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A Systematic Literature Review Focused on Determining Suitable Maintenance Technique / Strategy

Ipan Pandu Kusumah[1], Racheel Devi Shabrina[2], Rahil Azzahra[3], Hernadewita[4]
[1,2,3,4] Industrial Engineering Department, Mercu Buana University, Jl. Meruya Selatan No. 1, Jakarta 11610, Indonesia

ABSTRACT: Maintenance is a critical activity across sectors for sustaining asset performance over their intended service life; neglecting maintenance may result in catastrophic accidents, substantial loss of life, or asset damage. Maintenance is the process of restoring a physical or intangible asset to its original condition to ensure it fulfils its essential function throughout its life cycle. The purpose of this paper is to review the literature on maintenance technique strategies and maintenance management classifications, and to suggest a suitable maintenance strategy applicable to any particular asset or specific industry. The paper systematically categorizes the published literature and then methodically analyzes and reviews it. A new shift in maintenance paradigm is also highlighted. A total of 44 journal-reviewed articles on relevance, published between 2005 and 2025, were examined across various sectors. The paper review categorizes the literature using a maintenance management classification tree, and we focus on selecting a suitable maintenance strategy for a particular asset or industry, or for none at all.

KEY WORDS: Maintenance Technique, Maintenance Management, Maintenance Classification, Life Cycle

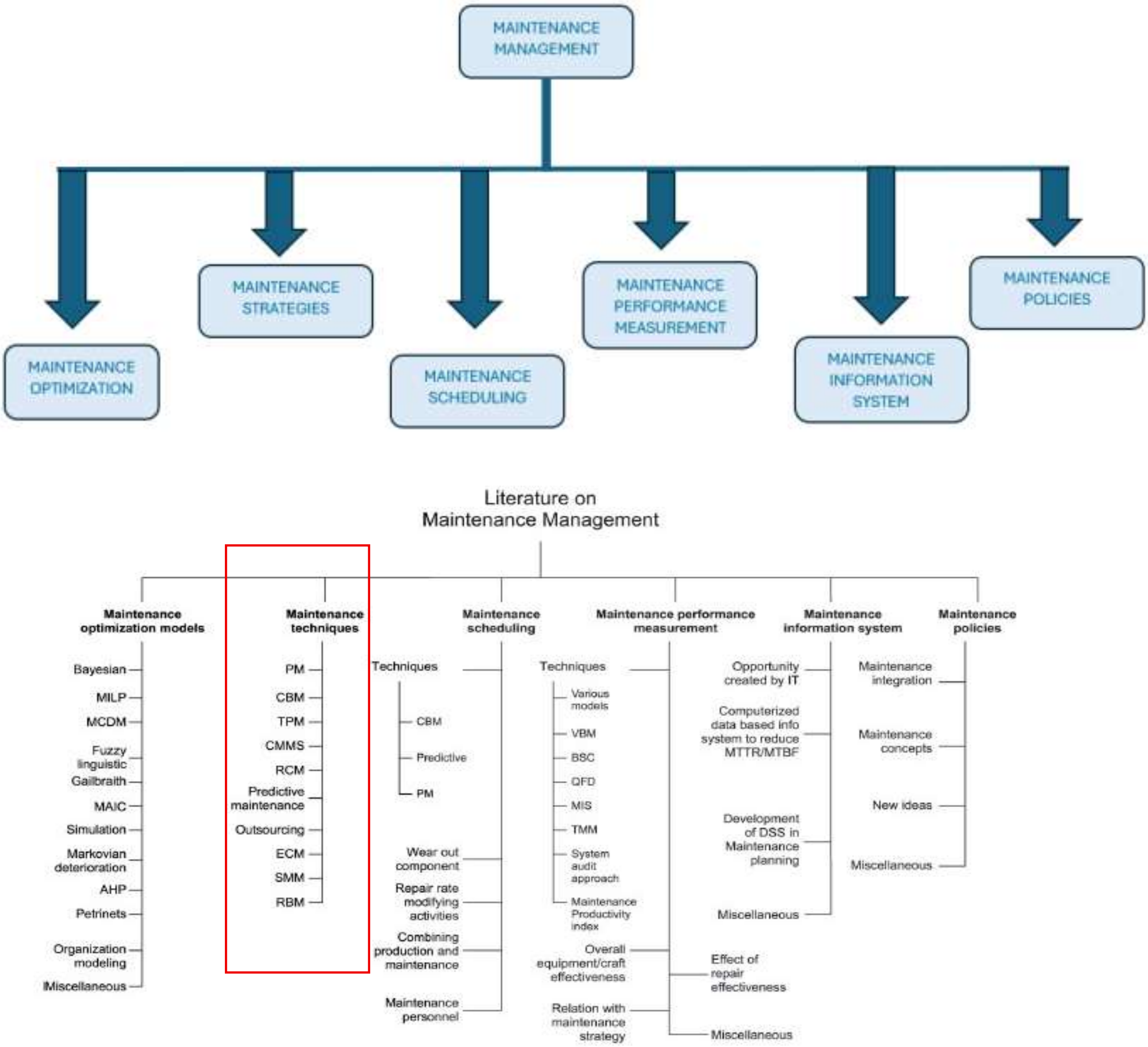
1. INTRODUCTION

1.1 Maintenance Management

Throughout the years, the importance of the maintenance function and, therefore, of maintenance management has grown. The widespread mechanization and automation have reduced the number of production personnel and increased the capital employed in the production equipment and civil structures. As a result, the fraction of employees working in maintenance, as well as the fraction of maintenance spending relative to total operating costs, has increased over the years. In refineries, for instance, it is not uncommon for the maintenance and operations departments to be the largest, each comprising 30 percent of the total workforce. Furthermore, maintenance costs can be the most significant component of an operational budget, particularly for energy-intensive processes. Yet, the main question faced by maintenance management is whether its output is produced more effectively, in terms of contribution to company profits, and efficiently, in terms of
manpower and materials employed are very difficult to answer.

Extensive literature is available from various sources in the field of maintenance management. Dekker and Scarf (1998) have presented various classifications of maintenance optimization models by analysing 112 papers. In maintenance performance measurement, an overview of various performance measurement systems (PMS), including indicators, reference numbers, and surveys, has been discussed in detail (Pintelon and Puyvelde, 1997). Various approaches for measuring maintenance performance have also been reviewed (Tsang et al., 1999). In another invited review, Wang (2002) surveyed maintenance policies for deteriorating systems and ultimately summarized, classified, and compared existing maintenance policies for both single- and multi-unit systems, with an emphasis on single-unit systems. The specific objectives of this paper are to provide a broad classification of this literature into six areas, with year-wise distribution, as shown in Table I. These areas are:

(1) (A) maintenance optimization models;
(2) (B) maintenance techniques;
(3) (C) maintenance scheduling;
(4) (D)maintenance performance measurement;
(5) (E) maintenance information systems; and
(6) (F) maintenance policies.



Notes: MILP: Mixed Integer Linear Programming; MCDM: Multiple Criteria Decision Making; MAIC: Materially per Apparecchiature de Impiariti Chemici; AHP: Analytic Hierarchy Process; PM: Preventive Maintenance; CBM: Condition Based Maintenance; TPM: Total Productive Maintenance; CMMS: Computerized Maintenance Management Systems; RCM: Reliability Centered Maintenance; ECM: Effectiveness Centered Maintenance; SMM: Strategic Maintenance Management; RBM: Risk Based Maintenance; VBM: Vibration Based Maintenance; BSC: Balanced Score Card; MTTR: Mean Time to Repair; MTBF: Mean Time Between Failure; QFD: Quality Function Deployment; MIS: Maintenance Information Systems; TMM: Total Maintenance Management; DSS: Decision Support Systems; ECM: Electronic Counter Measures

Fig.1 Maintenance management classification tree showing various sub-areas

1.2 Maintenance Technique/Strategies

According to Adaramola *et al.* (2024), a Maintenance Strategy must be developed for any industry that uses machines or tools, as it is a detailed plan that includes allocating resources, developing plans, maintaining focus on performance, and conducting reviews and evaluations. Researchers have been exploring maintenance optimization since the 1960s; for instance, Lee et al. (2023) and Szpytko and Duarte (2021) introduced self-maintenance techniques and machine learning approaches, as well as self-healing machines. Furthermore, Duffuaa and Al-Shayea (2020) illustrated the impact of maintenance effectiveness on manufacturing processes, highlighting the importance of unplanned downtime and poor-quality products in ensuring safe and optimal facility operation for the intended activities. Thereafter, the focus was directed towards Corrective Maintenance Strategy (CMS) and Predictive Maintenance Strategy (PdMS), which You et al. (2011) developed to optimize and control the level of preventive maintenance under varying operating conditions. Afterward, Boyce (2017) stated the 5P's Maintenance Strategies for asset performance "Panic Maintenance based on breakdowns, Preventive Maintenance,Performance Based Maintenance, Performance Productive Maintenance, and finally Performance-Based

Total Productive Maintenance". In addition, Gouiaa-Mtibaa *et al.* (2016) emphasized the integration between equipment maintenance and product quality, motivating researchers to establish a new simultaneous model. Recently, Sheikhalishahi et al. (2017) developed an advanced maintenance approach that employs a dynamic preventive maintenance model to identify imperfect maintenance issues. Furthermore, Gouiaa-Mtibaa *et al.* (2018) focused on the impact of Machine Failure Rates (MFR) and the need for quality control in selected maintenance approaches. Henceforth, Fan *et al.* (2019) established a hybrid maintenance program to avoid failures in offshore wind farms.

In the following subsections, explain the different maintenance strategies, including their advantages and disadvantages, using previous research's views as the foundation of the literature review.

1.2.1 Reactive Maintenance Strategy (RMS)

It is also referred to as the Corrective Maintenance Strategy (CMS), the Run-to-Failure Maintenance Strategy (RTFMS), or the Immediate Maintenance Strategy (IMS). This Strategy emphasizes identifying the root causes of malfunction from a failure perspective, which may involve multiple failure symptoms (Wang et al., 2014). RMS is typically performed whenever malfunctions or equipment breakdowns impose direct Health, Safety, Security, or Environmental risks; therefore, it's not required to have a planning process, which results in lower costs. For example, if there is an accidental spill from refinery piping into land or sea, or a failure of an elevator carrying people, immediate action shall be taken without delay to prevent massive environmental damage or loss of life (Kanoun et al., 2024). One serious concern is that RMS is unsuitable for critical equipment due to the high likelihood of sudden failure, given the lack of regular checks. Moreover, the RMS drawback for businesses is that the asset will quickly deteriorate, as noted by Van Horenbeek and Pintelon (2013).

1.2.2 Preventive Maintenance Strategy (PMS)

It is also known as the Scheduled Maintenance Strategy (SMS). The following maintenance strategy emphasizes developing a maintenance plan for all assets and performing it regularly, in accordance with the recommendations of the asset manufacturers or standard practices/guidelines. Ruberti *et al.* (2024) and Geurtsen *et al.* (2024) proposed a maintenance planning approach that anticipates wear and tear, thereby extending asset useful life, reducing maintenance costs, and maintaining reliability. Regardless of whether assets are critical or not, such as equipment, machines, tanks, vehicles, and/or buildings, they need to be checked regularly to avoid sudden breakdowns and keep the business running smoothly. Henceforth, the main advantages of PMS are reduced unplanned stoppages, aapproach, and improved safety during operation. On the other hand, drawbacks include the cost of required resources and the risk of overutilization if the asset is underutilized.

1.2.3 Reliability-Centred Maintenance Strategy (RCMS)

It is a systematic approach that focuses on sustaining asset functionality while accounting for failure modes and consequences. RCMS prioritizes maintenance activities based on asset criticality and the potential impact of asset failure (da Silva et al., 2023). RCMS is a comprehensive Maintenance Strategy that optimizes asset reliability and performance by identifying appropriate maintenance tasks for each asset based on its criticality and failure consequences. The U.S. aviation industry initially developed RCMS to support the airline industry and has since been gradually implemented in other sectors, including healthcare, energy, and manufacturing (Bai and Paik, 2024). Although assets operate in challenging environments and require high reliability, such as in the food industry, RCMS aims to sustain asset capability and performance without compromising any component's reliability (Yavuz et al., 2019). One significant advantage of RCMS is the ability to allow assets to run to failure without compromising performance, thereby benefiting organizations by improving resource utilization and reducing costs. RCMS may use various technologies, such as vibration analysis or thermal detection, to detect failures without requiring immediate maintenance. Conversely, the disadvantage of RCMS is its complexity of implementation and the time and effort required, which may not suit small businesses or new organizations (Jiang et al., 2024).

1.2.4 Total Productive Maintenance Strategy (TPMS)

It is a comprehensive Maintenance Strategy that aims to maximize equipment efficiency by involving all employees in maintenance activities, thereby enhancing workplace visibility and the team's knowledge and skills (Suzuki, 2017). TPMS requires following the Preventive Maintenance Strategy (PMS) and a continuous improvement and proactive approach, which will help eliminate equipment-related losses and improve overall productivity and Overall Equipment Efficiency (OEE) (Wolska et al., 2023). Historically, TPMS has been based on LEAN manufacturing principles, adapted from Japan between 1950 and 1970, as TPMS is primarily a combination of Preventive Maintenance Strategy and production activities (Agustiady and Cudney, 2023). TPMS activities are simple, such as cleaning and lubricating equipment, whereas deep maintenance will be performed by specialized personnel. One of the challenges for implementing TPMS is the deployment of time and resources, as it will require extensive training, workflow restructuring, and the development of standard operating procedures (SOPs), as explicated by Wardhani and Risonarta (2023). Henceforth, for organizations with limited resources or tight production schedules, TPMS will be challenging to implement successfully, as it requires strong leadership, sufficient resources, and a team-oriented mindset.

1.2.5 Risk-Based Maintenance Strategy (RBMS)

It is a proactive, systematic approach that prioritizes maintenance activities based on the potential risks of asset failure and the impacts on safety, the environment, operations, and costs (Collina et al., 2024). RBMS is primarily focused on high-risk industries, for instance, on corrosion in subsea pipelines. In contrast, the failure of critical assets may lead to severe damage, as discussed by Li *et al.* (2024). RBMS implements risk assessment tools like Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), or Reliability-Centred Maintenance Methodologies (RCMM) to evaluate critical assets, which support organizations to allocate resources for the most vulnerable and high-impact equipment (da Silva *et al.,* 2023; Yousofnejad and Es'haghi, 2024). One of the noteworthy advantages of RBM is its ability to enhance asset reliability and minimize unplanned downtime by identifying potential failure points and addressing them before they occur (Kiran et al., 2016). RBMS helps ensure consistent operations and appropriate resource allocation while mitigating the risk of downtime through a dynamic risk-based approach, as supported by the ISO 31000 risk management framework (Fernández et al., 2022). Despite RBMS's advantages, it has limitations: its complexity and high implementation cost, which require substantial investment in specialized tools, training, and expertise; therefore, RBMS may not be suitable for smaller organizations. Additionally, RBMS relies on accurate data; therefore, unreliable data may lead to incorrect prioritization and ultimately call into question the effectiveness of the RBMS strategy (Nguyen et al., 2022). Moreover, integrating RBMS into existing maintenance workflows requires substantial time and may encounter resistance from personnel accustomed to traditional maintenance approaches.

1.2.6 Condition-Based Maintenance Strategy (CBMS)

It is also known as Predictive Maintenance Strategy (PdMS). The Corrective Maintenance approach was prevalent; subsequently, the pattern shifted to the Preventive and Condition-Based Maintenance approaches, as reported by Guo *et al.* (2014). CBMS is associated with recent innovations and the 4.0 revolution in the industry by using condition-monitoring methodologies to identify indications of asset deterioration or failure well in advance, as demonstrated by Schneidhofer *et al.* (2023). Following the strategy improves maintenance expenditures, operational efficiency, and better manpower utilization (Munsamy et al., 2024). CBMS detects potential breakdowns and wear and tear in real time using advanced techniques, including vibration analysis, oil analysis, and thermography. CBMS minimizes downtime and enhances asset dependability, which enables maintenance teams to tackle problems at an early stage and whenever required by real-time monitoring; therefore, it is not required to keep spare parts, as highlighted and proved by different authors (Kampitsis and Panagiotidou, 2022; Zhang *et al.,* 2024a; Zhang *et al.,* 2024b). Implementing CBMS requires an initial moderate investment and time to set up sensors, indicators, or elements to monitor asset conditions, which may not be suitable for small organizations. Overall, CBMS is a powerful Maintenance approach that maximizes efficiency, reduces maintenance expenditures, and improves asset reliability over time.

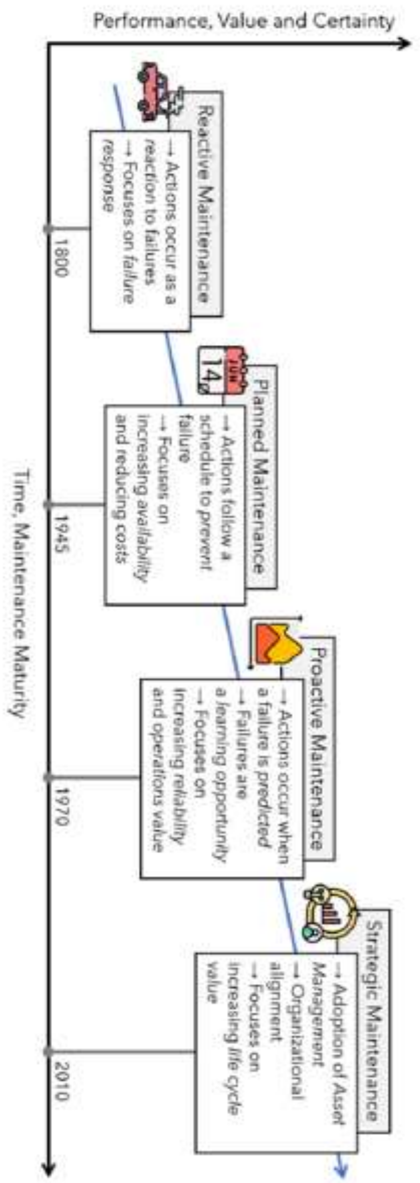


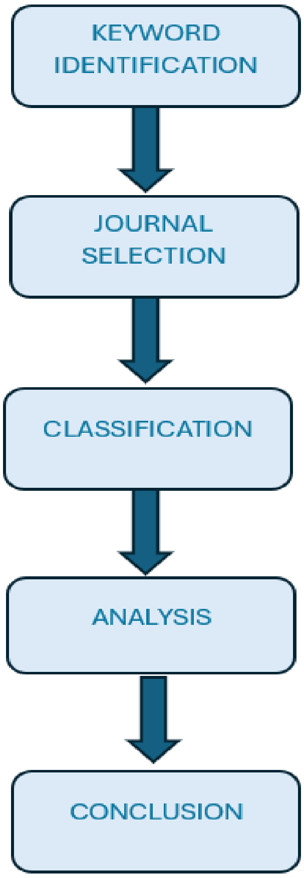
Fig. 2 Evolution of maintenance maturity in organizations, leading to the four main maintenance strategies; adapted from the GFMAM Maintenance Framework (GFMAM, 2021)

2. METHODOLOGY

The literature review is considered a fundamental methodological approach in management research, and particularly the Systematic Literature Review (SLR). According to Saunders *et al.* (2019) and Moschis (2024), SLR examines various elements, frameworks, models, and tools that are important for decision-making and for identifying what is known and what remains unknown. Henceforth, the following research employed SLR as the research methodology, as it is a rigorous approach to synthesizing prior research on the same topic.

This study employs a systematic literature review approach to identify and categorize methods used for determining maintenance strategies. The data source comprises 56 peer-reviewed articles published between 2011 and 2025 in international journals relevant to maintenance strategy methods.

Systematic Literature Review Flow Chart



3. ANALYTICAL TECHNIQUE

The analysis was conducted descriptively by identifying common patterns, dominant methodological approaches, and gaps in the literature. Each article was reviewed based on its abstract, methodology, and key findings relevant to Maintenance Method, Technique, and Strategy.

No	Paper identity	Research object	Result
1	Loufty A, Elhag T (2025) – A Review of Determining Suitable Maintenance Strategy	Development of maintenance strategies	Maintenance strategies matrix
2	Carpitella , Mzougui, Benítec, Carpitella, Certa, Izquierdo, La Cascia (2020)- A risk evaluation framework for the best maintenance strategy: The case of a marine salt manufacturing firm	A risk evaluation. The case of the marine salt manufacturing firm	This paper proposes a multi-criteria decision-making (MCDM) framework for evaluating the main risks associated with maintenance interventions.
3	Lundgren, Bokrantz, and Skoogh (2021) A strategy development process for Smart Maintenance implementation	Digitalized manufacturing. Maintenance in digitalized manufacturing Strategy development and road mapping	New way of perceiving and developing maintenance strategies. A cyclic process for strategy development is proposed to stimulate the development of maintenance organizations and support the implementation of smart maintenance.

No	Paper identity	Research object	Result
4	Garg and Deshmukh (2015) – APPLICATIONS AND CASE STUDIES Maintenance management: Literature review and directions	Maintenance Management	New way of perceiving and developing maintenance strategies. A cyclic process for strategy development is proposed to stimulate the development of maintenance organizations and support the implementation of smart maintenance.
5	Einabadi, Mahmoodjanloo, Baboli, Rother (2025) – Dynamic predictive and preventive maintenance planning with failure Risk and opportunistic grouping considerations: A case study in the automotive industry	Predictive Maintenance (PdM) Preventive Maintenance (PvM)	The results indicate that consideration of the mentioned aspects could significantly impact maintenance planning and overall maintenance costs.
6	Idriss El-Thalji (2025) – Emerging Practices in Risk-Based Maintenance Management Driven by Industrial Transitions: Multi-Case Studies and Reflections	Review of RBM applications across industries	Industry 4.0 impacts the entire risk-based maintenance management loop: it shifts emphasis toward the project phase and built-in features, enhances data collection and its fit-for-purpose use, and enables reinforcement learning across the maintenance management program.
7	Theyab O. Alamri, John P. T. Mo (2022) – Optimisation of Preventive Maintenance Regime Based on Failure Mode System Modelling Considering Reliability	Preventive maintenance schedule · Reliability analysis · Failure modes and effects analysis (FMEA) · Continuity of system output · Partially failure modes · Maintenance optimisation	By using the exhaustive search optimisation method, the maintenance cost is minimised by determining the optimal replacement interval for each FMEA block, subject to system reliability
8	Alizanjadeh M.R., Shayania, Movahedi. (2022) – Optimization of Maintenance in Supply Chain Process and Risk-Based Critical Failure Situations (Case Study: Iranian Oil Pipeline and Telecommunication Company, North District)	Effect analysis and failure mode, Risk-based maintenance, Process quality, Mathematical optimization	The results show that the proposed model is significantly more flexible in calculating equipment weight and dynamic rating and yields more logical rating results.
9	Tambare, Meshram, Cheng-Chi Lee, Ramteke, Lucky Imoize (2021) – Performance Measurement System and Quality Management in Data-Driven Industry 4.0: A Review	Performance measurement system, Industry 4.0, Internet of Things, Quality	This article presents several theoretical and practical models to understand how data-driven Industry 4.0 and smart manufacturing industries apply different performance standards and employ various frameworks to manage quality.
10	Van Oudenhoven, Van de Calseyde, Rob Basten & Demerouti	Predictive maintenance, Industry 5.0	The results contribute to a fundamental understanding of acceptance behaviour in

No	Paper identity	Research object	Result
	(2023) – Predictive maintenance for Industry 5.0: behavioural inquiries from a work system perspective		A PdM context and provide recommendations to increase the effectiveness of PdM implementations.
11	Chemweno, Liliane Pintelon, Muchiri, Adriaan Van Horenbeek (2023) – Risk assessment methodologies in maintenance decision making: a review of dependability modelling approaches	Asset failure, risk assessment, dependability modelling, uncertainty, maintenance decision making	The review structures knowledge on dependability modelling approaches and the treatment of uncertainty. It highlights key challenges that researchers and practitioners are likely to encounter when conducting risk assessments in maintenance decision-making.
12	Sanchez-Londono, Barbieri, Fumagalli (2022) – Smart retrofitting in maintenance: a systematic literature review	Smart retrofitting · Maintenance · Asset management · Industry 4.0	The analysis of the Smart Retrofitting in Maintenance (SRM) literature reveals that there are important research opportunities in the exploitation of SRM for strategic maintenance and asset management
13	Azlina, Nasution, Nurul Huda (2025) - Systematic Literature Review: Application of Work System from Lean Maintenance and its Methodology	Lean Maintenance, Maintenance Efficiency, Downtime,	Based on the research conducted, machine maintenance using the lean maintenance (LM) approach has been proven in all reviewed scientific articles to show an efficiency increase of 60.7%, a reduction in downtime, and the ability to determine maintenance schedules
14	Maletič, Pačaiová, Nagyová, Maletič (2020) – The Link Between Asset Risk Management and Maintenance Performance: A Study of Industrial Manufacturing Companies	Risk management; maintenance performance; physical assets	Provide additional management insights to support decision-making on the management of physical assets and maintenance.
15	Chemweno, P., Pintelon, L., Meyer, A. M. D. (2016). A Dynamic Risk Assessment Methodology for Maintenance Decision Support.	Development of a dynamic risk assessment framework for maintenance decision-making.	Proposing a dynamic risk assessment methodology based on hierarchical Bayesian inference and Monte Carlo simulation to address the limitations of traditional FMEA. This approach allows continuous updating of risk metrics as new data becomes available, enabling more objective failure prioritization and maintenance strategy selection. The framework was validated through a case study in a thermal power plant, demonstrating improved decision-making, cost efficiency, and asset reliability.
16	Gul, M., Celik, E., & Akyuz, E. (2017). A Hybrid Risk-Based Approach for Maritime Applications: The Case of Ballast Tank Maintenance.	Developing a hybrid risk assessment model to improve safety in maritime operations, specifically during ballast tank maintenance on cargo vessels.	Using the Fine-Kinney method integrated with Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy VIKOR (FVIKOR) to assess and prioritize occupational hazards in ballast tank maintenance. The hybrid model offers a more precise, flexible, and data-driven approach than traditional methods, thereby reducing subjectivity in risk evaluation. Results showed

No	Paper identity	Research object	Result
			that hazards such as high temperatures, falls, and head injuries during maintenance posed the greatest risks. The proposed approach enhanced decision accuracy, risk prioritization, and safety management in maritime operations.
17	Loutfy, A., & Elhag, T. (2025). A Review of Determining a Suitable Maintenance Strategy.	A systematic review comparing multiple maintenance strategies to identify the most effective approach for industrial applications.	Using a Systematic Literature Review (SLR), six maintenance strategies were compared: Reactive, Preventive, Reliability-Centred, Total Productive, Risk-Based, and Condition-Based Maintenance. The authors conclude that Risk-Based and Condition-Based strategies are most effective in Industry 4.0, as they provide predictive capabilities and reduce downtime.
18	Rezvanizaniani, S.M., Dempsey, J., & Lee, J. (2014). An Effective Predictive Maintenance Approach based on Historical Maintenance Data using a Probabilistic Risk Assessment: PHM14 Data Challenge.	To develop a probabilistic risk-based predictive maintenance model using historical maintenance data.	A Probabilistic Risk Assessment (PRA) model was built using maintenance history to predict failure intervals. The model successfully identified high-risk components, improving maintenance scheduling and reliability prediction. It proved effective in predictive risk modelling and proactive maintenance planning.
19	Leveson, N. (2015). A Systems Approach to Risk Management through Leading Safety Indicators.	To propose a systems-theoretic framework for identifying leading safety indicators in complex operations.	The paper introduces STAMP (System-Theoretic Accident Model and Processes), which focuses on system-level risk control and leading indicators. It highlights proactive monitoring and organizational learning as key to preventing accidents. The method strengthens systemic safety management in high-risk industries.
20	Abu-Siada, A., Islam, S., & Martin, D. (2018). A Review of Monitoring Methods for Predictive Maintenance of Electric Power Transformers Based on Dissolved Gas Analysis.	Review of predictive maintenance methods for power transformers using Dissolved Gas Analysis (DGA).	The paper reviews DGA-based condition monitoring and predictive techniques, emphasizing AI integration for improved diagnostic accuracy. It concludes that combining machine learning and pattern recognition enhances early fault detection and supports the evolution of smart maintenance systems under Industry 4.0.
21	Chemweno, P., et al. (2015). Development of a risk assessment selection methodology for an asset Maintenance decision making: An analytic network process (ANP) approach	Development of a methodology for selecting risk assessment techniques for asset maintenance decision-making.	Using the Analytic Network Process (ANP) method to develop a model based on 30 generic organizational competency criteria. The methodology helps practitioners select the most suitable risk assessment technique (e.g., FMEA, FTA, BN) based on their organization's specific competencies, thereby improving maintenance decision support.
22	Tan, Z., et al. (2011). An evaluation of maintenance strategy using risk-based inspection	Evaluation and selection of maintenance strategies for equipment in an oil refinery.	Implementation of Risk-Based Inspection (RBI) successfully categorized 390 equipment items into five risk zones. Using a developed Analytic Hierarchy Process (AHP) model to recommend different maintenance strategies for each risk level: Reliability centred

No	Paper identity	Research object	Result
			Maintenance (RCM) for the unsatisfactory area, Preventive Maintenance (PM) for the critical area, and Corrective Maintenance (CM) for the tolerable and acceptable/ favourable areas.
23	Chinniah, Y. (2015). Analysis and prevention of serious and fatal accidents related to moving parts of machinery	Analysis of the causes of serious and fatal accidents related to moving parts of machinery.	Analysis of 106 accident reports identified the primary causes as easy access to moving parts and inadequate safeguarding. Failure to apply lockout procedures during maintenance and troubleshooting. Worker inexperience, bypassing of safeguards, poor machinery design, and the absence of risk assessments.
24	Wijeratne, W.M.P.U., Perera, B.A.K.S., & De Silva, L. (2014). Identification and assessment of risks in maintenance operations.	Occupational risks and risk assessment methods within maintenance operations in the Sri Lankan manufacturing industry.	Identified common maintenance risks (e.g., cuts, falls, unsafe acts) and the primary risk assessment methods used (checklists, brainstorming, risk matrices). The study identified a lack of maintenance-specific risk assessment. It highlighted key drawbacks, including limited stakeholder awareness and the subjectivity of assessments, and proposed a framework for improvement.
25	Fernández, P. et. Al. (2022). Dynamic Risk Assessment for CBM-based adaptation of maintenance planning.	A practical method for dynamic maintenance planning based on Dynamic Risk Assessment (DRA) integrated with Condition-Based Maintenance (CBM).	Proposed a DRA method that uses three core concepts—Failure Modes, Events, and States—to dynamically interpret monitoring and maintenance data into risk levels. This method, aligned with the ISO 31000 framework, was successfully validated in a use case for high-speed train bearing maintenance, thereby demonstrating optimized, risk-informed maintenance scheduling.
26	Wang, Y., Liang, G., & Wang, N. (2011). Optimal Preventive Maintenance Strategy based on Risk Assessment.	Developing an optimal preventive maintenance strategy for manufacturing equipment based on quantitative risk assessment.	Established an "Optimal Preventive Maintenance Model based on Risk Assessment" (OPMMRA). The model uses a risk function (combining failure probability and consequence cost) and a cost function to determine the most economical maintenance intervals. The strategy was applied to a manufacturing control system, classifying maintenance actions based on calculated risk values to minimize total cost.
27	Babashamsi et al. (2022). Perspective of Life-Cycle Cost Analysis and Risk Assessment for Airport Pavement in Delaying Preventive Maintenance	Life-cycle costs and risks of delaying preventive maintenance for airport pavements.	A one-year delay in preventive maintenance increases life-cycle cost by 16%. A probabilistic model (PAVECO) helps stakeholders choose cost-effective strategies by showing that delaying maintenance increases costs and uncertainty.
28	Carrillo-Castrillo et al. (2014). Risk assessment of maintenance operations: the analysis of performing tasks and accident mechanisms	Risk assessment of occupational accidents during maintenance operations.	A Fuzzy Decision-Making Ant Lion Optimizer (FDMALO) method was developed to optimize maintenance schedules, simultaneously minimizing cost, risk, and reliability objectives, and provided a superior best-compromise solution.

No	Paper identity	Research object	Result
29	Conachey et al. (2008). Risk-Based Strategies for the Next Generation of Maintenance and Inspection Programs	Risk-based strategies (RBI & RCM) for ship and offshore asset integrity management.	The application of Risk-Based Inspection (RBI) for structures and Reliability-centred Maintenance (RCM) for machinery provides optimized, asset-specific maintenance plans that improve reliability and reduce costs by focusing resources on high-risk components.
30	Achouch, M. (2022). On Predictive Maintenance in Industry 4.0: Overview, Methods and Challenges. Applied Sciences.	Review of predictive-maintenance (PM) methods and tools in Industry 4.0	PM (CBM/PHM/RUL) strongly improves uptime and quality when IoT + analytics are disaggregated; highlights data & integration challenges.
31	Hector, I. et al. (2024). Predictive Maintenance in Industry 4.0: A Survey.	Survey of predictive maintenance techniques, sensors, and prognostics.	The survey summarizes methods (ML, DL, RUL) and notes evidence of reduced downtime and improved product consistency during production.
32	Ji, Z., Pons, D., Su, Z., Lyu, Z., & Pearse, J. (2022). Integrating Occupational Health and Safety Risk and Production Economics for Sustainable SME Growth.	Manufacturing SMEs, integration of risk management and production economics	Demonstrated that linking safety risk assessment with production cost optimization improves long-term productivity and sustainability in small manufacturing enterprises.
33	Drożyner, P. (2020). Risk Analysis in Maintenance Processes.	Industrial maintenance processes in manufacturing systems	Implementing structured risk analysis in maintenance planning identifies critical failure points and increases system reliability and productivity.
34	Bădescu, A., et al. (2022). Quality and Risk Management in Industrial Production Systems: A Literature Review.	Risk and quality integration in industrial production systems	Reviewed methods combining risk and quality control; emphasized the need for more holistic frameworks linking process safety and productivity.
35	El-Awady, S. M. M. (2023). Overview of Failure Mode and Effects Analysis (FMEA). (PMC review).	Review of FMEA applications across industries	FMEA remains practical and effective for identifying/prioritizing failure modes, but requires data and periodic updates to maximize impact.
36	Škůrková, K. Lestyánszka et al. (2023). Quality Improvement of The Forging Process Using Pareto Analysis & 8D Methodology: A Case Study.	Case study using Pareto + 8D to reduce nonconformities in forging line	Pareto enabled focus on a few root causes; the combined method reduced defect rate and improved throughput.
37	Alkiyat, M. (2021). A Practical Guide to Creating a Pareto Chart as a Quality Tool.	Tutorial/review on Pareto chart use in quality projects	Pareto charts effectively prioritize problems; recommended as the first step before deeper analyses (FMEA, DOE).
38	Olalere, I.O. (2024). Assessing Impact of Quality Improvement on Production: SPC & Pareto Application.	Empirical study of SPC and Pareto applications on the production line	Implementation led to measurable reductions in defect rates and increased OEE (overall equipment effectiveness).

No	Paper identity	Research object	Result
39	Kwilinski, A. & Kardas, M. (2024). The Role of the Pareto Principle in Quality Management within Industry 4.0: Bibliometric Analysis.	Bibliometric study on Pareto usage in quality management	Demonstrates the continued relevance of Pareto in Industry 4.0 literature and its integration with digital tools.
40	Kamgba, F. (2024). Development of Predictive Maintenance Technologies for Critical Industrial Systems Using AI and IoT.	Critical industrial systems, predictive maintenance technologies	The integration of AI and IoT in predictive maintenance improved machine health monitoring, prevented failures, and reduced maintenance costs.
41	Stan, C., Oprea, M., & Stan, A. C. (2024). A Case Study of Predictive Maintenance Using Data Analysis for a Flexible Manufacturing Line.	Flexible manufacturing line, predictive maintenance	Demonstrated how data-driven monitoring and early warning systems support maintenance scheduling, minimize production halts, and improve operational efficiency.
42	Ojha, V.K., et al. (2024). A Framework for Data-driven Decision Making in Advanced Manufacturing.	Framework paper for data-driven decisions in advanced manufacturing systems	Presents a practical pipeline from data collection → analytics → action; argues that data governance is key
43	Barraza de la Paz, J. V. (2023). A Systematic Review of Risk Management Methodologies (Comparison of Frameworks).	Systematic review comparing risk management frameworks across domains	Provides a taxonomy of methods and recommendations to choose frameworks adapted to the manufacturing context.
44	Sala, R. (2025). A Review on Three Decades of Manufacturing Maintenance and Its Effect on Quality & Productivity.	Long-range review of maintenance practices and their impact on production	Concludes preventive/predictive maintenance historically improves uptime and product quality; stresses the need for data maturity.

4. ANALYSIS

Based on the literature reviews presented above, each maintenance strategy has pros and cons that may suit a particular asset or industry, or may not. Henceforth, summarizing the findings for each strategy will support the identification of the most suitable maintenance strategy.

• Reactive Maintenance Strategy (RMS): Does not require any planning, no resources, and no investment for spares is required, as action will be taken whenever there is a breakdown. Henceforth, the drawbacks are asset downtime and rapid deterioration, which reduce the asset life cycle and, subsequently, its long-term cost impact.

• Preventive Maintenance Strategy (PMS): Helps extend assets’ life cycle and, in certain cases, may be more than the manufacturer's recommendation. However, PMS could be more costly than other strategies due to resource requirements, for instance, manpower and materials deployed for regular maintenance, and also, the probability of overdoing it in the case of assets that are not well utilized.

• Reliability-Centred Maintenance Strategy (RCMS): Ensures assets perform properly despite the chances of component failure. On the other hand, concerns about time and effort required for implementation make it unsuitable for large organizations.

• Total Productive Maintenance Strategy (TPMS): Helps extend assets’ life cycle by encouraging the accountability of assets’ users. Implementing TPMS depends on shared
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Responsibilities between maintenance and assets’ users are not limited to specialized personnel, as in traditional strategies. TPMS can enhance overall productivity; however, the cost is a concern due to resource requirements. • Risk-Based Maintenance Strategy (RBMS): Focusing on high-risk equipment, deferred maintenance on less critical assets could lead to cumulative issues over time; therefore, balancing attention across all asset categories is essential to prevent long-term operational inefficiencies. RBMS is a powerful

maintenance strategy that optimizes resources, improves safety, and enhances operational reliability. However, its successful implementation requires careful planning, investment in training and tools, and access to reliable and accurate data.

• Condition-Based Maintenance Strategy (CBMS): Providing real-time condition and enquiry of maintenance using innovative techniques in Industrial Revolution 4.0. CBMS differs from other strategies in that it does not require a fixed schedule; however, continuous monitoring and data collection (e.g., vibration, temperature, pressure, and wear) are required to support evaluation of asset condition. The main objective of CBMS is to maintain the asset in acceptable condition whenever required; hence, the following strategy is widely used in manufacturing, aerospace, energy, and transportation, where equipment reliability and availability are essential.

Based on the above, Table 1 presents a useful matrix (Maintenance Strategies Matrix – MSM) to guide the technical team in selecting a suitable Maintenance Strategy for equipment across organizations such as oil and gas, aerospace, food, automotive, and manufacturin

Table 1. Maintenance Strategies Matrix (MSM)

Maintenance strategy	Manpower and spare parts availability	Possibility of Downtime due to a breakdown	Implementation Cost	*HSE incident Risk	Quality incident Risk	Organization size Applicability
Reactive Maintenance Strategy (RMS)	Not Critical	High (More than 72 hrs.)	Low (No Investment)	High	High	Large
Preventive Maintenance Strategy (PMS)	Critical	Low (Less than 12 hrs.)	High (Availing spare parts & manpower)	Low	Low	Medium
Reliability-Centred Maintenance Strategy (RCMS)	Critical	Low (Less than 12 hrs.)	High (Availing spare parts & manpower)	Low	Low	Large
Total Productive Maintenance Strategy (TPMS)	Critical	Medium (More than 24 hrs.)	High (Availing spare parts & manpower)	Low	Low	Medium
Risk-based Maintenance Strategy (RBPS)	Critical	Low (Less than 12 hrs.)	High (Availing spare parts & manpower)	Low	Low	Large
Condition-Based Maintenance Strategy (CBM)	Not Critical	Low (Less than 12 hrs.)	Medium (Availing Monitor Elements)	Low	Low	Large

*HSE: Health, Safety & Environment

* Key Legend:

Not Critical/Low/Small Medium Critical/High

5. CONCLUSIONS AND FURTHER RESEARCH

Across decades, the Industrial Revolution introduced a rapid technological advancement and mechanization, which led organizations to focus on systematic maintenance to avoid business interruption. Therefore, selecting a suitable Maintenance Strategy is an essential part for assuring the reliability and productivity of the assets. The empirical works examined different Maintenance Strategies using a SLR based on previous research. Certainly, the selection of an appropriate Maintenance Strategy could vary based on the equipment's criticality, the nature of the business, and/or the organization's size; however, the following research examines the advantages and disadvantages of each Maintenance Strategy in a matrix titled "Maintenance Strategies Matrix - MSM". The developed MSM indicates the correlation between Maintenance Strategies and various business fundamentals, providing a useful tool for quickly making appropriate decisions.

Based on the findings, further study is required, including primary data collection and a deep analysis of the association between Maintenance Strategies and other business elements, while quantifying and accurately evaluating the differences before implementation. Moreover, monitoring the deterioration of assets relative to the implemented maintenance strategy is an area of interest and warrants further investigation, as the outcomes of such a study can accurately inform the decision to select a suitable maintenance strategy.

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