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Distributed Ledger Technology in the Airline Industry: Potential Applications and Potential Implications

Roberto Cassar
UN International Residual Mechanism for Criminal Tribunals

DISTRIBUTED LEDGER TECHNOLOGY IN THE AIRLINE INDUSTRY: POTENTIAL APPLICATIONS AND POTENTIAL IMPLICATIONS

ROBERTO CASSAR*

ABSTRACT

The objective of this article is to merge the growing phenomenon of distributed ledger technology with the airline industry.

This article attempts to attain its objective by succinctly clarifying what distributed ledger technology truly is without explaining the minutest of its details. Further, this article seeks to achieve its objective by suggesting potential manners in which this technology could apply to the airline industry; this is an endeavour that, so far, does not seem to have been undertaken in a strict academic sense. Lastly, this article strives to link these potential applications to the empire of the law by shedding light on the legal implications that could arise from them.

By attempting to achieve its objective in the manner laid down above, this article intends to both generate a discussion on the applicability of distributed ledger technology to the airline industry and encourage an influx of deeper studies on this innovative theme by lawyers, economists, and engineers alike.

I. INTRODUCTION

OVER THE PAST THIRTY YEARS, the airline industry has evolved significantly. This evolution has resulted from a range of phenomena that have affected its commercial surroundings—phenomena such as the rise and proliferation of

* The author is a *Pro Bono* Legal Assistant at the UN International Residual Mechanism for Criminal Tribunals. The author obtained an LLM (*Cum Laude*) in Advanced Studies in Air and Space Law, International Institute of Air and Space Law, Leiden University (2016–2017).

low-cost carriers, the spread of terrorism, the tensing of geopolitics, and the sporadic occurrence of natural calamities.[1]

Notwithstanding this spectrum of catalytic events, aviation has remained a financial stronghold. Evidence of this prowess stems from both its total global economic impact, which in the year 2014 rested at a comfortable 2.7 *trillion* U.S. dollars, and its healthy clientele, which in the year 2015 was composed of 3.6 billion passengers and 51.2 million tons of freight.[2]

Although the robustness of these figures certainly signifies an industrial strength of great proportions, the next thirty years of the airline industry are, however, forecast to be more turbulent than the former, particularly "as a new wave of technological . . . innovation unfurls."[3] One such innovation, it is contended, is that of distributed ledger technology, and against this backdrop this article seeks to determine how this technology can apply to the airline industry and what its effects could be from a legal perspective.

Since this article is seemingly the first of its kind in trying to combine the relative novelty of distributed ledger technology to the airline industry, it begins its first section by concisely clarifying the technology involved. In its second section it then proceeds by conducting a brief analysis of the structure of the airline industry and by exploring the possible ways in which the technology could apply thereto. This article draws the discussion to a close in its third section by demarcating the legal implications that could arise from the proposed applications of the technology to the industry, especially in terms of the legal architecture of the European Union (EU).

With regard to the methodology applied it seems necessary to indicate that, when carrying out the research and structuring the arguments, considerable effort was made to find an equitable balance between the more authoritative sources employed in "traditional" jurisprudential papers—sources such as monographs, journal articles, case law, and the law itself—and the more authoritative sources employed in "contemporary"

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[1] INT'L AIR TRANSP. ASS'N & SCH. OF INT'L FUTURES, *Future of the Airline Industry 2035*, 1, 5 (Aug. 29, 2017), https://www.iata.org/policy/Documents/iata-future-airline-industry.pdf [https://perma.cc/23DM-H74N].

[2] *Fact Sheet: Aviation Benefits Beyond Borders*, INT'L AIR TRANSP. ASS'N (Dec. 2017), http://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-economic-and-social-benefits-of-air-transport.pdf [https://perma.cc/C46A-7BUW].

[3] *See Future of the Airline Industry 2035*, *supra* note 1.

ones—such as electronic news reports, studies by intergovernmental organisations, and reports by law firms and financial institutions. These sources, it must be conclusively added, were reinforced as much as possible with quantitative and statistical figures found in various studies and analyses.

II. UNDERSTANDING THE MISUNDERSTOOD

Upon reading or hearing the word "blockchain," images of virtual currencies and vast riches instinctively race through the mind as if they were synonymous with this particular unit of language. Yet blockchain is much more than just these mental mirages. Suffice it to say, in order to elucidate this point better, that blockchain and "Bitcoin" are often used interchangeably and incorrectly so: although the two are strongly associated, the former is merely the technology through which the latter functions.[4]

Bitcoin is a virtual currency that provides its own unit of account and payment systems, allowing for peer-to-peer (person-to-person) transactions without central clearing houses and central banks.[5] Accordingly, Bitcoin is not saved in a file in a specific place, but it is "represented by transactions recorded in a blockchain": "a global . . . ledger, which leverages the resources of a [vast] peer-to-peer . . . network to verify and approve each . . . transaction."[6]

Defined in a more methodical fashion, blockchain is a ledger with three central elements: (1) it is distributed, in that it runs on computers worldwide; (2) it is public, in that, since it resides on the network, anyone can view it at any time; and (3) it is encrypted, in that it uses heavy-duty encryption, involving long numbers in the forms of "public" and "private" keys,[7] to maintain virtual security.

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4 Fiammetta S. Piazza, *Bitcoin and the Blockchain as Possible Corporate Governance Tools: Strengths and Weaknesses*, 5 PENN ST. J. L. & INT'L AFF. 262, 274 (2017).

5 Christine Lagarde, *Central Banking and Fintech—A Brave New World?*, INT'L MONETARY FUND (Sept. 29, 2017), https://www.imf.org/en/News/Articles/2017/09/28/sp092917-central-banking-and-fintech-a-brave-new-world [https://perma.cc/Z9N8-HHUF].

6 DON TAPSCOTT & ALEX TAPSCOTT, BLOCKCHAIN REVOLUTION: HOW THE TECHNOLOGY BEHIND BITCOIN IS CHANGING MONEY, BUSINESS, AND THE WORLD 6 (2016).

7 TAPSCOTT & TAPSCOTT, *supra* note 6, at 7. The public and private keys are similar to a two-key system used to access a safety deposit box. The public key is a long number available publicly and published by the private key owner, and anyone who would like to send the publisher an encrypted message can do so by

From this terminological dissection it is thus possible to draw that, while Bitcoin is a "digital money ecosystem,"[8] "blockchain is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way,"[9] with the "block" serving as the container of a short sequence of transactions,[10] and the "chain" resulting from all the blocks being stored in a certain order.[11]

At this juncture, it is to be further elucidated that, as with blockchain and Bitcoin, the terms blockchain and distributed ledger are erroneously interchanged.[12] For while the former is implicitly the latter, the latter is *not* implicitly the former. Indeed, a distributed ledger is a digital record "shared instantaneously across a [public *or* private] network of participants," with the record being held by each network user—or node—who must all agree on it, and with "each copy [of the record being] updated with new information simultaneously."[13]

Consequently, in light of the fact that a distributed ledger is a digital record shared across a public or private network, it can be deduced that blockchain, as a solely public ledger, is but one breed of this technology.[14] In this sense, while blockchain is necessarily a distributed ledger, a distributed ledger is not necessarily blockchain.

In fact, while blockchain is one breed of distributed ledger technology, it is not the only breed thereof, with another such type being "non-blockchain." Non-blockchain is a private distrib-

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using the published public key. The private key is a randomly generated, long number which is kept secret and held privately by the users, and its function is to decrypt the encrypted messages received. IMRAN BASHIR, MASTERING BLOCKCHAIN: DISTRIBUTED LEDGER, TECHNOLOGY, DECENTRALIZATION AND SMART CONTRACTS EXPLAINED 80–81 (2017).

8 ANDREAS M. ANTONOPOULOS, MASTERING BITCOIN: PROGRAMMING THE OPEN BLOCKCHAIN 1 (2d ed. 2017).

9 Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARV. BUS. REV., Jan.–Feb. 2017, https://hbr.org/2017/01/the-truth-about-blockchain [https://perma.cc/X675-DUGF].

10 Björn Tackmann, *Secure Event Tickets on a Blockchain*, *in* DATA PRIVACY MANAGEMENT, CRYPTOCURRENCIES AND BLOCKCHAIN TECHNOLOGY 437, 438 (J. Garcia Alfaro et al. eds., 2017).

11 Dirk A. Zetzsche et al., *The Distributed Liability of Distributed Ledgers: Legal Risks of Blockchain*, 52 UNIV. N.S.W. L. RES. SERIES 1, 11 (2017).

12 INT'L SWAPS & DERIVATIVES ASS'N, INC. & LINKLATERS, WHITEPAPER: SMART CONTRACTS AND DISTRIBUTED LEDGER – A LEGAL PERSPECTIVE 7 (Aug. 2017), https://www.isda.org/a/6EKDE/smart-contracts-and-distributed-ledger-a-legal-perspective.pdf [https://perma.cc/9PH7-NUJ2].

13 *Id.*

14 Piazza, *supra* note 4.

uted ledger, which is being designed and created to address the needs of areas like the financial services industry wherein it is not suitable for all transactions to be public.[15]

Setting this dichotomy in distributed ledgers aside, the crux of the underlying technology is that it allows for a system wherein, instead of having several competing sets of records that need to be continuously reconciled, there exists only one such set of records maintained on multiple interconnected nodes, which must reach consensus on that set.[16]

Still further, blockchain in particular has the potential to render third-party intermediaries and their incumbent costs redundant,[17] for these intermediaries subsist in the "centralized" and "replicated" ledger systems[18] where multiple repositories house data and continuously duplicate, update, and reconcile it, thereby leading to the incurring of "extra frictional costs."[19]

To this end, blockchain holds "profound implications for many institutions," and its applications are so vast that "[it] can be programmed to record virtually everything of value and importance to humankind: birth and death certificates, marriage licenses, deeds and titles of ownership, educational degrees, financial accounts, medical procedures, insurance claims, votes,

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15 *See* BAKER MCKENZIE & R3, BLOCKCHAINS AND LAWS. ARE THEY COMPATIBLE? 5–7 (July 2017), https://www.bakermckenzie.com/-/media/files/expertise/fig/br_fig_blockchainsandlaws_jul17.pdf?la=en.

16 *See* WHITEPAPER: SMART CONTRACTS AND DISTRIBUTED LEDGER – A LEGAL PERSPECTIVE, *supra* note 12.

17 *See* Christian Catalini, *How Blockchain Technology Will Impact the Digital Economy*, OXFORD BUS. L. BLOG (Apr. 24, 2017), https://www.law.ox.ac.uk/business-law-blog/blog/2017/04/how-blockchain-technology-will-impact-digital-economy [https://perma.cc/2GR7-6HUQ].

18 Peter Evans-Greenwood et al., *Bitcoin, Blockchain & Distributed Ledgers: Caught Between Promise and Reality*, DELOITTE AUSTRALIA 1, 12 (Mar. 2016), https://www2.deloitte.com/content/dam/Deloitte/au/Images/infographics/au-deloitte-technology-bitcoin-blockchain-distributed-ledgers-180416.pdf [https://perma.cc/G9SJ-QALS]. In centralized and replicated ledger systems, ledgers are updated and maintained by a central authority with whom other actors must communicate in order to submit records for inclusion in the ledgers. *Id.* The difference between these two systems is that, in the centralized system the actors must travel to the central authority if they want to consult records, whereas in the replicated system the "actors can obtain a copy of the ledger if they want to consult it." *Id.* In both cases, however, the central authority ensures ledger identity and integrity by restricting access to it. *Id.*

19 ROGER MAULL ET AL., *Distributed Ledger Technology: Applications and Implications*, *in* STRATEGIC CHANGE 481, 485 (2017).

provenance of food, and anything else that can be expressed in code."[20]

In conclusion, while distributed ledger technology and its derivatives such as blockchain are portrayed as tools to make money, in truth they are not solely money-making tools; rather, they are a stepping stone to a new world.

III. POTENTIAL APPLICATIONS IN THE AIRLINE INDUSTRY

The airline industry has a life of its own. Similar to many other living things, this industry is composed of numerous distinct organs interlinked into one seamless body. At the epicentre of this body lie the air carriers: the pounding heart of the industry. Above and below them lie two separate networks of indispensable actors: the veins and arteries that respectively transport blood to and from the heart.

On the one hand, the network of actors lying above the air carriers—the veins transporting blood to the heart—includes, *inter alia*, aircraft and aircraft component manufacturers, lessors, infrastructure providers such as airports, and service providers such as insurers.[21] On the other hand, the network of actors lying below the air carriers—the arteries transporting blood from the heart—includes, *inter alia*, freight forwarders, global distribution systems (GDSs), and online travel agencies (OTAs).[22]

By so likening the airline industry to a living organism, it is possible to extrapolate two correlative facts. First, it is possible to extrapolate that the industry clearly functions in a complex manner which is oft-overlooked. Second, it is possible to extrapolate that, because of this functional complexity, the exchange of data within the industry "is not always smooth."[23]

Indeed, in the background a web of intricate and endless data reconciliation is perpetually being weaved, because all the actors involved are constantly collecting, storing, and sharing information among each other, with the air carriers alone sharing data

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[20] TAPSCOTT & TAPSCOTT, *supra* note 6, at 7–8.

[21] Michael W. Threteway & Kate Markhvida, *The Aviation Value Chain: Economic Returns and Policy Issues*, 16 J. AIR TRANSP. MGMT. 3, 5 (2014).

[22] *Id.*

[23] *Beyond the Buzz: The Potential of Blockchain Technology for Airlines*, ACCENTURE CONSULTING (2017), https://www.accenture.com/us-en/insight-potential-blockchain-technology-for-airlines [https://perma.cc/8K44-496L].

even internally as it is stored in "isolated systems ranging from passenger service to crew management."[24]

Recalling at this point that a distributed ledger is a digital record of data "shared instantaneously across a network of participants,"[25] it follows without much difficulty that distributed ledger technology has the potential to apply like clockwork in an industry such as the one under consideration where multiple records of data are shared among and within a network of multiple actors. The concomitant question, therefore, is "how can it apply?"

A. Rational Application of Distributed Ledger Technology

In determining how distributed ledger technology can apply in the airline industry, it is suitable to depart from a succinct proposition. This proposition, as shall be seen, quite simply suggests that the industry ought to capitalize on the dichotomy of distributed ledger technology and apply both blockchain and non-blockchain ledgers.

As explained above, the airline industry has two major networks: (1) the network between the air carriers and the actors that distribute passengers and cargo, i.e. the network between the heart and the arteries; and (2) the network between the air carriers and the actors that provide the infrastructure, services, and aircraft or aircraft components, i.e. the network between the heart and the veins.

The difference between these two networks is that while the former "arterial network" has a predominantly *public* nature, the latter "venous network" has a predominantly *private* one. In other words, while the arterial network entails air carriers providing a product to the public, albeit through third party intermediaries such as GDSs and OTAs, the venous network entails air carriers being provided with a product by the private sector.

Following this line of thought, the airline industry could apply distributed ledger technology in a manner that reflects this rudimentary difference between its two networks: on the one hand, the industry could apply a public distributed ledger—blockchain—to its arterial network between the air carriers and

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24 *Id.*

25 Whitepaper: Smart Contracts and Distributed Ledger – A Legal Perspective, *supra* note 12.

the public, and on the other, it could apply a private distributed ledger—non-blockchain—to its venous network between the air carriers and the private industry.

Based on this proposition, there are two potential respects in which the airline industry could apply both blockchain and non-blockchain.

B. Applying Blockchain: A Case for E-Tickets

Starting with blockchain, the most critical respect in which it could apply is that of "e-tickets" (electronic tickets), which, according to the International Air Transportation Association (IATA), constituted 96.5% of all tickets issued worldwide by the year 2008.[26]

An e-ticket can be formally defined as (i) "the [i]tinerary [or] [r]eceipt issued by or on behalf of the [air] [c]arrier"; (ii) "the electronic coupons"; and (iii) "if applicable, a boarding document."[27] Notwithstanding this structural decomposition of the term, an e-ticket is but a database entry—data that, instead of being printed on a paper, is "dematerialized, stored in and called up from a massive database."[28]

In light of the fact that e-tickets are essentially dematerialized data, and recalling that blockchain, as a breed of distributed ledgers, is nothing more than a digital record of data shared across a network, it is possible to conclude that blockchain technology can be quite seamlessly fused with e-tickets.

This fusion can be achieved by "tokenizing" the e-tickets.[29] This means converting the rights to the ticket—the physical asset—into a "token,"[30] which is the digital equivalent of the asset.[31] To this end it must be added that, because tokens are themselves digital, when one buys a token one is effectively buying a private key (the long number mentioned previously) that

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[26] Peter Belobaba et al., *Information Technology in Airline Operations, Distribution and Passenger Processing*, *in* The Global Airline Industry 461, 481 (2d ed. 2016).

[27] Int'l Air Transp. Ass'n, Ticketing Handbook 1 (39th ed. 2007).

[28] *Beyond the Buzz: The Potential of Blockchain Technology for Airlines*, *supra* note 23.

[29] *Id.*

[30] Addison Cameron-Huff, *How Tokenization is Putting Real-World Assets on Blockchain*, Nasdaq (Mar. 30, 2017), http://www.nasdaq.com/article/how-tokenization-is-putting-real-world-assets-on-blockchains-cm767952 [https://perma.cc/6VYG-EYG8].

[31] *See* Preethi Kasireddy, *Bitcoin, Ethereum, Blockchain, Tokens, ICOs: Why Should Anyone Care?*, Hackernoon (July 5, 2017), https://hackernoon.com/bitcoin-ethereum-blockchain-tokens-icos-why-should-anyone-care-890b868cec06[https://perma.cc/68GE-ZKQP].

grants access to the token and therefore to the underlying asset,[32] *ergo* the ticket.

Having submitted how this fusion could be carried out, it is possible to submit what this fusion would lead to. To this end, it is necessary to reiterate the point that blockchain has the potential to render third-party intermediaries and their incumbent costs redundant,[33] because these intermediaries subsist in the centralized and replicated ledger systems, which are the diametrical opposites of the distributed ledger system that is blockchain.

On the ground of this submission it can be sensibly posited that, if the air carriers were to fuse blockchain with e-tickets, they could lead third-party intermediaries such as GDSs and OTAs to become less vital over time. In practice this would mean that the air carriers could lower transaction costs,[34] thereby making the most of blockchain, and thus *sell tickets at lower prices.*

Over and above, the air carriers could try to attract the $200 billion in additional revenue—or parts thereof—that is projected to migrate to the online channels by the year 2021.[35] This is all while breaking away from their current subservient position wherein they have little choice but to accept the terms of these third-party intermediaries, which at times can be of an anti-competitive nature as witnessed in *US Airways, Inc. v. Sabre Holdings Corp.*[36]

As innovative as this idea of fusing e-tickets with blockchain might sound, some actors of the industry have already begun to explore it. In fact, Swiss start-up Winding Tree has teamed up with Air New Zealand and Lufthansa to explore blockchain-

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[32] Vikram Dhillon et al., Blockchain Enabled Applications: Understand the Blockchain Ecosystem and How to Make it Work for You 81 (2017).

[33] *See* Catalini, *supra* note 17.

[34] Trevor I. Kiviat, *Beyond Bitcoin: Issues in Regulating Blockchain Transactions*, 65 Duke L.J. 569, 572 (2015).

[35] Henry H. Harteveldt, *The Future of Airline Distribution: 2016–2021*, Int'l Air Transp. Ass'n 1, 36 (2016), https://www.iata.org/whatwedo/airline-distribution/ndc/Documents/ndc-future-airline-distribution-report.pdf [https://perma.cc/C43X-6N78].

[36] *See* 105 F. Supp. 3d 265 (S.D.N.Y 2017). In this case, Sabre violated antitrust law as it forced US Airways to accept a contract on its terms, or risk being cut off from its network. *See* Nate Raymond, *American Airlines Wins $15 Million in Antitrust Case Against Sabre*, Reuters (Dec. 20, 2016), https://www.reuters.com/article/us-american-airline-sabre/american-airlines-wins-15-million-in-antitrust-case-against-sabre-idUSKBN1492K4 [https://perma.cc/LD55-2AT5].

based applications that could help them improve things like their booking service, thereby allowing both their customers to benefit from reduced transactional costs, and themselves to utilize the swift sharing of information.[37]

More audaciously, toward the end of July 2017, S7 Airlines started selling tickets through blockchain.[38] This move was supported by the largest private financial institution of Russia, Alfa-Bank, at the very least because "[t]he system of payments on the basis of the [blockchain] ensures the receipt of proceeds from sales, minus the commission of the agent immediately after the issuance of the ticket."[39]

Fusing e-tickets with blockchain, in sum, has both the potential to make the arterial network between the airlines and the public more lucrative and the potential to put it on an even keel.

C. Applying Non-Blockchain: A Case for Maintenance

Non-blockchain, on the other hand, is most applicable to aircraft maintenance. A study carried out by the Maintenance Cost Task Force of IATA demonstrated that global maintenance, repair, and overhaul spending was valued at $62.1 billion in the year 2014.[40]

According to the same study, developing trends and technologies in maintenance such as aircraft health monitoring systems and additive manufacturing (3-D printing) are estimated to decrease maintenance, repair, and overhaul spending by 15–20%.[41] This translates to a decrease of around $9.3–12.4 billion. This estimated decrease in spending could be pushed further down with the application of non-blockchain to maintenance.

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[37] *See* Gertrude Chavez-Dreyfuss, *Air New Zealand, Swiss Travel Platform Winding Tree in Blockchain Tie-Up*, Reuters (Nov. 22, 2017), https://www.reuters.com/article/us-blockchain-travel-airnewzealand/air-new-zealand-swiss-travel-platform-winding-tree-in-blockchain-tie-up-idUSKBN1DM2KQ [https://perma.cc/LD55-2AT5].

[38] Tom Ward, *An Airline Just Started Using an Ethereum Blockchain to Issue Tickets*, Futurism (July 26, 2017), https://futurism.com/an-airline-just-started-using-ethereum-blockchain-to-issue-tickets/ [https://perma.cc/VVH4-QJJU].

[39] Vladislav Noviiy, *Flights Pay for the Block*, Kommersant (July 27, 2017), https://www.kommersant.ru/doc/3365852.

[40] This excludes overhead. Int'l Air Transp. Ass'n Maintenance Cost Task Force, Airline Maintenance Cost Executive Commentary 14 (Dec. 2015).

[41] *Id.* at 15.

Modern aircraft consist of millions of components, with the lifecycle of each involving many actors—from manufacturer to transporter and from transporter to operator—all with a maintenance system of their own.[42] Due to this individuality, the systems are disparate, and because of this disparity between systems, the entire lifecycle of a specific component does not easily yield a singular string of coherent data.[43]

In addition, because the relevant data is maintained either on computerized records or on paper, synchronizing such computerized record systems (which can be incomplete), or such paperwork—"job cards with 'dirty finger prints'"—is not a smooth process and thus can introduce unwanted delays.[44] In this light, it is apparent that a link needs to be created between the various actors dealing with an aircraft component, such as between the repair organization and the maintenance organization.[45]

Clearly, from this exposition it emanates that the industry is yearning for non-blockchain to apply to maintenance as it could provide this much-needed link between the various actors involved. Considering that maintenance is rich in the sharing of data among a variety of actors, and considering that non-blockchain, as a breed of distributed ledger technology, is a digital record of data shared across a network, by combining the two together all the actors involved in maintenance could share one consolidated record for each aircraft component.

Translated into practical terms, the manufacturer would begin by creating a non-blockchain for a specific component, and all other actors would build upon that foundation by adding blocks whenever they come into contact with the component.[46] For instance, the distributor would add a block when a component is delivered from one location to another, and the operator would add a block with "the number of flight hours that the [component] has undergone."[47]

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[42] *See* Bas de Vos, *Blockchain for Aviation Asset Management*, FARNBOROUGH INT'L NEWS NET. (Aug. 1, 2017), https://www.wearefinn.com/topics/posts/blockchain-for-aviation-asset-management/ [https://perma.cc/4DMQ-SVYD].

[43] *Id.*

[44] INT'L AIR TRANSP. ASS'N, BEST PRACTICES FOR COMPONENT MAINTENANCE COST MANAGEMENT 12 (2d ed. 2015).

[45] *Id.* at 15.

[46] de Vos, *supra* note 42.

[47] *Id.*

Although this idea of combining maintenance with non-blockchain might seem forward-looking, as with the case of e-tickets and blockchain, some actors in the industry have already begun exploring it. Indeed, Boeing has designed a network that, by "integrat[ing] customers, parts suppliers, and component overhaul providers," seeks to "deliver a flexible suite of services supporting airline maintenance, repair, and overhaul services."[48]

While Boeing is mainly developing this network in order to "[reduce] outages and unplanned maintenance,"[49] Lufthansa is exploring, through a similar initiative, how this type of technology "can be used to increase transparency within flight maintenance."[50] Furthermore, Air France-KLM has started evaluating the potential of this type of technology becoming its "new digital ledger for managing replacement parts on in-service airplanes."[51]

Air France-KLM even went to the extent of demonstrating how this would work in practice: once a faulty aircraft component was identified on a mock flight, an engineer was able to acquire a replacement by creating a distributed ledger for that piece.[52] This ledger could be viewed by himself, the Air France-KLM logistics and loan officers, and other engineers or technicians responsible for obtaining the replacement part.[53]

All in all, applying non-blockchain to maintenance can lead the venous network between the airlines and the private sector to enjoy a wholly "verifiable, traceable and trustworthy history of the . . . lifecycle" of a component, leading to improved data

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48 Jeff Liu & Paul Brody, *Is Collaboration the New Innovation?*, HARVARD BUS. REV. 1, 4 (Nov. 2016), https://hbr.org/resources/pdfs/comm/ey/IsCollaborationTheNewInnovation.pdf [https://perma.cc/L58E-NMAZ].

49 Carlo Gutierrez, *Boeing Improves Operations with Blockchain and the Internet of Things*, ALTOROS (May 24, 2017), https://www.altoros.com/blog/boeing-improves-operations-with-blockchain-and-the-internet-of-things/ [https://perma.cc/S37R-ES7D] (quoting Robert Rencher, Senior Systems Engineer, Boeing).

50 Woodrow Bellamy III, *IOT, Blockchain Proposed to Improve Aircraft Maintenance Process*, AVIONICS (Jan. 13, 2017), http://www.aviationtoday.com/2017/01/13/iot-blockchain-proposed-to-improve-aircraft-maintenance-process/ [https://perma.cc/Q9D4-BK49].

51 Woodrow Bellamy III, *Air France KLM is Evaluating MRO Potential for Blockchain*, AVIONICS (Oct. 3, 2017), http://www.aviationtoday.com/2017/10/03/air-france-klm-evaluating-mro-potential-blockchain/[https://perma.cc/3JBL-RD5U].

52 *Id.*

53 *Id.*

quality, more accurate maintenance history, cheaper compliance and, in turn, increased airworthiness.[54]

IV. POTENTIAL IMPLICATIONS OF THE POTENTIAL APPLICATIONS

Having assessed the potential applications of blockchain and non-blockchain within the airline industry, a subsequent analysis of the potential legal implications resulting therefrom can be undertaken.

This analysis shall correspond to the proposition that blockchain and non-blockchain can be *both* applied to the airline industry. Thus, the analysis begins with the legal implications resulting from the application of blockchain to the arterial network of the industry, then the analysis shifts to the legal implications resulting from the application of non-blockchain to the venous network.

A. The Legal Implications of Blockchain

With regard to blockchain it has been suggested that a principal respect in which it could apply is that of e-tickets, done by converting the rights to an e-ticket into a "token" that in turn becomes the digital equivalent of the e-ticket.

This application could potentially result in a legal implication concerning data protection, most notably within the context of the EU. The EU has adopted the General Data Protection Regulation (GDPR) to ensure a consistent and high level of protection within its Member States of the rights and freedoms of natural persons with regard to the processing of "*personal data*,"[55] which has become as valuable a resource as oil.[56]

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[54] de Vos, *supra* note 42.

[55] Regulation (EU) 2016/679 of the European Parliament of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation), 2016 O.J. (L 119), art. 1(2) [hereinafter General Data Protection Regulation].

[56] World Econ. Forum, Personal Data: The Emergence of a New Asset Class 5 (Jan. 2011), http://www3.weforum.org/docs/WEF_ITTC_PersonalDataNewAsset_Report_2011.pdf [https://perma.cc/3PQB-HWY8]. Personal data is defined by the GDPR as "any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic,

The GDPR applies to "the processing of personal data wholly or partly by automated means and to the processing other than by automated means of personal data which form part of a filing system or are intended to form part of a filing system."[57] While the crux of this sentence is rather straightforward, the trained legal mind cannot help but question the meaning of certain key terms employed in it, such as "processing" and "filing system."

In satisfaction of this irrepressible inclination, it is to be explained that, while the "processing" of personal data is defined as "any operation or . . . operations which is [or are] performed on personal data . . . , whether or not by automated means, such as *collection*, . . . *storage*, . . . or *dissemination*,"[58] the "filing system" of which the personal data forms part is defined as "any structured set of personal data which [is] accessible according to specific criteria, whether centralised, decentralised or *dispersed* on a functional or geographical basis."[59]

With these definitions in place, it is possible to infer that the application of blockchain to e-tickets falls under the GDPR's purview. This inference is rooted in the fact that the information of the natural person divulged when buying an e-ticket would be stored and shared across a distributed ("dispersed," as per the GDPR) network. In simple terms, the personal data of the passenger will be processed by automated means and will form part of a filing system.

Since the GDPR applies to data controllers and processors both inside the EU[60] and outside the EU, so long as the processing activities of the latter relate to, *inter alia*, the offering of goods or services to subjects within the EU,[61] any air carrier that applies blockchain to e-tickets in the EU would be binding itself to comply with the provisions of the GDPR.

Among these provisions are a few that introduce liability, in the form of fines, to data controllers and processors that in-

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cultural or social identity of that natural person." General Data Protection Regulation, *supra* note 55, at art. 4(1).

57 General Data Protection Regulation, *supra* note 55, art. 2(1).

58 *Id.* art. 4(2) (emphasis added).

59 *Id.* art. 4(6) (emphasis added).

60 *Id.* art. 3(1).

61 *Id.* art. 3(2)(a); ALLEN & OVERY LLP, PREPARING FOR THE GENERAL DATA PROTECTION REGULATION 5 (Jan. 2018), http://www.allenovery.com/SiteCollectionDocuments/Radical%20changes%20to%20European%20data%20protection%20legislation.pdf [https://perma.cc/CSS9-ZZDL].

fringe the GDPR.[62] By way of example, the GDPR provides that "those who are at fault for data protection violations can be charged substantial fines," which in certain circumstances can be the higher of either "€20 million or 4 percent of an undertaking's total worldwide annual turnover in the preceding financial year."[63]

To this end, attention ought to be drawn to the fact that these fines can, however, be decreased, such as if the data controller or processor had implemented technical and organizational measures in compliance with the GDPR.[64] Thus, those air carriers deciding to apply blockchain to e-tickets would do well to put in place clear policies and well-practiced procedures which seek to ensure that one can react quickly to any data breach.[65]

In this light, therefore, it is evident that a legal implication potentially resulting from the application of blockchain to e-tickets relates not simply to data protection, but rather to the liability accompanying it. This implication, however, is not the only one that could potentially result from the application of blockchain to e-tickets, since there could also potentially result an implication related to competition (antitrust) law.

With regard to this potential implication of the applicability of blockchain to e-tickets, reference can be made to the statement of the European Securities and Markets Authority that "[t]he shared and public features of [blockchain] could facilitate market manipulation and other unfair practices. In the absence of proper safeguards, some could unduly exploit the information recorded in [blockchain] to front-run competitors or manipulate prices."[66] Although this statement was made in the context of the application of blockchain to securities, this statement can be transposed to the application of blockchain to e-tickets, especially in terms of the potential market and price manipulation that could result from it.

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62 PAUL VOIGT & AXEL VON DEN BUSSCHE, THE EU GENERAL DATA PROTECTION REGULATION (GDPR): A PRACTICAL GUIDE 31 (2017).

63 W. Gregory Voss, *European Union Data Privacy Law Reform: General Data Protection Regulation, Privacy Shield, and the Right to Delisting*, 72 BUS. LAW. 221, 229–30 (2016); General Data Protection Regulation, *supra* note 55, arts. 83(5), 83(6).

64 General Data Protection Regulation, *supra* note 55, art. 83(2)(d).

65 PREPARING FOR THE GENERAL DATA PROTECTION REGULATION, *supra* note 61, at 9.

66 EUROPEAN SEC. & MKTS. AUTH., REPORT: THE DISTRIBUTED LEDGER TECHNOLOGY APPLIED TO SECURITIES MARKETS 11–12 (Feb. 7, 2017), https://www.esma.europa.eu/sites/default/files/library/dlt_report_-_esma50-1121423017-285.pdf [https://perma.cc/Z2QW-59J3].

When analyzing cartel and collusion activity in the airline industry, a problem is that "the *prevalence of information* in the industry makes it fairly simple for airlines to match the prices and output of competitors."[67] This problem could only intensify if blockchain is applied to e-tickets, as the information in the industry will be not only prevalent but also organized on a digital record that is shared across a network.

Consequently, the air carriers would be able to match the prices and output of competitors far more easily than they do today—even through "tacit collusion" whereby they would coordinate their conduct without express communication, such as through price signaling[68]—and this could in turn lead to a surge in the number of cartels formed. To this end, the EU would be particularly prone to such a surge taking place on its soil, for the punishment imposed by the European Commission (EC) with respect to cartels lacks a criminal law nature.[69]

In fact, although the fines imposed by the EC seek to disincentivize the creation of cartels (not specific to the airline industry), they do not seem to serve as a sufficient disincentive since, as demonstrated by a statistical study of the EC itself, from the years 1990 to 1999 the Commission decided twenty cartel cases, from the years 2000 to 2009 it decided more than sixty cases, and from 2010 to November of 2017 it already decided forty-eight cases.[70]

While it is very plausible that this increase in the number of cartels corresponds with the growth of the internal market of the EU and with the existence of a "leniency policy,"[71] which helps uncover such illegal activities, it is unquestionable that this

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[67] BIJAN VASIGH ET AL., INTRODUCTION TO AIR TRANSPORT ECONOMICS: FROM THEORY TO APPLICATIONS 271 (2d ed. 2016) (emphasis added).

[68] *Id.* In terms of this statement it is to be added that, the fact that two air carriers have price fluctuations which match does not mean that they are definitely colluding, but it could mean that they are simply competing. *Id.*

[69] Council Regulation (EC) No 1/2003 of 16 December 2002 on the Implementation of the Rules on Competition Laid Down in Articles 81 and 82 of the Treaty, 2002 O.J. (L 001); *see* Wouter P.J. Wils, *Is Criminalization of EU Competition Law the Answer?*, 28 WORLD COMPETITION 1, 4 (2005).

[70] EUROPEAN COMM'N, CARTEL STATISTICS § 1.10 (Mar. 21, 2018), http://ec.europa.eu/competition/cartels/statistics/statistics.pdf [https://perma.cc/ETE2-5T78]. Note that, in this study, the EC considered only those cartel cases (which are not specific to the airline industry alone) where a fine was imposed.

[71] *See* Commission Notice on Immunity from Fines and Reduction of Fines in Cartel Cases, 2006 O.J. (C 298), as Amended by the Amendments to the Commission Notice on Immunity from Fines and Reduction of Fines in Cartel Cases, 2015 O.J. (C 256).

increase in cartels demonstrates that undertakings are not sufficiently deterred from forming cartels; rather, they are still quite willing to do so.

Accordingly, the EU should strongly consider criminalizing cartels similar to the United States where criminal enforcement is a "cornerstone" of the "successful campaign" of the Department of Justice against cartels[72] and where criminalization of cartel law infringements is adopted on the notion that imposition of a criminal sanction, such as that of imprisonment, serves as a "strong disincentive for individuals to participate in . . . cartel[s]."[73]

B. The Legal Implications of Non-Blockchain

With regard to non-blockchain it has been suggested that a primary respect in which it could apply is that of maintenance by serving as a link between the various actors involved that, through this technology, share one consolidated record for each aircraft component.

A legal implication that could potentially result from this application of non-blockchain relates to product liability, particularly in terms of the Product Liability Directive[74] (PLD) of the EU, which establishes the principle of liability without fault applicable to producers in the EU when a defective product causes damage to a consumer.[75]

In so establishing this principle of liability, the PLD provides several defenses that may exempt the producer from liability, with one such defence requiring proof that "it is probable that the defect which caused the damage did not exist at the time when the product was put into circulation or that this defect came into being afterwards."[76]

In this regard, it is added that, although there have been questions on what may amount to "put into circulation," the

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[72] Peter Whelan, *Legal Certainty and Cartel Criminalisation within the EU Member States*, 71 Cambridge L.J. 677, 678 (2012).

[73] Alexander Italianer, *Fighting Cartels in Europe and the US: Different Systems, Common Goals*, European Comm'n 1, 2 (Oct. 9, 2013), http://ec.europa.eu/competition/speeches/text/sp2013_09_en.pdf [https://perma.cc/82MS-KF96].

[74] Council Directive 85/374/EEC of 25 July 1985 on the Approximation of the Laws, Regulations and Administrative Provisions of the Member States Concerning Liability for Defective Products 1985 O.J. (L210) [hereinafter Product Liability Directive].

[75] *See* O'Byrne v. Sanofi Pasteur MSD Ltd., 2006 E.C.R.1-1343; Sidhant Sharma, *Aviation Product Liability in the European Union*, 15 Aviation & Space J. 1, 4 (2016).

[76] Product Liability Directive, *supra* note 74, art. 7(b).

Court of Justice of the European Union (then the European Court of Justice) has clarified that this term is to be interpreted as meaning "when [the product] is taken out of the manufacturing process operated by the producer and enters a marketing process in the form in which it is offered to the public in order to be used or consumed."[77]

In this context, the implication resulting from the application of non-blockchain to maintenance could be a positive one since, if the producer were to create a non-blockchain for a specific component and then all other actors were to build upon that foundation by adding blocks whenever they came in contact with the component, it would be possible to put a finger on the precise moment when a defect in that component arose.

As a result (considering that the typical case in which this defence may come into play is where it is claimed that the danger stems from lack of repair or servicing or from subsequent tampering of the product),[78] through non-blockchain the producer would be able to know exactly when the defect arose and thereby prove with certainty, rather than with probability, whether or not the defect that caused the damage existed at the time when the product was put into circulation.

Finally, a further legal implication that could potentially arise from the application of non-blockchain to maintenance is, once again, related to competition law since, if by applying non-blockchain to maintenance the various actors involved create a *de facto* consortium, it could be argued that there exists a cartel in the midst of it all.[79]

In this regard, it is once again opined that a surge in the number of cartels resulting from the application of non-blockchain to maintenance could plague the EU, and while it is not necessary to explain once more why such a surge could result, it can be simply restated that the EU should strongly consider criminalizing cartels in order to try and prevent this surge from happening.

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[77] O'Byrne v. Sanofi Pasteur MSD Ltd., 2006 E.C.R.1-1343, ¶ 32.

[78] C.J. Miller & R.S. Goldberg, Product Liability 486 (2d ed. 2004) (Note that the authors speak of Section 4(1)(d) of the Consumer Protection Act 1987 of the UK, which is the implementing provision of art. 7(b) of the PLD).

[79] *See* Sue McLean, *Blockchain: Key Legal and Regulatory Challenges with Distributed Ledger Technology*, Computerworld UK (Apr. 12, 2016), https://www.computerworlduk.com/data/key-legal-regulatory-challenges-with-distributed-ledger-technology-3638089/ [https://perma.cc/8Q77-357U].

V. CONCLUSION

Pursuant to this discussion on the potential applications and implications of distributed ledger technology, it is possible to conclude that, overall, this technology can serve as a stimulant to the airline industry. With regard to the applications, it is propounded that this technology offers the industry an opportunity to become more streamlined, as well as an opportunity to decrease its break-even load factors. With regard to the implications, it is propounded that, although this technology does not escape the grips of the law and does not bestow upon the industry complete legal freedom, it can serve, at times, as undeniable legal evidence and as a means of ensuring fair market conditions.

Still further, it can be concluded that an investment in distributed ledger technology could benefit the airline industry in the long-term for, ultimately, this technology can be compared to "digital land" on which "digital buildings," such as Bitcoin, are erected. Accordingly, by investing in the land rather than the buildings, the airline industry would be ensuring that, should the buildings collapse, it would still be in a strategic position as the land it would have invested in (i.e. the distributed ledger technology) would still be well in place.

In this context, therefore, the airline industry could be a present-day pioneer by increasing its research in and development of the infrastructure of the world of tomorrow: distributed ledger technology.