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Data Quality Maturity Assessment in Asset Management Systems: A Case Study from PT XYZ Energy and Utilities Companies.

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Abstract

Nowadays data assets have become critical for organizations, especially in asset-intensive industries like energy and utilities. PT XYZ, an energy, and utilities company in Indonesia, relies heavily on its assets and began transforming its asset management system using top-down approach in 2022. During this transformation, the organization faced significant challenges related to data quality. A maturity assessment based on David Loshin's framework evaluated eight data quality domains and revealed an average maturity score of 2.06, indicating an initial-repeatable level with significant gaps in standards, technologies and performance management. These gaps hinder the achievement of strategic goals, including ISO 55001 certification. By integrating best practices from DMBOK and the Institute of Asset Management, a comprehensive recommendation was developed to address 31 identified gaps and elevate data quality maturity to defined level. Key recommendations include establishing robust governance, adopting advanced data quality technologies and implementing standardized policies, procedures and reporting to improve organizational performance.

A. Introduction

In today's era, data plays a critical role in nearly every business process within organizations [1]. Technology advancements such as sensor, IoT and AI have simplified data collection process, enabling organizations to gather vast amounts of data in a short period [2]. In power industry, this amount of data can offer significant economic and social benefits if managed scientifically and rationally [3]. Electric and utilities companies, in particular, rely heavily on physical grid assets to transport electricity from generators to consumers [4]. To ensure reliable and economically efficient power supply, these companies require optimal asset management.

Research has demonstrated that an effective asset management system is a key success factor for managing assets across various industries [5]. Asset Management is a discipline that depends on a substantial amount of high-quality data to generate accurate information that supports strategic, tactical, and operational decision making [6]. The benefits of implementing an asset management system are extensive, including enhanced asset investment decisions, better risk management, improved efficiency and effectiveness, improved asset availability, and greater organizational sustainability, coordination and communication [7]. However, achieving these benefits depends on the availability of high-quality data.

PT XYZ is one of the largest energy and utilities companies in Indonesia with assets valued at nearly 100 billion dollars. Their portfolio includes short-term and long-term assets, which are utilized over periods ranging from 10 to 50 years. Seeking to achieve a 4% return on assets (ROA), the company recognized the necessity of effective asset management. As part of its 2022 strategic programs, PT XYZ introduced a centralized asset management system, aiming to comply with ISO 55001 and to integrate data across its generation, transmission, and distribution business units. However, during the transformation, the company faced significant challenges, including data inconsistency, integration issues across platforms, and incomplete asset records.

ISO 55001 is widely recognized best-practices for asset management [8]. At the start of transformation program, PT XYZ assessed its asset management activities against ISO 55001 and identified nonconformities with clauses 7.5 and 7.6, which focus on managing and documenting information. According to ISO 55001 [9], organizations shall determine and maintain the quality of identified information and also perform proper documentation to support effective asset management. During preliminary interviews, it was revealed that PT XYZ relied on a variety of technologies that operated in silos at business-unit level. This fragmentation raised significant concerns about data quality in terms of accuracy, completeness, and consistency.

Data quality is crucial in the energy and utilities sector because decisions about physical assets in generation, transmission , and distribution rely heavily on accurate information [2]. Two critical activities in asset management are maintenance planning and asset replacement, both requires high-quality data to perform effectively [4]. One of the first steps in understanding data quality management (DQM) is to measure organization's level of maturity [10]. A data maturity assessment helps companies identify their core strengths, gain a

comprehensive understanding of their business conditions, and provide clear guidance on maximizing the potential of existing data [11].

Theoretical Background

Several studies have investigated data quality assessment and evaluation specifically for asset management systems in asset-intensive industries. Purnomoadi et al. (2023), Kang et al. (2024) and Khaleghian and Shan (2023) propose evaluation frameworks focused on dimensions like completeness, consistency, and accuracy [12], [13], [14]. Grueneberg et al. (2019) define a policy-based approach to measure data quality across four dimension [1], while Tian et al. (2023) introduce Back Propagation (BP) neural network framework to test accuracy, effectiveness, and safety. Moreover, Oyoo and Berleant (2021) suggest an automatic validation approach to enhance data quality assessment for power and utilities companies as part of the ETL process [2]. Collectively, these studies evaluate asset management systems against various data quality dimensions, with completeness and consistency emerging as the most prevalent issues [1], [2], [4], [6], [13], [14].

While most research has focused on evaluating data quality from a technical aspect, studies examining data quality within the strategic context of asset management systems remain limited. According ISO 55001, an asset management system consists of coordinated activities aimed at realizing value from asset investment [15]. These activities include policies, standards, processes, and a strategic asset management plan. Building on this background, the present study measures the maturity of DQM within the Asset Management System of PT XYZ, using David Loshin's data quality framework as a baseline. Loshin's framework has been applied in various studies to assess data quality across eight domains which is data quality expectation, data quality dimension, information policy, data quality protocol, data governance, data standard, data quality technology and performance management [16]-[20]. By offering a balanced technical and strategic perspective, the framework can be adapted for diverse industries and specific applications [21].

The result of assessment then used as a baseline for developing recommendation strategies. DAMA-DMBOK is comprehensive framework that is widely used for data management and governance practices, it contains 11 knowledges areas that relevant to data quality [22].Meanwhile, the Information Quality Framework by The Institute of Asset Management (IAM) used as balancing recommendation as it provides asset management best practices specifically tailored to asset-intensive industries [23]. Figures 1 illustrates how the definitions of data quality, data and information assets, and asset management information quality feed into understanding the dimensions of data quality for asset management. Guided by these dimensions, the organization's data quality maturity measured using Loshin's framework. Finally, based on measurement results a gap for desired rating is identified and becomes baseline for developing recommended strategies with reference framework is DAMA-DMBOK and IAM best practices.

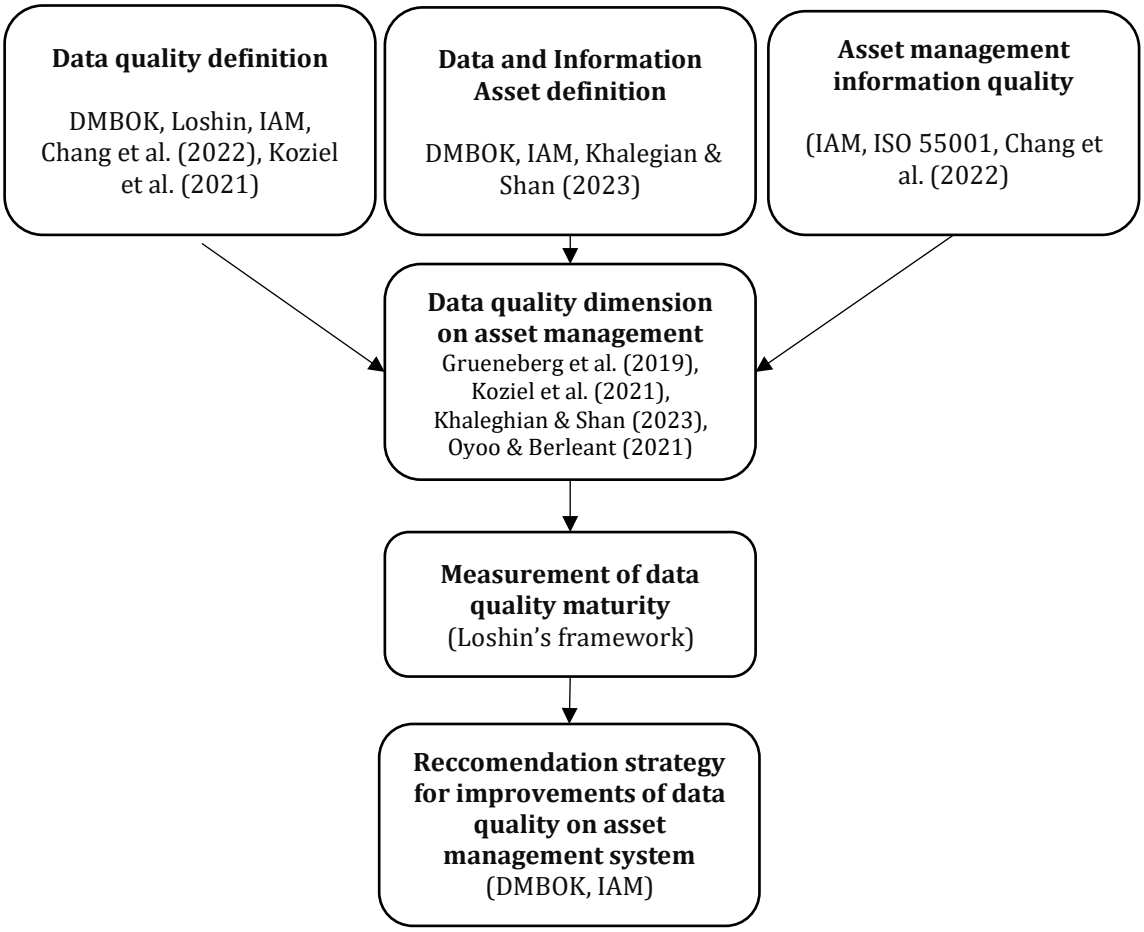

Figure 1. Theoretical Framework

This research can serve as a foundation for measuring data quality in asset management systems on other assets-intensive companies. Hence, the research questions in this study are (1) What is the maturity level of DQM in PT XYZ's asset management systems? and (2) What are the recommendations to improve their data quality management? The remainder of this paper is organized as follows: section B outlines the research methodology. Section C presents the results and discussion, and section D concludes with recommendations and direction for future research.

B. Research Method

Research Stages

This study employs a qualitative approach and classified as a single-case study with deductive processing theory. Qualitative-deductive research confirms the data obtained in the field with theoretical framework that has been formed [24]. Both primary and secondary data are used to assess the data quality maturity of the asset management systems. The results then guide the formulation of recommendations strategies for improvements. The overall stages of this research is illustrated in Figure 2.

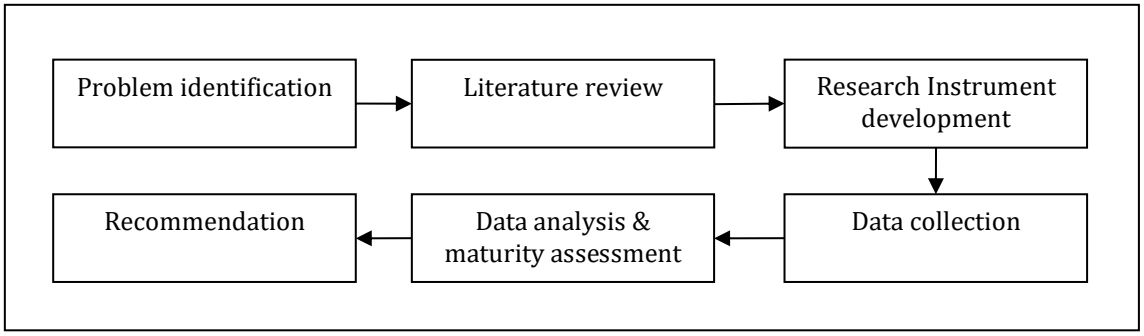

Figure 2. Research stages

This research began with problem identification through interviews with the Head of Asset Management Division. The problem found during the preliminary interviews used as the basis for selecting relevant literature, which then used to develop research instruments aimed at addressing research questions. Data collected through semi-structured interviews with asset management subject matter experts (SMEs) and relevant stakeholders, followed by a review of practices documentation. Subsequently, the maturity rating was assessed, and gap analysis was conducted to identify suitable recommendations for achieving the desired maturity level.

Research Instrument

The instrument used in this study is Loshin's data quality framework. There are 133 characteristics across eight domains within five levels of maturity rating in Loshin's framework [21]. Each characteristic assessed through semi-structured interviews, followed by a review of practice documentation. The assessments are supported by findings such as policy documents, procedure, guidelines, or other evidence that demonstrate whether the evaluated criteria are met. If the evidence meets the criteria, a score of 1 assigned; otherwise, a score of 0 given.

The sample for this study were selected using non-probability sampling method, as an in-depth understanding of the organization's asset management system was essential to obtain relevant information. This approach does not limit the number of interview participants, as its primary objective is to gather comprehensive insights on specific topics [24]. The matrix of characteristics and domains is presented in Table 1.

Table 1. Matrix domain characteristics and maturity level

	Initial	Repeatable	Defined	Managed	Optimized	Total
Data Quality Expectations	3	3	4	4	4	**18**
Data Quality Dimensions	3	2	3	3	3	**14**
Information Policies	3	3	4	5	2	**17**
Data Quality Protocols	4	3	4	6	3	**20**
Data Governance	4	3	4	5	2	**18**
Data Standard	3	6	3	4	4	**20**

Data Quality Technology	2	3	4	2	1	**12**
Performance Management	1	2	4	6	1	**14**
Total	**23**	**25**	**30**	**35**	**20**	**133**

Data Collection

The selection of interviewees began with the Head of Asset Management Division and then expanded using a snowball approach to identify additional asset management experts. In total, five SMEs participated in this study, including one Head of Asset Management division, one Asset Management Expert, two Heads of Asset Management Sub-divisions and one Head of Data Analytics. The final score was assigned only to statements that is supported by documented evidence.

Data Processing

The findings from interviews and document review were analyzed using Microsoft Excel. After calculating the current maturity level, the gaps were identified by comparing current maturity level with the desired state. These identified gaps were then mapped to the DQM activities outlined in DMBOK [22]. Finally, to ensure alignment with industry best practices, the recommendations were further refined using the Information Quality best practices by the Institute of Asset Management (IAM) [23].

C. Result and Discussion

The results of data quality maturity assessment are presented in Table 2. Among the eight Loshin's framework domains, five have reached the repeatable level, while three remain at the initial level. The highest score, 2.57, was achieved in the Information Policies domain, placing it at repeatable level. In contrast, the lowest score, 1.17, occurred in the Performance Management domain, reflecting its initial status. These findings align with feedback from SMEs, confirming that centralized asset management systems across the organization are still under development, and performance management has not yet been prioritized. The three domains that are at initial level are Data Standard, Data Quality Technology and Performance Management. Data standard is still in its formulation stage, and the available data quality technologies have not been fully utilized.

Table 2. Summary of DQM Maturity Level Assessment

No	Dimensions maturity	Maturity score	Description	Target level
1	Data Quality Expectations	2,5	Repeatable	3
2	Data Quality Dimension	2	Repeatable	3
3	Information Policies	2,57	Repeatable	3
4	Protocols	2,33	Repeatable	3
5	Data Quality Governance	2,37	Repeatable	3
6	Data Quality Standard	1,67	Initial	3
7	Data Quality Technology	1,92	Initial	3
8	Performance Management	1,17	Initial	3

The remaining five dimensions have reached a repeatable level, indicating that good practice is already performed but without consistency and documentations across organization. Although policies, expectations, and some procedures have

been established, detailed operational guidelines, such as standard operating procedures (SOPs) haven't been available at organization-wide level. For instance, certain policies and procedures related to metadata and operational requirements already exist only at the business-unit level and this can be leveraged to develop organization wide standards. The target maturity level is set at Level 3 (defined), which aligns with PT XYZ's ISO 55001 requirements for managing and documenting information in support of its asset management systems.

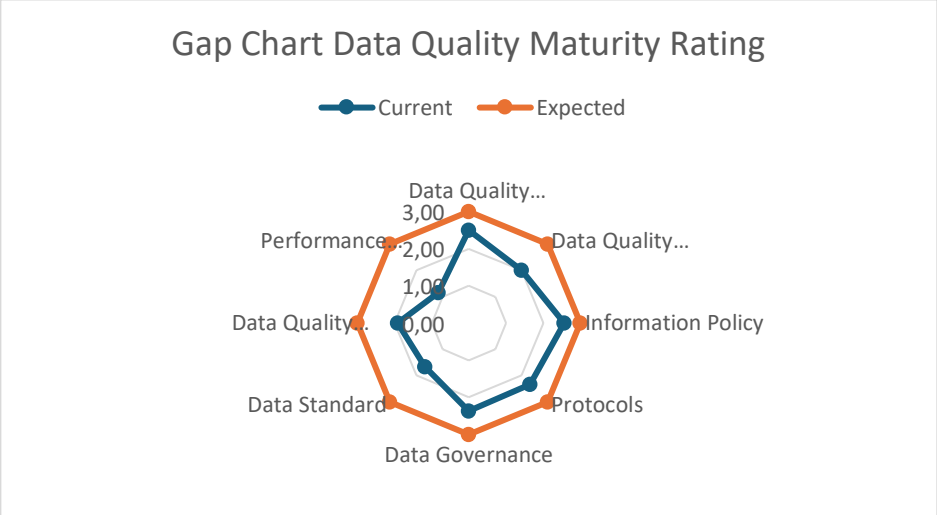

Figure 3. Radar chart data quality maturity gap

From the radar chart shown in Figure 3, it can be seen which of Loshin's domains require attention to reach the desired maturity level. Although some practices identified during interviews have been implemented at business-unit level, no evidence was found at the organizational level. To develop suitable strategies for improving data quality, the identified gaps were mapped to DMBOK DQM activities and IAM information quality best practices. The mapped summary to achieve repeatable data quality maturity is presented in Table 3.

There are six Loshin's data quality domains that need to be improved to fully achieve repeatable level. Most of the missing characteristics are related to data standards, technology, and performance management. The main challenge PT XYZ faces in its centralized asset management systems is the prevalence of siloed practices. To address these gaps, it is advisable to formulate master data, reference data, standard data or a data asset dictionary. Additionally, the technology used by the Data Analytics Division can be utilized to maintain high-quality asset data. Furthermore, root cause analysis and business impact analysis should be conducted when establishing data quality rules to prevent the recurrence of similar issues in the future.

Table 3. Mapped DMBOK and IAM for repeatable level

Repeatable			
Dimension of Maturity	**DQM DMBOK Activities**	**IAM Best practices**	**Missing Characteristics**

Information Policy	• Develop operational procedures for managing data issues	• Information Lifecycle	• Policies to react into data quality issues have not defined
Data Protocols	• Identify critical data and business rules • Develop operational procedures for managing data issues	• Data Standard • Data Governance	• Root cause analysis on data quality issues not performed
Data Governance	• Define a data quality strategy	• Governance, the organization, and the people	• Data quality best practices have not collected across business units.
Data Standard	• Define high quality data • Define a data quality strategy • Manage data quality rules	• Information asset strategy • Standard, specifications, and information asset requirements • Information Lifecycle • Monitoring, Audit, Assurance and Benchmarking	• Reference data for whole organizations is not defined • Trusted data sources have not certified • Metadata standards have not defined for whole organizations • Data exchange standards have not created
Data Quality Technologies	• Perform an initial data quality assessment • Manage data quality rules	• Data Quality Technology • Performance management	• Data quality technology have not fully utilized
Performance Management	• Perform an initial data quality assessment • Manage data quality rules	• Information Lifecycle • Monitoring, Audit, Assurance and Benchmarking	• Characteristics and specific areas that is affected by data quality have not defined

Industry best practices, such as those outlined in the IAM and DMBOK frameworks, provide valuable guidelines for developing actions to enhance DQM. The integration of policy-based templates and automated validation methods, as recommended by [1] and [2], offers practical solutions for addressing gaps in standards and technology. Achieving a defined maturity level requires documenting all relevant DQM practices and making them accessible throughout the organization. Once these practices are documented and made available across organization, consistent implementation across business units becomes feasible [21]. The mapped summary required to achieve defined data quality maturity rating is presented in Table 4.

Table 4. Mapped DMBOK and IAM for defined level

Defined			
Dimension of Maturity	**DQM DMBOK Activities**	**IAM Best practices**	**Missing Characteristics**
Data Quality Expectation	• Identify critical data and business rules	• Standard, specifications, and information asset requirements • Information Lifecycle	• A clear view of data quality expectations is not available. • Business impact analysis for data quality issues have not performed.
Data Quality Dimension	• Measure and monitor data quality • Develop data quality reporting	• Information Lifecycle • Monitoring, Audit, Assurance and Benchmarking	• Expectations of data quality have not been set into detailed such format, value, or semantics data. • Validation based on data quality rules is still under development • Report to measure data quality objectively on organization level is not defined
Information Policy	• Define data quality strategy • Establish data quality service level agreements	• Information Asset Strategy	• Certification for trusted data sources is not implemented • SLA for data quality on asset management systems have not defined
Data Quality Protocols	• Define a data quality strategy • Develop operational procedures for managing data issues	• Information Asset Strategy • Information Lifecycle	• Procedure to check quality of data assets have not defined at organization level • Data quality management practices still siloed in business unit level • Metadata standards have not created for whole organizations • Data exchange standards have not created
Data Governance	• Define a data quality strategy	• Governance, the organization, and the people.	• Organization structure for data governance and data stewardship under development. • Data stewardship program is still on awareness stage
Data Standard	• Define high quality data • Define a data quality strategy • Manage data quality rules	• Standard, specifications, and information asset requirements • Information lifecycle	• Standard data have not defined for each element data • Data exchange schema have not defined
Data Quality Technology	• Define a data quality strategy • Manage data quality rules	• Standards, Specifications, and information asset requirements	• Standards and procedures to use technology for measuring data quality have not made available

	• Develop operational procedures for managing data issues • Develop data quality reporting	• Governance, the Organization, and the People	• Technology component that supports validation, certification, assurance and reporting have not defined at all asset management processes. • Technology component for data quality have not standardized in all asset management environment
Performance Management	• Perform an initial data quality assessment • Develop operational procedures for managing data issues • Establish data quality service level agreements	• Monitoring, Audit, Assurance and Benchmarking	• Formalized process for impact analysis on data quality not yet defined. • Component for Data quality service are not available • Issue tracking systems for data quality issues have not adopted.

A total of 31 missing characteristics were identified that must be addressed to achieve the defined maturity level. These gaps were mapped to DMBOK activities and IAM best practice, as summarized in Tables 3 and 4. The following recommendations provide a high-level summary of actions to address the identified gaps.

1. Analysis and Strategy Development
   Conduct a study to identify critical data assets and analyze the root cause and business impacts, as outlined in DMBOK data quality framework. This process provides a comprehensive understanding of the information required by business. Documents the results as data quality rules and formalize into policies, regulations, and strategies for data quality.
2. Governance and Standardization
   Establish data and information asset governance, and develop documentation, standardization, and reporting for data quality. The standards should include detailed specifications such as format, values, exchange protocols, procedures, and their relevance within a business context, defined in a specific and measurable manner. IAM best practices recommend the creation of an asset data dictionary as a common standard for asset-intensive industries. This effort should be supported by a data governance committee for strategic oversight and a data stewardship program, serving as escalation points for monitoring and addressing data quality issues.
3. Technology Adoption and Optimization
   Adopt data quality measurement and validation technologies to improve process efficiency. Validation processes should be integrated into functional systems and minimize reliance on manual validation to reduce errors. Optimize the use of data validation technologies by standardizing processes and creating organization-wide SOPs. Technologies such as data profiling and

cleansing, as recommended in DMBOK are beneficial but must be managed carefully to avoid introducing new issues. Additionally, adopt technologies such as issue tracking systems to address data quality issues and build a repository of knowledge related to data quality.

4. Monitoring and Continuous Improvement
   Formalize the reporting of data quality assets and publish it on a platform accessible to all employees. This approach enhances user confidence in data assets and encourages participation by providing a clear sense of progress toward improvement. Reporting can begin with simple metrics, such as accuracy and completeness, and should be standardized and supported by technology for efficiency. Define Service Level Agreements (SLAs) to set expectations for data quality, following IAM best practices for asset-intensive industries. Establish trusted data sources to improve the reliability of reported information and minimize inconsistencies. Address issues identified through the issue tracking system and use the insights as a basis for continuous improvement, aligning it with DMBOK's activities on developing operational procedures for managing data issues.

D. Conclusion

The energy and utilities company in this study manages a large number of assets. Therefore, it has adopted centralized asset management systems to support effective strategic decision-making. During their transformation, the organization recognizes that high-quality asset data is essential for effective asset management. Without high-quality data, users of asset management systems may lack the confidence needed to make strategic, data-driven decisions.

The data quality maturity assessment revealed that the organization is at an initial-repeatable level with an average score of 2,06, indicating significant room for improvement in both strategic and technical aspects of data quality. This study identified 31 key gaps, which were mapped to established frameworks, including Loshin's data quality maturity framework, DMBOK, and IAM best practices. The IAM Information Quality framework provides best practices asset management for industries that manages large number of physical assets, while DMBOK offers comprehensive framework for Data Management on technological aspect. Together, these frameworks complement each other in formulating balanced recommendations for improving data quality management.

The limitation of this study is lack of sufficient technical data samples, as asset management data is often confidential. Further study can be carried with focus on technical aspects, such as data architecture or data integration, to provide deeper insights and practical solutions relevant to organizational needs.

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