BLOCKCHAIN TECHNOLOGY

A SOLUTION IN SEARCH OF A PROBLEM—OR A REVOLUTION?

BY DAVID TOCHEN

Mention the word *blockchain* and most people will immediately associate it with Bitcoin and other cryptocurrencies, many of which are characterized by wide fluctuations in value and a number of which are little more than fraudulent schemes.[1] This article will describe blockchain technology and how it operates, the views of its proponents and detractors, and the current and planned applications of this technology in the aviation industry. On this latter issue, there are numerous pilot programs underway in the aviation sector that hold real promise in ensuring accurate and secure transactions, data storage and record keeping. This article will highlight a number of these current efforts.[2]

WHAT IS BLOCKCHAIN?

Origin. In the immediate aftermath of the 2007–2008 global financial crisis, an unknown, and still unidentified, person or persons named Satoshi Nakamoto published a white paper describing a new peer-to-peer electronic cash system known as Bitcoin.[3] The paper also established a set of rules that ensured the integrity of the system data without going through a trusted third party (i.e., a government entity or a financial institution). This set of rules has come to be known as *blockchain*. Simply put, the information available in a blockchain is stored in groups—called blocks—and each block is time-stamped and linked to one generated before it in time, creating a linear chain of blocks.[4]

Blockchain technology has already been implemented in an impressive array of industries and government programs. While blockchain is being used most widely in cryptocurrency transactions, its use in the financial industry is also burgeoning. Other examples include the following: in West Virginia, a limited number of counties implemented a blockchain-based voting system in 2018 as an option for overseas voters; a number of countries have created blockchain land use registries; Walmart developed a program using blockchain to track contamination in its suppliers' lettuce and spinach; the diamond industry relies on a blockchain-based registry of every certified diamond in the world; and shipping giant Maersk uses blockchain to track shipping containers worldwide.

***Blockchain* defined.** Unfortunately, there are a multitude of definitions of *blockchain*, many of which either are too simplistic (e.g., "a blockchain is a database"), beg the question (e.g., a blockchain is a "distributed ledger technology"), or are hopelessly convoluted. The U.S. Congress, too, is grappling with a workable, formal definition of *blockchain*. The Blockchain Promotion Act of 2019, H.R. 1361, introduced in February 2019, would require the secretary of commerce to establish a blockchain working group to submit a report to Congress that, among other things, includes a recommended definition of *blockchain technology*.[5]

One helpful, plain English description appeared in a 2018 article in the *New Yorker*:

> Broadly speaking, a blockchain is an evolving record of all transactions that is maintained, simultaneously and in common, by every computer in the network of that blockchain, be it Ethereum, Bitcoin, or Monero. Think, as some have suggested, of a dusty leather-bound ledger in a Dickensian counting house, a record of every transaction relevant to that practice. Except that every accountant in London, and in Calcutta, has the same ledger, and when one adds a line to his own the addition appears in all of them. Once a transaction is affirmed, it will—theoretically, anyway—be in the ledger forever, unalterable and unerasable. . . . With blockchains, the records, under a kind of cryptographic seal, are distributed to all and belong to no one. You can't revise them, because everyone is watching, and because the software will reject it if you try. There is no Undo button. Each block is essentially a bundle of transactions, with a

TIP
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tracking notation, represented in a bit of cryptographic code known as a "hash," of all the transactions in the past. Each new block in the chain contains all the information (or, really, via the hash, a secure reference to all the information) contained in the previous one, all the way back to the first one, the so-called genesis block.[6]

Delving a bit deeper, as described in a *Harvard Business Review* article about blockchain, there are five basic principles underlying blockchain technology:[7]

- *Distributed database:* Each participant in the blockchain has access to the entire database. No single party controls the data in the blockchain, and every party can directly verify the data transactions of every other party.
- *Peer-to-peer transmission:* Communication occurs directly between peers rather than through a central depository.
- *Transparency with pseudonymity:* Each blockchain user (also known as a "node") has a unique 30-plus-character alphanumeric address that identifies the user.
- *Irreversibility of records:* Once a transaction is entered in the database and the accounts are updated, the records cannot be altered because they are linked to every prior recorded transaction. Computational algorithms ensure that each blockchain transaction is permanent, in chronological order, and available to all other users. (This feature is often described as "immutability," which, at least in theory, prevents hacking into a blockchain.)[8]
- *Computational logic:* Blockchain transactions can be programmed and thus enable users to set up algorithms and rules and automatically trigger transactions between nodes.

Smart contracts. A key term in blockchain technology is a so-called *smart contract*. Rather than an actual contract, a smart contract is a software program that runs on the blockchain. It allows different organizations or users to share control of the blockchain data and sets parameters that the parties to a transaction agree upon (i.e., payment terms, confidentiality, and enforcement provisions). As self-executing code on the blockchain, the smart contract automatically implements the terms of the agreement between the parties and minimizes the need for intermediaries.[9]

Consensus mechanism and proof of work. As one blockchain primer has described, in the pre-blockchain world, trust in transactions derived from individuals, intermediaries (i.e., banks, governments, PayPal, credit card companies, Apple, Google, and others). In blockchain technology, there is no trusted third party to certify transactions. Instead, trust and consensus among network users are established algorithmically, and each transaction is recorded cryptographically.[10] For example, in the Bitcoin network and other networks, consensus is established under the so-called proof of work method. Under this method, a network participant—called a *miner*—publishes the next block by being the first to solve a computationally intensive puzzle. The solution to this puzzle is the "proof" they have performed work. The puzzle is designed such that solving the puzzle is difficult but checking that a solution is valid is easy. This enables all other [participants] to easily validate any proposed next blocks, and any proposed block that did not satisfy the puzzle would be rejected.[11]

While blockchain technology has "enabled a worldwide network where every transaction is verified and the blockchain is kept in sync amongst a multitude of users," the proof of work method for Bitcoin transactions can require vast amounts of energy to run computers that support a large blockchain.[12] One estimate claims that one Bitcoin transaction consumes as many kilowatt-hours as are needed to power a house for one week.[13] It is important to point out that public blockchain networks, such as bitcoin, can pose significant drains on energy resources, despite continuing improvements in hardware and software. In contrast, the aviation blockchain networks described below are private, permissioned networks with known business participants that are subject to smart contracts agreed to by the participants.

BLOCKCHAIN: REVOLUTIONARY OR JUST PLAIN HYPE?

The debate over the value and utility of blockchain technology is intense.[14] While hyperbole is evident on both sides of the public debate, it must be remembered that the technology is still relatively new and is merely in its late infancy. Also, several large consulting companies (including IBM, PricewaterhouseCoopers, Accenture, Deloitte, KPMG, and EY) play an increasingly large role in working with governments and

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industry actors (including the aviation sector, as described further below) to develop and implement blockchain technologies and have issued reports and survey results regarding the benefits of the technology.

The *Harvard Business Review* article referenced above offers important insights into the potential role of blockchain and the likely time frame for its impacts to be realized:

> True blockchain-led transformation of business and government, we believe, is still many years away. That's because blockchain is not a "disruptive" technology, which can attack a traditional business model with a lower-cost solution and overtake incumbent firms quickly. Blockchain is a *foundational* technology: It has the potential to create new foundations for our economic and social systems. But while the impact will be enormous, it will take decades for blockchain to seep into our economic and social infrastructure. The process of adoption will be gradual and steady, not sudden, as waves of technological and institutional change gain momentum.[15]

BLOCKCHAIN AND AVIATION

Overview. Blockchain technology is attracting increased attention in the aviation industry. According to one survey, 59 percent of airlines and 34 percent of airports have pilot, proof of concept, or research programs involving blockchain planned for implementation by 2021.[16] This growing aviation industry interest in blockchain is also illustrated by the April 2019 International Civil Aviation Organization (ICAO)–United Arab Emirates Blockchain Summit and Exhibition in Dubai. The program hosted over 1,000 attendees from over 90 countries and featured 50 speakers. At the conference, ICAO Council President Dr. Olumuyiwa Benard Aliu nicely summarized the potential role of blockchain in aviation:

> Blockchain has the potential to virtually exclude loss, distortion, or forgery of vital log data in all aviation sectors where certificates are issued and controlled . . . . It can ensure the integrity of the ever growing certification-based system which is integral to aviation, with the potential to increase efficiency while reducing errors, and therefore enhancing both safety and security.[17]

Despite this surge in blockchain activity, it nonetheless should be pointed out that these aviation industry efforts are still in a nascent stage and significantly trail blockchain implementation in other industries. For example, *Forbes* recently announced the Forbes Blockchain 50—companies that are leading the way in adapting blockchain technology. None of these companies provides aviation goods or services.[18]

Aviation blockchain entities. The Société Internationale de Télécommunication Aéronautique (SITA) is owned by members of the international air transport industry. It specializes in air transport communications and IT solutions. One year ago, SITA's research arm—SITA Lab—launched a research project to explore the potential for blockchain in the aviation industry. SITA Lab has been building a cloud-based multiorganizational blockchain network, known as the SITA Aviation Blockchain Sandbox. Among the areas that SITA Lab is evaluating for blockchain usage are flight information, passenger counting/tracing, baggage, cargo, aircraft maintenance, and identity management.[19] As part of the Sandbox's focus, SITA has made its FlightChain research project available to airlines and airports. FlightChain is a private, permissioned air transport industry blockchain of real-time flight status data established by SITA Lab in conjunction with Heathrow Airport Holdings Limited and International Airlines Group (holding company of Aer Lingus, British Airways, Iberia, and Vueling) and later joined in the project by Geneva Airport and Miami International Airport.[20]

The Blockchain in Transport Alliance (BiTA), established in August 2017, has nearly 500 members drawn from the freight, transportation, and logistics industries. It serves as a forum for the development of blockchain standards and education. Its aviation industry members include UPS and FedEx.[21]

AS A SOFTWARE PROGRAM THAT RUNS ON THE BLOCKCHAIN, A SMART CONTRACT ALLOWS DIFFERENT ORGANIZATIONS OR USERS TO SHARE CONTROL OF THE BLOCKCHAIN DATA AND SETS PARAMETERS THAT THE PARTIES TO A TRANSACTION AGREE UPON.

BLOCKCHAIN USES IN AVIATION

The following types of aviation data and information have been the focus of various blockchain storage efforts:

- Flight information (see discussion above on FlightChain),
- Passenger ticketing, counting, and tracking (single-token travel),
- Baggage, cargo, and bills of lading,
- Aircraft parts and maintenance,
- Loyalty/frequent flyer program management,
- Pilot logs,
- Flight data,
- Passenger and crew identity management,
- Training records,
- Digital passports,
- Aircraft leasing,
- Payment management,
- Air traffic management,
- Unmanned aircraft systems (UAS) registration, and
- Insurance.

A number of these efforts are highlighted below.

Ticketing/loyalty. As Accenture has pointed out, an e-ticket is essentially a database entry—information that is stored in and retrieved from a large database. The blockchain can "tokenize" this information, and airlines, through the use of smart contracts, can add terms and conditions regarding how the ticket is sold and used. Similarly, airlines can tokenize loyalty points on the blockchain and can instantly redeem them.[22] Regarding the use of blockchain to issue passenger tickets, one report describes how Russia's biggest airline, S7, and its ticketing agent, S7 Ticket, are now issuing passenger tickets on a blockchain with support from the country's largest private bank, Alfa-Bank. By using the blockchain, settlement times between the airline and the agent can be reduced, and the payment process can be streamlined by deducting the agent commission automatically after a ticket sale.[23] Similarly, Singapore Airlines has implemented a blockchain-based digital wallet, developed with Microsoft and KPMG, that enables travelers to convert air miles into cryptocurrency to purchase goods and services.[24]

AVIATION DATA AND INFORMATION THAT HAVE BEEN THE FOCUS OF VARIOUS BLOCKCHAIN STORAGE EFFORTS INCLUDE TICKETING, AIRCRAFT PARTS AND MAINTENANCE, AIR TRAFFIC MANAGEMENT, AND PAYMENT MANAGEMENT.

Aircraft parts and maintenance. Various notable efforts are underway or have been announced to address supply chain assuredness. In general, these efforts have several common purposes: to track and authenticate critical aircraft parts and materials, deter the use of counterfeit parts, and ensure greater accuracy in determining the life cycle of replacement parts while achieving cost savings. The application of blockchain technology to achieve these goals is particularly important given the life cycle of many aircraft and the continued prevalence of paper-based documentation.[25]

Among these efforts to employ blockchain for maintenance and spare parts are the following:

- At the July 2018 Farnborough Air Show, Accenture and Thales demonstrated a prototype blockchain-based system that can track, trace, and authenticate aircraft parts and materials in the aerospace and defense industry.
- In December 2018, Honeywell Aerospace launched a blockchain-based GoDirect Trade aircraft parts e-commerce portal.
- GE Aviation Digital and Microsoft Azure have announced they are developing a blockchain to track parts in GE engines.
- GI Aerospace is developing a blockchain platform for electronic record keeping of life cycle data on aircraft and parts.
- Lufthansa Industry Solutions has initiated the Blockchain for Aviation (BC4A) initiative to evaluate how the technology can be used to increase transparency within flight maintenance.

Aircraft leasing. The aircraft leasing industry is highly capital-intensive. The need to manage assets and necessary financial transactions, ensure aircraft availability, and minimize aircraft on-ground times are all important factors in the leasing industry. The streamlining of record keeping discussed above is also important for aircraft lessors. In addition, Accenture has estimated that the application of blockchain technology in the aircraft leasing sector could eliminate 20 days from the 65- to 70-day engine overhaul cycle.[26] It is evident, however, that efforts to implement blockchain technology in the aircraft leasing

segment are not as far along as in other industry segments.

Air traffic management. In January 2019, the National Aeronautics and Space Administration (NASA) published a research paper that presented an engineering prototype employing an open-source, permissioned blockchain to enable secure, private, and anonymous communication with air traffic services.[27] The paper indicates that current ground-based radar systems and Mode-C transponders to track aircraft, which are under the exclusive control of the Federal Aviation Administration (FAA), ensure operational privacy for military and approved civil aircraft by blocking operations from public view. The FAA's mandate for national adoption of Automatic Dependent Surveillance-Broadcast (ADS-B) in 2020, however, does not provide the same level of FAA exclusive control for ADS-B data. The ADS-B system contains other security risks, including third-party spoofing (false aircraft position reports), malicious interference, and denial of service attacks. As described in the paper, the proposed framework

> features certificate authority, smart contract support, and higher-bandwidth communication channels for private information that may be used for secure communication between any specific aircraft and any particular authorized member, sharing data in accordance with the terms specified in the form of smart contracts.[28]

The paper concludes that the proposed blockchain infrastructure can be rapidly deployed and economically maintained.[29]

Payment management. The International Air Transport Association (IATA) is studying the role that blockchain can play in what it calls "rebalancing the value chain."[30] The value chain refers to the chain of business entities that are involved in processing airline ticket transactions. As IATA has pointed out, an airline is one of 26 business partners involved in the aviation chain, and the profit margin of each business partner is often higher than that of the air carrier. In addition, IATA's financial settlement systems handle approximately $400 billion per year, and of that around $7.7 billion represents banking fees—more than 20 percent of the estimated new profit of the entire global airline industry in 2016.[31]

In an effort to sustain the financial health of its member airlines, IATA is exploring a blockchain payment system. It has established a pilot project but has been hampered "because the global regulatory framework has not been updated to meet the requirements of these new distributed ledger systems."[32]

CONCLUSION

Despite the hype and misperceptions surrounding blockchain, the aviation and other industries are taking discrete, measured steps in exploring its potential uses. This caution is prudent and reflects the recognition that blockchain is a tool that needs to be carefully tested and evaluated. While some critics argue that blockchain is a solution in search of a problem, this ignores the fact that the technology is being tested to address significant risks and costs. It is safe to assume, however, that in the upcoming years blockchain will become better understood and applied on a more widespread basis while at the same time posing new technical and legal challenges. ■

NOTES

1. One prominent critic of Bbitcoin—Warren Buffett—characterized it as "a delusion" and "rat poison squared."

2. This article omits a discussion of more technical aspects of blockchain technology. For an excellent presentation of many of these technical issues, see Dylan Yaga et al., Nat'l Inst. of Standards & Tech., NISTIR 8202, Blockchain Technology Overview (2018), https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf.

3. Approximately two years ago, a group known as Satoshi Nakamoto Republic created a virtual monument in Kiev, Ukraine, of the Bitcoin and blockchain progenitor. Curiously, the virtual statue has "three heads . . . and has robot-like legs and stomach." Lesia Dubenko, *Statue of Satoshi Nakamoto: This Is What He Looks Like*, Medium (Sept. 30, 2018), https://medium.com/@altcoinbuzz/statue-of-satoshi-nakamoto-this-is-what-he-looks-like-abbf520b6bde.

4. Luc Dossis, *Blockchain Explained in 1000 Words*, Good Audience (Sept. 17, 2018), https://blog.goodaudience.com/blockchain-explained-in-1000-words-6bb83020b036; *see also* Mohit Mamoria, *WTF Is the Blockchain?*, Hackernoon (June 28, 2017), https://hackernoon.com/wtf-is-the-blockchain-1da89ba19348.

5. H.R. 1361, 116th Cong. (2019).

6. Nick Paumgarten, *The Prophets of Cryptocurrency Survey the Boom and Bust*, New Yorker (Oct. 15, 2018), www.newyorker.com/magazine/2018/10/22/the-prophets-of-cryptocurrency-survey-the-boom-and-bust.

7. Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, Harv. Bus. Rev., Jan.–Feb. 2017, https://hbr.org/2017/01/the-truth-about-blockchain.

8. The immutability of blockchains has been called into question. *See* Mike Orcutt, *Once Hailed as Unhackable, Blockchains Are Now Getting Hacked*, MIT Tech. Rev. (Feb. 19, 2019), www.technologyreview.com/s/612974/once-hailed-as-unhackable-blockchains-are-now-getting-hacked.

9. Nick Szabo, Smart Contracts (1994) (unpublished manuscript), www.fon.hum.uva.nl/rob/Courses/

InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html.

10. Don Tapscott & Alex Tapscott, Blockchain Revolution: How the Technology behind Bitcoin Is Changing Money, Business, and the World 11, 32–33 (2016).

11. Yaga et al., *supra* note 2, at 19.

12. *Id.* at 38–39.

13. Christopher Malmo, *One Bitcoin Transaction Consumes as Much Energy as Your House Uses in a Week*, Motherboard (Nov. 1, 2017), www.vice.com/en_us/article/ywbbpm/bitcoin-mining-electricity-consumption-ethereum-energy-climate-change.

14. For every strong endorsement of the technology, there seems to be an equally passionate dismissal of its limitations. *Compare* H.R. Rep. No. 115-596, at 214 (2018) ("[T]he potential for blockchain is truly revolutionary."), *and* Josh Rogin, *China Is Racing Ahead of the United States on Blockchain*, Wash. Post (Mar. 7, 2019), www.washingtonpost.com/opinions/global-opinions/china-is-racing-ahead-of-the-united-states-on-blockchain/2019/03/07/c1e7776a-4116-11e9-9361-301ffb5bd5e6_story.html (reporting that Chinese President Xi Jinping told the Chinese Academy of Sciences: "'Ever since the start of the 21st century, a new generation of industrial revolution is substantially reshaping the global economic structure,' based on artificial intelligence, the Internet of things and blockchain."), *with* Nikolai Hampton, *Understanding the Blockchain Hype: Why Much of It Is Nothing More Than Snake Oil and Spin*, Computerworld (Sept. 5, 2016), www.computerworld.com.au/article/606253/understanding-blockchain-hype-why-much-it-nothing-more-than-snake-oil-spin, *and* Bruce Schneier, *There's No Good Reason to Trust Blockchain Technology*, Wired (Feb. 6, 2019), www.wired.com/story/theres-no-good-reason-to-trust-blockchain-technology, *and* Kai Stinchcombe, *Blockchain Is Not Only Crappy Technology but a Bad Vision for the Future*, Medium (Apr. 5, 2018), https://medium.com/@kaistinchcombe/decentralized-and-trustless-crypto-paradise-is-actually-a-medieval-hellhole-c1ca122efdec.

15. Iansiti & Lakhani, *supra* note 7.

16. Joe Bates, *Airport Interest Growing in Blockchain Technology*, Airport World (Oct. 8, 2018), www.airport-world.com/news/general-news/6846-airport-interest-growing-in-blockchain-technology.html.

17. News Release, Int'l Civil Aviation Org., Blockchain's Aviation Potential Explored at Inaugural ICAO-UAE Summit (Apr. 3, 2019), www.icao.int/Newsroom/Pages/Blockchains-aviation-potential-explored-at-inaugural-ICAO-UAE-Summit.aspx.

18. Michael del Castillo, *Blockchain 50: Billion Dollar Babies*, Forbes (Apr. 16, 2019), https://www.forbes.com/sites/michaeldelcastillo/2019/04/16/blockchain-50-billion-dollar-babies/#256fff2f57cc.

19. Barry McLaughlin, *Let's Collaborate to Explore Blockchain: SITA's "Aviation Blockchain Sandbox,"* Blogs@CITA (Aug. 23, 2018), www.sita.aero/resources/blog/lets-collaborate-to-explore-blockchain-sitas-aviation-blockchain-sandbox.

20. SITA, FlightChain (2017), www.sita.aero/resources/type/white-papers/flightchain-shared-control-of-data.

21. *See* BiTA, https://www.bita.studio (last visited Sept. 10, 2019).

22. *Beyond the Buzz: The Potential of Blockchain Technology for Airlines*, Accenture, www.accenture.com/us-en/insight-potential-blockchain-technology-for-airlines (last visited Sept. 10, 2019).

23. Wolfie Zhao, *A Russian Airline Is Now Using Blockchain to Issue Tickets*, Coindesk (July 25, 2017), https://www.coindesk.com/russian-airline-using-blockchain-for-tickets.

24. Jo Perks, *How the Aviation Industry Is Turning to Blockchain*, Crypto News Rev. (Oct. 21, 2018), https://cryptonewsreview.com/6143-2.

25. According to Boeing Digital Aviation, paper accounts for about 90 percent of all commercial airline maintenance records globally. Paul Seidenman & David J. Spanovich, *Why Airlines, Aftermarket Struggle with Digital Record-Keeping*, InsideMRO (Sept. 9, 2016), https://aviationweek.com/connected-aerospace/why-airlines-aftermarket-struggle-digital-record-keeping.

26. Michael Bruno, *Blockchain Eyed for Holy Grail: Aircraft Availability*, InsideMRO (Sept. 26, 2018), www.mro-network.com/technology/blockchain-eyed-holy-grail-aircraft-availability; *see also* Lory Kehoe, *Blockchain—A Game Changer in Aircraft Leasing?*, Airfinance J., 2017/2018, at 84, www2.deloitte.com/content/dam/Deloitte/ie/Documents/Tax/ie-blockchain-a-game-changer-in-aircraft-leasing.pdf.

27. Ronald J. Reisman, NASA Ames Research Ctr., Paper Presented at the AIAA SciTech Forum: Air Traffic Management Blockchain Infrastructure for Security, Authentication, and Privacy (2019), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190000022.pdf.

28. *Id.* at 1.

29. *Id.* at 2.

30. Int'l Air Transp. Ass'n, Future of the Airline Industry 2035, at 55 (2018), www.iata.org/policy/Documents/iata-future-airline-industry.pdf; *see also* Houman Goudarzi & Juan Ivan Martin, Int'l Air Transp. Ass'n, Blockchain in Aviation: Exploring the Fundamentals, Use Cases, and Industry Initiatives (2018), www.iata.org/publications/Documents/blockchain-in-aviation-white-paper.pdf.

31. *Blockchain Can Rebalance the Value Chain to Benefit Airlines and Passengers*, Int'l Air Transport Ass'n (Sept. 26, 2017), https://airlines.iata.org/blog/2017/09/blockchain-can-rebalance-the-value-chain-to-benefit-airlines-and-passengers.

32. *Id.*