

ISO 55001 Asset Management Maturity Model Linked to KPIs

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Abstract

Organizational performance, especially in industries, has been affected by the rising relevance of asset management maturity. This review paper highlights the relevance of the integration of ISO 55001 standards pertaining to asset management maturity modeling and key performance indicators as tools to enhance organizational performance. Through the analytical study of literature conducted between 2020-2025, the present study establishes the theoretical and performance-measurement aspects of the relevance of the concept of asset management maturity and its performance measures. It was inferred in this review that organizations possessing higher asset management maturity perform well in their operational and financial key performance indicators. On the other hand, substantial differences have been observed pertaining to the standardized approach of maturity and the correlation of the performance indicators and the standardized level of maturity. This paper embodies efforts to conceptualize a framework related to the relevance of the concept of linkages and integrations of organizational performance using the frames of ISO 55001 and associated measures of maturity and performance tools for organizations that are likely to require transformation regarding their asset management.

Keywords: Asset Management, ISO 55001, Maturity Model, Key Performance Indicators, Organizational Performance, Asset Management System

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1. Background and Context

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“The Paradigm Shift” within the realm of decision-making through data analysis and digital change brings a completely new era within the context of asset management practices within different industries (Karim et al., 2021). This growing necessity within the realm of boundaryless improvement related to cost optimization and value attainment within complex tangible resources † leads different entities towards this process. Under this scenario, ISO 55001 acts as a distinct “International Standard” related to Asset Management, which further helps within the process of organizing different activities within the realm of “assets” based on the objectives of “business” itself (ISO, 2014). The question of maturity in asset management can be viewed as the company’s ability to manage assets from start to finish within their lifecycle and also during the disposal of assets. This was presented by (Hastings in 2022). The maturity model has recently received widespread acceptance in its use due to the ability to compare the

status of the company and optimize improvements in the best practices available. It seems there is still a gap in understanding the level of maturity in the relationship between performance and investment. This is in regard to justifying the investment in maturity improvements.

1.2 Problem Statement

Even after the adoption of ISO 55001 standardization to a large extent, with different asset management maturity models in development, there exist a number of challenges as follows. Firstly, the identification of the KPIs influenced by the degree of maturity is a problem for different entities. Secondly, the relevance and linkage between impact and effect for different dimensions and performance measures in different industries has not so far been established. Lastly, all different proposed maturity models seem to be inclined towards the performance aspect in the context of an entity, as opposed to the compliance aspect in the context of the particular standard, thereby making a gap in the results of application and the vision/entity strategy. In addition, due to recent developments in digital technology, such as the use of artificial intelligence, the internet of things, and predictive analytics, new ways exist in the area of asset management maturity, beyond what the current approaches have been able to encompass (Chatterjee et al., 2024). Instead, what is now needed are theories and approaches that encompass ISO 55001, Maturity models, and KPI optimization, considering the aspect of digital transformation.

1.3 Research Object

This review paper has the following objectives:

1. To assess the theoretical foundation and applicability of models of asset management maturity in relation to the standard set down in ISO 55001.
2. To identify and categorize the KPIs capable of measuring the performance of asset management of different levels of maturity and industries.
3. Review the existing empirical literature on the relationship between different maturity levels of asset management and organizational outcomes.
4. Compilation of best practices on combining the evaluation of maturity with performance measurement systems.
5. To determine the gap that has existed in previous literature regarding management maturity in relation to optimizing its performance.

1.5 Research Significance

Concerning research, this paper is significant as it fills an important gap by giving an extensive review of the related literature on maturity models as well as performance of asset management, which is utilized to reference gaps of research from theories. In practicality, the paper provides an important literature review of maturity models of asset management to policymakers, organizations, or other stakeholders as the review indicates regions which need to be standardized so that maturity models are efficient.

1.6 Paper Structure

The rest of the document is organized in the following manner:

Sec 2: Explaining the steps in a systematic review.

Sec 3: Describing the theory of ISO 55001, Maturity Models, and Key Performance Indicators.

Sec 4: Discussing reviews of Maturity Model frameworks in terms of compatibility with ISO 55001.

Sec 5: Critiquing the links between Maturity Models and Key Performance Indicators.

Sec 6: Outlining the results discussed in the subsequent sections.

Sec 7: Providing advice with regard to future study and application.

2. Methodology

2.1 Research Approach

The relevance of the study is based on the way the systematic approach is used for the review of the existing body of knowledge concerning the relationship between KPIs and asset management maturity models for the context of ISO 55001. The systematic approach allows the study to make the process transparent, replicable, and exhaustive in the identified literature review (Denyer & Tranfield, 2009).

2.2 Literature Search Strategy

The literature review was carried out through several academic portals such as Scopus, Web of Science, IEEE Xplore, and ScienceDirect. The literature review was based on publications between January 2020 and December 2025. The literature was searched using Boolean operators on three concept groups:

- Topics in Asset Management: “asset management,” “physical asset management,” “ISO 55001,” “ISO
- Maturity concepts: ‘maturity model’, ‘maturity assessment’, ‘capability maturity’, ‘maturity
- Related concepts regarding the topic of performance measures in business: ‘KPI’, ‘key performance indicator’, ‘performance measurement’,

The search term was designed to meet the specific syntax and terminology of the database. Furthermore, both forward and reverse citation chaining techniques were employed in the core papers in order to obtain all the literature.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria in studies were:

- Date range: from January 2020 to December 2025
- Research Articles, Presentations, and Whitepapers by others
- Evaluation of Maturity of Asset Management or ISO 55001 Implementation
- Discussion surrounding Performance measurement/KPIs as related to Asset Management
- English language

The categories of studies that were excluded in doing research are:

- Excl. focus on Software Maturity or Organiz. Maturity NOT related to Physical Assets
- Empirical data and theoretical frameworks were not developed
- Whether there are duplicated publications and/or existing versions of updated reviews

2.4 Study Selection Procedure

The search yielded 847 potential publications. Excluding theuplicates (n=213), the manuscripts were screened for the title and abstract (n=634) for potential studies by two reviewers. Those clearly not meeting criteria (n=478) were removed from contention, leaving 156 for further review after evaluation. In the end, 73 studies were used to synthesize the findings. The agreement measure Cohen’s Kappa value was substantial at 0.87.

2.5 Data Extraction and Analysis

Using a standardized data extraction form, the following details were gathered for each trial:

- Study description (authors, year, study type, industry type)
- Asset management maturity model framework & dimensions
- ISO 55001 alignment method
- List of Identified KPIs
- Empirical findings on the Maturity-Performance Relationship

- Methodological approaches and limitations

The data was coded for patterns, associations, and/or gaps through thematic synthesis. The findings are coded in categories that include maturity model constructs, key performance indicators, and industry types.

2.6 Quality Assessment

The quality of the studies is measured through a series of CASP criteria that have been adapted for the purpose of systematic reviews, in terms of the quality of the methodologies, the theories, the appropriateness of the sample, and the findings' validity. There have been studies involving a degree in methodology, and all studies, regardless of the degree, have helped in the current status and the focus for research.

3. Theoretical Foundations

3.1. ISO 55001 Asset Management Standard

ISO 55001 identifies the specific requirements for an asset management system related to the organizational context (ISO, 2014). This international standard equally applies the PDCA cycle. This identifies the use of the PDCA cycle for the purpose of the continual improvement of asset management processes (Wijnia & de Croon, 2020). The essential elements of ISO 55001, which is a global standard, are commitment, alignment, risk-based thinking, engagement & interaction, and management for the whole life span (Hastings, 2022). The benefit that the standard has to offer utilizes the ability to integrate asset management decision-making and business objectives in order to achieve value for money. However, it should be noted that “what” has to be achieved rather than the “how” in the gap in the latter is identified by the maturity model in standards such as ISO 55001, according to Schönbeck et al. (2021).

3.2 Concepts of Maturity

Maturity models assist in shaping a process of measuring an organizational capability, which also develops incrementally towards improvement (De Bruin et al., 2005). In addition, asset management maturity describes an extent to which the defined process of an organization is planned, managed, and reduced (Laue et al., 2021). The theoretical foundations for maturity models have been derived from the principles of capability maturity models, which were originally developed for the software engineering discipline by Paulk et al. in 1993. Current maturity models, which can be applied to the area of asset management, have been conventionally consisting of a progression of five stages, namely, the Initial stage, Developing stage, Defined stage, Managed stage, and Optimizing stage (Mahmood et al., 2020). These stages range with varying levels depending upon the maturity for practices associated with asset management, which progress from being reactive to being optimized.

3.3 Key Performance Indicators in Asset Management

Key Performance Indicators or KPIs are those indicators that can be quantified to assess how well an organization has achieved their strategic objectives (Parmenter, 2020). For asset management, key performance indicators are seen as those instruments that turn general statements concerning “asset maximization” targets to be measured and improved (Komljenovic et al., 2020). Key performance indicators of asset management define different points of views, starting with its operational, for example, those concerning availability, reliability, and utilization, then financial, for example, life cycle cost, return on investment, effectiveness of maintenance, then strategic, for example, strategic fit, satisfaction of stakeholders, and other strategic points of views, down to risks, for example, incidents

concerning safety, non-compliances, and those concerning environments, and finally, incidents concerning risk factors (Oliveira et al., 2023). There are different priorities concerning key performance indicators, depending on circumstances within an organization, situation, and expectations of stakeholders, criticality of an asset, among others (Verbano and

4. Asset Management Maturity Models and Alignment of ISO 55001

4.1 Maturity Model Framework

The literature illustrates that numerous structures in maturity models have been created to address the context of Asset Management. The Institute of Asset Management's (IAM's) Asset Management Landscape is one of the most common structures that include 39 subjects and are further categorized into six subject groups, which are Strategy and Planning, Asset Management Decision-Making, Lifecycle Delivery, Asset Information, Organization and People, and Risk and Review (IAM, 2015). The structure is created to address the criterion required in the ISO 55001 standard, which includes more detailed factors in assessing each subject field in a detailed and uniform way. Other structures include the Global Forum on Maintenance and Asset Management's (GFMAM's) Asset Management Landscape that emphasizes the importance of standardization in relation to cross-reference to global landscape (Ouertani et al., 2020). Other structures have been developed in relation to other sectors such as utility sector, transportation sector, and manufacturing sector, respectively, in other research articles, which are explained in the research articles of van der Lei et al. in 2021, and in the research articles of Silva et al. in 2020, and in the research article of Macchi et al. in 2024. Every structure has its own set of definitions, methods, and processes in relation to its respective levels.

4.2 Maturity Assessment Criteria

Analysis based on the maturity model reveals that there are also some common dimensions of assessments. The dimensions have emerged in different models of maturity: Strategic Alignment: The level to which strategic planning is integrated with organizational planning and strategic requirements (Hastings, 2022). More advanced organizations have visibly clear points of linkage between strategic planning and organizational strategic requirements in terms of structural accountability (Trindade et al., 2021).

Process Standardization: This refers to the extent to which the process in the management of assets has been developed and implemented in a standard way in the organization (Schönbeck et al., 2021). The process of growing in maturity entails improving practices from experience-based methods into developed processes continuously (Mahmood et al., 2020).

Data and Information Management: These are the abilities for acquiring, storing, evaluating, and utilizing data that relate to assets for decision-making (Karim et al., 2021). Indeed, for an advance state of maturity, there would be the engagement of information systems, data quality, and data analysis functions for the processing of data into information (Chatterjee et al., 2024).

Competence & Culture: Maturity here encompasses organizational capabilities, such as competence within the organization, commitment, and culture, that are attuned to the principles of asset management. Capabilities for greater levels of maturity involve competency framework management, learning, and culture focusing on the whole lifecycle for value realization. For example, authors El-Akruti et al. (2021) see high levels of maturity for competency management as involving competency framework management, learning,

Risk Management: The use of risk-oriented thinking in the decision-making of asset management. This comprises risk identification and risk mitigation as well as risk control through continuous risk monitoring (Komljenovic et al., 2020). Enhancing risk management maturity involves shifting from being reactive to pro-active in risk optimization according to risk tolerance of the organization (Oliveira et al., 2023).

specific criteria

4.3 ISO 55001 Compliance and Maturity

There may be various linkages between ISO 55001 and maturity that could provide certain synergies and conflicts. ISO 55001 certification shows the capability bench-marked at the level of 'Defined' (Laue et al., 2021). However, this only acts as the first step for improvement and has a continuous process for improvement through the concept of Maturity (van der Lei et al., 2021). ISO 55001-certified organizations could make use of Maturity evaluation for improvement and monitor progress from the initial bench-mark level (Wijnia and de Croon, 2020). On the other hand, aligning ISO 55001 and Maturity could make the process of ISO 55001 certification simpler and raise capabilities for better performance (Trindade et al., 2021).

5. Linking Maturity Levels and Key Performance Indicators

5.1 KPI Categorization in Asset Management

In reviewing literature, it was identified that there are four key categories of KPI, and they seem to be important in terms of determining asset management maturity assessment: Operational KPIs relate to the measurement of asset and system performance in terms of Availability, Reliability, Mean Time Between Failures (MTBF), Overall Equipment Effectiveness (OEE), and Capacity Utilization (Verbano & Turra, 2020). The Key Performance Indicators directly illustrate the ability of the asset to offer required functions and services (Silva et al., 2020). The Financial Key Performance Indicators provide inputs on the economic aspects of managing the asset in terms of Total Cost of Ownership, Maintenance Cost Percentage of Replacement Asset, Return on Assets, and Cost Optimization over the life cycle of the asset (Roda & Garetti, 2020). The Financial Key Performance Indicators provide inputs on business results, which relate to higher management and shareholders of an organizational unit (Oliveira et al., 2023). The Strategic Key Performance Indicators assess the degree of alignment of the asset management functions with the strategies of the organizations. The KPIs include factors such as Stakeholder Satisfaction, Sustainability Performance, Innovation, and Achievement of Strategic Outcomes (Hastings, 2022). The category of key performance indicators aligns the management of assets to the creation of value over the long term and Competitive Positioning in various markets and sectors (Trindade et al., 2021). The Risk & Compliance Key Performance Indicators assess the performance on Safety, Environmental Compliance, and Exposure to Risk, which include factors such as Safety Events, Rate of Environmental Violations, Audit Outcomes, and Risk Mitigation Efficiency (Komljenovic et al., 2020). The category of KPIs ensures that the management of assets does not impact negatively on sustainability and Social License to operate an organization.

5.2 Maturity-Performance Relationships

Research on the correlation of maturity levels related to KPIs using an empirical approach indicates that there are certain patterns which are always found to persist. Enterprises on higher levels of maturity perform well on several categories of issues related to KPIs, especially on the correlation of viability/efficiency-related indicators of operations and financial efficacy in particular (Mahmood et al.,

2020). Also, there is an observation of non-linear correlation of efficacy for higher maturity levels and efficacy of the enterprise, which tends to saturate on reaching higher efficacy levels, meaning that there is an optimum threshold to reach, which, when surpassed, shows reduced efficacy gains or has diminishing returns (Schönbeck et al., 2021). Enhancement from the Initial Maturity stage to the Developing stage offers an impressive improvement in the KPIs, largely due to the simpler process of optimization as well as more effective handling of the related data generated from it (Laue et al., 2021). Enhancement to the stage of Defined/Mature offers a fair amount of improvement in efficacy, largely due to the process of optimization and integration (Wijnia & de Croon, 2020). On reaching the stage of Optimizer maturity, there is an ensured smaller amount of improvement restricted to highly complex procedures alone (van der Lei et al., 2021). Industry environments have been found to create an intense moderating variable on the efficacy-related correlation of maturity levels of an enterprise. Enterprises in more capital-intensive environments, especially in environments where the involvement of capital is for long periods of time (for instances, the transport service sectors), offer greater efficacy levels of correlation related to finance-related KPI measures, as compared to environments which are short-term involvement-oriented sectors, especially the sectors of newer technology-related businesses (Macchi et al., 2024). Enterprises of highly controlled sectors offer greater efficacy of correlation related to efficacy requirements of related regulatory measures of authorities compared to sectors of other types of involvement environments, especially the newer technology-related sectors (Ouertani et al., 2020).

5.3 Leading And Lagging Indicators

There are leading indicators that forecast future performance and lagging indicators that reveal past performance according to Komljenovic et al. (2020). The maturity level in itself for asset management has been noticed to be a leading indicator that forecasted improvements in KPIs before measuring their resultant outcomes in the future according to Verbano & Turra (2020). In measuring maturity level, the different dimensions of processes related to standardization, documentation, and consistency are measured and noticed to be the leading indicator of KPIs aimed at outcomes regarding availability and cost efficiency according to Silva et al. (2020). The organization can benefit from this forecast through monitoring maturity measurements before changes in the performance of lagging indicators according to El-Akruti et al. (2021).

6. Discussion

6.1 Key Findings

This systematic review has presented a number of findings with respect to the interaction between ISO 55001, Maturity Models for Asset Management, and KPIs.

Finding 1: Convergence Toward Joint Maturity Factors

Although there is proliferation in various frameworks for maturity model development, there is apparent convergence around what the dimensions for assessment should be: strategic alignment, process standardization, data management, competence development, and risk management (Hastings, 2022; Wijnia & de Croon, 2020). This clearly confirms that some degree of commonality exists within the development phase of asset management competence.

There are certain aspects

Empirical Support for Maturity

Empirical research investigations have demonstrated that there exists a positive correlation between the maturity of asset management and organizational key performance indicators (KPIs), particularly in

regard to business reliability and cost of ownership (Schönbeck et al., 2021; Mahmood et al., 2020). Although the methods to measure maturity are relatively well described, the excellence in using the results of maturity measurements for planning improvements in a resource-efficient manner is relatively unexplored (Trindade et al., 2021). It is difficult to allocate among the multiple options for improvements in the context of organizing the advance in maturity.

Conclusion 4: Lack of Integration of Digital Capabilities

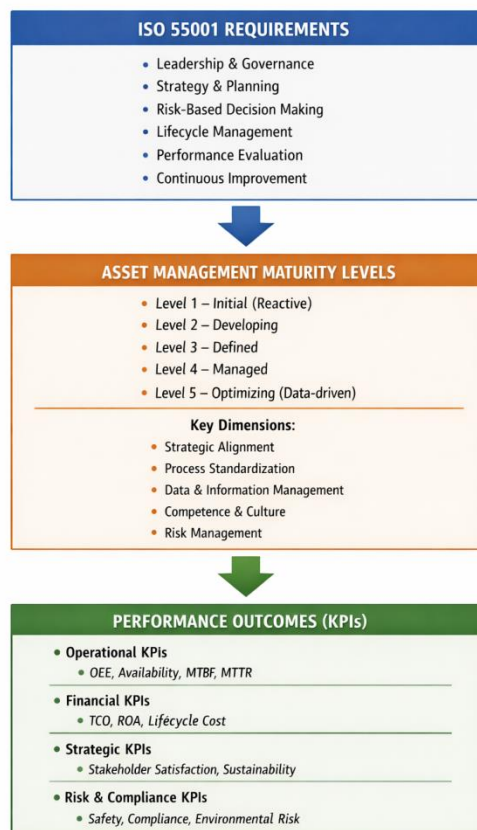
The traditional maturity models have been unable to effectively integrate the latest digital technologies, which are the essence of the subject matter of asset management as a practice. This has resulted in a mismatch between the outcomes of the maturity models and the demands for digital transformation of an organisation.

6.2 Conceptual Framework

Based on the outcome of the literature review, Figure 1 below illustrates the conceptual framework that integrates the needs of ISO 55001, Maturity Models, and KPIs. The graphical illustration of Figure 1 above captures the imperative role of the ISO 55001 standard that establishes fundamental needs, while Maturity Models represent the medium used to deliver these needs on the ground, as far as the effectiveness of this intervention is quantified through the lens of KPIs for Asset Management Transformation.

[Please refer to Figure 1: Integrated Framework for ISO 55001 Maturity-Driven Performance Optimization.]

Figure 1. Integrated Framework Linking ISO 55001 Requirements, Asset Management Maturity Levels, and KPI Outcomes



The framework highlights the three fundamental aspects

Strategic Integration: Strategic integration enables linking strategies for both the business and its assets, and for improving business maturity, which helps meet the requirements of the business through the creation of business capabilities (Hastings, 2022).

Performance Integration: The direct relationships between dimensions and KPIs make possible the forecasting of the effects of investments in maturity in terms of organizational performance. This optimizes improvements from an ROI point of view, as suggested by Verbano & Turra (2020).

Digital Integration: It assists in integrating aspects of digital maturity to make frameworks up-to-date in a world that has AI, IoT, and analytics capabilities (Chatterjee et al., 2024).

6.3 Practical Implications

There are a number of implications of these findings for asset management practitioners: For organizations pursuing ISO 55001, the assessment for maturity has to be conducted before achieving the competency for it, to cover the deficiencies (Wijnia & de Croon, 2020). Lastly, once certified, the maturity assessment of the organization in a systemic manner helps in achieving betterment beyond the compliance (Laue et al., 2021).

For Senior Management: The measure of asset maturity will serve as an indication for the estimation of the coming performance of the operations and financial reports of an organisation, as pointed out by Verbano and Turra (2020). There will be no investment for the capability of maturity concerning the strategic priorities of an organisation, according to the views of Mahmood et al. (2020).

For Asset Management Professionals:

Maturity models help in a systematic manner to build capabilities, but there is a requirement to tailor the process in which this model can be delivered within the organizational framework and the stakeholders involved for assessment (El-Akruti et al., 2021).

Leadership and stakeholder buy-in is greatly required to get support and to keep the momentum for improvement.

6.4: Research Gaps and Future Directions

Some of the most significant research gaps emerging out of this review are:

Gap 1: Longitudinal Research on Maturity-Performance Relationships Most of the existing research has been carried out using cross-sectional study design. In this design, comparisons are made between different organizations at various levels of maturity. There would be many insights gained using longitudinal study design. In this study design, changes in organizations at various levels of maturity are measured over time (Schönbeck et al., 2021).

Gap 2: Integration of Digital Maturity and Traditional Maturity Dimensions Further research is required to develop and test models of maturity, which would take into consideration digital competency, along with current factors in asset management, in the overall model of maturity (Chatterjee et al., 2024).

Future work:

Future researchers can utilize the findings, conclusions, and discussions presented within this paper on various topics. They can write articles, case studies, or carry further research on

Gap 3: Industry-specific Maturity Models and Benchmarks Even though generic maturity models can also be referenced, having industry-specific variants, which consider the nature of the respective industries, government regulations, and competitive environment, will make the process more viable (Macchi et al., 2024). Industry-specific norms would also facilitate comparisons.

Gap 4: Prioritization Techniques for Improvement Based Upon

There is a need to research methodologies to optimize such maturity evaluations to develop road maps of improvements taking into consideration the resource restrictions, strategic outlooks, and key performance indicators (Trindade et al., 2021). The use of optimization tools needs to optimize investments in improvements.

Gap 5: SMEs' Models of Maturity

The five gaps lie between three

Current state-of-the-art approaches in terms of CSfM can be largely related to large companies with specific departments for asset management. Less resource-intensive approaches that can be efficiently used for improvement purposes are areas of promising research in the near future and can be applicable to SMEs (Ouertani et al., 2020). There are a number of weaknesses inherent in the review, which ought to be addressed. Firstly, given that the best practices in asset management are continually evolving, this suggests that the latest information may not yet be reflected within the peer reviewed literature, such that the review may be out of date. Secondly, vulnerability to bias in that it may be affected by studies which find a positive result for the association between maturity and performance, compared to those that did not. Thirdly, it may be difficult to pool information for the KPI measures. Finally, it has been reviewed from an academic perspective.

7. Conclusion

This systematic review covered the integration of ISO 55001 standards on asset management with maturity models and KPIs. Based on the review of literature of the last five years (2020-2025), the findings from the collection of literature of about 73 studies clearly state the development of significant bases for maturity evaluation but some challenges still prevail for the integration of results for improved performance. There exist positive correlations between the evaluation of asset management maturity and the collective output of KPIs from the operational, financial, strategic, as well as risk dimensions of organizations. However, the strengths of these correlations can vary greatly depending on some differences of industries, organizations, and various other factors. ISO 55001 provides some supportive basic structures that can be further developed with the help of maturity models for solution development for execution. The proposed systematic integration framework of ISO 55001, Maturity, and KPI improvement provides some systematic supportive arrangement for innovative execution of various managerial tasks for all interested practitioners. The proposed systematic integration framework clearly suggests that there is some fundamental extensive need to emphasize on the linkage of organizational performances, on integration of various performances on competency development on digital platforms for execution. The guidelines for further development of some gaps for studies of associations of long-term maturity performances might be required for some gaps to cover the association of digital integration maturity more efficiently. On the other hand, development of some parameters for respective industries for some further innovative development of prioritization of performances on maturity might also be required. Further, application of development on the basis of maturity for SMEs might also result in further improvement of management of various organizations on maturity of performances. In short for interested practitioners, this systematic literature paper clearly proves that some comprehensive improved performances might be realized on various dimensions after strategic execution on management of various organizations on innovation of management on maturity. However, for further comprehensive execution, some modifications might be further required to be made according to respective dimensions of organization performances with some comprehensive emphasis on some

linkage of various enhancement on maturity on respective performances of organizations. Further organizations might also conceive improving some collective evaluation of systematic performances for evaluation of maturity on predictive future performances of organizations.

Tables and Figures

Table 1: Comparison of Asset Management Maturity Model Frameworks

Model Framework	Developing Organization	Maturity Levels	Scope Components	Alignment with ISO 55001	Industry Applicability	Key Reference
IAM Asset Management Landscape	Institute of Asset Management (IAM)	5 levels (Initial to Optimizing)	39 subjects grouped into 6 domains	Explicit alignment	Cross-industry	El-Akruti et al. (2021)
GFMAM Landscape	Global Forum on Maintenance and Asset Management (GFMAM)	5 levels	39 asset management subjects	Full alignment	Cross-industry	Ouertani et al. (2020)
PAS 55 Maturity Scale	British Standards Institution (BSI)	5 levels	28 asset management elements	Foundation for ISO 55001	Cross-industry	Wijnia & de Croon (2020)
Utility-Specific Asset Management Model	Various utility organizations	4–5 levels	Infrastructure- and lifecycle-focused assets	Partial alignment	Electric and Water Utilities	van der Lei et al. (2021)
Manufacturing Asset Management Maturity Framework	Academic researchers	5 levels	Production and manufacturing asset focus	Aligned with ISO 55001	Manufacturing sector	Silva et al. (2020)
Digital Asset Management Maturity Model	Technology consultancies	6 levels	Emphasis on digital capabilities and analytics	Extended ISO 55001	Cross-industry	Chatterjee et al. (2024)

Table 2: Key Performance Indicators by Category and Maturity Level Relevance

KPI Category	Specific KPI	Unit of Measurement	Relevance at Maturity Level	Primary References
<i>Operational</i>	Overall Equipment	Percentage (%)	All levels; sophistication	Verbano & Turra

KPI Category	Specific KPI	Unit of Measurement	Relevance at Maturity Level	Primary References
	Effectiveness (OEE)		and analytics depth increase with maturity	(2020)
	Asset Availability	Percentage uptime (%)	All levels	Silva et al. (2020)
	Mean Time Between Failures (MTBF)	Hours	Levels 2–5	Komljenovic et al. (2020)
	Mean Time to Repair (MTTR)	Hours	Levels 2–5	Mahmood et al. (2020)
<i>Financial</i>	Maintenance Cost Ratio	Cost / Asset Value (%)	All levels	Roda & Garetti (2020)
	Total Cost of Ownership (TCO)	Currency	Levels 3–5	Oliveira et al. (2023)
	Return on Assets (ROA)	Percentage (%)	Levels 3–5	Trindade et al. (2021)
	Lifecycle Cost Optimization	Currency saved	Levels 4–5	Hastings (2022)
<i>Strategic</i>	Stakeholder Satisfaction Index	Score (1–10)	Levels 3–5	El-Akruti et al. (2021)
	Sustainability Performance	Composite environmental & social metrics	Levels 3–5	Schönbeck et al. (2021)
	Strategic Goal Achievement	Percentage completed (%)	All levels	Wijnia & de Croon (2020)
	Asset Portfolio Optimization	Value improvement (%)	Levels 4–5	Trindade et al. (2021)
<i>Risk & Compliance</i>	Safety Incident Rate	Incidents per work hours	All levels	Komljenovic et al. (2020)
	Regulatory Compliance Score	Compliance index / audit score (%)	All levels; automation improves accuracy at higher levels	El-Akruti et al. (2021); ISO 55001 (2014)

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