



AIRCRAFT LOGISTICS USING BLOCK CHAIN

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Abstract

It is just as important to maintain the aircraft's reliability as it is to serve customers. The other equation to the above is providing better service to customers than competitors, and to do so the supply chain management (SCM) department of many organizations are taking advantage of the new technologies such as Block Chain and Big Data analytics. These technologies are allowing SCM teams to develop and provide complex supply chain products and services with incredible speed and reliability. As the aviation industry is spreading its wings wider, and all the required parts of the aircraft comes with specifications, parameters, and numerous number of manufacturers- it is the MRO & SCM's responsibility to deal with the network of supply chains for spare parts, purchase them and deliver them. This complex data driven approach is done by building supply chain network models. Block Chain is all about decentralized system and in this paper we are analyzing the necessity, advantage, disadvantage of having a decentralized system based on distributed data driven application. The analysis is done through proposing a model block chain that will not only assist in maintaining inventory of the aircraft's parts but also to monitor the performance and the usage of the parts leading to a transparent network of supply chain for aircraft parts and reduction in Counterfeiting.

Key Words – Aircraft Logistics, Maintenance, Repairs and Overhaul (MRO), Supply Chain management, Counterfeit, Block chain.

Introduction

Supply chain management can be called as the pillars of the industrial sector. This is mainly due to the fact that the final product that is produced by one unit becomes the raw material for the other. Numerous organizations across the globe act as the manufacturing unit that utilizes the parts manufactured by other industry. This movement of parts is done with the help of various supply chain networks which help one producer accumulate all the required products before they assemble them to create a new one. In light to the above, we can say that aviation industry is an optimal model for this perplexed process.

Since the publication of Block Chain by Satoshi Nakamoto in 2008, this technology has drawn a lot of attention. Block Chain gets its glory from crypto currency, but it is more than that. Block chain is a shared electronic ledger for digital data records that are managed by a number of participants of a distributed peer-to-peer network without the initial requirement of confidence among the members. This means that any transaction between 2 parties can be done with complete trust without the help of a mediator. Smart Contracts use this feature to enable the secure and automatic execution of program code between parties.

SCM up gradation has to promise better reliability on the data and data management. It should be able to provide the industry highly efficient reliable system that can not only source data but also can store and integrate the data precisely. Keeping the above said in mind, we are able to see that SCM managers are now heading towards integration on Block chain technology in Supply chain management.

Aviation industry is a complex industry that utilizes various spare parts or aircraft body. These are not manufactured by one manufacturer nor dealt by one single market. All the required parts are imported from various suppliers, manufacturers, documented and then assembled. Assembly is mainly taken care by the individual airline's MRO or OEM's (Original equipment manufacturer). These above said functional areas adopt a concept of Multi-level supply network chain to source the spare parts. Though these multi – level supply network chain is regulated by the international regulator and monitored by the company officials, there are high chances that bad quality replica, first copy replica, decommissioned parts or different design products can be



sold. The supply chain is not independent but is interconnected and the manufacturers are interdependent. There is always a certain level of pre requisites that needs to be fulfilled by the spare part producer before his product become worth the next level. However, this can be skipped by many segment producers fearing delay in obtaining final products, returns or rejections. This becomes the underlying issues of the aircraft supply network systems.

The old school supply chain management only provides great results when the data is small and the networks are limited. However, as the data and networks increase, so does the complexity of the problem. The problem in the aircraft spare parts is the amount of spare parts that are used by the MRO and numerous manufacturers for the same who are spread across the globe. In this scenario if the SCM process is not backed by advanced technology it might lead to purchasing counterfeit products which might compromise the reliability of the aircraft. If not, delay in purchases which might incur loss to the organization due to delay in maintenance.

Literature Review

In the recent past a lot of research has been done on Block chain integrated SCM. This concept came into picture when in 2008, Satoshi Nakamoto published his study on “Bitcoin: A Peer-to-Peer Electronic Cash System”, in which a peer-to-peer (P2P) electronic cash system was suggested with the help on Block Chain (Nakamoto, 2008). Though the application of block chain started in Crypto currencies, the trend is moving towards analyzing application of block chain in non-financial sectors such as e commerce and its impact is being measured ((Allen et al., 2019; Hald&Kinra, 2019; Juma et al., 2019). (Jiang &Ke, 2019) In his paper explains how SCM is a complex problem to certain category industries and how Block Chain can change the face of information flow and retention and collaboration between suppliers and buyers. (Zhang &Guin, 2020) suggests how this technology can be used in tracking the products and reducing counterfeiting. (Wang et al.(2019)) has also conducted an extensive research on the application of block chain in food traceability and visibility.

Statement of the problem

Despite all the research that has been conducted before we do not see any concrete research done on the aviation industry and its supply chain management. This paper emphasizes on understanding the importance, impact of Block Chain with references to its application in SCM of Aircraft Logistics. Though Block Chain has been viewed as a positive change and some specific systems design has been introduced in some industries, we have not come across any Block Chain integrated SCM for Aircraft logistics. Hence in this paper we will be proposing a model block chain for aviation logistics that will not only assist in maintaining inventory of the aircraft's parts but also to monitor the performance and the usage of the parts.

Objectives

- To understand the application of Block Chain In SCM
- To understand the MRO & OEM's role in the SCM of Aircraft logistics
- To build a conceptual model of block chain integrated SCM for aircraft logistics
- To understand the pros & cons of the model and the integration of such model in aircraft logistics.

Methodology

A conceptual model is built to understand the impact of the Block Chain intergraded SCM in Aircraft logistics management and what would be the issues in the same.

Limitations

- This study is a conceptual study of the integration of Block Chain technology in SCM.
- As all integrated systems are to be tagged as permissible and permissioned systems, the model constructed in this paper needs to be further researched with quantitative data.
- The time that was available to do the research was limited.



Concept and Conceptual Model of Block Chain integrated SCM in Aircraft Logistics
Current Status of Block Chain Technology

The original purpose of creating a Block Chain was to support transactions between different users who are not a part of a centralized network, yet complete the transaction directly and securely avoiding the requirement of an intermediary. Block Chain technology is not a single system but a combination of various technologies which integrates components such as peer-to-peer technology, asymmetric cryptography, digital signature etc. The below figure shows an abstract of the Block Chain data structure.

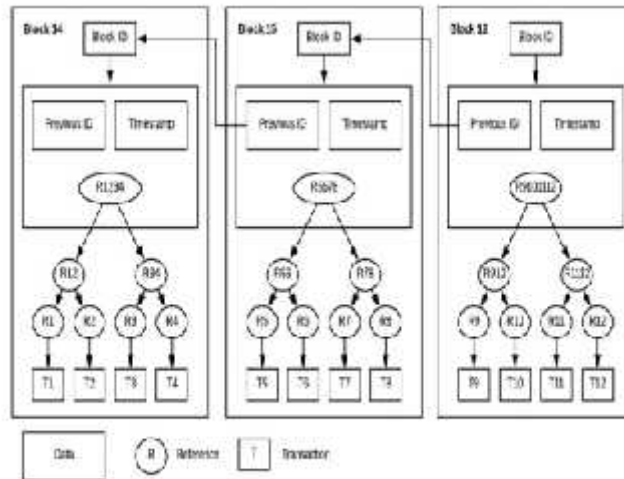


Figure 1: Abstract from a Blockchain data structure

The above data structure links two different parties who are entering into a transaction effectively and in a manner that can be verified. Transactions are linked by so-called hash references inside of a block. The blocks additionally contain a timestamp with the time of block creation, its own cryptographic hash value (Block ID) and the Block ID of the previous block, therefore building a chain of blocks. The transactions and blocks are created and validated by the nodes communicating through a peer-to-peer network. When the peer-to-peer network validates the information proof of work is generated. If the proof of-work algorithm is applied, the block is sized with the data. Hence this makes it difficult for anyone to alter the data in the block. Even if someone has to do so, they have to change the block ID, Time stamp, and also redo all the proof of work on a particular block. Even if the block ID and the time stamp is hampered it becomes extremely difficult to change the proof of work as they are created by various peers from their decentralized network. This makes it close to impossible to change the data as it is way too time consuming.

This technology now has been used in lot of functional areas as it allows an individual to see who the parties are and with the help of the hashes, Block ID, Timestamp and proof of work it facilitates the buyer to be aware of the previous transactions. And as this technology is based on decentralized network anyone, anywhere can access the transaction details and consolidate information for further requirement.

Supply Chain of Aviation Industry

Covid Breakout has temporarily affected the growth of the aviation industry. Even in this unprecedented times we see that the aviation industry is spreading its wings in the form of regional airports, low cost carriers etc. As per the reports of ICAO and IATA the aircraft production and maintenance will be on a constant rise as the passenger traffic is going to grow leaps and bounds by 2035. Due to which the demand for the aircraft spares is projected to increase. This increase in demand can lead to high pressure on the supply chain resulting in its failure. Example, unable to handle the present circumstance could be at any level where the provider can't handle requests because of inaccessibility of items before going to the next level. In this climate of inventory network,



individual level contends with the other rather than co-working, by not sharing the data. This leads to blunder as we continue up the store network. Behind each eventual outcome, there is a long chain or levels of congregations, however, some researchers have consolidated these singular levels, which produce for OEMs into 3 primary levels supplies: -

- **Stage 1:** OEM's Main work, for example, dealing with engines, brakes, etc. First set of suppliers for the MRO.
- **Stage 2:** Are the suppliers to Stage 1, they supply products, which are manufacture from their own productions. Example, assembling individual parts of Engine.
- **Stage 3:** Small-scale component production companies, which provides small components like electrical components, raw material.

Below is the Aircraft Turbine assembly supply chain. At this junction we can understand that the Airline or the supplier can be part of its own supply chain or can be part of some other companies supply chain as well.

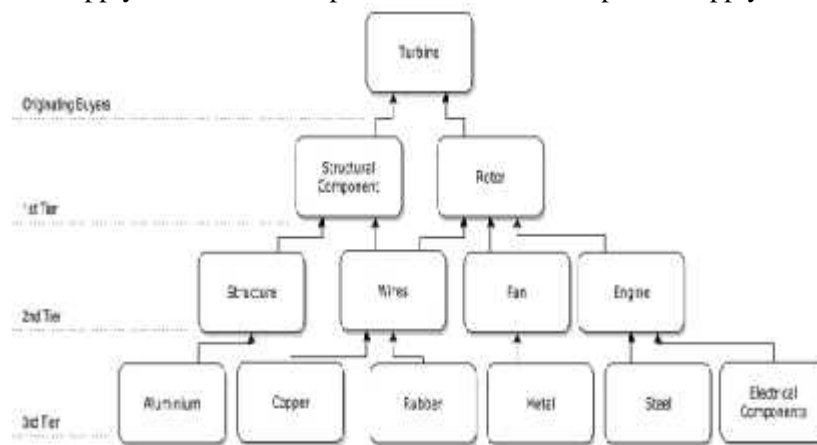


Fig- 2 Aircraft Turbine's supply Chain

Though the company / MRO always has a concrete path of the supply chain, the complexity of the chain can hinder the quality of the products and the interdependency amongst the parties may impact the MRO in its operations.

The MRO's main objective is to complete the maintenance on time and allow the aircraft to operate in the air. This can only be achieved if the MRO has an able and well established supply chain. The main agenda of the supply chain is to make sure that the right products are reaching the MRO at the right time. That means it has to fight the market which are flooded with counterfeit products. This is only possible when the complex supply chain has a clarity in its role which can be based on the below: -

- Inventory planning i.e. MRO hub, supplier accessibility.
- Establishing the relation with supplier of raw material and products.
- Quality measurement.
- Final Delivery
- Finally testing.

There are occasions when an airplane requires assistance, part substitution, or at some point immediate overhaul or reliability testing. In these scenarios, aircrafts are moved to the MRO's of different hub or is overhauled as a particular hub where that particular maintenance is available. During such scenarios the supply chain has to be spot on so that it can deliver the spare parts / components to the required hub. For this reason alone the MRO should be able to reach out the SCM to procure the same. This can become challenging if the MRO or SCM is unaware of the suppliers whereabouts which might lead to delayed maintenance.



Conceptual Model

As Block Chain is an open ledger where in traceability of the product, transaction details, parties can be easily done. As much as procurement is important so is the returns of the defected goods. In the SC network if there are any errors or defects in the components purchased, we can easily track them back to the supplier. In the below design major elements emphasized are:-

- Integration – As each segment is built with unique Id numbers, these can be used to connect different tires and interact with each other.
- Transparency - As the timestamp are not alterable and if any changes are to be done to an existing transaction new timestamp is created and the same information is distributed to the entire network
- Assistance – Decision making ability often MRO, planning and problem solving is done in a better manner due to the above said points.
- Decision – As the block chain is a decentralized network, different functional area of the MRO can take decisions with respect to supplies and inventories

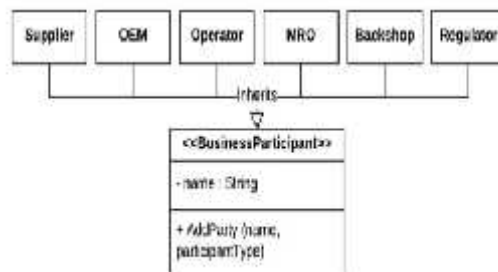


Fig-3 Block Chain Class Diagram

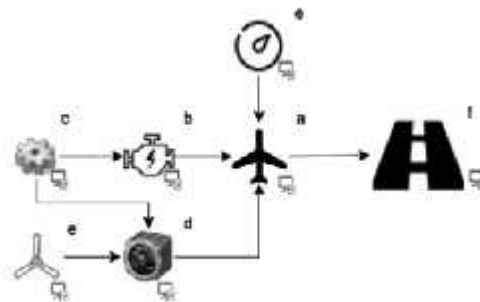


Fig-4 – Supply Chain of Aircraft Parts at MRO and OEM level

From the above figure we can understand that Hub ‘A’ is the assembly hub where all the different part are assembled from different areas. This hub acts as one of the factor in the supply chain, and procures parts from B and D respectively. Hence when the transaction happens from differ locations and from different suppliers the digital ledger is updated and is stored in blocks and the unique ID of the turbine that is newly assembled is also generated with the assembly is completed at hub A. This ledger will keep the record of the relative multitude of new items produced at each level, which would be coordinated with exchange record that will show the executing sub levels among the person/individuals. This entire organization could likewise function as stock library for individual organizations alongside sub level of the items.

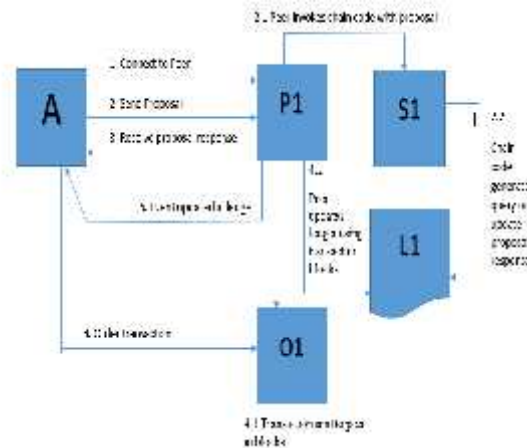


Fig.5 – Prototype N - Block Chain for Aircraft spare parts at MRO and OEM level

N	A	P	S	L	O
Block chain network	Application	Peer	Chain code	Ledger	Order

As block chain integrated SCM for aviation industry cannot be constructed with open source, the ledger is composed in a fabric of database called World State. This world state uses the smart contracts called chain codes in fabric. The ledger is composed of the World State and the Block Chain data structure, whereby the Block Chain data structure determines the World State. The fundamental blocks of the chain are the peers who provide in data of the right producer, manufacturer or supplier of the spare parts. They do this activity with the help of peer approval on a requested transaction. This makes the information legitimate and avoids counterfeit. Further, the peer approval is obtained in the form of a stamp on the application. Once the application receives sufficient acceptance or approval from the peers the order is sent and converted into a block. Once the block is verified and transaction is completed the information is added to the block and the block is added back to the block chain and the world state is updated. At the end the applications notify whether the transaction was a success or a fail. This can be done with the help of digital certificate issued by the chain. As this prototype will be applicable for the aviation industry only, the fabric network can be formed with a consortium of several companies who will be ready to share the documents and the information about the suppliers in the block chain. If the companies are not willing to get into the consortium they can build the network on a common consensus on Kafka protocol. Kafka uses Apache Kafka, an opensource stream processing platform that enables processing of continuous data streams of structured data (Apache, 2017).

Strength and weakness of the Model

- The decentralized network is supposed to be distributed with the participating organizations. If the consortium needs to be built for the same it can lead to partial centralized network which will defeat the purpose of the network.
- If the participants are assigned to separate organization and the information is assimilated from that point onwards, the information can be better circulated.
- This distributed power to all the organizations in the network can push the organization to release more data so that they can be mutually benefited.
- If the participants are distributed the information to supply, spare parts requirement and many other can be informed well ahead.
- Keeping all the above, we cannot forget that the bigger the network grows the higher the risk of data.



- As the entire network is built in the fabric, the nodes of the chain codes can only be shared with the peers of the network which will help in maintaining secrecy of the data. This can also be used to avoid sharing the data with the competitors and at the same time provide it to the participants.

Implication on the MRO due to Block chain integrated SCM.

- By applying the block chain in the aircraft logistics, the organization can indeed reduce cost and save a lot of time.
- This will ultimately help the MRO reduce the downtime of the aircraft and send it back to the operations.
- As the logistics of the aircraft is a complex process which involves certification of each spare parts this integrated SCM system will help the MRO to understand the authenticity of the spare part and the certificate attached. This is given utmost importance as the counterfeit products used in the aircraft can cause a lot of damage and can cost lives too.
- In the block Chain integrated system as the peers are required to authenticate the seller and as it is a transparent system counterfeiting can be reduced to a larger extent.
- MRO spend billions of dollars on maintenance records that are generated due to the ownership transfer of the aircraft from the manufacturer to the operator. In addition to this the maintenance cost and verification of maintenance records has to be borne by the operator. The digital tractability of this SCM model can help reduce the cost that is incurred in document inspection.
- If any data is lost in the transit, as the digital stamps are always available the document can be retrieved or supplier can be tracked down easily.
- All the above said can only become a reality if the systems of the MRO and the network is interoperable. For which SAP Software Company is coming up with various versions and fabrics for the ledger.
- Challenges can also arise due to lack of regulation in this area. Concept of block Chain is burdened with legal issues and are yet not clearly defined.
- As the fabric used smart contracts, the application and implication of smart contracts has to be well defined in the contract laws that are currently missing.
- Lastly, the fabric will be a success only if the participants are willing to form the consortium which might be an issues due to various internal and competition issues.

Conclusion

Block chain might be introduced in 2008 but the concept to fabric, ledger and hyper ledger was introduced only in the late 2015. This gives a lot of room for changes in the regulations and technology itself. Though it is extremely important to understand the application of technology of the MRO, at the same time we need to understand how this huge functional area can be interoperable with the upgradation. Keeping in mind the process that takes place in the MRO the above conceptual model to integrate Block Chain in its SCM was framed. The above model assures potentially increase in the overall efficiency of the MRO and especially in the area of procurement of spare parts and avoiding the counterfeit products. This above model will help the SCM build better network with suppliers, better traceability and transparency in the system. The integrated system can definitely help in the reduction of cost that is incurrent in warehousing, documentation verification, and downtime reduction. It will also contribute in the increase of the aircraft reliability as the counterfeit parts are avoided. Though there are pressing issues with regards to laws and regulation the MRO can definitely work on implementing the integrated SCM in non-critical data systems which may help them gear up to the Block chain level.

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