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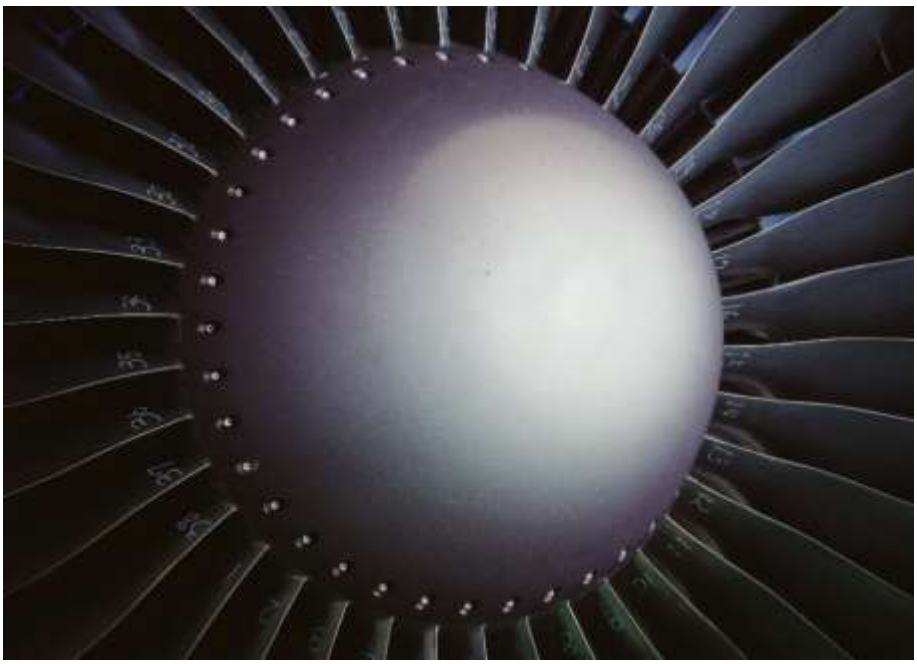

Blockchain in Aviation Technical Records:

A Growing Frontier

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Executive Summary

Blockchain is poised to change the way aviation technical records, and associated data, are stored, managed, and exchanged. With the majority of technical records still in paper-based records today, it is imperative that the industry come together in a cooperative way to begin moving toward a decentralized, yet secure & compliant, way in sharing component records across the world. Despite the noted challenges, there is much promise and efficiencies shown in moving into blockchains.

Presented is a **proposed roadmap** for the evolution of blockchain in aviation technical records. Blockchain development in this space will evolve in four distinctive phases:

Phase 0. Governance and Standardization

Phase 1. Part Tracking and Configuration History

Phase 2. Deeper Data and Warranties

Phase 3. Market Facilitation

As blockchain technology is implemented with key participant input, key trends will emerge as participants seek to leverage the full capability of this emerging technology in this space. Blockchain has a bright future in the aviation technical records space and will revolutionize how aviation assets are managed in the future

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BLOCKCHAIN: A GROWING TECHNOLOGY IN AVIATION

Blockchain; there is no doubt that it has, and will, revolutionize how transactional data records are handled. From the early days of Bitcoin in 2009 to now, many different industries from finance to health care, and beyond, have begun investing in the blockchain movement, with research firms, such as Polaris Market Research, projecting blockchain technology being a $16.82 billion market by 2026 at its current pace.[1]

One specific industry sector that has seen increased attention over the last few years is aviation. Many different areas of aviation can benefit from blockchain technologies, including:

- Passenger Ticketing
- Freight Tracking
- Financial Transactions
- And many, many more use cases….

A specified area of blockchain use in aviation is with *technical records*.

AVIATION TECHNICAL RECORDS

According to Fortune Business Insights, the aviation MRO software market is projected to reach $8.78 billion by 2027. [2] Many MRO software providers have provided products and services to help track the receipt, maintenance/repair, and disposition of aircraft systems & parts. Due to strict compliance, security, and safety requirements, technical records are kept ensuring continued airworthiness of aircraft around the world, with jurisdictions requiring varying levels of documentation requirements.

Keeping these technical records, for many years, has been a painstaking process; even today, with millions of paper-based records following aircraft and components around. An attributed quote to John Maggiore, a Director at Boeing mentioned:

"There are literally millions of boxes of paper-based documents, which would circle the Earth 25 times if laid end to end."

Knowing the complex systems and components required to manufacture and maintain large commercial aircraft, it is not hard to imagine the detailed history of components required for compliance, let alone tracking its maintenance history.

Many service providers have provided software and labor solutions to help manage, track, and maintain these technical records, moving toward digital record formats, a positive step in the right direction to reduce the inefficiencies and problems of paper-based records. However, when

transferring assets, whether aircraft, systems, or components, between parties, many issues may arise beyond paper-based records issues, such as data mismatch, different standards, or lack thereof, and a longer cycle time during transfer of assets, due to sorting through digital records. Blockchain can provide a long-term solution, but it does face challenges across this worldwide industry.

BLOCKCHAIN IN AVIATION TECHNICAL RECORDS

Using blockchain to track aviation technical records can provide many benefits to many parties involved, whether it be airlines, regulatory bodies, MRO facilities, lessors, and beyond. Some of these benefits include, but are not limited to:

- Aircraft and component history, potentially back-to-birth.
- Immutability and security.
- Facilitation of transfer of data using private, unique keys.
- Potential decentralization, helping reduce risk of loss and changes.
- Faster Airworthiness Directive/Service Bulletin disposition as required.
- Smart contract implementation.

Many organizations have recognized the value of blockchain in aviation technical records, with literature from the past few years discussing the topic, as well as providing general solutions and guidelines around implementation, with all sources discussing very important points. [3] [4] [5] [6]

By far, the most notable step in this direction was made by the MRO Blockchain Alliance, led by SITA. [7] With the Alliance's focus on part history, including back-to-birth traceability, as well as facilitation of this data, is a worthwhile endeavor, and a great step in the right direction, with Aviation Week reporting the proofs-of-concept pursued by the Alliance to have been successful. [8] Blockchain is a viable technique to store and transfer technical records while maintaining compliance, security, and transparency across the supply chain.

CHALLENGES IN FURTHER IMPLEMENTATION

While the proof-of-concept by the Alliance has shown to be successful, for large scaling and implementation to occur, many obstacles will need to be overcome over time. This will provide some challenges in creating a blockchain that is accepted by the industry as a whole worldwide.

CHALLENGE #1: ERP/IT ROLLOUT

A major challenge in rolling out a blockchain solution for aviation technical records is software related. With many different players in this sector of the industry, including airlines, OEMs, lessors, MRO organizations, CAMOs, and regulatory bodies to name a few, each specific organization may have its own ERP/IT infrastructure that may not "be ready" to implement and facilitate a decentralized blockchain solution. As mentioned

before, many organizations still use paper-based records; this creates a major hurdle for many to participate.

CHALLENGE #2: DIFFERENT STANDARDS OF DIGITAL INFORMATION

Throughout the world, due to varying requirements and other reasons, organizations inside the same jurisdictions, let alone outside in different countries, may have different digital storage standards of aviation technical records. This creates potential mismatches between different organizations, thereby making implementation more difficult. A proposed standard, Spec 2000, from Airlines for America, was used by the MRO Blockchain Alliance and has backing from many in the industry, including OEMs, large MRO organizations, and more. [9]

CHALLENGE #3: INCENTIVES AND DECENTRALIZATION

With the nature of blockchain stepping toward decentralization, it may be difficult to organize a decentralized solution. First, many technical records software providers have begun creating their own, interconnected networks of data exchange, which they may want to conserve for a competitive edge. Additionally, since quality, security, and compliance are at the heart of commercial aviation, a gatekeeper may be needed for a federated/hybrid blockchain scheme, which can be difficult with many players, including competitors, trying to work together. Lastly, as the data, whether paper-based or digital, needs to be put onto the blockchain first, there are initial costs involved, and sometimes heavy costs if the digital data collection infrastructure is not currently available for an organization. Finding a "first-mover" for full-scale implementation, beyond a proof-of-concept, may be difficult, though the MRO Blockchain Alliance helps soften this point.

CHALLENGE #4: PART TRACKING AND SERIALIZATION

Many components and parts on aircraft are tracked by part number and uniquely by serial number. While this may not be a major problem for Life-Limited Parts (LLPs), tracking of serialized, non-LLPs is not necessarily mandatory in many environments, creating a digital data gap. Furthermore, many parts are not serialized, making tracking certain components difficult. For example, while low-pressure turbine blades are not tracked uniquely, experience shows that where the turbine blade was history-wise can greatly influence its performance and repairability over time, having potential safety and cost consequences.

These challenges, among others not mentioned, will be hurdles to overcome concerning large scale adoption of blockchain for aviation technical records.

A PROPOSED ROADMAP

Much of the literature and concepts discussed elsewhere touch well on this subject. However, when viewing the full picture, blockchain can completely revolutionize how the commercial aviation world approaches the management of assets, not only technical records, but also warranties, deeper maintenance & engineering records, aircraft flight records & parameters, and market facilitation,

of course, other benefits can apply. This paper provides a proposed roadmap for blockchain use for use in aviation technical records, and beyond, noted visually in ***Error! Reference source not found.***.

While each phase is chronologically separated in this roadmap, by no means is it suggested that the roadmap items discussed cannot happen in a different order or parallel.

PHASE 0: GOVERNANCE AND STANDARDIZATION

Before implementation of an aviation technical records blockchain, proper governance and standardization must be established in large by the industry players. Today, different organizations could play this role; what will be important for long-term adoption is that the governance should be established by a non-profit and/or neutral organization, governing the federated/hybrid blockchains that will come out of this effort. Otherwise, the governing body may be swayed negatively due to competitive reasons between participants.

On the standardization front, today, the ATA e-Business Program attempts to do so from the format of a digital record, with many major participants on-board. [9] This may be a great, and suggested, start concerning how these digital records are stored and managed before being put into a blockchain. SPEC 2000 and the related specifications are noteworthy in this endeavor.

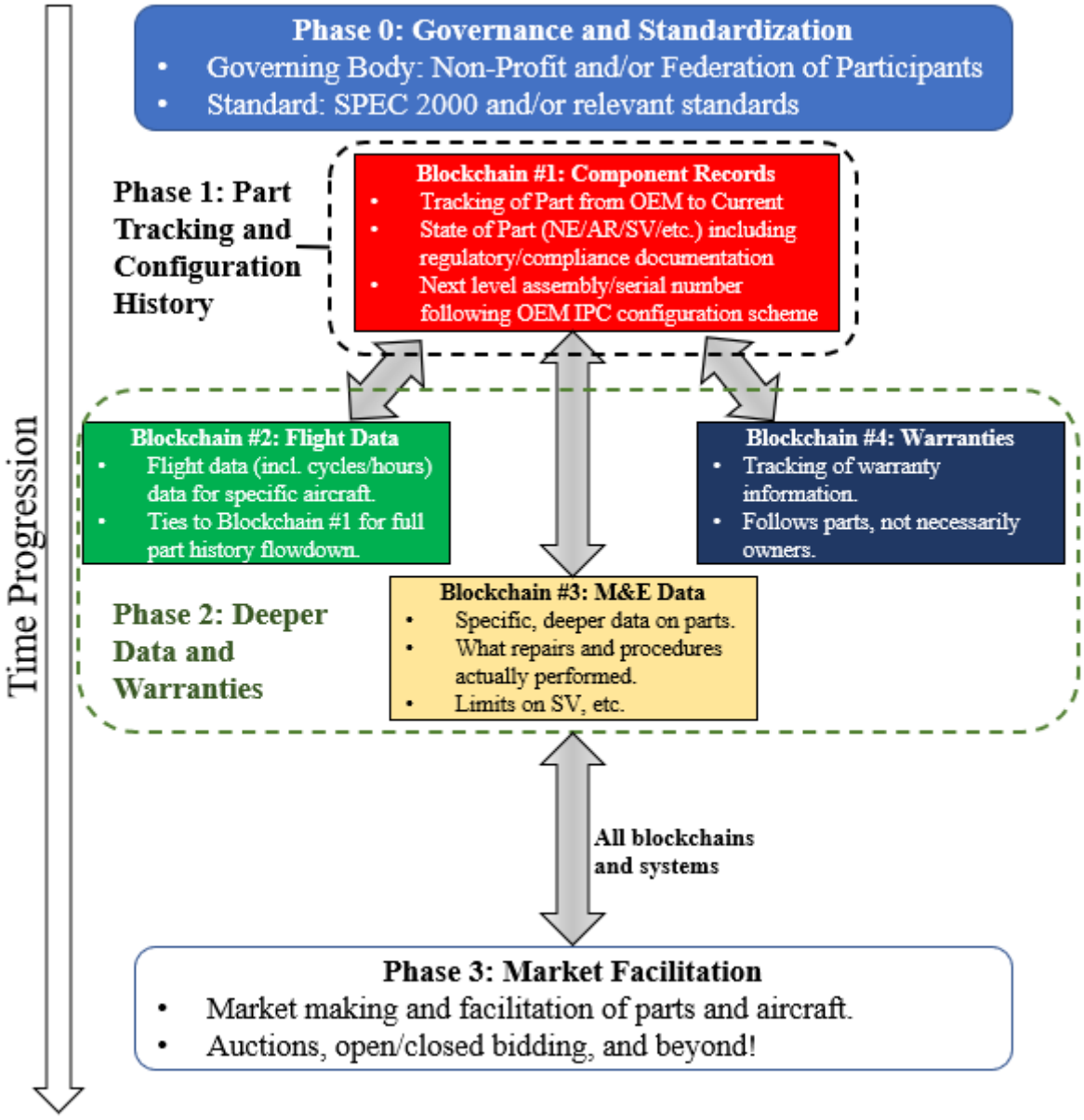
Lastly, of importance, the blockchain governance, standards, and protocols used must be as ERP/IT agnostic as possible, else many prospective organizations will likely not participate.

PHASE 1: PART TRACKING AND CONFIGURATION HISTORY

As pursued previously, the first blockchain, Blockchain #1, for full aviation technical records should focus on the component records themselves. This includes key data, such as:

- Part number and serial number, if applicable.
- Qty and QPC, if applicable.
- History of manufacture, installation, removal, and repair/maintenance.
- Cycles and time.
- Regulatory and compliance documentation.
- Installed next-level assembly number and serial number.
- OEM Illustrated Parts Catalog (IPC), or other, configuration position.

While many different types and amounts of data could be argued for or against, the items of focus here are the next-level assembly number, its serial number, and IPC configuration position. Tracking of this key information would allow a full roll-up of the aircraft into the blockchain, providing a full record of all components for the whole aircraft. Reported proofs-of-concept have looked at the full history of a part but have been perceived to neglect this key detail. When other systems and blockchains are tied to this initial



blockchain, assuring that key installed information is available will allow valuable data in the form of flight data, warranty records, and detailed Maintenance & Engineering (M&E) data to flow, tied directly to the affected parts in a top-down manner.

Figure 1: Proposed Roadmap of Blockchain Implementation

PHASE 2: DEEPER DATA AND WARRANTIES

At this phase, with the Component Records blockchain foundation laid, incorporating further data can provide further history and visibility, adding to the quality and insights available for participants.

- **Blockchain #2: Flight Data**

With flight data available, such as cycles/time, temperatures, conditions, humidity, thrust, etc., this can enable participants to analyze various aspects of the performance of their assets, including life, performance, repair, and scrap analytics, and beyond.

- **Blockchain #3: M&E Data**
  Deeper data coming from the Maintenance & Engineering organizations (MROs, airlines, etc.) may include inspection and repair data for better tracking, not only if a component or system was repaired, but what exact repairs were performed. With the dawn of IoT, key characteristics and dimensions can also be tracked over time, throughout the life of a component.
- **Blockchain #4: Warranty Information**
  It can be argued that Blockchains #1 and #4 could be combined, for reference. Many parts today, including OEM installed and/or spares, have warranties tied to components. No doubt, noted in many places, that millions per year is lost due to unclaimed warranties, and/or confusion surrounding them. Having aviation technical records in this form allows for more accurate tracking of parts for warranty facilitation.

PHASE 3: MARKET FACILITATION

As the blockchain infrastructure is built through Phases 0 through 2, this will naturally create an environment conducive for market facilitation, including the sale, lease, auction, or other transactions around components and aircraft. Due to the decentralized nature surrounding blockchain in this context, multiple market makers and facilitators will likely emerge, seeking to aid participants in these activities. A good indicator surrounds cryptocurrencies, such as Bitcoin, with many exchanges in existence today.

FUTURE TRENDS

As blockchain grows into the frontier of aviation technical records management, it is important to note some trends that will likely emerge as it advances.

MONETIZATION OF IMPLEMENTATION

To implement blockchain in the fashion described, monetization initially will occur in two ways:

1. **ERP/IT Infrastructure Setup**
   Regardless of what ERP/IT system or infrastructure an organization has, work must be performed to set up the output to the blockchain, requiring expertise either internally or externally to implement effectively.
2. **Technical Records Input into Blockchain**
   No matter what digital system is used, whether native/conventional or blockchain-based, physically processing the parts into the digital space takes time and money. Organizations will be able to offer this as a potential service for long-term value.

Fixed investments in assets to be able to capture this information effectively on the floor will also be important at this step.

UTILIZATION OF EMERGING TECHNOLOGIES

As more component and system, data is processed and available, greater abilities will be available for leveraging emerging technologies for further insights and efficiencies. This includes areas such as data analytics and artificial intelligence, allowing participants to find deeper insights than what was possible before, as well as better forecasting abilities.

SMART CONTRACT USAGE

As the blockchains mature, the use of smart contracts will likely become more widespread in many ways. An example is a lessor requiring an aircraft to be returned on end-of-lease in a certain configuration from a lessee, such as an airline. Other examples include warranty claims, guarantees of operation from MRO shops, and more.

GRADING OF COMPONENTS AND AIRCRAFT

While many components, non-LLPs more specifically, already have back-to-birth traceability, a pricing factor for components or aircraft will be the ability for organizations to prove a component's history, backed by the blockchain. If organizations can show this value, it may provide a competitive advantage for pricing and the willingness of buyers to purchase versus other components with incomplete histories. Furthermore, pricing discrimination may start occurring depending on what temperatures and conditions a component sees throughout its life; an example being engine components.

CONCLUSION

With the tentative, proposed roadmap of this paper, it can be shown that blockchain will change the way aviation technical records are managed, stored, and beyond. The benefits and trends from having data in a blockchain format will provide long-term value to the participants around the world. The key to starting in the right direction will be key stakeholder input on governance and standardization from the beginning. The aviation industry is here to stay and moving away from paper-based and simple digital records to blockchain will provide dividends long into the future.

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