International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Integrating 3D Printing Technology into the MRO Supply Chain in the Aviation Industry

Khalifa Alshaiba

Abstract: ***The following study will identify and analyze the challenges associated with integrating 3D printing technology into the MRO supply chain in the aviation industry, ultimately providing insights and recommendations for effective implementation. Maintenance, repair, and operations (MRO) items are part of the supply chain, MRO includes all maintenance parts used for repairs and support of production. It is basically includes all activities associates to maintenance that ensures the safety and smooth process of an aircraft. Managing the MRO in any company is very important to keep the supply chain running smoothly and without interruptions that may lead to increase in cost and effect the company. MRO supplies are essential for maintaining and repairing aircraft and ensuring the safety of air travel. The growth of MRO supplies in the aviation sector has been significant, and the industry is constantly looking for ways to improve efficiency and reduce costs. One of the ways the industry is exploring is the use of 3D printing technology in MRO. This paper discusses how 3D printing can impact forecasting and demand management practices, and how it can prepare the supply chain for future challenges such as pandemics. However, implementing 3D printing technology in the aviation industry presents significant challenges that must be addressed. The paper highlights these challenges and proposes potential solutions. Overall, the use of 3D printing technology in MRO has the potential to evolve in the aviation sector with respect to the supply chain management practices.***

Keywords: 3D printing Aviation MRO Supply Chain Management Challanges supply Distribution Transportation Facilities Information Sourcing Pricing

Figure 1: MRO in Aviation Industry

1. Introduction

A supply chain includes all parties who are directly or indirectly involved in fulfilling a consumer request. Not only does the supply chain involve the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers. The supply chain encompasses all functions involved in receiving and fulfilling a customer request inside each firm, such as a manufacturer. New product creation, marketing, operations, distribution, financing, and customer support are examples of these functions. A typical supply chain include:

Figure 2: Supply Chain Network

MRO stands for maintenance, repair, and operations.MRO supplies refer to the tools, equipment, and materials used to support maintenance, repair, and operations activities in various industries. These supplies can include things like replacement parts, tools, lubricants, cleaning supplies, safety equipment, and other consumables needed to keep equipment and facilities running smoothly. MRO supplies are essential to the upkeep of industrial machinery and equipment, and they are typically purchased and managed by maintenance departments or facility management teams.

These supplies are necessary for keeping machinery and equipment in good working condition, preventing breakdowns, and ensuring optimal performance. Some uses of MRO supplies include:

- **Maintenance and repair of machinery and equipment:** MRO supplies such as replacement parts, lubricants, and cleaning supplies are used to maintain and repair machinery and equipment, which helps to extend their lifespan and prevent costly breakdowns.
- **Facility maintenance:** MRO supplies such as cleaning supplies, safety equipment, and building maintenance supplies are used to keep facilities clean, safe, and in good condition.
- **Operational support:** MRO supplies such as office supplies, warehouse equipment, and packaging materials are used to support daily operations in industries such as manufacturing, logistics, and distribution.

Overall, MRO supplies are essential for the proper functioning of various industries, and they play a critical role in ensuring that machinery, equipment, and facilities are well-maintained, safe, and efficient.

MRO growth in aviation sector

The growth of this industry is driven by several factors, including an increase in air travel, the aging aircraft fleet, and a greater focus on cost-effective and efficient maintenance practices.Another factor contributing to the growth of the MRO supplies industry is the aging aircraft fleet. As many aircraft reach the end of their useful lives, they require more maintenance and repair work to keep them in operation. This has led to a significant demand for MRO supplies to support these aging aircraft.

Supply Chain Management and 3D printing in MRO Of Aviation Industry

Our chosen supply chain network drivers related to MRO aviation industry and 3D printing are

Facilities, Inventory, and Information

Inventory management

Is a critical component of the MRO process. It involves effective inventory management that result in a balance between maintaining necessary stock level of spare parts while minimizing the cost. To ensure the day by day operation and smooth process the aviation industry rely heavily on just in time production (JIT) that will ensure the right part will be available for MRO in the aviation industry at the right time. With 3D printing, the industry can produce aircraft parts on-demand, reducing the need for extensive inventories of spare parts.

This can help to reduce inventory carrying costs and improve inventory management practices, leading to more efficient and cost-effective operations.

The inventory management will help in the availability of parts and reduce lead time of for production of spare parts by direct printing parts that are needed for MRO which will help in decreasing the maintenance and repair time and will result in a smoother aircraft operation.

Figure 3: Inventory Management of MRO

MRO Facilities
Are very important sector of the supply chain network which offer a great responsiveness. To ensure an effective supply chain MRO facility will be located within the boundaries of the airport. Production facilities are where 3D printing takes place. These facilities typically house a range of 3D printers, each capable of producing parts of different sizes and materials.

MRO facilities to produce 3D printed spare parts on demand, can help to reduce the risk of supply chain disruptions caused by factors such as shipping delays or production interruptions.

An example can be Emirates which perform all maintenance activities outside the boundaries of the airport which can increase the time of MRO and will lead to interruption of the operation. Even for small activities such as turbine overhauling or blade functional test is done towards an external facility and this can be shortened by using facilities that serves parts on demand directly.

MRO information
Can determine which parts are suitable for 3D printing and can begin producing these parts when needed. Gathering this information will give the accurate engineering and design of MRO and will ensure an agile supply chain.

3D printing technology can have an enormous impact on the drivers of MRO aviation supply chains. Reducing lead times for spare parts, minimizing inventory costs, increasing supply chain flexibility, and increasing design flexibility. MRO providers can shorten their delivery times and reduce aircraft damage by allowing them to produce parts on demand. To enhance the functionality, reliability and safety of aircraft components, 3D printing allows advanced designs to be produced.

Figure 4: MRO In Aviation Industry (3D printed Parts)

How 3D printing impact the forecasting and demand management practices
3D printing technology would impact the forecasting and demand management practices by allowing more flexible and agile process in which allows for greater flexibility in the production process, as parts can be produced on-demand and in small quantities as needed. This can improve forecasting accuracy by allowing for more precise planning of inventory levels and reducing the risk of overproduction or stock outs.

Time series forecasting method will use historical demand to make a forecast in this industry we will adopt the push view when producing the standardized parts which are consumable and have short life span and high usage rates those components experience wear and tear(bearings, blades, and connectors) . However, pull view are implemented when demand for parts that are instantly needed and produce to avoid long lead time of repair which will affect the industry operation.

How 3D printing Prepare Supply Chain for Future Challenges in Pandemics
3D printing enables faster innovation and prototyping. This is useful during a pandemic when new products are needed immediately. It will reduce reliance on global supply chains by enabling local production. This can help to mitigate disruptions to supply chains caused by pandemics, as production can continue even if global supply chains are disrupted. It also allows customization of parts and products, which can be particularly useful in the context of pandemics.

One example is the maintenance of aircraft cabin parts which requires the production of 3D printing equipment's. As the pandemic puts more demand on health and safety measures, airlines had to quickly refurbish and upgrade their cabins to improve ventilation and reduce the risk of infection. MRO vendors could use 3D printing to quickly create custom parts such as air ducts and bulkheads that could be incorporated into aircraft cabins. This will help in a faster operation and efficient repair process.

Another example is using 3D printing to create tools and fixtures for MRO operations. As traditional suppliers face delays and shutdowns, MRO vendors can use 3D printing to create custom tools and fixtures on demand for faster maintenance and repairs.

3D printing allows for greater customization of spare parts to meet specific needs, such as fitting unique aircraft configurations or addressing specific repair needs. This can improve forecasting accuracy by providing more precise demand information and reducing the risk of waste due to overproduction of standardized parts. This will be very helpful in pandemics since asking for unique configurations may not be applicable at this time or even effect the quality of parts for maintenance purposes since the companies are forced to get standardized parts not customized.

3D printing will allow the airline industry to be more agile and responsive to changing conditions like a pandemic. Leveraging the speed and flexibility of 3D printing technology, MRO providers can rapidly manufacture the parts and tools needed to fly aircraft safely and efficiently. Lots of examples of successful organizations that took the step forward and entered the 3D printing regime which allowed them to diminish and eliminate all challenges and threats during Covid-19.

Etihad Airways Engineering, a UAE-based provider of MRO services, used 3D printing to manufacture airplane parts during the pandemic. They used his 3D prints to manufacture cabin components such as tray table latches and ventilation grilles. They are in high demand due to increased health and safety requirements.

Delta Air Lines: used 3D printing to reduce parts for aircraft interiors during the pandemic. Such as seat armrests and video monitor brackets

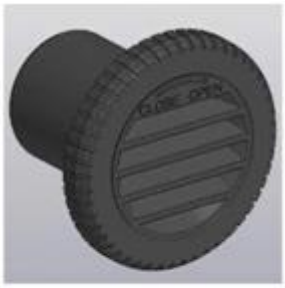

Fig 1.1 Etihad Airways Ventilation grilles

GE Aviation: Used 3D printing to produce parts for its engines during the pandemic. GE Aviation is using 3D printing to manufacture fuel nozzles. The 3D printed fuel nozzles are lighter and more durable than traditional cast nozzles.

Figure 5: Delta Airlines Monitor Brackets

Figure 6: GE Aviation

Strata Manufacturing: It is an Abu Dhabi based company, that have partnered with 3D printing company Siemens to produce aircraft interior parts using a selective laser sintering process. Strata has also 3D printed a cabin interior part for Etihad Airways using the same technology.

Representatives of Strata Manufacturing, Etihad Airways, and Siemens hold the 3D printed

Figure 1.1: Challenges in Aviation Industry

Challenges of implementing 3D printing technology in MRO Aviation Industry

1) Quality control: Inconsistencies in component quality can occur with 3D printing, affecting the dependability and durability of the parts created. For MRO applications where safety and reliability are paramount, consistent, and high-quality printing is critical.
2) Material selection: When compared to traditional production techniques, the material choices for 3D printing is restricted. It is critical to choose the proper material for the specific MRO application, and the quality of the material may have a major influence on the performance and longevity of the components.
3) Cost: The cost of 3D printing technology, including equipment, materials, and staff, can be a considerable obstacle to adoption. 3D printing may be more expensive than traditional production processes in certain circumstances.
4) Experience and knowledge: 3D printing necessitates specific knowledge and experience that may not be accessible in-house. Many firms have difficulties in investing in training and employing individuals with the requisite capabilities.
5) Intellectual property: The use of 3D printing technology raises concerns about intellectual property and copyright. There is a possibility of unlawful replication of patented parts, which might result in legal difficulties.
6) Regulatory compliance: Depending on the business and application, 3D printing may be subject to onerous regulatory compliance requirements.

2. Discussion and analysis

To conclude, the use of 3D printing technology can play a significant role in the aviation industry's MRO process, impacting inventory management, facilities, and information. 3D printing technology enables faster innovation, prototyping, customization of parts and products, and local production, mitigating disruptions to supply chains caused by pandemics. 3D printing technology can also help to reduce inventory carrying costs, shorten delivery times, and reduce aircraft damage by allowing MRO providers to produce parts on demand.

By analyzing the three main drivers that has been chosen, it can be clearly observed that 3D printing can improve inventory management practices by reducing inventory

carrying costs and improving the availability of spare parts. It can also decrease maintenance and repair time, resulting in smoother aircraft operations. Moreover, 3D printing technology can impact the forecasting and demand management practices of the industry by allowing for more precise planning of inventory levels and reducing the risk of overproduction or stock outs.

Figure 7: Emirates Aviation MRO

Finally, it was highlighted how 3D printing can prepare the supply chain for future challenges, particularly pandemics, by enabling faster innovation and prototyping, reducing reliance on global supply chains, and allowing customization of parts and products.

In a fast moving and continuous changing world, it can be observed clearly how different MRO vendors could use 3D printing to create custom parts for aircraft cabins, tools, and fixtures on demand for faster maintenance and repairs.

Overall and despite the challenges, the potential of 3D printing technology in the MRO aviation industry is numerous, particularly in terms of reducing costs, increasing efficiency, and preparing the industry for future challenges.

References

[1] ThomasNet. (2022, April 11). What Is MRO? Retrieved from https://www.thomasnet.com/articles/plant-facility-equipment/what-is-mro/
[2] Bertoni, M. (2020, September 15). How 3D Printing Is Helping Airlines Keep Their Planes Clean During Covid. Forbes. Retrieved fromhttps://www.forbes.com/sites/airbus/2014/07/15/how-adding-a-new-dimension-to-airplanes-is-delivering-parts-on-demand/?sh=1b7971923d55
[3] GE Additive. (2021, March 29). New Manufacturing Milestone: 30,000 Additive Fuel Nozzles. GE Additive Stories. https://www.ge.com/additive/stories/new-manufacturing-milestone-30000-additive-fuel-nozzles
[4] Kaufman, M. (2017, May 17). Etihad Airways displays first 3D printed parts for plane interiors from Strata Manufacturing and Siemens. 3D Printing Industry. Retrieved from https://3dprintingindustry.com/news/etihad-airways-displays-first-3d-printed-parts-plane-interiors-strata-manufacturing-siemens-109577/
[5] Bogaisky, J. (2020, April 21). 3D printing in the time of coronavirus. Aviation Week Network. https://aviationweek.com/mro/3d-printing-time-coronavirus.
[6] Goudarzi, V., & Wang, T. (2020). Challenges of Implementing 3D Printing Technology in MRO Aviation Industry. International Journal of Aerospace Engineering, 2020, 1-8. doi: 10.1155/2020/9123270
[7] Viktoria Grokhovskaya Aviation Consultant at VD Gulf Viktoria Grokhovskaya is an independent aviation expert currently working within the aircraft maintenance. (2022, December 5). MRO supply chain challenges in aviation industry. The Network Effect. Retrieved April 15, 2023, from https://supplychainbeyond.com/5-mro-supply-chain-challenges-in-aviation/
[8] Lutkevich, B. (2021, June 2). What is a supply chain? - definition, models and best practices. WhatIs.com. Retrieved April 15, 2023, from https://www.techtarget.com/whatis/definition/supply-chain