected, corrective measures are applied. Corrective actions must be selected and implemented to improve the process and achieve the desired results. Once corrective action has been taken, the PDCA cycle can restart with the planning phase

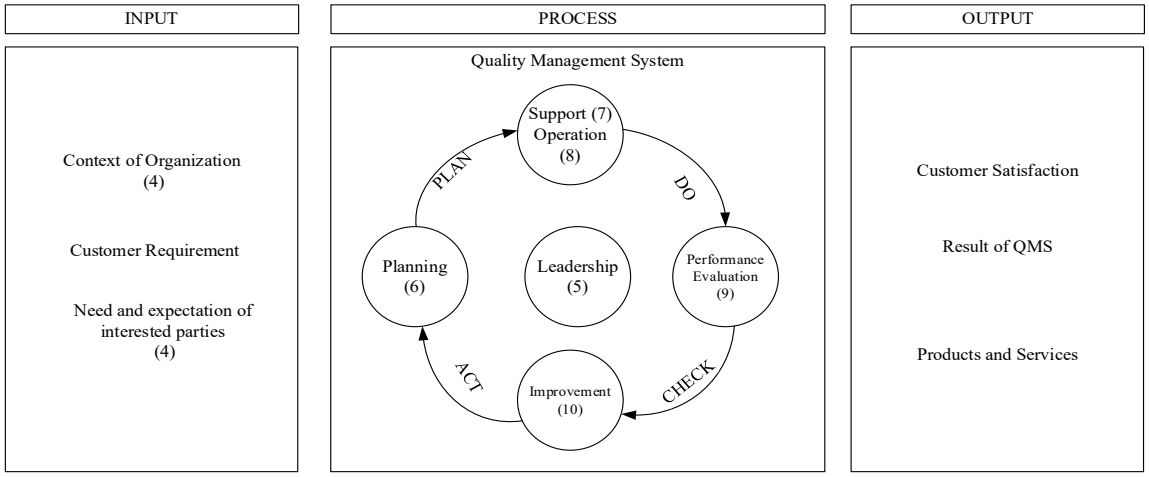

Figure 1. PDCA cycle in ISO 9001:2015 [4]

A.2.Capability Maturity Model Integration (CMMI)

CMMI has updated the version since 2018. CMMI standard version 2.0 is released which is an updated version of the previous CMMI 1.3 framework in 2018 [5]. CMMI 3.0 provides a structured framework for measuring and enhancing the maturity of organizational processes in software development. This model consists of several maturity levels, starting from Level 1 (Initial) to Level 5 (Optimizing) [6]. CMMI-Dev 1.3 grouped four categories for 22 Process Areas as follow [7] :

- **Project Management**: Project Planning (PP), Project Monitoring and Control (PMC), Supplier Agreement Management (SAM), Risk Management (RSKM), Integrated Project Management (IPM), Quantitative Project Management (QPM), Requirement Management (REQM)
- **Process Management**: Organizational Process Focus (OPF), Organizational Process Definition (OPD), Organizational Training (OT), Organizational Process Performance (OPP), Organizational Performance Management (OPM)
- **Engineering**: Requirement Development (RD), Technical Solution (TS), Product Integration (PI), Verification (VER), Validation (VAL)

- **Support**: Configuration Management (CM), Process and Product Quality Assurance (PPQA), Measurement and Analysis (MA), Decision Analysis and Resolution (DAR), Causal Analysis and Resolution (CAR)

CMMI roadmap encompasses practice areas in CMMI 1.3 covering project roadmap, product roadmap, product integration roadmap, process roadmap, and measurement roadmap. The roadmap has specific goals to achieve for organization as following [8] :

- **Project Roadmap**: organizations with project management-related goals or business problems
- **Product Roadmap**: organizations with product-related goals (e.g., for improved product quality) or business problems
- **Product Integration Roadmap**: for organizations with product-assembling goals or business problems. Applicable when the primary challenge for projects is correctly integrating software components, hardware components, or both software and hardware components
- **Process Roadmap**: organizations with process management-related goals or business problems
- **Measurement Roadmap**: organizations with measurement-related goals or business problems

B. Research Method

B.1.Literature Review

To identify and analyze scientific publications related to the comparison between the CMMI-DEV model and ISO/IEC 9001:2015, the following sequence of literature review was proposed based on [9][10] :

- Formulation of the research question. Main Objective of Systematic Review is to carry out the identification and analysis of the studies carried out on the map of the model and the quality standards applied. Based on this objective, the following research question was posed:

  Has there been any published research comparing the CMMI model with ISO 9001:2015?

- Definition of the search strategy. The search strategy was designed to identify publications that answered the research question by identifying search strings to be applied across the three databases.
  Search string: ("CMMI " OR "ISO 9001") AND "Software Development")
  Databases: IEEEXplore Digital Library, ACM Association for Computing Machinery and ScienceDirect.
- Definition of inclusion and exclusion criteria. The literature review was not based on any primary body of research. All publications are the result of applying the research strategy and defined selection criteria.
  The inclusion criteria used for study is research conducted between 2018 to 2023.
  The exclusion criteria used for is publication from books or thesis and not related of CMMI and ISO 9001 for software development

- Selection of primary studies. To select primary studies, search strings were entered into each database. Then, for each result obtained, selection criteria are applied, based on an examination of the title, keywords and abstract. If these criteria were met, they were added to all primary studies, otherwise they were removed.
- Extraction of results. After identifying and collecting the main studies, we conducted a full-text analysis of each study, extracting information to answer the research question.
- Analysis of results. Proceeded to answer the research question

B.2.Adjustment

Software development project using CMMI 3.0 is composed by reference of CMMI 1.3. Therefore, adjustment using CMMI 3.0 need to be done. Following steps for adjustment area :

- Combination of Project Domain and Project Roadmap. This research will combine of CMMI 1.3 between Project Domain [7] and Project Roadmap [8].
  Project management of CMMI 1.3 consist of Project Planning (PP), Project Monitoring and Control (PMC), Supplier Agreement Management (SAM), Risk Management (RSKM), Integrated Project Management (IPM), Quantitative Project Management (QPM), Requirement Management (REQM)[7].
  The practice areas contained in the CMMI project roadmap consist of Requirements Management (RQM), Project Planning (PP), Project Monitoring and Control (PMC), Configuration Management (CM), and Process and Product Quality Assurance (PPQA)[8].

Table 1. Comparison Project Domain and Project Roadmap

Process Area of Project Domain CMMI 1.3	Process Area of Project Roadmap CMMI 1.3
• Project Planning (PP) • Project Monitoring and Control (PMC) • Supplier Agreement Management (SAM) • Risk Management (RSKM) • Integrated Project Management (IPM) • Quantitative Project Management (QPM) • Requirement Management (REQM)	• Project Planning (PP) • Project Monitoring and Control (PMC) • Requirement Management (REQM) • Process and Product Quality Assurance (PPQA) • Configuration Management (CM)

Comparison in Table 1 to oversee project domain and project roadmap that applies in CMMI-Dev 1.3. Combination of Process Area in this research are Project Planning (PP), Project Monitoring and Control (PMC), Requirement Management (REQM), Process and Product Quality Assurance (PPQA), Configuration Management (CM), Supplier Agreement Management (SAM), and Risk Management (RSKM).

- Transistion to CMMI 3.0
  CMMI has been developed from version 1.3 to 2.0 and 3.0. Reference related project of software development is using CMMI 1.3. Combination of Project Management in CMMI 1.3 will be adjusted into CMMI version 3.0.

Table 2. CMMI Transition of Project Management

Process Area (1.3)	Practice Area (3.0)
• Project Planning (PP) • Project Monitoring & Control (PMC) • Requirements Management (REQM) • Configuration Management (CM) • Process and Product Quality Assurance (PPQA) • Supplier Agreement Management (SAM) • Risk Management (RSKM)	• Requirements Development & Management (RDM) • Planning (PLAN) • Monitor & Control (MC) • Estimating (EST) • Process Quality Assurance (PQA) • Configuration Management (CM) • Risk Management (RSK) • Supplier Agreement Management (SAM)

Practice area are selected in Table 2 are Planning (PLAN), Estimating (EST), Monitoring and Control (MC), Supplier Agreement Management (SAM), Risk Management (RSK), Requirement Development and Management (RDM), Process Quality Assurance (PQA) and Configuration Management (CM). These practice area then combined to ISO 9001:2015 to oversee correlation in software development project

C. Result and Discussion

Literature Review identified five articles publish in IEEEXplor, ACM, and ScienceDirect related to research during 2018 to 2023. Some article related to this research has long time publication related ISO 9001:2000 and CMMI 1.2 [11]. Mapping CMMI 1.3 and ISO 90003:2014 [12] is close related, but having different scope area of this research.

Table 3. Article Reference

No	**Article**	***Year***
1	A Novel Model to adapt CMMI Level 2 by Assessing the Local SME of Bangladesh [13]	2023
2	Agile-CMMI V2.0 Alignment: Bringing To Light The Agile Artifacts Pointed out by CMMI [14]	2022
3	Digital Quality Management Audit with Extra Criteria for Data Safety and Personal Data Requirement [15]	2022
4	Quality Management System Certification in The Russian Software Development Industry [16]	2021
5	Software Project Management in High Maturity: A Systematic Literature Mapping [17]	2019

The literature review identified that CMMI is using as model to implement software development project [13][14][17]. After implementation of CMMI model, organization can asses implementation then result of assessment can be used as evidence of continual improvement.

Implementation ISO 9001:2015 in software development industry can be applicable [16]. Organization must identify and evaluate risk management process [15]. No study was identified model CMMI 3.0 and ISO 9001:2015 in scope of software development project. Mapping between requirement clause of ISO 9001:2015 and Practice Area of CMMI 3.0 in software development project has result as Table 4

Table 4. Mapping Clauses and Practice Area

		ISO 9001 Clauses						
		4	5	6	7	8	9	10
Practice Area CMMI	PLAN	0	0	0	1	15	0	0
	PQA	0	0	0	0	6	0	0
	RDM	2	0	0	0	13	0	0
	RSK	0	0	8	0	0	0	0
	MC	1	0	0	2	10	0	0
	EST	0	0	0	0	6	0	0
	CM	0	0	0	0	7	0	0
	SAM	0	0	0	0	12	0	0

Based on Table 4, mostly Practice Area of CMMI 3.0 are mapped into Operational domain in clause 8. Only Practice Area Risk and Opportunity Management (RSK) is mapped into Planning domain in clause 6.

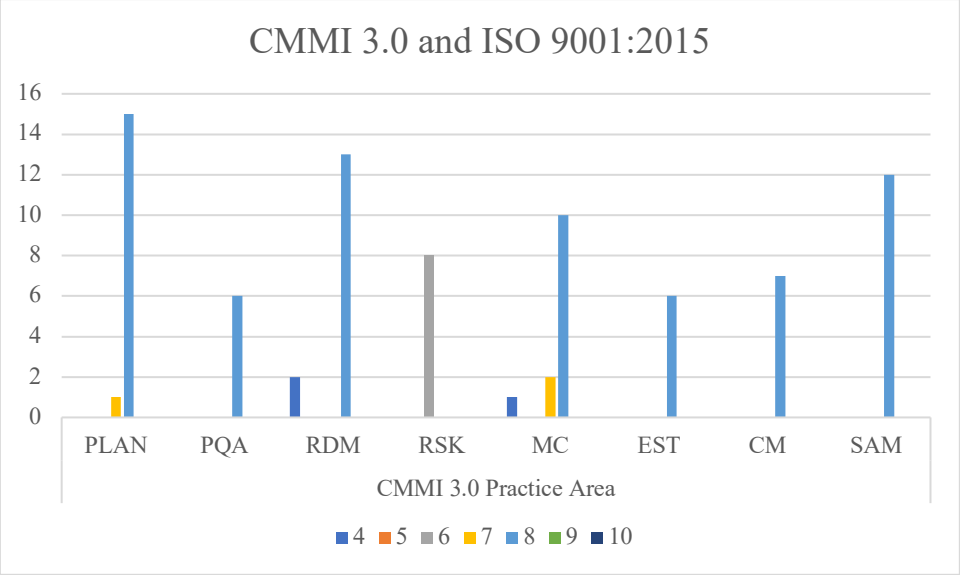

Figure 2. Mapping of CMMI 3.0 and ISO 9001:2015 in Software Development Project

Clause 5, 9, 10 are not applicable in selected Practice Area of this research. These clauses are domain of ISO framework that not related to Practice Area of software development project. Table 5 and Table 6 shows result of sample mapping in clause 6 and clause 8.

Table 5. Mapping Clauses 6 and Practice Area

		ISO 9001 Clauses		
		6.1	6.2	6.3
Practice Area CMMI	PLAN	0	0	0
	PQA	0	0	0
	RDM	0	0	0
	RSK	8	0	0
	MC	0	0	0
	EST	0	0	0
	CM	0	0	0
	SAM	0	0	0

Practice Area mapped into subclause of 6.1 Action to adress risk and opportunities. Intent of RSK is to identify, analyzes, and do treatment of risk management. There is correlation between Risk Management in Subclause 6.1 of ISO 9001:2015 and CMMI 3.0 Practice Area of RSK.

Most Practice Area CMMI 3.0 of Software Development Project are mapped into clause 8 of ISO 9001:2015. As PDCA cycle in ISO 9001:2015 [2] clause 8 is cycle "Do" that organization within scope operates. Table 6 shows that correlation CMMI 3.0 selected Practice Area and ISO 9001:2015.

Table 6. Mapping Clauses 8 and Practice Area

		ISO 9001 Clauses						
		8.1	8.2	8.3	8.4	8.5	8.6	8.7
Practice Area CMMI	PLAN	15	6	5	0	1	0	0
	PQA	0	3	3	0	0	2	1
	RDM	0	12	7	0	0	1	0
	RSK	0	0	0	0	0	0	0
	MC	7	4	1	0	1	0	2
	EST	0	0	1	0	1	0	0
	CM	0	0	0	0	7	0	0
	SAM	0	0	0	10	0	0	0

Practice Area of PLAN and MC are mapped into subclause 8.1 Operational planning and control. This indicates that PLAN and EST is planning phase and control whole process of software development is keep on track of project.

RDM is mapped into subclause 8.2 Requirement for product and services. Requirement of product and conformity with stakeholder needs is equal to subclauses 8.2 in software development.

SAM is mapped into subclause of 8.4 Control of externally provided processes, products and services. External provider relationship including evaluation of external provider process is done both SAM and clause 8.4

CM is mapped into subclause of 8.5 Production and service provision. According Guidlines of implementation ISO 9001:2015 in software development [3] that configuration management is arranged in subclause of ISO 90003:2018 in 8.5.2.3 Configuration management process. Cycle of configuration management are equal in ISO 9001:2015 for context of software development.

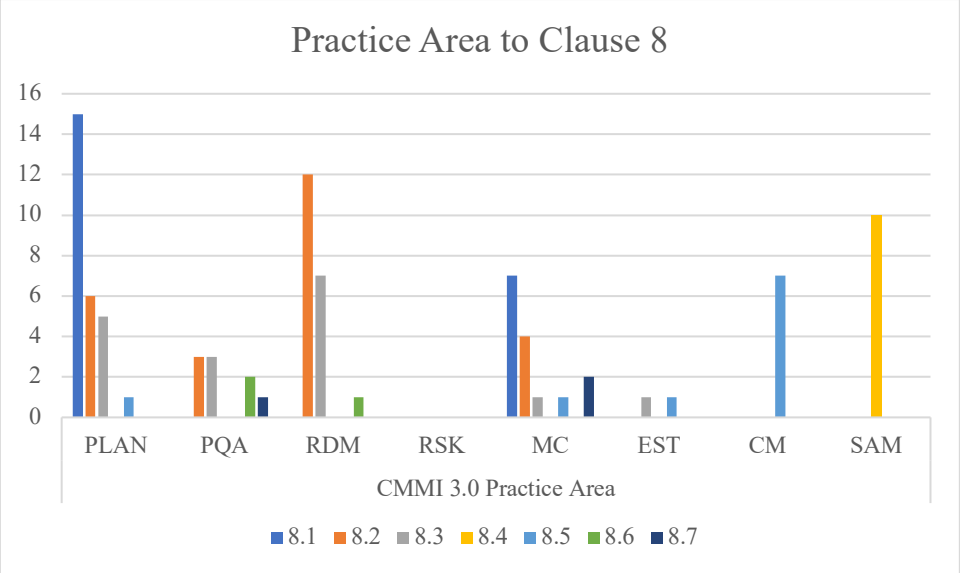

Figure 3. Practice Area to Clause 8 of ISO 9001:2015

MC and PQA is almost in all subclause 8 due to controlling process in steps of software development project. Some Practice Area may apply in clauses and subclauses of ISO 9001:2015 due to process is similar.

D. Conclusion

Systematic Literature review identified that five researches in 2018-2023 related into evaluation of software development using ISO 9001:2015 and CMMI. Mapping between ISO 9001:2015 and CMMI 3.0 with selected Practice Area are mapped into clause 8 Operation and 6.1 Action to adress risk and opportunity.

This research can be developed further for mapping into ISO/IEC 20000-1:2018 related into IT Service Management System. Selected Practice Area can be chosen related into Product roadmap, Product Integration roadmap, Process roadmap or Measurement roadmap.

Other standard related of Security and Resilience such as ISO/IEC 27001:2022 and ISO 22301:2019 can be research for further research. Practice Area of CMMI 3.0 has specific topic of both standard.

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