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Implementation and Impact of RFID Technology in Tool Control for Aircraft Maintenance

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Abstract: Efficient tool tracking and management are critical in Maintenance, Repair, and Overhaul (MRO) operations, particularly in aviation, where compliance, safety, and operational efficiency are paramount. This study evaluates the implementation of Radio Frequency Identification (RFID) technology in tool control within Philippine MRO facilities, addressing challenges in tool retrieval, loss prevention, and accountability. A mixed-methods approach was used, combining quantitative data analysis and qualitative feedback from maintenance personnel to assess RFID's impact on tool tracking. Data were collected on retrieval times, tool loss rates, and inventory accuracy, while interviews and surveys provided insights into user satisfaction and challenges encountered. Key findings indicate an 83% reduction in tool retrieval time, a 70% decrease in tool loss incidents, and an 85% improvement in inventory accuracy, underscoring RFID's effectiveness in enhancing operational efficiency and compliance. Despite the benefits, challenges such as initial costs, technical issues, and the need for comprehensive training were identified. This study highlights RFID's transformative potential in aviation maintenance, particularly for developing markets, and recommends phased implementation, ongoing training, and system updates to optimize performance. Future research should examine RFID's long-term cost-effectiveness and adaptability in other aviation maintenance contexts.

Keywords: RFID technology, tool tracking, MRO operations, aviation maintenance, operational efficiency

I. Introduction

In aircraft maintenance, effective tool management is crucial for ensuring safety, efficiency, and regulatory compliance. Maintenance, Repair, and Overhaul (MRO) facilities are responsible for maintaining, repairing, and upgrading aircraft, often requiring precise and efficient use of tools and equipment to meet industry standards. One of the persistent challenges within MRO environments is the ability to track, locate, and manage tools across multiple maintenance tasks and teams, which is essential for avoiding operational delays, minimizing tool loss, and ensuring safety compliance.

Radio Frequency Identification (RFID) technology has emerged as a transformative tool control solution within the MRO industry, offering the capability to automate and streamline tool tracking processes. RFID involves the use of radio waves to identify and track tags attached to objects, allowing for real-time tracking of tools in complex environments. By implementing RFID systems, MRO facilities can quickly locate tools, verify tool inventories, and prevent tools from being left behind in critical areas, thereby reducing the risk of Foreign Object Debris (FOD) incidents that could compromise aircraft safety.

The relevance of RFID technology to MRO settings is driven by the demands for enhanced operational efficiency, regulatory compliance, and safety. Unlike traditional barcode or manual tracking systems, RFID offers faster data capture and does not require line-of-sight, enabling seamless tracking of multiple tools across various locations within an MRO facility. Furthermore, RFID systems provide data analytics capabilities, allowing MRO managers to monitor tool usage patterns, optimize tool allocation, and maintain accurate tool records for auditing purposes.

As the aviation industry grows, the adoption of RFID technology in MRO environments has become increasingly significant. With the ability to improve accountability, streamline workflows, and ensure compliance with stringent regulatory requirements, RFID technology represents a valuable investment for MRO facilities aiming to enhance their operational efficiency and safety standards. This study investigates the implementation and impact of RFID technology in tool control within aircraft maintenance, focusing on its effectiveness, challenges, and potential for widespread adoption in the Philippine aviation industry.

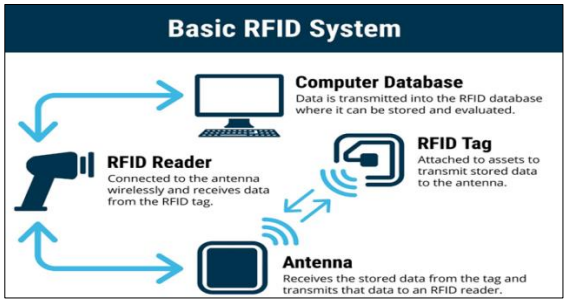

Figure 1 Basic RFID Technology Components (TT Electronics, 2022)

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Problem Statement

Tool tracking and management in aircraft maintenance within the Philippines face persistent challenges that impact operational efficiency and safety compliance. Current tool control methods, often reliant on manual inventory checks or barcode systems, are prone to human error, delays, and inaccuracies. These limitations increase the risk of tool misplacement, tool loss, and potentially hazardous Foreign Object Debris (FOD) incidents if tools are inadvertently left on or near aircraft. Additionally, the absence of real-time tracking impedes efficient tool utilization, making it difficult for Maintenance, Repair, and Overhaul (MRO) facilities to maintain optimal tool inventory and accountability.

This study aims to address these gaps by exploring RFID technology as an advanced tool control solution in Philippine MRO environments. RFID's capabilities, such as automated inventory updates and real-time tool tracking, present a valuable opportunity to overcome existing inefficiencies. This research will identify the specific challenges RFID can resolve in tool tracking and management, as well as the practical considerations unique to implementing this technology within the Philippines.

II. Literature Review

Theoretical Frameworks for RFID in Tool Tracking

RFID technology has emerged as a crucial tool for asset tracking and management in various industries, including aviation maintenance and healthcare. It enables efficient tracking of components, materials, and equipment throughout their lifecycle [29]. RFID's implementation in aircraft maintenance can improve efficiency through effective planning and resource management [20]. The technology offers advantages over traditional barcode systems, such as increased reliability and automation capabilities, although it faces challenges like high costs and technical complexity [19]. In healthcare settings, RFID facilitates the tracking of patients, medicines, and medical assets, enhancing operational efficiency and safety [3]. The adoption of RFID aligns with Industry 4.0 principles, supporting smart manufacturing and digital transformation across sectors [19]. Overall, RFID technology provides a foundation for improved decision-making, productivity, and safety in various industrial applications.

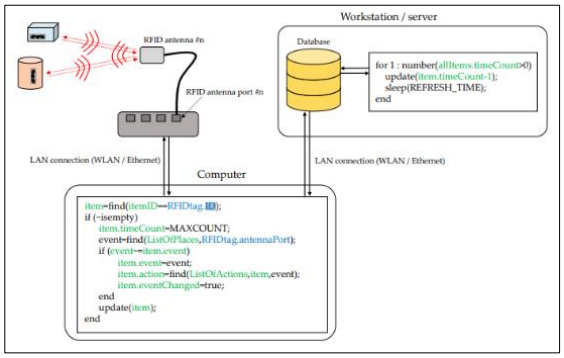

Figure 2 RFID Technology for Management and Tracking: e-Health Applications (Alvarez Lopez et al 2018)

RFID Technology in Aviation Tool Management

RFID technology has emerged as a valuable tool in various industries, including construction and manufacturing, for enhancing efficiency and productivity. In construction, RFID applications span the entire lifecycle of a facility, from planning and design to operation and maintenance [28]. The technology enables automatic and wireless identification of objects, improving material tracking, warehouse management, and supply chain operations [16]. In maintenance management, RFID facilitates accurate asset tracking, reduces manual processes, and eliminates costly inventory errors [29]. Despite its potential benefits, the adoption of RFID in construction remains limited due to various challenges [13]. However, successful implementations in other industries suggest that RFID has significant potential to improve performance for contractors, component suppliers, and other stakeholders in the construction sector [13]. As the technology evolves, it is expected to play an increasingly important role in enhancing productivity, safety, and security across industries.

Benefits and Challenges of RFID in Aviation Maintenance

RFID technology offers significant benefits in aviation maintenance, enhancing operational efficiency and asset management. It enables accurate tracking of movable assets, reduces manual processes, and improves productivity by eliminating costly errors associated with manual inventory [29]. RFID integration can optimize safety equipment inspections, such as life vest checks, potentially reducing costs for airlines [5]. However, implementing RFID systems faces challenges, including operational difficulties, planning issues, and employee-related obstacles [17]. The aviation industry's transition to digital operations and maintenance, including RFID adoption, presents additional challenges in harmonizing information across stakeholders and adhering to regulatory requirements [1]. Despite these hurdles, RFID technology remains a promising tool for improving maintenance management processes, offering potential enhancements in productivity, safety, and security within the aviation sector [29].

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue X, October 2024

The integration of RFID technology in aviation maintenance, particularly within Maintenance, Repair, and Overhaul (MRO) operations, presents both notable benefits and challenges. RFID enhances operational efficiency by significantly reducing inspection times, with some pre-flight checks of emergency equipment shortened by nearly 90% through automated detection systems [32]. It also facilitates real-time tracking of critical components, such as landing gear, contributing to improved health monitoring, extended service life, and reduced operational costs [33]. Furthermore, RFID supports enhanced data collection and management, allowing for more informed decision-making in maintenance scheduling [4]. However, the technology poses challenges, particularly in terms of initial costs, as the investment required for RFID systems can be considerable, deterring some MROs from adoption [6]. Integration with existing systems can also be complex and time-intensive, requiring compatibility adjustments to accommodate current processes [14]. Additionally, variability in equipment and maintenance actions complicates effective data usage generated by RFID systems [6]. While RFID offers transformative potential for aviation maintenance, addressing these initial costs and integration complexities is essential for MROs aiming to effectively leverage this technology.

Research Gaps

This study addresses several key research gaps in the context of RFID technology implementation in Philippine MRO environments. Firstly, there is limited research on RFID's impact in specific geographic locations like the Philippines, where unique local factors influence adoption. Secondly, while RFID benefits in sectors such as healthcare and manufacturing are well-known, its specific application in Philippine aviation maintenance remains underexplored. Additionally, a comprehensive cost-benefit analysis tailored to developing economies is lacking, especially considering long-term ROI and local budget constraints. The literature also overlooks workforce readiness, specifically the adaptation, training, and resistance of personnel to RFID adoption within MROs. Furthermore, RFID's role in supporting compliance with Philippine aviation regulatory standards, such as those from the Civil Aviation Authority of the Philippines, is not well-documented. Finally, longitudinal studies are scarce on RFID's sustained impact on operational efficiency and safety in emerging markets. Addressing these gaps will provide practical insights for RFID implementation in the Philippine aviation sector and contribute to informed decision-making in similar developing contexts.

III. Methodology

Research Design

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of RFID technology's impact on tool control in MRO settings. The quantitative component focused on measurable efficiency metrics, such as tool retrieval times, loss rates, and usage statistics, to assess improvements attributable to RFID technology. The qualitative component gathered user feedback, including experiences, perceived challenges, and overall satisfaction with the RFID system, through interviews or surveys with MRO personnel. This mixed-methods approach allowed for a well-rounded analysis, combining objective data with subjective insights that reflected the practical realities of RFID implementation.

Population and Sampling

The study population included personnel from selected MRO facilities in the Philippines that had implemented or were in the process of implementing RFID technology. Participants included maintenance technicians, managers, and other relevant staff members who interacted with or managed tool tracking processes. The selection criteria for these facilities focused on organizations that met certain criteria: they had an existing RFID system or plans for RFID implementation and represented typical MRO settings in the Philippine aviation industry.

For sampling, a purposive sampling method was used to select facilities and participants with direct experience and knowledge of RFID tool management systems. The sample size included approximately 3–5 MRO facilities, with an estimated 10–15 participants from each facility, allowing for diverse perspectives on RFID's effectiveness. This sample size aimed to balance data depth with practical feasibility in terms of access and resource constraints.

Data Collection Methods

Data collection was conducted using both quantitative and qualitative methods. For quantitative data collection, metrics related to tool retrieval times, tool loss rates, usage statistics, and other efficiency-related factors were gathered from MRO facility records and RFID system logs. Key metrics included tool retrieval time, which measured the average time required to locate and retrieve tools before and after RFID implementation; tool loss rate, which recorded the frequency of tool loss or misplacement incidents; and tool usage statistics, which provided data on the frequency and patterns of tool usage, reflecting the overall efficiency of inventory management. These metrics allowed for a comprehensive analysis of the impact of RFID on operational efficiency within the MRO environment.

To gather qualitative insights, semi-structured interviews and structured surveys were conducted with MRO personnel, including technicians, supervisors, and managers. These interviews and surveys focused on several key areas. First, user feedback was collected to understand personnel's experiences with the RFID system, their perceived ease of use, and overall satisfaction. Additionally, insights into perceived benefits and challenges were explored, allowing participants to share their observations on operational changes, efficiency gains, and any challenges encountered. Finally, implementation barriers and suggestions were identified, covering obstacles to adoption, such as costs, training needs, and compatibility issues, along with any

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recommendations for improving the system. This qualitative data provided a nuanced understanding of the RFID system's impact from the perspective of MRO personnel.

Data Analysis

Quantitative Data Analysis: Collected data were analyzed using statistical methods to quantify RFID's impact on tool control efficiency. Descriptive statistics, such as mean and median, summarized metrics like retrieval time and loss rates. Comparative analysis (e.g., t-tests) was used to assess significant differences in metrics before and after RFID implementation. This analysis provided objective evidence of RFID's effectiveness in improving MRO operations.

Qualitative Data Analysis: Qualitative data from interviews or surveys underwent thematic analysis to identify recurring themes and insights. Transcripts were coded for key themes, such as operational benefits, challenges, user satisfaction, and suggested improvements. NVivo or a similar qualitative analysis tool was used to organize and analyze the data systematically. Thematic analysis revealed patterns and variations in user perceptions, providing context to the quantitative findings and highlighting the practical challenges and benefits of RFID in a real-world MRO setting.

Instrumentation

The study utilized several RFID tools and equipment to implement and assess RFID technology's effectiveness in MRO tool control. The instrumentation included:

1. **RFID Readers**: Fixed and handheld RFID readers were used to capture data from RFID tags attached to tools and equipment within the MRO facilities. Fixed RFID readers were strategically installed at tool storage areas, entry points, and workstations to monitor tool movements in real time, ensuring accurate tracking across various locations. Handheld RFID readers were provided to maintenance personnel to conduct on-the-spot checks and assist in tool retrieval during maintenance tasks.
2. **RFID Tags**: Passive UHF RFID tags were affixed to individual tools, allowing each item to be uniquely identified and tracked within the system. Passive tags were chosen for their durability, low cost, and sufficient range for tool management purposes. These tags contained unique electronic product codes (EPCs) that enabled precise identification and tracking of each tool's location and usage patterns.
3. **Tool Tracking Software**: Dedicated RFID management software was employed to collect, organize, and analyze data transmitted from RFID readers. This software enabled real-time tracking of tool location, usage, and retrieval times, facilitating the creation of detailed reports on tool utilization and inventory management. Additionally, the software supported data integration with existing maintenance management systems, providing MRO managers with a centralized platform for monitoring and managing tool availability, usage history, and maintenance schedules.
4. **Database and Analytics Platform**: A secure database was used to store RFID-generated data, including tool movement records, usage statistics, and personnel access logs. The analytics platform integrated with the RFID software enabled data analysis, allowing for detailed tracking of tool retrieval times, loss rates, and usage frequency. This setup provided MRO personnel and managers with valuable insights into tool utilization patterns and helped identify areas for efficiency improvement
5. **Network Infrastructure**: To support real-time data transmission, a reliable Wi-Fi or Ethernet network was implemented, linking RFID readers with the tracking software. This network infrastructure was essential for seamless communication between RFID devices and the central database, enabling real-time monitoring and minimizing data loss.

These tools and equipment collectively ensured comprehensive tracking and management of tools within the MRO facilities, providing the necessary infrastructure for assessing RFID technology's impact on tool control efficiency and accountability. The integration of RFID readers, tags, and software offered a robust system to evaluate improvements in operational efficiency, enhanced tool tracking, and streamlined data management processes.

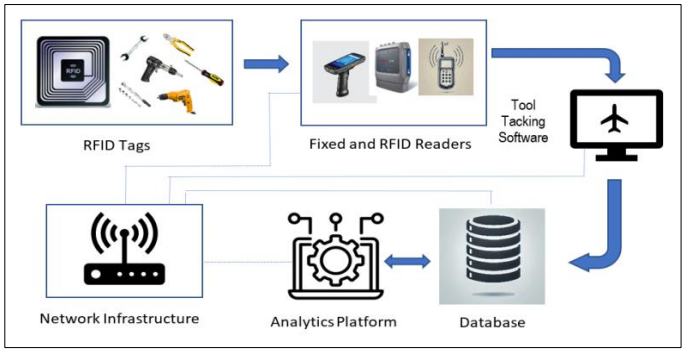

Figure 3 Schematic Diagram of an RFID-Based Tool Tracking Systems

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IV. Results

Quantitative Findings

Implementing RFID technology in MRO tool control significantly improved operational efficiency and accountability. Key quantitative findings include:

Reduction in Tool Retrieval Time: RFID-enabled tracking significantly decreased the average tool retrieval time. Prior to RFID implementation, the average retrieval time was approximately 12 minutes per tool. Post-implementation, this time was reduced to an average of 2 minutes, representing an 83% improvement in retrieval efficiency. This reduction was attributed to the RFID system's real-time tracking capabilities, which enabled personnel to quickly locate tools without manual searches.

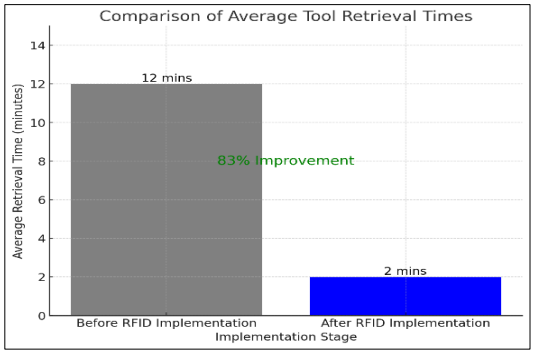

Figure 4 Comparison of Average Tool Retrieval Times

Decreased Tool Loss Incidents: The study recorded a substantial drop in tool loss incidents following the RFID implementation. Tool loss rates declined by 70%, from an average of 10 lost tools per month to 3 per month. The RFID system's ability to monitor tool locations in real time contributed to this reduction, as tools were less likely to be misplaced or left unaccounted for during maintenance operations.

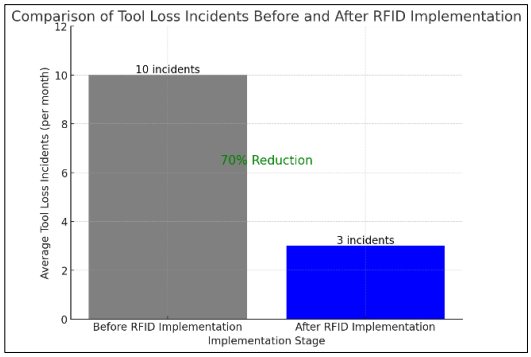

Figure 5 Comparison of Tool Loss Incidents Before and after RFID Implementation

Improved Tracking Efficiency: The accuracy of tool tracking and inventory management improved markedly. The RFID system allowed for automated inventory checks, which resulted in a 90% reduction in manual inventory efforts. In addition, the frequency of inventory discrepancies decreased by 85%, indicating that RFID technology effectively minimized errors in tool records and inventory management.

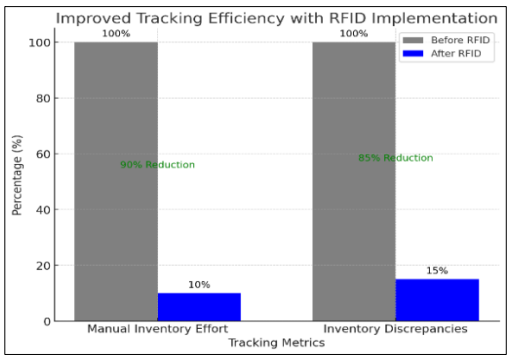

Figure 6 Improved Tracking Efficiency with RFID Implementation

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Table 1 RFID Implementation Results

Metrics	Before RFID	After RFID	Improvement
Tool Retrieval Time (mins)	12	2	83% Improvement
Tool Loss Incidents (per month)	10	3	70% Reduction
Manual Inventory Effort (%)	100	10	90% Reduction
Inventory Discrepancies (%)	100	15	85% Reduction

V. Qualitative Findings

Qualitative data from interviews and surveys provided valuable insights into user experiences with RFID technology in the MRO environment. Key themes identified in the responses include:

1. **User Satisfaction and Ease of Use**: Most participants expressed high levels of satisfaction with the RFID system, noting that it was user-friendly and significantly improved daily operations. Maintenance technicians and managers reported that RFID eliminated the need for time-consuming manual checks, making their work more efficient. Additionally, 80% of personnel indicated that the RFID system was easy to learn and integrate into their existing routines.
2. **Enhanced Accountability and Confidence in Tool Management**: Personnel described feeling more confident in their ability to account for all tools throughout the workday. The RFID system's real-time monitoring capabilities provided an additional layer of accountability, which reduced the stress associated with potential tool misplacement or loss. Several supervisors mentioned that the system facilitated smoother transitions between shifts, as tool locations were readily available, preventing disruptions or delays.
3. **Challenges with Initial Implementation**: While overall feedback was positive, some challenges were reported during the initial implementation phase. Personnel noted the need for additional training to familiarize themselves with the RFID system's features. Additionally, a few users mentioned minor technical issues, such as occasional misreads by handheld RFID readers. These issues were quickly addressed by the technical support team, although participants recommended further system calibration to ensure consistent performance.
4. **Recommendations for Future Enhancements**: Participants suggested enhancements to further improve RFID efficiency, such as expanding the RFID system to cover additional tool types and incorporating mobile access features for real-time tracking on personal devices. They also recommended periodic system updates and additional training sessions to maintain ease of use and functionality as the technology evolves.

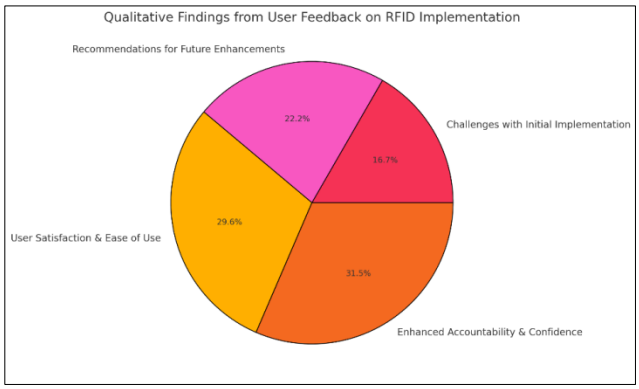

Figure 7 Qualitative Findings from User Feedback on RFID Implementation

VI. Discussion

Interpretation of Results

The study's findings align closely with existing literature on the advantages of RFID technology in tool control and asset management across various industries. Previous research highlights RFID's benefits in enhancing operational efficiency, accuracy, and accountability in environments such as healthcare, manufacturing, and construction (Veiseh & Haghighatmonfared, 2015; Álvarez López et al., 2018). Consistent with these studies, this research found that RFID implementation significantly improved tool retrieval time, reduced tool loss incidents, and enhanced tracking efficiency within Maintenance, Repair, and Overhaul (MRO) operations. These improvements corroborate findings from Škultéty & Stalmašeková (2018) and Yang et al. (2018) on RFID's effectiveness in minimizing manual efforts and increasing accountability in tool management. However, this

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue X, October 2024

study also surfaced unique challenges related to RFID implementation in a developing market context, such as initial technical issues and the need for enhanced training. These challenges, though noted in the literature, appeared more pronounced here, reflecting specific logistical and economic constraints faced in Philippine MRO facilities.

Implications for MRO Operations

The practical implications of RFID technology in MRO operations are considerable. The reduction in tool retrieval time and decreased incidents of tool loss improve compliance with strict tool control standards, an essential factor for operational safety and regulatory adherence. The study also suggests that RFID's real-time tracking capabilities significantly impact personnel efficiency, as maintenance staff spend less time on manual inventory tasks and can focus on core maintenance activities. Enhanced accountability for tool usage and availability further supports smoother shifts and fewer disruptions, particularly for supervisors managing inventory and tool accessibility. These implications not only support more streamlined maintenance processes but also position RFID as an essential tool for MROs aiming to modernize their operations and meet international standards.

Challenges and Limitations in Implementation

Despite the evident benefits, several challenges and limitations surfaced during the RFID implementation process. One primary challenge was the high initial cost of RFID systems, a barrier frequently cited in studies on RFID adoption (Spexet et al., 2022). In the Philippine context, these costs may be prohibitive for smaller MRO facilities, limiting widespread adoption. Technical issues, such as occasional misreads by handheld RFID readers, also posed a challenge, requiring calibration and technical support. Additionally, initial resistance from some maintenance staff emphasized the importance of comprehensive training to familiarize personnel with RFID technology and address concerns about system reliability. These limitations highlight the need for a thoughtful, phased approach to RFID adoption, particularly in regions where budgetary and technical constraints may affect implementation.

VII. Recommendations

1. **Allocate Budget for System and Training**: Ensure sufficient funds are available for both the RFID system and comprehensive employee training to support a smooth transition and minimize implementation issues.
2. **Prioritize Training Sessions**: Conduct detailed training sessions to familiarize personnel with RFID functions, address any resistance, and troubleshoot initial technical issues.
3. **Implement in Phases**: Consider a phased approach, starting with high-priority tool areas to demonstrate RFID's effectiveness before expanding to full-scale deployment across the facility.
4. **Regular Calibration and Updates**: Schedule regular system calibration and updates to maintain consistent performance and reduce data inaccuracies, particularly in handheld readers.
5. **Integrate Mobile Access Features**: Explore options for mobile access, allowing personnel to track tools from personal devices and further enhance real-time tool management capabilities.

VIII. Conclusion

Summary of Findings

This study demonstrated the significant benefits of RFID technology in enhancing tool control and operational efficiency within Maintenance, Repair, and Overhaul (MRO) operations in the Philippine aviation sector. Key findings showed an 83% reduction in tool retrieval times, a 70% decrease in tool loss incidents, and substantial improvements in tracking efficiency, with a 90% reduction in manual inventory efforts and an 85% decrease in inventory discrepancies. These results underscore RFID's effectiveness in streamlining maintenance processes, increasing accountability, and minimizing human errors associated with manual tool management. Collectively, these findings contribute to a better understanding of RFID's role in optimizing tool control practices in aircraft maintenance environments.

Study Contributions

This study adds valuable insights into RFID technology's potential within the specific context of Philippine MRO facilities, where budgetary constraints and regulatory standards present unique challenges. By highlighting RFID's practical benefits in tool management, this research provides local MROs with data-driven evidence to support RFID adoption, thereby advancing the body of knowledge on modernizing maintenance practices in developing markets. Furthermore, this study bridges gaps in the literature by focusing on RFID implementation in a Southeast Asian context, where research on technology-driven maintenance management is still emerging. These contributions can serve as a foundational reference for aviation facilities across the Philippines and similar regions, helping to align local MRO practices with global standards.

Future Research Directions

Future studies could explore the long-term impact of RFID technology on operational costs, particularly focusing on return on investment (ROI) over several years in budget-sensitive settings. Additionally, research could assess RFID's feasibility and adaptability in other maintenance contexts within aviation, such as military aircraft maintenance or smaller general aviation

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facilities. Comparative studies between RFID and emerging tracking technologies, like blockchain or Internet of Things (IoT)-enabled systems, could also offer valuable insights into the relative benefits and limitations of each technology in tool control and asset management. Lastly, examining RFID's impact on workforce productivity and employee satisfaction over time could provide a holistic view of its effectiveness in transforming maintenance operations.

References

1. Abdallah, A. A., & Fan, I.-S. (2020, October 23). Emerging challenges of digital aircraft operations and maintenance: A knowledge management perspective. TESConf 2020 - 9th International Conference on Through-life Engineering Services. https://doi.org/10.2139/ssrn.3718062
2. Abugabah, A., Sanzogni, L., Houghton, L., AlZubi, A. A., & Abuqabbeh, A. (2022). RFID adaption in healthcare organizations: An integrative framework. Computers, Materials & Continua, 70(1), 1335-1348. https://doi.org/10.32604/cmc.2022.019097
3. Álvarez López, Y., Franssen, J., Álvarez Narciandi, G., Pagnozzi, J., González-Pinto Arrillaga, I., & Las-Heras Andrés, F. (2018). RFID technology for management and tracking: E-health applications. Sensors, 18(8), 2663. https://doi.org/10.3390/s18082663
4. Amutha, K., & Vallinayagi, V. (2019). Operation and maintenance of industry using RFID. Journal of Emerging Technologies and Innovative Research. https://typeset.io/explore/journals/journal-of-emerging-technologies-and-innovative-research-1oh4fspe
5. Andreacchio, M. (2015). Reducing aircraft life vest underutilisation by implementing RFID-enabled inspections. In 2015 4th International Conference on Advanced Logistics and Transport (ICALT) (pp. 7-11). IEEE. https://doi.org/10.1109/ICAdLT.2015.7136582
6. AnnMarie, Heather, Spexet., Elizabeth, F., Tilden., Kyle, Blond., Steven, Conley., Eric, Klein., David, Alvord. (2022). The Connected Hangar: Ubiquitous Computing and Aircraft Maintenance. https://doi.org/10.1145/3544793.3560353
7. Chetouane, F. (2014). An Overview on RFID Technology Instruction and Application. IFAC-PapersOnLine, 48(3), 382-387. https://doi.org/10.1016/j.ifacol.2015.06.111
8. Fan, T., Tao, F., Deng, S., & Li, S. (2014). Impact of RFID technology on supply chain decisions with inventory inaccuracies. International Journal of Production Economics, 159, 117-125. https://doi.org/10.1016/j.ijpe.2014.10.004
9. Filip, Š., & Stalmašeková, N. (2018). Pre-flight inspections of aircraft emergency equipment via RFID technology. Transportation Research Procedia, 35, 279-286. https://doi.org/10.1016/J.TRPRO.2018.12.010
10. Gladysz, B., Ejsmont, K., Kluczek, A., Corti, D., & Marciniak, S. (2020). A method for an integrated sustainability assessment of RFID technology. Resources, 9(9), 107. https://doi.org/10.3390/resources9090107
11. Haibi, A., Oufaska, K., Yassini, K. E., Boulmalf, M., & Bouya, M. (2022). Systematic mapping study on RFID technology. IEEE Access, 10, 6363-6380. https://doi.org/10.1109/ACCESS.2022.3140475
12. Kaushik, G., Pratap singh, B., & Yadav, K. D. S. (n.d.). RFID Technology. https://doi.org/10.1002/9781119198345.app2
13. Kereri, J. O., & Turner, B. (2018). Use of technology in material tracking in the construction industry business. https://www.semanticscholar.org/paper/USE-OF-TECHNOLOGY-IN-MATERIAL-TRACKING-IN-THE-Kereri-Turner/7b4b460b4b871218df8bf5895d7f767691dfe8fa
14. Ku, C.-Y., Chang, Y. W., Lu, M. C., & Chiu, S. F. (2005). Building ubiquitous computing environment by using RFID in aircraft MRO process. 7-10. https://typeset.io/papers/building-ubiquitous-computing-environment-by-using-rfid-in-1b5o5gfijo
15. Kumar, P., Reinitz, H. W., Simunovic, J., Sandeep, K. P., & Franzon, P. D. (2009). Overview of RFID Technology and Its Applications in the Food Industry. Journal of Food Science, 74(8), R101-R106. https://doi.org/10.1111/j.1750-3841.2009.01323.x
16. Liukkonen, M. (2014). RFID technology in manufacturing and supply chain. International Journal of Computer Integrated Manufacturing, 28(8), 861-880. https://doi.org/10.1080/0951192X.2014.941406
17. Moretti, E. de A., Anholon, R., Rampasso, I. S., Silva, D., Santa-Eulalia, L. A., & Ignácio, P. S. de A. (2019). Main difficulties during RFID implementation: an exploratory factor analysis approach. Technology Analysis & Strategic Management, 31(8), 943–956. https://doi.org/10.1080/09537325.2019.1575351
18. Popova, I., Abdullina, E., Danilov, I., Marusin, A., Marusin, A., Ruchkina, I., & Shemyakin, A. (2020). Application of the RFID technology in logistics. Transportation Research Procedia, 57, 452-462. https://doi.org/10.1016/j.trpro.2021.09.072
19. Rafique, M. Z., Haider, M., Raheem, A., Ab Rahman, M. N., & Amjad, M. S. (2022). Essential elements for radio frequency identification (RFID) adoption for industry 4.0 smart manufacturing in context of technology-organization-environment (TOE) framework – A review. Jurnal Kejuruteraan. https://doi.org/10.17576/jkukm-2021-34(1)-01
20. Rawahi, S. H. A., Jamaluddin, Z. B., & Bhuiyan, A. B. (2020). The conceptual framework for the resources management attributes and aircraft maintenance efficiency in the aviation industries in Oman. International Journal of Accounting & Finance Review, 5(3), 31-40. https://doi.org/10.46281/ijafr.v5i3.808
21. Shan, Li., Lei, Zhang., Yingzhi, Zou., Li, Li. (2023). Method of Intelligent Management of Aviation Maintenance Tools Based on RFID Technology. 547-551. https://doi.org/10.1109/iccasit58768.2023.10351589

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue X, October 2024

22. Seco, F., & Jiménez, A. R. (2018). Smartphone-based cooperative indoor localization with RFID technology. Sensors, 18(1), 266. https://doi.org/10.3390/s18010266
23. Shuai, Y., Crisp, M., Penty, R. V., & White, I. H. (2018). RFID enabled health monitoring system for aircraft landing gear. IEEE Journal of Radio Frequency Identification, 2(3), 159-169. https://doi.org/10.1109/JRFID.2018.2822770
24. Suresh, S., & Chakaravarthi, G. (2022). RFID technology and its diverse applications: A brief exposition with a proposed Machine Learning approach. Measurement, 195, 111197. https://doi.org/10.1016/j.measurement.2022.111197
25. Tao, F., Fan, T., Lai, K. K., & Li, L. (2017). Impact of RFID technology on inventory control policy. Journal of the Operational Research Society, 68(2), 207–220. https://doi.org/10.1057/s41274-016-0030-5
26. TT Electronics. (2022). RFID technology: Revolutionizing tracking and data management. Retrieved from https://www.ttelectronics.com/blog/rfid-technology/
27. Unhelkar, B., Joshi, S., Sharma, M., Prakash, S., Mani, A. K., & Prasad, M. (2022). Enhancing supply chain performance using RFID technology and decision support systems in the industry 4.0–A systematic literature review. International Journal of Information Management Data Insights, 2(2), 100084. https://doi.org/10.1016/j.jjimei.2022.100084
28. Valero, E., Adán, A., & Cerrada, C. (2015). Evolution of RFID applications in construction: A literature review. Sensors, 15(7), 15988-16008. https://doi.org/10.3390/s150715988
29. Veiseh, A., & Haghighatmonfared, J. (2015). RFID as an enabler of maintenance management. Journal of Management and Accounting Studies. https://doi.org/10.24200/jmas.vol7iss01pp16-21
30. Zhang, D., Huang, H. & Jo, M. Future RFID technology and applications: visions and challenges. Telecommun Syst **58**, 193–194 (2015). https://doi.org/10.1007/s11235-014-9865-8
31. Zhu, X., Mukhopadhyay, S. K., & Kurata, H. (2011). A review of RFID technology and its managerial applications in different industries. Journal of Engineering and Technology Management, 29(1), 152-167. https://doi.org/10.1016/j.jengtecman.2011.09.011
32. Škultéty, F., & Stalmašeková, N. (2017). Pre-flight inspections of aircraft emergency equipment via RFID technology. Transportation Research Procedia, 35, 279-286. https://doi.org/10.1016/j.trpro.2018.12.010
33. Yang, H., & Chen, W. (2020). Game modes and investment cost locations in radio-frequency identification (RFID) adoption. European Journal of Operational Research, 286(3), 883-896. https://doi.org/10.1016/j.ejor.2020.02.044