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Enhancing Aircraft Spare Parts Procurement Efficiency in Indonesian MRO Companies: A Business Process Reengineering Approach Using AHP and Simulation

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Abstract. This study aims to optimize the aircraft spare parts procurement process in Maintenance, Repair, and Overhaul (MRO) companies in Indonesia using a Business Process Reengineering (BPR) approach. The research addresses the significant inefficiencies in the current procurement process, which lead to extended cycle times for Repair Orders (RO) and Purchase Orders (PO), ultimately impacting fleet availability and operational effectiveness. The authors collected data from historical records and expert questionnaires and applied the Analytic Hierarchy Process (AHP) to identify and prioritize key improvement criteria, such as Time Management, Human Resources, and Support Systems. A simulation study using iGrafx software was conducted to compare the as-is and to-be processes, demonstrating the potential for cycle time reduction through process optimization. The findings highlight the importance of streamlining payment requests, enhancing budgeting, and improving supplier collaboration to achieve industry-standard Turnaround Times (TATs). This study contributes to the field of aviation supply chain management by providing a structured approach for optimizing spare parts procurement and offers practical recommendations for MRO companies to enhance their operational efficiency and competitiveness.

Keywords: Procurement, Business Process Reengineering, AHP, MRO

1. Introduction

The acquisition of aircraft spare parts played a pivotal role in the aviation industry. Timeliness in this procedure profoundly influences the overall functioning of an airline or aviation entity. With modern aircraft technology becoming more complex, having the right spare parts available when needed is crucial for endurance and operational effectiveness. The punctuality in obtaining aircraft spare parts not only impacted fleet accessibility but also had repercussions on safety, dependability, and the standing of the airline. In the fiercely competitive aviation sector, the failure to promptly secure spare parts could result in operational disruptions, flight postponements, and unanticipated supplementary expenses. Consequently, adept and efficient management of the supply chain for aircraft spare parts was essential to ensure timely procurement. Employing cutting-edge technology, fostering robust collaboration with suppliers, and meticulous planning constituted pivotal factors in upholding the seamless progression of this process.

In a more nuanced context, several factors could impede the procurement of aircraft spare parts. One of them was the global availability of spare parts, which could be influenced by centralized production in specific regions. Additionally, the lead time in the purchase order (PO) and repair order (RO) processes became a crucial factor affecting the speed of procurement, with stock policies and purchase approval requiring special attention. The shipping and import-export processes could also significantly contribute to delays in obtaining spare parts, especially when involving cross-border transactions. The responsiveness of vendors was another important consideration, as effective collaboration relied on swift and responsive communication.

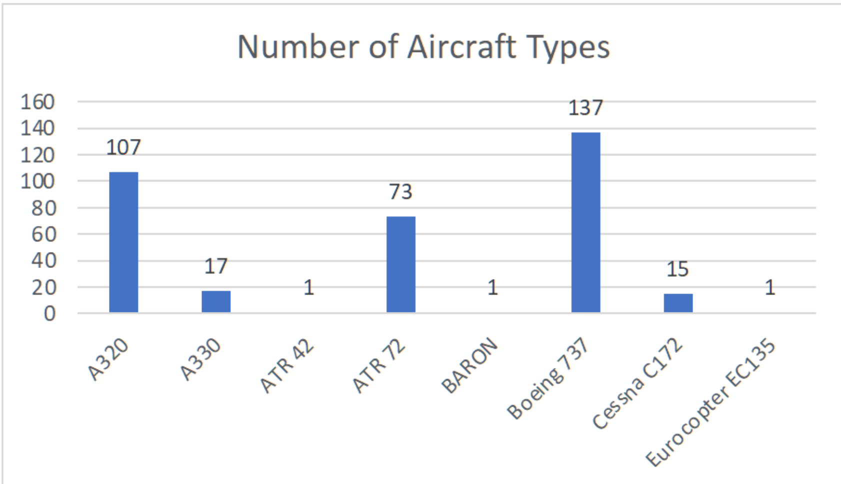

Fig. 1: The number of aircraft types

Based on Figure 1, we observe that this MRO company manages a total of 352 aircraft. However, there is an issue with 94 of these aircraft being in an unserviceable condition, meaning there are 26% aircraft are not permitted to fly. One of the primary factors contributing to this unserviceable status is the delay in procuring spare parts, which exceeds the standard Turnaround Time (TAT) as detailed in Table 1 below.

Table 1. TAT (Turnaround Time) for each process in the procurement of spare parts

No	Description	Average Current TAT	Target Standard TAT
1	Repair Order (RO) Process	120 Days	95 Days
2	Requisition (RQ) to Purchase Order Process	5 Days	3 Days

3	Repair Quotation Approval Process (without discrepancy)	4 Days	3 Days
4	Payment Propose Process	56 Days	30 Days

This study aimed to design an improvement in aircraft spare parts procurement processes, especially focusing on the Turnaround Time (TAT) factor, to achieve the standard TAT in MRO companies through the Business Process Reengineering (BPR) approach. BPR is distinguished by its capacity to significantly enhance business performance through comprehensive alterations to virtually all aspects of business processes, leveraging state-of-the-art technologies to enhance process quality. The author plans is the result of BPR could give the impact for the TAT on procurement process in one of the Indonesian MRO companies. The data was obtained through historical data analysis and questionnaire distribution to experts involved in the aircraft spare parts procurement process.

2. Literature Review

2.1. Procurement

Procurement, the acquisition of goods and services, stands as a crucial activity within the supply chain. Given its substantial time consumption, the cost levels, profits, and competitiveness of a company hinge heavily on the efficiency of its procurement processes. The procurement process encompasses various activities, beginning with the identification of needs for goods/services, followed by the search and selection of suppliers, the creation of purchase orders (PO) with the chosen supplier, the management of logistics until goods are ready for use by end-users, and the submission and monitoring of the payment process for completed purchase orders (Bag et al., 2020).

2.2. Inventory

In a fiercely competitive corporate landscape, inventory management emerges as a cornerstone activity within the realm of supply chain management. This endeavor aims to optimize market demand fulfillment while simultaneously driving inventory efficiency and cost reduction (Žic et al., 2023). Inventory serves as a cornerstone activity in supply chain management, providing businesses with a crucial buffer against diverse challenges. Nonetheless, the quantities of individual items or services are subject to fluctuations. Hence, adept management of goods and services availability is paramount. A pivotal aspect of effective inventory management involves inventory classification. Through meticulous categorization, companies can mitigate inventory costs, elevate customer satisfaction levels, and optimize production efficiency (Cakmak & Guney, 2023).

2.3. Maintenance for Aircraft

An aircraft's systems, components, and structure undergo processes such as overhaul, repair, inspection, or modification as part of maintenance procedures to preserve the airworthiness status of the aircraft. Commercial aircraft must undergo routine maintenance to prevent failures in components or systems during operations. Aircraft maintenance is determined by various parameters, such as the total flight hours (FH), the number of flight cycles (FC), or based on a specified time (calendar days/DY). Inspection intervals for aircraft are established to define the maximum parameters permissible for safe operation (Deng et al., 2021).

2.4. Business Process Reengineering

A complete transformation of business processes is essential to develop a swiftly integrated system. All organizations and companies are expected to uphold efficiency and speed. Business process reengineering involves examining and enhancing outdated or conventional systems within an organization or company to adapt to modern standards (Zen & Dachyar, 2021). The main objective of Business Process Reengineering (BPR) is to cultivate an organizational culture, functional mindset, and emphasis on process-driven approaches, recognizing that business processes contribute more to long-term success than the products themselves. It entails organizing activities into cohesive flows and integrating the necessary skills, tools, and materials. BPR should be approached with a distinct business viewpoint and precise redesign goals. Its execution is motivated by enhancing performance, lowering organizational expenses, reducing task processing durations, and elevating both product/service quality and employee well-being (Dachyar, 2020).

The use of BPR methods to improve a business process has been widely adopted in various fields, such as in the improvement of Indonesia's E-Procurement system, which can minimize corruption and enhance procurement efficiency by up to 40% (Dachyar, 2020). Furthermore, the BPR approach has also been used to improve the small delays in the Intensive Care Unit (ICU) by employing a combination of IoT-Based Patient Monitoring and Intelligent Monitoring Analytics, resulting in the greatest reduction in process time at 37.10%(Zen & Dachyar, 2021).

The significance of e-procurement in improving supply chain effectiveness in the aviation MRO sector is emphasized. Contrasting traditional procurement with e-procurement systems reveals the drawbacks of manual, paper-based processes, including longer lead times, higher costs, and limited communication with supply chain partners. Despite concerns about implementation costs, user acceptance, and supplier capabilities, the necessity for e-procurement adoption arises from these challenges. Through an analysis of a case study involving a helicopter maintenance company in India, the research demonstrates the concrete benefits of e-procurement in boosting supply chain efficiency and performance. Using a qualitative single case study approach, the study highlights how e-procurement streamlines processes, enhances communication and achieves cost savings. Ultimately, the findings underscore the transformative potential of e-procurement in optimizing supply chain operations and gaining a competitive advantage in the aviation MRO industry (Basak, 2016).

Exploring procurement challenges within Indonesia's Maintenance, Repair, and Overhaul (MRO) industry revealed crucial aspects such as Custom Clearance, Supplier Location, and Parts Availability, which significantly influenced procurement lead times. The study emphasized the importance of factors like Cost and Lead Time in shaping supplier preferences and decisions regarding supplier selection. It underscored the crucial role of lead time management and strategic supplier selection in improving procurement efficiency and performance in Indonesia's Aviation MRO sector. Additionally, the research offered actionable insights for refining procurement strategies and enhancing operational efficiency. By elucidating the interrelationships among factors like Cost, Custom Clearance, and Lead Time in Preferred Supplier selection, the study provided valuable implications for industry professionals. Not only did this research enhance the understanding of procurement challenges in Indonesia's MRO industry at the time, but it also laid a strong groundwork for future research, suggesting potential areas for further investigation and practical implementation in the field (Fahriza et al., 2024).

Drawing from prior research and identifying research gaps, the author intends to employ the BPR approach to enhance aircraft spare parts procurement within Indonesian MRO companies. The optimal scenario will be determined through expert opinion analysis utilizing the Multiple-Criteria Decision-Making (MCDM) method, notably the Analytical Hierarchy Process (AHP) for assessing critical attributes.

Although previous studies have underscored the efficacy of BPR in refining procurement processes, scant attention has been paid to its application within the procurement context, specifically the Repair Order (RO) process for sourcing necessary spare parts in MRO companies. This study aims to bridge this research void by integrating MCDM and BPR methodologies, alongside iGrafx simulation, to prioritize quality attributes and revamp the procurement process within Indonesian MRO companies.

3. Research Methods

This research followed the BPR approach in three main stages. The first stage involved mapping the as-is process. During this stage, the current procurement process model was created and simulated to understand the flow and time of the process. The second stage focused on analyzing the as-is process using the Analytic Hierarchy Process (AHP) to identify and rate the potential criteria that needed improvement from the current process. The last stage entailed designing the to-be model by modifying the as-is model. The model flow was created using Business Process Modelling Notation (BPMN) and simulated in iGrafx software.

4. Data Collection

The data was obtained through historical sources, including the number of aircraft, part requirement data, and lead time data for part procurement. Additionally, questionnaires were distributed to experts involved in the aircraft spare parts procurement process. In this journal, questionnaires were given to five experts, namely the General Manager of Tools and Material Management, Part Review Coordinator, Warranty
Claim Coordinator, Consumable Procurement PIC, and Rotable Procurement PIC.

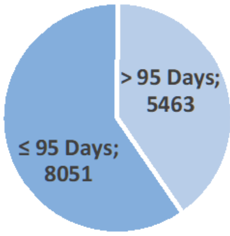

Fig. 2: Total RO on 2023

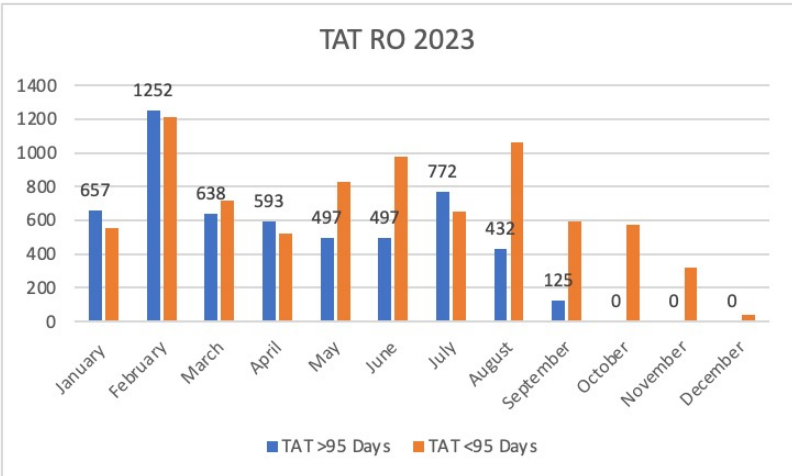

Fig. 3: Detail TAT RO on 2023

Based on Figure 2, it was observed that out of 8051 Repair Orders (ROs), 5463 exceeded the standard Turnaround Time (TAT), accounting for more than 60% of the total ROs. This significant delay indicated inefficiencies in the spare parts procurement process, which impacted the operational availability of aircraft. The detailed monthly breakdown of orders that exceeded the standard TAT can be seen in Figure 3.

To address these inefficiencies, an improvement assessment was conducted using various criteria collected from several sources. Six experts in Table 2, who specialize in the aircraft spare parts procurement process were involved in validating these criteria. The validated criteria, which are detailed in Table 3, are used to evaluate and guide the necessary improvements in the procurement process. These criteria ensure that the assessment is thorough, relevant, and based on expert knowledge, thereby enhancing the effectiveness of the proposed improvements.

Table 2. Experts List

Position	**Work Experience**
General Manager	10 Years
Coordinator Part Review	8 Years
Coordinator Warranty Claim	15 Years
PIC Procurement Consumable	10 Years
PIC Procurement Rotable	19 Years
Manager Procurement	8 Years

Table 3. Improvement criteria

Description	Improvement Scale						Weight Geomean	Geomean	Result
	1	2	3	4	5	6			
The waiting time in the provision of goods from the purchase order (PO) and repair order (RO) processes	5	5	5	4	5	5	4,82	4,33	Accept
The duration of procurement, starting from the order creation process until the goods are received	5	4	5	5	5	5	4,82		Accept
The time taken by a worker to provide a response related to their work to other teams or vendors	4	5	5	3	4	5	4,26		Reject
How to convey work-related information with teammates as well as with other teams	4	5	4	5	4	5	4,47		Accept
Allocation of workload to each worker that must be carried out and accounted for	4	5	4	5	4	5	4,47		Accept
The level of knowledge and skills of workers in completing the assigned tasks	4	5	5	3	4	4	4,11		Reject
Honesty, ethics, and morality in carrying out tasks and job responsibilities	4	5	5	3	5	5	4,42		Accept
The level of knowledge and understanding of workers regarding the scope of the work being done	4	5	5	4	4	4	4,31		Reject

Readiness of the technology used to support the procurement process	4	5	4	4	4	4	4,15	Reject
The system used in the procurement process is already integrated/interconnected	4	5	4	5	4	5	4,47	Accept
The job database of each procurement team is related to updating the order status, both Purchase Orders (PO) and Repair Orders (RO)	4	5	4	3	5	5	4,26	Reject
Ease of use of technology in the procurement process	3	5	4	4	4	4	3,96	Reject
Estimating the quantity of parts that will be used	4	4	5	4	4	5	4,31	Reject
Monitoring the stock of parts	4	4	5	4	3	5	4,11	Reject
Focusing monitoring on urgently needed parts	3	5	5	3	4	5	4,06	Reject
The process of submitting payment invoices by the procurement team to the accounting and finance team	4	5	4	5	4	5	4,47	Accept
The process of creating a monthly budget is carried out by the procurement team	4	4	4	4	5	5	4,31	Reject

After validation from the experts, the improved criteria were grouped into several criteria to be calculated using AHP. This was aimed at ensuring that the technology implementation encompassed all factors that could influence the spare parts procurement process. Table 4 shows the results of grouping the improved criteria.

Table 4. Improve Criteria Grouping

Criteria	**Sub-criteria**	**Description**	**References**
Time Management	Lead Time	The waiting time in the provision of goods from the purchase order (PO) and repair order (RO) processes	(Milambo & Phiri, 2019; Tripathi & Gupta, 2021; Wang et al., 2020)
	Turnaround Time	The duration of procurement, starting from the order creation process until the goods are received	(Milambo & Phiri, 2019; Tripathi & Gupta, 2021; Wang et al., 2020)
Human Resource	Communication	How to convey work-related information with teammates as well as with other teams	(Chiara Leva et al., 2022; Coşkun & Kazan, 2023; Sa'adah & Arokiasamy, 2023)

Criteria	Sub-criteria	Description	References
	Workload	Allocation of workload to each worker that must be carried out and accounted for	(Chiara Leva et al., 2022; Coşkun & Kazan, 2023; Nino et al., 2020)
	Integrity	Honesty, ethics, and morality in carrying out tasks and job responsibilities	(Poon & Yu, 2010; Sa'adah & Arokiasamy, 2023; Wang et al., 2020)
Support System (Technologies)	Integrated system	The system used in the procurement process is already integrated/interconnected	(Coşkun & Kazan, 2023; Muffatto & Payaro, 2004; Poon & Yu, 2010)
Financial Management	Payment request	The process of submitting payment invoices by the procurement team to the accounting and finance team	(Chiara Leva et al., 2022; Coşkun & Kazan, 2023; Nino et al., 2020)

5. Result and Discussion

5.1. As Is Process

Data was collected through a review of the historical procurement processes at one Maintenance, Repair, and Overhaul (MRO) company, encompassing the entire workflow from the initial request for a part until it became available. This data was also enhanced by interviews with six experts specializing in the aircraft spare parts procurement process. The existing process, or "as-is" process, was mapped and simulated using the Business Process Modelling Notation (BPMN) diagram in iGrafx software. This detailed mapping split the procurement process into two main types: Repair Orders (RO). For the RO process, the workflow was segmented into six sections involving different teams (Warehouse Team, Export and Import Team, Shipment Team, Procurement Team, Accounting and Finance Team, Receiving Team).

From the simulation results presented in Table 5, it was observed that the average cycle time for RO was 53.47 weeks. This duration significantly exceeded the standard Turnaround Time (TAT), which was set at only 95 days (approximately 13.57 weeks). These findings highlighted major inefficiencies in the procurement cycles of RO, suggesting substantial room for process optimization to meet industry-standard TATs. This data and these insights were critical for guiding process improvement efforts to enhance efficiency and reduce cycle times in the procurement process.

Table 5. As Is Simulation Result for RO

Elapsed Time (Weeks)
53,47

Transaction Statistics (Weeks)

Count	Avg Cycle	Avg Work	Avg Wait	Avg Res Wait	Avg Block	Avg Inact	Avg Serv
1	53,47	12,80	40,67	0,00	0,00	40,67	12,80

Transaction Statistics (Weeks)

	Count	Avg Cycle	Avg Work	Avg Wait	Avg Res Wait	Avg Block	Avg Inact	Avg Serv
Proses Repair Order/Accounting dan Finance team								
Proses Repair Order/Export Import team	1	11,03	2,65	8,39	0,00	0,00	8,39	2,65
Proses Repair Order/Procurement team	1	32,58	7,72	24,86	0,00	0,00	24,86	7,72
Proses Repair Order/Receiving team	1	0,42	0,13	0,29	0,00	0,00	0,29	0,13
Proses Repair Order/Shipment team	1	7,82	1,83	5,99	0,00	0,00	5,99	1,83
Proses Repair Order/Warehouse team	1	1,62	0,47	1,15	0,00	0,00	1,15	0,47

To obtain the simulation results in Table 5, it was necessary to conduct a thorough simulation of the RO process based on the detailed As-Is process depicted in Figure 4. The figure revealed the complexity of the RO process, highlighting its involvement with up to 6 distinct team divisions that were interconnected. Each division played a crucial role in the overall procurement process, from the initial request to the final delivery of the parts. By simulating each step of this process, including interactions between teams and potential bottlenecks, a comprehensive understanding of the current cycle times and inefficiencies could be obtained. This detailed analysis laid the foundation for identifying areas of improvement and implementing strategies to optimize the procurement process and reduce cycle times.

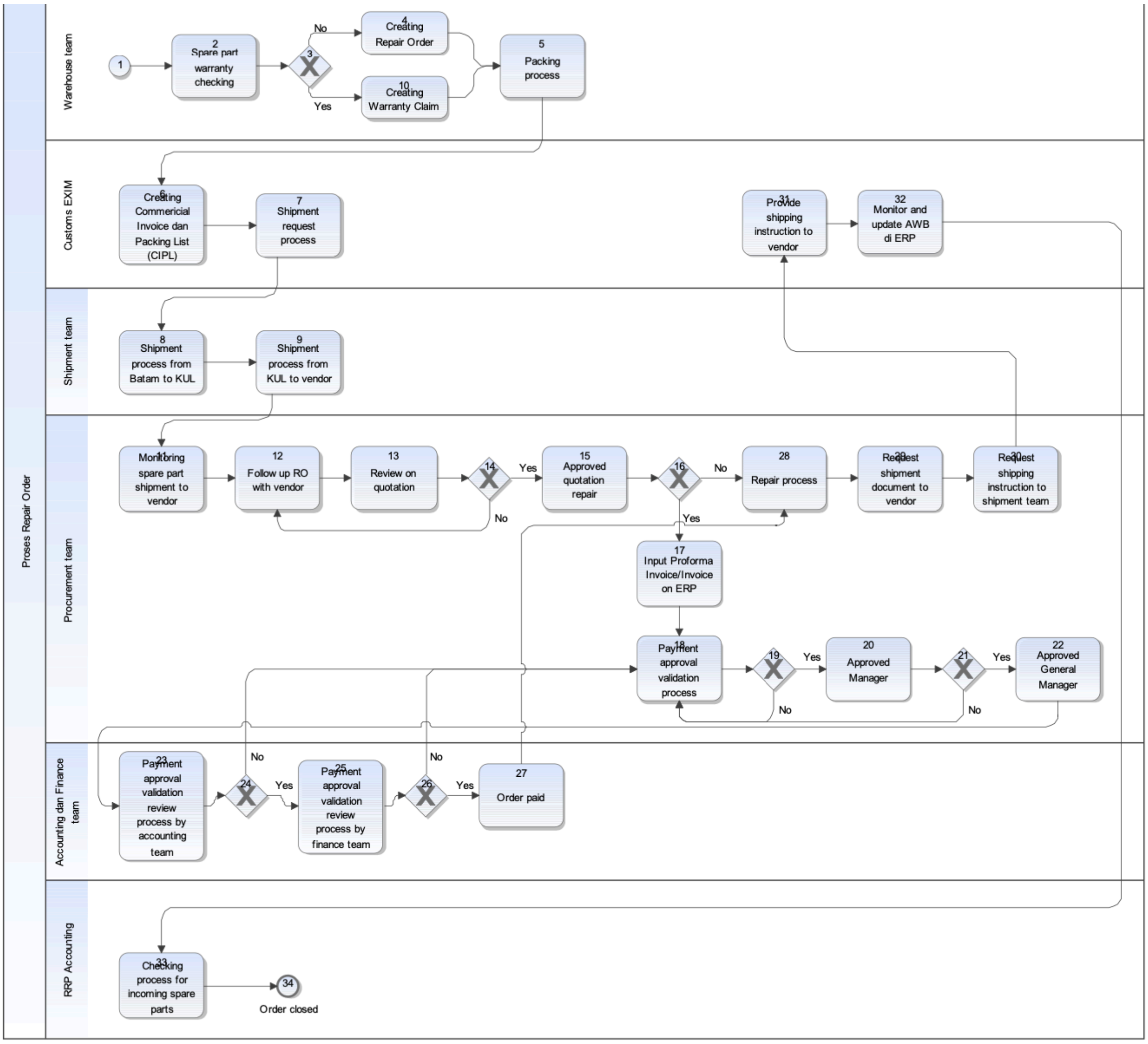

Fig. 4: RO Simulation for As-is Process

5.2. Data Analysis for the Importance Factor on Procurement Process using AHP

For evaluating and optimizing the procurement process in an MRO company using the criteria validated by experts, the method involved conducting structured interviews with six experts in the field. These interviews utilized a list of pre-defined criteria outlined in Table 2, which consisted of five key areas impacting the procurement process: Time Management, Human Resources, Support System (Technologies), and Financial Management. The results of determining the weights of each criterion using a method like the Analytic Hierarchy Process (AHP) are shown in Tables 6, 7, and 8.

Table 6. Pairwise Comparison Matrix

Criteria	Time Management	Human resource	Support system	Financial Management
Time Management	1,00	1,73	2,50	1,94
Human resource	0,57	1,00	2,33	1,91
Support system	0,40	0,43	1,00	1,05
Financial Management	0,51	0,52	0,45	1,00

To determine the weights of the elements, the AHP relies on the eigenvector principle of the comparison matrix. This method ensures that the combined insights from the six experts are effectively integrated and analyzed. Table 6 presents the outcome of processing the data, providing valuable insights into the relative importance of each criterion in the procurement process optimization. These weightings serve as a foundation for prioritizing improvement efforts and allocating resources effectively.

Table 7. Normalized Pairwise Comparison Matrix

Criteria	Time Management	Human resource	Support system	Financial Management
Time Management	0,40	0,47	0,40	0,33
Human resource	0,23	0,27	0,37	0,32
Support system	0,16	0,12	0,16	0,18
Financial Management	0,21	0,14	0,07	0,17

The pairwise comparison matrix for the improvement criteria undergoes normalization to ensure consistency and comparability across different criteria. Table 7 provides a detailed overview of the normalization process for the pairwise comparison outcomes, offering insights into the relative importance of each criterion with others. This step is crucial for accurately determining the weights of the criteria and guiding decision-making processes in the procurement optimization efforts.

Table 8. Ranked Weight of Criteria

Criteria	Weight	Rank
Time Management	0,402	1
Human resource	0,291	2
Support system	0,158	3
Financial Management	0,147	4

In Table 8, the weight of importance from technology selection is delineated, illustrating the significance of this criterion in the research. A higher weight denotes a greater level of importance assigned to technology selection in the context of procurement process optimization efforts. This weighting provides valuable guidance for prioritizing technology-related enhancements to achieve desired improvements in efficiency and performance. Effective time management plays a vital role in procurement, ensuring timely completion of tasks, capitalizing on opportunities, maximizing resource utilization, minimizing risks, meeting stakeholder expectations, and adhering to regulatory requirements. Skillful time management not only streamlines procurement processes but also bolsters the overall prosperity and competitive edge of a company.

5.3. To Be Process

The transition from the As-Is to the To Be process involves refining and optimizing various aspects, particularly focusing on enhancing time management criteria. Through simulation using iGrafx software, the effectiveness of these modifications can be assessed. Tables 9 provide valuable insights into the performance improvements achieved, with the average cycle time for RO reduced to 36.19 weeks. This reduction signifies the success of the optimization efforts and highlights the potential for further enhancements in the procurement process.

Table 9. To Be Simulation Result for RO

Elapsed Time (Weeks)

Elapsed Time (Weeks)
36,19

Transaction Statistics (Weeks)

Count	Avg Cycle	Avg Work	Avg Wait	Avg Res Wait	Avg Block	Avg Inact	Avg Serv
1	36,19	8,66	27,53	0,00	0,00	27,53	8,66

Transaction Statistics (Days)

	Count	Avg Cycle	Avg Work	Avg Wait	Avg Res Wait	Avg Block	Avg Inact	Avg Serv
Proses Repair Order/Accounting dan Finance team	1	35,92	8,59	27,33	0,00	0,00	27,33	8,59
Proses Repair Order/Customs (EXIM)	1	11,11	2,40	8,71	0,00	0,00	8,71	2,40
Proses Repair Order/Procurement team	1	61,58	14,33	47,25	0,00	0,00	47,25	14,33
Proses Repair Order/RRP Accounting	1	6,23	1,52	4,71	0,00	0,00	4,71	1,52
Proses Repair Order/Shipment team	1	38,15	9,49	28,67	0,00	0,00	28,67	9,49
Proses Repair Order/Vendor	1	89,26	21,21	68,04	0,00	0,00	68,04	21,21
Proses Repair Order/Warehouse team	1	11,11	3,11	8,00	0,00	0,00	8,00	3,11

Conducting a thorough simulation of the RO process based on the detailed To-Be process depicted in Figure 5 enabled a comprehensive assessment of the proposed improvements. The interconnected nature of the six distinct team divisions, along with the involvement of vendors in the repair process, highlighted the complexity of the procurement process. By simulating each step and interaction, a detailed understanding of the anticipated outcomes could be gained. The simulation results presented in Table 9 provided valuable insights into the effectiveness of the optimization efforts, with a notable reduction in the average cycle time for RO. This reduction underscores the success of the proposed improvements in enhancing the efficiency of the procurement process.

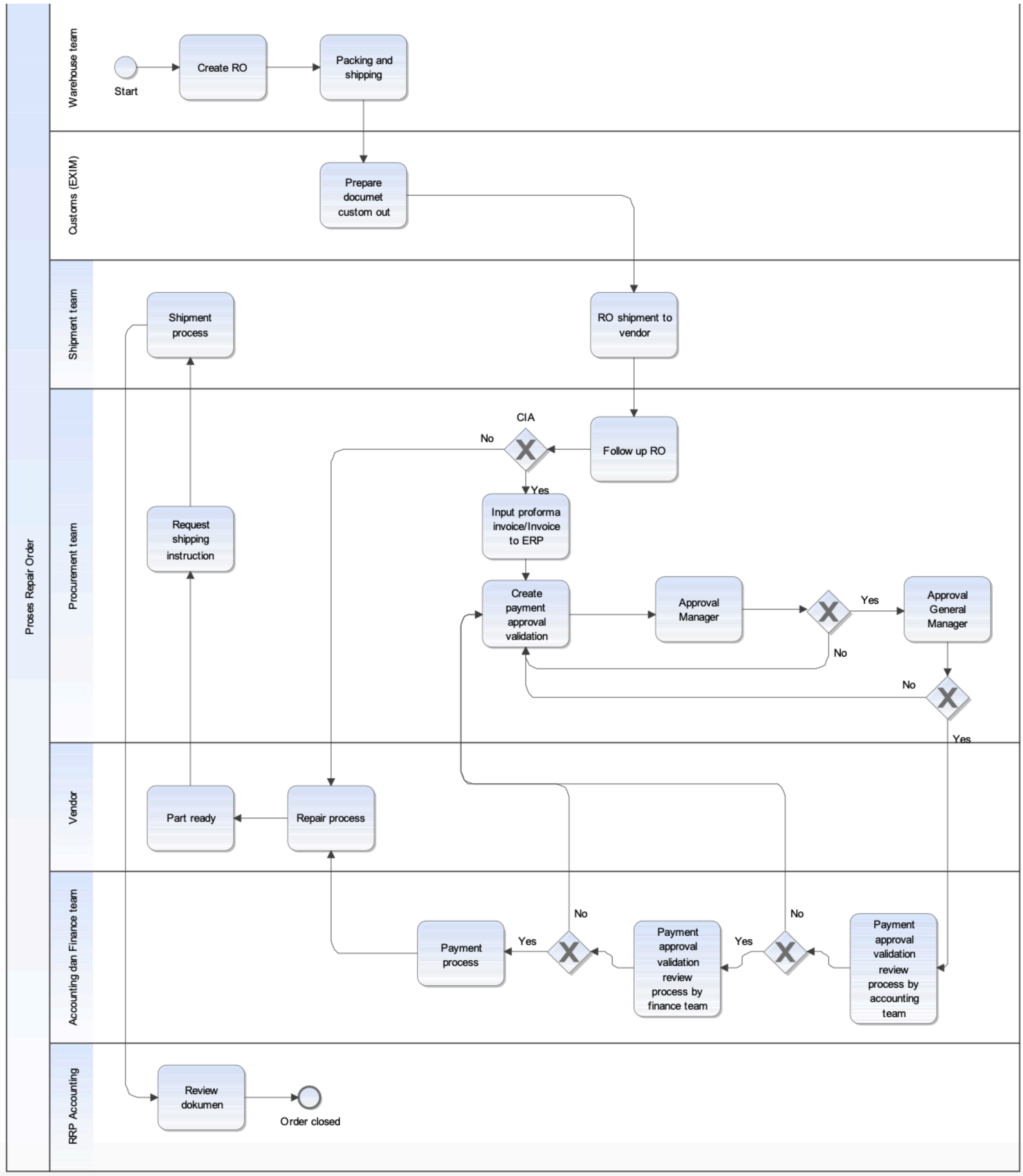

Fig. 5: RO Simulation for To-Be Process

In contrast to the previous As-Is model, the To-Be process integrated several previously separate processes, leading to a more streamlined workflow and ultimately a faster turnaround time. This improvement was evidenced by a notable 32% difference between the two models, with the To-Be model demonstrating enhanced efficiency by achieving a quicker cycle time compared to the As-Is model. This significant enhancement underscores the effectiveness of the optimization efforts undertaken in the procurement process. Although the simulation results of the to-be process have already reduced the cycle time by up to 32%, the target of the TAT (Turnaround Time) of around 13.57 weeks still cannot be achieved. Additionally, the integration of digitalization technologies, such as Artificial Intelligence (AI) and Business Intelligence (BI), is expected to enhance agility within the procurement process.

6. Conclusions

In conclusion, this study has successfully applied a Business Process Reengineering (BPR) approach to optimize the aircraft spare parts procurement process in Indonesian MRO companies. Through a combination of historical data analysis, expert input, and simulation modeling, the authors have identified significant inefficiencies in the current process and proposed an optimized to-be process that can reduce cycle times and improve operational performance.

The key findings of the study highlight the importance of Time Management, Human Resources, and Support Systems in driving procurement efficiency. By streamlining critical processes such as payment requests, budgeting, and supplier collaboration, MRO companies can achieve industry-standard Turnaround Times (TATs) and enhance their competitiveness in the market.

The study makes a valuable contribution to the field of aviation supply chain management by providing a structured framework for procurement process optimization that can be adapted to different contexts and settings. However, the authors acknowledge the limitations of the study, such as the small sample size for expert input and the need for further validation of the proposed improvements through real-world implementation.

Future research could focus on expanding the scope of the study to include other aspects of the MRO supply chain, such as inventory management and logistics, and could investigate the impact of emerging technologies such as Industry 4.0 and blockchain on procurement efficiency. Additionally, researchers could explore the potential for collaborative procurement strategies among MRO companies to leverage economies of scale and reduce lead times.

References

Bag, S., Wood, L. C., Mangla, S. K., & Luthra, S. (2020). Procurement 4.0 and its implications on business process performance in a circular economy. Resources, Conservation and Recycling, 152, 104502. https://doi.org/10.1016/j.resconrec.2019.104502

Basak, M. (2016). Achieving E-procurement Benefits in an Aviation MRO Environment. OPERATIONS AND SUPPLY CHAIN MANAGEMENT, 9(1), 50–60.

Cakmak, E., & Guney, E. (2023). Spare parts inventory classification using Neutrosophic Fuzzy EDAS method in the aviation industry. Expert Systems with Applications, 224. https://doi.org/10.1016/j.eswa.2023.120008

Chiara Leva, M., Demichela, M., Comberti, L., & Caimo, A. (2022). Human performance in manufacturing tasks: Optimization and assessment of required workload and capabilities. Safety Science, 154. https://doi.org/10.1016/j.ssci.2022.105838

Coşkun, S. S., & Kazan, H. (2023). Bayesian analysis of the relationship between process improvement practices and procurement maturity. Computers and Industrial Engineering, 181. https://doi.org/10.1016/j.cie.2023.109297

Dachyar, M. K. F. (2020). E-Procurement Process Reengineering for Prohibiting The Corruption Initiatives by Proposing a Real-Time and Integrated Bidding Solution. Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management, 7–10.

Deng, Q., Santos, B. F., & Verhagen, W. J. C. (2021). A novel decision support system for optimizing aircraft maintenance check schedule and task allocation. Decision Support Systems, 146, 113545. https://doi.org/10.1016/j.dss.2021.113545

Fahriza, B., Shuib, A., & Mohamed, W. M. W. (2024). Procurement Issues in the Indonesian Maintenance, Repair, and Overhaul (MRO) Industry. GATR Global Journal of Business Social Sciences Review, 12(1), 34–43. https://doi.org/10.35609/gjbssr.2024.12.1(4)

Milambo, D., & Phiri, J. (2019). Aircraft Spares Supply Chain Management for the Aviation Industry in Zambia Based on the Supply Chain Operations Reference (SCOR) Model. Open Journal of Business and Management, 07(03), 1183–1195. https://doi.org/10.4236/ojbm.2019.73083

Muffatto, M., & Payaro, A. (2004). Integration of web-based procurement and fulfillment: A comparison of case studies. International Journal of Information Management, 24(4), 295–311. https://doi.org/10.1016/j.ijinfomgt.2004.04.008

Nino, L., Marchak, F., & Claudio, D. (2020). Physical and mental workload interactions in a sterile processing department. International Journal of Industrial Ergonomics, 76. https://doi.org/10.1016/j.ergon.2019.102902

Poon, P. L., & Yu, Y. T. (2010). Investigating ERP systems procurement practice: Hong Kong and Australian experiences. Information and Software Technology, 52(10), 1011–1022. https://doi.org/10.1016/j.infsof.2010.04.003

Sa'adah, N., & Arokiasamy, L. (2023). A qualitative study on the urgency of attitude in designing effective procurement certification training. Journal of High Technology Management Research, 34(2). https://doi.org/10.1016/j.hitech.2023.100472

Tripathi, S., & Gupta, M. (2021). A framework for procurement process re-engineering in Industry 4.0. Business Process Management Journal, 27(2), 439–458. https://doi.org/10.1108/BPMJ-07-2020-0321

Wang, Q., Zhang, R., & Liu, J. (2020). Price/time/intellectual efficiency of procurement: Uncovering the related factors in Chinese public authorities. Journal of Purchasing and Supply Management, 26(3). https://doi.org/10.1016/j.pursup.2020.100622

Zen, S. G., & Dachyar, M. (n.d.). Intensive Care Unit (ICU) Patient Monitoring Improvement Using Internet of Things (IoT) Based on BPR Approach.

Žic, S., Žic, J., & Đukić, G. (2023). Efficient planning and optimization of inventory replenishments for sustainable supply chains operating under (R, s, S) policy. Sustainable Futures, 5. https://doi.org/10.1016/j.sftr.2023.100110