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Systems Integration Aimed At Improving Quality And Safety In Technical Training Management In Aircraft Engine Components Maintenance Organizations

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Abstract

Aircraft maintenance plays a pivotal role in ensuring the safety of global air transportation, impacting the daily travel experiences of millions of passengers. However, a substantial proportion of operational challenges within this domain arise from human factors, including communication errors, inadequate training, fatigue, and stress. These human errors frequently result in flight delays, increased operational costs, and heightened safety risks. This study addresses the imperative for technical training management system integration to guarantee that only qualified individuals undertake maintenance services. The primary focus is on augmenting quality control measures and ensuring strict adherence to regulatory standards. The study seeks to answer four fundamental questions about aircraft engine maintenance tools, precautions, techniques, and regulatory compliance. The underlying hypothesis posits that integrating systems and unifying information can effectively ensure compliance with regulatory requirements. This, in turn, holds the potential to markedly improve operational efficiency and the overall quality of maintenance services. As a methodological approach, a case study was conducted to analyze the process of managing technical training in Aircraft engine components maintenance organizations and propose an integration method for the different control systems. The research is structured to scrutinize the integration method that best meets the stipulated demands, encompassing a comprehensive analysis of the integration process. This involves an examination of the intricate relationships between various systems and assuring data integrity for immediate and accurate utilization. This study's overarching objective is to enhance the safety and reliability of training management systems in the aircraft maintenance industry. By contributing to improved quality control measures and the seamless functioning of independent systems working in tandem, the research aims to bring about positive advancements in aviation maintenance.

Keywords: systems integration; quality and safety; aircraft engine components maintenance; industrial automation

1. Introduction

The contemporary landscape of aircraft maintenance holds a pivotal role in ensuring the safety and reliability of global air transportation, impacting the lives of millions of passengers daily. Despite its critical significance, operational challenges within this domain predominantly arise from human factors, spanning miscommunication, insufficient training, and the effects of fatigue and stress. These human errors result in delays, rework, increased costs, and significant compromises in both customer satisfaction and flight safety. An intricate aspect identified in the study is the complexity of overhauling aircraft engines, where the execution of tasks by unqualified personnel can lead to failures and errors in various engine disassembly and assembly processes. The absence of a method ensuring that only qualified individuals undertake maintenance services, considering diverse tools and information sources, can result in non-conformities. Integrating systems emerges as a solution to enhance quality control and mitigate operational risks. As highlighted by Alarfaj and Khan (2018), a substantial portion of operational errors in aircraft maintenance emanate from human factors, encompassing miscommunication, lack of training, inadequate technical skills, fatigue, distraction, and stress. The failure to utilize approved technical documentation further compounds these challenges, resulting in delivery delays, rework, unnecessary material purchases, errors

in judgment, and incorrect actions during maintenance, ultimately amplifying customer dissatisfaction and overall maintenance costs.

Efficiently interconnecting systems and ensuring the competence of workers can positively impact the aviation maintenance industry. The objective is to address issues of inadequate access and continuously improve processes, adhere to regulatory standards, and elevate quality control. Central to this endeavor is integrating tools and techniques, emphasizing the care needed to prevent the loss of critical information. The dispersion of information in non-interconnected systems, originally not designed to operate collaboratively, leads to errors primarily attributed to human factors. A pressing need exists to implement an integrated system preventing unqualified individuals from undertaking tasks for which they lack adequate qualifications. A systems integration method ensures that only qualified individuals can perform services on the articles being worked on, utilizing different tools and accounting for various sources of information. This study investigates a method encompassing all tools to ensure access only for qualified individuals. It identifies precautions to prevent information loss when working with different tools, explores new ways and techniques to enhance data handling and process improvement, and verifies that integration complies with industry regulatory standards for daily production use. This study examines the engine overhaul process using multiple control methods, emphasizing the importance of understanding all systems for product quality. Focusing on an aircraft engine maintenance organization as a primary example, it delves into the complexities and challenges organizations face using multiple management systems in daily production operations. Aircraft engine maintenance, a critical and highly regulated process, requires a well-defined quality system to ensure passenger safety and aircraft reliability. Given the substantial daily global air passenger count, errors in maintenance processes can impact millions of people and lead to large-scale accidents. A well-defined quality system minimizes errors, ensures consistency, and contributes to obtaining and maintaining internationally recognized certifications. Four essential questions are posed to address the proposed objectives,

Research Question 1: What tools and techniques are used in the integration to ensure that only people who meet specific requirements can perform maintenance operations?

Research Question 2: What are the main precautions to take when working with different tools, and how to ensure that no information is lost during the integration process?

Research Question 3: What are the new ways and techniques of working with data that can continuously improve the systems integration process in a maintenance industry?

Research Question 4: How do we ensure that an integration complies with the regulatory standards of this industry and can be used in day-to-day production without compromising safety and the quality of the service provided?

The hypothesis is that integrating different systems, security measures, and information unification ensures compliance with customers and regulatory requirements.

Section 1 introduces the scenario, outlines objectives, justifies the study's relevance, and presents research questions. Subsequent chapters will delve into the detailed exploration of the identified issues and proposed solutions.

2. Literature Review

This section presents recent studies on access to information systems in production, information technology, information systems, the difference between data and information, integration of information systems, file integration, advantages, disadvantages and applications of file integration, precautions when using the file integration method, quality, and safety in information systems. The search for previous studies aimed to find a satisfactory way of integrating systems to reduce operational errors in aircraft engine maintenance. In order to study the subject, it was necessary to understand what information management is. Tarapanoff (2006) states that correctly using information management means knowing how to maximize resources and adapt, i.e., a company with effective information quality control is prepared to face challenges and changes. Through the research carried out, it can be concluded that the answer to the alternatives could lie either in the method of using a shared database, using a program that extracts the information from it and modifies it for the desired use, or in the extraction/import of data from the different systems with the help of a single piece of software to carry out the actions, or even by communicating and altering data between application and application through an API that allows communication between one system and another.

2.1. Access to Information Systems in Production

According to Baltzan and Phillips (2012), Information Technology (IT) is a sector dedicated to applying technology to the management and processing of information, with its success hinging on the skills of those

employing it. When leveraged appropriately, IT can potentially drive success and creativity in the business realm. A management information system, described by the same authors, is a business function employing people, technology, and procedures to solve business problems. Many organizations house in-house IT departments, also known as information systems (IS) or management information systems (MIS). These systems not only provide information but also automate processes, aiding in the monitoring, control, and optimization of organizational activities. The distinction between data and information is pivotal in data analysis. As defined by Baltzan and Phillips (2012), data are raw facts describing events, while information is data transformed into practical relevance, such as sales metrics or customer behavior. This distinction leads to business intelligence, facilitating in-depth analyses and informed decision-making. A Training Management System (TMS) or Learning Management System (LMS), as discussed by Turnbull, Chugh, and Luck (2020), is an online platform streamlining tasks related to virtual learning. This tool plays a crucial role in offering distance learning courses, eliminating the need for face-to-face meetings. The TMS optimizes training processes, offers flexible access to educational materials, and creates a collaborative virtual learning environment. It automates administrative tasks, generates reports, and ensures compliance with regulations, making it essential for organizations seeking to enhance training effectiveness and employee skills. According to Shehab (2004), a Production Management System (PMS) or Enterprise Resource Planning (ERP) integrates various software modules to optimize organizational functions. These systems cover accounting, sales, distribution, materials management, human resources, and production planning. ERP is crucial for operational efficiency, promoting strategic decision-making, and automating business processes throughout the supply chain. ERP is considered fundamental for organizational survival and performance in the modern business landscape. Understanding the relevance of Information Systems (IS) in the contemporary business context is emphasized by Senger (2022). IS, classified into different types such as Executive Support Systems (ESS), Management Information Systems (MIS), Office Automation Systems (OAS), and Transaction Processing Systems (TPS), cater to different organizational levels. These systems provide essential information for decision-making, automate processes, and support the monitoring and optimization of organizational activities. Effectively implementing these IS becomes essential for operational efficiency and competitive advantage.

2.2. Integration of Information Systems

Systems integration serves as the foundation for enabling diverse applications and systems to exchange information and operate cohesively. The choice of the integration method depends on factors such as organizational needs, the involved systems, and the types of data to be processed. File integration emerges as a primary method, offering versatility and commonality. This analysis focuses on how file integration allows systems to exchange data through electronic files, detailing its advantages and challenges and exploring its implementation in the engine repair industry management system. As highlighted by Hohpe & Woolf (2004), file integration involves the exchange of information via electronic files. Different applications generate files with relevant data, which are shared with others in varied formats such as documents, spreadsheets, text files, XML, or JSON. XML, for instance, is adept at representing structured data. Integrators are crucial in transforming and processing these files to ensure compatibility with target applications. This facilitates effective communication between independent systems written in different languages and platforms. The file-based integration process typically involves one system generating a data file, which is then transferred to a target system for processing. This procedure, often automated and scheduled, is especially beneficial when disparate systems need to communicate, transcending language and platform barriers. Despite its simplicity and accessibility, file-based integration presents challenges. Infrequent updates can lead to synchronization issues, necessitating proper processing of input and output files, including data transformations and validations. Security during file transfer and mechanisms to address transfer failures are crucial. While file processing can be resource-intensive, it remains a practical solution for scenarios requiring information exchange and flexible data representation. In the context of the engine overhaul industry, characterized by distinct systems, file integration proves suitable despite its challenges. It provides a valuable alternative for achieving interoperability, allowing comprehensive analysis of available data. The literature review emphasizes that, despite its difficulties, file-based integration meets the industry's needs, aiding communication between heterogeneous systems and contributing to informed decision-making. Nadhan (2004) underscores the complexity of file-based integration, advocating for precautions like clearly defining project requirements, choosing appropriate file formats, and standardizing data. Giordano (2010) emphasizes the importance of robust error management mechanisms and comprehensive documentation for successful integration.

Additionally, implementing a backup system adds an extra layer of security and facilitates data recovery in case of errors. In contrast to file integration, other methods like API-based integration and database sharing are

widely used. Per Pavaneli (2023), APIs enable efficient communication between different components of a project, offering agility, security, and efficiency. Database sharing, described by De Melo (2021), centralizes dispersed information, enhancing access, manipulation, and interpretation. Each integration method has its advantages, and the choice depends on the specific requirements and characteristics of the systems involved.

In conclusion, effective systems integration, mainly through file-based methods, requires a combination of well-defined requirements, data standardization, error management, thorough documentation, and robust backup practices. Collectively, these elements contribute to the reliability, success, and sustainable maintenance of integrations over time. While file integration remains a practical solution, alternatives such as API-based integration and database sharing offer distinct advantages depending on the context and requirements of the systems involved.

2.3. Quality and Safety in Information Systems

Drawing upon the AS9100D standard as a framework for delineating this subject, the Quality Assurance Management System (QAS) can be defined as the organizational management system responsible for directing and controlling an entity's quality assurance activities. This encompasses the organizational structure, policies, procedures, processes, and resources required to implement and sustain quality assurance. It involves identifying quality issues, conducting root cause analysis, implementing corrective actions, and preventing recurrences. AS9100, an international standard delineating the requirements for a quality management system in the aerospace industry, serves as the basis for the QMS definition in this context. While rooted in ISO 9001, AS9100 adds industry-specific requirements. The standard certifies companies globally in the aerospace sector and serves as the foundational document for internal and external quality audits. According to Evans and Lindsay (1999), quality is fulfilling or surpassing customer expectations for products or services. Tailoring efforts to understand and meet specific customer needs, rather than merely producing high-quality goods or services, is crucial. Quality can be assessed through adherence to internal or external performance, safety, reliability, and other criteria. Implementing a quality control system aid in achieving these objectives and addressing quality issues proactively. Moura (1996) extends the concept of quality to information systems, defining it as an indication of how well products and services meet user needs. Total quality in information systems involves organizing companies to consistently deliver high-quality products and services, satisfying all stakeholders, including customers, shareholders, employees, suppliers, and the community. ISO 9001:2015, analogous to AS9100D, positions adopting a quality management system as a strategic decision that enhances overall performance. The PDCA cycle (Plan, Do, Check, Act) is foundational for planning, implementing, controlling, and responding to failures, facilitating process improvement. ISO 9001:2015 aligns its requirements with the PDCA cycle, ensuring comprehensive improvement adherence. In the realm of systems integration, quality is paramount. Ensuring effective and fault-free interconnection of diverse systems involves well-documented and monitored integration processes. Continuous monitoring, focusing on customer satisfaction, and evidence-based decision-making contribute to effective integration. As highlighted by Moura (1996), quality in information systems is fundamental. Information, considered a valuable asset, requires proper management. Information quality is critical in business operations' effectiveness, impacting the ability to meet market demands and optimize processes. McGee (2004) emphasizes that information involves collecting, organizing, and assigning meaning and context to data, making it a powerful strategic tool. Information's unique attributes underscore the importance of proper management. Dos Santos Nonato (2021) stresses the role of information management in ensuring quality in systems integration processes. Information quality is integral to strategic information management and vital to achieving overall company objectives. Roth (1996) underscores the importance of organizational documentation, advocating for well-established internal manuals and procedures. These documents provide clear guidelines, fostering a cohesive organizational culture, promoting continuous learning, and contributing to operational efficiency. Pereira et al. (2015) stated that using probabilistic risk analysis in the jet engines' manufacturing process is essential to prevent failure. The authors presented a probabilistic risk analysis model to analyze the safety of this process. Pereira and Fayer (2020) proposed a method for strategic decision making, considering the identification and prioritization of the potential risks that could stop production in the steel production processes in a water crisis scenario. Pereira et al. (2015) stated that using probabilistic risk analysis in the jet engines' manufacturing process is essential to prevent failure.

Pereira et al. (2017) study show that the current dependency of industries on quality management for economic development shows the need of research into the sustainability of organisations. At present, studies on quality and organisational sustainability do not include quality management risk factors that could affect the sustainability of organisations. Fayer et al (2018) created a model and risk analysis combined with the use of AHP and BBN tools to analyse the risks arising from the water crisis scenario for the steel industry in order to guarantee the availability of the water resources needed to ensure the safe operation of this type of industry. Pereira et al (2014) used the design thinking as an adequate technique for human factors risk analysis in preparation for quantitative risk

analysis. The authors state that the benefits of the technique are evident and have practical implications for specialists dealing with the identification of human factor risk factors in the quantitative risk analysis. In conclusion, the previous studies show that pursuing quality, whether in the aerospace industry, information systems, or organizational processes, is fundamental. Adopting standards, employing systematic approaches, and valuing information as a strategic asset are essential for achieving and maintaining high-quality outcomes. Well-documented processes, continuous monitoring, and a commitment to improvement contribute to organizational effectiveness and adaptability.

3. Methodology

The study adopted the approach of building theory from Case Study Research proposed by Eisenhardt (1898), Baxter and Jack (2010), Yin, R. (2014), and Hancock et al. (2021). It combined data from standards, civil aviation regulations, archives, and interviews. The steps taken to capture the data needed to analyze the risk factors are 1 - Analysis of the theoretical framework and up-to-date literature and procedures; 2 – Identification of programs and spreadsheets used to manage technical training; 3 - Interviews with experienced experts to verify the options for systems integration; 4 – Analysis of state of the art literature, systems being used and the input from experts to propose desirable actions for integration.

3.1. Population and Sample

The study analyzed the best way to integrate the systems to avoid the risk of non-compliance with applicable aircraft components maintenance regulations related to technical training. These stakeholders were selected based on their expertise in a specific domain. The sample size is adequate and meaningful since all the areas studied are covered.

3.2. Instruments and Tools

The study adopted a theory-building approach based on case study research. It combined data from archives, interviews, and observations of technical training management used by aircraft engine components maintenance organizations. The different systems and processes used to manage technical training are presented and the recommendations for integrating the systems and avoiding violating regulations and requirements.

3.3. Data Collection

Data was collected by analyzing aviation regulations, reviewing state-of-the-art literature, and interviewing stakeholders involved with technical training management from aircraft component maintenance companies to understand the options for integration and the associated risk factors.

3.4. Data Analysis

The different systems used to manage technical training were analyzed with the help of experts in training and regulations, and an in-depth literature review was carried out on the impact of integrating systems and the risks of violating regulatory requirements. The experts helped to understand the different systems and processes. Once the systems and processes were analyzed, appropriate actions were recommended for integration.

4. Results

This section delves into the relevant systems generally used to manage Aircraft engine components maintenance organizations' training programs. Each system's functionality is explained in detail.

4.1. Training Management System (TMS)

This section analyzes different relevant systems utilized to manage training programs in Aircraft engine components maintenance organizations. Each system's functionality is thoroughly examined, providing an overview of its operations while highlighting the primary challenges encountered during the integration process. Additionally, the discussion encompasses the types of data generated by each system and their consequential

impact on overall control mechanisms. The chosen integration method and tool selected for this purpose are expounded upon, offering a detailed explanation of their functionality and distinctive characteristics. Finally, the chapter concludes with a comprehensive analysis of the results obtained and provides concluding insights into the entire process.In the context of an aero engine repair station, implementing a Training Management System (TMS) plays a pivotal role in the effectiveness of training and development programs. As discussed in the literature review chapter, a TMS is an online software platform designed to manage, deliver, and evaluate educational content, fostering virtual and flexible learning. In this specific scenario, introducing the TMS enables the optimization of employee training and the centralizing of educational resources. It ensures compliance with regulations specific to the aeronautical sector, enhancing operational efficiency and safety in aircraft engine component maintenance activities. The TMS used in Aircraft engine components maintenance organizations comprises two fundamental parts: Part 1: Training Management: The first part outlines the training required for each employee based on positions and areas following the company's internal manuals. It monitors the fulfillment of these trainings and issues alerts to ensure compliance. Part 2: Online Training Platform: The second part of the TMS is an online platform where employees access and complete assigned training. It tracks progress, collects feedback, and generates data that updates the training status of each employee in the system. The system collects and generates various types of data for analyses as shown in Table 1.

Table 1. Data generated in the TMS.

Type of Data	Description
Student Data	Information on participants, such as name, position, department, and history of training completed.
Course Data	Details of the courses, including description, dates, instructors, and resources required.
Participation Data	Records of who attended which courses, start and completion dates, and progress information.
Compliance Data	Information relating to the fulfilment of regulatory and compliance requirements.

4.2. Practical Training Management System (PTMS)

A Practical Training Management System (PTMS) is a meticulously designed software platform to document and oversee the practical training schedules or in-service training of individual employees within a company. These regimens are further categorized into groups corresponding to locations where services or maintenance activities are conducted, tailoring each practical training regimen to specific positions within the organization. The system efficiently organizes the tasks outlined in each practical training plan and utilizes the distinct digital identifiers of each employee for the roles of mentor (conducting the training), assessor (evaluating progress), and trainee (the employee undergoing training). This approach ensures that training is conducted comprehensively and is systematically recorded. The subsequent list delineates the data types that prove valuable for analysis and integration purposes, as presented in Table 2.

Table 2. Data generated in the PTMS.

Data Type	Description
Employee	Unique identification of each employee.
Training Group	Groups representing training locations or functions.
Training Plan	Specific practical training plans for each group.
Completion Date	The date on which the employee completed the training plan.
Completion Status	Indicates whether the employee has completed the training plan or not.

4.3. Additional Control and Procedures

Many organizations use spreadsheets to consolidate pertinent employee information and regulate access to the company's production management system. Examples of control sheets related to access control are outlined in this section. Each sheet is monitored and made accessible through reports or direct update links managed by different individuals or departments within companies, posing challenges for seamless integration. Regulatory Agency Certification Control Worksheet is utilized in some companies to record and oversee certification cards issued by regulatory agencies. These cards validate that employees have completed the certification process with these agencies, enabling them to provide services on aero engines. The spreadsheet contains vital information such as the employee's name, certification card number, issue date, expiry date, and any other pertinent details associated with the certification, as shown in Table 3. The company's human resources department typically provides Employee Registration Control Spreadsheets. This spreadsheet maintains comprehensive information about the company's employees. It includes the employee's ID number, full name, work area, leadership role,

position, date of employment, e-mail address, and other relevant registration details. This spreadsheet aids in organizing and managing human resources, offering an overview of employee information, and facilitating access to essential details. Data generated from this control is shown in Table 4. Other companies use Control Sheets for Personnel Authorized to Sign return to Service Forms to manage a controlled list of individuals authorized to sign return-to-duty release forms. Inclusion on this list entails thorough verification by the quality department against the pre-defined requirements of regulatory agencies outlined in the company's internal procedures. This list ensures that only qualified and authorized individuals can approve the release of services post-maintenance on aero engines. The data generated from the control is presented in Table 5. Most organizations use Internal Manuals and Procedure to establish standards and guidelines governing maintenance and repair activities in adherence to national and international regulations. These manuals provide comprehensive direction to employees on executing maintenance tasks, thereby ensuring safety, quality, and compliance with regulations. Customizing these documents to align with the specific regulations of the country in which the company operates is paramount, all while adhering to local aviation rules. The Internal Manuals and Procedures play a pivotal role in delineating the requisite criteria for access, determining individuals authorized to engage in specific work operations, and specifying the necessary training for each position and area. They also outline whether holding a license from the regulatory agency is mandatory for each function and define the criteria for inclusion on the controlled list of individuals authorized to sign release forms. Moreover, these documents underscore the significance of practical training as a prerequisite for accessing specific groups. Both clients and regulatory agencies conduct audits to verify compliance with the stipulations outlined in the Internal Manuals and Procedures. Non-compliance with these requirements can impact the quality of work performed and compromise the safety of aircraft component maintenance organizations. Essentially, these manuals form the entire organization's bedrock, ensuring the quality, compliance, and safety of the company's activities. They serve as the primary reference for integrating systems, emphasizing the importance of adhering to these established standards for optimal operational efficiency.

In the aircraft component maintenance industry context, organizations use a software platform that plays a crucial role in overseeing and optimizing various facets of component production and maintenance. It functions as a centralized hub for manufacturing processes, maintenance planning, parts inventory, resource allocation, and activity tracking information. This system incorporates digital stamps that serve as verifiable proof of the completion of specific procedures and activities conducted on the engine during its progression through the company. This functionality ensures precision, traceability, and adherence to relevant regulations. It significantly contributes to the efficient management of aero-engine maintenance and the requisite documentation to guarantee the quality and safety of operations. This system determines access based on pre-defined requirements outlined in the company's internal manuals and procedures. The system is the gatekeeper, determining whether individuals are granted or denied access, thereby contributing to the overall security and integrity of aero-engine maintenance processes.

Table 3. Data generated from Control of Regulatory Agency Certification.

Data Type	Description
Certification Number	Number identifying the employee's certification by the regulatory agency.
Employee Name	Full name of the certified employee.
Certification Date	Date the certification was obtained.
Certification Type	Description of the type of certification, indicating specific skills and authorizations.

Table 4. Data generated from Control of Employee Registration.

Data Type	Description
Identification Number	Unique identification of the employee in the company.
Employee Name	Employee's full name.
Area	Sector or department to which the employee is assigned.
Leadership	Information on the employee's leadership or supervisory position.
Position	Position or function performed by the employee.
Date of Admission	Date the employee joined the company.
E-mail address	The employee's e-mail address.
Other information	Any other relevant information about the employee.

Table 5. Data generated from Control of Personnel Authorized to Sign Return to Service Forms.

Data Type	Description
Employee Name	Full name of the employee authorized to sign.
Identification Number	Unique identification of the employee within the company.
Pre-Defined Requirements	Description of the requirements established by the regulatory agencies and the company's internal procedures for inclusion on the list.
Checks Carried Out	Record of the checks carried out to ensure compliance with the requirements.
List Inclusion Date	The date on which the employee was added to the authorized list.
Position Authorised	Position or role enabling the employee to sign the release forms.
Other Comments	Description

4.4. Integration System

An Integration System is a comprehensive platform that consolidates reports derived from preceding systems, encompassing the training management system, practical training management system, and supplementary control sheets. Primarily rooted in the Microsoft Excel platform, this system harmonizes information typically extracted in XLSX or XLSM formats. It scrutinizes and allocates access based on the outcomes of these analyses. The system aims to ensure compliance with defined processes and requirements and is developed to adhere to the specific company's manuals and internal procedures. The File Integration method, elucidated in this paper, provides a more detailed understanding of the integration system's functionality. This elucidation involves the examination of reports generated by antecedent systems, adhering to the guidelines and sequence delineated in Figure 1.

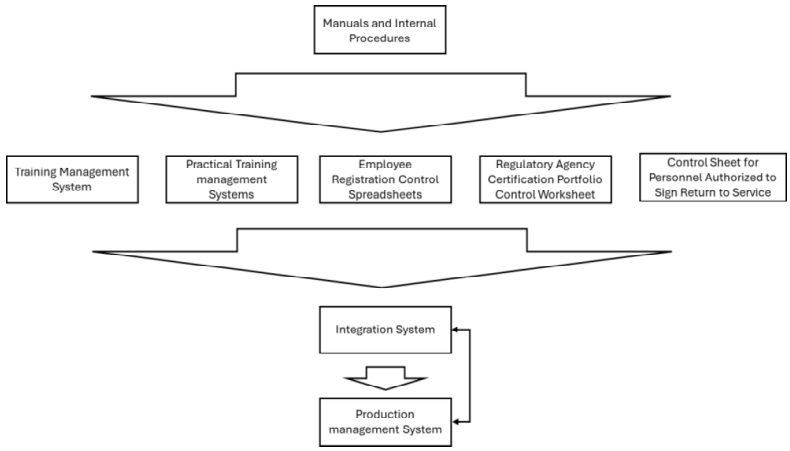

Fig. 1. File Integration Method.

As depicted in Figure 1, it is evident that the integration system functions as the central hub responsible for regulating access to the Production Management System (PMS). This involves analyzing data according to parameters predetermined by the company's internal manuals and procedures, yielding results for configuring parameters within the PMS. Subsequently, the PMS generates reports for the integration system, which conducts an analysis of the amalgamated information, ensuring daily oversight of the PMS. Daily backups are initiated upon system initialization to safeguard the integrity of the integration system. This practice allows for tracking modifications to the system and the information it generates daily. In the event of failures in the analysis process whether stemming from the operator or the system itself—configurations can be reinstated in the PMS. This is especially crucial in cases of alterations to the files received by the system. Given the illustrative nature of the file integration method portrayed in Figure 1, the integral role of the integration system in maintaining operational coherence and data integrity within the production management system is clearly delineated. This PMS system encompasses all the controls and furnishes data to the integration system for thorough analysis. The integrator system consistently assesses the information within the PMS in conjunction with the data extracted by preceding systems. This control mechanism operates within a closed loop, as illustrated in Figure 1, wherein the information within the PMS undergoes perpetual analysis and regulation based on data acquired from other systems. Every

piece of information and requirement outlined earlier undergoes this retrospective analysis, ensuring continuous monitoring.

5. Discussion of Results

In the results section, the final system analysis revealed the initial hypothesis's validation. It was confirmed that integrating systems successfully ensures that only authorized individuals—those meeting all requirements outlined in the manuals and procedures can access operations within the production management system. This effective integration, achieved through feedback from the production management system to the integrating system, can enhance control efficiency. Unlike a one-time process prone to future errors, ongoing analysis can be conducted, combining feedback with periodically extracted reports from systems preceding the integrator system. This constant monitoring maintains control, continually updating the status of company employees. Furthermore, the importance of relationships between each system and their respective reports/data for the outcome has become evident.

Consequently, ensuring the efficient integrity of data transmitted by these systems becomes paramount. As described earlier, safety techniques can be implemented to prevent information loss during the integration and access control process. The successful integration and continuous feedback from the production management system to the integrating system significantly influence quality analysis. By effectively integrating systems and restricting access to authorized personnel in the production management system, the company can uphold high levels of quality and compliance. Continuous feedback and constant employee status updates facilitate more accurate analysis, promptly identifying deviations and enabling immediate corrections. Moreover, data integrity is pivotal in ensuring the quality of process information, safeguarding against errors or failures that could compromise decision-making and operational efficiency.

6. Conclusion

In conclusion, the analysis of the results presented in Chapter 4, coupled with the literature review on quality control and systems integration, mainly focusing on file-based systems integration, indicates the successful resolution of the research problem addressed in this study and the validation of the initial hypothesis. Addressing Research Question 01 concerning tools and techniques for ensuring restricted access to maintenance operations, integrating systems and quality control proved to be instrumental. The feedback loop from the production management system, periodic data analysis, establishment of efficient communication, and appropriate interaction methods are effective tools. Additional measures, such as implementing locks, periodic checks, and attention to detail can further enhance the reliability of day-to-day quality control. In response to Research Question 2 regarding precautions when working with different tools and preventing information loss during integration, clear objective definition, appropriate file format selection, and data standardization were highlighted. Robust error management mechanisms, adequate backups, and meticulous documentation were emphasized to ensure information integrity and facilitate a secure and efficient onboarding process. For Research Question 3, exploring new ways and techniques to improve systems integration in the maintenance industry continuously, the careful selection of tools and techniques, especially the Integrating System based on the File Integration method, was underscored. When combined with robust integration methods, detailed technical documentation, employee status checks, and periodic analysis significantly contribute to ongoing improvement and operational efficiency. Adopting international quality standards, periodic checks, locks, and additional controls is deemed essential and adresses Research Question 4 on ensuring regulatory compliance and safe day-to-day production use. Continuous feedback from the production management system to the Integrator System is crucial in maintaining compliance, ensuring authorized access, and upholding service quality. Implementing this unified system notably enhances control over each employee's activities, positively impacting the company's production management system. It ensures that only qualified individuals have access to work on specific aeronautical articles, reducing human errors and positively influencing the final product's quality. As a suggestion for future work, exploring other integration methods, such as database integration and integration via APIs, is recommended. The study emphasized the importance of continuous research and exploration of different integration approaches to inform strategic choices that meet specific integration demands, considering factors like security, quality, data integrity, and overall functionality.

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