Development of Integrated Information Systems for Project Control Based on PMBOK in Construction Consulting Services Companies to Improve Company Performance

Annisa Sabrinia Sagita[1], Rully Andhika Karim[1]
[1]*Department of Civil Engineering, University of Indonesia, Indonesia*

ABSTRACT: *This thesis examines the development of an integrated information system for project control in construction consultancy firms to improve company performance. Effective project management is crucial in the construction industry to achieve optimal results, avoid delays, control costs, and minimize risks. This research identifies challenges faced by companies, such as project completion delays, cost overruns, and a lack of coordination and communication among teams. Through needs analysis and system design, this study proposes an integrated information system that includes planning, implementation, and project monitoring based on the PMBOK 6th edition 2017. The system aims to enhance transparency, facilitate collaboration among stakeholders, and provide analytical reports to support more accurate and faster decision-making. Thus, this system is expected to optimize project management and improve the performance of construction consultancy firms in facing the increasingly complex industry challenges.*

KEYWORDS –*Company Performance, Integrated Information Systems, Project Management, PMBOK*

I. INTRODUCTION

The development of Information Technology (IT) is crucial for enhancing the effectiveness and efficiency of organizations, particularly in construction project management. IT integration in the Industry 4.0 era can improve performance by up to 50%, supporting the management of time, cost, and project quality. Management Information Systems (MIS) play an essential role in managing information and supporting decision-making, while Decision Support Systems (DSS) accelerate decision analysis in complex situations.

In construction projects, the use of project control software helps streamline monitoring and evaluation processes, thereby improving project efficiency. PT XYZ, a technical consultancy firm, uses information systems such as SIGAP, ERP, and SMART, which share similar data inputs. Based on PT XYZ's 2022-2026 Information Technology Master Plan, this research aims to develop an integrated information system between SIGAP, ERP, and SMART using APIs, based on the PMBOK 6th edition 2017. This integration is expected to reduce data gaps between systems and improve project control, ultimately enhancing the company's performance.

II. THEORY

2.1 Project Management

Based on PMBOK 6th Edition, 2017, Project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements. Project management is achieved through the proper application and integration of the project management processes identified for the project. Project management enables organizations to execute projects effectively and efficiently.

Project Management Knowledge Areas:

- Project Integration Management
- Project Scope Management
- Project Schedule Management
- Project Cost Management
- Project Quality Management
- Project Resource Management

- Project Communications Management
- Project Risk Management
- Project Procurement Management
- Project Stakeholder Management

2.2 Management Information System

Rusdiana et al., (2014) explained that Management Information System is an information system that is able to balance the costs and benefits to be obtained. The use of information systems is expected to save costs, increase income and provide very useful information for users.

Types of Information Systems:

1. Transaction Processing System (TPS)
   This system is a system used in all transaction processes which is useful for collecting and storing transaction information.
2. Office Automation System (OAS) dan Knowledge Work System (KWS)
   Both are knowledge levels of the organization. OAS supports data workers who usually do not create new knowledge but only analyze information in such a way as to transform data or manipulate it in certain ways before sharing or disseminating it as a whole with the organization. While KWS creates new knowledge and contributes it to the organization so that it can be done effectively and efficiently.
3. Management Information System (MIS)
   MIS is a computerized information system that works because of the interaction between humans and computers. MIS supports a wider spectrum of organizational tasks than Transaction Processing Systems, including decision analysis and decision making.
4. Decision Support System (DSS)
   Computer-based information system designed to assist in decision-making processes, particularly for complex and unstructured problems. It helps decision-makers analyze data, evaluate different scenarios, and make more informed decisions.
5. Executive Support System (ESS)
   ESS is aimed at providing high-level information and support for long-term decision-making, often involving complex, unstructured, or semi-structured problems.

2.3 Application Programming Interface (API)

A RESTful API is an interface used by two computer systems to exchange information securely over the Internet. Most business applications can communicate with other internal and third-party applications to perform a variety of tasks. RESTful APIs support the exchange of information by following secure, reliable, and efficient software communication standards(Jin et al., 2018) .

Benefit RESTful API:

- Scalability
- Flexibility
- Independence

How RESTful API works:

1. The client sends a request to the server. The client follows the API documentation to format the request in a format that the server understands.
2. The server authenticates the client and confirms that the client has the right to make the request.
3. The server receives the request and processes it internally.
4. The server returns a response to the client. The response contains information that tells the client if the request was successful. The response also includes any information that the client requested.

2.4 SIGAP (Company Expert Information System)

SIGAP is an information system of one of the construction consulting service companies in Indonesia that contains data on permanent and non-permanent expert personnel and project data. SIGAP is expected to be a means of data base related to the progress of projects that have been, are still being and will be implemented (Laporan Akhir Masterplan TeknologiInformasi PT XYZ, 2022).

Current conditions, the implementation of SIGAP in the Engineering Consultant Services Company is still at the Transaction Processing System (TPS) stage. The SIGAP application is a container for personnel data transactions and project data. Personnel data includes personal data, education, experience, certification and training. Project data includes new project info, tender stages, ongoing projects, completed projects, and report recaps (Laporan Akhir Masterplan TeknologiInformasi PT XYZ, 2022).

2.5 SMART (Integrated Risk Management Information System)

SMART is an Integrated Risk Management Information System consisting of 6 Modules (Dwy Prasetya, 2024). The 6 Modules are:

1. Enterprise Risk Management Module
2. Project Risk Management Module
3. Risk Profile Module
4. Loss Event Database Module
5. Risk Maturity Index Assessment Module
6. Dashboard Module

The goals and objectives of SMART implementation are as follows:

1. Provide convenience for the Company in integrating the preparation of risk identification, monitoring and evaluating risk mitigation plans across all projects managed by PT XYZ;
2. Increase the effectiveness and efficiency of risk management data processing, because the data in the risk management information system is data that is presented accurately and in real time (on time);
3. Provide convenience for the Company in building Big Data on risk history at PT XYZ;
4. Provide speed in the risk-based decision-making process to PT XYZ;
5. Able to minimize company losses from potential risks that will occur;
6. As a means of improving the competence of PT XYZ HR.

2.6 ERP (Enterprise Resource Planning)

ERP as the basis of e-business, all company transactions are connected, the process of selling messages, equipment management and control, production and distribution planning, and finance. ERP is a multifunctional company system driven by integrated application modules that help the company's internal business processes.

Benefit ERP:

1. Offers an integrated system within the company, so that processes and decision-making can be carried out more effectively and efficiently.
2. Eliminates the need for updating and correcting data as occurs in separate systems.
3. Allows management to manage operations and not just monitor and is better able to answer all existing questions.
4. Helps smooth the implementation of supply chain management and integrates it.
5. Facilitates communication relationships internally and externally within and outside the organization.
6. Can reduce the gap between programming and legitimate system maintenance methods.
7. Can reduce the complexity of applications and technologies.

2.7 Data Flow Diagram

Data Flow Diagram (DFD) is a logical model of data or process created to describe where data comes from and where data goes when it leaves the system, where data is stored, what process produces the data and the interaction between the stored data and the process applied to the data. DFD describes data storage and the processes that transform the data. DFD shows the relationship between data in the system and the processes in the system

There are several instructions that can be used in the process of creating DFD symbols, namely:

1. Clear naming.
2. Number the processes.
3. Redrawing.
4. Avoid processes that have input but no output, and vice versa, avoid processes that have output but no input.
5. Be careful with unnamed data flows and processes.

There are two basic DFD techniques commonly used, namely Gane/Sarson and Yourdon/De Marco. The symbols used in DFD can be seen in the table below:

Table 2.1. DFD Symbols

Symbol		Explanation
Gane/Sarson	Yourdon/De Marco	
		External entities are the source or destination of data flow or to the system. External entities are the environment outside the system.
		Data flow, describes the flow of data from one process to another.
		The process shows the transformation from input to output.
		Storage space is a component that functions to store data or files.

(Source: Kristanto, 2003)

2.8 PIECES Analysis

PIECES analysis is a framework developed by James Watherbe to analyze manual and computerized systems. This analysis is conducted for consumers and internal parties of the company. PIECES analysis is used to analyze existing systems and proposed systems. PIECES analysis is

an analysis method consisting of 6 assessment indicators, namely Performance, Information, Economy, Control, Efficiency, and Service. This analysis is a way to identify and solve problems that occur in a running system (Wetherbe, 2012).

This analysis uses six evaluation variables, namely:

1. Performance
   Performance is the first variable in the PIECES analysis method. Where it has an important role to assess whether the existing process or procedure can still be improved in performance and see how far and how reliable an information system is in processing to produce the desired goals.
2. Information
   Assess whether the current procedures can be improved so that the quality of the information produced becomes better. The information presented must truly have useful value.
3. Economy
   Assess whether the benefits (use value) of the current procedures can be increased or the costs of implementing them reduced.
4. Control
   Assess whether existing procedures can be improved so that the quality of control improves and the ability to detect errors/fraud improves.
5. Efficiency
   Assess whether the current procedures can be improved, so that operational efficiency can be increased and must be superior to manual systems.
6. Service
   Assess whether the current procedure can still be improved in its ability to achieve increased service quality. Very friendly service quality for end users so that users get good service quality.

III. RESEARCH METHODOLOGY

The research steps for each research question are as follows:

1. **Analysis of the Current System**: This step is conducted through a PIECES analysis (Performance, Information, Economic, Control, Efficiency, and Service), which includes interviews with company representatives and observations of the current system, particularly related to project monitoring, costs, and reporting. After the analysis of the current system is completed, an identification of the integrated system needs based on PMBOK 6th edition 2017 is carried out. The interviewees include application users and heads of relevant departments.
2. **System Framework Development**: After obtaining the results of the analysis of the current system and integrated system needs, the data is used as the basis for designing the system framework using a Data Flow Diagram (DFD). The resulting system framework will then be validated by experts in the field.

Research Variables

No	Variable	Indicator		Sources
X1	Performance	X1.1	Process Efficiency	Slack, N., Cambers, S., & Johnston, R, 2010
		X1.2	Data Accuracy	Laudon, K.C., & Laudon, J.P, 2018
		X1.3	Hardware	Laudon, K.C., & Laudon, J.P, 2018
X2	Information	X2.1	Quality of Information	Laudon, K.C., & Laudon, J.P, 2018
		X2.2	Relevance of Information	O'Brien J.A &Marakas G.M, 2011
		X2.3	Accessibility	Turban E &Volonino L, 2011
X3	Economic	X3.1	Operating costs	O'Brien J.A &Marakas G.M, 2011

No	Variable	Indicator		Sources
		X3.2	Productivity	Turban E &Volonino L, 2011
X4	Control	X4.1	Security	Whitman M.E, &Mattord H.J 2018
		X4.2	Change Control	Dhillon, G., 2007
X5	Efficiency	X5.1	Output generated	Turban E &Volonino L, 2011
		X5.2	Processing Time	Laudon, K.C., & Laudon, J.P. 2018
X6	Services	X6.1	Quality of Service	Parasuraman, A., Zeithaml, V.A., &Berry, L.L. 1988
		X6.2	Satisfaction Level	O'Brien J.A &Marakas G.M, 2011
Y1	Company Performance	Y1.1	Profitability	Brigham, E.F., & Ehrhardt, M.C, 2016
		Y1.2	Operational Efficiency	Slack, N., Cambers, S., & Johnston, R, 2010

(Source: Author's Editing, 2024)

IV. RESULT AND DISCUSSION

4.1. PIECES Analysis

PIECES analysis in this study is used to evaluate and analyze the system running in the company PT XYZ, with the aim of identifying various problems and finding the right solution to improve the efficiency and effectiveness of the system. The analysis process is carried out by compiling several relevant statements in the form of a questionnaire, which is then submitted directly to respondents through structured interviews. The questionnaires distributed have been validated by experts, so that the statements submitted have relevance in obtaining the information needed to analyze the system as a whole.

The results of the evaluation and analysis that have been carried out on the system running in the company PT XYZ through the PIECES analysis approach can be seen in more depth and detail in Table 4.1. This analysis process was carried out by utilizing the PIECES framework, which is a method consisting of six main interrelated variables, which are then further described through fourteen indicators designed to measure the performance, effectiveness, and efficiency of the system as a whole. By using this PIECES approach, it is expected to obtain a clearer and more detailed picture of the actual condition of the system in the company, and certain areas can be identified that may require further attention, improvement, or even optimization to improve overall system performance. Therefore, the results of this analysis are expected to provide deeper insights, which can ultimately be the basis for strategic decision making to improve the system in the company PT XYZ.

Table 4.1 PIECES Analysis Results

		SIGAP		ERP	SMART	$\bar{x}$	$\bar{x}$ variable	$\bar{x}$ Total
Performance	The system makes it easier for users to search for project data	4,29		3,47	3,76	3,84	3,92	3,74
	The data available in the system is in accordance with the existing data (Data accuracy 95% - 98%)	3,94		3,35	3,76	3,69		
Information	Access to software is good (smooth) to support the running system	4,24		4,24	4,24	4,24	3,45	
	The data available in the system is complete	3,53		2,71	3,06	3,10		
	The data entered in each system is the same	3,00		3,00	3,00	3,00		

		SIGAP		ERP	SMART	$\bar{x}$	$\bar{x}$ variable	$\bar{x}$ Total
	The availability of information on the system is very easy for users to access.	4,18		3,59	4,06	3,94		
	The menu options available make it easier to use the system	4,00		3,24	4,06	3,76		
Economic	Use of the system minimizes unit expenditure	3,71		3,76	3,82	3,76	3,81	
	The system optimizes the use of resources to increase productivity and work results.	4,06		3,65	3,88	3,86		
Control	There is a potential for data in the system to be accessed by people who do not have an interest in the work unit or production unit.	2,82		2,29	2,12	2,41	3,33	

		SIGAP		ERP	SMART	$\bar{x}$	$\bar{x}$ variable	$\bar{x}$ Total
	The system can output information related to data changes in real time.	4,12		4,29	4,35	4,25		
Efficiency	The system provides the information needed for each work unit and production unit.	4,35		3,82	4,24	4,14	4,01	
	Waiting time in system access is relatively fast (<5 seconds)	3,88		3,65	4,12	3,88		
Services	The system can meet the needs of business objectives	4,18		3,65	4,12	3,98	3,92	
	The system can assist users in project control.	4,00		3,65	3,94	3,86		

(Source: Author's Editing, 2024)

4.2. Integrated System Development based on PMBOK

In addition to submitting a questionnaire related to the evaluation and analysis of the running system, the author also asked for suggestions and input from respondents regarding the development of an integrated system. The development of this system is expected to accommodate various needs in project control based on PMBOK 6th edition 2017. Figure 4.1 shows the project management business process based on PMBOK 6th edition 2017. In the figure, the area marked with a red circle is the knowledge area that has been accommodated by the SMART system. SMART accommodates develop project charter and project risk management. While the area marked with a blue circle is the knowledge area that has been accommodated by SIGAP. SIGAP accommodates project integration management, project scope management, project schedule management, project cost management, project quality management and project resource management. While the area marked with a green circle is the knowledge area that has been accommodated by

the ERP system. ERP accommodates project cost management and project schedule management. However, in Figure 4.1, it can be seen that there are still knowledge areas that have not been accommodated by the three systems. Knowledge areas that have not been accommodated by the three systems are project communication management, project procurement management, and project stakeholder management. Through this questionnaire, the author expects suggestions and input from respondents for system development, by considering knowledge areas that have not been accommodated.

Figure 4.1 Mapping Existing Systems by Knowledge Area

(Sources: Author Editing, 2024)

1. Development of SIGAP System

Based on the interview results regarding suggestions and input regarding the SIGAP system, the author groups the suggestions and input into the knowledge areas listed in PMBOK, which can be seen in Table 4.2 below.

Table 4.2 Results of SIGAP System Development Analysis

No	Suggestions and Feedback	Knowledge Area
1	Customer satisfaction survey	- Project Stakeholder Management - Project Communication Management
2	Experts - Availability - *Track record* - Evaluation	- Project Resources Management - Project Stakeholder Management
3	User interaction column	Project Communication Management
4	Marketing monitoring	Project Integration Management
5	Company Procedure	Project Quality Management
6	MoU with Partners	Project Stakeholder Management

(Source: Author's Editing, 2024)

2. Development of SMART System

Based on the interview results regarding suggestions and input regarding the SMART system, the author groups the suggestions and input into the knowledge areas listed in PMBOK, which can be seen in Table 4.3 below.

Table 4.3 Results of SMART System Development Analysis

No	Suggestions and Feedback	Knowledge Area
1	K3L Data	- Project Quality Management - Project Resources Management - Project Risk Management - Project Stakeholder Management
2	Chat and comment system	Project Communication Management

(Source: Author's Editing, 2024)

3. Development of ERP System

Based on the interview results regarding suggestions and input regarding the ERP system, the author groups the suggestions and input into the knowledge areas listed in PMBOK, which can be seen in Table 4.4 below.

Table 4.4 Results of ERP System Development Analysis

No	Suggestions and Feedback	Knowledge Area
1	Real time job progress updates	Project Integration Management
2	Notification regarding RAPP Project	Project Communication Management
3	Resume of SIMAS, SIMPRO and SIMAK	Project Quality Management

(Source: Author's Editing, 2024)

Based on the results of the integrated system development interview analysis, the author maps the results of the development analysis of the three systems into the knowledge areas listed in PMBOK. The mapping of the results of the development analysis of the three systems can be seen in Figure 4.2.

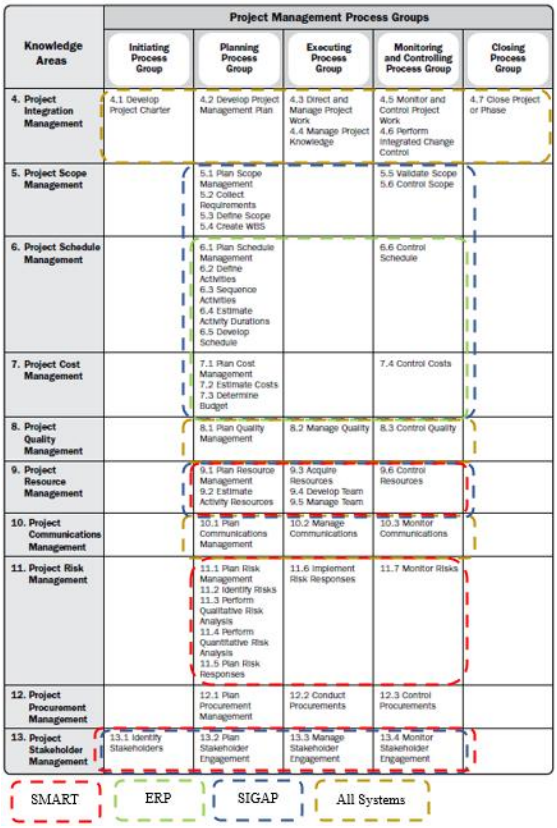

Figure 4.2 Integrated System Mapping by Knowledge Area

(Sources: Author's Editing, 2024)

4.3. Integrated System Development Data Flow Diagram Framework

Based on the questionnaire of the running system analysis and suggestions related to the development of an integrated system, the author created a basic framework using data flow diagrams that have been validated by experts. The basic framework can be seen in Figures 4.3 to 4.12. Figure 4.3 shows the basic framework of the data flow diagram for the existing SIGAP system level 0. The image shows the user inputting project data, expert data and project report data into the SIGAP system so that the manager gets information about the project and experts. Figure 4.4 shows the basic framework of the data flow diagram for the existing SMART system level 0. The image shows the user inputting general project data and project risk register into the SMART system which later the manager will get information about the RMI (Risk Maturity Index) results and Figure 4.5 shows the basic framework of the data flow diagram for the existing ERP system. The image shows the user inputting general project data, work item data and

financial data into the ERP system which later the manager gets the scheduling and RAB results.

Figure 4.3 DFD SIGAP Level 0
(Source: Author Editing, 2024)

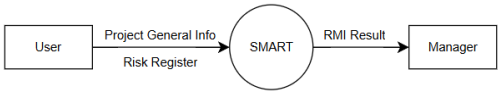

Figure 4.4 DFD SMART Level 0
(Source: Author Editing, 2024)

Figure 4.5 DFD ERP Level 0
(Source: Author's Editing, 2024)

Once integrated, the level 0 data flow diagram (DFD) framework becomes a complete unit. The Level 0 DFD framework can be seen in Figure 4.6. The figure shows that users only need to input general project data, personnel data and project report data once into the SIGAP system. The data entered will then be sent via API to the SMART and ERP systems. The SMART system will then manage risk data using project data sent by the SIGAP system and risk profile data that has been input by the user. Based on suggestions and input that have been submitted by users and validated by experts, the integrated SMART system allows users to input K3L data. Thus, managers will get information related to the Risk Maturity Index (RMI) results and K3L data through the SMART system. On the other hand, the ERP system will manage the schedule and RAB using general project data sent by the SIGAP system and work item data input by the user, so that managers will get information related to the RAB and project schedule. Through this integrated system, managers get more accurate results because project data input is only done once, thus reducing the gap between systems.

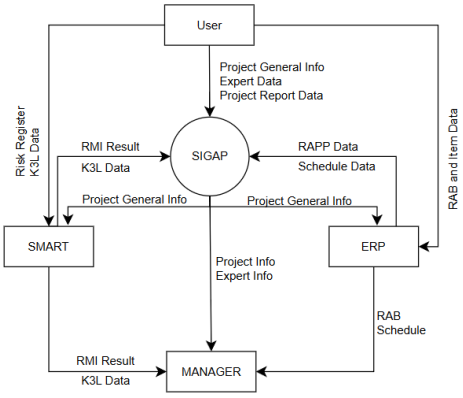

Figure 4.6 DFD Integrated Level 0
(Source: Author's Editing, 2024)

Figures 4.7 and 4.8 show the existing SIGAP level 1 DFD and the integrated SIGAP level 1 DFD. In the figure, it can be seen that the existing SIGAP system only accommodates expert data, general project data and project report data. Meanwhile, the integrated SIGAP system has additional stakeholder data. This additional data is based on user input with the hope that the SIGAP system can record more complete data for project control and improve company performance.

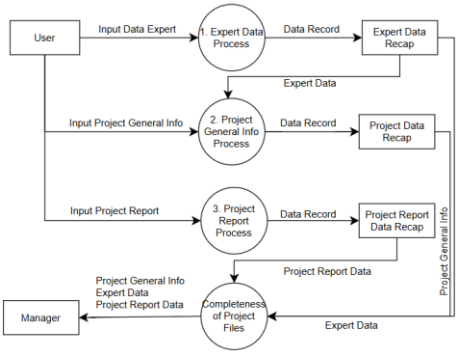

Figure 4.7 DFD SIGAP Level 1
(Source: Author's Editing, 2024)

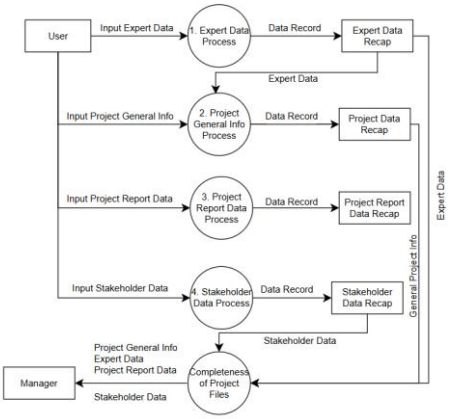

Figure 4.8 DFD SIGAP Integrated Level 1
(Source: Author's Editing, 2024)

Figures 4.9 and 4.10 show the existing SMART level 1 DFD and the integrated SMART level 1 DFD. In the figure, it can be seen that the existing SMART system only accommodates general project data and risk register data. Meanwhile, the integrated SMART system has additional K3L data. This additional data is based on user input with the hope that the SMART system can record more complete data related to risk data that occurs in the field.

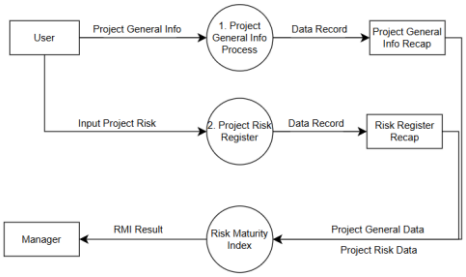

Figure 4.9 DFD SMART Level 1
(Source: Author's Editing, 2024)

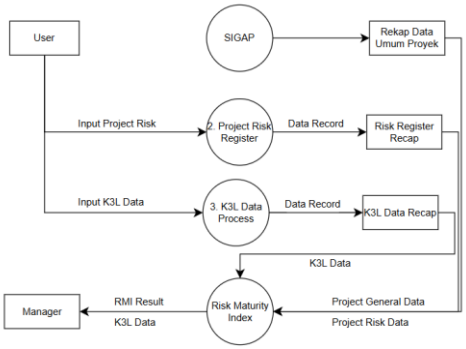

Figure 4.10 DFD SMART Integrated Level 1
(Source: Author's Editing, 2024)

Figures 4.11 and 4.12 show the existing ERP level 1 DFD and the integrated ERP level 1 DFD. In the figure, it can be seen that there is no change in data in the ERP system, only the integration of general project data from the SIGAP system. There is no additional data because the ERP system is in accordance with the Financial Accounting Standards Statement (PSAK) so it is not allowed to have additional data.

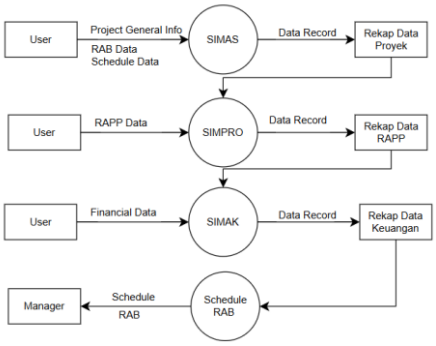

Figure 4.11 DFD ERP Level 1
(Source: Author's Editing, 2024)

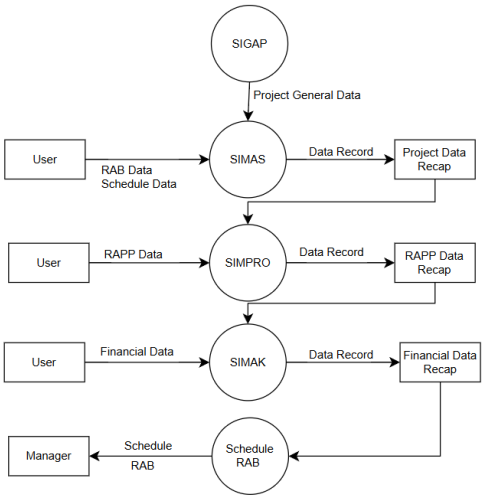

Figure 4.12 DFD ERP Integrated Level 1
(Source: Author's Editing, 2024)

V. CONCLUSION

Based on the results of the study on the analysis of existing systems, analysis of integrated system needs based on PMBOK, and the basic framework for developing integrated systems, it can be concluded as follows:

1. The implementation of the SIGAP, ERP, and SMART systems at PT XYZ has shown quite good conditions with a scale value of 3.74, which reflects an adequate level of efficiency and effectiveness. However, when compared to PMBOK, the existing system still does not cover the area of project management knowledge as a whole. Therefore, it is necessary to add several elements according to the results of the integrated system analysis to improve project control, so that the system becomes more efficient and effective and can improve company performance.
2. The basic framework for developing an integrated information system compiled based

on the system needs analysis has covered important aspects that have not been accommodated in the running system, thus providing a solid foundation for developing a better system in the future.

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