Blockchain in Aerospace
Towards Transformational Air Travel

Paul NICULESCU-MIZIL GHEORGHE, Victor Emmanuell BADEA

National Institute for Research and Development in Informatics – ICI Bucharest

paul.gheorghe@ici.ro, emmanuell.badea@ici.ro

Abstract: Blockchain is a different way of thinking, it's not just a technology. The Blockchain technology has the power to create a "digital birth certificate" for every part installed on an aircraft and update it whenever – and wherever – the aircraft is serviced or inspected. The opportunities of Blockchain technology deployment in aerospace count in sub industrial domains as: engineering process optimization, manufacturing and quality, supply chain tracking, identity, data integrity and finance.

Keywords: Blockchain technology, aerospace industry, smart aviation, engineering, aerospace

INTRODUCTION TO BLOCKCHAIN TECHNOLOGY IN THE AVIATION INDUSTRY

Blockchain technology is already having a major impact in most of the industries, through its power and capability to fundamentally change processes and value chains. While industries such as the financial sector have started significant blockchain-based initiatives, large tourism and mobility companies are slowly starting to decentralize their networks. Blockchain technology in the aviation industry can have constructive effects on issues like: engine maintenance real time monitoring, in the context that engines data are not stored in a single available location, making it problematic to improve and estimate. The advantage of the blockchain is that it can store information in a public database, protected by cryptography. Briefly, the Blockchain is a distributed database that preserves a dynamic list of records efficiently, verifiably, permanently and in an immutable way.

A dedicated blockchain for aviation for particular market goals implies functionability, deployment, real usability and end markets. Logs-keeping and embedded transactions are protected by the capabilities of the Blockchain technology. Public, private and hybrid blockchain system deployment is part of the market opportunity and includes a digital ecosystem with end markets as international airports, airlines, MRO – Maintenance, Repair and Operations, lessors, manufacturers and third-party service providers, as represented in *Figure 1*. [ADS, 2019]

Air services market stakeholders: Blockchain Developers/Solution Providers/Service Providers; Integrators; MRO (Maintenance, Repair and Operations); Airlines; Airports; Lessors; Government Bodies, Agencies and Regulators; Investors and Financial Community Professionals.

The Blockchain market for the aviation industry is increasing at a substantial speed. Enhanced traveler experience, compact maintenance costs,

Fig. 1: Aviation markets covered by the blockchain technology (Markets and Markets (2019), Aviation Blockchain Market – Global Forecast to 2025)

superior transparency and traceability of the operations and complexity of transactions are the key factors for this type of market. The usage of Blockchain technology can diminish documentation time and ease the transaction processes. Blockchain also adds a high level of security to every transaction that takes place within the dedicated network and maintains the track record keeping in a tamperproof manner, represented in *Figure 2*. [ADS, 2019]

The industry of commercial aviation is a complex work frame, in which numerous entities intricate in the distribution of travel services and products. This fact that is recognized as a compact product from the perception of the client.

These influences are related to co-deliver quality and meet the expectation of travelers. From the moment the passengers require information online about airline tickets until they reach their desired destination, the airlines are an entity of the numerous business partners in the aviation value chain of the industry (*Figure 3*).

BLOCKCHAIN, AVIATION AND CORONAVIRUS PANDEMIC | COVID-19

In 2020, a crucial year with unprecedented series of events at a global level hit first and most severely affected industries in the long-term like the aviation industry, for which the losses will be massive. In this period of time, when there is no immunity or vaccines to COVID-19, the only way to stop or slow its spread is done by physically isolating individuals. That is fundamentally in disapproval to what aviation is, it works to bring people together.
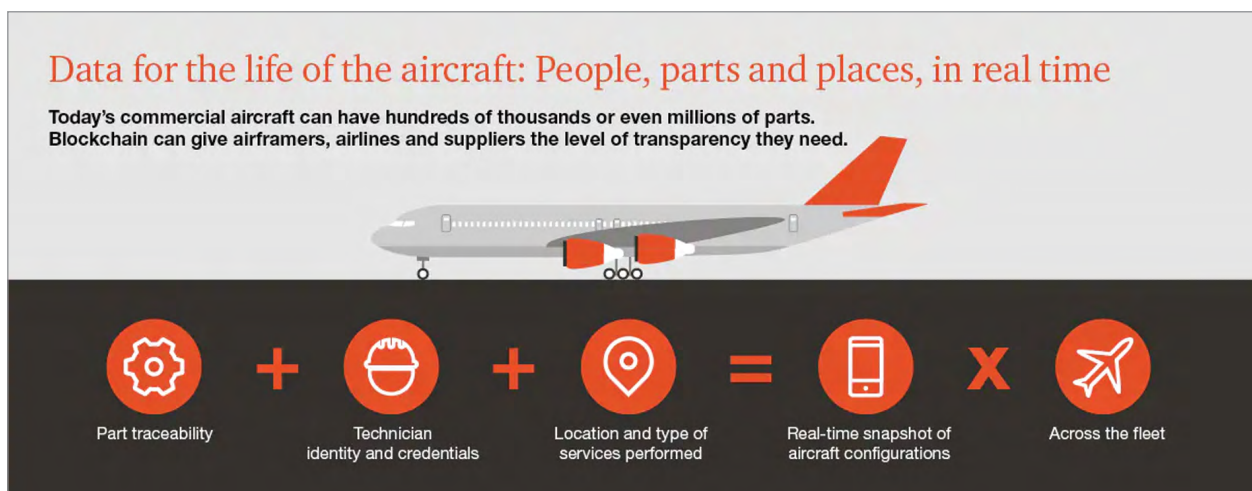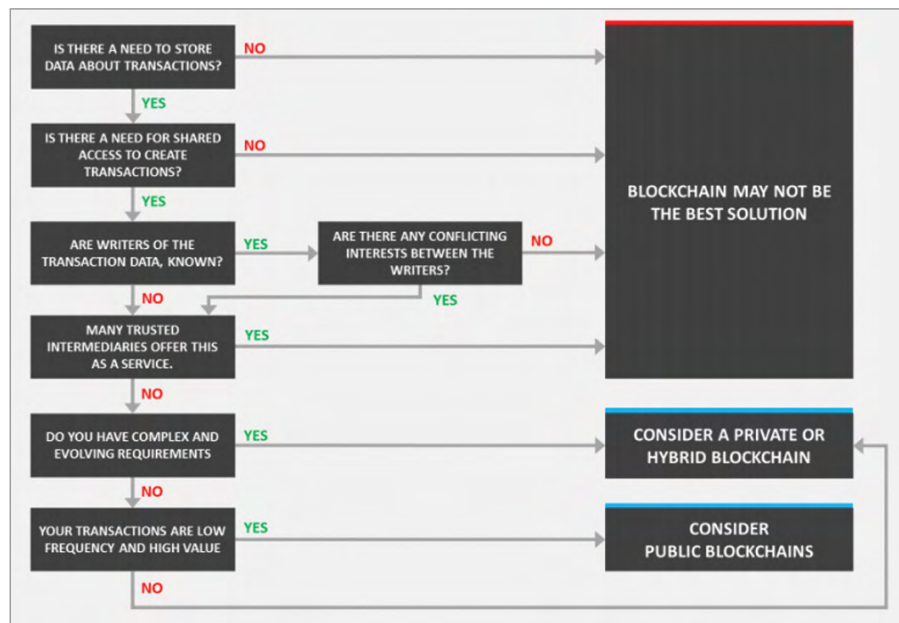

Fig. 2: Aircraft configuration and maintenance logs (https://www.pwc.com/gx/en/industries/aerospace-defence/publications/blockchain-in-aerospace.html)
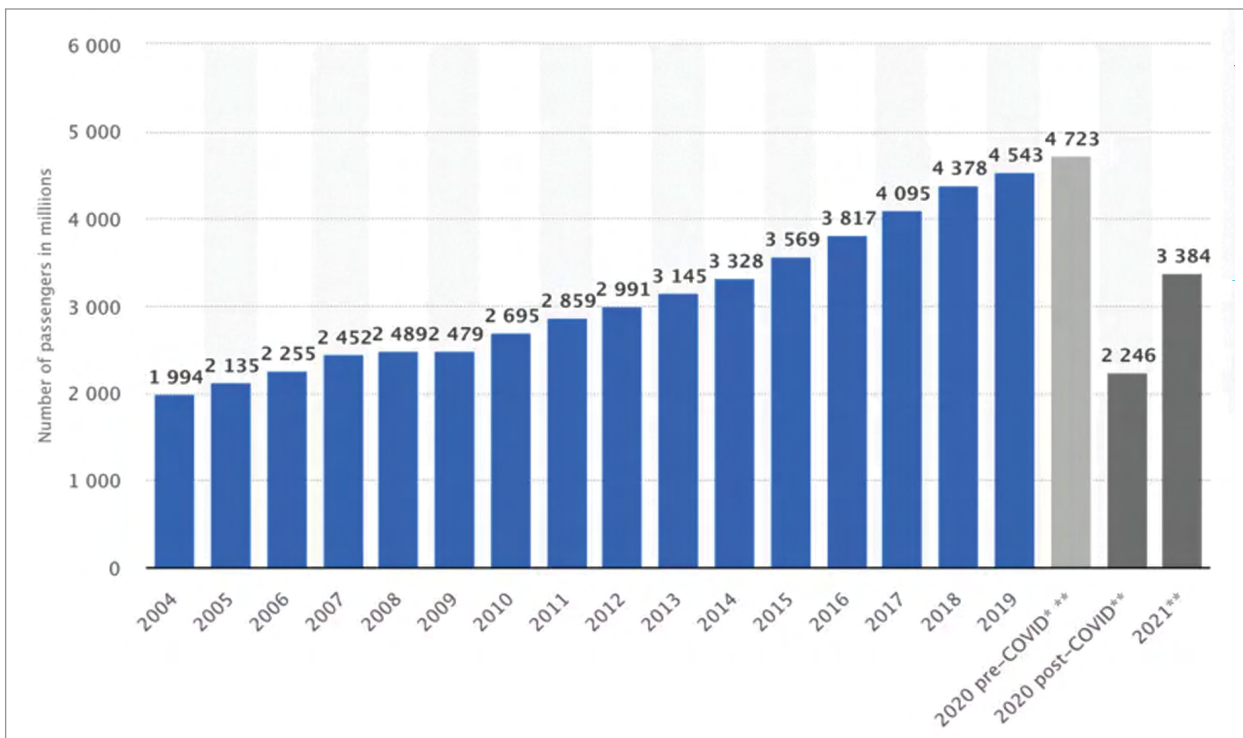
The entire aviation industry value chain is working on solutions planned to help airplane travelers feel safe again, as shown in *Figure* 4.

GE Aviation (General Electric) is global leader in providing jet engines for military and commercial aircrafts, as well as electrical power systems and digital solutions for airline fleets, introduced Health Application ID, in order to assure that "workers and passengers" have

Fig. 3: Blockchain solution assessment diagram (https://www.iata.org/contentassets/ 2d997082f3c84c7cba001f506edd2c2e/blockchain-in-aviation-white-paper.pdf)

been separated from the COVID-19 issues. This credential app, uses the Microsoft Azure Blockchain Service with the aim to embed passenger information, such as passenger identity, ticket information and medical screening outcomes into the airfreight boarding process. The goals of this new application are to make again a safe airline travel, facilitating a safe return to work of employees and regaining passenger confidence. *[GE, 2020]*

Fig. 4: Number of scheduled passengers boarded by the global airline industry from 2004 to 2021 (Available at: https://www.weforum.org/agenda/2020/06/covid-19-sustainable-aviation/)
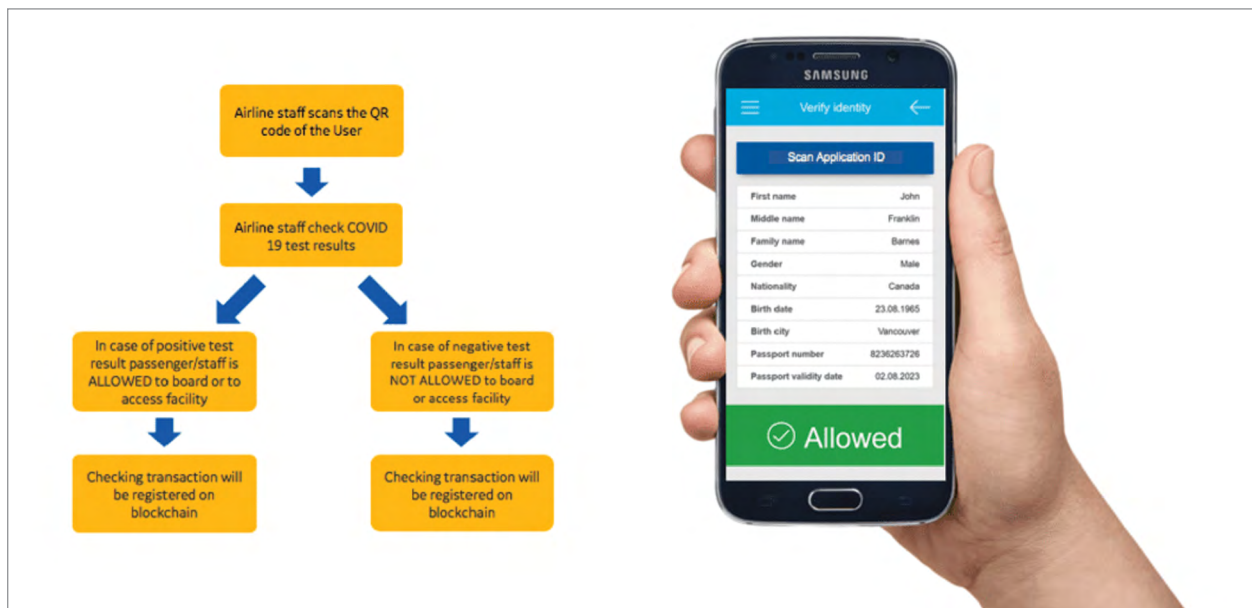
Fig. 5: *Example of results for a COVID-19 antibody test. Positive means the person is immune. Negative means at-risk (https://blog.geaviation.com/technology/new-health-app-id-aims-to-restore-passenger-confidence/)*

In order to make this happen, Health Application ID focuses on three important areas, revealed in ***Figure 5***:

• **Employee Control:** Screening workers for a safe return to their workplace;

• **Passenger Control:** Screening passengers in order to certify safe and clean flights;

• **Object Control:** Sanitized objects on aircraft. *[GEA, 2020]*

THE POTENTIAL OF BLOCKCHAIN TECHNOLOGY IN AEROSPACE INDUSTRY

Some of the most relevant domains where Blockchain technology solutions are being applied by the developers of the air travel ecosystems are:

• **ID (Identity Management)** – By eliminating paperwork such as passport, visa, etc. for an improved ID management of the passengers;

• **Customs Clearance** – Air cargo inactivity will be a resolved issue due to implementation of blockchain technology;

• **Air Traffic Control** – Blockchain manages to ease the process of monitoring flights and reduce congestion in airport terminals;

• **Enhanced Security** – Enables trust between the travelers, travel agents, airports and airplane crew personnel;

• **Reducing flight delays** – With the authority of IoT and Blockchain technology it is possible to identify flights delays and decrease them;

• **Payments** – There is no need to exchange money in order to use it in airports and their commercial merchants;

• **Aircraft maintenance** – Flight operations can be effectively supervised in real-time.

THE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR INTERNATIONAL AIRLINES

International airlines can design and incorporate Blockchain technology in cargo & baggage tracking and smart contracts system architectures. While an airplane is located on the ground for extended time period, its maintenance is a major worry as the aviation industry operates within limited profit margins, and it can incur an operational loss. These inconveniences can be sidestepped by introducing Blockchain technology between international partners, in so called consortiums. The precise aspect of the configuration and maintenance of an aircraft management will facilitate the decrease

of costs and losses, affiliated to downtime and unplanned maintenance schedules. Airlines can incorporate Blockchain systems in cargo and baggage tracking, traveler ID management, data management of flight and crew/board personnel, frequent flyer programs, smart contracts deployment and supply chain management. [ADS, 2019]

THE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR MRO (MAINTENANCE, REPAIR AND OPERATIONS)

Blockchain technology in Maintenance, Repair and Operations is applied for the deployment of dedicated smart contracts, the maintenance of aircraft and supply chain management.

In the domain of MRO (Maintenance, Repair and Operations), Blockchain technology has the capability to be used to track and record aircraft's component movements, it's maintenance and repair logs history. An aircraft, over its lifecycle, goes through diverse entities, including lessees, airlines, lessors, original equipment manufacturers (OEMs), logistics suppliers and maintenance providers. Blockchain system architectures in MRO is applied for the development and deployment of smart contracts for supply chain management and aircraft maintenance.

This collaboration of various members of the aviation value chain will help generate a single shared blockchain solution, which helps create an accurate digital record of asset transactions, providing every end-to-end user visibility of the aircraft's health.

THE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR AIRPORTS

The Executives of airports are adopting Blockchain technology in smarting the activities of a very crowded and intense management between man and technology.

With the growing quantity of inbound and outbound flights and passenger traffic indexes, the management of international airports is concentrating on automating and digitalizing processes, in order to optimize the speed and efficiency dynamic operations. Airports are implementing Blockchain technology in smart contract scenarios, passenger identity management and cargo and baggage tracking dedicated systems.

Blockchain is expected to be useful at airports to enhance security and traceability of baggage as well as digital ID management of passengers. [ADS, 2019]

THE POTENTIAL OF BLOCKCHAIN TECHNOLOGY FOR MANUFACTURERS

The manufacturers of Aircraft like Boeing or Airbus, are focusing on Blockchain technology deployment for optimize the efficiency of operations and are keen on implementing solutions, tools and emerging technologies that will facilitate them a superior performance, whether it is acquiring improved software suites to increase its operational efficiency or generating more fuel-efficient designs.

Manufacturers can highly profit from using blockchain, as it can transform the current supply chain management entirely. Manufacturers can use this technology to trace the history logs of all its components by sustaining a digital blockchain-based record of all individual parts that are used in the different models of aircraft in their portfolio. Manufacturers usually adopt blockchain technology in smart contracts and supply chain management applications. [ADS, 2019]

TRANSFORMATIONAL AEROSPACE INDUSTRY

The CGAR (Compound Annual Growth Rate) of the Blockchain technology in the aerospace industry is estimated to be over 37% between 2020 and 2025, namely around 2.3 bill. USD. Blockchain technology is significant to the aviation and aerospace industry because it provides a boost of immutable security, computational power and efficiency to the industry, especially in unprecedented times like the COVID-19. We will regard two industry applications. [Business, 2020]

• **Airline booking system:** Travelers book airline tickets from online agencies or offline agencies. The traditional global ticket supply relies on Global Distribution System (GDS) and Billing and Settlement Plan (BSP). This process causes higher distribution costs and also higher ticket price for air travel customers. An airline ticket formerly priced at 1.000 USD, will turn out to be 1.742 $ by going through GDS and BSP. Blockchain technology can replace the GDS and BSP for online airline ticket distribution. Its benefits are: without a middle-man (intermediator), the airline tickets are significantly less expensive; Blockchain would seriously reduce those payment acceptance costs and will eliminate fraud, due to its immutability; opportunity of a better cash flow for small travel agencies in particular, they will receive immediately payment for each ticket sold rather than waiting for the airline to pay them back at the end of the week/month. This technology offers win-win solutions.

• **Aerospace industry supply chain:** A full supply chain includes aircraft manufacturer, assembly manufacturer and airline companies. These digital/physical ecosystems have common needs such as: raw component obtaining, inventory management, MRO (Maintenance, Repair and Operation) and workforce management, as their main objectives. As an example, an Airbus A380 has over 4 million individual parts and kilometers of electrical wires, assembled in a very sophisticated manner. The lifecycle of an aircraft is expected to be around 20–30 years. The components necessitate constant safety inspection and maintenance. The maintenance process contains several suppliers without direct data and information data sharing between them. At the present time, much of this information is collected manually, a highly costly and time-consuming process. No real-time information is accessible to deliver compliant aircraft condition or maintenance history. Through the smart contract, blockchain technology can proactively alert and send notification in advance to the requirements of maintenance or component replacement based on the aircraft lifecycle and state. All real-time information is immutable and highly secured/encrypted, generating greater trust for all involved parties.

CASE STUDIES IN THE AEROSPACE INDUSTRY USING BLOCKCHAIN TECHNOLOGY

• China Aerospace Science and Industry Corporation has broadcasted that it is developing a Blockchain real-time invoice system by augmenting its electronic invoices, so they can better track their invoices and ensure that their accounts are accurate. *[Crypto, 2018]*

• GE – General Electric Aviation partnered with Microsoft, for using the Azure ecosystem to develop blockchain based solutions and models, in order to track components of aircrafts and diminish errors and operational inefficiencies;

• KLM and Air France joined with Winding Tree to setup solutions based on Blockchain technology to offer superior services to air travel clients;

• Accenture and Thales introduced Blockchain prototype supply chain services for aerospace and defense business;

• SIA – Singapore Airlines, implemented Blockchain to benefit passengers make best use of their loyalty points and boost their experience;

• Air New Zealand joined forces with the Winding Tree company, in order to use Blockchain to optimize its operations;

• S7 – a Russian Airline S7 implemented Blockchain based platform for digital ticket sales;

• Moog uses Blockchain solution for designing and producing airplane parts with 3D printing technology;

• Fizzy is a model of travel insurance that uses dedicated smart contract technology. *[ADS, 2019]*

CARGO AND BAGGAGE TRACKING DEDICATED SYSTEMS

The Blockchain technology has a major ability in pursuing the condition and position of valuable assets such air cargo and passenger suitcases. The baggage management system is a

sophisticated designed system that guarantees that the baggage reaches its destination accurately and on time. Millions of bags are mishandled by airlines each year and the costs of airlines are rising to millions of dollars every year upsetting the customers. This fact offers an occasion to improve transparency and visibility for these assets and items when they traffic across the value chain. Blockchain technology could answer to new areas of product development, sustain and support the flow of managerial process and educate the service providers to manage disruptions while increasing operational efficiency.

THE MANAGEMENT OF DIGITAL PASSENGER ID

Biometrics of passenger and travel history can be entirely recorded and managed in Blockchain dedicated systems. With advancements in electronic industry and emerging technologies like Artificial Intelligence (AI), Blockchain and the Internet of Things (IoT), air passengers processing at airports can transform drastically. The personal ID information collected from travelers via biometrics are preserved in a centralized cloud storage platform. Nowadays where all the customers' data is stored on centralized cloud-based storage, is vulnerable to hackers for stealing sensitive data, so a better Cybersecurity approach is needed. This could be mitigated by using the Blockchain to store and record events/transactions and become decentralized. *[ADS, 2019]*

Other considerable domains within the air travel industry where the Blockchain technology is being used are:

The management flight and crew information

Blockchain technology delivers real-time information about international flights to all implied participants. Data sharing can be unwieldly in the airline industry with information stored on different databases by multiple players such as air traffic control (ATC), airlines, airports, MRO, and other flight operators. *[ADS, 2019]*

Frequent Flyer Programs

By digitally tokenizing the air miles flown by clients into a digital currency by implementing the Blockchain technology, the management of frequent flyer programs are being made possible. Numerous airlines offer encouragements for frequent flying passengers. The reason is to value their customers as well as inspire them to fly again with the same airline. Users of the airline's loyalty program are presented with credits for the miles they flew. The conversion of credits and miles flown can be stimulating as it is error-prone and time-consuming. Smart contracts technology is able to simplify and automate the process among airlines, minimize the error risk and considerably increase customer fulfillment.

Singapore Airlines (SIA) has established a digital wallet that allows travelers to use frequent flyer miles at partner retail merchants. *[ADS, 2019]*

Air Travel Insurance

Blockchain technology is used in insurance policies due to the need for high-quality information and the capability of smart contracts to automate decisions based on data. Smart contracts enable blockchain users to transfer value without the implication of intermediaries. Smart contracts specify the rules between two parties. Distinct to physical contracts, the smart contracts are able to track insurance claims from customers and hold either party responsible.

E-Ticketing and Ticket Tokenization

E-Ticketing and digital tokenization will substitute the usage of classic paper tickets. Currently, flight tickets are in form of paper or electronic. With the inauguration of the Blockchain technology, the request for paper tickets can be totally substituted and digital tokenization of e-tickets will be thinkable through the deployment of smart contracts technology.

At the time a ticket is sold, the airlines frequently have to deal with multiple players from the industry such as Global Distribution Systems (GDSs), other airlines or travel agents.

These facts give rise to a complex web of revenues and payments that need to be reconciled. Presently, the international airlines rely on IATA, which sets industry standards and acts as a payment clearinghouse. Blockchain technology will automate and streamline these settlement processes, eliminate disputes, keep booking data secure and significantly reduce complicated and time-consuming reconciliation work. *[ADS, 2019]*

Aircraft refueling

The use of smart contracts technology for aircraft refueling is able to automate the payment process elimination delays. One of the major costs for an airline is fueling. A smart contract will simplify automated payment for aircraft refueling. It can be programmed by using a computer digital algorithm that obtains real-time information from sensorial architectures. This info can be confirmed and stored in Blockchain (public and/or private). Consequently, post-completion of refueling of an aircraft, payment is automatically made by fixing the initial fuel and its settled price. The info is used afterwards to assign technical duties to a tanker driver at the airport. *[ADS, 2019]*

BLOCKCHAIN & IOT IN AEROSPACE INDUSTRY

The Internet of Things (IoT) – are networks of intelligent devices, sensor-equipped with exponential usage that have the capability to gather information, analyze and interpret it and consequently take action – it is considered a game-changer.
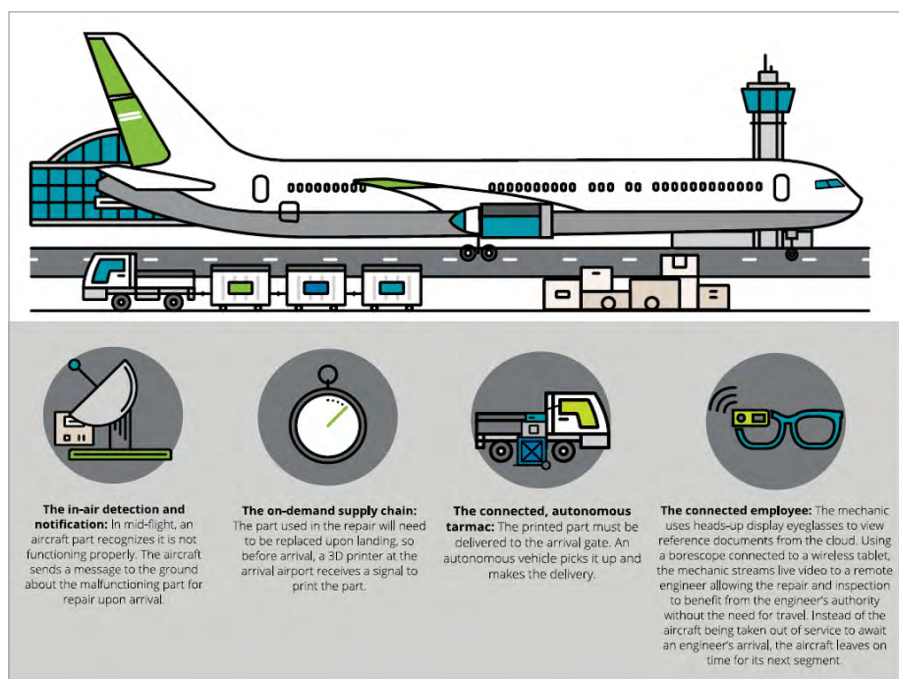
By 2020, 20.8 billion objects are assumed to be interconnected to the Internet of Things

and numerous major new business enterprise processes and systems will use IoT within their business models. The international airlines will claim a share of those funds and use them for ground equipment, toolboxes and lifejackets that screen and report their own status.

Drones that are able to check the aircrafts for lightning damages. Engine borescopes that a dedicated engineer can operate from another city, or sensitive info from employee wearables that leads to lesser insurance rates. By optimizing repetitive processes and educating people towards efficiency, IoT will help transform the savings of savings from an incremental skirmish to a wide-open borderline.
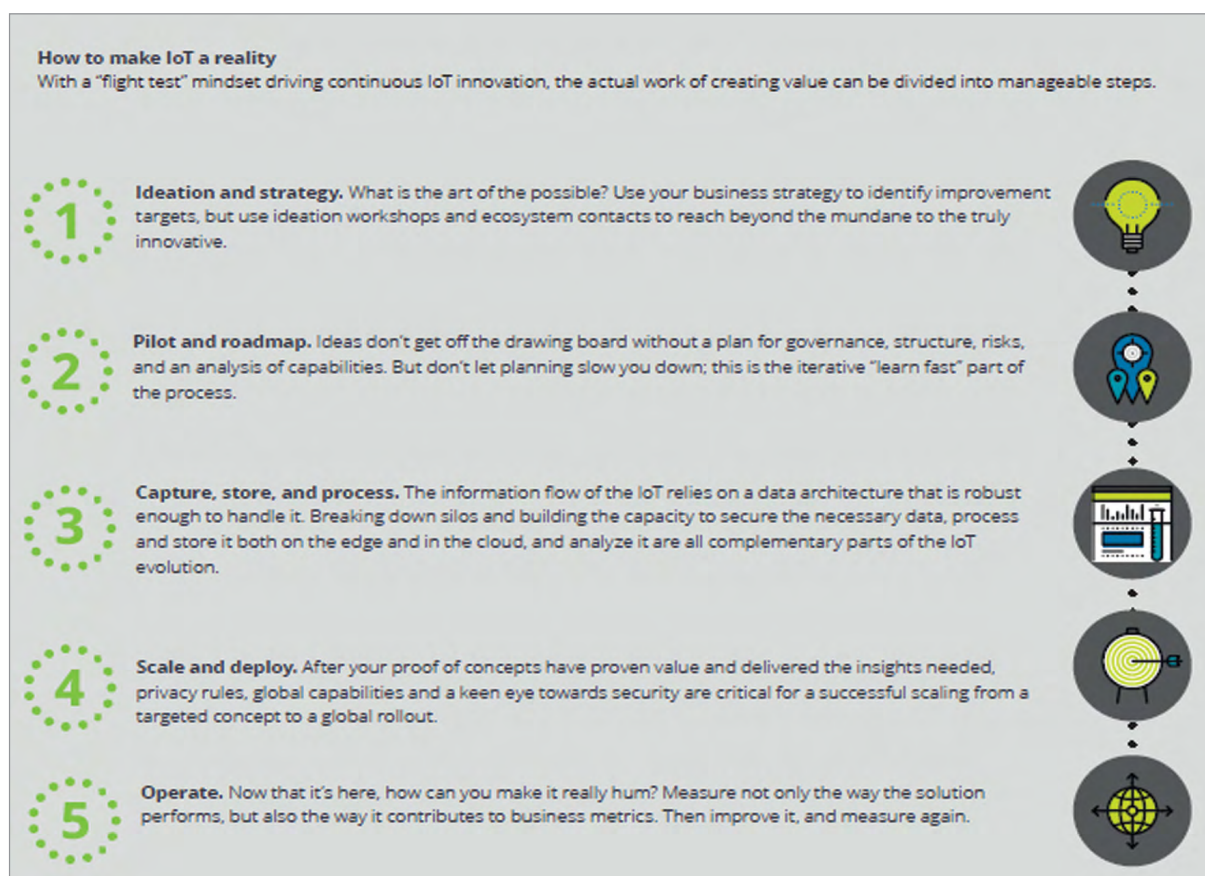
Airline companies are introducing new concepts able to predict necessity of maintenance, digital and physical asset tracking, and invest in smart work labor. By assimilating the capabilities of Internet of Things networks with exponential technologies like 3D printing and robotics, they will comprehend scenarios like the image in *Figure 6*. *[Deloitte, 2017]*

It is addressed to the main purpose of maintaining an airplane in a secure operation while improving the operation of the aircraft

Fig. 6: IoT in aviation system architectures (https://www2.deloitte.com/content/dam/Deloitte/us/Documents/consumer-business/us-cb-traveling-at-the-speed-of-knowledge.pdf)

Fig. 7: How to make IoT reality (https://www2.deloitte.com/content/dam/Deloitte/us/ Documents/consumer-business/us-cb-traveling-at-the-speed-of-knowledge.pdf)

and its crew. A comparable way in the value loop of data and information, is able to fine-tune baggage handling, save fuel and optimize the speed of back-office operations, as shown in *Figure 7*. [Deloitte, 2017]

FUTURE OF AIRLINE INDUSTRY

The industry of aviation has advanced in a higher manner than it was ever believed to be achieved. Space travel for private persons is already a reality of the year 2020. Dennis Tito was able to experience space travelling in 2001, due to constantly development of technologies. Travel in space will become more accessible in the near future.

In 2004, Sir Richard Branson introduced the pioneer company Virgin Galactic. It offers suborbital space launches and flights to potential tourists and missions for scientific domains. By the late 2010, Elon Musk introduced alternative space technology with the launching

of his private company SpaceX, founded in 2002. It became the first provider able to launch and recuperate spacecraft fuel tanks from the orbit of Earth.

It is expected that space tourism is becoming the next most desired travel sensation in this decade. Wired magazine informs that the flying cars from Uber are due to arrive in Texas/USA and Dubai/UAE by the end of 2020. More significantly, the company Uber has partnered various contracts with companies that are currently developing electric aircrafts that are able to vertical takeoff and landing. *[Aeron, 2018]*

In *Figure 8*, a list of 50 key drivers of change were identified that will have an impact on the industry until 2035.

An initial scan of the near horizon was conducted by using a 'STEEP' framework (Society, Technology, Economics, Environment, Politics). The purpose was to recognize relevant drivers and trends that encourage the phenomena
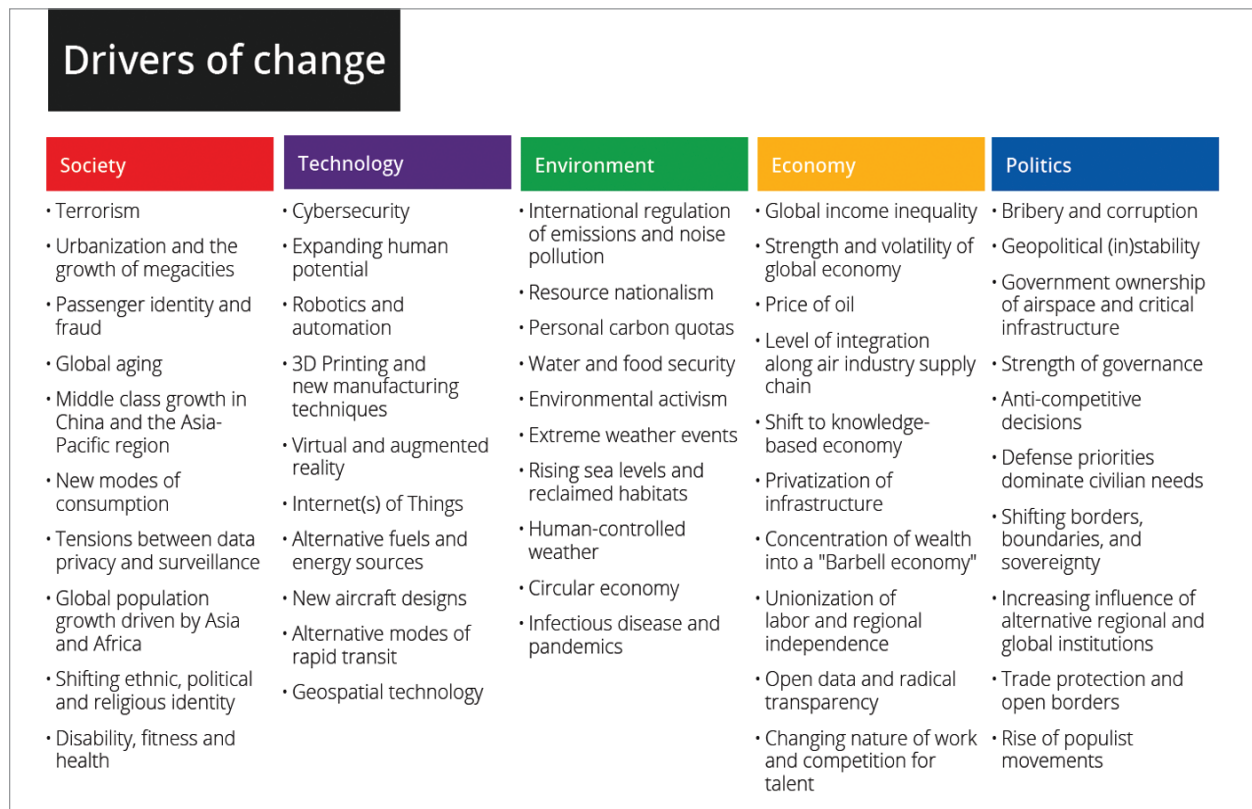
Fig. 8: *50 Change drivers for the airline industry (In: International Air Transport Association (2018), Future of the Airline Industry 2035)*

of change, as well as development of new technologies, lifestyles, threats and possible wild cards, that might influence the industry's external operating framework. *[IATA, 2018]*

BLOCKCHAIN INITIATIVES IN AEROSPACE INDUSTRY

IATA Coin

The IATA Coin is an idea of the aviation industry owned as a supranational digital currency. This concept is deals with Blockchain technology and Smart Contracts embedded in IATA systems for settlement, specifically the IATA Clearing House.

IATA Digital Certification Authority

IATA is the certification authority in air management (e.g. IOSA28). At present times, IATA is stepping into the new era of digital technology. The DCA – Digital Certification Authority notion is an online platform designed to reduce complexity of digital ID management in the commercial aviation and space of distribution (i.e.: agents, airport personnel,

aggregators, passengers, airports international airlines and many others) implementing emerging compliance ready technologies like Blockchain, Artificial Intelligence, Internet of Things and Biometrics. *[IATAa, 2018]*

International initiatives for air travel industry using Blockchain technology

This segment enlarges a list of non-exhaustive projects crossover the travel industry, developing and implementing solutions with Blockchain technology.

• **Aeron** – Blockchain system architectures for Aviation Safety. The preliminary scenario was based on the way airlines developed and constructed their business model, in order to deliver the aircraft's and pilot's flight logs. It is designed for delivering superior security options when dealing with airplane proprietors or signing private licensed pilots.

• **Loyyal** – reinventing the customer incentives of management, reward and conception. It

envisages to be scalable for networks of partners and at the same time, easing the costs associated with settlement and reconciliation with real-time functions and insights.

• **Ozone** – an alternative distribution system designed for air transportation, in order to overcome the restrictions of legacy systems. The company is building a secondary market place with numerous customers and distributors, by enabling next generation range of products.

• **SITA FlightChain** – developed for real-time flight information shared in a Blockchain ledger in collaboration with delegated authorities. FlightChain, is a digital file document that uses smart contracts technology, in order to increase the results of the research and development together with international partners such as British Airways, Geneva Airport, Heathrow Airport and Miami International Airport.

• **TravelBlock** – a Global Distribution System (GDS) alternative based on the Blockchain technology, designed for increasing security, generating cost savings and transparency for the clients of airlines.

• **TravelChain** – an open source Blockchain solution for collaborative management for all market participants crossover the air travel industry.

• **TripBit** – a Blockchain token based on cryptocurrency facilities for payment systems across the travel industry, with embedded optional information about hotel reservations, payment for flights or booking events.

• **Trustabit** – offers digital services to support customers get compensation for delayed/annulled flights of different airlines. This feature is available only by using Blockchain technology and smart contracts, in order to generate vouchers in an automatic manner to travelers, at the moment of a flight disruption.

• **Winding Tree** – its objectives are to disrupt inventory and distribution management for the air travel industry, hotels and flights. The business model generates a marketplace on Blockchain that records the travel associated transactions and reservations through digital channels with direct access to the list of air travel products and service providers in the industry. *[IATAa, 2018]*

CONCLUSIONS

The nowadays question is what are the benefits that Blockchain offers for the aerospace industry? Provenance of information, real cost transparency transactions or elimination of economic inefficiencies. The digital innovation has become imperative and this technology is crucial, because it is a real need not only to visualize real-time data of components and engines of an aircraft in operation, but also to simulate and create new and more powerful dynamic models where the developers can create scenarios like weather issues, passenger management, maintenance issues, cargo and logistics, COVID-19 pandemic management and many others. Using Blockchain technology allows us to inspire the physical world related issues.

Blockchain technology can effortlessly challenge the aerospace industry weak points and there is trust that the power and efficiency of Blockchain technology will positively innovate the whole aerospace industry, around the world.

A substantial conclusion is that institutions and organizations of the air travel industry, who early embrace the superiority of a blockchain based ecosystem with Asset Tokenization, Governance layers and adequate cyber security monitoring, stand to take advantage from its exclusive benefits. Among these organizations count the airlines, air cargo carriers or operators – who will earn considerable revenues due to increased availability of aircrafts. Other partakers in the Blockchain ecosystem could also benefit, through enhanced component traceability – verifying their location and use – or the capability to generate innovative revenue business models.

In Romania, the research and development in Blockchain technology (public or private) for the national air travel industry and services, could create new business opportunities for

incumbent manufacturers, maintenance companies and startups, to develop and implement next generation solutions of the Industry 4.0, on outsourcing, traceability management, air-traffic control, 3D printing and systems modelling. *[Chuck et al., 2019]*

REFERENCE LIST

ADS reports (2019) Aviation Blockchain Market – Global Forecast to 2025. Market and Markets official web page, https://www.asdreports.com/market-research-report-505281/aviation-blockchain-market-global-forecast

AERON (2018) Blockchain for Aviation Safety. Aeron official webpage. https://aeron.aero/

BusinessWire Online Magazine (2020) Blockchain in the Aerospace and Defense Market 2020-2025 – Anticipated to Register a CAGR of over 35%. BusinessWire online web page, https://www.businesswire.com/news/home/20200701005410/en/Blockchain-Aerospace-Defense-Market-2020-2025---Anticipated

Chuck M. C., Parker R., Thomson S. (2019) How Blockchain can improve the aviation industry. Strategy + Business online magazine, https://www.strategy-business.com/article/How-blockchain-can-improve-the-aviation-industry?gko=9e976

Crypto World Network Online News (2018) Chinese Aerospace develops Blockchain invoice system. https://www.cw-nn.com/chinese-aerospace-develops-blockchain-invoice-system/

Deloitte Report (2017) Travel at the speed of knowledge. Exploring operation and profit benefits of deploying the Internet of Things. Deloitte official web page, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/consumer-business/us-cb-traveling-at-the-speed-of-knowledge.pdf

General Electric (GE) Aviation (2020) GE Aviation launches health application ID for the aviation industry. GE Aviation Press release, https://www.geaviation.com/press-release/digital-solutions/ge-aviation-launches-health-application-id-aviation-industry

General Electric (GE) Aviation (2020) New health app ID aims to restore passenger confidence. GE Aviation Blog, https://blog.geaviation.com/technology/new-health-app-id-aims-to-restore-passenger-confidence/

IATA International Air Transport Association (2018) Future of the Airline Industry 2035. IATA international webpage, https://www.iata.org/contentassets/690df4ddf39b47b5a075bb5dff30e1d8/iata-future-airline-industry-pdf.pdf

IATA International Air Transport Association (2018) Blockchain in aviation white paper. IATA international web page, https://www.iata.org/contentassets/2d997082f3c84c7cba001f506edd2c2e/blockchain-in-aviation-white-paper.pdf