



MANAGING INVENTORY

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Summary

Introduction: This technical report addresses the challenges faced by Toon Air, a small UK airline specialising in regular routes within the UK and various Greek islands. Despite success in a niche market, the company has encountered issues with efficiency improvement, purchasing, and materials management. As the new material manager, the objective is to enhance the acquisition, storage, and distribution of supplies, including spares and consumables. As the new material manager, the objective is to enhance the acquisition, storage, and distribution of supplies, including spares and consumables. However, initial investigations have revealed significant challenges in the purchasing and supply chain processes.

Question 1: Analysing critical issues such as the supply of spares to the end of use, delayed spare parts acquisition, excessive inventory investments, challenges in maintaining optimal stock levels, direct engineer orders, lack of purchase order documentation, and centralised spare storage in the context of aircraft company recycling.

Question 2: Outlining the importance of outsourcing in managing warehouse parts and supply functions, considering that 71% of outsourcing is in the maintenance and repair industry. Emphasis is placed on the significance of clear communication and expectations in service level agreements (SLAs) and the utilization of Activity Based Costing (ABC) for cost and demand planning.

Question 3: Identifying priority actions and areas requiring major attention, with a focus on implementing a clear Network sub-model to address operational challenges.

Recommendations: The report concludes with recommendations for short, medium, and long-term strategies, emphasising human, financial, and operational considerations to address the identified issues effectively.

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Introduction

The main case study of this technical report is based on Toon Air, which is a small UK airline, that operates regular routes within the UK and to the several Greek Islands.

Despite its success in a niche market, increased competition from low-cost carriers has prompted the company to focus on cost reduction and efficiency improvement, particularly in purchasing and materials management.

As the new material manager, the aim is to enhance the acquisition, storage and distribution of supplies including spares and consumables. However, initial investigations reveal many challenges in the purchasing and supply chain:

1. Spares are centralised at the warehouse 30 miles from the nearest airport, causing delays in obtaining parts for on-site maintenance and destination airports.
2. High Inventory investments, which can involve high risks due to continuous design changes and aircraft regulation.
3. Inventory management issues, with parts issued in kit form for maintenance routines, but lead times and demand patterns often lead to stockouts of key components.
4. The engineer bypasses the purchasing department and orders parts directly from suppliers, as they have a better knowledge of the parts required
5. Lack of purchasing orders, leading to unclear terms and conditions with a lack of differentiation between high and low-value orders.

Effectively managing inventory structure

Effectively managing inventory structure is vital for a small business like Toon Air, especially when dealing with high competition and abnormal cost efficiency. While inventories provide stability by balancing supply and demand fluctuations, they also entail costs such as excessive capital and administrative overheads, alongside the need for enormous space. Moreover, they can reveal operational issues and carry risks like deterioration over time. Despite these challenges, inventories serve critical functions such as ensuring availability during uncertain demand periods and compensating for inflexible operations. However, Toon Air's extensive inventory holdings hint at potential inefficiencies and financial resource wastage. By implementing astute inventory management practices, Toon Air can reduce excess inventory, and save a bit more capital for more productive uses like fleet modernization (Laura, 2019).

Another crucial consideration is maximizing aircraft utilization, as delayed parts procurement can result in lost revenue due to idle aircraft. Ensuring timely availability of essential parts enables Toon Air to minimize downtime and optimize revenue and operational efficiency. Planned downtime refers to intentional halts in production activities for reasons like preventive maintenance or improvement projects, while planned operation time is the designated duration for production processes as determined by management (Subramaniam, et al., 2008). In addition, implementing machine learning algorithms can provide real-time visibility into inventory levels, allowing for more accurate demand forecasting and proactive replenishment strategies (Nguyen, 2024).

Question 1

It is important to understand that (Kilpi, 2008):

QT1. “Aircraft line maintenance has to be performed where the plane lands because it primarily takes place between revenue flights during the plane’s natural downtime”(Kilpi,2008,p.20).

The main aspect that the supply of spares to the end user can be improved is the correctly reclining materials, for instance, Engines, landing gear avionics and other electric components. Environmental regulations are subject to change, and staying compliant requires continuous monitoring and adaptation. Figure 1 shows the main model used by the Aircraft Fleet Recycling Association (AFRA) which consists of 40 companies dedicated to offering environmentally sustainable solutions preservation, resale, and reintroduction of dependable aeroplanes into service. Additionally, AFRA provides services for safe part recovery, scrapping, and recycling of aircraft that are deemed unfit for service return (Keivanpour, et al., 2013).

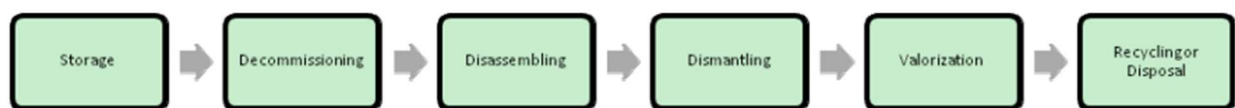


Figure 1. The main framework end-of-use in an aircraft (Keivanpour, Ait-Kadi, & Mascle, 2013,p.77)

Currently, many airline reservation systems have transitioned to catering to specific customers with real-time and online queries, rather than relying solely on predetermined plans. Toon Air, like many airlines, faces the challenge of balancing demand fulfilment with minimizing excess stock. To address this, the company must determine optimal inventory levels for each item, considering the costs associated with stockouts versus holding inventory (Feng & Xiao, 2001). Moreover, lead time plays a crucial role in logistic management. Following the principles of Just-in-time production, reducing lead times can enhance productivity and boost the company's competitive position. Long lead times, particularly in the face of uncertain customer demand, pose significant risks of stockouts. To effectively manage lead times, Toon Air should foster close collaboration with suppliers to streamline logistics and supply chain management practices, thereby improving responsiveness and reducing reliance on excess inventory (Glock, 2012).

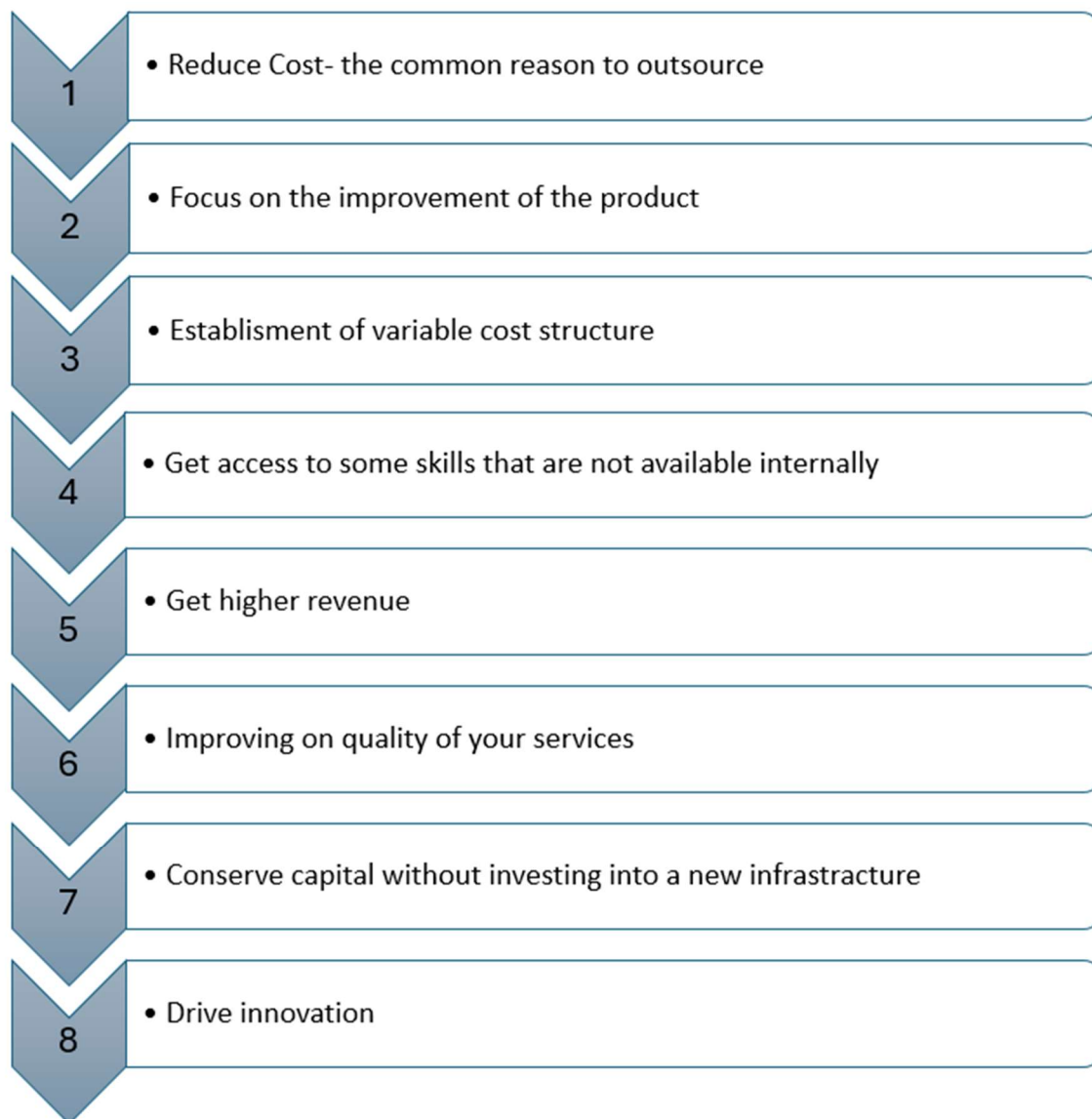
Current issues revealed in Toor Air includes:

1. Delaying in acquiring spare parts due to the distance of 30 miles to the closest airport, dealing with downtime and reduced operational efficiency.
2. Excessive inventory investment, resulting in significant investment and regulatory changes along with design improvements.
3. Parts are often ordered in kits for specific maintenance routines, leading to challenges in maintaining optimal stock levels and meeting demand fluctuations.
4. Engineers order directly from the purchasing department directly from suppliers, leading to inconsistencies in procurement processes and potential issues with compliance and cost control.
5. Lack of Purchase Order Documentation: Many high-value items are ordered without purchase orders.
6. Centralised storage of spares at a distant warehouse results in delays in obtaining parts at destination airports, leading to idle aircraft and lost revenue opportunities.

Question 2: Outsourcing

The Outsourcing has led to a reduction in operational cost and capital investment, while simultaneously improve product and service quality, further, Table 1 illustrates the main 8 benefits of a outsourcing in an aircraft industry (Durmaz & Adiller, 2010).

Table 1. Main benefits of outsourcing (Durmaz & Adiller, 2010)



Outsourcing in the context of Toon Air involves contracting external service providers to manage the parts warehouse and supply functions. This decision is significant due to the challenges posed by the distant warehouse location, which leads to delays in obtaining spares at destination airports. Outsourcing can potentially address these challenges by leveraging the expertise and resources of third-party providers to streamline inventory management and

improve supply chain efficiency. For large airlines with extensive fleets, outsourcing may be justified as they have the resources to establish multi-level maintenance capabilities. However, smaller airlines like Toon Air, with limited capital and a smaller fleet, may find it more practical to outsource maintenance requirements. Furthermore, heavy maintenance will require a substantial investment in facilities and equipment which is commonly outsourced by airlines. In the United States, 71% of heavy maintenance is outsourced, with engine maintenance as one of the fastest-growing segments of the maintenance and repair and overhaul (MRO) industry (McFadden & Worrells, 2012).

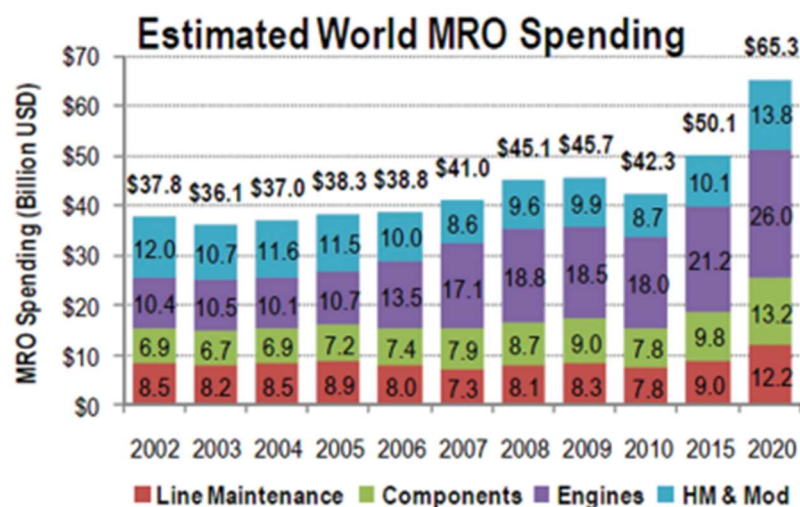


Figure 2. Estimated expenditure world form the MRO ((McFadden & Worrells, 2012,(Kilpi, 2008,p.19).

Figure 2 illustrates the MRO phases to third-party service providers, as noted in the global MRO revenue range of \$25 to \$30 billion. While recent economic conditions have led to lower short-term estimates of MRO demand, long-term growth is projected at 4.3% through 2018. From 2002 to 2010, the average spending on MRO was approximately \$340.2 billion (McFadden & Worrells, 2012). Outsourcing MRO phases can be costly if conducted in-house due to labour expenses, particularly when sourced from foreign nations (Olaganathan, et al., 2020). Additionally, the importance of the service level agreement (SLA) is highlighted in Table 2, emphasizing its crucial role in facilitating clear communication and expectations between outsourcing parties. Prioritizing the development of such an agreement, structured as both a contract and an SLA, is essential for ensuring efficient coordination and reducing delays in spare parts procurement and actions (Subramaniam, et al., 2008) .

Table 2. *The major importance of a Service level agreement (SVLAs) (Sakburanapech, 2008,p.56)*

Contract	Service Level Agreement or Annex
• Service definition • Provisions of service • Charges and payment • Warranties and correction of defects • Contract change control procedures • Intellectual property rights • Liability • Change of law • Insurance of policies • Confidentiality • Force majeure • Termination • Consequence of termination • Law • Jurisdiction • Dispute resolution procedure	• Baseline and additional services • Representatives • Contacting points • Procedures of problem escalation and problem solving • Service delivery process • Performance measurement • Incentives and penalties

Figure 3 illustrates the key performance indicators in the MRO providers, key performance indicators, service definition, service expectation and regular communication. However, the most important are defined contracts/agreements lead at 84% and key performance indicators to be at 67% (Sakburanapech, 2008).

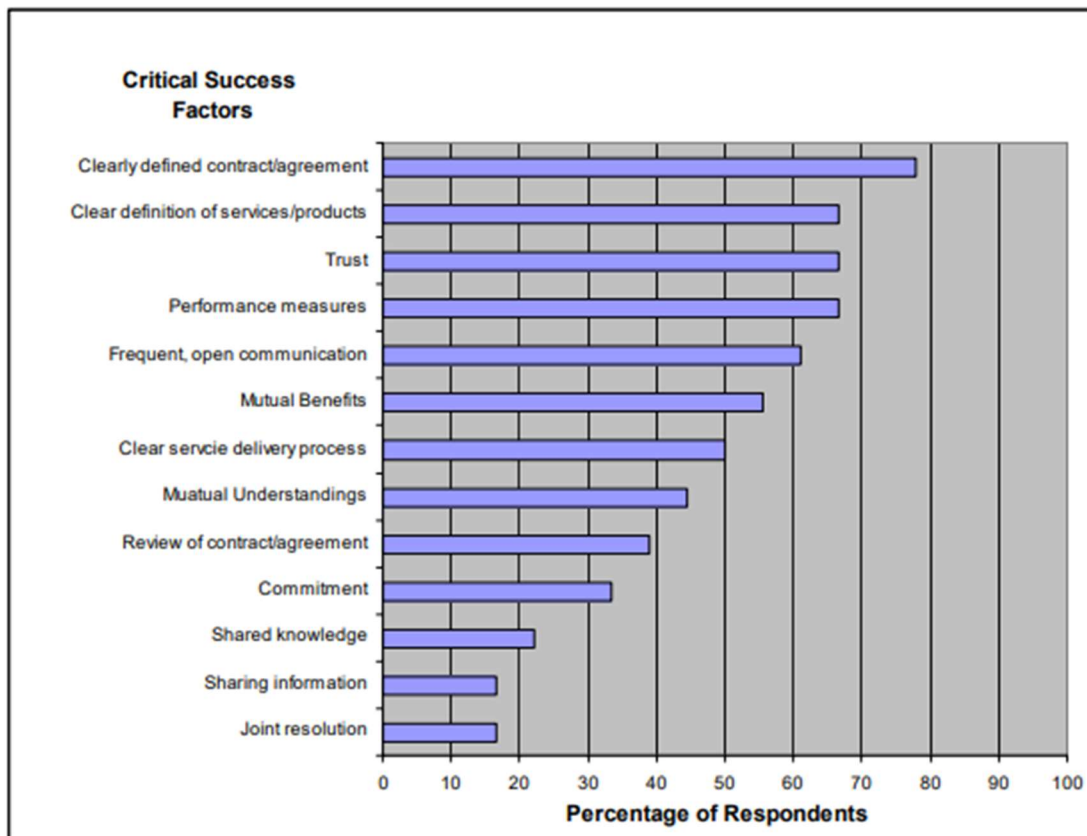


Figure 3. The percentage of the 5 most important factors of the SLAs (Paduano, 2001, p.65)

Along with the implementation of inventory optimization techniques such as the Activity Based Costing (ABC) analysis, which can utilize forecasting models and demand planning tools to better anticipate spare parts demand and adjust inventory levels accordingly. ABC analysis is particularly valuable as it provides insights into the cost drivers associated with various activities involved in product manufacturing. Figure 4 shows the ABC model where the manager can easily identify activities that are cost-effective more than anticipated. By delving into these activities, they can uncover the reasons behind the higher costs and take action to reduce them (Paduano, 2001).

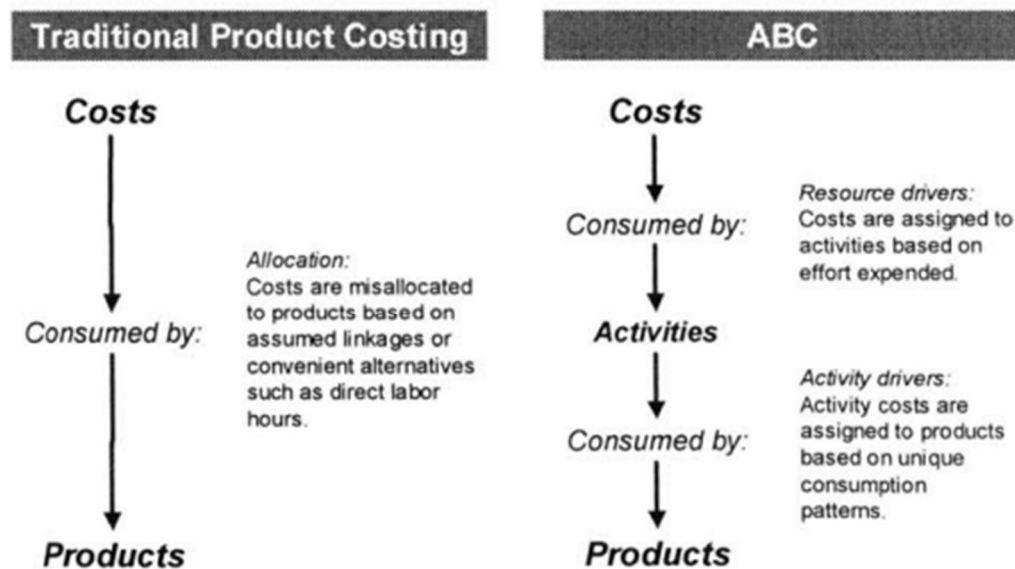


Figure 4. Normal product costing against the ABC strategy (Paduano, 2001,p.18)

In the view of Rosember cited in Al-kaabi, Potter, & Naim, 2007, the trend of outsourcing will rise by 65% in the MRO system. Although, outsourcing offers potential benefits, such as reduced operations costs and capital investment, maintaining the best quality is fundamental for an aircraft company. For Toon Air, delegating parts procurement, storage, and distribution to a third party can leverage specialized expertise and potentially reduce operational costs. However, outsourcing is not without risks, as it may lead to supplier dependencies and price increases, or loss of critical capabilities in the short term (Al-kaabi, et al., 2007). Ensuring quality control and strict adherence to maintenance standards and regulatory requirements is essential for aircraft safety and reliability. Challenges such as limited internet access and unreliable communication facilities in some MROs can impact operations. Language barriers may also hinder effective communication between Toon Air and outsourcing partners.

Establishing clear communication channels is essential for smooth information flow, where establishing a good connection with suppliers can avoid the dissemination of information (Rasheed & Manarvi, 2008). Effective communication between Toon Air and outsourcing partners, particularly regarding MRO activities, is crucial for ensuring timely parts availability and optimal performance, in line with FAA regulations English proficiency is mandatory for supervisors employed at foreign MROs (Olaganathan, et al., 2020).

Performance Measurement

In the context of aircraft Maintenance, Repair, and Overhaul (MRO), performance measurement is crucial for operational efficiency and financial viability. The Key Performance Indicators (KPIs) can be used to measure both operational and financial values.

The main objective of the KPIs is to track the downtime of the aircraft, where tracking maintenance related to the downtime is crucial for maximizing revenue by swiftly addressing issues and minimising the disruptions to flight schedules (Goossens, et al., 2011). Meanwhile having an efficient Mean Time Between Failures (MTBF) can provide insight into aircraft reliability, guiding procurement decisions and optimizing inventory management strategies based on the CMMS data.

However, Piechnicki, Dos Santos, Loures, and Dos Santos cited in Karar (2023), proposed that to track the cost measures, the matrix performance and the risk assessment metrics to audit and track the results, the Reliability-Centred Maintenance can be implemented (Karar, 2023). Regarding service quality, the MRO accuracy upholds safety standards and prevents reworks, which are crucial for minimizing operational risks. Moreover, having an Effective Procurement Management performance is vital for an aircraft maintenance enterprise due to the intricate nature of high maintenance and specific items.

Failure to do so could result in increased operational costs and lengthy lead times. Quantifying outsourcing benefits justifies decisions and ensures overall cost-effectiveness (Ng, et al., 2015). In addition, special attention will be given, as mentioned before, to the service quality and along with managing customer expectations and experiences. Despite challenges such as rising fuel costs, companies in the aviation sector must prioritize enhancing services and refining customer management practices. While fuel prices may remain beyond carriers' control, they have opportunities to optimize their operations and ensure alignment with operational objectives to maximize benefits while prioritizing passenger safety and satisfaction (Tolpa, 2012).

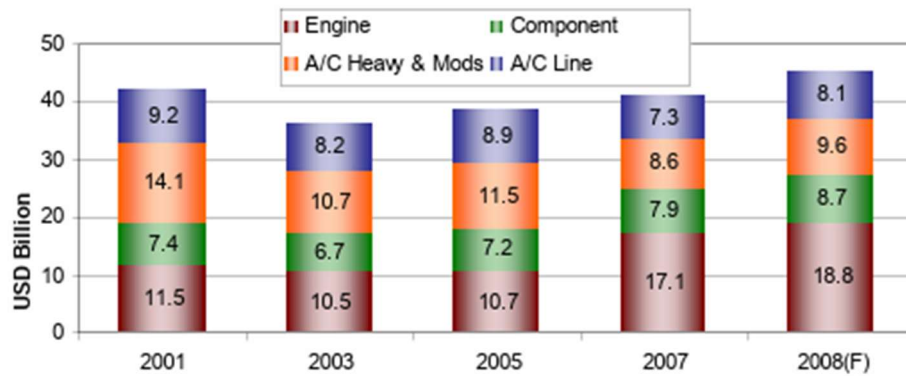


Figure 5. Trend of the Market Value MRO Worldwide (Kilpi, 2008,p.19)

Figure 5 provides insight into the composition and distribution of value within the MRO market as of 2006. The breakdown of labour and supplementary costs is derived from an analysis conducted by Aerostrategy Consultancy. The data reveals that engine-related tasks are primarily material-intensive, whereas aircraft-related tasks rely more heavily on labour. Parts requiring repair can be categorized into materials, labour, and part repair of sub-assemblies, with a distribution corresponding to the component worked on (Kilpi, 2008).

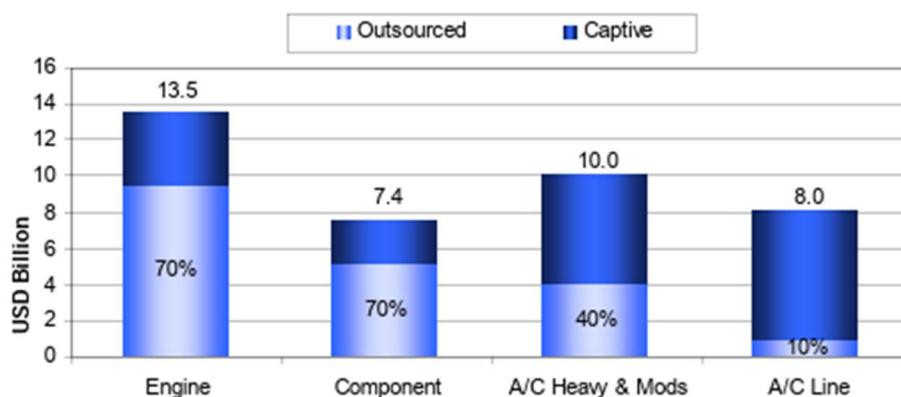


Figure 6. MRO outsourcing in 2006 (Kilpi, 2008,(p.20))

In 2006 the commercial airlines outsourced USD 19.5 billion of MRO services, that has been considered the 50% of the MRO market value. Figure 6 shows that on average the materials outsourced included (Kilpi, 2008):

- 70% of engine and component worked
- 40 % of the airframe
- 10% of line maintenance worked.

In the view of Aero Strategy consultancy, the share of the MRO increased to 65% in 2016. Therefore, that will establish that the trend of outsourcing will increase followed by the MRO service (Kilpi, 2008).

Question 3

Assessing the performance measures for outsourcing the aircraft parts warehouse of Toon Air is crucial for ensuring successful operations in an expanded global economy. With the sourcing and procurement processes becoming increasingly complex, robust performance measures are essential (Okeyo & Kabare, 2019). Traditionally, inventory was purchased in advance or on an as-needed basis, but the latter option often leads to extended lead times and higher expenses, particularly for rush orders and logistics arrangements, especially for Aircraft on Ground (AOG) situations (Temesgen, 2017).

Lead time for stock requirements

It is important to understand that:

QT2. *“Due to special engineering requirements, processes, and materials, the lead time for many of the parts can be several months resulting in a long aircraft lead time”*(Marsh,2014(p.3)).

If the lead time of aircraft increases, the manufacturer has to forecast further into the future, leading to more uncertainty. Therefore, cutting the lead times becomes more crucial for better forecasting. Also, shorter lead time will bring added benefits such as improved production flexibility, lower inventory costs and reduced work in progress.

Therefore, monitor the inventory availability of critical parts at destination airports to support maintenance activities and evaluate lead times for replenishing stock to ensure timely access to parts and minimize aircraft downtime is fundamental (Marsh, 2014).

Another important aspect is managing inventory obsolescence. As aircraft approach the End-of-Life (EOL) phase, managing spare parts becomes complex and costly. Maintaining end-of-life inventory below 5% of the total inventory value is a key target. Regularly reviewing inventory to identify parts nearing obsolescence, negotiating flexible return policies with suppliers, and implementing proactive measures to phase out end-of-life parts are essential actions (Hur, et al., 2018).

The main action plan is to regularly review inventory to identify parts nearing obsolescence, negotiate flexible return policies with suppliers and implement proactive measures to phase out end-of-life parts from inventory.

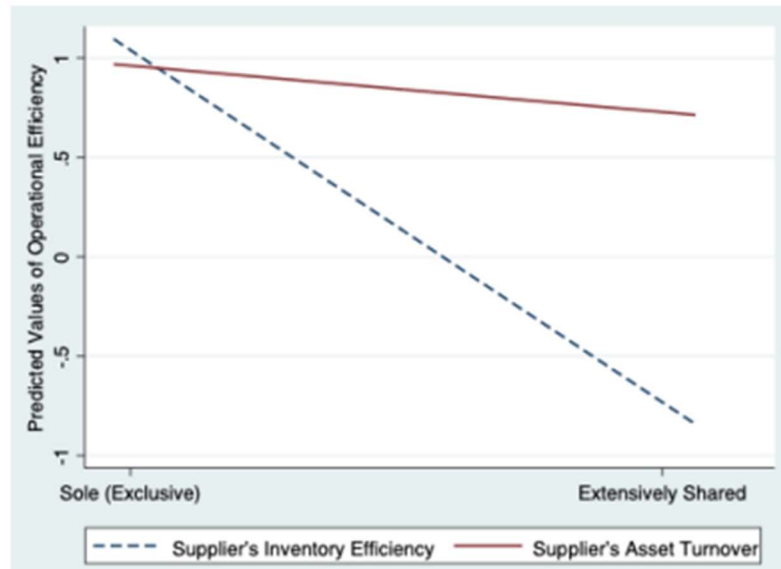


Figure 7. Operational efficiency (Schmelzle & Mukandwal, 2023, p.24)

Figure 7 illustrates the adverse impact of a supplier extensively shared configuration on inventory efficiency, which is significantly more pronounced compared to its effect on asset turnover. However, the data indicate that a supplier's less-shared relationship configuration is associated with enhanced operational efficiency in both inventory efficiency and asset turnover (Schmelzle & Mukandwal, 2023).

The main action plan: It is fundamental to regularly evaluate supplier performance, provide feedback and establish service level agreements to ensure timely communication and delivery.

Moreover, a strategic Network Sub- Model will need to be included in Toon Air to improve its supply chain efficiency as illustrated in the model in Figure 8.

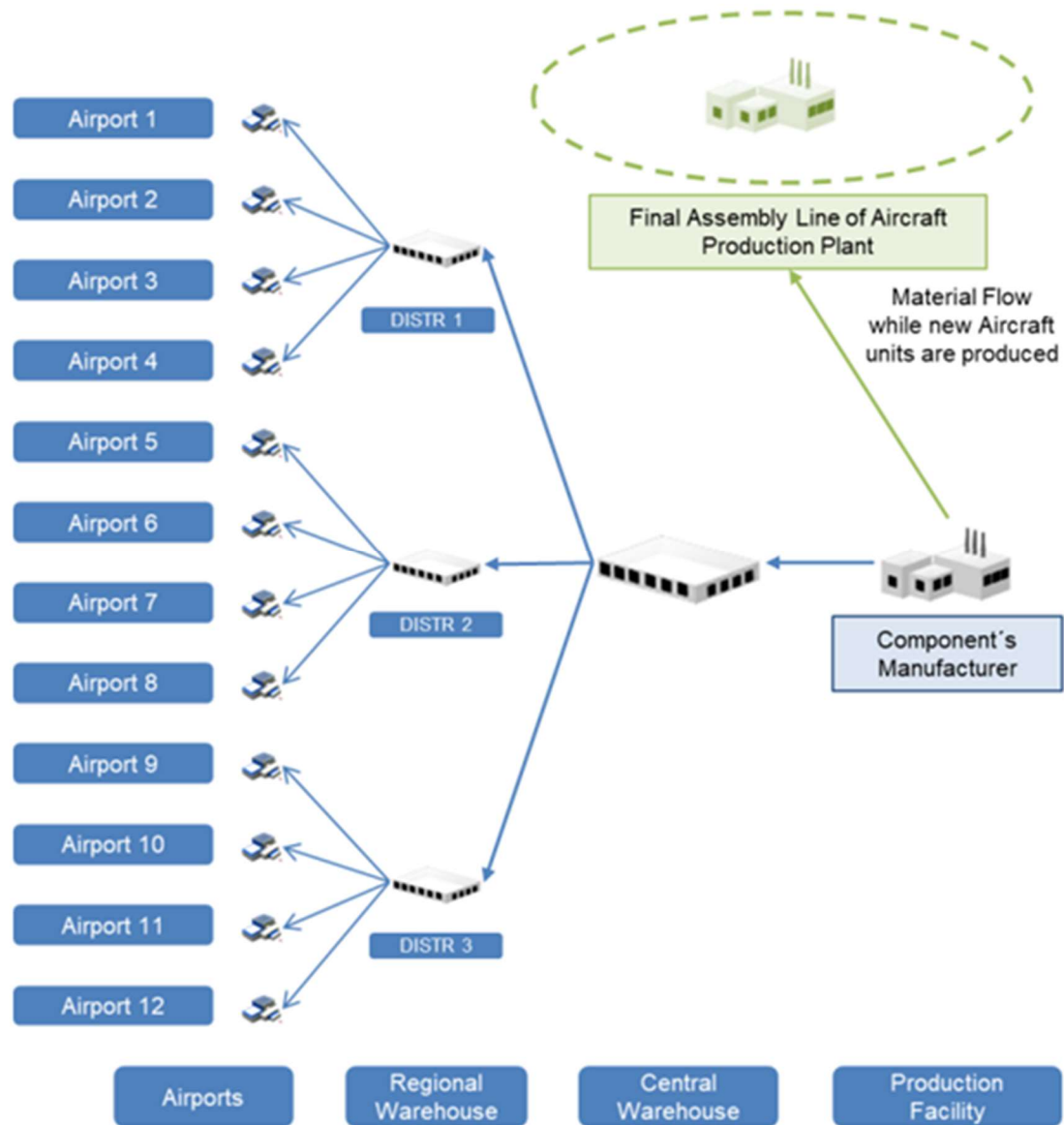


Figure 8. Distribution of Network sub model (Gallego-García, Gejo-García, & García-García, 2021,p.14)

Therefore, to tackle the challenges effectively, Toon Air can integrate the network sub-model as follow (Gallego-García, et al., 2021):

1. **Transportation planning:** Development of a transportation plan to optimise goods movement from central warehouse. This involves identifying cost-effective transportation modes and routes, minimizing transit times, and reducing delays.
2. **Inventory Management:** Use the Network sub-model to optimize inventory levels across different locations. Set up central and satellite hubs strategically, analyse demand patterns, and conduct regular audits to optimize stock levels and identify redundant parts.

3. **Demand Forecasting and Stock Optimization:** Implement advanced forecasting techniques to predict spare parts demand accurately. Develop predictive models integrating historical data and operational insights to enable proactive stock replenishment and minimize idle aircraft time.
4. **Procurement Standardization:** Standardize procurement processes by centralizing functions and implementing clear guidelines. Enforce the use of purchase orders, conduct audits, and ensure compliance with procurement policies to streamline the ordering process.
5. **Documentation and Compliance:** Enhance documentation practices to maintain transparency and accountability. Maintain accurate records of procurement activities to mitigate compliance risks and ensure adherence to regulatory requirements.
6. **Warehousing Optimization:** Optimize warehouse locations closer to airports to reduce lead times and improve spare parts availability. Conduct network analysis to identify optimal storage facilities and leverage third-party logistics providers if needed.

Recommendations

The recommendations for this report are based on short term (0-6 months), medium Term (6-12 months) and long term (6-12 months).

Short-term (0-6 months)

Human considerations

Collaborate with outsourcing partners to streamline spare parts acquisition processes, emphasizing the importance of clear communication and collaboration. Provide necessary training and support to ensure smooth integration of new protocols and procedures. Additionally, consider partnering with organizations like the Aircraft Fleet Recycling Association (AFRA) to explore environmentally responsible options for spare parts acquisition and disposal, aligning with the company's sustainability objectives.

Financial considerations

Negotiate partnership agreements with outsourcing partners, focusing on service level agreements (SLAs), pricing structures, and delivery schedules to optimize cost-efficiency.

Operational considerations

Ensure that partnership agreements include provisions for regular communication, performance monitoring, and dispute resolution mechanisms to address any operational challenges quickly.

Medium-term (6-12 months)

Human considerations

It is vital to develop comprehensive training programs to ensure that the staff will be covering the importance of the ABC analysis and KPI tracking process.

Collaboration will be another key to ensuring alignment and sharing of insights for effective implementation.

Financial considerations

Integrating the MRO analysis along with the ABC and the KPI implementation is fundamental for efficient spare part management to control the finances of the company.

Therefore using an effective ABC methodology leads to having a better forecasting model and demand planning and extensively reduces inventory costs. The beauty of the ABC model is the cost-effectiveness which can identify the reductions of high costs and excel tool on problem solving.

Operational considerations

In the operational Identifying and mitigating operational risks is crucial to prevent disruptions of spare parts management which involves a risk assessment to identify potential issues such a stockouts or delays. Importantly, implement a strong KPIs system, and conduct a regular performance review to prevent downtime and minimize disruption during the flight schedule.

Long term (12 +months)

Human considerations

Provide an ongoing training and development programs to ensure employees are prepared for new process technology and explain the benefits of long-term initiatives effectively.

Financial considerations

Develop an investment strategy and the integration of support long-term initiatives integrating the network sub-models.

Operational considerations

To optimize and address the challenge sustained in the aviation industry and Toon Air a British company, the integration of network sub-model will be included as follows:

1. With an effective transportation planning using the network sub model as illustrated in Figure 7, which will be able to optimize goods movements from the central warehouse. This includes identifying cost-effective transportation modes and routes, minimizing transit times, and reducing delays.
2. Along with an excellent Inventory Management establish central and satellite hubs strategically, analyse demand patterns, and conduct regular audits to optimize stock levels and identify redundant parts.

3. Developing a predictive model which integrates historical data to enable proactive stock and minimize aircraft downtime.
4. Establish a centralized procurement system where all procurement requests, including those from engineers, are directed through a designated department or platform. By centralizing procurement and standardizing procedures, Toon Air can enhance consistency, compliance, and cost control, leading to improved operational efficiency.
5. Maintaining accurate record of the procurement activities to mitigate compliance risks and ensure that meet the regulatory requirements.
6. Warehouse optimization to optimize a warehouse location closer to the airports to reduce lead time and enhance spare parts availability. Monitor KPIs such as lead times, inventory turnover, and transportation costs to assess the effectiveness of the optimized warehouse network.

Despite the challenges faced by the Toon Air aircraft company, this report highlights that with a well-defined plan and precise execution, the company can overcome these obstacles. To conclude, by addressing this key challenge and leading with analytics tools, Toon Air can streamline spare parts management, reduce lead times, and improve overall supply chain performance. Consequently, the firm will be strategically positioned to achieve sustained competitiveness in the dynamic aviation industry.

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